

**OXIDATIVE STABILITY
ENHANCEMENT OF EDIBLE OILS
USING NANO-CERIA FOR FOOD
APPLICATIONS**

Thesis

submitted by

Sreemoyee Chakraborty

Doctor of Philosophy (Engineering)

**Department of Food Technology
& Biochemical Engineering**

**Faculty Council of Engineering & Technology
Jadavpur University**

Kolkata, India

2026

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All information in this thesis have been obtained and presented in accordance with existing academic rules and ethical conduct. I declare that, as required by these rules and conduct, I have fully cited and referred all materials and results that are not original to this work.

I also declare that I have checked this thesis as per the “Policy on Anti Plagiarism, Jadavpur University, 2019”, and the level of similarity as checked by iThenticate software is 9%.

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SREEMOYEE CHAKRABORTY

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Preface

The preservation of food quality has always stood at the heart of food science, and among the many factors that challenge this objective, lipid oxidation remains one of the most persistent and scientifically demanding. Edible oils, particularly those rich in polyunsaturated and monounsaturated fatty acids, are nutritionally valuable yet inherently vulnerable to oxidative degradation. The consequences of this deterioration extend beyond rancid flavor and reduced shelf life; they encompass nutrient loss, formation of potentially harmful compounds, economic inefficiencies, and diminished consumer trust. Despite extensive research and the routine use of synthetic and natural antioxidants, oxidative instability continues to pose significant limitations in both industrial processing and domestic storage conditions.

The motivation for this thesis arose from a fundamental question: can we move beyond conventional, consumptive antioxidants toward a regenerative system capable of sustained protection? Traditional antioxidants function through stoichiometric radical trapping, meaning their protective action diminishes as they are consumed. Moreover, concerns surrounding the thermal instability of natural antioxidants and the safety and regulatory scrutiny of synthetic additives have intensified the need for innovative, durable, and consumer-aligned alternatives. Addressing this gap requires not merely incremental improvement, but a conceptual shift in antioxidant strategy.

This work, titled *Oxidative Stability Enhancement of Edible Oils Using Nano-Ceria for Food Applications*, explores such a shift through the integration of nanotechnology into lipid oxidation science. Cerium oxide nanoparticles (nano-ceria) possess a unique ability to reversibly cycle between Ce^{3+} and Ce^{4+} oxidation states, enabling catalytic and regenerative scavenging of reactive oxygen species. Unlike traditional antioxidants, nano-ceria is not rapidly depleted during redox reactions, offering the potential for prolonged oxidative protection even under thermal stress. The hypothesis underpinning this research is that engineering the physicochemical properties of nano-ceria—particularly oxygen vacancy concentration and surface redox balance—can yield a thermally stable, redox-regenerative antioxidant platform suitable for food applications.

This thesis systematically investigates the synthesis, characterization, and functional evaluation of nano-ceria, with emphasis on establishing synthesis–structure–function relationships. By optimizing parameters such as pH, temperature, and dispersant systems, the

study seeks to tailor redox behavior and maximize radical scavenging efficiency. The practical relevance of this approach is evaluated through application in two widely consumed oils—sunflower oil and rice bran oil—under varying storage and thermal conditions. The work extends beyond laboratory-scale antioxidant assays to real-system validation using peroxide value analysis over prolonged storage periods.

At its core, this research represents an interdisciplinary convergence of materials science, nanotechnology, and food chemistry. It attempts to bridge theoretical redox mechanisms with applied food preservation challenges. While acknowledging the importance of safety, regulatory considerations, and long-term evaluation, this study aspires to contribute toward the development of next-generation antioxidant systems that align with modern food industry demands for stability, sustainability, and innovation.

Through this exploration, the thesis endeavors to advance both scientific understanding and practical strategies for enhancing oxidative stability in edible oils, offering a step toward more resilient and forward-looking food preservation technologies.

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CHAPTER 1: Introduction

1.1 Background: Lipid Oxidation and its Food System Challenges

Edible oils, particularly those rich in poly- and monounsaturated fatty acids (PUFAs and MUFAs), are indispensable to human nutrition (Chow, 1985), serving as vital carriers of fat-soluble vitamins (A, D, E, K), essential fatty acids (e.g., linoleic and α -linolenic acids), and contributing to the flavor, texture, and mouthfeel of food products. Common oils such as sunflower, rice bran, and soybean oil are composed mainly of triacylglycerols, along with minor constituents like free fatty acids, phospholipids, tocopherols, and polyphenols that influence oxidative stability (Sharma & Sharma, 2017; Maszewska et al., 2018).

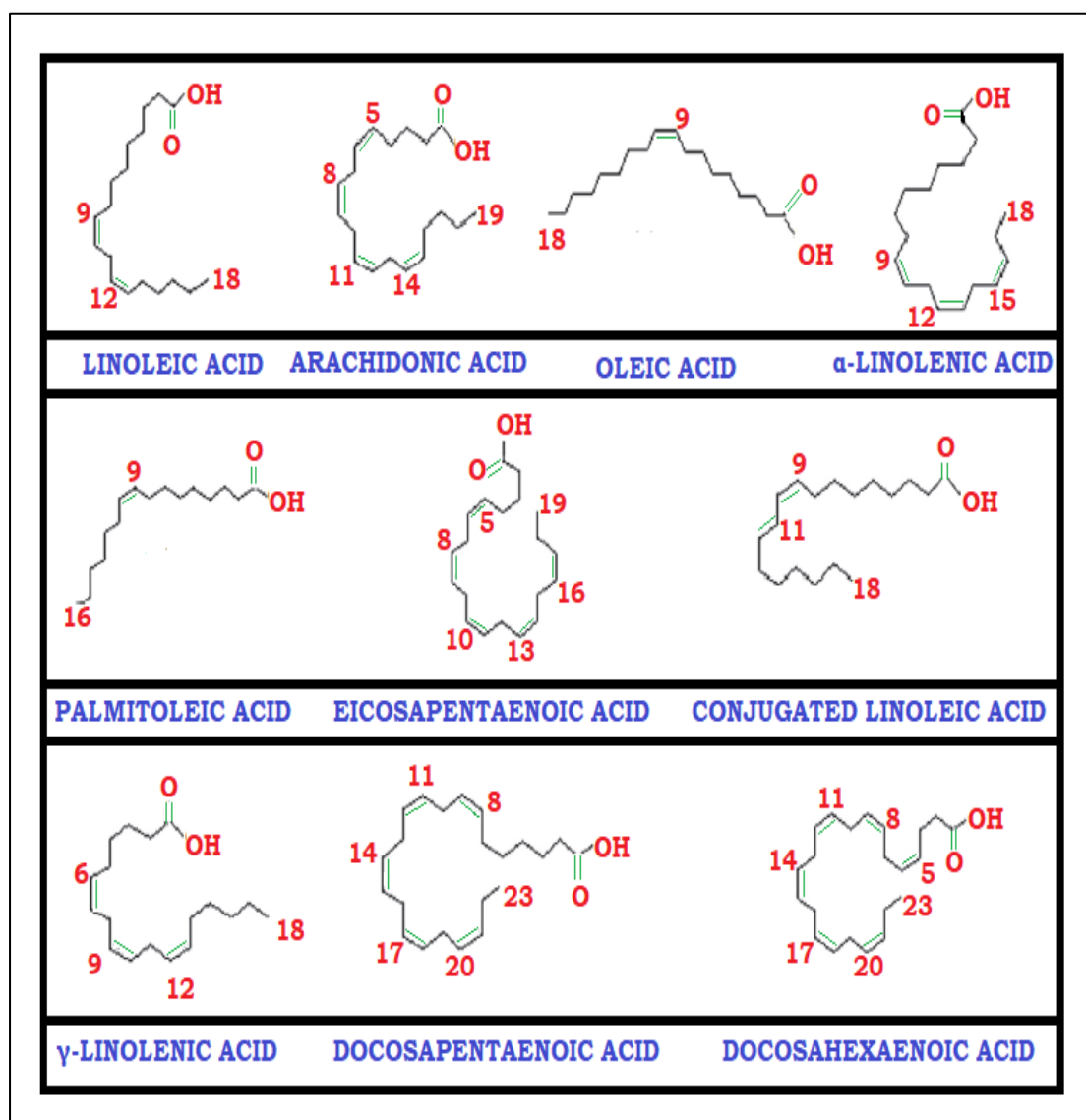


Figure 1.1: PUFA and MUFA commonly found in edible oils

The presence of multiple double bonds in PUFA as shown in Figure 1.1, while nutritionally beneficial, facilitates autoxidation processes under exposure to heat, light, and oxygen (Hernandez, 2016; Kaleem et al., 2020). Oxidative rancidity, driven by autoxidation and photo-oxidation mechanisms, follows a free-radical chain reaction that includes initiation (formation of lipid radicals), propagation (peroxidation of fatty acids), and termination (generation of non-radical end products). Initiation typically begins with the abstraction of a hydrogen atom from bis-allylic positions in PUFAs, forming lipid radicals that react with oxygen to create peroxy radicals, which in turn attack additional lipid molecules. Concurrently, light-induced photo-oxidation involving singlet oxygen and photosensitizers like chlorophylls accelerates the formation of lipid hydroperoxides. These oxidative pathways result in the formation of undesirable compounds, loss of essential nutrients, and deterioration in sensory quality—manifesting as off-flavors, discoloration, and rancidity. Consequently, maintaining the oxidative stability of edible oils throughout their lifecycle has emerged as a critical challenge and a central focus of innovation in food science and industry.

Consumption of oxidized or rancid edible oils poses serious health risks due to the accumulation of toxic secondary oxidation products. During lipid oxidation, reactive compounds such as malondialdehyde (MDA) and 4-hydroxynonenal (4-HNE) are generated, which can form adducts with DNA and proteins, leading to cytotoxicity, genotoxicity, and a heightened risk of carcinogenesis (Valgimigli et al., 2018). Oxidized oils have been linked to endothelial dysfunction and the promotion of low-density lipoprotein (LDL) oxidation, both of which are major contributors to atherosclerosis and cardiovascular disease. Additionally, chronic ingestion of rancid oils can cause hepatic stress, increasing liver enzyme activity, promoting fat accumulation, and exacerbating inflammation, thereby contributing to non-alcoholic fatty liver disease (NAFLD) (Hosseini & Mozafari, 2020). Pro-inflammatory responses and disturbances in gut microbiota associated with these oxidized compounds also elevate the risk of metabolic syndrome, insulin resistance, and type 2 diabetes. Emerging evidence further implicates lipid peroxidation in neurodegenerative conditions such as Alzheimer's and Parkinson's diseases, where oxidative stress damages neuronal membranes (Naganuma & Traversa, 2014). Recent studies confirm that repeated exposure to oxidized oils intensifies oxidative stress biomarkers and causes cellular degeneration *in vivo*, underscoring the urgency of improving oxidative stability in edible oils for both food quality and human safety (Arab Ahmadi & Alemi, 2025).

1.2 Current Challenges in Oxidative Stability of Edible Oils

1.2.1 Storage Stability

Oxidative stability is a key determinant of oil shelf life and marketability (Maszewska et al., 2018). Even under optimal storage conditions, refined oils undergo gradual oxidative deterioration. Studies indicate a ~30% decline in oxidative stability for common oils after 12 months at 25 °C (Maszewska et al., 2018; Ettalibi et al., 2020), with pronounced losses at elevated temperatures or during household storage after package opening (Boukandoul et al., 2019). Factors such as oxygen ingress, light exposure, and residual pro-oxidants exacerbate lipid degradation. The industry thus faces mounting pressure to enhance oxidative stability without resorting to synthetic additives increasingly rejected by consumers.

1.2.2 High-Temperature Processing

In industrial applications, particularly in the ready-to-eat snack food sector, oils are subjected to high-temperature frying (150–280 °C) for extended periods (Kaleem et al., 2015). Thermal oxidation occurs at accelerated rates, surpassing autoxidation mechanisms and leading to rapid accumulation of peroxides and secondary oxidation products (Aleena et al., 2020). Studies show that peroxide values of frying oils exceed acceptable thresholds within 3–4 hours of operation (Boukandoul et al., 2019), necessitating frequent oil replacement and contributing to significant economic losses. Current antioxidants often fail to provide adequate protection under such harsh thermal conditions.

1.2.3 Post-Unsealing Domestic Use

Oxidation continues after oils are opened for household use, with peroxide and acid values increasing markedly within days (Maszewska et al., 2018; Kaleem et al., 2015). This presents a key consumer-facing challenge, as oil degradation during domestic storage undermines both product quality and brand trust. The lack of effective, consumer-safe oxidative stabilization strategies for this phase remains a critical gap.

1.3 Antioxidant Challenges in Complex Lipid Systems: Oxidative Stability, Safety, and Quality Dimensions

Lipid oxidation represents a major pathway of quality degradation in food systems, contributing not only to rancid flavors, color and texture deterioration, but also to the generation of potentially cytotoxic aldehydes and peroxides. The oxidative stability of complex lipid systems—encompassing composite fats, emulsions, and structured food matrices—is governed by multiple interrelated physicochemical factors. These include the degree of unsaturation in the lipid fraction, presence of catalytic pro-oxidants (e.g., trace metals, light,

oxygen), endogenous antioxidant content, physical microstructure, and external conditions such as temperature and storage atmosphere (Frankel, 2005; Chaiyasit et al., 2007).

Highly unsaturated fatty acids, particularly polyunsaturated (PUFAs) and monounsaturated fatty acids (MUFAs), are significantly more prone to oxidation than saturated counterparts due to the susceptibility of their double bonds to radical attack (Choe & Min, 2006). In emulsified systems, the presence of large interfacial areas intensifies oxidation processes due to increased exposure of lipids to aqueous phase pro-oxidants (McClements & Decker, 2000). Furthermore, endogenous antioxidants like tocopherols provide only limited defense, as they are rapidly consumed and may even transition into pro-oxidants once oxidized (Mukai et al., 1991). Heat, oxygen, and light exposure during frying or prolonged storage dramatically accelerate lipid peroxidation (Chaiyasit et al., 2007).

To mitigate these oxidative pathways, both synthetic and natural antioxidants are commonly employed. Synthetic compounds such as butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), tert-butylhydroquinone (TBHQ), and propyl gallate have been favored due to their cost efficiency and effectiveness at low concentrations (Yanishlieva et al., 2006). However, mounting evidence links these additives to toxicological concerns including hepatotoxicity, carcinogenicity, and endocrine disruption in animal studies, prompting regulatory scrutiny (Botterweck et al., 2000; Williams et al., 1999). Moreover, their thermal instability reduces efficacy during cooking or high-temperature processing, and their non-regenerative action limits their capacity to provide prolonged antioxidant protection (Frankel, 2005).

On the other hand, natural antioxidants derived from plant extracts (e.g., rosemary, sage, pomegranate peel, tocopherols, flavonoids) have gained attention for their consumer-friendly perception and potential sustainability. While these compounds exhibit antioxidant activity, their utility is constrained by thermal degradation, poor solubility in lipid phases, and batch-to-batch variability due to inconsistent phytochemical composition (Shahidi & Ambigaipalan, 2015; Brewer, 2011). Phenolics such as gallic acid, for instance, degrade rapidly upon mild heat exposure, while hydrophilic antioxidants struggle to distribute evenly in lipid matrices (Laguerre et al., 2010). Additionally, some polyphenols exhibit pro-oxidant behavior in the presence of metal ions or at high concentrations, paradoxically accelerating lipid oxidation (Yanishlieva et al., 2006).

1.4 Limitations of Conventional Antioxidant Strategies

One of the most pressing technical limitations of both synthetic and natural antioxidants lies in their stoichiometric mode of action. These molecules typically neutralize one free radical per antioxidant molecule, becoming inactive thereafter. As a result, they lack regenerative redox activity, making them insufficient for sustained protection, particularly in storage conditions where oxidation is a continuous process (Frankel, 2005; Shahidi & Zhong, 2010). Furthermore, many antioxidants exhibit poor compatibility with lipid-rich food matrices. Hydrophilic antioxidants may require emulsifiers or solvents for dispersion, while lipophilic variants often localize away from oxidation-prone sites such as oil–water interfaces (McClements & Decker, 2000; Poprac et al., 2017).

Both classes of conventional antioxidants suffer from inherent limitations that restrict their long-term efficacy and compatibility with modern food system demands:

- **Regulatory Constraints and Consumer Acceptance:** The use of synthetic antioxidants is increasingly subject to stringent regulatory oversight due to concerns over their potential adverse health effects (Scrinis & Lyons, 2007). Several jurisdictions have imposed usage restrictions or maximum permissible levels for synthetic antioxidants in food products. Simultaneously, there is a growing consumer preference for "clean label" and "natural" food formulations, further driving the decline in acceptance of synthetic additives.
- **Heat Sensitivity and Instability of Natural Antioxidants:** Although natural antioxidants are widely perceived as safer alternatives, many exhibit poor thermal stability and are prone to degradation under typical food processing and storage conditions (Poprac et al., 2017). For instance, polyphenolic compounds and tocopherols can undergo oxidative breakdown or polymerization at elevated temperatures encountered during frying, baking, or pasteurization, thereby losing their protective efficacy.
- **Finite Radical Trapping Capacity:** Both synthetic and natural antioxidants primarily function through stoichiometric (consumptive) mechanisms, wherein antioxidant molecules donate hydrogen atoms or electrons to neutralize lipid radicals (Sharpe et al., 2011). This mode of action inherently limits their capacity to provide long-term protection, as once the antioxidant molecules are consumed, the system becomes vulnerable to renewed oxidative attack. In complex and dynamic food matrices, particularly those with high unsaturated fatty acid content, this finite capacity often proves insufficient to ensure sustained oxidative stability.

- **Compatibility and Sensory Impact:** The incorporation of high levels of antioxidants, particularly natural extracts, may impart undesirable flavors, odors, or color changes to the final product, thereby affecting sensory quality and consumer acceptance.

1.5 Identified Research Gap

Despite decades of optimization, the antioxidant strategies employed in complex lipid systems remain largely depleting and non-catalytic, offering only transient protection. There exists a critical research gap for development and application of potential antioxidant materials that are:

- Redox-regenerative, enabling repeated free radical scavenging without rapid depletion,
- Thermally and chemically stable under food processing conditions,
- Biocompatible and non-toxic, meeting both food safety and consumer acceptability standards,
- Phase-compatible, allowing uniform dispersion and function across diverse food structures.

These limitations create an ideal context for exploring nanostructured antioxidants—particularly —which exhibit enzyme-like catalytic activity, persistent redox cycling, and tunable surface chemistry.

1.6 Nanotechnology-Based Solutions: Mechanisms and Potential

Nanoparticles offer transformative potential for addressing lipid oxidation (Deligiannakis et al., 2012; Amorati et al., 2012). Engineered nanomaterials can function as radical scavengers, regenerative antioxidants, and interfacial stabilizers (Morry et al., 2017; Amorati et al., 2012). Nanoparticles can be employed either as carriers for conventional antioxidants or as intrinsic antioxidants via their engineered surface chemistry (Sharpe et al., 2011). Recent studies demonstrate promising antioxidant effects of gold, silver, silica, and metal oxide nanoparticles (Watanabe et al., 2009; McEwen et al., 1992; Maqbool et al., 2016). Among these, cerium oxide nanoparticles (nano-ceria) exhibit uniquely advantageous properties.

The application of nanotechnology to food systems is emerging as one of the most promising avenues for enhancing food quality, safety, and stability. Since the conceptual origins of nanotechnology, articulated by Richard P. Feynman's visionary lecture in 1959 and further popularized by Drexler's *Engines of Creation* in 1986, nanoscale materials have become pervasive in biotechnology, healthcare, and now the food industry (Sekhon, 2014; Chen et al., 2006; Dasgupta et al., 2015). The capacity to engineer materials at the nanoscale — conferring

unique physicochemical, optical, catalytic, and biological properties — has enabled solutions to longstanding problems in food preservation and functionality.

Nanomaterials, typically defined by particle sizes between 1 and 100 nm, exhibit properties profoundly different from their bulk counterparts (He & Hwang, 2016). Their high surface-to-volume ratio, tunable surface chemistry, and quantum size effects enable enhanced reactivity and functionality. As a result, nanoparticles have found applications in diverse food-related domains, including packaging, pathogen sensing, nutrient delivery, and—most relevant to this thesis—oxidative stabilization of lipid-based systems (Chaudhry et al., 2008; Narayanan et al., 2012).

The global nanotechnology market is projected to exceed USD 124 billion by 2024 (Osman, 2019), reflecting its rapid integration across industries. In parallel, the food processing market, valued at USD 7.48 trillion in 2020, is expanding steadily (Statista, 2020), with growing consumer demand for minimally processed, stable, and safe food products (Scrinis & Lyons, 2007). Within this context, nanotechnology offers a paradigm shift in food preservation, particularly for improving the oxidative stability of edible oils — a critical but still inadequately addressed challenge in the food industry.

1.7 Problem Statement: Why Current Antioxidants Fail

Conventional antioxidants, whether synthetic (e.g., BHA, BHT, TBHQ) or natural (e.g., tocopherols, rosemary extract), are limited by poor thermal stability, finite radical-trapping capacity, and consumer safety concerns. Their consumptive mode of action means protection ends once the antioxidant is depleted, particularly under high-temperature or prolonged storage conditions.

1.8 Nano-Ceria - Proposed Solution

Cerium oxide nanoparticles (nano-ceria) are an innovative class of materials capable of regenerative antioxidant activity via redox cycling between Ce^{3+} and Ce^{4+} states. This catalytic mechanism allows nano-ceria to repeatedly scavenge reactive oxygen species without being consumed, offering prolonged protection even under thermal stress.

1.8.1 Nanotechnology-Based Approaches for Enhancing Oxidative Stability of Edible Oils

Various nanotechnology-driven strategies have been investigated to improve the oxidative stability of edible oils, broadly categorized into nano-encapsulation systems, inorganic barrier-based nanomaterials, and metal nanoparticles (Table 1.1). While nano-encapsulation enhances antioxidant delivery and dispersion, its protection remains limited by the consumptive nature

of conventional antioxidants. Inorganic nanoparticles primarily function as oxygen barriers without direct radical-scavenging capability, whereas metal nanoparticles offer surface-mediated antioxidant activity but face cost, regulatory, and thermal stability constraints. Collectively, these approaches provide partial oxidative protection, yet their long-term efficacy under high-temperature conditions such as frying remains a critical limitation.

Table 1.1 Comparative Analysis of Nanotechnology-Driven Strategies for Mitigating Lipid Oxidation

Strategy Category	Representative Systems	Mechanism of Action	Key Limitations	Suitability for High-Temperature Applications	Key References
Nano-encapsulation of Conventional Antioxidants	Polymeric nanoparticles, liposomes, solid lipid nanoparticles (SLNs), nano-emulsions; encapsulated tocopherols, polyphenols, carotenoids, essential oils	Improves solubility, dispersion, and controlled release of antioxidants within lipid matrices; scavenges radicals via hydrogen-donation mechanisms	Stoichiometric (consumptive) radical scavenging; gradual antioxidant depletion; no regeneration mechanism; limited long-term protection	Often reduced stability during prolonged heating; degradation of encapsulated antioxidants under frying conditions	McClements & Decker, 2000; Salvia-Trujillo et al., 2017; Frankel, 2005; Shahidi & Zhong, 2010
Inorganic Nanoparticles for Barrier Protection	Silica (SiO ₂), zinc oxide (ZnO), titanium dioxide (TiO ₂), clay-based nanocomposites	Reduce oxygen diffusion; enhance barrier properties; packaging-mediated protection	No direct radical scavenging; lacks intrinsic antioxidant or regeneration capability; indirect protection	Moderate effectiveness; primarily useful in packaging systems rather than direct oil stabilization under high thermal stress	Chaudhry et al., 2008; He & Hwang, 2016
Metal Nanoparticles	Gold (Au), silver (Ag) nanoparticles	Surface-mediated radical scavenging due to high surface reactivity	High cost; regulatory uncertainty; limited catalytic longevity; potential safety concerns	Performance may decline under prolonged high-temperature processing; limited validation for frying systems	Amorati et al., 2012; Chaudhry et al., 2008; Frankel, 2005

1.8.2 Emerging Food-Related Applications of Nano-Ceria

Although nano-ceria has been extensively investigated in biomedical systems, its application in food science and food-related technologies is comparatively recent but rapidly expanding. Preliminary studies have explored cerium oxide nanoparticles as antioxidant additives in edible oils, demonstrating improved resistance to thermo-oxidative degradation and reduced formation of primary and secondary lipid oxidation products during storage and heating (Amorati et al., 2012; Baldim et al., 2018). Nano-ceria has also been investigated in active food packaging systems, where its redox-active surface contributes to oxygen scavenging and extended shelf life of lipid-containing foods (Chaudhry et al., 2008; He & Hwang, 2016).

In addition, nano-ceria has been explored for its enzyme-mimetic redox activity in food sensing and quality monitoring applications, including peroxide detection and oxidative stress indicators relevant to food spoilage and safety (Pirmohamed et al., 2010; Celardo et al., 2011). Importantly, emerging evidence suggests that at low concentrations and with appropriate surface functionalization, nano-ceria exhibits acceptable stability and biocompatibility, supporting its potential use in food and nutraceutical systems (Baldim et al., 2018; Lord et al., 2021).

However, despite these promising findings, comprehensive studies integrating structure–function relationships, kinetic modeling, real food matrices, and thermal processing conditions remain limited in the current literature. This knowledge gap underscores the need for systematic investigation of nano-ceria as a regenerative antioxidant within edible oil systems, an objective directly addressed by the present research.

1.9 Nanoceria as an Antioxidant: Applications in biological systems and Safety

Nanoceria (CeO_2 nanoparticles, CeNPs) demonstrate a unique redox cycling between Ce^{3+} and Ce^{4+} oxidation states, allowing them to mimic natural antioxidant enzymes like superoxide dismutase (SOD) and catalase. This redox behavior is auto-regenerative, meaning CeNPs can persistently scavenge reactive oxygen species (ROS) in both in vitro and in vivo environments. Surface oxygen vacancies and Ce^{3+} abundance are critical to this function. The enzyme-mimetic activity enables the degradation of harmful species such as superoxide and hydrogen peroxide (Baldim et al., 2018; Lord et al., 2021). Green synthesis methods using plant extracts yield biocompatible CeNPs with high Ce^{3+} content and enhanced ROS-scavenging ability (Dhall & Self, 2018). Structural modifications like oxygen deficiencies (CeO_{2-x}) further improve redox cycling and allow tunable antioxidant responses, making them adaptable for

therapeutic applications (Ma et al., 2021). Hence, nanoceria offers a robust platform for ROS regulation through redox tunability, surpassing conventional antioxidants in longevity and catalytic efficiency.

Previously nanoceria have been extensively used in have been shown to exert neuroprotective, anti-inflammatory, and wound-healing effects in different studies. CeNPs modulate apoptotic and survival pathways in HT22 cells providing neuronal protection (Das et al., 2007). The duality of nanoceria in their redox behavior have made them the perfect candidate in drug delivery for cancer treatment. Nano ceria acts as antioxidants in normal pH and pro-oxidant in acidic tumor environments, selectively targeting cancer cells (Suresh et al., 2019). When synthesized via green methods nanoceria were seen to be especially effective in wound healing and angiogenesis (Celardo et al., 2011). Scognamiglio et al (2023) have demonstrated that functionalized CeNPs facilitate sustained and targeted therapeutic delivery.

Most studies agree that well-coated and properly sized nanoceria exhibit minimal toxicity at low and acute doses. Surface coatings like PEG and poly(acrylic acid) significantly reduce aggregation and enhance biocompatibility, while citrate coatings can lead to agglomeration and cytotoxicity at higher doses (>1 mM) (Hirst et al., 2009). In vivo studies show that low-dose exposure does not provoke immune or fibrotic responses; however, chronic or high-dose administration may result in granuloma formation or pulmonary fibrosis (Lord et al., 2021). The size and dispersion of CeNPs are also crucial: smaller, monodisperse particles are generally safer than large aggregates (Saranya et al., 2023). These researches conclude that at low dosages, particularly with surface-functionalization, nanoceria is well-tolerated in biological systems, though long-term exposure data remains limited and should be expanded.

Nanoceria (CeO_2 nanoparticles) exhibit a uniquely regenerative antioxidant mechanism driven by reversible cycling between Ce^{3+} and Ce^{4+} states, along with abundant surface oxygen vacancies, enabling persistent and enzyme-mimetic ROS scavenging. This redox behavior is highly tunable through controlled synthesis—particularly green routes and engineered oxygen deficiencies—allowing customization for diverse biomedical applications. Studies demonstrate potent neuroprotective, anti-inflammatory, and wound-healing effects, as well as selective pro-oxidant action in acidic tumor microenvironments, supporting its use in targeted cancer therapy. Importantly, nanoceria shows proven biocompatibility at low dosages; well-dispersed particles with appropriate surface coatings (e.g., PEG, polyacrylic acid) remain stable and nontoxic in both in vitro and in vivo systems, whereas cytotoxicity only emerges at high concentrations or with poorly coated, aggregated forms. Collectively, these findings position nanoceria as a powerful, versatile redox nanomaterial with significant translational potential, provided that its

long-term biosafety and regulatory considerations are systematically addressed through standardized synthesis and extended exposure studies.

1.10 Novelty and Significance of the Study

While nanotechnology has previously been explored for improving oxidative stability of lipid systems, most reported nano-based strategies rely on passive antioxidant delivery or physical protection mechanisms. These approaches include nano-encapsulation of conventional antioxidants, antioxidant-loaded emulsions, solid lipid nanoparticles, polymeric nanoparticles, and inorganic nanomaterials designed to improve dispersion or reduce oxygen diffusion (McClements & Decker, 2000; Chaudhry et al., 2008; Salvia-Trujillo et al., 2017). Although such systems can delay oxidation, their protective effect remains fundamentally stoichiometric and depleting in nature, as the antioxidant molecules are gradually consumed during radical scavenging and require replenishment (Frankel, 2005; Shahidi & Zhong, 2010).

In contrast, the present research introduces cerium oxide nanoparticles (nano-ceria) as an intrinsically antioxidant system for edible oils. Unlike other nanomaterials such as silica, titanium dioxide, zinc oxide, or polymer-based nanocarriers—which lack catalytic redox functionality—nano-ceria exhibits reversible $\text{Ce}^{3+}/\text{Ce}^{4+}$ redox cycling, enabling sustained scavenging of reactive oxygen species without structural depletion (Pirmohamed et al., 2010; Heckert et al., 2008). This behavior fundamentally distinguishes nano-ceria from previously reported nano-antioxidant platforms that rely on consumptive radical trapping (Celardo et al., 2011; Baldim et al., 2018).

Further, while many nanomaterials act indirectly by improving antioxidant dispersion or protecting encapsulated compounds, nano-ceria functions as an active catalytic antioxidant, continuously neutralizing peroxy radicals and hydrogen peroxide generated during lipid oxidation (Amorati et al., 2012). Importantly, this activity is retained under thermal stress, addressing a major limitation of both conventional antioxidants and most nano-delivery systems, which exhibit thermal degradation or loss of efficacy during frying and prolonged heating (Frankel, 2005; Morry et al., 2017).

The novelty of this study lies not only in applying nano-ceria to edible oil systems, but in systematically engineering its redox behavior through controlled synthesis and correlating structural features—such as oxygen vacancy concentration and Ce^{3+} fraction—with oxidative stability outcomes in real food matrices (Deshpande et al., 2005; Ma et al., 2021). Additionally, this work integrates kinetic modeling, food system compatibility, and application-level

validation, aspects that have been largely absent in prior nanotechnology-based antioxidant studies focused on edible oils (Frankel, 2014; McClements, 2015).

Therefore, this research establishes nano-ceria as a next-generation, regenerative antioxidant platform, offering a mechanistically superior and thermally resilient alternative to existing nano-based solutions for improving oxidative stability in edible oils and lipid-rich food systems.

1.11 Research Objectives

To develop and validate a regenerative, nano-ceria-based antioxidant platform for enhancing the oxidative stability of edible oils and lipid-rich food systems this research is based upon the following objectives:

- I. Design and engineering of oxidant/antioxidant properties of nano ceria*
- II. Improvement of oxidative stability of edible oils (e.g. sunflower oil & rice bran oil) using engineered nano ceria.*
- III. Use of nanoceria fortified sunflower oil and rice bran oil in food applications.*

1.12 Research Question and Hypothesis

Building upon the above objectives, this research seeks to systematically explore how the oxidant/antioxidant properties of nano-ceria can be engineered through controlled synthesis strategies and leveraged to enhance oxidative stability in edible oils and lipid-based food systems. Specifically, the study addresses five core questions:

- (i) how synthesis parameters (dispersant system, pH, temperature, calcination) influence the redox-active properties of nano-ceria;
- (ii) to what extent nano-ceria can improve the oxidative stability of sunflower oil and rice bran oil under storage and high-temperature processing;
- (iii) how its regenerative antioxidant behavior compares with conventional synthetic and natural antioxidants;
- (iv) whether incorporation of nano-ceria fortified oils into emulsified food systems improves functional stability and maintains sensory quality;
- (v) whether the antioxidant effects of nano-ceria can be quantitatively modeled for shelf-life prediction.

These questions are guided by the following hypotheses:

- Optimized nano-ceria with higher oxygen vacancy concentration and enhanced $\text{Ce}^{3+}/\text{Ce}^{4+}$ redox cycling is likely to exhibit superior radical scavenging activity

- Nano-ceria is generally non-toxic in nature so it can be used to enhance oxidative stability of oils during storage and thermal processing; its regenerative antioxidant mechanism will outperform conventional antioxidants

Addressing these questions will advance both fundamental understanding and practical application of nano-ceria as a next-generation antioxidant in food systems.

1.13 Conclusion: From Conventional Antioxidants to Redox-Regenerative Nanomaterials

The reviewed literatures illustrates a critical technological and functional gap in current antioxidant strategies applied to complex lipid systems. Conventional antioxidants—both synthetic and plant-derived—are inherently limited by thermal degradation, phase incompatibility, toxicity (in the case of synthetic variants), and most fundamentally, their stoichiometric, non-regenerative nature. These molecules are rapidly depleted during oxidative stress events and require continual replenishment, which is often impractical in real-world applications, particularly under dynamic conditions such as cooking, long-term storage, or multi-phase food environments. Moreover, lipid matrices pose dispersion and partitioning challenges for many conventional antioxidants, especially when attempting to protect oxidation-prone interfacial regions in emulsified or colloidal systems.

In contrast, the emerging class of redox-regenerative nanomaterials—specifically cerium oxide nanoparticles (nanoceria)—presents a paradigm shift in antioxidant science. As reviewed in Section 1.9, nanoceria's dynamic $\text{Ce}^{3+}/\text{Ce}^{4+}$ redox cycling and oxygen vacancy-driven reactivity enable persistent, enzyme-mimetic radical scavenging, distinguishing it from conventional antioxidants. Its catalytic behavior allows for repeated neutralization of reactive oxygen species (ROS) without structural depletion, while green synthesis methods and surface coatings can significantly enhance biocompatibility and dispersion across lipid and aqueous phases. The demonstrated low-dose safety profile in biomedical contexts further supports its consideration for integration into food-grade and nutraceutical applications.

Taken together, these insights underscore the need for advanced antioxidant platforms that combine thermal and storage stability, regenerative redox function, and broad matrix compatibility. Nanoceria, with its adaptable physicochemical properties and catalytic longevity, holds significant potential to address the long-standing limitations of conventional antioxidant systems in lipid-rich environments. Future research should focus on optimizing its food-grade synthesis, evaluating its performance in real food systems under thermal and oxidative stress, and establishing regulatory frameworks for safe integration into the food supply chain.

In summary, this thesis is positioned at the intersection of nanotechnology, food chemistry, and lipid oxidation science, aiming to address critical gaps in the development of sustainable antioxidant strategies for edible oils and lipid-based food systems. Building on the foundational concepts outlined in this chapter, the subsequent sections detail the design, synthesis, and characterization of engineered nano-ceria, its application in edible oils, and its functional performance in real-world food formulations. Through this integrated approach, the study seeks to advance both scientific understanding and practical innovation in the field of food antioxidant technologies.

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CHAPTER 2: Synthesis of Cerium Oxide nanoparticle and assessment of its antioxidant potential for application in edible oils

2.1 Introduction

Cerium oxide nanoparticles (CeO₂ NPs) have garnered immense attention due to their unique redox switching properties, exceptional thermal stability, and remarkable ability to scavenge reactive oxygen species (ROS) (Dhall & Self, 2018). These properties make them highly desirable in a wide range of applications, including biomedical therapies, catalysis, and food preservation (Celardo et al., 2011; Dhall & Self, 2018). The synthesis of CeO₂ NPs with precise control over particle size, morphology, and surface chemistry is crucial, as these parameters directly influence their functional performance. Among the various synthesis methods, the precipitation method stands out for its simplicity, cost-efficiency, and ability to produce nanoparticles with tunable properties. A key factor in the successful synthesis of CeO₂ NPs is the choice of solvents and stabilizing agents. Dispersing and stabilizing solvents such as ammonium bicarbonate (NH₄HCO₃), n-butyl alcohol (CH₃(CH₂)₃OH), polyethylene glycol (PEG-400), and polyvinyl pyrrolidone (PVP) play a pivotal role in modulating the nucleation and growth processes (Baqer et al., 2017; Raharjo et al., 2019; Li et al., 2021). These solvents act as surfactants, controlling the particle size by capping the growing nanoparticles, preventing agglomeration, and ensuring uniform dispersion (Chitsaz et al., 2013). The pH of the solution, choice of precipitating reagent, reaction temperature and calcination environment further influence the creation of oxygen vacancies and the oxidation state balance between Ce³⁺ and Ce⁴⁺, both of which are critical for the antioxidant activity of CeO₂ NPs (Ma et al., 2021; Li et al., 2021). This study explores the synthesis of CeO₂ NPs using cerium nitrate and various organic solvents via the precipitation method. It highlights the impact of synthesis conditions on the nanoparticles' antioxidant potential in controlling rancidity of edible oils.

Edible oils are crucial elements of our daily nutritional requirements, which contains essential fatty acids, and serve as a carrier of fat-soluble vitamins. There are a wide variety of edible oils available in the market out of which two of the most widely used cooking oils in India are rice bran oil and sunflower oil. Rice bran oil (RBO) which is obtained from rice bran (the outer

layer of the rice grain consisting of the pericarp and aleurone layer) is a rich source of mono and polyunsaturated fatty acids (MUFA & PUFA) (Chandrashekar et al., 2014). Also, it contains γ -oryzanol and tocopherol which are known high functioning antioxidants (Pestana-Bauer et al., 2012). However, the total phenolic content of RBO is significantly reduced during refining, followed by prolonged storage period and different high temperature conditions during food processing (Yamamoto et al., 2020). Sunflower oil (SFO) is mainly a triglyceride extracted from sunflower seed containing about 19.5% MUFA and 65.7% PUFA (Salas et al., 2021). It is also a rich source of Vitamin E and contains trace amounts of Vitamin K (Salas et al., 2021). However refining and high temperature processing causes significant loss in both (Grilo et al., 2014; Pestana-Bauer et al., 2012). Since both these edible oils are primarily composed of PUFA and MUFA, they are particularly susceptible to degradation by high temperature, air, and light, which can instigate and increase oxidation and rancidity (Yamamoto et al., 2020). While natural and synthetic antioxidants like tocopherols, BHA, and BHT are routinely used to delay oxidative degradation, their limitations—such as thermal instability, potential toxicity, or degradation over time—necessitate the search for more robust, sustainable alternatives (Celardo et al., 2011).

This chapter systematically investigates the synthesis–structure–function relationship of nanoceria and evaluates their efficacy as novel, redox-active antioxidants for extending the shelf life of edible oils. By tailoring the particle synthesis conditions to enhance ROS scavenging properties and applying them in real food matrices, this work proposes a scalable and thermally resilient solution to oil rancidity—addressing a critical challenge in food quality preservation and safety

2.2 Material & Methods

2.2.1 Development of nanoceria (CNP)

CeO₂ nanoparticles had been prepared by a precipitation method as described by Zhang et al. with slight modifications (Zhang, Q., et al. 2009). In this study, cerium (III) nitrate hexahydrate [Ce(NO₃)₃·6H₂O] was utilized as the cerium source, while ammonium acid carbonate (NH₄HCO₃) acted as the precipitating agent. Organic compounds (dispersant agent) such as n-butyl alcohol (CH₃(CH₂)₃OH), polyethylene glycol (PEG-400), and polyvinyl pyrrolidone (PVP) were incorporated to stabilize the nanoparticles, prevent clumping, and control particle growth. High-purity solvents, including doubly distilled water and absolute ethanol were used to ensure a clean reaction environment. The pH of the solution was carefully adjusted to 3, 5,

7, or 9 using ammonia and conc. hydrochloric acid, which influenced the nanoparticle formation process. The synthesis procedure involved dissolving $\text{Ce}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$ in distilled water, followed by the gradual addition of NH_4HCO_3 over 75 minutes at specific temperatures (80°C, 90°C, and 100°C). The mixture was stirred continuously for an additional 30 minutes to complete the reaction. The resulting precipitate was repeatedly washed with distilled water and ethanol to remove impurities, dried at 80°C for 5 hours, and then calcined at 800°C for 2hrs to produce a fine yellow powder of CeO_2 NPs.

2.2.1.1 Characterization of synthesized nanoceria

The crystalline structure was studied by X-ray diffractometer ULTIMA IV x-ray diffractometer (Rigaku), operating at 40 kV and 40 mA with radiation ($\lambda = 1.5404 \text{ \AA}$). The crystallite size was estimated from XRD patterns by using Scherrer equation. Crystallite size is a critical parameter in the characterization and antioxidant functionality of nanoceria due to its direct influence on surface chemistry, redox behavior, and defect structure. The ROS scavenging properties were estimated using DPPH and ABTS assay methods and the affectivity of the nanoparticles in controlling oxidative rancidity was measured by fortifying rice bran oil and sunflower oil with the synthesized nanoparticles.

2.2.2 Preservation of Edible Oil

The edible oil samples were divided into four experimental batches based on the concentration of cerium oxide nanoparticles (CNPs). One batch served as the control without CNP addition, while the remaining three batches were fortified with CNPs at concentrations of 5 ppm, 10 ppm, and 15 ppm, respectively. These concentration levels were selected based on preliminary screening studies and literature reports indicating that nanoceria exhibits optimal antioxidant activity at low parts-per-million concentrations, while higher concentrations may induce pro-oxidant behavior due to surface redox imbalance and excessive reactive oxygen species generation, in addition to raising safety and toxicity concerns related to nanoparticle accumulation and aggregation (Celardo et al., 2011; Pirmohamed et al., 2010; Baldim et al., 2018; Lord et al., 2021).

For each experimental condition (Table 2.1), a fixed volume of 250 mL of oil was used to ensure uniform exposure to thermal and oxidative stress. The required amount of CNPs was accurately weighed and dispersed into the oil using continuous magnetic stirring, followed by mild agitation to ensure homogeneous nanoparticle distribution. The samples were stored at 20 °C, 30 °C, and 40 °C representing ambient storage conditions. Temperature control was

achieved using calibrated temperature-controlled incubators, with continuous monitoring to ensure ± 1 °C stability throughout the storage period. The oils were stored for a total duration of four months, during which oxidative stability parameters were periodically evaluated. This experimental design enabled systematic evaluation of the antioxidant efficacy of CNPs under different thermal conditions and allowed assessment of concentration-dependent protection against oxidative degradation during storage.

Table 2.1 Experimental Conditions for Preservation of Edible Oils

Parameter	Description
Type of oil	Refined edible oil (as specified in Section 2.1)
Volume of oil per sample	250 mL
CNP concentration levels	0 ppm (control), 5 ppm, 10 ppm, 15 ppm (higher concentration showed pro-oxidant behaviour)
Method of CNP incorporation	Magnetic stirring followed by mechanical agitation
Storage temperatures	20 °C, 30 °C, 40 °C
Temperature control	Temperature-controlled incubators (± 1 °C)
Storage duration	4 months

2.2.3 Test for Rancidity – Peroxide Value

PV was determined according to Cd 8b-90 (AOCS official method) on triplicate basis. About 5.0 g oil (RBO and SFO) was dissolved in 30 mL of a mixture of acetic acid and chloroform (3:1 volumes). 0.5 mL of saturated KI solution was added and was stirred for 1 minute, followed by addition of 30 mL of distilled water. The sample was then titrated against 0.1 M sodium thiosulphate until it turned into colourless. 0.5 mL of 1% starch solution was added as end point indicator and titration was continued until blue colour just disappeared. Blank test was performed under the same conditions and PV was evaluated using the following equation:

$$PV = \frac{M \times (A - B)}{W} \times 1000 \quad (5)$$

where, M is the molarity of sodium thiosulphate; A and B represent sample and blank titre value respectively (mL); W is the weight of oil in grams.

2.2.4 Antioxidant activities CeO₂ nanoparticles

2.2.4.1 DPPH scavenging Assay

Free radical scavenging activity of the nanoparticles was studied by DPPH assay (Nezhad, S. A., et al. 2019). 1.0 ml of each CeO₂ nanoparticles suspension of different concentrations (5, 10, 15 ppm) were mixed with 1.0 ml of methanolic solution of DPPH (2,2-diphenyl-1-picrylhydrazyl) solution (1.0 mM) and incubated under dark at room temperature for 30 minutes. Aliquots (200 µl) of sample solution were taken and absorbance was recorded at 517 nm using UV-Vis spectrophotometer (Systronics, AU-2701). Ultrapure water was used as a control, while methanol was used as a blank solution. Scavenging activity was evaluated as the percentage of change in the absorbance of DPPH at the characteristic wavelength using the following formula:

$$\left[(A_{\text{DPPH control}} - A_{\text{DPPH sample}}) / A_{\text{DPPH control}} \right] \times 100 \quad (6)$$

wherein, $A_{\text{DPPH control}}$ and $A_{\text{DPPH sample}}$ represent absorbance without and with sample respectively.

2.2.4.2 ABTS scavenging Assay

For assessing free cationic radical scavenging property of the as prepared CeO₂ nanoparticles (Nezhad, S. A., et al. 2019), firstly, stock (7.0 mM) of ABTS radical cationic solution (ABTS⁺) was produced by mixing ABTS(2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) solution with potassium persulfate (2.45 mM), followed by incubation under dark at room temperature (~ 12 h). Then, ABTS⁺ solution was diluted with ethanol until absorbance, recorded on UV-Vis spectrophotometer (Systronics, AU-2701), at 734 nm reached ~ 0.70 (+/- 0.02) at 30°C. 1.0 ml of diluted ABTS⁺ solution was added to 10 µl of extract and incubated under dark at 30°C for 30 minutes, after which absorbance were recorded, while using ethanol as control. Free radical scavenging activity (in %) was evaluated using the following formula:

$$\left[(A_{\text{ABTS control}} - A_{\text{ABTS sample}}) / A_{\text{ABTS control}} \right] \times 100 \quad (2)$$

where, $A_{\text{ABTS control}}$ and $A_{\text{ABTS sample}}$ denote absorbance of control and sample respectively.

2.2.5 Statistical Analysis

To statistically evaluate the influence of synthesis parameters, the experimental data were subjected to two-way analysis of variance (ANOVA), considering dispersant system, reaction pH, and reaction temperature as independent factors. Interaction effects between factors were also examined. Where significant main effects were observed, Tukey's Honestly Significant Difference (HSD) post-hoc test was applied for pairwise comparisons between pH levels. Additionally, effect size analysis (η^2) was performed to quantify the relative contribution of each synthesis parameter to the observed antioxidant activity. This experimental design enabled

isolation of the individual and combined effects of reaction pH, temperature, and dispersant system on the antioxidant behavior of nanoceria, providing a robust basis for identifying dominant synthesis parameters governing redox activity.

2.3 Results and Discussion

2.3.1. Structural Characterization and Antioxidant Activity of Synthesized Nanoceria

X-ray diffraction was employed to characterize the crystal structure and phase purity of the synthesized cerium oxide (CeO_2) nanoparticles using various dispersant agents: polyethylene glycol (PEG), n-butyl alcohol (nBA), polyvinyl pyrrolidone (PVP), and their combinations. As shown in Figure 2.1, the XRD patterns revealed distinct and sharp diffraction peaks at 2θ values of approximately 28.5° , 33.1° , 47.5° , 56.3° , and 59.1° , corresponding to the (111), (200), (220), (311), and (222) planes of a face-centered cubic fluorite structure. All reflections were in excellent agreement with standard cerium dioxide diffraction data (JCPDS No. 34-0394), confirming the successful formation of single-phase CeO_2 . No secondary peaks related to cerium hydroxides ($\text{Ce}(\text{OH})_4$), cerium sesquioxides (Ce_2O_3), or other intermediate cerium compounds were observed, indicating high purity of the synthesized nanoparticles. This structural homogeneity is critical for antioxidant applications, as impurities or mixed phases could potentially disrupt the redox-active surface sites responsible for free radical scavenging.

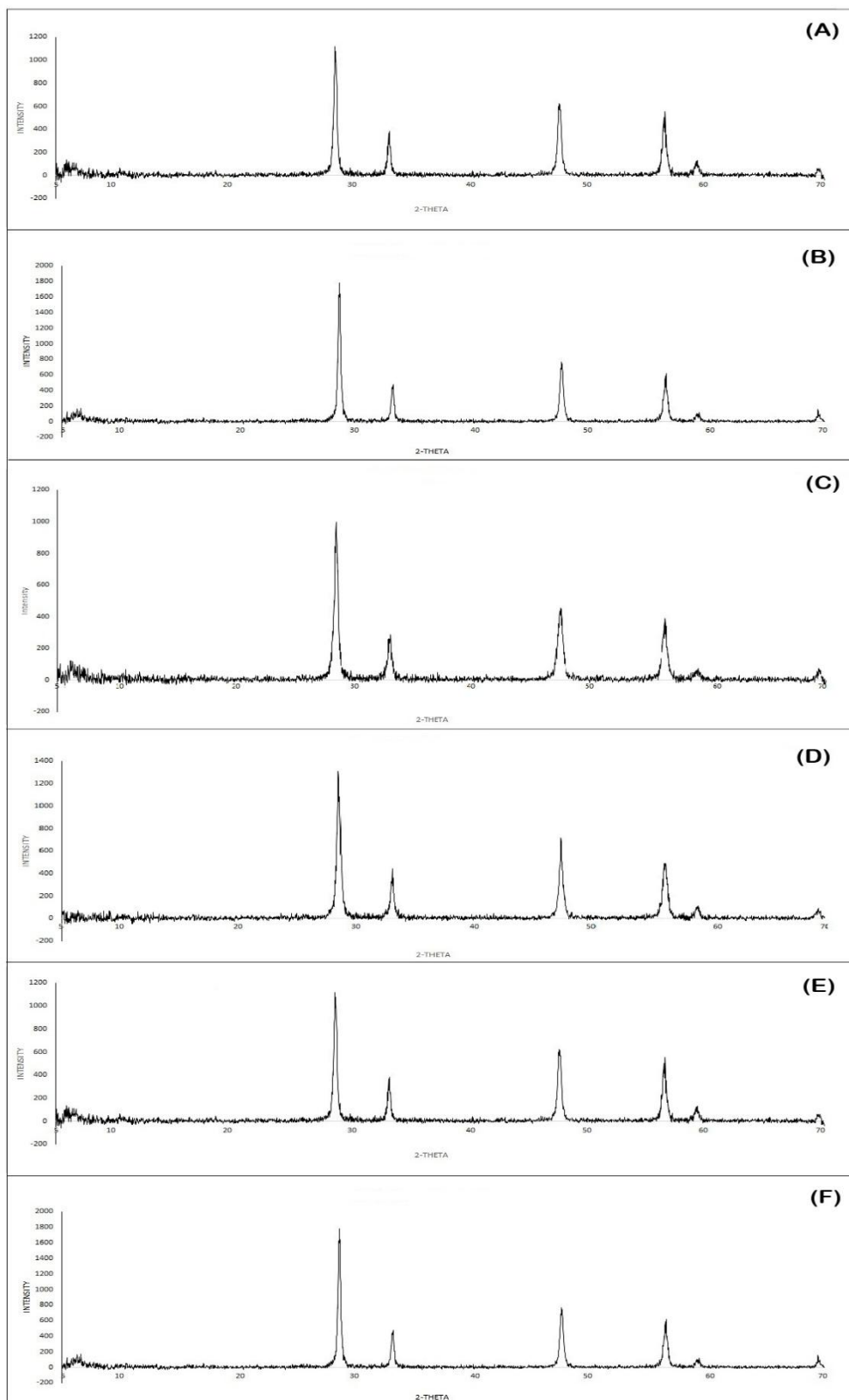


Figure 2.1: X-ray diffraction pattern of CeO₂ nanoparticles synthesized with (A) PEG (B) nBA (C) PVP (D) PEG + nBA (E) PEG+PVP (F) nBA + PVP

The fluorite crystal structure of CeO₂ is known for its intrinsic ability to accommodate oxygen vacancies without compromising lattice stability. Within this structure, Ce⁴⁺ ions occupy the

face-centered lattice positions, while O^{2-} ions are arranged in interstitial tetrahedral sites. At the nanoscale, lattice strain and surface effects promote the formation of oxygen vacancies and enhance the presence of surface Ce^{3+} ions. These structural defects act as electron donors, facilitating the redox cycling between Ce^{3+} and Ce^{4+} , which is a key mechanism underlying the enzyme-mimetic antioxidant activity of nanoceria. These structural features, confirmed through XRD, provide a strong foundation for the observed antioxidant activity discussed in subsequent sections. The presence of a pure cubic fluorite phase, small crystallite size, and defect-rich lattice together contribute to the enhanced ROS-scavenging capacity of the synthesized nanoceria.

Figure 2.2 compares the average crystallite sizes of the synthesized particles as calculated using Scherrer equation.

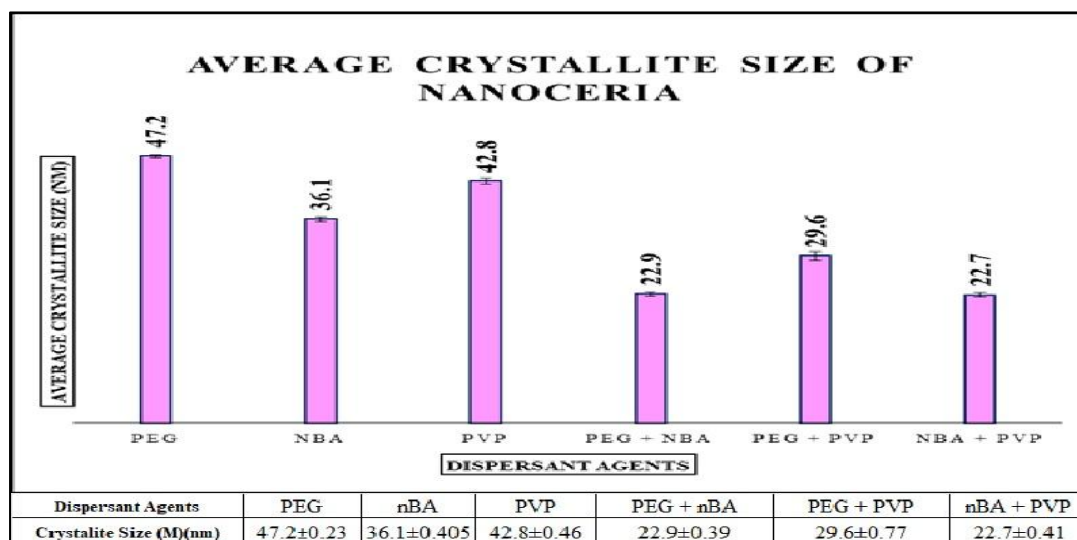


Figure 2.2: Average Crystallite Size of Nanoceria

It was observed that nanoceria synthesized with PEG+nBA and nBA+PVP combinations exhibited the smallest crystallite sizes - 22.9 ± 0.39 nm and 22.7 ± 0.41 nm, respectively. These particles also showed the highest radical scavenging activity, as evidenced by DPPH (60.77%) and ABTS (52.07%) inhibition values (Figure 2.3). This enhancement can be attributed to the ability of dispersants to decrease surface energy, eliminate interparticle charge accumulation, and reduce surface polarity, thereby limiting agglomeration and improving dispersion. Smaller crystallites offer larger specific surface areas and higher concentrations of redox-active surface sites, which directly enhance antioxidant potential. Therefore, PEG+nBA and nBA+PVP systems were selected for further studies.

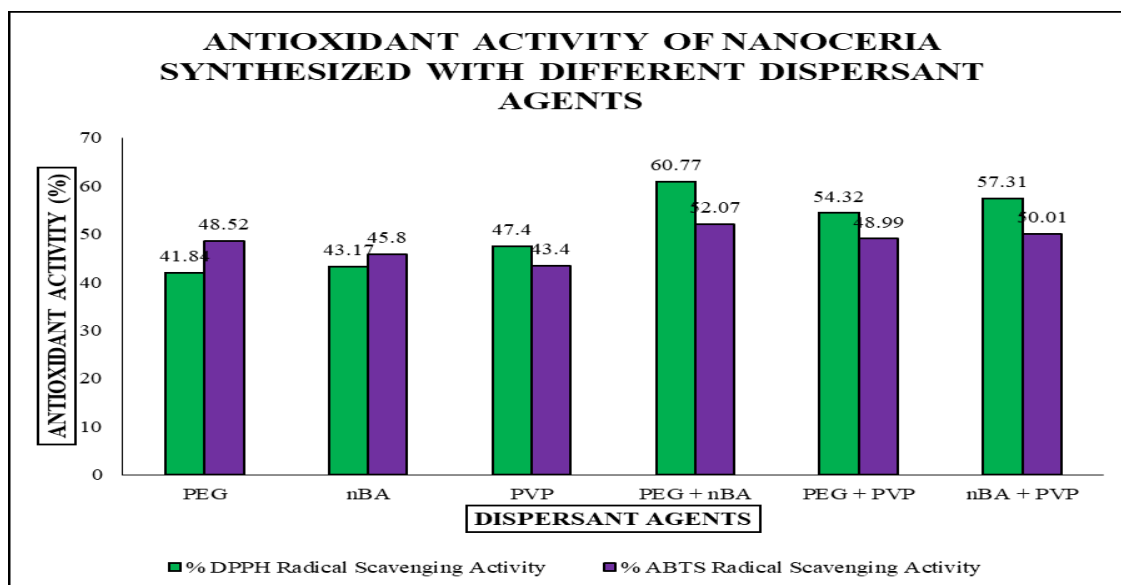


Figure 2.3. Radical scavenging activity of nanoceria synthesized with different dispersant agents.

2.3.2. Selection of Synthesis Conditions: pH and Reaction Temperature

The impact of reaction pH and temperature on the antioxidant potential of nanoceria was systematically studied using 24 experimental trials (Table 2.2) based on the two sets of particles which showed the highest redox activity. These synthesized nanoparticles were evaluated for reactive oxygen species (ROS) scavenging potential at a fixed concentration of 10 ppm.

Table 2.2. Effect of pH and reaction temperature on the antioxidant activity of nanoceria.

Trial No.	Dispersant Agents	Reaction pH	Reaction Temperature (°C)	% DPPH Inhibition*	% ABTS Radical Scavenging Activity*
1	PEG + nBA	3	80	53.21±0.52	46.98±0.36
2			90	60.12±0.31	51.33±0.41
3			100	59.98±0.76	51.37±0.56
4		5	80	54.35±0.53	38.95±0.45
5			90	54.88±0.44	43.08±0.73
6			100	47.27±0.27	42.23±0.21
7		7	80	49.69±0.6	43.17±0.78
8			90	53.75±0.86	43.09±0.8
9			100	46.91±0.25	39.72±0.44
10		9	80	49.17±0.61	38.53±0.76
11			90	54.95±0.4	41.94±0.86

Trial No.	Dispersant Agents	Reaction pH	Reaction Temperature (°C)	% DPPH Inhibition*	% ABTS Radical Scavenging Activity*
12	nBA + PVP	3	100	55.24±0.5	37.67±0.34
13			80	54.31±0.71	44.17±0.45
14			90	57.44±0.52	49.83±0.65
15		5	100	55.32±0.2	48.97±0.83
16			80	51.62±0.83	42.71±0.75
17			90	49.48±0.65	38.84±0.42
18			100	49.27±0.57	38.53±0.83
19		7	80	51.2±0.19	45.4±0.9
20			90	48.02±0.79	45.96±0.73
21			100	49.93±0.39	44.76±0.61
22		9	80	53.71±0.34	37.17±0.71
23			90	52.69±0.66	39.17±0.59
24			100	51.32±0.61	37.91±0.86

Note: All measurements were conducted in triplicates. Data shown as mean ± SD.

The antioxidant activity of nanoceria was evaluated using DPPH and ABTS radical scavenging assays across varied synthesis conditions involving pH, temperature, and dispersant systems. A comprehensive statistical analysis (Table 2.3) revealed that reaction pH is the dominant factor influencing both DPPH and ABTS activities, while temperature and dispersant type had minimal or no statistically significant effect.

Table 2.3: Statistical Analysis of Influence of Synthesis Parameters on Antioxidant Activity

Two-Way Interaction ANOVA Results (%DPPH)			
Factor	F-value	p-value	Interpretation
Dispersant	1.53	0.263	Not significant
pH	8.36	0.0145	Significant
Temperature	1.52	0.292	Not significant
Dispersant: pH	0.20	0.892	No significant interaction
Dispersant :Temp	2.11	0.202	No significant interaction
pH :Temp	1.24	0.399	No significant interaction
Two-Way Interaction ANOVA Results (%ABTS)			

Factor	F-value	p-value	Interpretation
Dispersant	0.25	0.633	Not significant
pH	32.24	0.0004	Highly significant
Temperature	2.49	0.163	Not significant
Dispersant : pH	2.74	0.136	Marginal but not significant
Dispersant :Temp	0.50	0.628	Not significant
pH :Temp	1.40	0.346	Not significant
Tukey HSD Results for %DPPH (Grouped by pH)			
Comparison	Mean Diff	p-adj	Significant
3 vs 5	4.92	0.018	Highly significant
3 vs 7	6.06	0.003	Highly significant
3 vs 9	3.41	0.177	Not significant
5 vs 7	1.14	0.825	Not significant
5 vs 9	-1.51	0.697	Not significant
7 vs 9	-2.65	0.277	Not significant
Tukey HSD Results for %ABTS (Grouped by pH)			
Comparison	Mean Diff	p-adj	Significant?
3 vs 5	8.70	0.001	Highly significant
3 vs 7	3.88	0.141	Not significant
3 vs 9	11.13	0.001	Highly significant
5 vs 7	-4.82	0.046	Highly significant
5 vs 9	2.42	0.470	Not significant
7 vs 9	7.24	0.004	Highly significant
Effect Size Analysis (η^2) %DPPH Scavenging			
Factor	η^2 (Effect Size)	Interpretation	
pH	0.523	Very strong effect (52.3% of total variance)	
Temperature	0.063	Small effect	
Dispersant	0.032	Minimal effect	
Effect Size Analysis (η^2) %ABTS Scavenging			
Factor	η^2 (Effect Size)	Interpretation	
pH	0.770	Dominant effect (77% of total variance)	
Temperature	0.040	Small effect	

Dispersant	0.002	Negligible effect
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Two-way ANOVA indicated a significant main effect of pH on %DPPH scavenging ($F = 8.36$, $p = 0.0145$), contributing to 52.3% of the total variance ($\eta^2 = 0.523$). In contrast, temperature ($F = 1.52$, $p = 0.292$) and dispersant system ($F = 1.53$, $p = 0.263$) were not statistically significant, with effect sizes of 0.063 and 0.032 respectively. No interaction effects between factors were statistically significant, suggesting that pH acts independently to affect radical scavenging. Tukey's HSD post-hoc test further confirmed that nanoceria synthesized at pH 3 exhibited significantly higher DPPH scavenging than those prepared at pH 5 ($p = 0.018$) and pH 7 ($p = 0.003$), while the difference with pH 9 was not statistically significant ($p = 0.177$). A stronger effect was observed in ABTS results where pH accounted for a dominant 77% of the variance ($\eta^2 = 0.770$), with a highly significant main effect ($F = 32.24$, $p = 0.0004$). Neither temperature ($F = 2.49$, $p = 0.163$) nor dispersant ($F = 0.25$, $p = 0.633$) showed significant contributions. Interestingly, while the interaction between dispersant and pH approached marginal significance ($p = 0.136$), it still fell short of statistical relevance. Post-hoc comparisons highlighted that pH 3 outperformed pH 5 ($p = 0.001$) and pH 9 ($p = 0.001$). Moreover, scavenging at pH 7 was significantly better than at pH 5 ($p = 0.046$) and pH 9 ($p = 0.004$), indicating some mid-range pH resilience for ABTS activity not observed in DPPH data. These findings reinforce the known acidic pH-favoring mechanism of cerium oxide's redox behavior, where the $\text{Ce}^{3+}/\text{Ce}^{4+}$ ratio — critical for antioxidant performance — is more favorable at low pH (Ma et al., 2021). The higher surface availability of Ce^{3+} species at acidic conditions likely enhances electron transfer in radical quenching mechanisms. Temperature showed a mild improving trend, especially at higher values (90–100 °C), though not reaching significance. This suggests possible enhancement of crystallinity or surface activation at elevated temperatures, without dominating the pH effect. For example, the highest recorded %DPPH (60.47%) and %ABTS (51.61%) were both observed at pH 3 and 90–100 °C, particularly with the PEG + nBA dispersant. The dispersant system had negligible standalone impact, which may indicate that the antioxidant behavior is more strongly driven by the intrinsic surface chemistry of nanoceria rather than minor variations induced by polymeric stabilizers.

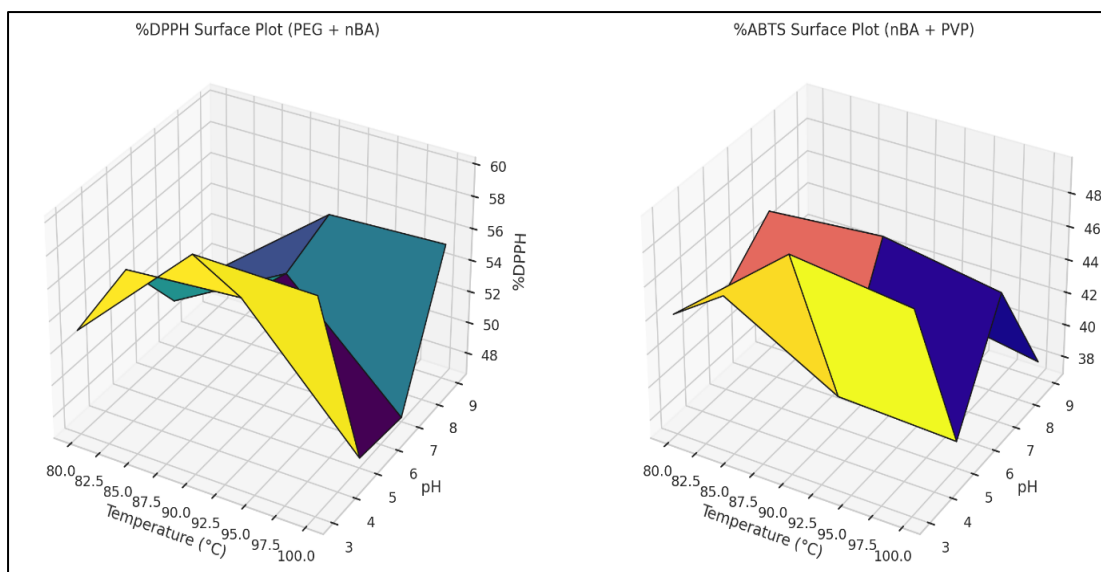


Figure 2.4: 3D Surface Plots

Figure 2.4 shows 3D surface plots which provides further confirmation, displaying steep performance peaks at pH 3. For DPPH, activity was maximized at pH 3 and 90–100 °C, with smoother gradients implying predictable behavior. ABTS plots were more abrupt, suggesting higher sensitivity to pH shifts.

These visualizations reinforce statistical conclusions, showing pH as the sole robust predictor of antioxidant capability across both assays.

Table 2.4. Comparison of Marginal Means of Antioxidant Activity at Different Synthesis pH Levels

(A) %DPPH Radical Scavenging			%ABTS Radical Scavenging		
pH	Mean $\pm$ SD (%)	Tukey Group	pH	Mean $\pm$ SD (%)	Tukey Group
3	56.73 $\pm$ 2.55	a	3	48.78 $\pm$ 2.48	a
9	52.85 $\pm$ 2.08	ab	7	43.68 $\pm$ 2.37	b
5	51.81 $\pm$ 2.83	b	5	40.72 $\pm$ 2.17	c
7	49.92 $\pm$ 2.14	b	9	38.73 $\pm$ 1.67	c

Estimated comparison of marginal means were computed (Table 2.4) to compare antioxidant performance across synthesis pH levels. For %DPPH scavenging, nanoceria synthesized at pH 3 (56.73 $\pm$ 2.55%) exhibited significantly higher activity than pH 5 and pH 7, while pH 9 showed intermediate performance without statistical difference from pH 3. In the ABTS assay, pH 3 (48.78 $\pm$ 2.48%) demonstrated significantly superior activity compared to all other pH levels. Additionally, pH 7 showed significantly higher activity than pH 5 and pH 9. These results confirm that strongly acidic synthesis conditions maximize antioxidant potential.

2.3.3. Effect of Nanoceria on Oxidative Stability of Edible Oils

To evaluate the efficacy of the synthesized cerium oxide nanoparticle (CNP) in extending oil shelf life, oxidative stability tests were performed on rice bran oil (RBO) and sunflower oil (SFO) over a 120-day storage period under different temperatures (20°C, 30°C, and 40°C). The CNP synthesized with PEG + nBA at pH 3 and 90°C was selected for this study as it showed the highest antioxidant activity (Table 2.2). CNPs were added to the oils in concentration of 5, 10 and 15ppm respectively. Both untreated and CNP-treated oil samples were stored in the dark in sealed conical flasks, and peroxide value (PV) was monitored every 15 days. PV a primary indicator of lipid peroxidation, was used to quantify the extent of oxidative degradation and the assess the effectivity of cerium oxide nanoparticles as potential anti-oxidants.

2.3.3.1. Trends in peroxide formation in rice bran oil (RBO)

As shown in Figure 2.5, PV in control samples (0 ppm CNP) increased significantly over the 120-day storage, particularly at elevated temperatures. At 40°C, PV rose from 5.13 ± 0.18 meq/kg to 24.87 ± 3.94 meq/kg, indicating a substantial increase in primary oxidation products. The trend was consistent across all temperatures, with the rate of increase positively correlated with temperature, confirming the well-documented thermal sensitivity of polyunsaturated-rich oils like RBO (Yamamoto et al., 2020).

The inclusion of CNPs reduced the rate of PV accumulation in a concentration-dependent manner. At 15 ppm CNP, PV at 40°C rose only to 9.05 ± 1.49 meq/kg by Day 120, representing a 76% reduction compared to the control. At 20°C and 30°C, the reduction was similarly notable, with final PV values of 6.15 ± 1.07 meq/kg and 8.6 ± 1.39 meq/kg, respectively. This confirms the antioxidant efficacy of nanoceria, attributed to its redox-switching capacity between Ce^{3+} and Ce^{4+} states, which scavenges reactive oxygen species (Celardo et al., 2011; Dhall & Self, 2018).

2.3.3.2. Trends in peroxide formation in Sunflower Oil (SFO)

Sunflower oil, being richer in polyunsaturated linoleic acid, showed even faster oxidation than RBO under identical conditions. As depicted in Figure 2.5, PV in control SFO samples at 40°C reached 30.89 ± 3.39 meq/kg by day 120—well above the critical limit (10 meq/kg) defined by Codex Alimentarius for edible oil quality. Even at 20°C, PV reached 14.53 ± 2.35 meq/kg in control samples, indicating inherent susceptibility to oxidation in the absence of protective agents.

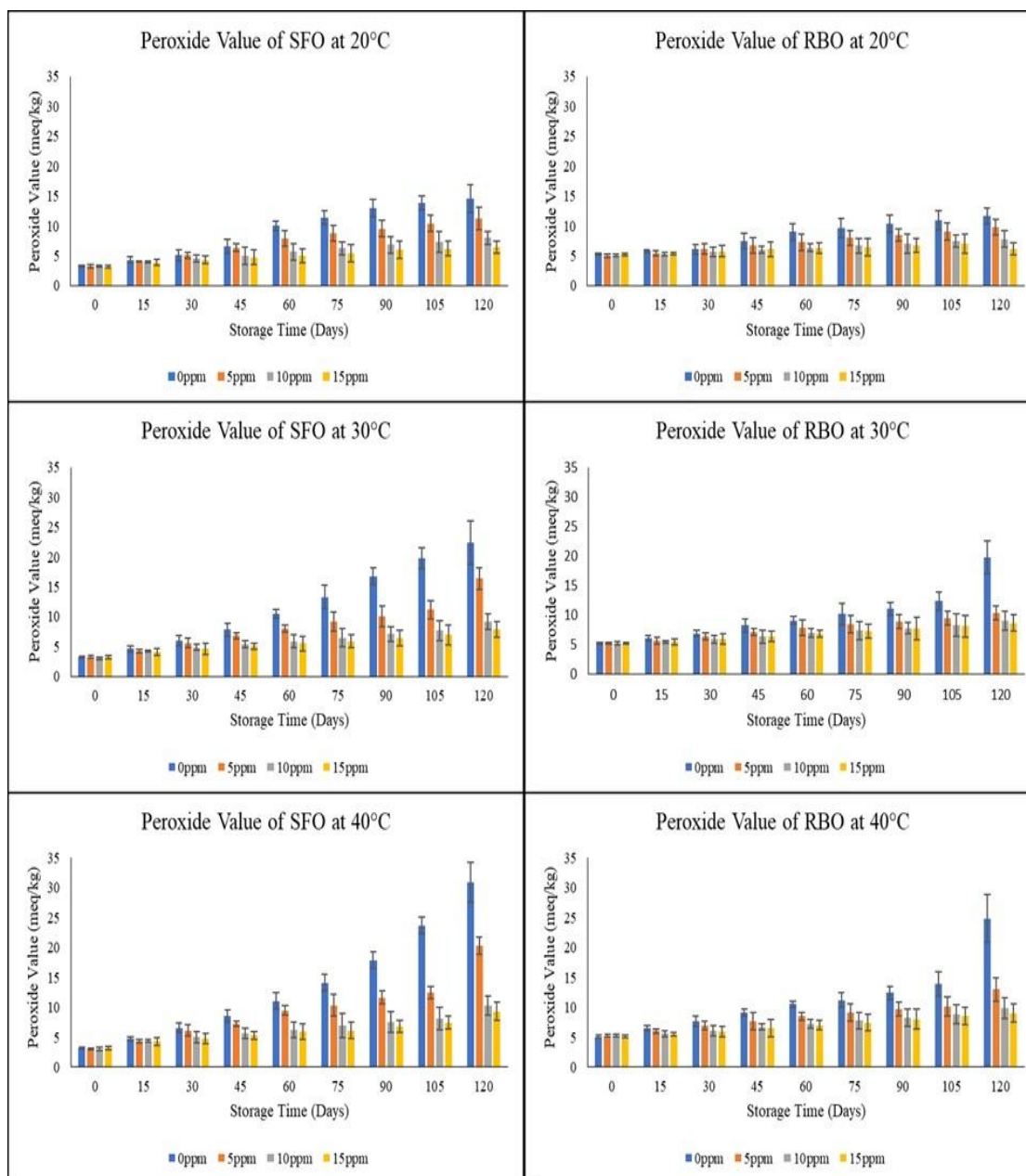


Figure 2.5: Progression of peroxide formation in rice bran & sunflower oil at different temperatures with/without CNPs over 120 days.

Addition of CNPs markedly mitigated this degradation. At 15 ppm, the final PVs were reduced to 6.48 ± 1.04 meq/kg (20°C), 7.87 ± 1.25 meq/kg (30°C), and 9.33 ± 1.54 meq/kg (40°C). These values still reflect effective control of oxidation, as they remained well below the usability threshold in the harshest conditions.

2.3.3.3 Interactive effects of time, temperature, and nanoparticle concentration

Across both oils, PV increased progressively with storage time and temperature, demonstrating that oxidative degradation is a time- and temperature-dependent process. The addition of CNPs

successfully delayed this progression, especially in the early and mid-storage phases. Even, at longer durations and higher temperatures, CNP-protected oils exhibited significantly slower rising rates of PVs compared to controls.

Notably, the interaction between nanoparticle concentration and temperature was critical. At moderate storage temperatures (20–30°C), all CNP concentrations exhibited antioxidant behavior, but at 40°C, the benefits of higher concentrations diminished slightly especially in lower concentrations of nanoparticles in SFO, possibly due to thermal destabilization or since SFO has a higher percentage of PUFA/MUFA in its chemical structure than RBO.

These findings underscore the importance of precise control of CeO₂ nanoparticle dosage, synthesis characteristics, and storage environment in ensuring oxidative protection without invoking unintended redox cycling effects. The Ce³⁺/Ce⁴⁺ balance and oxygen vacancy concentration, which govern ROS-scavenging efficiency, are highly sensitive to synthesis and application conditions (Dhall & Self, 2018; Celardo et al., 2011).

2.4 Conclusion

In this study, nanosized cerium oxide (CeO₂) particles with a fluorite-type cubic structure were successfully synthesized via a controlled precipitation method. The optimized formulation, involving the simultaneous use of n-butyl alcohol and polyethylene glycol as dispersant agents, effectively minimized nanoparticle agglomeration and yielded crystallite sizes in the range of 22–23 nm. The synthesis parameters—including reaction pH and temperature—played a pivotal role in modulating both the physical characteristics and antioxidant potential of nanoceria, particularly by influencing surface oxygen vacancies and the Ce³⁺/Ce⁴⁺ redox balance.

Functional characterization revealed that nanoceria exhibited strong radical scavenging activity, which translated into effective inhibition of lipid oxidation in edible oils. Incorporation of 15 ppm nanoceria into rice bran oil (RBO) and sunflower oil (SFO) significantly delayed peroxide formation over a 120-day storage period, especially under thermal stress. Furthermore, the acceleration of lipid peroxidation with rising temperature confirms that thermal activation energy is a dominant factor in shelf-life prediction. The application of nanoceria not only extended the usable life of oils beyond standard peroxide value thresholds but also demonstrated their potential as thermally stable, redox-active additives suitable for industrial food applications.

Taken together, this work supports the viability of nanoceria as a novel antioxidant strategy for enhancing the oxidative stability of PUFA-rich oils. Their tunable synthesis, high surface

activity, and compatibility with food matrices suggest broad potential in the development of sustainable, next-generation food preservation systems. Future research may explore targeted surface functionalization and integration into edible oil or emulsion systems to further harness their multifunctional properties.

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CHAPTER 3: Modification and engineering surface defect chemistry of nanoceria for enhanced antioxidant performance in edible oils

1.1 Introduction

The previous chapter have established a synthesis route for nanoceria using a precipitation method optimized to yield particles with high antioxidant activity, guided by systematic control of synthesis parameters such as pH, precursor concentration, and aging time. The resulting nanoparticles exhibited stable redox cycling between Ce^{3+} and Ce^{4+} states and demonstrated functional compatibility when incorporated into edible oils, effectively delaying oxidative rancidity (Das et al., 2007; Pirmohamed et al., 2010; Lee et al., 2020). These promising outcomes highlighted nanoceria's potential as an innovative antioxidant additive for food applications and provided a solid platform for further engineering.

A key insight that emerged from this initial phase of work is that the antioxidant efficacy of nanoceria is intimately linked to its defect chemistry, particularly the presence and nature of surface oxygen vacancies (Wang et al., 2018; Xu & Qu, 2014). Oxygen vacancies serve as active sites that facilitate redox transitions and radical scavenging reactions, directly influencing the material's ability to interrupt oxidative chain reactions in lipid matrices (Karakoti et al., 2008; Celardo et al., 2011). However, oxygen vacancy concentration and distribution are highly sensitive to post-synthesis processing conditions (Trovarelli, 1996; Nolan et al., 2005), presenting an opportunity for targeted material engineering.

This chapter therefore focuses on advancing the design of nanoceria by engineering its surface defect chemistry through controlled modification of the calcination atmosphere. By systematically varying the gas environment and thermal parameters during post-synthesis treatment, it is possible to fine-tune the generation of oxygen vacancies, enabling enhanced control over the nanoparticle's functional properties (Wang et al., 2018; Zhang et al., 2021). The engineering process was informed by principles of defect thermodynamics (Trovarelli, 1996; Nolan et al., 2005) and aimed at achieving a balance between maximizing surface reactivity and maintaining structural stability.

To rigorously characterize the effects of this defect engineering, a comprehensive suite of analytical techniques was employed. X-ray diffraction (XRD) combined with Rietveld refinement provided insights into lattice strain and crystallite size evolution (Young, 1993), while Fourier-transform infrared spectroscopy (FTIR) and X-ray photoelectron spectroscopy (XPS) probed surface chemistry and defect states (Nolan et al., 2005; Zhang et al., 2021).

Ultraviolet-visible (UV-Vis) spectroscopy was used to monitor changes in optical properties associated with defect formation (Xu & Qu, 2014), and density functional theory with Hubbard U correction (DFT+U) modeling offered atomic-level understanding of oxygen vacancy energetics and their impact on redox activity (Loschen et al., 2007).

Given the intended application in food systems, an essential aspect of this work involved evaluating the biocompatibility of the engineered nanoparticles. Cytotoxicity testing using the MTT assay ensured that the modified nanocerium formulations remained within safe limits for potential dietary exposure (Heckert et al., 2008; Hirn et al., 2011).

Finally, the practical performance of the defect-engineered nanocerium was validated through detailed oxidative stability studies in edible oil systems. Comparative analyses under accelerated storage conditions (Lee et al., 2020; Singh et al., 2019) demonstrated that strategic engineering of surface oxygen vacancies resulted in significantly improving the antioxidant performance as relative to the baseline nanoparticles developed in Chapter 2.

Stability was assessed using a suite of analytical markers: peroxide value (PV) for primary oxidation, para-anisidine value (p-AnV) for secondary oxidation, iodine value (IV) for unsaturation degree, acid value (AV) for free fatty acid content, Kries test for rancidity onset, refractive index (RI) as an indicator of oil degradation, and TOTOX value as a cumulative oxidative metric.

This chapter thus provides a comprehensive exploration of how defect chemistry engineering can be harnessed to optimize nanocerium's functional properties for food applications. The insights gained contribute not only to the development of advanced antioxidant additives but also to the broader understanding of structure–property relationships in redox-active nanomaterials.

3.2. Material & Methods

3.2.1 Raw Material & Reagents

All the analytical reagents were procured from Merck, India and used without any purification. The packaged refined rice bran oil (RBO) and sunflower oil (SFO) were obtained from a local market of South Kolkata, India.

3.2.2 Synthesis of CeO₂ nanoparticles

Particle synthesis was carried out using the method described in Chapter 2 Section 2.2.1 with the following modifications. Calcination was carried out either under a nitrogen atmosphere for 4 hours (designated as CNP_{N4}), or under open atmospheric conditions for 2 and 4 hours, denoted as CNP_{A2} and CNP_{A4}, respectively.

3.2.3 Characterization

The crystallographic structure, phase composition, atomic positions, and bond lengths of the synthesized nanoceria samples were determined through powder X-ray diffraction (XRD) analysis performed using a ULTIMA IV diffractometer (Rigaku), operating at 40 kV and 40 mA with Cu K α radiation ($\lambda = 1.5404 \text{ \AA}$). Structural and microstructural parameters were extracted and illustrated via Rietveld refinement using the FullProf Suite software. Background fitting was carried out using linear interpolation, and a Pseudo-Voigt function with asymmetry correction was applied to model the diffraction peak profiles.

Morphological features and elemental composition of the synthesized particles were further examined through field emission scanning electron microscopy (FESEM; S-4800, Hitachi, Japan). Surface charge (zeta potential) and hydrodynamic diameter of the nanoparticles were assessed using a ZetaSizer Pro instrument (Malvern Co.).

Vibrational characteristics were investigated through Fourier-transform infrared spectroscopy (FTIR), recorded using a Shimadzu IRPrestige-21 spectrometer. Additionally, optical absorption properties of the samples were evaluated using a UV-Visible spectrophotometer (Systronics, AU-2701).

Surface elemental composition and chemical states were characterized by X-ray photoelectron spectroscopy (XPS) employing a PHI 5000 VersaProbe II system (FEI Inc.) with Al K α radiation (1486 eV).

3.2.4 Computational details

First-principles density functional theory (DFT) calculations were performed using a plane-wave pseudopotential framework as implemented in the Vienna Ab-initio Simulation Package (VASP). The generalized gradient approximation (GGA) was employed to model the exchange-

correlation functional. To accurately capture the effects of the localized Ce 4f orbitals, a spin-unpolarized DFT + U approach was used, incorporating a Hubbard U parameter of 5 eV. The plane-wave cutoff energy was set at 520 eV, ensuring sufficient convergence of the calculations. The Brillouin zone was sampled using a $5 \times 5 \times 5$ Monkhorst-Pack k-point mesh. During structural optimizations, the applied Hellmann–Feynman force threshold per atom was set to 0.015 eV/Å, and the electronic energy convergence criterion (EDIFF) was fixed at 10^{-6} eV (Sözen et al., 2023).

3.2.5 Antioxidant activities CeO₂ nanoparticles

3.2.5.1 ROS scavenging Assay

Free radical scavenging activity of the nanoparticles was studied by % DPPH (Nezhad, S. A., et al. 2019) and %ABTS (Nezhad, S. A., et al. 2019) radical scavenging assay as discussed in Chapter 2 Section 2.2.4.

3.2.5.2 Hydrogen peroxide degradation (catalase equivalent) assay

The ability of CeO₂ nanoparticle to degrade hydrogen peroxide was determined according to the method of Ruch *et al.* (1989). A solution of H₂O₂ (40 mM) was prepared in phosphate buffer (pH 7.4), then 1.0 ml of each nanoparticles of different concentrations (5, 10, 15 ppm) were added to 0.4 ml of phosphate buffer and 0.6 mL (40 mM) H₂O₂ solution. Absorbance of H₂O₂ at 230 nm was determined 10 minutes later against a blank solution containing phosphate buffer without H₂O₂, while the percentage of H₂O₂ scavenging capacity was calculated as follows:

$$\left[(A_{\text{control}} - A_{\text{sample}}) / A_{\text{control}} \right] \times 100 \quad (3)$$

where, A_{control} and A_{sample} denote absorbance of control and sample respectively.

3.2.6 Cytotoxicity of CeO₂ nanoparticles

The cytotoxicity assay was performed through the MTT reagents according to our previous protocol (Sahoo, P., et al. 2022). In brief, HEK-293 cells were seeded at a density of 1.6×10^4 cells/mL in a 96-well plate (100 µL/well). Nanoparticles were administered in cell line for 24 h at various concentrations (0, 10, 20, 30, 40, 50, upto 150 µg/mL). Following the respective incubation periods, 10 µL of 5 mg/mL MTT stock solution was added to each well and allowed to incubate for 4 h at 37°C. The resultant formazan crystals were dissolved with the stopping reagents i.e. dimethyl sulfoxide (DMSO), and the absorbance were quantified at 570 nm using

a Multiskan™ FC Microplate Photometer (Thermo Fisher Scientific). The percentage cell viability was determined from the following equation:

$$\% \text{ cell viability} = \frac{OD \text{ of treated cells}}{OD \text{ of control cells}} \times 100 \quad (4)$$

The outcome of triplicate reports were used to determine IC₅₀.

3.2.7 Preservation of Edible Oil and rancidity tests through refractive index (RI), peroxide, p-anisidine, oxidative stability, iodine value (IV), Kreis-test

The oil samples were categorised in four different batches. In the first, no nanoparticles were added, while in others three different nanoparticles of 5, 10 and 15 ppm concentrations were added. In an effort to estimate antioxidant efficacy, nanoparticles had been subjected to heat treatment, agitation and aeration during or after processing the oils. As full-scale preservation study is very time-consuming, hence accelerated shelf-life study was chosen as an alternative to measure the antioxidant effect of the nanoparticles. Depending on reaction sensitivity of oils at elevated temperatures, storage temperatures were selected at 20, 30 and 40°C for a period of 4 months with 20°C being the reference temperature for Arrhenius model.

All tests were performed according to AOAC protocol (2024) in triplicate basis.

3.2.7.1 Refractive index: Refractive index of CeO₂ nanoparticles treated and untreated samples were measured using Abby refractometer. Briefly, test plate was attached with the refracting prism of the refractometer, followed by focusing light on the test plate. Then instrument was set in such a way that borderline of the critical angle coincides with cross-hairs within the telescope and the reading was recorded. Prior to measurement, refractometer was standardized with distilled water of refractive index ~ 1.3315 ($D^{29.5}$).

3.2.7.2 Peroxide value (PV): PV was determined according to Cd 8b-90 (AOCS official method) on triplicate basis as discussed in Chapter 2 section 2.2.3.

3.2.7.3 p - Anisidine value (p-AV): The p-anisidine value (p-AV), an indicator of aldehyde content, was determined in triplicate for each sample following the standard Cd 18-90 protocol. Approximately 1.0 g of the oil sample was dissolved in 25 mL of isooctane, and the initial absorbance (AB_{S_i}) of the solution was recorded. Subsequently, 5 mL of this solution was transferred to a test tube, to which 1.0 mL of a 10.0% p-anisidine solution prepared in glacial acetic acid was added. The mixture was vortexed briefly to ensure proper mixing. A blank

sample was prepared by replacing the oil sample with pure isooctane. After allowing the reaction to proceed for 10 minutes, the absorbance (AB_{S_2}) was measured at 350 nm. The p-AV was then calculated using the following formula.:

$$p-AV = 25 \times \frac{1.2AB_{S_2} - AB_{S_1}}{m} \quad (6)$$

where, 'm' represents mass of the sample (in g).

3.2.7.4 Total oxidation (TOTOX) value: TOTOX value had been calculated from the equation:

$$TV = 2 \times PV + p-AV \quad (7)$$

Prior to measure, oils were heated at temperatures around 120-150°C for 5 minutes, while pressurised air was used to pass through it to stimulate oxidation.

3.2.7.5 Iodine value (IV): The iodine value (IV) was determined following the guidelines of the Food Safety and Standards Authority of India (FSSAI, 2021). For each measurement, 0.2 g of the oil sample was mixed with 15 mL of carbon tetrachloride (CCl_4) and 25 mL of Wijs reagent, and the mixture was incubated for 1 hour in the dark to prevent photodegradation. Following incubation, 20 mL of an aqueous potassium iodide (KI) solution (10 g/100 mL), 15 mL of distilled water, and 5 drops of a 1% starch indicator paste were added to the reaction mixture. The resulting solution was titrated with 0.1 N sodium thiosulfate ($Na_2S_2O_3$) solution until the blue coloration disappeared, indicating the end point. A blank determination was performed under identical conditions, replacing the oil sample with CCl_4 . The iodine value was subsequently calculated using the following formula.

$$IV = \frac{V_0 - V_1}{m} \times 12.69 \times T \quad (8)$$

where, V_0 , V_1 (in mL) denote volume of the thiosulphate solution for blank and sample respectively. 'T' is the Titer of the sodium thiosulfate solution (mL) and M (in g) represents mass of the test portion.

3.2.7.6 Kries Test (KT): Currently, 5.0 mL of oils (RBO and SFO) were dissolved in 5 mL chloroform, followed by addition of 10 mL of a 30% solution of trichloroacetic acid in glacial acetic acid and 1.0 mL of 1.0% solution of phloroglucinol in glacial acetic acid. Test tubes were incubated at 45 °C for 15 min, whereas 4 mL of ethanol was added to the test tube. Finally, absorbance was measured at 545 nm.

3.2.7.7 Acid value (AV): AVs were determined according to Ca5a-40 protocol on triplicate basis. Briefly, 10 g of oils (RBO and SFO) were boiled with 50 mL of freshly prepared neutralized alcohol and 1 mL phenolphthalein in a water bath. The heated mixture was then titrated against 0.1 N KOH solution adding the titrant drop wise (max. 10ml) with intermittent shaking, until the pink colour stabilizes for a few minutes. Finally, AV was determined from the equation:

$$AV = \frac{V \times N}{M} \times 56.1 \quad (9)$$

where, V and N stand for volume (mL) and normality of KOH solution respectively, M for mass of the sample (in g).

1.3 Results and discussion

3.3.1 Phase, crystal structure and micro-structure analyses of CeO₂ by XRD, FESEM

The XRD patterns of all the synthesized samples (Figure 3.1a–c) exhibit six well-defined diffraction peaks located at 28.3°, 32.9°, 47.1°, 56.1°, 58.7°, and 69.1°, corresponding to Bragg reflections from the (111), (200), (220), (311), (222), and (400) planes, respectively. These reflections can be indexed to the cubic fluorite structure of CeO₂ (JCPDS No. 34-0394; space group: Fm $\bar{3}$ m). The absence of any extraneous or secondary peaks in the diffractograms confirms the formation of a phase-pure CeO₂ structure. This structural purity is critical, as the presence of impurities or secondary phases may alter nanoparticle–oil interactions, potentially triggering undesirable side reactions or diminishing the antioxidative efficiency of the nanoceria.

Additionally, Rietveld refinement was employed to evaluate long-range structural order and disorder. The refined structural parameters, including lattice constants, unit cell volume, microstrain, and Ce–O bond lengths for all samples, are summarized in Table 3.1. These values closely align with those reported in the literature (Dhruv et al., 2024; de Lima Batista et al., 2018; Ma et al., 2020). Furthermore, the goodness-of-fit indicators (e.g., χ^2 values) affirm the reliability and accuracy of the refinement process.

Table 3.1: Rietveld Refinement Parameters of CeO₂ Samples

Parameters	CNP _{N4}	CNP _{A2}	CNP _{A4}

Lattice constants	a = b = c = 5.4162 (2) Å, V = 158.883 (11)Å ³	a = b = c = 5.41142 (14) Å, V = 158.465(7) Å ³	a = b = c = 5.41038 (15) Å, V = 158.373 (8) Å ³
Goodness of Fit Parameters (GoF)	R _p = 25.4 R _{wp} = 44.0 R _{exp} = 17.2 χ^2 = 6.57	R _p = 24.6 R _{wp} = 41.6 R _{exp} = 18.7 χ^2 = 4.96	R _p = 23.8 R _{wp} = 45.3 R _{exp} = 17.0 χ^2 = 7.05
Ce-O bond length (×8) in Å	2.34528 (9)	2.34321 (6)	2.34276 (7)
<Ce-O-Ce angle in degree	109.4712 (0)	109.4712 (0)	109.4712 (0)
Crystallite size (Å) with standard deviation	290.34 (0.25)	254.27 (0.35)	224.59 (0.35)
Micro-strain with standard deviation	19.0299 (0.0055)	20.0792 (0.0078)	21.7379 (0.0055)

The unit cell of CeO₂, constructed using refined structural parameters, was visualized and analyzed for both electronic and structural properties using the VESTA software. In this model, Ce ions occupy the (0 0 0) lattice positions, while O ions are positioned at ($\frac{1}{4}$ $\frac{1}{4}$ $\frac{1}{4}$), with no positional degrees of freedom permitted (as illustrated in Figure 3.1(d)). It is also notable from Table 3.1 that lattice parameter, unit cell volumes, Ce – O bond length, crystallite size are measured in the following order CNP_{A4}>CNP_{A2}>CNP_{N4}, while strain varies reversely. Presently, the variation is attributed to oxygen vacancy (V_O) in CNP_{N4} due to annealing in reducing N₂ atmosphere, which gets lowered due to annealing under open atmospheric condition in case of CNP_{A2} and CNP_{A4}. By optimizing the concentration of oxygen vacancies, the nanoparticles can more effectively scavenge free radicals and inhibit lipid oxidation in edible oils, thereby extending their shelf life.

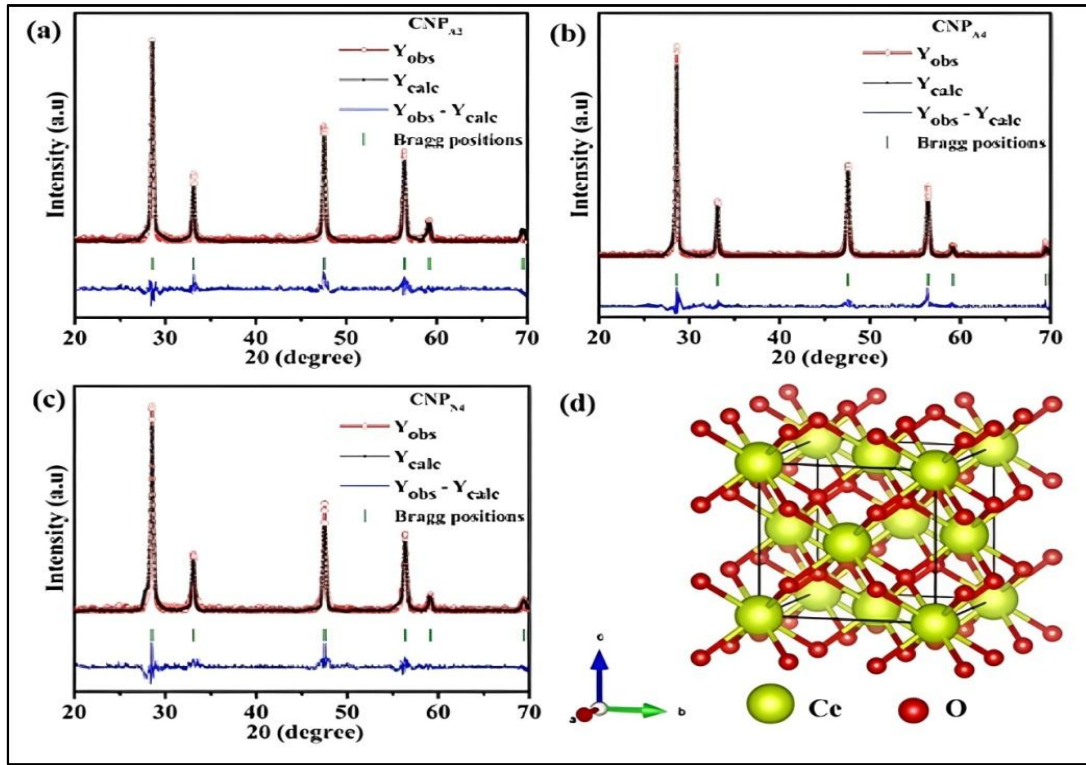
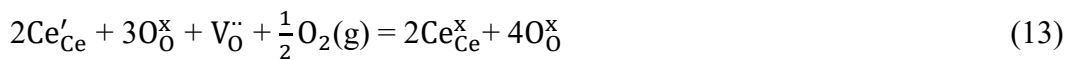


Figure 3.1: (a-c) X-ray diffraction pattern, fitted Rietveld refinement, of CeO₂ nanoparticles, (d) Schematic unit cell structure of CeO₂.

Herein, the phenomenon can be understood in terms of Kröger – Vink notation which is given in equation (12) for annealing under reducing atmospheric condition (Das, S., et al. 2017; Das, S., et al. 2022):



where, $\text{Ce}_{\text{Ce}}^{\text{x}}$ and $\text{O}_{\text{O}}^{\text{x}}$ represent neutral Ce and O on Ce and O sites respectively; Ce_{Ce}' and $\text{V}_{\text{O}}^{\text{..}}$ denote singly negatively charged cerium (i.e. Ce^{3+}) at cerium lattice site and doubly positively charged vacancy at oxygen lattice site respectively. Two excess electrons get localized onto nearby Ce^{4+} ions and reduces them into Ce^{3+} during formation $\text{V}_{\text{O}}^{\text{..}}$ (Keating, P. R. L., et al. 2012). From equilibrium constant, it has been found that $[\text{Ce}_{\text{Ce}}']$ is proportional to partial pressure of oxygen $[(p_{\text{O}_2})^{-1/2}]$ indicating more formation of Ce_{Ce}' during annealing in the presence of N_2 . However, annealing in open atmospheric condition, reverse reaction happens which can be expressed by equation (13):



Thus, annealing in open atmosphere reduces $\text{V}_{\text{O}}^{\text{..}}$ which in consequence enhances lattice parameter, unit cell volumes, Ce – O bond length, crystallite size etc. of $\text{CNP}_{\text{A}2}$, $\text{CNP}_{\text{A}4}$. Also, the slight variations in lattice parameters, unit cell volumes, and Ce–O bond lengths among the samples provide insights into the fine-tuning of nanoparticle properties. Smaller nanoparticles

with optimized lattice structures can interact more effectively with the oil matrix, providing better dispersion and a more consistent antioxidant effect.

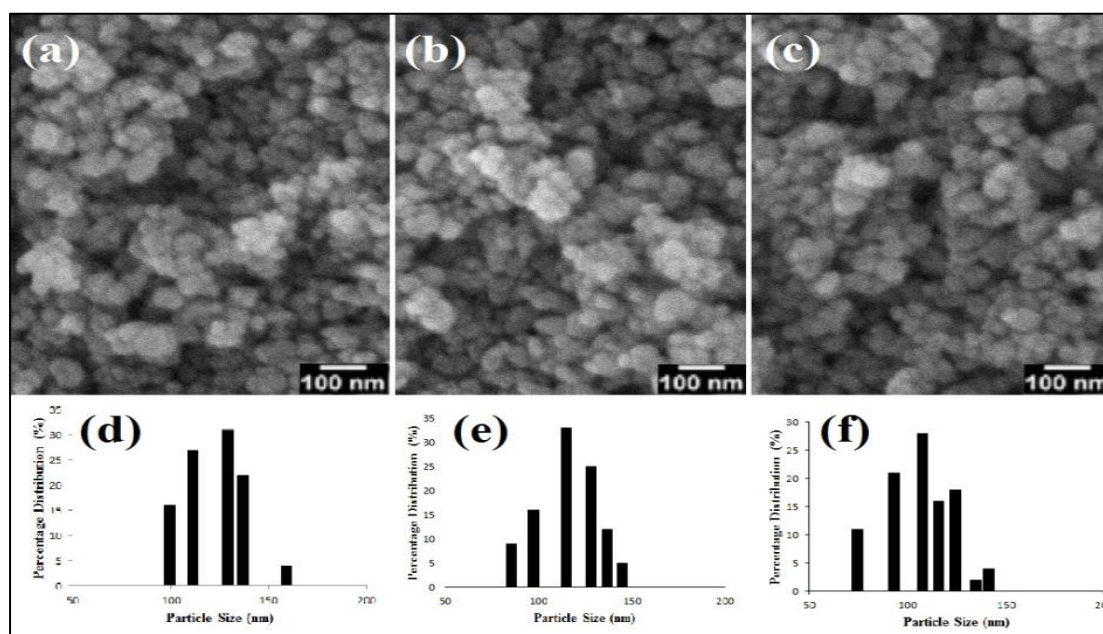


Figure 3.2: (a-c) FESEM image and (d-f) Histogram plot of CNP_{A4} , CNP_{A2} , CNP_{N4} .

The FESEM micrograph and corresponding particle size distribution histogram (Figure 3.2) reveal a distinctly agglomerated and non-uniform morphology of the synthesized nanoceria, with an average particle size centered around ~ 100 nm. This aggregation and size variation are likely influenced by the high-temperature calcination process, which can promote partial sintering and fusion of adjacent particles, thereby reducing surface energy. Despite the observed agglomeration, the particle size remains within a range considered optimal for dispersibility in lipid-based matrices.

Nanoparticles of this scale possess a sufficiently large surface area-to-volume ratio to enable efficient interaction with lipid molecules when incorporated into edible oils. Although uniformity is somewhat compromised, the nanoscale dimensions ensure that a significant portion of the particles remains active in the dispersion. These dispersed nanoparticles can establish a barrier against oxidative species or catalyze the decomposition of peroxides, thereby mitigating lipid peroxidation. Thus, the structural features observed via FESEM analysis suggest that the synthesized CeO_2 particles, despite minor agglomeration, are suitably dimensioned to exert a stabilizing antioxidant effect in oil systems.

3.3.2 Investigations of defects in CeO_2 nanoparticles by FTIR, x-ray photoelectron and UV-Vis spectroscopies

To investigate local structural distortions in the CeO₂ unit cell arising from oxygen deficiency, FTIR spectroscopy was employed, as this technique is particularly effective in revealing short-range order–disorder phenomena.

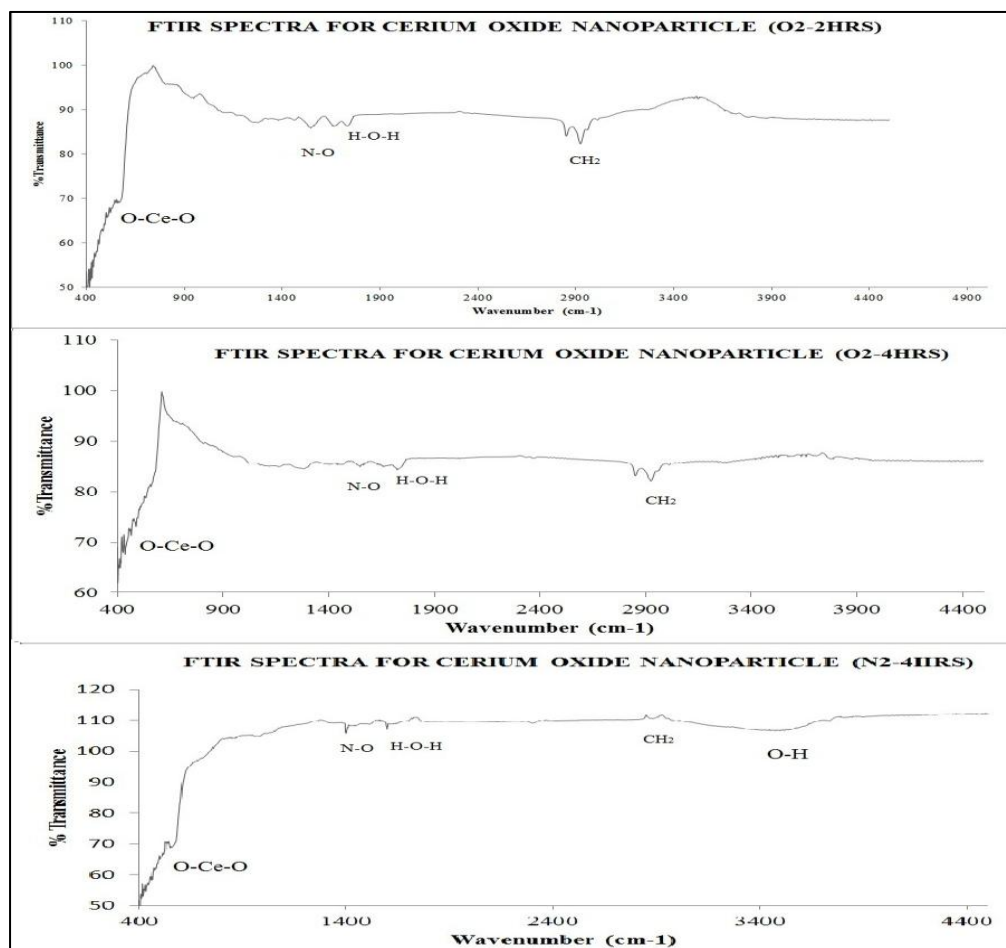


Figure 3.3: Fourier Transform Infrared Spectroscopy (FTIR) spectrum representing the absorbance spectra of cerium oxide nanoparticles.

The FTIR spectra (Figure 3.3), recorded in the range of 400–1000 cm⁻¹, exhibit a prominent absorption band at approximately 560 cm⁻¹. It is well-established that vibrational modes occurring between 500 and 570 cm⁻¹ are indicative of lattice defects associated with Ce³⁺–O–Ce⁴⁺ linkages. Hence, the pronounced absorption observed at 560 cm⁻¹ strongly suggests the presence of mixed-valence states (Ce³⁺ and Ce⁴⁺) within the synthesized samples, confirming oxygen vacancy-induced structural distortions (Ma et al., 2020).

To gain deeper insights into the chemical bonding characteristics of the constituent elements, X-ray photoelectron spectroscopy (XPS) was employed to analyze the valence states of cerium (Ce) and oxygen (O). All measured binding energies were calibrated relative to the C 1s peak at 284.6 eV, attributed to adventitious carbon. The XPS survey spectra, recorded over the 0–

1100 eV range, captured the core-level binding energies of Ce and O across all synthesized samples. Additionally, high-resolution spectra for both Ce and O were acquired for more detailed analysis.

As shown in Figure 3.3(a, b, c), the high-resolution Ce spectra exhibit two prominent peaks within the 880–897 eV and 900–920 eV ranges, corresponding to the spin-orbit splitting of the Ce 3d_{5/2} and 3d_{3/2} orbitals, consistent with the trivalent oxidation state of cerium. Due to the inherent asymmetry of these spectral features, detailed deconvolution was performed, revealing three distinct component peaks of Ce 3d_{3/2} orbitals with binding energies ~ 900.4, 906.9 and 916.0 eV and they are assigned to Ce²⁺ - 3d_{3/2}, Ce³⁺ - 3d_{3/2} shakeup and Ce⁴⁺ - 3d_{3/2} respectively. A careful deconvolution reveals $\text{Ce}^{4+} / (\text{Ce}^{4+} + \text{Ce}^{3+})$ ratio ~ 0.45, 0.50 and 0.51 for CNP_{N2}, CNP_{A2}, CNP_{A4} suggesting monotonic increase of Ce⁴⁺ which may be attributed annealing effect in open atmospheric condition which is in agreement with Rietveld analysis in consequence with equation (1) and (2).

Simultaneously, deconvolution of O 1s peak (Figure 3.3(d -f)) yields two peaks at 529 and 530.8 eV and they can readily be assigned to adsorbed oxygen (O₂(ads)) species at V_O site and lattice oxygen (O_{lat}). Herein, careful analysis illustrates that O₂(ads)/ O_{lat} ratio (~ 1.33, 1.34, and 0.87) decreases from CNP_{N2} to CNP_{A4} corroborating increasing tendency of Ce⁴⁺. Hence, it may be inferred that annealing in N₂ atmosphere leads formation of V_O which gets diminished due to annealing in open atmospheric condition.

In order to examine V_O related modification of optical properties, we have measured absorption spectra which consists of strong absorption band (Figure 3.5) in the UV-Vis region and it can readily be ascribed to the charge transfer-transition from O²⁻ to the Ce⁴⁺ orbitals within the fluorite cubic structure of CeO₂. However, a close inspection of absorption edge reveals that the synthesized nanoparticles possess different band gap (E_g).

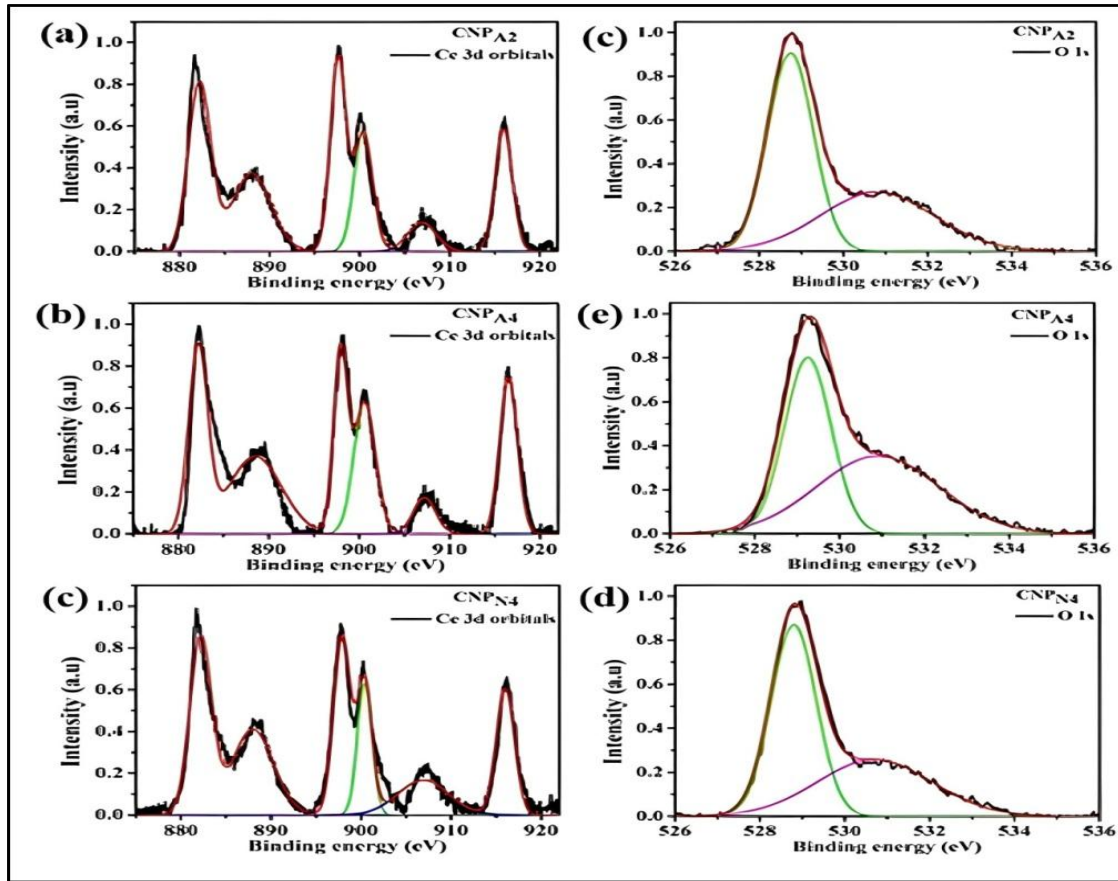


Figure 3.4a: Deconvoluted x-ray photoelectron spectra of (a - c) Ce 3d and (d - f) O 1s.

In this context, direct E_g , evaluated from well-known Tauc's plot, has been found to be ~ 2.25 , 2.84 and 2.86 eV for CNP_{N2} , CNP_{A2} and CNP_{A4} respectively. The variation of E_g can be attributable to the presence of $V_O^{\bullet\bullet}$. Herein, it is believed that excess electrons occupy empty 4f states of Ce^{4+} and causes distinctive red-shift of 4f peak within conduction band edges, thus band E_g is lowered in CNP_{N4} . In contrast, CNP_{A2} and CNP_{A4} contain less $V_O^{\bullet\bullet}$ which lowers 4f contribution in between band edges leading blue-shift of conduction band edge, thus E_g gets enhanced.

In order to gain deep understanding about the defect related modification of optical properties of our synthesized CeO_2 nanoparticles, we have carried out a series of *ab initio* electronic structure of CNP_{N2} , CNP_{A2} and CNP_{A4} along high symmetry points within the Brillouin zone using density functional theory. In these calculations, top of the valence band maxima (VBM) has been set at zero. It is notable from Figure 3.4 that valence band maxima (VBM) lies at M-point, while conduction band minima (CBM) appears along M – Γ line indicating indirect E_g for CeO_2 . Our calculation also illustrates that electronic structure remains unchanged for all three samples, except reduction of E_g (~ 2.459 , 2.461 and 2.464 for CNP_{N2} , CNP_{A2} and CNP_{A4})

which agrees well with experimental results of E_g . TDOS and PDOS (total and partial electronic density of states) calculations demonstrate predominant contribution from hybridization between $O\ 2p_y, 2p_z - Ce\ 4fz^3$ to upper part of the valence band near VBM, while lower part of valence band comprises of $O\ 2p_x - Ce\ 4fxyz$ hybridized state. In contrast, conduction band purely originates from $Ce - 4f$ orbitals with contributions in the following order $Ce - 4fz^2, fy^3x^2, fz^3 > Ce - 4fxyz, fx^3 > Ce - 4fyz^2, fxz^2$. Presently, enhancement of E_g is attributable to blue-shift of CBM comprising of $Ce - 4fz^2, fy^3x^2, fz^3$ orbitals. Therefore, it may be inferred that annealing in oxygen atmosphere reduces $V_O^\bullet$ which eventually causes blue-shift of CBM in case of CNP_{A2} and CNP_{A4} corroborating variation of E_g .

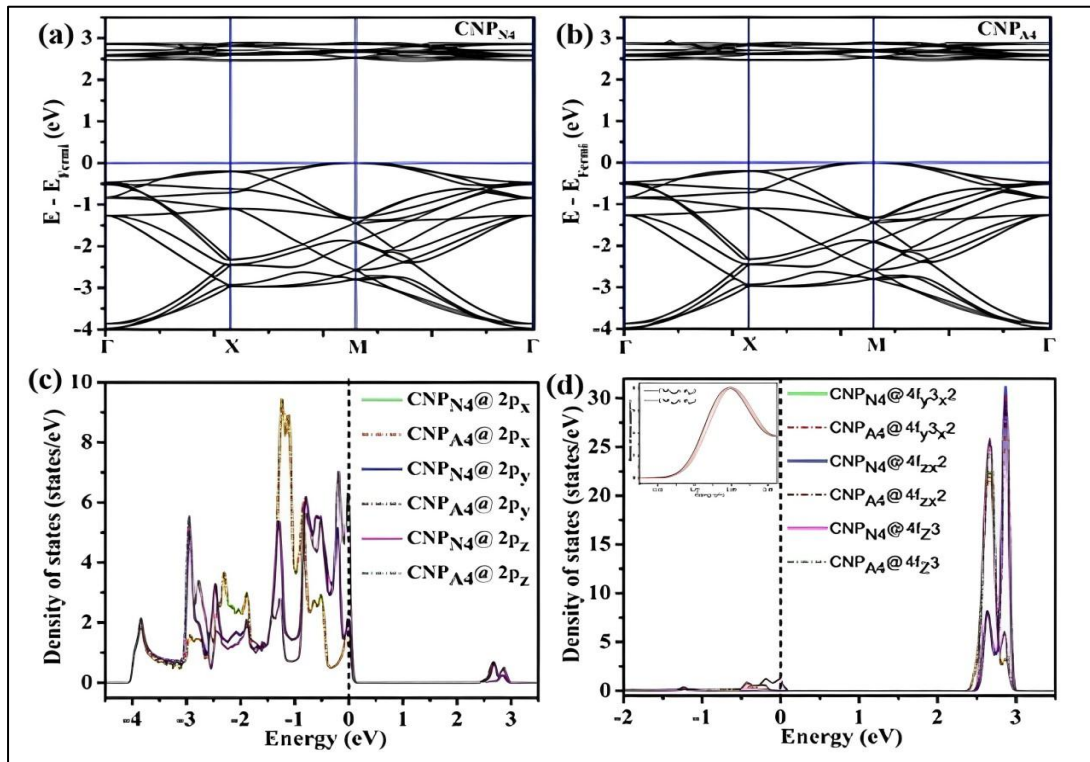


Figure 3.4b: Deconvoluted x-ray photoelectron spectra of (a - c) Ce 3d and (d - f) O 1s.

The findings from the investigation of defects in nanoceria, as characterized by FTIR, XPS, and UV-Vis spectroscopies, provide critical insights that align with the objective of extending the shelf life of edible oils using nanoparticles. The detection of oxygen vacancies and the mixed valence states of Ce^{3+} and Ce^{4+} , as revealed through XPS and FTIR, are directly linked to the redox properties of the nanoparticles.

Hence, it is proved from our experiments that CeO_2 nanoparticles possess a regenerative antioxidant activity due to the reversible redox cycling in the presence of both Ce^{3+} and Ce^{4+} which makes them excellent scavengers of many free radicals. These properties are essential

for enhancing the antioxidant activity of CeO₂ in edible oils, as they enable effective scavenging of free radicals, thereby inhibiting oxidative degradation.

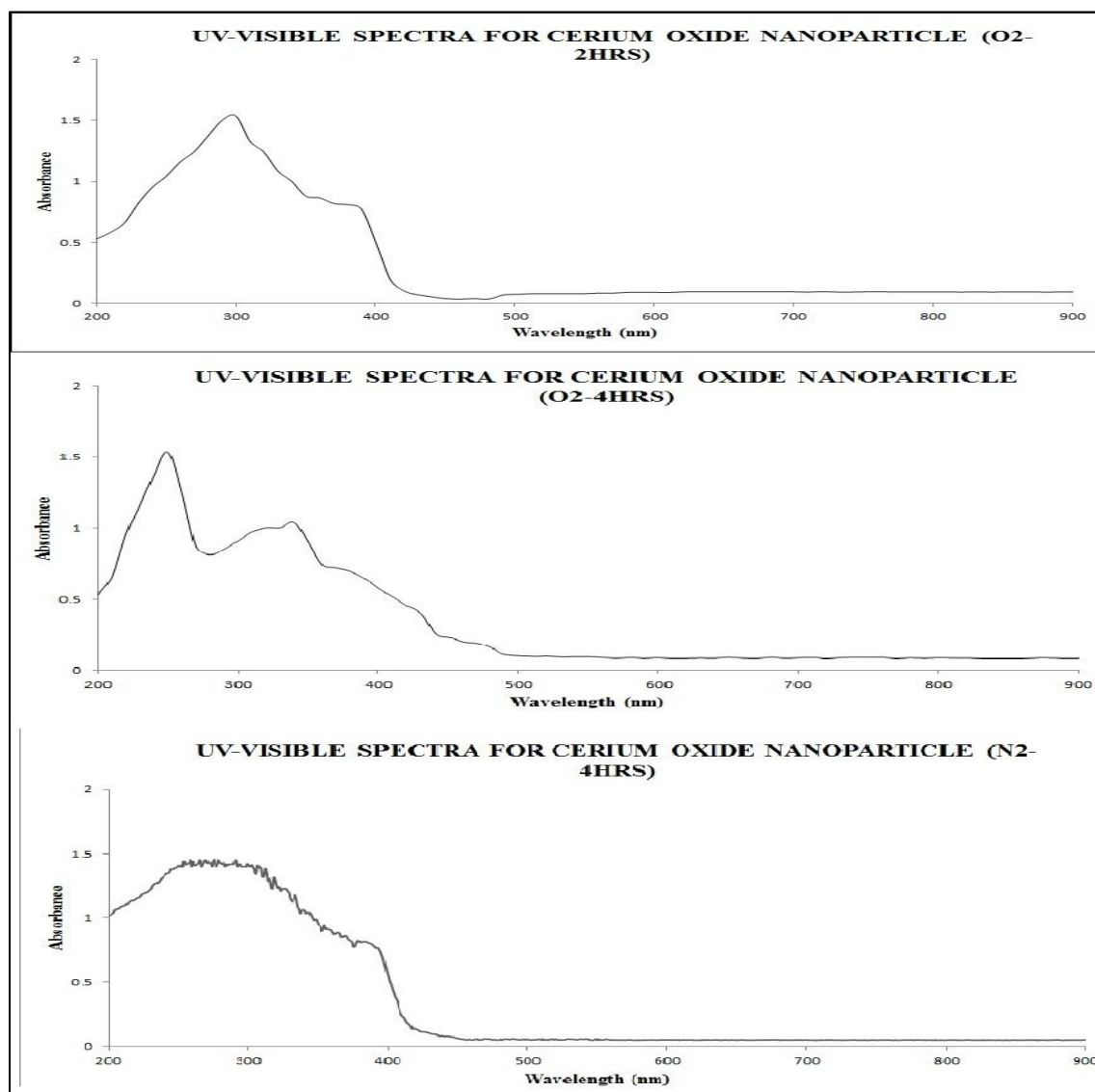


Figure 3.5: UV-VIS scan image of synthesized cerium oxide particles

Additionally, the band gap variations observed in UV-Vis spectroscopy (Figure 3.5) suggest that nanoparticles can be tailored to optimize their interaction with edible oils, further contributing to their efficacy in extending shelf life. The integration of these spectroscopic findings with DFT calculations, which corroborate the experimental results, reinforces the potential of these nanoparticles to maintain their structural and functional integrity under different processing conditions, making them highly suitable for practical applications in the food industry.

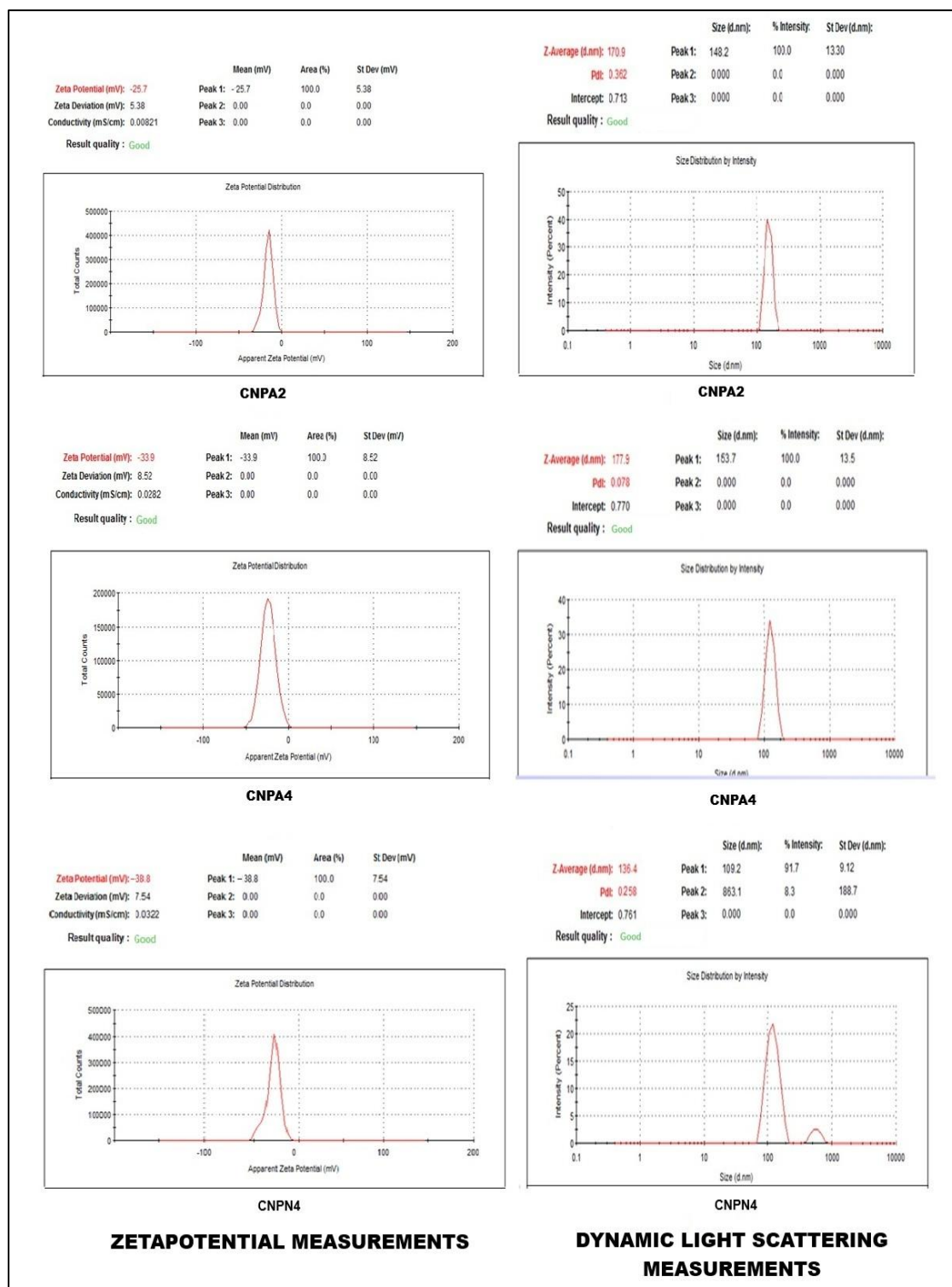


Figure 3.6: Zetapotential and DLS measurements of synthesized particles

The synthesized cerium oxide nanoparticles were subjected to dynamic light scattering experiments to analyse the particle size distribution, the hydrodynamic diameter, distribution, and zeta potential of the particles.

The DLS measurements, as shown in Figure 3.6, show the Z-average hydrodynamic particle diameters of the CeO₂ NPs. The particle synthesized at oxygen excess conditions (CNP_{A4}) had particle sizes of 153.7±13.5 nm with a polydispersion index (PDI) of 0.078 suggesting a narrow unimodal particle size. The particles synthesized at normal oxygen condition (CNP_{A2}) and the oxygen starved conditions (CNP_{N4}) had average particle sizes of 148.2±13.3 and 109.2±9.2 with a uniform dispersion in aqueous solvent at pH 7±0.2. The sizes are comparatively bigger than those observed in SEM, suggesting a slight agglomeration of particles. The DLS measurements, as shown in Table 3.2, show the Z-average hydrodynamic particle diameters, polydispersion index and zeta potential of the CeO₂ NPs.

Table 3.2: DLS measurements of synthesized particles

NP Type	Average Particle Size Distribution (nm)	Z-average (hydrodynamic particle diameter) (nm)	Polydispersion Index (PDI)	Zeta Potential (mV)
CNP _{A4}	153.7±13.5	177.9	0.078	-25.7
CNP _{A2}	148.2±13.3	170.9	0.362	-32.7
CNP _{N4}	109.2±9.2	136.4	0.258	-33.9

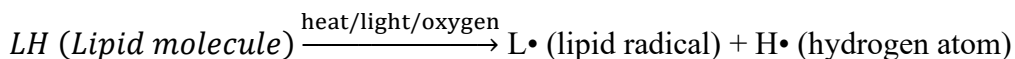
Absolute zeta potential values above 30 mV indicate physical stability. Values below 20 mV indicate limited stability, and values lower than 5 mV are evidence of agglomeration. The negative sign symbolizes the difference in charge between the particle and the dispersed medium (Shah et al., 2014; Cacua et al., 2019; Kosmulski et al., 2022). In this study the particles were dispersed in de-ionized water at pH 7±0.2. The zeta potential of the particles noted are given in Table 3.2 (Figure 3.6). From the values observed it can be concluded that all the four types of particles were physically stable in the medium with the standard particle showing slightly lesser stability than the rest of the particles.

3.3.3 Free radical and hydrogen peroxide degradation activities of the as-prepared CeO₂ nanoparticles

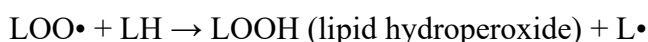
In general, primary lipid oxidation in the presence of air, heat and light produces lipid radical (L•) and hydroxyl radicals (i.e. •OH), while lipid oxidation in the presence of Cu, Fe catalysts leads generation of lipid peroxy radical (LOO•) and few others like super oxide (O₂⁻) anion.

In presence of sunlight and UV light singlet oxygen ($^1O_2$) can also initiate lipid peroxidation. Secondary lipid oxidation results lipid hydroperoxide and hydrogen peroxide (H_2O_2).

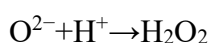
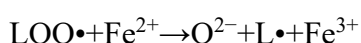
Initiation stage:



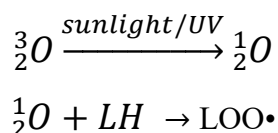
Propagation stage:



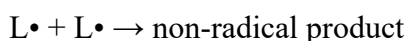
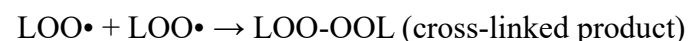
Propagation in presence of metal catalysts:



Propagation in presence of sunlight and UV light:



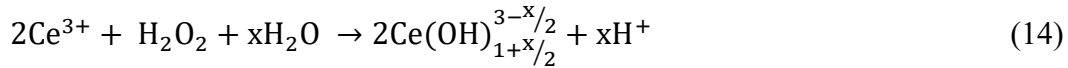
Termination stage:



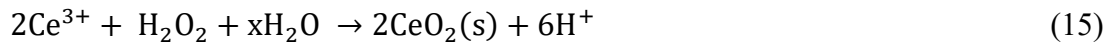
It has been studied by many researchers including us that V_0 often scavenges oxygenated free radicals (Podder, S., et al. 2018). As our synthesized nanoparticles have V_0 , so it is expected to be beneficial to impart scavenging activity of CeO_2 nanoparticles. Prior to examine free radical scavenging activity, we have validated their dispersion characteristics through DLS and zeta potential measurements. As shown in Figure 3.6, Z-average hydrodynamic diameter of CeO_2 nanoparticles is measured to be within the range of 130 – 150 nm at pH 7 ± 0.2 , while polydispersity index (PDI) is ~ 0.078 , 0.362 and 0.310 for CNP_{N4} , CNP_{A2} and CNP_{A4} suggesting narrow unimodal size of CNP_{N4} in comparison with CNP_{A2} and CNP_{A4} . Thus, it may be concluded that annealing in N_2 facilitates to reduce particle size distribution. Zeta potentials of three respective samples are measured to be -25.7 , -32.7 and -33.8 mV; hence it may be concluded that all the nanoparticles provide physically stable dispersion.

Suitability of CeO_2 nanoparticles as potential antioxidants for edible oil preservation, has been tested by evaluating DPPH, ABTS and hydrogen peroxide scavenging activities. Herein, dose

dependent scavenging studies (shown in Table 3.2) reveal that all CeO₂nanoparticles exhibit DPPH, ABTS and H₂O₂scavenging capabilities in the following order CNP_{N4}>CNP_{A2}>CNP_{A4}. Thus, highest scavenging activity of CNP_{N4}can be attributed to more electron storage capability of V_O[•]. This Ce³⁺ gets oxidized easily by oxidizing radicals (i.e. •OH, O₂⁻, ¹O₂, H₂O₂ etc.), while typical overall reaction for H₂O₂can be written as equation (14)



Herein, the half-cell reaction for hydrogen peroxide can be expressed as: H₂O₂ + 2H⁺ + 2e⁻ → 2H₂O, while the overall reaction can be summarized as equation (15):



Therefore, it can be understood that V_O[•]leads adsorption of hydroxyl radicals which simultaneously get scavenged by Ce³⁺.

Among all three synthesized samples, CNP_{N4} possesses maximum Ce³⁺ in comparison with CNP_{A2} and CNP_{A4}, thus its highest scavenging activity is certainly be ascribed to presence of Ce³⁺. Annealing in oxidizing open atmosphere (i.e. CNP_{A2}andCNP_{A4}) reduces Ce³⁺, thus successively scavenging activity gets reduced. Our study shows that 15ppm of CNP_{N4} nanoparticles possess the highest ROS scavenging activity (Table 3.3).

Table 3.3: ROS scavenging activity of synthesized nanoparticles

Particle Type	Concentration (ppm)	% DPPH Inhibition	% ABTS Radical Scavenging Activity	% H ₂ O ₂ Radical Scavenging Activity
		Mean ±SD	Mean±SD	Mean±SD
CNP _{A2}	5	42.41±1.981	44.32±3.266	39.36±2.636
	10	57.22±3.517	49.12±4.879	51.17±2.389
	15	60.94±4.399	53.18±1.449	52.06±2.31
CNP _{A4}	5	42.68±2.858	40.95±3.115	37.81±1.537
	10	46.94±4.704	54.32±4.796	46.63±1.99
	15	57.21±0.874	60.07±2.14	53.64±4.659
CNP _{N4}	5	48.32±2.549	42.09±0.773	42.20±4.445
	10	62.45±1.764	56.44±1.719	57.44±0.833
	15	70.27±3.21	67.06±0.78	67.66±4.191

3.3.4 Cytotoxicity of CeO₂ nanoparticles

MTT assay was carried out to determine cytotoxicity of the as prepared CeO₂ nanoparticles. A dose-response curve was generated from serially diluted nanoparticle concentrations (0–1000 µM) over a 24 hours period. All the three types of samples (CNP_{A2}, CNP_{A4}, CNP_{N4}) displayed similar results.

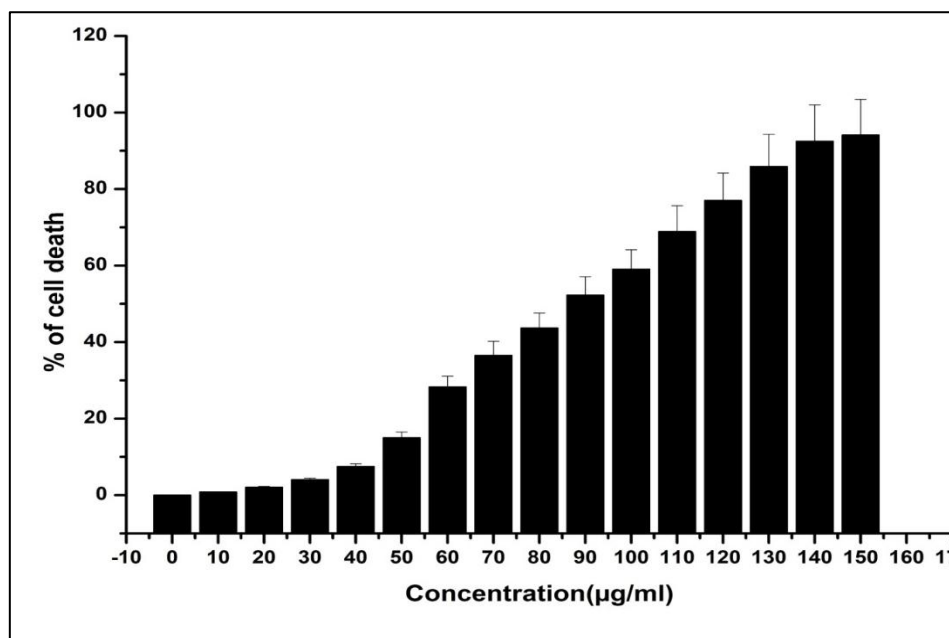


Figure 3.7: The effect of cerium oxide nanoparticles (CNP_{N2}) on Hek-293 cell viability.

Figure 3.7 shows the dose-dependent cytotoxicity data of CNP_{N4}, taken against HEK-293, reveals IC₅₀ ~ 88 ± 7.08 µg/ml (i.e. 88 ppm) indicating that any lower dose can be accepted to examine shelf life in terms of determining rancidity parameters of RBO and SFO.

3.3.5 Role of CeO₂ nanoparticles on oxidative stability and shelf life of rice bran and sunflower oils

For detailed oxidative studies, edible oils were placed in conical flasks under controlled environment. The samples marked as “Untreated” represent edible oils procured from the market without addition of any nanoparticle. Three differently synthesized nanoparticles were added in other flasks containing oils at concentrations of 5, 10, and 15 ppm. Samples were stored under varying conditions: temperatures of 20°C, 30°C, and 40°C, and either open (cotton-plugged for controlled air flow) or closed (airtight) conditions. Analytical parameters, i.e. peroxide value (PV), p-anisidine value (p-AV), total oxidation (TOTOX) value, iodine value (IV), refractive index (RI), Kries Test (KT), and acid value (AV), were monitored at 7-day intervals over a period of 9 weeks.

The oxidative stability of all rice bran oil (RBO) and sunflower oil (SFO) samples was systematically assessed through the determination of peroxide value (PV), para-anisidine value (p-AV), and total oxidation value (TOTOX), as presented in Table 3.4A. Among these, the PV serves as a primary marker of lipid peroxidation and is indicative of the extent of primary oxidative degradation. An increase in PV reflects the formation of lipid hydroperoxides, primarily initiated by the interaction of reactive oxygen species (ROS) with polyunsaturated fatty acids (PUFAs).

The underlying mechanism involves a sequence of radical-driven peroxidation reactions, wherein ROS or other free radicals abstract hydrogen atoms from the methylene (-CH₂-) groups located between double bonds of PUFAs. This abstraction initiates a chain reaction of lipid peroxidation, leading to the generation and propagation of lipid radicals and hydroperoxides (Lin & Chiu, 2009). Such oxidative degradation not only compromises the nutritional and sensory quality of edible oils but also poses significant health risks. Chronic dietary intake of oils with elevated PV levels is associated with detrimental health outcomes. Peroxides and their secondary decomposition products have been implicated in the disruption of cellular membrane integrity and are considered cytotoxic.

Table 3.4A: Storage conditions showing highest control on oxidative rancidity

Oil Type	Open/ Closed storage	Temperature (°C)	CNP	CNP Conc. (ppm)	Peroxide Value (meq. of O ₂ /kg)	p-Anisidine (units)	TOTOX Value (units)
RBO	Open	20	Untreated		23.11±0.12	35.83±1.82	68.11±4.11
			CNP _{N4}	15	8.52±1.23	19.66 ±0.79	43.67 ±3.53
		30	Untreated		26.05±2.82	38.65±1.62	71.84±3.27
			CNP _{N4}	15	8.91±0.98	22.35 ±0.78	54.46 ±2.44
		40	Untreated		28.84±1.18	38.97±1.28	45.27 ±5.16
			CNP _{N4}	15	10.63±0.37	24.43 ±0.87	63.38 ±3.07
	Closed	20	Untreated		21.37 ± 1.95	35.38±3.01	65.11 ±3.84
			CNP _{N4}	15	8.01±2.34	17.02 ±1.22	41.7 ±2.32
		30	Untreated		24.99 ± 3.87	35.63±1.97	74.08 ±2.93
			CNP _{N4}	10	8.77±1.42	18.68 ±1.51	46.95 ±2.65
		40	Untreated		27.47 ± 2.97	38.44±3.47	76.88 ±3.01
			CNP _{N4}	15	9.98±2.8	20.7±1.59	51.73 ±0.21
SFO	Open	20	Untreated		23.23 ± .23	37.06±2.43	51.25 ±3.21
			CNP _{N4}	15	8.18 ± 0.31	18.18 ±0.56	42.37 ±0.98
		30	Untreated		24.98 ± 3.99	37.11±3.19	62.94 ±1.97

Oil Type	Open/ Closed storage	Temp- erature (°C)	CNP	CNP Conc. (ppm)	Peroxide Value (meq. of O ₂ /kg)	p-Anisidine (units)	TOTOX Value (units)
		40	CNP _{N4}	15	8.44 ± 0.43	20.87 ±1.92	58.57 ±3.14
			Untreated		29.47 ± 1.9	37.58±2.13	66.37 ±4.44
			CNP _{N4}	15	8.91 ± 0.09	22.95 ±0.52	62.49 ±1.66
	Closed	20	Untreated		21.37 ± 2.52	36.59±2.33	47.37 ±3.53
			CNP _{N4}	10	7.99 ± 0.87	15.54 ±0.91	40.93 ±0.61
		30	Untreated		24.31 ± 3.5	36.91±1.73	54.33 ± 3.02
			CNP _{N4}	15	8.01 ± 0.56	17.2±1.59	45.68±2.91
		40	Untreated		29.91 ± 3.42	36.22±2.18	62.91 ± 4.21
			CNP _{N4}	15	8.33 ± 0.52	19.22±1.16	51.75±1.85

Note: All measurements were conducted in triplicates. Data shown as mean ± SD.

Table 3.4B: Storage conditions showing highest control on oxidative rancidity

Oil Type	Open/ Closed storage	Temp (°C)	CNP	CNP Conc. (ppm)	Iodine Value (g)	Kries Test	Refractive Index	Acid Value (mg of KOH/gm)
RBO	Open	20	Untreated		49.75 ± 0.77	0.237±.003	1.34 ± 0.05	25.34 ± 2.27
			CNP _{N4}	15	64.07 ±0.38	0.151 ± 0.002	1.33 ± 0.07	25.09 ±1.23
		30	Untreated		41.48 ± 0.97	0.234 ± 0.006	1.43 ± 0.02	25.64 ± 2.29
			CNP _{N4}	15	57.85 ±0.93	0.157 ± 0.004	1.39 ± 0.04	25.96 ±0.77
		40	Untreated		47.006 ± 0.92	0.247 ± 0.009	1.47 ± 0.02	25.67 ±1.22
			CNP _{N4}	15	54.33 ±1.01	0.165 ± 0.009	1.39 ± 0.06	25.24 ±2.667
	Closed	20	Untreated		45.22 ± 0.87	0.237 ± 0.005	1.37 ± 0.03	24.99 ± 2.23
			CNP _{N4}	15	69.51 ±0.20	0.14 ± 0.003	1.30 ± 0.02	25.64 ±1.36
		30	Untreated		41.07 ± 0.29	0.245 ± 0.004	1.35 ± 0.03	25.31 ± 3.27
			CNP _{N4}	10	66.26 ±0.67	0.145 ± 0.005	1.30 ± 0.06	25.66 ±1.33
		40	Untreated		40.16 ± 0.19	0.25 ± 0.006	1.39 ± 0.02	25.77 ±2.34
			CNP _{N4}	15	60.01 ±0.84	0.149 ± 0.007	1.34 ± 0.07	26.20 ±1.34
SFO	Open	20	Untreated		85.24 ± 0.887	0.195 ± 0.002	1.42 ± 0.09	26.01 ± 3.71
			CNP _{N4}	15	92.94 ±0.59	0.151 ± 0.004	1.38 ± 0.05	26.52 ±3.62

Oil Type	Open/ Closed storage	Temp (°C)	CNP	CNP Conc. (ppm)	Iodine Value (g)	Kries Test	Refractive Index	Acid Value (mg of KOH/gm)
		30	Untreated		85.5 ± 0.82	0.196 ± 0.006	1.46 ± 0.09	25.91 ± 0.98
			CNP _{N4}	15	87.99 ± 0.74	0.162 ± 0.005	1.4 ± 0.06	25.37 ± 0.667
		40	Untreated		71.033 ± 0.22	0.187 ± 0.009	1.44 ± 0.01	25.11 ± 6.1
			CNP _{N4}	15	85.08 ± 0.96	0.177 ± 0.001	1.4 ± 0.02	25.16 ± 4.01
	Closed	20	Untreated		85.24 ± 0.604	0.18 ± 0.005	1.41 ± 0.07	24.27 ± 2.86
			CNP _{N4}	10	100.08 ± 0.61	0.141 ± 0.003	1.37 ± 0.04	25.81 ± 3.33
		30	Untreated		84.41 ± 0.74	0.18 ± 0.008	1.44 ± 0.08	26.51 ± 3.66
			CNP _{N4}	15	96.88 ± 0.72	0.141 ± 0.007	1.38 ± 0.01	26.73 ± 2.617
		40	Untreated		70.49 ± 0.68	0.196 ± 0.002	1.47 ± 0.04	25.31 ± 1.96
			CNP _{N4}	15	90.34 ± 0.53	0.161 ± 0.006	1.39 ± 0.07	25.15 ± 3.3

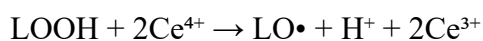
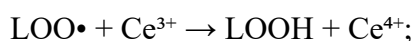
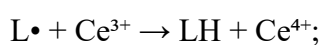
Note: All measurements were conducted in triplicates. Data shown as mean ± SD.

Accumulating evidence links prolonged exposure to oxidized lipids with the pathogenesis of several diseases, including gastric and hepatic carcinogenesis, atherosclerosis, and myocardial infarction. Therefore, maintaining low PVs is critical for ensuring both the oxidative stability and the safety of edible oils intended for human consumption.

After 9 weeks of storage, the peroxide value (PV) of untreated rice bran oil (RBO) increased markedly from an initial 0.55 ± 0.016 meq O₂/kg to 23.11 ± 0.12 , 26.05 ± 2.82 , and 28.84 ± 1.18 meq O₂/kg at 20 °C, 30 °C, and 40 °C, respectively and exceed the widely accepted oxidative stability limit of 10–12 meq O₂/kg, confirming rapid peroxidative degradation under elevated temperature conditions. These findings align with prior studies indicating that thermal stress accelerates lipid oxidation by enhancing the generation of reactive oxygen species (ROS), which initiate peroxidation chain reactions (Zhang et al., 2024). In contrast, RBO samples treated with cerium oxide nanoparticles (CNP_{N4}, 15 ppm) showed a significant attenuation in PV accumulation. Under open storage, PVs were reduced to 8.52 ± 1.23 , 8.91 ± 0.98 , and 10.63 ± 0.37 meq O₂/kg at 20 °C, 30 °C, and 40 °C, respectively, while closed storage conditions further lowered these values to 8.01 ± 2.34 , 8.77 ± 1.42 , and 9.98 ± 2.80 meq O₂/kg.

This represents a relative PV suppression of 63–72% compared to untreated controls, with all treated values falling within acceptable safety thresholds.

A comparable pattern was observed in sunflower oil (SFO), where untreated samples demonstrated PVs ranging from 25 to 30 meq O₂/kg, while CNPN₄-treated samples exhibited values between 8.18 ± 0.31 and 8.91 ± 0.09 meq O₂/kg under open conditions, and 7.99 ± 0.87 to 8.33 ± 0.52 meq O₂/kg under closed conditions. The antioxidative efficacy of CNPN₄ is attributed to its enhanced redox cycling capability, facilitated by a high Ce³⁺/Ce⁴⁺ ratio and abundant oxygen vacancies (V_O^{••}), which contribute to radical scavenging activity. Mechanistically, CNPN₄ participates in a redox-mediated neutralization of lipid radicals (L•) and lipid peroxy radicals (LOO•) through the reactions:



This cycle efficiently disrupts the propagation phase of lipid peroxidation, thereby maintaining the oxidative stability of oils under both ambient and elevated storage conditions.

Complementary assessment using iodine value (IV), a direct indicator of unsaturation and the presence of carbon–carbon double bonds, further confirmed these results. Fresh RBO and SFO had IVs of 107.22 ± 0.36 and 136.93 ± 0.69 g I₂/100 g, respectively. Over the 9-week period, untreated samples showed significant declines in IV—to 40–60 g I₂/100 g for RBO and 70–85 g I₂/100 g for SFO—suggesting substantial oxidation and loss of unsaturation. In contrast, CNPN₄-treated samples maintained higher IVs, with a modest decline of only 20–30%, in comparison to the 50–65% decrease observed in untreated controls. The inverse relationship between PV and IV strengthens the evidence that CNPN₄ inhibits oxidative deterioration not only by reducing hydroperoxide accumulation but also by preserving the structural integrity of unsaturated fatty acids. Collectively, these findings demonstrate that CNPN₄ exerts a pronounced protective effect against lipid oxidation, maintaining both chemical stability and nutritional quality of edible oils across varied storage conditions.

Peroxides, formed during the initial stages of oxidation (measured by the peroxide value), break down into secondary oxidation products such as aldehydes, ketones, and other carbonyl compounds. The p-anisidine value (p-AV) is a measure of secondary oxidation products of lipid oxidation like α , β -unsaturated aldehydes (Koch, E., et al. 2022). Initially p-AV is recorded around 4.53 ± 1.4 and 1.98 ± 0.26 unit in fresh RBO & SFO respectively. After 9 weeks, p-AV of the same samples were found to be 37.5 ± 1.23 and 37 ± 0.22 units. This increase in the p-AV indicates significant chemical changes in the oil, primarily due to the degradation of peroxide

residues into aldehydes, ketones, and other carbonyl compounds. However, rate of change in p-AV gets reduced significantly for treated samples depending on concentration of the nanoparticle (shown in Table 3.4A), hence the result indicates that the synthesized nanoparticles have the capability to inhibit the oxidative changes due to their scavenging property. CNP_{N4}-treated RBO stored under closed conditions at 20°C, 30°C, and 40°C had p-AVs of $\sim 16.86 \pm 1.86$, 19.03 ± 0.59 , and 21.86 ± 1.08 units and 17.26 ± 1.40 , 19.63 ± 1.69 , 22.04 ± 3.37 units for RBOs kept in open atmosphere, compared to untreated samples exceeding 37 units. Similarly, treated SFO demonstrated reduced p-AV values 17.37 ± 0.33 , 20.01 ± 1.16 , 23.11 ± 1.19 units and 17.55 ± 0.64 , 20.89 ± 0.30 , 24.42 ± 0.65 units for CNP_{N4} (15 ppm) treated SFO, kept at three respective temperatures under closed and open atmosphere, emphasizing the nanoparticles' efficiency in inhibiting secondary oxidation.

TOTOX values, which provide a comprehensive assessment of lipid oxidation, were also notably lower in treated samples. Presently, we have noticed TOTOX value $\sim 63 - 72$ and $51 - 63$ for RBO and SFO, stored in closed environment, while these respective TOTOX values have been found to be $\sim 65 - 74$ and $45 - 47$ (units) for storage oils in open environment. Importantly, TOTOX values (shown in Table 3.4A) are found to be decreasing with increase of nanoparticle concentrations, while lowest TOTOX value has been noticed from CNP_{N4} (15 ppm).

In this context CNP_{N4} exhibited the most significant reductions, with TOTOX values reduced by 25–35% for RBO and 7–16% for SFO, highlighting its superior antioxidative potential. The relationship between TOTOX and storage conditions further underscores the role of nanoparticles in mitigating oxidation. Oils stored in closed environments consistently showed lower TOTOX values compared to their counterparts stored in open conditions, reinforcing the importance of storage atmosphere in oxidative stability.

Refractive index (RI) is an important parameter for assessing the quality of edible oil as it provides insights into the structural and compositional changes occurring during oxidation. RI changes with the breakdown of triglycerides into free fatty acids, aldehydes, and other oxidative byproducts, which directly related to progression of rancidity. Also, secondary oxidation products (mainly 2-alkenals and 2,4-dienals formed due to breakdown of peroxide residues) can polymerize, leading to the formation of high molecular weight compounds. These changes negatively affect the physical properties of the oil, such as increased viscosity and darker color. This study showed that RI remained relatively stable across storage conditions but was slightly lower in oils stored in closed environments, indicating control in autoxidation (Table 3.3B). The consistent RI measurements also suggest that nanoparticle treatment has a

stabilizing effect on oil quality, limiting the structural changes associated with oxidation and formation of peroxide residues. These observations are also substantiated by the control in increase of PV, p-AV and IV. RI varies in between 1.33 ± 0.07 at the start and 1.39 ± 0.06 at the end of 9 weeks period. However interestingly it is noteworthy that RI is less for both oils, stored in closed environment, indicating less autoxidation under closed condition i.e. autoxidation can be limited significantly by closed storage system.

Acid value (AV), which reflects free fatty acid formation by triacylglycerol hydrolysis, showed nominal changes, and remained within 25–27 mg KOH/g oil. The lower AV values observed in nanoparticle-treated samples suggest reduced hydrolytic splitting of triglycerides and enhanced overall stability.

The role of RI and AV in assessing oil quality highlights the multifaceted impact of nanoparticle treatment. While RI provides insights into molecular interactions and stability, AV reflects the extent of hydrolytic degradation. These parameters collectively highlight the advantages of nanoparticle treatment in maintaining oil quality across different storage conditions.

Higher temperatures accelerate lipid oxidation, as reflected in the increased Kries test values over time. Increasing concentrations of cerium oxide nanoparticles generally reduce Kries test values, indicating enhanced antioxidative action. This effect is more pronounced at higher nanoparticle concentrations (e.g., 15 ppm). At lower temperatures, nanoparticle treatment is particularly effective in slowing rancidity progression. At higher temperatures, the antioxidative effect of nanoparticles diminishes over time but still provides a significant reduction in oxidation compared to untreated samples.

1.4 Conclusion

This study presents a comprehensive approach to designing and engineering nanoceria (CeO_2) with tailored redox and defect properties for antioxidant applications in edible oil preservation. A novel synthesis strategy was developed using controlled precipitation techniques with dual-dispersant systems, yielding uniformly dispersed nanoceria with crystallite sizes in the range of $\sim 22\text{--}23$ nm. Structural and chemical tailoring via annealing conditions—particularly nitrogen atmosphere and extended duration—was shown to significantly increase oxygen vacancy concentrations and $\text{Ce}^{3+}/\text{Ce}^{4+}$ ratios, thereby enhancing redox activity. This fine control over defect chemistry was validated through integrated XRD-Rietveld refinement, FTIR, XPS, UV-Vis spectroscopy, and DFT+U calculations, establishing clear structure–function relationships.

Functionally, the engineered nanoceria exhibited potent antioxidant capacity, as confirmed by DPPH, ABTS, and H₂O₂ scavenging assays, with the N₂-annealed variant (CNP_{N4}) achieving >70% inhibition at a low concentration of 15 ppm. When incorporated into rice bran oil (RBO) and sunflower oil (SFO), these nanoparticles effectively mitigated oxidative degradation over a 9-week storage period across multiple temperatures (20 °C, 30 °C, and 40 °C) and storage atmospheres (open vs. closed). Key indicators of lipid oxidation—including peroxide value (PV), p-anisidine value (p-AV), TOTOX index, and Kries test—were significantly suppressed in CNP_{N4}-treated oils, maintaining values well within acceptable quality standards. Simultaneously, the iodine value (IV) was better preserved, reflecting protection of unsaturated fatty acids essential for the oils' nutritional quality.

Importantly, the effective 15 ppm dosage remains well below the cytotoxic threshold (IC₅₀ ~ 88 ppm), as established through MTT assays in HEK-293 cells, ensuring safety for food-grade applications. The integration of physicochemical evaluations, spectroscopic signatures, and redox mechanisms supports a unified model wherein ceria nanoparticles act as radical interceptors through redox cycling: Ce³⁺ quenches lipid radicals (L•, LOO•), and Ce⁴⁺ is reduced back via subsequent reactions, breaking the lipid peroxidation chain.

Overall, this work advances the rational design of nanoceria as a multifunctional antioxidant system, bridging the gap between fundamental defect chemistry and real-world application in food preservation. The low-dose efficacy, safety margin, and clear mechanistic basis demonstrated here establish nanoceria—particularly those engineered under reducing atmospheres—as promising, scalable additives for enhancing the oxidative stability and shelf life of edible oils. This framework also opens avenues for applying nanoceria in broader antioxidant contexts within the food and nutraceutical industries.

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CHAPTER 4: Nanoceria-Enhanced Stabilization of Edible Oils: Strategies for Shelf-Life Extension

4.1 Introduction

Edible oils are fundamental components of the human diet and play a vital role in culinary applications and processed food systems. However, the oxidative degradation of these oils during storage and thermal processing presents a major challenge to food quality, safety, and economic viability. Lipid oxidation not only deteriorates the sensory attributes of oils—such as flavor, aroma, and color—but also leads to the formation of harmful compounds, including aldehydes and peroxides, which compromise consumer health and limit shelf life.

The susceptibility of edible oils to oxidation varies considerably depending on their fatty acid composition. Oils such as rice bran, sunflower, and soybean are widely used in households and industry but contain significant levels of polyunsaturated fatty acids (PUFAs), making them particularly vulnerable to oxidative breakdown. High temperatures, prolonged frying, light exposure, and oxygen availability further accelerate these degradation processes. Key indicators used to monitor oil quality include peroxide value (PV), p-anisidine value (p-AV), TOTOX value, residual antioxidant activity (RAA), iodine value (IV), and refractive index (RI), among others.

To counteract oxidation, antioxidants are routinely added to oils. Synthetic antioxidants such as BHA, BHT, and TBHQ have been widely employed due to their efficacy, but growing safety concerns and regulatory restrictions have reduced their appeal. On the other hand, natural antioxidants like tocopherols and polyphenolic compounds offer a safer alternative but suffer from low thermal stability, often degrading during cooking or extended storage. This creates a pressing need for more stable, food-compatible antioxidants that can maintain oil quality under real-use conditions.

Recent advances in food nanotechnology have introduced nanoparticles such as cerium oxide (CeO_2 , or nanoceria) as promising antioxidant agents. Unlike conventional antioxidants, nanoceria exhibits a regenerative redox mechanism that enables sustained scavenging of reactive oxygen species even under prolonged oxidative stress. Its catalytic properties, thermal stability, and long-lasting activity make it a candidate for enhancing oil shelf life. While much of the existing literature has focused on the structural and mechanistic properties of nanoceria,

its functional role in preserving oil quality—particularly under practical conditions such as high heat and air exposure—has not been sufficiently studied.

This chapter takes a factor-based, application-driven approach to investigate how nanoceria affects the stability and quality of edible oils. Rather than delving into structural chemistry, the focus here is on understanding how various parameters—such as nanoparticle concentration, oil type, temperature, oxygen exposure, and storage duration—influence oil degradation patterns. By analyzing changes in key stability indicators like PV, p-AV, TOTOX, RAA, and IV, the chapter aims to identify optimal conditions for antioxidant performance.

Despite promising preliminary results, gaps remain in the application of nanoceria in oil stabilization. Limited data exist on how it behaves across different oils or processing conditions. Moreover, the potential of residual antioxidant activity (RAA) as a shelf life predictor remains underexplored. There is also a lack of comprehensive statistical modeling to determine which factors most significantly influence oil stability in the presence of nanoceria. Accordingly, the objectives of this chapter are to evaluate the effect of nanoceria on oil stability under various processing and storage conditions; identify critical factors influencing oxidative quality parameters; explore the potential of using RAA and other indices as predictors for oil shelf life; utilize statistical and data-driven tools (e.g., regression analysis, design of experiments) to develop optimized antioxidant strategies.

This work contributes to the development of more reliable, efficient, and safe approaches to oil preservation, particularly in thermal processing and food storage. The findings may inform industrial applications, from frying oil stabilization to formulation of long-shelf-life packaged foods, and support efforts to reduce oxidative spoilage and improve sustainability in edible oil systems.

4.2 Material & Methods

4.2.1 Raw Material & Reagents

All the analytical reagents were procured from Merck, India and used without any purification. The packaged refined rice bran oil (RBO) and sunflower oil (SFO) were obtained from a local market of South Kolkata.

4.2.2 Synthesis of CeO₂ nanoparticles

CeO₂ nanoparticles had been prepared by a precipitation method as described by Zhang *et al.* with slight modifications (Zhang, Q., et al. 2009). The detailed method is discussed in Chapter 2 Section 2.2.2

4.2.3 Preservation of Edible Oil and rancidity tests

The oil samples were categorised in four different batches. In the first, no nanoparticles were added, while in others three different nanoparticles of 5, 10 and 15 ppm concentrations were added. In an effort to estimate antioxidant efficacy, nanoparticles had been subjected to heat treatment and agitation and aeration during or after processing the oils. Depending on reaction sensitivity of oils at different temperatures, storage temperatures were selected at 20, 30 and 40°C for a period of 4 months. The parameters that were measured are Peroxide value (PV), p - Anisidine value (p-AV), Total oxidation (TOTOX) value, Iodine value (IV), Kries Test (KT), Acid value (AV), Refractive index (RI) and % Residual Antioxidant Activity in terms of % DPPH radical scavenging activity. The methods have already been discussed in details in Chapter 3 Section 3.2.7. All tests were performed according to AOAC protocol (2024) in triplicate basis.

4.2.4 Statistical Analysis and Kinetic Modeling

Descriptive statistics, including mean, median, standard deviation (SD), coefficient of variation (COV), minimum, and maximum values, were computed to summarize the distribution and variability of oxidative stability markers across experimental conditions. One-way and factorial analysis of variance (ANOVA) were employed to assess the significance of key factors—including storage period, temperature, oil type, nanoparticle type, nanoparticle concentration, and storage condition—on the progression of oxidation markers. Post-hoc comparisons were conducted where appropriate to identify significant differences between treatment groups.

Correlation analyses (Pearson's *r*) were performed to examine relationships among oxidative stability markers and between residual antioxidant activity (RAA) and oxidative outcomes. Regression analysis was applied to model the kinetics of peroxide value (PV) using both simple Arrhenius-based models and a reparameterized multi-parameter kinetic model incorporating time, temperature, nanoparticle type, oil type, and storage condition.

The standard Arrhenius equation was used to estimate activation energy (*E_a*) and temperature dependence of oxidation rates. A mixed-effects generalized linear model (GLM) framework was adopted for the multi-parameter kinetic modeling, enabling simultaneous evaluation of multiple covariates influencing oxidative stability. Model fits were evaluated using coefficient

of determination (R^2), and experimental vs. theoretical plots were generated to validate model performance.

All statistical analyses and modeling were conducted using standard computational tools (e.g., Microsoft Excel, R, Spyder, Origin and SPSS), with significance thresholds set at $p < 0.05$ unless otherwise specified.

4.2.5 Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was employed to reduce the dimensionality of the multivariate oil quality dataset and to uncover latent structures among key physicochemical parameters. The dataset included standard quality indices such as Peroxide Value (PV), p-Anisidine Value (p-AV), Total Oxidation Value (TOTOX), Iodine Value (IV), Refractive Index (RI), Kries Test Value, and Acid Value (AV), collected from oil samples subjected to various treatments including nanoparticle-based antioxidants.

Prior to PCA, the data were standardized using z-score normalization to ensure uniform scaling across all variables. PCA was performed using the scikit-learn library in Python. Eigenvalues, explained variance ratios, and component loadings were extracted to identify the most significant principal components. Graphical tools such as scree plots, heatmaps of loadings, and biplots of PC scores were generated using matplotlib and seaborn to visualize patterns and groupings in the data.

The resulting principal components were interpreted based on the loading matrix, allowing for dimensionality reduction while preserving the majority of information. These PCs were subsequently used to classify oil stability profiles and to investigate the multivariate impact of nanoparticle treatments on shelf life and degradation dynamics.

4.3 Result & Discussion

4.3.1 Shelf-life study of edible oils

This report presents an in-depth technical analysis on the enhancement of oxidative stability in edible oils through the use of engineered cerium oxide (CeO_2) nanoparticles. Nanoparticles were synthesized under controlled O_2 and N_2 atmospheres for 2 and 4 hours. Concentrations tested were 5, 10, and 15 ppm. Oils were stored at 20°C , 30°C , and 40°C under open and closed conditions. The study spans storage condition variations, ceria type and concentration, temperature effects, and extensive oxidation metrics including PV, AV, p-AnV, TOTOX, IV, Kries test, RI and residual antioxidant activity values. Each experimental combination was

tested in triplicate across weeks of storage, generating a high-resolution dataset of lipid oxidation behavior. The detailed experimental data is provided in Appendix A (Table 4.1A). The oxidative stability enhancement observed across different storage setups is closely linked to the intrinsic physicochemical characteristics of the cerium oxide (CeO₂) nanoparticles. Crystallographic analysis via XRD confirmed the formation of a pure cubic fluorite CeO₂ phase across all samples. Crucially, nitrogen-annealed samples (CNP_{N2}, CNP_{N4}) exhibited reduced crystallite sizes and elevated microstrain levels, which strongly suggest increased oxygen vacancy concentrations—a known factor that enhances free radical scavenging due to redox cycling between Ce³⁺ and Ce⁴⁺ states.

XPS and FTIR analyses further revealed that nitrogen atmosphere annealing (especially for CNP_{N4}) promotes a higher Ce³⁺/Ce⁴⁺ ratio and greater surface oxygen vacancy density. This was supported by UV-Vis spectroscopy, which showed a red shift in band gap (from ~2.86 eV in oxygen-annealed to ~2.25 eV in CNP_{N4}), indicating localized defect states conducive to radical scavenging.

4.3.2 Trends in quality stability in different types of oils

Table 4.1 shows descriptive statistics and coefficient of variation (CoV) for primary (PV), secondary (p-AV), and combined (TOTOX) lipid oxidation indices, iodine value (IV), and residual antioxidant activity (RAA) in rice bran (RB), sunflower (SF), and soybean (SB) oils treated with 15 ppm N₂-annealed nanoceria. Data reflect values across total shelf-life period. Results highlight oil-specific oxidative trends and confirm the broad efficacy of nanoceria in preserving antioxidant activity and stabilizing diverse oil matrices. Covariance and descriptive analysis of key oxidation metrics revealed a strong interplay between lipid peroxidation dynamics and the regenerative antioxidant behavior of N₂-annealed nanoceria. In all oil matrices tested, positive covariance between peroxide value (PV) and p-anisidine value (p-AV) reflected the expected progression from primary to secondary oxidation products (Shahidi & Zhong, 2005). Negative covariance between these oxidation markers and residual antioxidant activity (RAA) further confirmed that nanoceria acts catalytically to scavenge radicals, with antioxidant activity diminishing in proportion to oxidative stress (Celardo et al., 2011).

Table 4.1: Descriptive statistics and coefficient of variation (CoV) for Oxidative Stability Markers

		PV	p-AV	TOTOX	IV	RAA
RB	Mean	3.0067	9.9994	16.0128	95.6528	90.029

	Std Dev	3.3107	7.2541	13.7313	12.3328	6.2645
	Median	0.9932	7.4144	9.4007	100.283	88.92
	Co-Var	1.1012	0.7255	0.8576	0.129	0.0696
	Min	0.5338	4.1797	5.2473	65.2234	80.13
	Max	9.9543	28.0264	47.9352	107.41	100
SF	Mean	3.51703	7.77931	14.8134	126.739	89.695
	Std Dev	3.3814	7.2541	13.8868	12.5265	6.83044
	Median	1.47015	5.1944	8.1347	131.113	89.19
	Co-Var	0.96144	0.93249	0.93745	0.09884	0.07615
	Min	1.0108	1.9597	3.9813	95.5534	77.77
	Max	10.7647	25.8064	47.3358	138.74	100
SB	Mean	5.31896	12.3893	6.48025	132.653	89.822
	Std Dev	4.9042	7.2541	5.59473	12.3328	6.4665
	Median	2.561	9.8044	4.0807	137.283	89.21
	Co-Var	0.92202	0.58551	0.86335	0.09297	0.07199
	Min	1.5616	6.5697	2.1899	102.223	79.16
	Max	16.3861	30.4164	20.5313	144.41	100

Despite oil-specific baseline differences, nanoceria consistently mitigated oxidation. Rice bran oil (RB), inherently rich in γ -oryzanol and tocopherols (Xu & Godber, 2001), exhibited the lowest mean PV (3.0) and TOTOX (16.0), as well as the most stable antioxidant profile (RAA CoV = 0.0696), suggesting strong synergy between nanoceria and native antioxidants. In contrast, soybean oil (SB), with higher unsaturation, showed greater oxidative variability (PV max 16.4; p-AV max 30.4) despite comparable RAA (~90%), highlighting nanoceria's capacity to buffer even challenging matrices. Sunflower oil (SF) exhibited intermediate trends but benefited markedly in terms of p-AV control (median 5.19), again projecting nanoceria's protective efficacy.

Importantly, high RAA retention across oils (RB: 90.0%; SF: 89.7%; SB: 89.8%) demonstrates that nanoceria does not deplete in a stoichiometric manner but instead maintains catalytic redox cycling. This regenerative behavior, combined with its defect-engineered surface chemistry (Paick et al., 2023; Tu et al., 2024), positions N₂-annealed CeO₂ as a robust, broadly applicable antioxidant platform for edible oil stabilization. Our findings echo recent advances in nanostructured antioxidant systems, which increasingly leverage catalytic rather than consumable antioxidant strategies to enhance lipid shelf life (Zhang et al., 2023).

4.3.3 Effect of Nano-Ceria on Oxidative Stability of Oils Over Time

The impact of nano-ceria concentration on oxidative stability was systematically evaluated across three oil types. The threshold crossing periods—expressed as the number of storage weeks required to reach critical oxidative stability limits—for peroxide value (PV = 10 meq/kg), p-anisidine value (p-AnV = 20 units), and TOTOX (40 units) across different oils, storage conditions, and nano-ceria treatments. These thresholds are based on internationally recognized standards for edible oil quality, including the Codex Alimentarius guidelines and FSSAI (Food Safety and Standards Authority of India) specifications [Codex Alimentarius, 2019; FSSAI, 2021].

In untreated oils (NIL), PV, p-AnV, and TOTOX values exceeded critical thresholds within 7–8 weeks for RB (Figure 4.1) and even earlier for SF and SB oils. In contrast, nano-ceria supplementation at 5–15 ppm significantly delayed oxidative progression in all oils. Notably, 15 ppm nano-ceria extended PV and TOTOX thresholds to Week 9 in RB oil and improved RAA retention markedly. SF oil exhibited intermediate stabilization, while SB oil—due to its higher polyunsaturation—remained more challenging to stabilize, though nano-ceria still conferred meaningful protection. These trends demonstrate the broad-spectrum efficacy of engineered nano-ceria in modulating lipid oxidation dynamics in diverse edible oils.

The temporal analysis of oxidation markers clearly demonstrates that N₂-annealed nano-ceria significantly enhances the oxidative stability of edible oils, with a pronounced concentration-dependent effect. Without antioxidant intervention, rice bran oil (NIL control) exhibited rapid oxidative deterioration: peroxide value (PV) crossed the critical 10 meq/kg threshold by Week 7, accompanied by parallel increases in secondary oxidation products (p-AnV) and overall oxidation (TOTOX). In contrast, nano-ceria treatments at 5, 10, and 15 ppm uniformly delayed PV and TOTOX threshold crossings to Week 9—effectively extending the functional shelf life of the oil by 2 or more weeks.

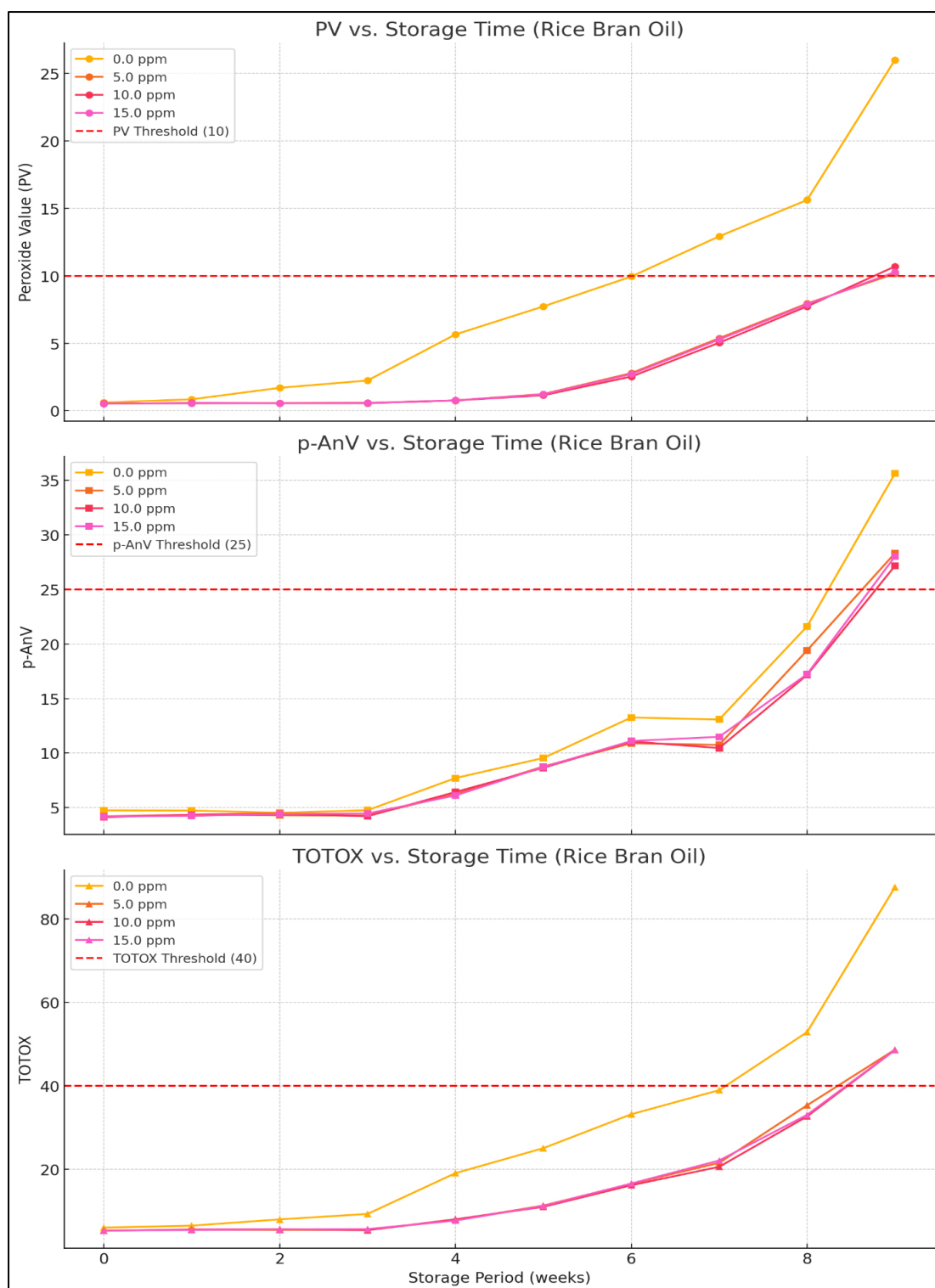


Figure 4.1: Threshold crossing time analysis for Rice Bran Oil

Residual antioxidant activity (RAA), a sensitive indicator of antioxidant system integrity, provided further mechanistic insight. While untreated oils experienced a precipitous decline in RAA (~29% remaining by Week 9), nano-ceria treatments preserved RAA in a dose-responsive manner: ~50% at 5 ppm, ~63% at 10 ppm, and an impressive ~80% at 15 ppm. These findings

align with the catalytic, regenerative antioxidant behavior of defect-rich nano-ceria, where $\text{Ce}^{3+}/\text{Ce}^{4+}$ redox cycling and oxygen vacancies facilitate continuous neutralization of reactive oxygen species without rapid depletion (Celardo et al., 2011; Paick et al., 2023).

Importantly, nano-ceria not only delayed primary oxidation (PV) but also modulated the propagation to secondary oxidation (p-AnV), maintaining a more favorable TOTOX trajectory. This is critical, as secondary products such as aldehydes have greater sensory and toxicological relevance in food systems (Shahidi & Zhong, 2005). The consistent extension of all oxidative thresholds in treated oils underscores the broad-spectrum efficacy of nano-ceria as a nano-antioxidant platform.

Moreover, the strong preservation of RAA suggests that nano-ceria complements endogenous antioxidants rather than replacing them, likely acting in synergy with minor bioactives such as γ -oryzanol in rice bran oil (Xu & Godber, 2001). This is in contrast to conventional antioxidants, which are consumed stoichiometrically and often exhibit diminishing returns at later storage stages.

Collectively, these results position engineered N_2 -annealed nano-ceria as a highly promising antioxidant for lipid-rich food matrices. By combining catalytic radical scavenging with the ability to sustain antioxidant capacity under prolonged oxidative stress, nano-ceria offers a new paradigm for shelf-life extension in edible oils. The dose-dependent trends observed further provide practical guidance for optimizing nano-ceria concentrations in future applications.

4.3.4 Time dependant oxidation trends

To comprehensively assess the antioxidant impact of engineered nano-ceria on lipid oxidation, the progression of key oxidative stability markers—peroxide value (PV), p-anisidine value (p-AnV), TOTOX, Acid Value (AV) and Iodine Value (IV)—was monitored over the storage period. These time-resolved profiles provide a detailed view of how nano-ceria influences both primary and secondary oxidation dynamics under varying storage and treatment conditions. The following results highlight the protective effects of nano-ceria across different oils and clarify the role of nanoparticle synthesis parameters in modulating antioxidant efficacy.

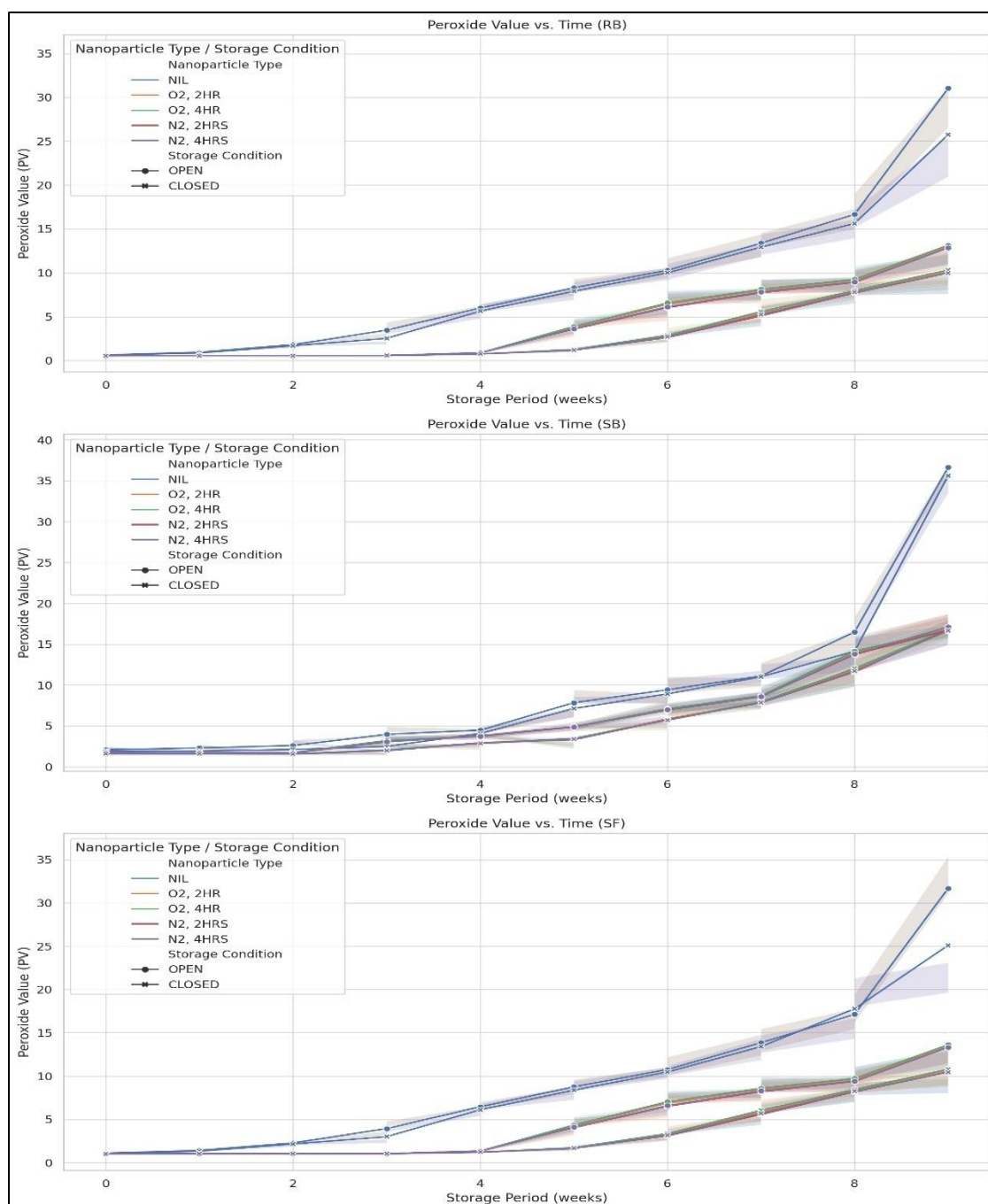


Figure 4.2: Change in peroxide value with time

4.3.4.1. Trends in Primary Oxidation: Peroxide Value (PV)

The PV vs. time profiles (Figure 4.2) illustrate how primary lipid oxidation progresses during storage across different experimental conditions. In all oils tested (rice bran, soybean, sunflower), the control samples showed a sharp increase in PV, particularly under open storage and elevated temperatures. This confirms that unsaturated oils are highly prone to oxygen-driven degradation. In contrast, nano-ceria-treated oils exhibited much slower PV increases.

The protective effect was strongest at higher ceria concentrations (10 ppm, 15 ppm) and when using N₂-synthesized nano-ceria (2H and 4H), supporting its superior antioxidant performance. Among these, N₂-4HR ceria was the most effective, with the lowest PV accumulation over time. N₂-2HR also improved stability, outperforming O₂-synthesized ceria but falling short of N₂-4HR. This suggests that longer N₂ annealing enhances antioxidant properties, likely by increasing oxygen vacancy sites. While O₂-synthesized ceria did offer some protection, it was generally less effective than N₂-based variants, in line with the view that surface oxygen vacancies improve catalytic antioxidant activity. Oils stored in closed containers consistently showed lower PV increases compared to open storage, underscoring the importance of limiting oxygen exposure during storage.

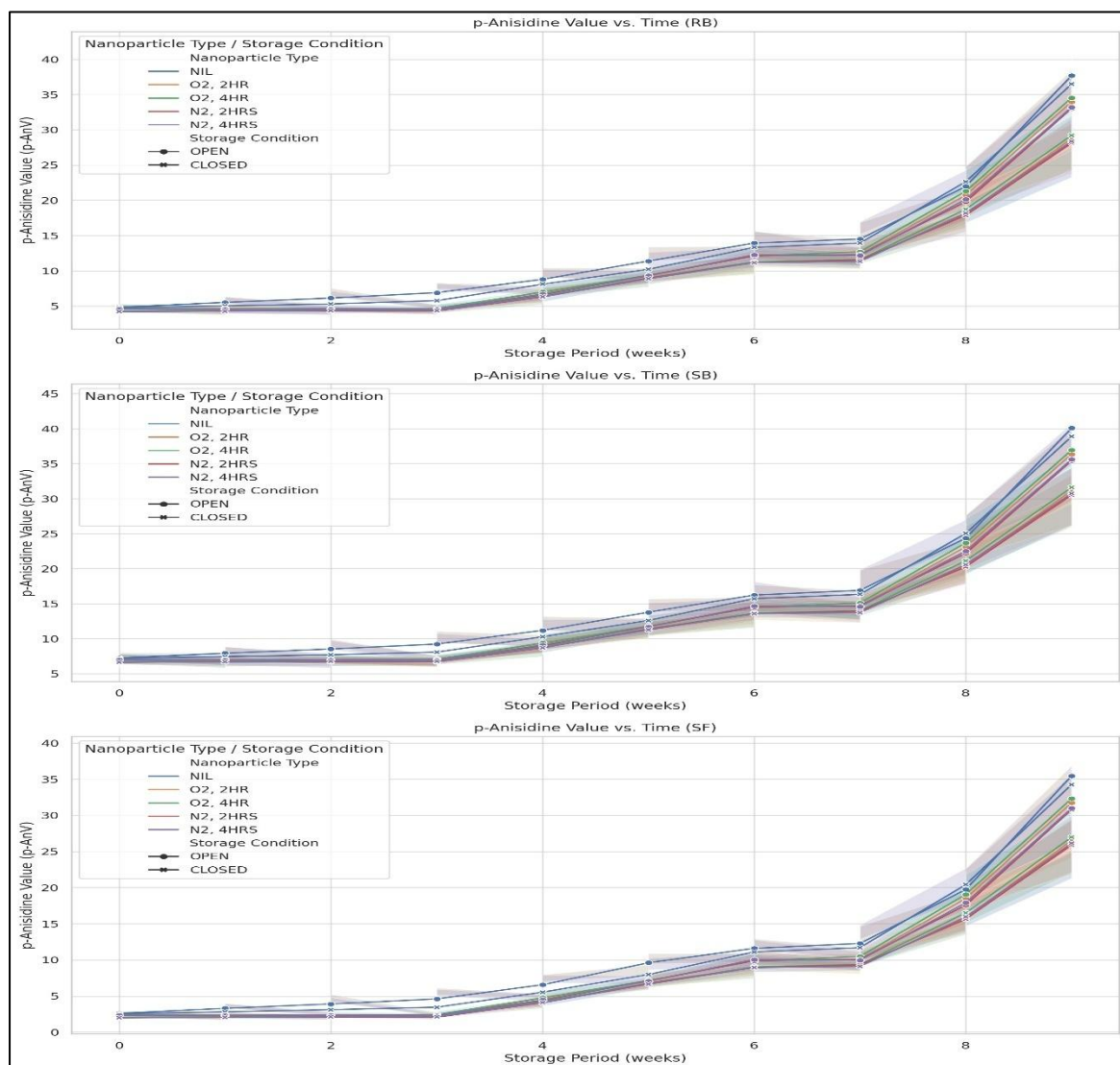


Figure 4.3: Change in para-anisidine value with time

4.3.4. 2. Secondary Oxidation: p-Anisidine Value (p-AnV)

The p-AnV vs. time plots (Figure 4.3) further confirm the antioxidant effect of engineered nano-ceria. In control oils, secondary oxidation advanced rapidly under open storage, as shown by increasing p-AnV values. All nano-ceria treatments slowed this progression, with N₂-4H formulations providing the strongest stabilization across all oil types. The protective effect was especially pronounced in sunflower oil, which is highly polyunsaturated and thus highly sensitive to oxidation. Results clearly indicate that longer N₂ annealing, which increases oxygen vacancies and Ce³⁺ content, enhances antioxidant performance. The trend of improved stability under closed storage was also observed here, further emphasizing the role of oxygen availability in lipid oxidation.

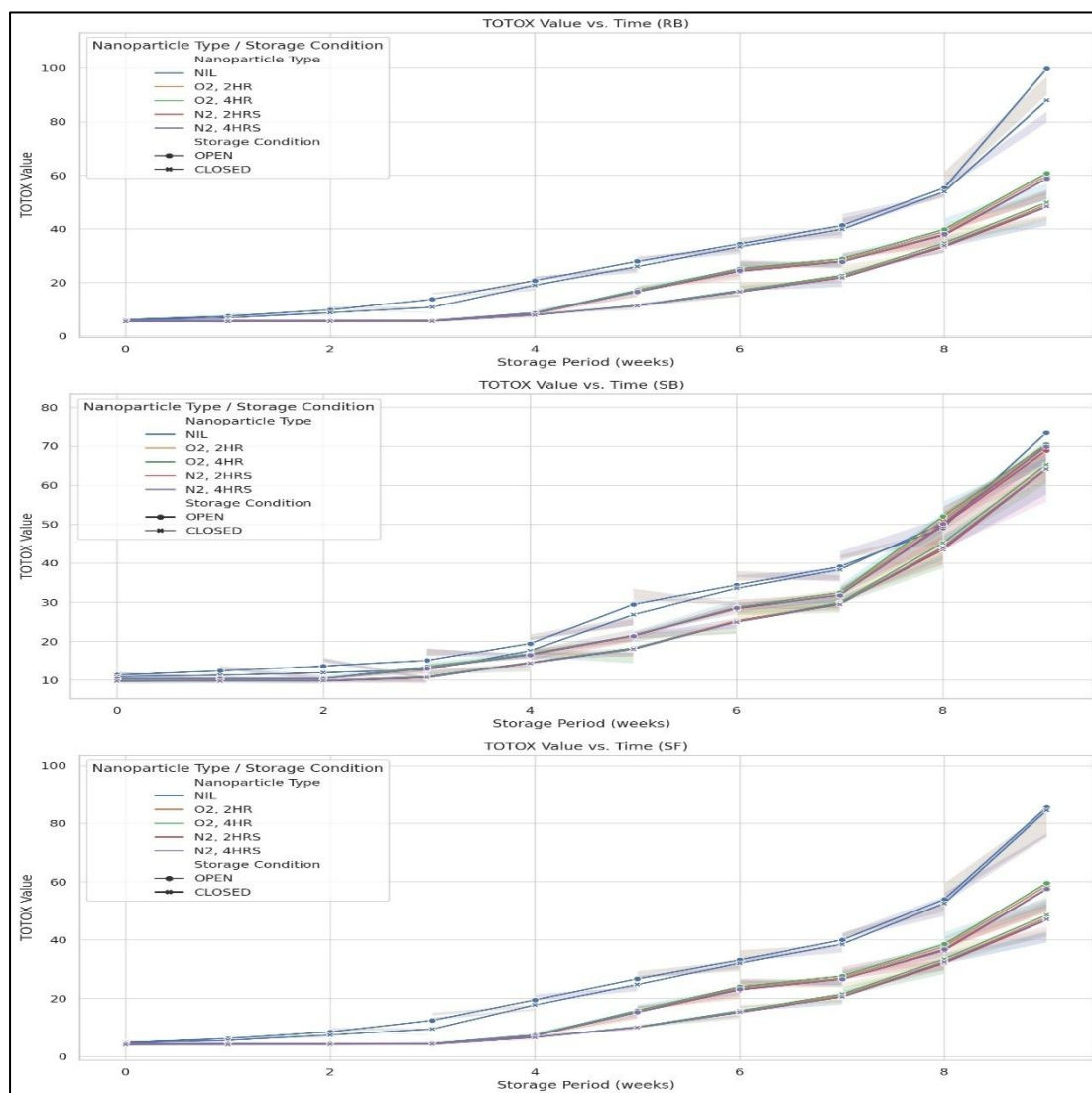


Figure 4.4: Change in TOTOX Value

4.3.4.3 Cumulative Oxidative Stability: TOTOX Value

The TOTOX vs. time plots (Figure 4.4) offer an integrated view of oxidative degradation, as TOTOX combines both primary and secondary oxidation markers ($\text{TOTOX} = 2 \times \text{PV} + \text{p-AnV}$). Control oils showed a rapid rise in TOTOX, particularly under open storage at 40 °C, highlighting severe cumulative oxidation. Nano-ceria treatments substantially reduced TOTOX accumulation, confirming their ability to limit both primary and secondary oxidative processes. N₂-4H ceria at 15 ppm provided the greatest protection across all oils, showing the lowest overall TOTOX values. In comparison, oils treated with O₂-synthesized nano-ceria—especially O₂-4HR—exhibited higher TOTOX accumulation, underscoring their lower redox efficiency relative to N₂-based formulations.

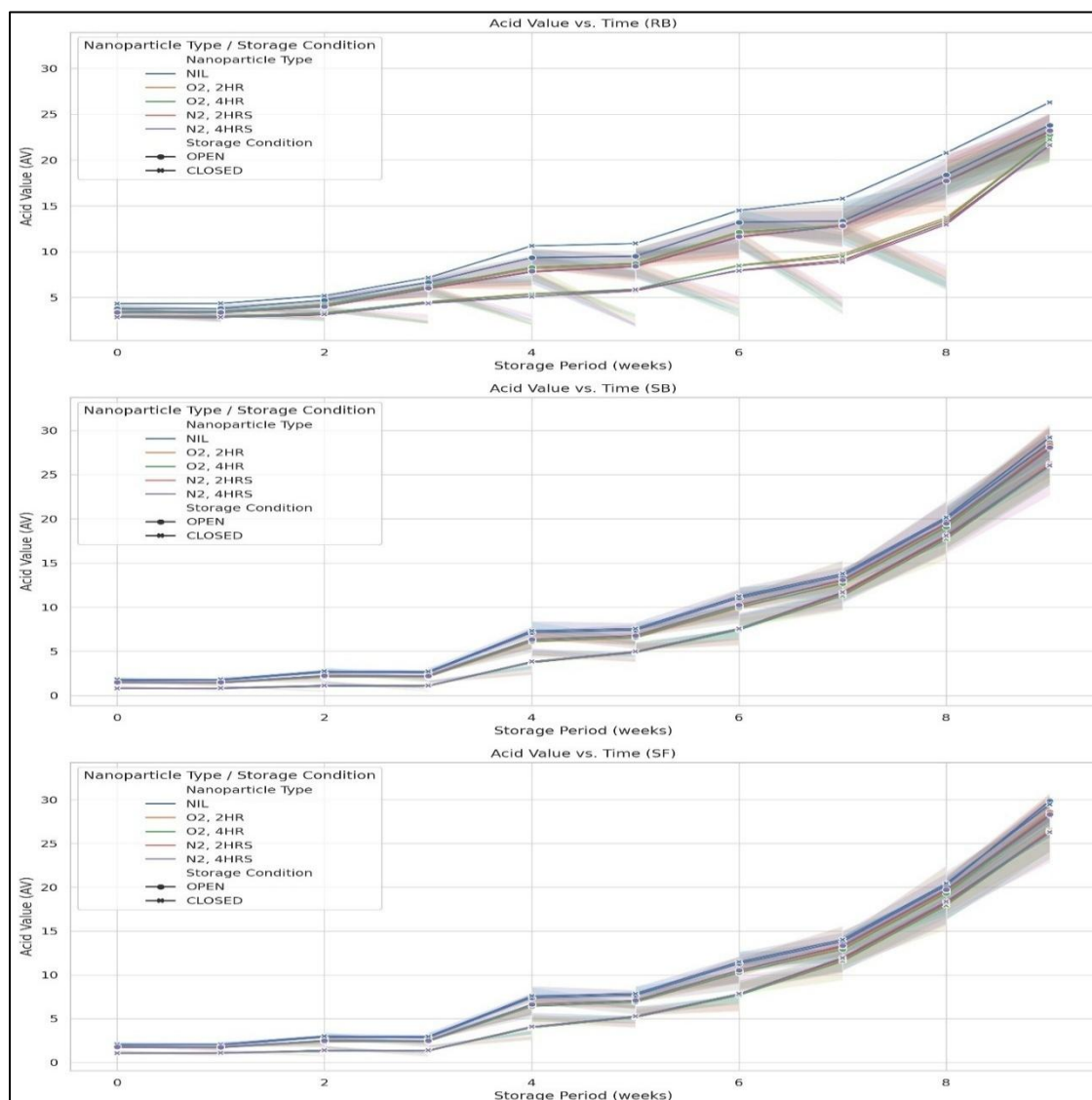


Figure 4.5: Change in Acid Value with Time

4.3.4.4 Free Fatty Acid Accumulation: Acid Value (AV)

The AV vs. time profiles (Figure 4.5) track the progression of lipolytic degradation during storage. In control oils, AV increased steadily, reflecting hydrolysis and the formation of free fatty acids through both primary lipolysis and secondary oxidative breakdown. In contrast, nano-ceria treatments slowed this increase, suggesting that reducing oxidative stress also helps preserve ester integrity. Among treatments, N₂-synthesized ceria provided the strongest stabilization of AV. This indicates that effective control of oxidation indirectly supports the maintenance of oil quality by limiting pathways that lead to acid formation.

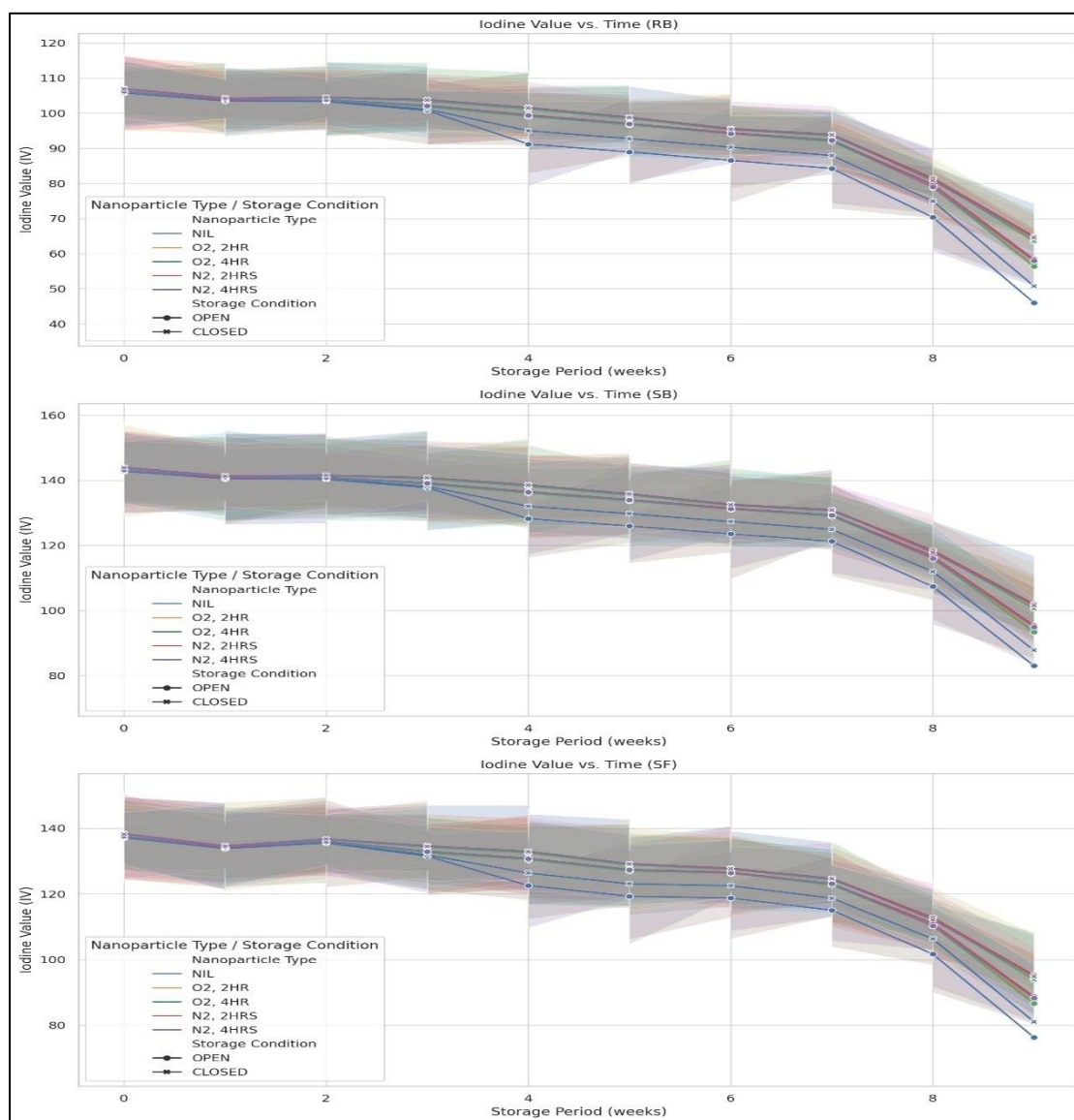


Figure 4.6: Change in Iodine Value with time

4.3.4.5 Preservation of Unsaturation: Iodine Value (IV)

The IV vs. time plots (Figure 4.6) reflect the extent of unsaturation loss in the oils. Control samples exhibited a steady decline in IV over time, consistent with the oxidative degradation of double bonds. Nano-ceria treatments helped preserve IV, especially under closed storage conditions where oxygen availability was limited. N₂-4H ceria at 15 ppm was the most effective, showing the smallest loss of IV across all oils. This result underscores its ability to protect unsaturated lipids from oxidative damage, helping to maintain oil nutritional and functional quality during storage.

4.3.4.6 Integrated Impact of Nano-Ceria on Oxidative Stability Markers in Edible Oils

The combined trends observed across PV, p-AnV, TOTOX, acid value (AV), and iodine value (IV) provide compelling evidence that engineered nano-ceria functions as a highly effective, multi-functional antioxidant system. The results demonstrate that the introduction of surface oxygen vacancies—achieved through N₂ atmosphere synthesis—substantially enhances antioxidant performance. Among the tested formulations, N₂-synthesized nanoparticles consistently outperformed O₂-synthesized variants, underscoring the critical role of synthesis atmosphere and annealing conditions.

A clear concentration dependence was observed across all oxidative markers. Higher nano-ceria concentrations conferred progressively greater protection, with 15 ppm emerging as the optimal dose. This was particularly evident under conditions of elevated temperature and extended storage duration, where oxidative stress was most pronounced.

Storage atmosphere significantly influenced outcomes. Oils stored in closed containers exhibited superior stability across all markers, highlighting the importance of oxygen exclusion. Nonetheless, nano-ceria imparted meaningful protective effects even under open storage, demonstrating its potential to mitigate oxidation in suboptimal storage environments—a relevant finding for real-world applications.

The performance hierarchy among the tested nano-ceria formulations was consistent across all oils and oxidative markers:

$$\text{N}_2\text{-4HR} > \text{N}_2\text{-2HR} > \text{O}_2\text{-2HR} > \text{O}_2\text{-4HR}$$

Nanoparticles exhibiting higher Ce³⁺ content, greater oxygen vacancy density, stable dispersion behavior, and smaller hydrodynamic sizes yielded the most robust oxidative protection. The N₂-4HR formulation, in particular, combined these advantageous properties, resulting in the slowest progression of primary and secondary oxidation, minimal loss of unsaturation, and the lowest accumulation of free fatty acids.

Mechanistically, the enhanced antioxidant efficacy of N₂-4HR nano-ceria can be attributed to its superior redox cycling capacity. Prolonged N₂ annealing (4 hours) increases Ce³⁺ content and stabilizes oxygen vacancies, facilitating efficient scavenging of lipid radicals and decomposition of peroxides. These structural advantages align with the nanoparticle characterization and ROS scavenging assay results presented in Chapter 4, which also identified 15 ppm as the optimal concentration for maximum activity.

The strong dose–response relationship observed here confirms that 15 ppm N₂-4HR nano-ceria represents a practical and highly effective formulation for protecting polyunsaturated oils from oxidative degradation.

In summary, engineered N₂-annealed nano-ceria offers a powerful, tunable antioxidant platform capable of extending the shelf life of edible oils across a range of storage conditions. Its performance is governed by synthesis parameters that control Ce³⁺ content, oxygen vacancy density, and nanoparticle dispersion stability. The integrated analysis of oxidative stability markers confirms that N₂-4HR nano-ceria at 15 ppm provides optimal protection, with broad implications for both food industry applications and the design of next-generation nano-antioxidant systems.

To further elucidate the mechanistic relationships between the observed oxidative stability markers, a correlation analysis was performed. This provided deeper insight into how primary, secondary, and tertiary oxidative processes interact during oil degradation, and how these dynamics are modulated by nano-ceria treatment.

4.3.5 Corelation between oxidative markers

The correlation analysis of oxidative stability markers (Figure 4.7) offers important insights into the physical and chemical processes governing lipid degradation. Positive correlations indicate that markers tend to evolve together during oxidation. As expected, primary oxidation (PV) was positively correlated with secondary oxidation (p-AnV), consistent with the well-established mechanism where lipid hydroperoxides decompose into aldehydes and ketones.

The TOTOX value, which integrates both PV and p-AnV by design, exhibited strong positive correlations with both markers, validating its role as a comprehensive indicator of cumulative oxidation. Acid value (AV) showed moderate positive correlations with oxidative markers, reflecting the contribution of oxidative stress to triglyceride hydrolysis and free fatty acid formation.

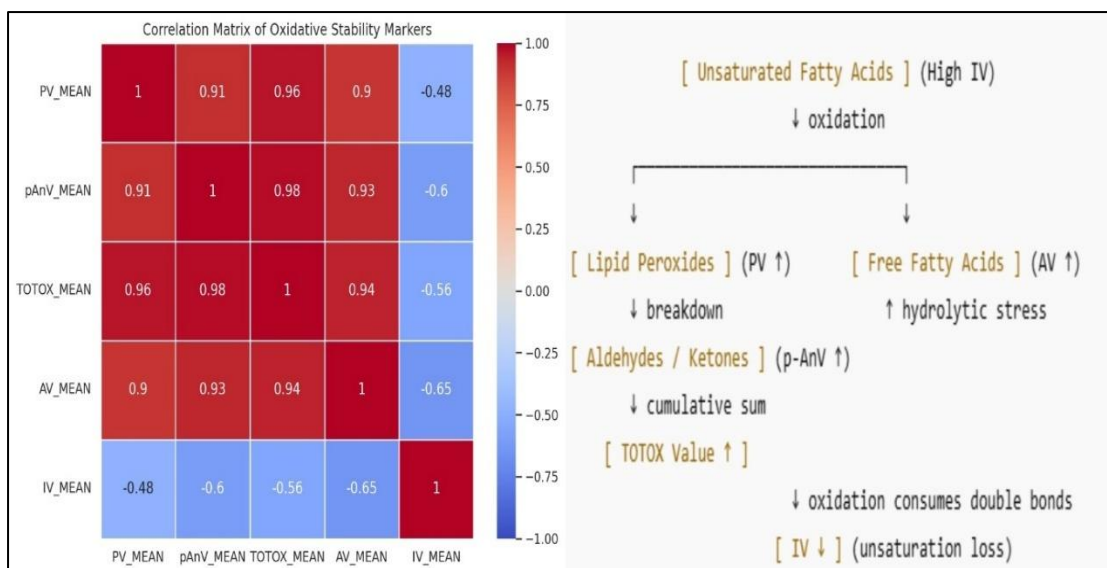


Figure 4.7: Conceptual diagram illustrating the interrelationships between oxidative stability markers and lipid degradation pathways in edible oils

In contrast, iodine value (IV), which quantifies unsaturation, exhibited negative correlations with all oxidation markers, consistent with the progressive loss of double bonds during lipid peroxidation. These trends align with the mechanistic understanding of lipid oxidation and underscore the complementary nature of the analytical markers employed.

The correlation analysis between residual antioxidant activity (%RAA) and oxidative stability markers (Figure 4.8) further reinforced the protective role of nano-ceria. %RAA exhibited strong negative correlations with PV, p-AnV, and TOTOX, consistent with the ability of antioxidant capacity to suppress both primary and secondary lipid oxidation. A negative correlation with AV was also observed, indicating that stronger antioxidant protection reduces free fatty acid formation during storage. Conversely, IV correlated positively with %RAA, as effective antioxidant function preserved unsaturation in the oils.

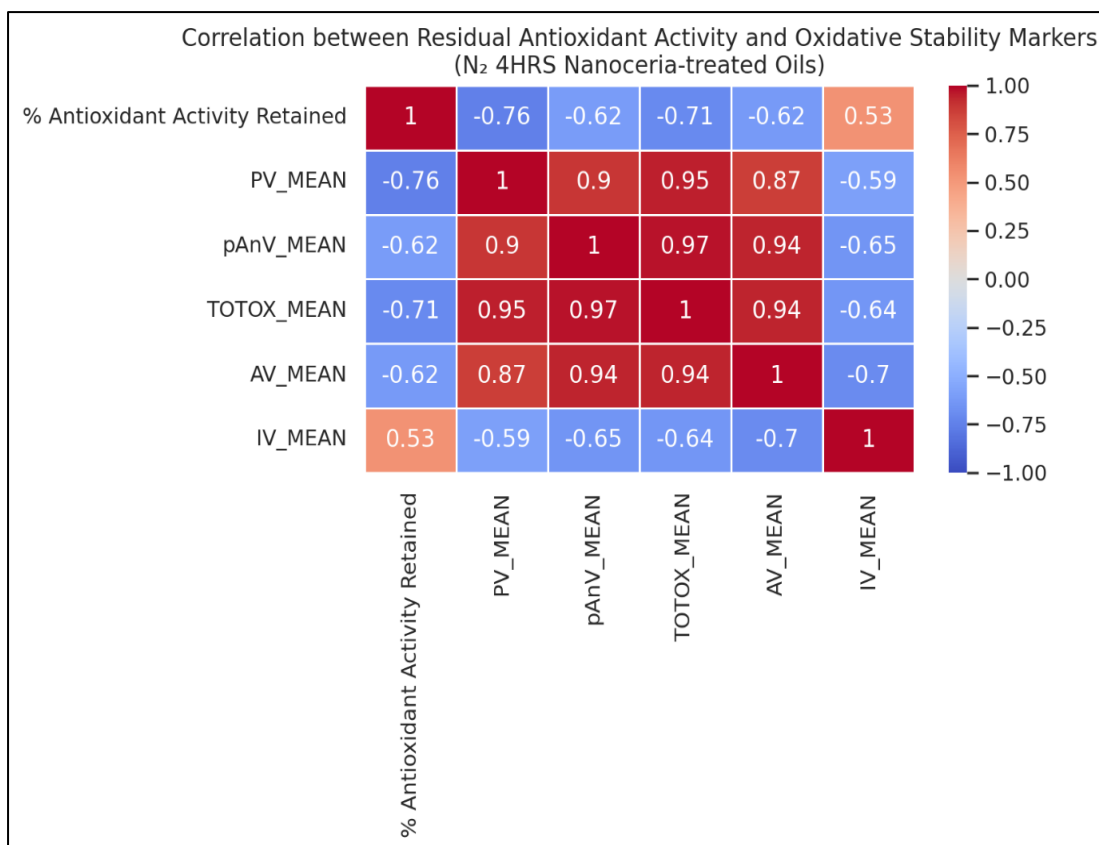


Figure 4.8: Co-relation between residual antioxidant activity and other oxidative markers

Table 4.2: Co-relation between residual Antioxidant Activity and Oxidative Markers

Marker	Correlation with % Antioxidant Activity Retained	Physical interpretation
PV	-0.76 → Strong negative	Higher antioxidant activity → lower primary oxidation (PV ↓)
p-AnV	-0.62 → Moderate negative	Higher antioxidant activity → less secondary oxidation (aldehydes ↓)
TOTOX	-0.71 → Strong negative	Higher antioxidant activity → lower total oxidation
AV	-0.62 → Moderate negative	Higher antioxidant activity → lower free fatty acid formation
IV	+0.53 → Moderate positive	Higher antioxidant activity → better preservation of unsaturation (IV ↑)

Quantitatively, as shown in Table 4.2, higher residual antioxidant activity in N₂-4HRS nano-ceria-treated oils was associated with significantly lower peroxide value ($r = -0.76$), lower levels of secondary oxidation products (p-AnV, $r = -0.62$), and reduced cumulative oxidation (TOTOX, $r = -0.71$). Acid value was likewise inversely correlated ($r = -0.62$), indicating that robust antioxidant protection helps maintain ester integrity and limit free fatty acid accumulation. In contrast, iodine value exhibited a positive correlation with %RAA ($r = +0.53$), reflecting improved retention of unsaturation in oils with higher antioxidant capacity.

Overall, these results confirm that the enhanced antioxidant performance conferred by engineered nano-ceria translates directly into improved oxidative stability and preservation of oil quality during storage. The correlation patterns observed here provide strong mechanistic support for the efficacy of nano-ceria as a regenerative, multi-functional antioxidant in edible oils.

To further quantify the relative influence of key experimental factors on oxidative stability, an ANOVA analysis was performed across all measured markers. This statistical approach highlights the dominant variables driving oxidation and clarifies the specific role of nano-ceria in modulating these processes.

4.3.6 ANOVA analysis of Oxidative Stability Markers

The ANOVA analysis provided a robust statistical framework to dissect the factors influencing oxidative stability markers (Tables 5.3–5.7). Across all markers, *storage period* emerged as the dominant variable, underscoring the critical role of time-dependent oxidative progression in edible oils.

Table 4.3: ANOVA results for Peroxide Value (PV)

Factor	F-value	p-value	Significance	Interpretation
Temperature	13.36	1.70e-06	Highly significant	Higher temp → faster oxidation (PV ↑)
Storage Condition	116.54	1.52e-26	Very highly significant	Open storage → much higher PV (oxygen access)
Nanoparticle Type	97.26	1.27e-76	Extremely significant	Different nano types affect PV greatly

Oil Type	159.17	1.61e-65	Extremely significant	Different oils have different oxidation behavior
Nanoparticle Concentration	0.003	0.95	Not significant → concentration itself not a strong factor here (but Type is!)	
Storage Period	6498.77	< 1e-300	Dominant effect	Longer storage → strongly increases PV

*Footnote: ns – not significant ($p \geq 0.05$); * – significant ($p < 0.05$); ** – highly significant ($p < 0.01$); *** – very highly significant ($p < 0.001$); **** – extremely significant ($p < 0.0001$).*

For primary oxidation (PV), storage period exerted the strongest influence ($F = 6498.77$, $p < 0.0001$), followed by oil type, storage condition, nanoparticle type, and temperature. Nanoparticle concentration was not significant ($F = 0.003$, $p = 0.95$), suggesting that the antioxidant efficacy depends more on the intrinsic properties of the nano-ceria formulation than on its dosage. Open storage and elevated temperatures significantly accelerated peroxide formation, with susceptibility varying by oil type.

Table 4.4: ANOVA for p-Anisidine Value (p-AnV)

Factor	F-value	p-value	Significance	Interpretation
Temperature	23.56	7.42e-11	Highly significant	Higher temperature accelerates secondary oxidation
Storage Condition	35.62	2.77e-09	Very significant	Open storage greatly increases aldehyde formation
Nanoparticle Type	6.48	3.46e-05	Significant	Nano type affects secondary oxidation rates

Oil Type	218.29	1.30e-87	Extremely significant	Strong oil-type dependence in aldehyde formation
Nanoparticle Concentration	0.14	0.71	Not significant → dosage again not critical here	
Storage Period	6334.22	< 1e-300	Dominant effect	Time strongly drives secondary oxidation

*Footnote: ns – not significant ($p \geq 0.05$); * – significant ($p < 0.05$); ** – highly significant ($p < 0.01$); *** – very highly significant ($p < 0.001$); **** – extremely significant ($p < 0.0001$).*

Secondary oxidation (p-AnV) followed a similar pattern. Storage period again dominated ($F = 6334.22$, $p < 0.0001$), with significant contributions from oil type, temperature, storage condition, and nanoparticle type. The non-significance of nanoparticle concentration ($F = 0.14$, $p = 0.71$) further reinforces that nano-ceria structure governs its ability to suppress secondary oxidation, but concentration of nanoceria do not possess the same level of significance in imparting oxidative protection of edible oils. These findings highlight the central roles of storage time, oil matrix, and nano-ceria formulation in modulating aldehyde and ketone accumulation.

Table 4.5: ANOVA for TOTOX value

Factor	F-value	p-value	Significance	Interpretation
Temperature	23.22	1.04e-10	Highly significant	Higher temperature increases cumulative oxidation
Storage Condition	91.34	2.95e-21	Very highly significant	Open storage drives higher TOTOX
Nanoparticle Type	36.61	1.01e-29	Very highly significant	Nano type greatly impacts cumulative oxidation load

Factor	F-value	p-value	Significance	Interpretation
Oil Type	191.99	6.66e-78	Extremely significant	Strong dependence on oil type for TOTOX trends
Nanoparticle Concentration	0.055	0.81	Not significant → dosage again not critical for total oxidation	
Storage Period	8063.34	< 1e-300	Dominant effect	Time is the primary driver of cumulative oxidation

*Footnote: ns – not significant ($p \geq 0.05$); * – significant ($p < 0.05$); ** – highly significant ($p < 0.01$); *** – very highly significant ($p < 0.001$); **** – extremely significant ($p < 0.0001$).*

For cumulative oxidation (TOTOX), storage period was again the primary factor ($F = 8063.34$, $p < 0.0001$), followed by oil type, storage condition, nanoparticle type, and temperature. The lack of concentration effect ($F = 0.055$, $p = 0.81$) persisted, confirming that nano-ceria type is more influential than dosage in controlling cumulative oxidative stress. This result emphasizes the synergistic effects of time, oxygen availability, oil composition, and nano-ceria properties on long-term oxidative stability.

Table 4.6: ANOVA for Acid Value (AV)

Factor	F-value	p-value	Significance	Interpretation
Temperature	42.46	7.71e-19	Very highly significant	Higher temperature accelerates AV increase
Storage Condition	119.40	3.86e-27	Extremely significant	Open storage → higher FFA formation
Nanoparticle Type	7.65	4.02e-06	Significant	Nano type affects AV trends
Oil Type	5.70	3.41e-03	Significant	Oil type impacts AV trends

Factor	F-value	p-value	Significance	Interpretation
Nanoparticle Concentration	0.013	0.91	Not significant → dosage again not critical for AV	
Storage Period	9245.28	< 1e-300	Dominant effect	Time is the primary driver of AV increase

*Footnote: ns – not significant ($p \geq 0.05$); * – significant ($p < 0.05$); ** – highly significant ($p < 0.01$); *** – very highly significant ($p < 0.001$); **** – extremely significant ($p < 0.0001$).*

Acid value (AV) analysis showed a similar trend. Storage period was the strongest driver of free fatty acid formation ($F = 9245.28$, $p < 0.0001$), followed by storage condition, temperature, nanoparticle type, and oil type. The absence of a concentration effect ($F = 0.013$, $p = 0.91$) again suggests that structural attributes of nano-ceria formulations primarily govern their ability to mitigate hydrolytic degradation.

Table 4.7: ANOVA for Iodine Value (IV)

Factor	F-value	p-value	Significance	Interpretation
Temperature	29.38	2.51e-13	Highly significant	Higher temperature accelerates loss of unsaturation (IV ↓)
Storage Condition	43.04	6.59e-11	Very highly significant	Open storage → more rapid IV decrease
Nanoparticle Type	14.67	7.69e-12	Very significant	Nano type strongly impacts IV preservation
Oil Type	5969.07	< 1e-300	Dominant oil type effect	IV is heavily oil-type dependent (as expected)
Nanoparticle Concentration	0.0028	0.96	Not significant → dosage again not critical	

Storage Period	6322.34	< 1e-300	Very strong effect	Time drives loss of unsaturation over storage period
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*Footnote: ns – not significant ($p \geq 0.05$); * – significant ($p < 0.05$); ** – highly significant ($p < 0.01$); *** – very highly significant ($p < 0.001$); **** – extremely significant ($p < 0.0001$).*

For iodine value (IV), which reflects unsaturation loss, oil type was the dominant factor ($F = 5969.07$, $p < 0.0001$), followed closely by storage period. Nanoparticle type contributed significantly ($F = 14.67$), while concentration remained non-significant ($F = 0.0028$, $p = 0.96$). These findings confirm that oil composition, storage time, and oxygen availability drive double bond loss during storage, with nano-ceria providing measurable, formulation-dependent protection.

Factorial ANOVA confirmed strong effects of oil type, storage temperature, storage atmosphere and nanoparticle type. The non-significant effect of concentration ($p = 0.95$) is particularly important: it supports a catalytic action mechanism, where ceria regenerates its antioxidant capacity via $\text{Ce}^{3+} \leftrightarrow \text{Ce}^{4+}$ cycling rather than being consumed stoichiometrically. This is consistent with regenerative behaviors reported by Celardo et al. (2011) and Das et al. (2020). The PV suppression observed here parallels earlier work demonstrating that metal-oxide nanostructures can inhibit hydroperoxide formation, but the durability of nano-ceria's effect—observed even in week 9—is notably greater than that of classical antioxidants such as tocopherols, which degrade early during oxidation (Shahidi & Ambigaipalan, 2015).

Collectively, the ANOVA results yielded several key insights. Storage period is the dominant factor influencing oxidative stability across all markers. Oil type exerts a strong influence, particularly for IV and p-AnV, highlighting the role of fatty acid composition and endogenous antioxidants. Nanoparticle type is consistently significant across all markers, confirming that the formulation and surface chemistry of nano-ceria critically affect antioxidant performance. Nanoparticle concentration was not significant for any marker, indicating that surface properties and redox activity of the particles matter more than simple dosage. Storage condition (open vs. closed) is strongly significant across all markers, reinforcing the central role of oxygen availability in driving oxidation. Temperature is consistently significant, with higher temperatures accelerating oxidation and degradation processes across the board. These findings strongly support the conclusion that the antioxidant efficacy of engineered nano-ceria is governed by its formulation (surface chemistry, Ce^{3+} content, oxygen vacancies) rather than dosage alone. They also highlight the critical importance of managing storage conditions

(oxygen exposure, temperature) in conjunction with nano-antioxidant application to optimize oil stability. The consistency of these patterns across all oxidative markers reinforces the robustness and practical relevance of the current results.

4.3.7 Principal Component Analysis

4.3.7.1 Explained Variance by Each Principal Component

Table 4.8 presents the explained variance ratio and eigenvalues associated with each of the seven principal components (PCs) derived from the PCA of standardized oil quality parameters.

Table 4.8: Explained Variance by Each Principal Component

	PC	Explained Variance Ratio	Eigenvalue
0	PC1	0.804635	5.639676
1	PC2	0.142816	1.000994
2	PC3	0.030458	0.213481
3	PC4	0.005691	0.099804
4	PC5	0.014239	0.039886
5	PC6	0.001667	0.011681
6	PC7	0.000494	0.003464

- PC1 alone explains 80.46% of the total variance, indicating that a single latent factor—likely related to oxidative degradation—dominates the variability in the dataset.
- PC2 contributes an additional 14.28%, bringing the cumulative explained variance by the first two components to approximately 94.75%. This suggests that the majority of information in the original seven-variable dataset is effectively captured by just two principal components.
- The remaining components (PC3 to PC7) together explain only about 5.25% of the variance, and are therefore considered less significant in describing the underlying data structure.

The dominance of the first two PCs justifies focusing interpretation and correlation analysis primarily on PC1 and PC2, simplifying the model without substantial loss of information. This also enables the effective use of PCA scores for antioxidant performance evaluation and shelf life prediction.

4.3.7.2. Component Loading Table

The loadings Table 4.9A and 4.9B, reveal the strength and direction of contribution from each original variable to the principal components: (i) PC1: High positive loadings from PV (0.396), pAV (0.418), TOTOX (0.418), AV (0.404), and Kries (0.395). Negative contribution from IV (−0.417) → Represents cumulative oxidative degradation; higher scores correspond to greater deterioration. (ii) PC2: Dominated entirely by RI (1.000) → Captures variation in structural or molecular properties, possibly influenced by polymerization or refractive changes not linked to oxidation. (iii) PC3: High positive Kries (0.694), negative PV (−0.614), and AV (−0.239) → Highlights early oxidative signals or freshness (Kries) opposing peroxide buildup. (iv) PC4: Strong positive loading from AV (0.808), and negative PV → Reflects free fatty acid (FFA) generation and hydrolytic degradation.

Table 4.9A. Component Loadings

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
PV	0.396385	0.008839	- 0.613892	-0.545047	0.344046	-0.104369	0.198748
pAV	0.417609	-0.015239	0.168734	0.014548	-0.464422	0.310412	0.696164
TOTOX	0.418018	-0.008502	-0.172697	-0.053830	-0.346129	0.490286	-0.657481
IV	-0.417463	0.009478	-0.159934	0.019104	0.364930	0.796967	0.177089
RI	0.011668	0.999739	0.013219	0.000545	-0.014171	0.003173	0.100149
Kries	0.395449	-0.006395	0.694292	-0.216571	0.536818	0.128184	-0.100149
AV	0.403671	0.003059	-0.238844	0.807803	0.352833	-0.027824	0.046712

Table 4.9B. Component Loadings

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
PV	0.396	0.009	-0.614	-0.545	0.344	-0.104	0.199
pAV	0.418	-0.015	0.169	0.015	-0.464	0.310	0.696
TOTOX	0.418	-0.009	-0.173	-0.054	-0.346	0.490	-0.657
IV	-0.417	0.009	-0.160	0.019	0.365	0.797	0.177
RI	0.012	1.000	0.013	0.001	-0.014	0.003	0.001
Kries	0.395	-0.006	0.694	-0.217	0.537	0.128	-0.100
AV	0.404	0.003	-0.239	0.808	0.353	-0.028	0.047

4.3.7.3 PCA Loadings Heatmap Visualization

Color gradients used in the Figure 4.9 below confirm these relationships, with high contrasts between oxidative and structural indices.

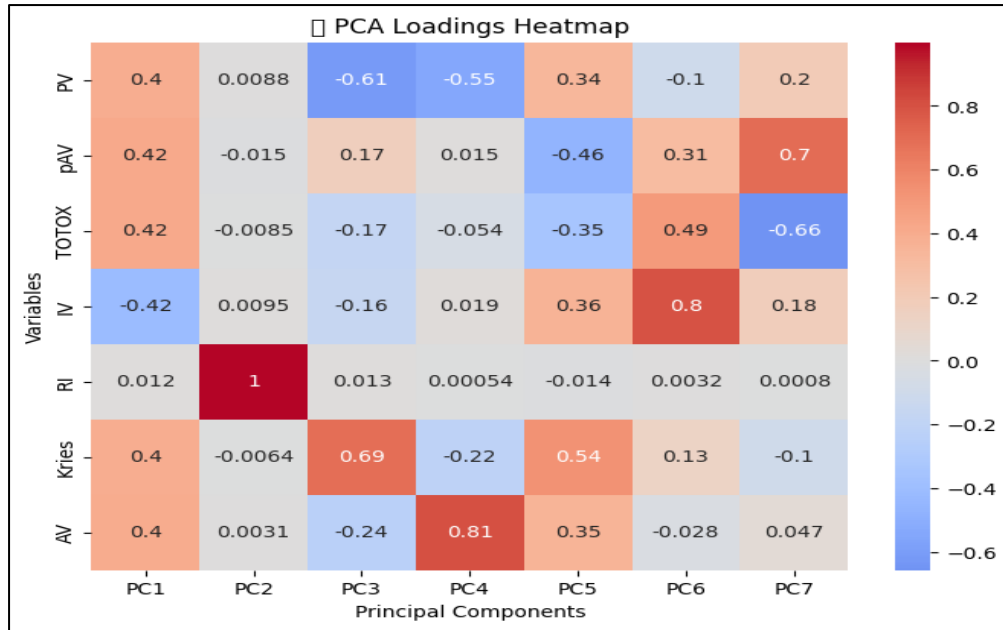


Figure 4.9: PCA Loadings Heatmap

- PCs can be used to classify **fresh vs. deteriorated** oil samples.
- Separation of hydrolytic and oxidative mechanisms allows targeted interventions (e.g., using nanoparticles to suppress FFA generation vs. oxidation).

4.3.7.4. Principal Component Expressions from PCA

The following are the linear expressions for the first seven Principal Components (PCs) derived from the PCA of standardized oil quality parameters. Each PC is expressed as a weighted combination of the Z-scores of the original variables (standardized values). These coefficients represent the contribution (loadings) of each variable to the corresponding principal component.

$$\begin{aligned}
 \text{PC1} &= 0.396 \cdot Z_{\text{PV}} + 0.418 \cdot Z_{\text{pAV}} + 0.418 \cdot Z_{\text{TOTOX}} - 0.417 \cdot Z_{\text{IV}} + 0.012 \cdot Z_{\text{RI}} + 0.395 \cdot Z_{\text{Kries}} + 0.404 \cdot Z_{\text{AV}} \\
 \text{PC2} &= 0.009 \cdot Z_{\text{PV}} - 0.015 \cdot Z_{\text{pAV}} - 0.009 \cdot Z_{\text{TOTOX}} + 0.009 \cdot Z_{\text{IV}} + 1.000 \cdot Z_{\text{RI}} - 0.006 \cdot Z_{\text{Kries}} + 0.003 \cdot Z_{\text{AV}} \\
 \text{PC3} &= -0.614 \cdot Z_{\text{PV}} + 0.169 \cdot Z_{\text{pAV}} - 0.173 \cdot Z_{\text{TOTOX}} - 0.160 \cdot Z_{\text{IV}} + 0.013 \cdot Z_{\text{RI}} + 0.694 \cdot Z_{\text{Kries}} - 0.239 \cdot Z_{\text{AV}} \\
 \text{PC4} &= -0.545 \cdot Z_{\text{PV}} + 0.015 \cdot Z_{\text{pAV}} - 0.054 \cdot Z_{\text{TOTOX}} + 0.019 \cdot Z_{\text{IV}} + 0.001 \cdot Z_{\text{RI}} - 0.217 \cdot Z_{\text{Kries}} + 0.808 \cdot Z_{\text{AV}}
 \end{aligned}$$

$$\begin{aligned}
PC5 &= 0.344 \cdot Z_{PV} - 0.464 \cdot Z_{pAV} - 0.346 \cdot Z_{TOTOX} + 0.365 \cdot Z_{IV} - 0.014 \cdot Z_{RI} + 0.537 \cdot Z_{Kries} + 0.353 \cdot Z_{AV} \\
PC6 &= -0.104 \cdot Z_{PV} + 0.310 \cdot Z_{pAV} + 0.490 \cdot Z_{TOTOX} + 0.797 \cdot Z_{IV} + 0.003 \cdot Z_{RI} + 0.128 \cdot Z_{Kries} - 0.028 \cdot Z_{AV} \\
PC7 &= 0.199 \cdot Z_{PV} + 0.696 \cdot Z_{pAV} - 0.657 \cdot Z_{TOTOX} + 0.177 \cdot Z_{IV} + 0.001 \cdot Z_{RI} - 0.100 \cdot Z_{Kries} + 0.047 \cdot Z_{AV}
\end{aligned}$$

- PC1 seems to reflect general oxidation/degradation (since PV, pAV, TOTOX, Kries, AV all contribute positively).
- PC2 is almost purely driven by Refractive Index (RI).
- PC3 strongly contrasts Kries (positive) vs. PV and AV (negative) → may relate to antioxidant influence vs. peroxidation.
- PC4 has a strong AV component, possibly capturing free fatty acid formation.
- PC6 is heavily influenced by IV and TOTOX, pointing to unsaturation stability.
- PC7 mixes pAV and TOTOX, could relate to secondary oxidation vs. stability tradeoffs.

4.3.7.5 PCA Sample Scores and Scree Plots

Table 4.10 contains the PC scores for each sample, representing projections into the principal component space. For instance:

- Samples with low PC1 scores exhibit lower oxidative degradation.
- High PC2 scores reflect changes in refractive index, possibly due to thermal or nanoparticle interactions.
- Trends in PC3 and PC4 can track antioxidant activity (Kries) and hydrolysis (AV) separately.
- These scores can be plotted over time or treatment (e.g., with/without nanoparticles) to study effectiveness in maintaining oil quality.
- Also useful for clustering similar treatments, identifying optimal nanoparticle concentrations, or visualizing degradation patterns.

Table 4.10: Sample PCA Scores

	PC1	PC2	PC3	PC4	PC5	PC6	PC7
0	-2.087543	0.221480	0.029626	-0.167384	-0.031186	0.091283	0.026866
1	-2.078620	1.664861	0.045920	-0.168901	-0.045879	0.109375	0.030574

2	-2.089020	0.187258	0.029247	-0.166349	-0.015740	0.116078	0.031698
3	-2.056759	1.733183	0.054372	-0.168051	-0.057146	0.083033	0.024588
4	-2.081561	0.015310	0.023129	-0.170886	-0.023211	0.097764	0.026637

The scree plot (Figure 4.10A and Figure 4.10B given above) illustrate the proportion of total variance explained by each principal component (PC). In this analysis:

- PC1 alone explains 80.46% of the total variance.
- PC2 adds 14.28%, bringing the cumulative explained variance to 94.75%.
- Remaining components (PC3 to PC7) each contribute less than 3%, with diminishing returns.

The dominance of PC1 and PC2 indicates that the multidimensional behavior of the oil quality parameters can be effectively summarized using just two principal components.

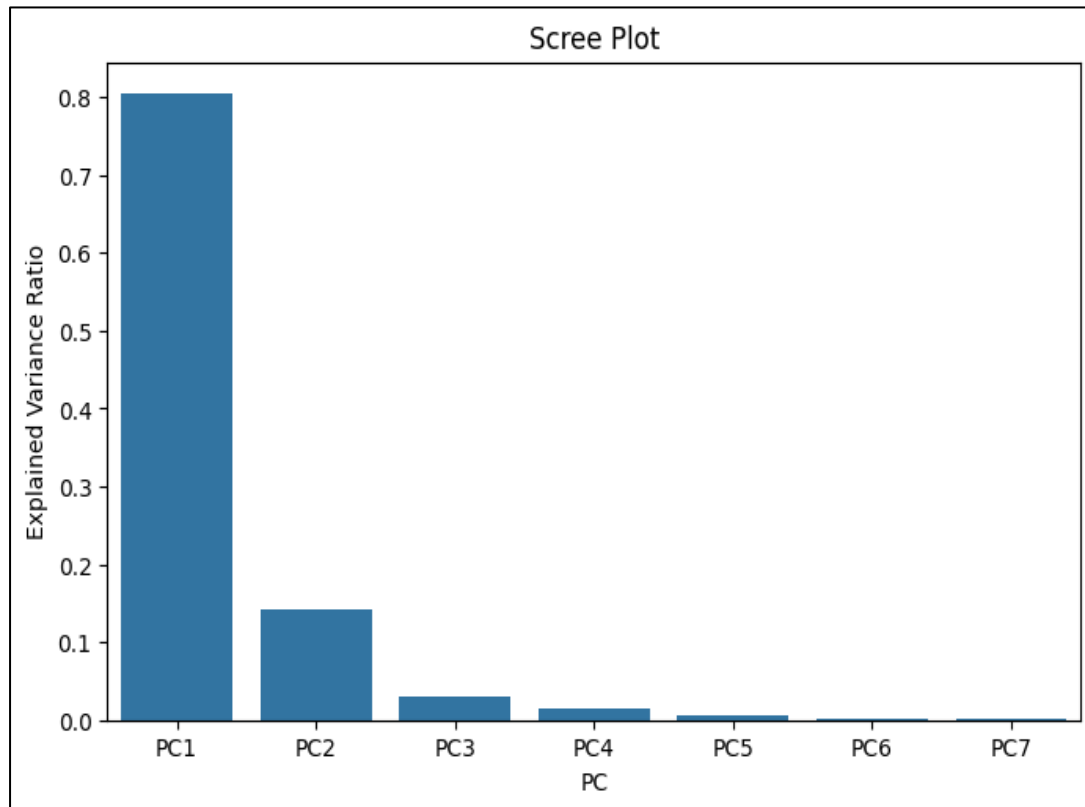


Figure 4.10a Screeplot-Explained variance ratio by PCs

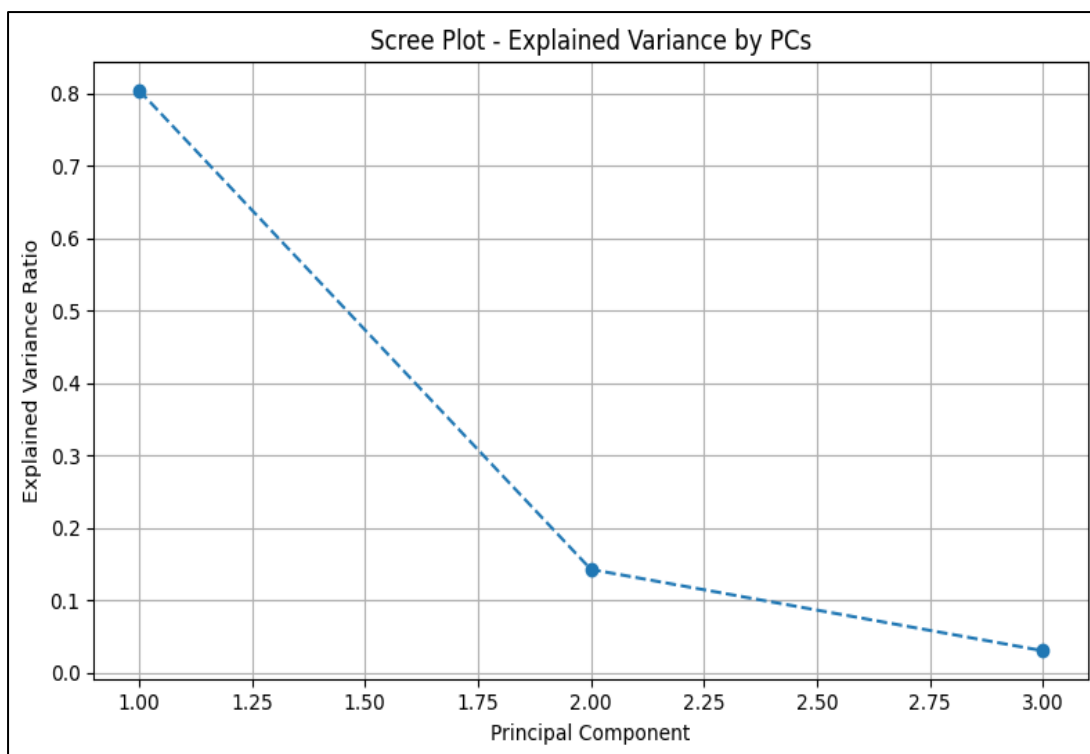


Figure 4.10b B.Screeplot- Explain Variance by PCs

This significant reduction in dimensionality supports focused analysis and interpretation without much loss of information.

This justifies using a reduced PC space for monitoring stability trends, especially when testing the impact of nanoparticle antioxidants on oxidative parameters.

4.3.7.6 PCA Scores Plot (PC1 vs PC2)

This scatterplot in fig given below visualizes how individual samples are distributed in the new coordinate system defined by PC1 and PC2:

- **X-axis (PC1):** Oxidative degradation index
- **Y-axis (PC2):** Structural variation index (RI)

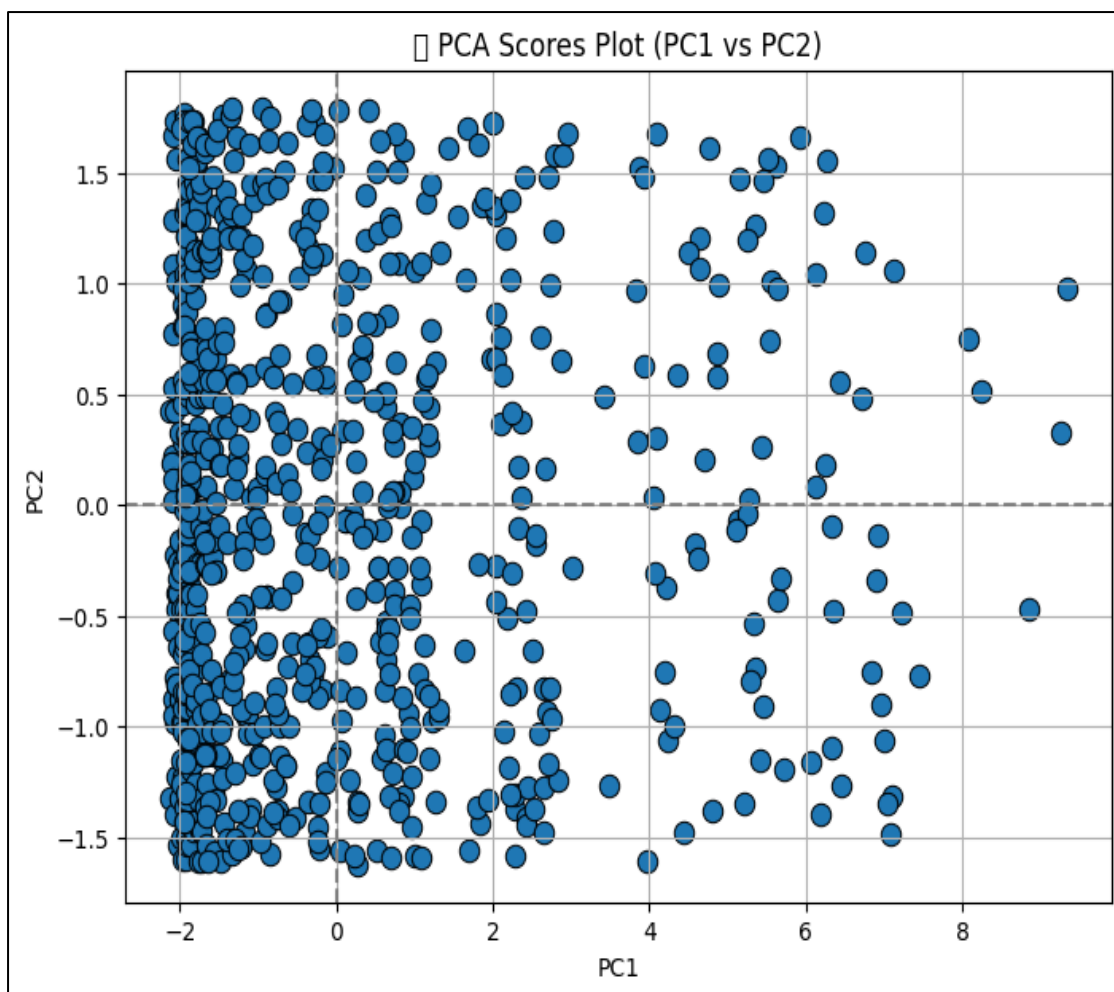


Figure 4.11: PCA ScorePlot

- Clusters or separations among samples may indicate distinct nanoparticle effects **or** treatment categories.
- Samples in the bottom-left quadrant are likely the most stable (low oxidation and low structural deviation).

This plot (Figure 4.11) helps in visual group-wise comparison—critical in evaluating different formulations, concentrations, or storage conditions

4.3.7.7 Correlation of PCA-Derived Scores with Antioxidant Efficacy

In this study, the efficacy of antioxidant treatments was evaluated using rice bran oil samples by analyzing the relationship between Principal Component Analysis (PCA)-derived scores and Residual Antioxidant Activity (RAA%). PCA was employed to summarize the multivariate oil quality data into a few key components that represent major degradation pathways. The first three principal components (PC1, PC2, and PC3) were examined for their correlation with

RAA%, a critical functional marker of oxidative stability. Table 4.11 presents the Pearson correlation coefficients between the PCA scores and RAA%:

Table 4.11: Correlation between PC scores and RAA (%)

	PC1	PC2	PC3	RAA
PC1	1.000	0.000	-0.000	-0.591
PC2	0.000	1.000	0.000	-0.017
PC3	-0.000	0.000	1.000	0.256
RAA	-0.591	-0.017	0.256	1.000

- PC1 and RAA% showed a moderate negative correlation ($r = -0.591$), indicating that higher PC1 scores correspond to lower antioxidant retention. Since PC1 captures oxidative degradation (with strong positive loadings for PV, pAV, TOTOX, and AV), this confirms that oxidative spoilage is directly impacted by the effectiveness of antioxidant prese in rice bran oil.
- PC3 and RAA% exhibited a positive correlation ($r = 0.256$). PC3 had a high positive loading for the Kries test (indicative of early-stage rancidity or antioxidant presence) and negative loadings for PV and AV. This suggests that higher PC3 scores may reflect preservation of early freshness indicators, and thus partially align with antioxidant efficacy.
- PC2 was dominated by refractive index (RI) and showed negligible correlation with RAA%, reinforcing that structural optical properties are relatively independent of antioxidant function.

This correlation analysis validates the functional utility of PCA-derived components in predicting antioxidant behavior:

- PC1 serves as a reliable degradation index: A sample with a high PC1 score is more oxidized and likely to exhibit lower RAA%.
- PC3 may serve as a secondary freshness index, particularly sensitive to antioxidant preservation during early storage.

Such insights can guide targeted selection and dosage optimization of nanoparticle-based antioxidants in rice bran oil, particularly for shelf life extension and functional food applications.

4.3.7.8 Overall Implications and Nanoparticle Context

The application of PCA in this study is particularly valuable for understanding the multifaceted impact of nanoparticle-based antioxidants on oil quality. Oils treated with nanoparticles often exhibit complex and delayed oxidation patterns that are not easily captured by single-parameter monitoring. Through PCA, the combined effects of multiple degradation markers (PV, p-AV, TOTOX, Kries, etc.) are synthesized into fewer, more interpretable principal components.

- PC1, heavily weighted by oxidative markers, serves as a composite degradation index that reflects how effectively nanoparticles suppress both primary and secondary oxidation products.
- The clear delineation of PC2 (dominated by RI) and PC4 (driven by AV) allows researchers to assess whether nanoparticles also influence structural stability and hydrolytic degradation, respectively.
- The behavior of PC3 and PC5, which involve Kries and TOTOX in opposing patterns, may reveal early antioxidant action or the delayed onset of rancidity, which is critical when evaluating slow-release or encapsulated nano-additives.

In shelf-life modeling PCA score trends over time, especially for PC1 and PC3, provide quantifiable evidence of how long nanoparticle-treated oils retain their oxidative stability. These scores can be integrated into predictive models (e.g., RSM, regression) to optimize the type, concentration, and combination of nanoparticles that maximize residual antioxidant activity (RAA) or minimize TOTOX over storage. PCA also aids in identifying which oil-nanoparticle combinations behave similarly in stability terms, enabling clustering or segmentation for targeted formulation strategies.

From an industrial perspective, these insights help in developing data-driven formulations of functional edible oils, reducing trial-and-error in selecting nanoparticle types (e.g., ZnO, TiO₂, Se-NPs), and improving both product performance and regulatory compliance for shelf life declarations.

The PCA analysis confirms that oxidative degradation (PC1), molecular structure (PC2), and rancidity markers (PC3–PC4) can be efficiently captured and interpreted in reduced dimensions. These components serve as composite metrics for evaluating how different nanoparticle antioxidants (e.g., nano-ceria, ZnO, etc.) influence oil quality over time.

This statistical foundation enhances:

- Formulation screening for optimal nanoparticle type/concentration
- Predictive shelf-life modeling

- Comparative effectiveness evaluation of different treatments or storage setups

4.3.8 Regression Modeling and Predictive Applications:

A second-order response surface model was developed to evaluate the influence of nanoparticle concentration, temperature, and storage period on the Residual Antioxidant Activity (RAA%) of rice bran oil. The model was built using ordinary least squares (OLS) regression (Table 4.12) with interaction and quadratic terms to capture both linear and non-linear effects.

Table 4.12: Regression Model Summary

OLS Regression Results				
=====				
===				
Dep. Variable:	RAA	R-squared:	0.653	
Model:	OLS	Adj. R-squared:	0.639	
Method:	Least Squares	F-statistic:	48.02	
Date:	Mon, 16 Jun 2025	Prob (F-statistic):	5.25e-	
48				
Time:	01:24:51	Log-Likelihood:	-	
933.44				
No. Observations:	240	AIC:	1887.	
Df Residuals:	230	BIC:	1922.	
Df Model:	9			
Covariance Type:	nonrobust			
=====				
=====				
		coef	std err	t
[0.025	0.975]			P> t

Intercept		77.7383	15.535	5.004
47.129	108.348			0.000
Concentration		3.0006	0.741	4.050
1.541	4.460			0.000
Temperature		0.2191	1.016	0.216
-1.784	2.222			0.829
StoragePeriod		-4.7864	1.461	-3.276
-7.665	-1.908			0.001
I(Concentration ** 2)		-0.0862	0.031	-2.764
-0.148	-0.025			0.006
I(Temperature ** 2)		-0.0042	0.017	-0.254
-0.037	0.028			0.800
I(StoragePeriod ** 2)		0.0076	0.107	0.071
-0.204	0.219			0.944
Concentration:Temperature		-0.0045	0.017	-0.261
-0.038	0.029			0.794
Concentration:StoragePeriod		0.1165	0.049	2.398
0.021	0.212			0.017
Temperature:StoragePeriod		0.0026	0.033	0.080
-0.063	0.068			0.937
=====				
=====				
Omnibus:	35.205	Durbin-Watson:	1.861	
Prob (Omnibus) :	0.000	Jarque-Bera (JB) :	150.158	

Skew:	0.457	Prob (JB) :	2.48e-
33			
Kurtosis:	6.766	Cond. No.	2.24e+04
=====			
===			

Notes:

[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

[2] The condition number is large, 2.24e+04. This might indicate that there are strong multicollinearity or other numerical problems.

4.3.8.1 Model Performance and Significance

The regression model achieved an R^2 of 0.653 and an adjusted R^2 of 0.639, indicating that approximately 65% of the variance in RAA% was successfully explained by the model. The overall model was statistically significant ($F = 48.02$, $p < 0.0001$), confirming its reliability in capturing the functional relationships among the selected variables.

4.3.8.1.1 Interpretation of Regression Coefficients

Nanoparticle Concentration had a strong and significant positive linear effect on RAA ($\beta = 3.00$, $p < 0.001$), demonstrating that increasing concentration enhances antioxidant retention. The quadratic term of concentration was significantly negative ($\beta = -0.0862$, $p = 0.006$), indicating a curvilinear response and suggesting that excessively high concentrations may lead to diminishing returns or slight performance decline. Storage Period showed a significant negative linear effect ($\beta = -4.7864$, $p = 0.001$), aligning with expectations that antioxidant effectiveness diminishes over time. The interaction between concentration and storage period was also statistically significant ($\beta = 0.1165$, $p = 0.017$), implying that the effect of concentration on RAA varies depending on how long the oil is stored. Temperature and its related terms were not statistically significant ($p > 0.79$), suggesting minimal direct influence of temperature on RAA within the studied range. Other diagnostic metrics such as the Durbin-Watson statistic (1.861) indicate the absence of autocorrelation, and although the condition number is high (~22,400), no severe multicollinearity was evident from the p-values or coefficient behavior.

4.3.8.2 Response surface plot

This 3D surface plot visualizes the predicted Residual Antioxidant Activity (RAA%) as a function of two key independent variables: nanoparticle concentration (x-axis) and storage period in weeks (y-axis), while keeping the storage temperature constant (likely at the median value used during modeling). Z-axis (vertical): Predicted RAA (%), representing the effectiveness of antioxidant preservation in rice bran oil under given conditions. X-axis (left to

right): Nanoparticle concentration — increases from 0 to 15. Y-axis (front to back): Storage period — increases from 0 to 8 weeks.

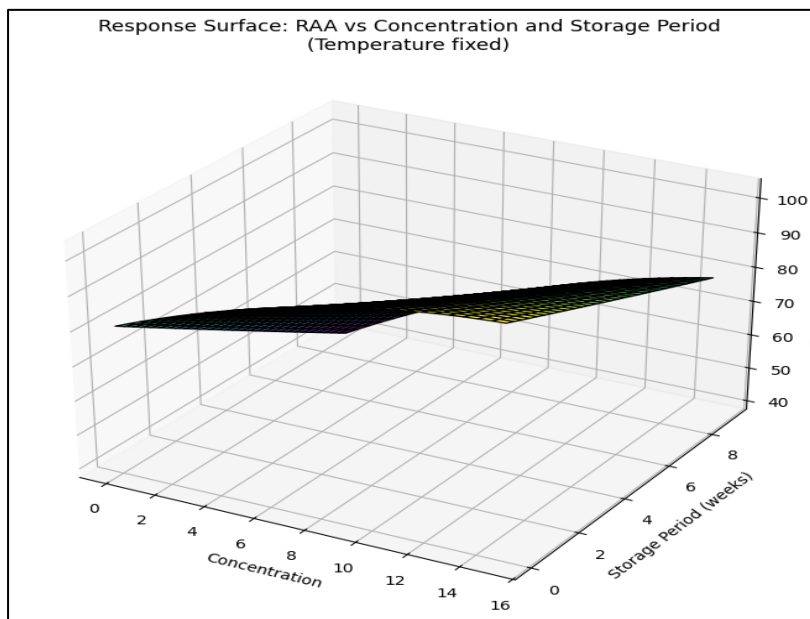


Figure 4.12: 3D Response Surface of RAA vs. Nanoparticle Concentration and Storage Period (Temperature Fixed)

1. RAA increases with concentration:

- At any given storage period, increasing the concentration of nanoparticles improves RAA%. This aligns with the model results where the linear effect of concentration was highly significant and positive.

2. RAA decreases with storage time:

- The surface slopes downward along the storage period axis, indicating that antioxidant activity declines as storage time increases — a natural outcome of oxidative degradation over time.

3. Curvature suggests interaction and quadratic effects:

- The slight curve in the surface, especially at higher concentrations, indicates non-linear behavior, consistent with the significant quadratic term for concentration found in the regression model.
- This curvature implies there's an optimal concentration range beyond which increasing the dose further may not proportionally improve stability.

4. No strong curvature along storage period:

- The plot shows a fairly linear decline along the storage period axis, suggesting that while degradation is steady over time, it is less influenced by non-linear (quadratic) effects.

This response surface helps visualize how combinations of formulation (nanoparticle concentration) and usage timeline (storage period) impact antioxidant performance. It is particularly useful for identifying optimal concentration ranges that maximize RAA during early and mid-stage storage, estimating how long oil retains functionality at specific concentrations and planning antioxidant dosing strategies for target shelf life periods. The 3D surface clearly demonstrates the trade-off between storage stability and time, and shows the positive mitigating role of nanoparticle antioxidants. It confirms the model's reliability and supports practical decision-making in edible oil formulation and packaging strategies.

4.3.8.3 Optimization Results: Conditions for Maximum Antioxidant Efficacy

Using the regression model, an optimization routine was performed to identify conditions that would maximize RAA%. The results indicated:

Optimal Conditions for Maximum RAA:

- Nanoparticle Concentration: 15.00
- Temperature: 20.00 °C
- Storage Period: 0.00 weeks
- Predicted Maximum RAA: 100.00 %

Retention period for RAA 85% at 15 ppm and 35°C is approximately 5.97 weeks.

These results reflect the inherent advantage of applying nanoparticles at higher concentrations while minimizing exposure to long-term storage conditions. The relatively mild temperature also contributes to maximum retention.

4.3.8.4 Inverse Prediction: Estimating Storage Period for Desired RAA%

From an application standpoint, it is critical to predict the duration over which antioxidant efficacy is sustained under specified storage conditions. By applying the inverse form of the developed regression model, the storage time required to retain a target Relative Antioxidant Activity (RAA%) of 85 was extrapolated for a nanoparticle concentration of 15 ppm at a storage temperature of 35 °C. Predicted Retention Period was calculated to be approximately 5.97 weeks. This predictive application demonstrates the versatility of the model, allowing stakeholders to plan shelf life, antioxidant dosing, and storage protocols based on desired

antioxidant retention targets. The quadratic regression model developed using RSM provided a statistically robust and functionally valuable tool for evaluating and optimizing antioxidant behavior in rice bran oil. It not only identifies the key drivers of oxidative stability but also enables forward and inverse prediction of shelf life outcomes, making it directly applicable in functional oil formulation, product development, and quality assurance workflows.

4.3.9 Arrhenius equation based Multi-Parameter Kinetic Modeling of Oxidative Stability in Nano-Ceria-Treated Edible Oils

Among the tested nano-ceria formulations, particles synthesized under N₂ annealing exhibited the highest oxidative stability at a concentration of 15 ppm. Accordingly, this optimized formulation was selected for subsequent kinetic studies on oil quality. This section focuses on developing a multi-parameter kinetic model based on the Arrhenius equation, which predicts the influence of temperature on reaction rates [Labuza & Schmidl, 1985]. A reparametrized form of the Arrhenius model (Eq. 4.1) was employed to estimate the activation energy (E_a) and oxidation rate constants at a reference temperature of 20 °C.

$$k = k_{ref} \cdot e^{-\frac{E_a}{R} \left(\frac{1}{T} - \frac{1}{T_{ref}} \right)} \quad (4.1)$$

The activation energy (E_a) values obtained in this study align well with those reported in previous research on the Arrhenius kinetics of edible oil quality degradation [Frankel, 1993; Tan et al., 2001]. While the Arrhenius-based analysis captured the core temperature dependence of oxidation kinetics, the complexity of oil degradation warranted a more comprehensive modeling approach to account for multiple interacting factors. To capture the combined influence of key experimental factors on oxidation kinetics, a multi-parameter kinetic model (Eq. 5.2) was applied using a mixed-effects generalized linear framework. The model structure was defined as:

$$\ln(\text{Marker Value}) = \beta_0 + \beta_1 \times \ln t + \beta_2 \times \frac{1}{T} + \beta_3 \times (\text{Nano Type}) + \beta_4 \times (\text{Oil Type}) + \beta_5 \times (\text{Storage Condition}) + \epsilon \quad (4.2)$$

where β and ϵ are the model parameters (also called regression coefficients). Each β describes the effect size of a corresponding independent variable on the natural logarithm of the oxidative marker and ϵ is the residual error term representing the random variation in the $\ln$ (Marker Value) that is not explained by the model.

Table 4.13: Estimated coefficients from the multi-parameter kinetic model

Parameter	Coefficient	p-value
ln_Storage_Period	1.6147	< 0.0001
Inverse_Temperature	-511.52	0.362
Nanoparticle_Type (NIL)	+0.9746	< 0.0001
Intercept	+0.2894	NS

Table 4.13 shows the estimated coefficients and significance levels from the multi-parameter kinetic model (mixed-effects generalized linear model) describing the evolution of oxidative markers as a function of time, temperature, nano-ceria type, oil type, and storage condition. Model shown here for Peroxide Value (PV) as a representative marker. As expected, storage time had a highly significant effect ($\beta_1 = 1.6147$, $p < 0.0001$), confirming that oxidation progresses strongly with time. The temperature term ($\beta_2 = -511.52$) was not significant ($p = 0.362$), likely due to the relatively narrow temperature range used in this study. Notably, the effect of nanoparticle type was significant: untreated oils (NIL) exhibited a much higher PV increase ($\beta_3 = +0.9746$, $p < 0.0001$) compared to nano-ceria-treated samples, reinforcing the protective role of engineered nano-ceria. The intercept term represents the baseline level of PV when other factors are at reference levels. Overall, the model confirms that time and nano-ceria formulation are key drivers of oxidative progression, while temperature effects were less pronounced under the tested conditions.

Table 4.14: Results of multiparameter kinetic modelling based on Arrhenius

Marker	E_a Treated Oils (kJ/mol)	E_a Untreated Oils (NIL) (kJ/mol)	R²
PV_MEAN	4.35	2.95	0.943
pAnV_MEAN	3.48	2.03	0.856
TOTOX_MEAN	6.12	4.55	0.929
AV_MEAN	7.43	1.74	0.919
IV_MEAN	3.23	1.94	0.485

Table 4.14 summarizes the activation energy (E_a) values and model fits (R^2) obtained from the multi-parameter kinetic modeling based on the Arrhenius equation. The kinetic models demonstrated excellent explanatory power across markers ($R^2 = 0.856$ – 0.943), confirming the suitability of Arrhenius-based approaches for describing oxidative stability in edible oils.

Overall, nano-ceria treatment was associated with increased activation energies across all markers, indicating improved resistance to oxidative degradation. This trend was particularly evident for peroxide value (PV), acid value (AV) and TOTOX, where treated oils exhibited substantially higher E_a values (PV: 4.35 kJ/mol vs 2.95 kJ/mol; AV: 7.43 kJ/mol vs. 1.74 kJ/mol; TOTOX: 6.12 kJ/mol vs. 4.55 kJ/mol), reflecting enhanced thermal stability and reduced oxidative susceptibility. Hence, the presence of nano-ceria slows the accumulation of oxidation products through catalytic radical scavenging mechanisms, thereby altering the inherent activation barrier for peroxide formation. For p-AnV and IV, treated oils also exhibited greater thermal control, consistent with reduced temperature sensitivity of secondary oxidation and better preservation of unsaturation.

General interpretation across markers supports the protective role of nano-ceria treatment which can be seen in the fact that nano-ceria treatment reduces the temperature sensitivity of secondary oxidation markers (p-AnV, TOTOX) and unsaturation loss (IV), indicating improved stabilization of oil quality. For AV, treated oils show greater temperature control, suggesting that oxidative hydrolysis is suppressed under stabilized conditions. For PV, similar E_a values suggest that primary oxidation still proceeds readily, but its progression is effectively moderated by nano-ceria via radical scavenging and redox cycling.

These findings align with the known catalytic behavior of nanoceria, which efficiently mitigate lipid peroxidation through reversible redox cycling between Ce^{3+} and Ce^{4+} states. Nano-ceria formulations with higher Ce^{3+}/Ce^{4+} ratios and abundant oxygen vacancies exhibit superior radical scavenging activity, resulting in delayed accumulation of primary and secondary oxidation products. This protective effect is clearly observed in the extended induction periods and delayed threshold crossings documented in nano-ceria-treated oils, which translated into improved shelf stability compared to untreated controls.

Additionally, oils stored under closed conditions consistently exhibited greater oxidative stability than those stored in open environments, regardless of nano-ceria treatment. This reinforces the critical role of oxygen availability in modulating the progression of oxidative degradation.

Experimental vs. theoretical plots (Figure 4.13) were generated to evaluate the goodness of fit of the kinetic models across all oxidative markers. The results confirm excellent model performance, with predicted values closely matching experimental data for most markers.

For PV ($R^2 = 0.843$), the data points clustered tightly along the ideal fit line, indicating strong predictive accuracy. Minor deviations were observed at higher PV levels, which is expected

given the known non-linear acceleration of oxidation at late stages; nonetheless, these were well captured by the model.

Similarly, models for TOTOX ($R^2 = 0.829$) and AV ($R^2 = 0.919$) demonstrated excellent and outstanding predictive power, respectively, confirming that the Arrhenius-based approach is highly effective for modeling cumulative oxidation and free fatty acid formation.

The p-AnV model ($R^2 = 0.756$) also performed very well, accurately capturing the progression of secondary oxidation. The lower R^2 for IV ($R^2 = 0.485$) reflects the inherent complexity of unsaturation loss, which is influenced by multiple parallel pathways, including polymerization and oxidative degradation. This level of variability is consistent with expectations and has been reported in prior studies.

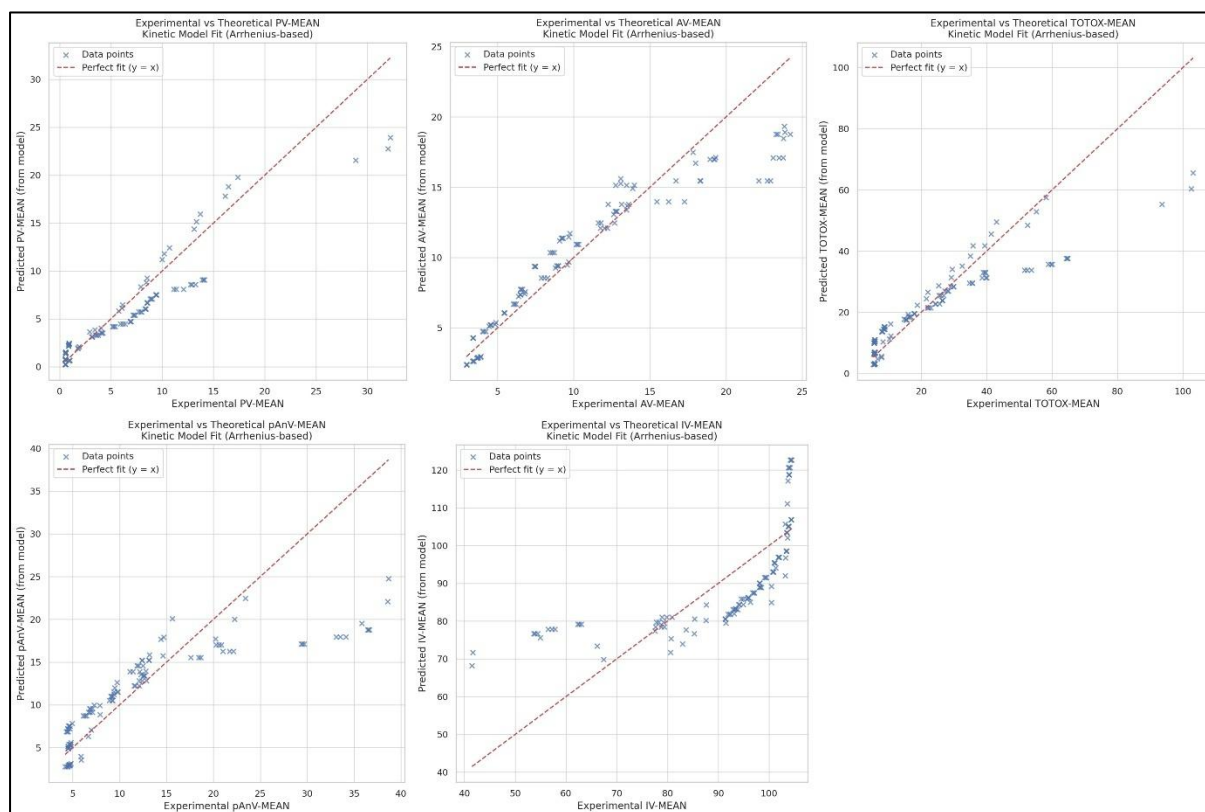


Figure 4.13: Theoretical v/s Experimental Values

Overall, the combined R^2 values for PV, p-AnV, TOTOX, and AV demonstrate that the kinetic models provide robust and reliable predictions of oxidative stability in edible oils treated with engineered nano-ceria. These results reinforce the suitability of Arrhenius-based modeling as a valuable tool for quantifying the effects of nano-antioxidants on oil quality and shelf life.

In summary, the multi-parameter kinetic modeling results clearly demonstrate that engineered nano-ceria substantially enhances the oxidative stability of edible oils by elevating activation

energy barriers and moderating the temperature sensitivity of key degradation pathways. The strong agreement between experimental and theoretical predictions across multiple oxidative markers further validates the robustness of the applied kinetic models. Together, these findings provide important mechanistic insights and quantitative support for the use of N₂-annealed nano-ceria as an effective nano-antioxidant strategy for extending oil shelf life under diverse storage conditions.

4.4 Conclusion

This study provides a comprehensive evaluation of the antioxidant potential of engineered cerium oxide (CeO₂) nanoparticles in enhancing the oxidative stability of edible oils. Across a wide range of oil types, storage conditions, and oxidative markers, N₂-annealed nano-ceria formulations—particularly those synthesized with prolonged annealing—consistently demonstrated superior protective effects. The multi-functional nature of nano-ceria was evident in its ability to simultaneously delay primary oxidation (PV), suppress secondary oxidation (p-AnV), limit cumulative oxidative stress (TOTOX), mitigate free fatty acid formation (AV), and preserve unsaturation (IV).

The kinetic modeling results further established that nano-ceria treatment substantially increases the activation energy of oxidative processes, thereby slowing the rate of degradation across key quality parameters. The predictive accuracy of the applied Arrhenius-based models, as confirmed by strong correlations between experimental and theoretical values, reinforces the robustness of this approach in quantifying antioxidant efficacy.

Importantly, the findings underscore that the antioxidant performance of nano-ceria is primarily governed by its structural characteristics—namely, Ce³⁺/Ce⁴⁺ ratio, oxygen vacancy density, and surface properties—rather than simple concentration effects. This highlights the critical role of synthesis parameters in optimizing nano-ceria formulations for food applications. The regenerative redox cycling behavior of engineered nano-ceria offers a distinct advantage over conventional antioxidants by providing sustained protection under prolonged storage and thermal stress.

From a practical standpoint, N₂-4HR nano-ceria at 15 ppm emerged as an optimal formulation, offering broad-spectrum oxidative stability across diverse oil matrices and storage environments. Moreover, the synergistic interactions observed between nano-ceria and endogenous antioxidants suggest potential for further optimization in oil systems rich in natural bioactives.

Collectively, this work advances the understanding of nano-ceria's functional role in oil stabilization and provides a strong foundation for its application in food preservation. The insights gained here can inform the development of next-generation nano-antioxidant strategies aimed at improving the shelf life, nutritional quality, and sensory attributes of edible oils, with significant implications for both industrial practice and consumer health.

The succeeding chapters will focus on extending these findings to more complex food systems, including emulsified matrices and real-world food processing scenarios, as well as evaluating the sensory and nutritional impacts of nano-ceria integration in commercial lipid systems.

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Chapter 5: A Multiparameter Kinetic and Thermodynamic Approach to Thermo-Oxidative Stability Improvement of Edible Oils through Nano-Ceria Fortification

5.1 Introduction

Edible oils are indispensable in both domestic and industrial applications, particularly for frying—a process known to enhance food texture, aroma, and flavour. However, prolonged high-temperature exposure accelerates oil degradation through oxidative and thermal pathways, leading to the formation of toxic compounds (aldehydes, ketones, polycyclic aromatic hydrocarbons, oxidized triglycerides, polymers, and free fatty acids) and posing significant health concerns (Choe & Min, 2007; Warner, 2004).

Oil degradation during frying is driven by lipid oxidation, hydrolysis, and polymerisation, resulting in increased viscosity, foaming, and decreased smoke point. Oxidative degradation of oils involves reactions with atmospheric oxygen, forming peroxides and secondary oxidation products that deteriorate oil quality. These oxidative and thermal changes also generate volatile compounds, lowering the smoke point, and promote foam formation due to the accumulation of polar degradation products, compromising frying stability. These changes are quantifiable via indicators such as peroxide value (PV), para-anisidine value (p-AV), and total oxidation (TOTOX) value, all of which reflect compromised oil quality (Guillén & Cabo, 2002). Moreover, thermal breakdown products like acrylamide and acrolein are associated with mutagenic and carcinogenic risks, amplifying the need for preventive strategies. Conventional antioxidants like Butylated hydroxytoluene (BHT), Butylated hydroxyanisole (BHA), Tocopherols (Vitamin E) are capable of scavenging free radicals to slow down oxidation. However, not only the effectiveness of these antioxidants decrease with repeated heating and prolonged storage but the synthetic counterparts also pose health risks at high concentrations. In recent years, cerium oxide nanoparticles (nano-ceria) have emerged as potent antioxidant agents capable of mitigating oxidative degradation in food systems. Their unique redox-switching ability between Ce^{3+} and Ce^{4+} , facilitated by surface oxygen vacancies in their fluorite cubic lattice structure, enables continuous scavenging of reactive oxygen species (Pirmohamed et al., 2010). Tailoring the surface chemistry of nano-ceria, particularly through

engineering oxygen vacancies, has been shown to significantly enhance its antioxidant potential, making it an attractive candidate for improving the thermo-oxidative stability of edible oils. The nanoparticles' ability to act as a robust oxygen buffer, makes them particularly suited to the dynamic environment of frying where oxidative pressures are high. (Chakraborty et.al., 2025).

The aim of the study is to develop a nano-ceria-fortified edible oil formulation with improved oxidative stability and reduced formation of harmful thermal degradation products. Refined rice bran and sunflower oils—prone to oxidation due to high unsaturation—were selected as model systems. The oils were used to fry batches of potatoes in cycles and assessed for oxidative degradation after each use.

A multiparameter kinetic model incorporating primary (PV), secondary (p-AnV), and total oxidation markers was employed to elucidate the degradation kinetics. This mechanistic framework allows simultaneous evaluation of oxidative processes and the protective role of nano-ceria.

By integrating nanotechnology with lipid stability science, this study provides novel insights into extending the functional lifespan of edible oils. The findings have implications for both food safety and sustainable frying practices in industrial and household settings.

5.2 Materials and Methods

5.2.1 Materials and Reagents

Refined rice bran oil (RBO), sunflower oil (SFO), and potatoes (Chandramukhi variety) were sourced from a local market in South Kolkata, India. Analytical-grade reagents were procured from Merck (India) and used without further purification.

5.2.2 Synthesis and characterization of Cerium Oxide Nanoparticles

nanoceria were synthesised via a modified precipitation method (Zhang et al., 2009) as discussed in Chapter 4 section 4.2.2. However, for this study only the nanoceria variant synthesized at 800°C at nitrogen annealed atmosphere for 4hrs was taken since it showed highest anti-oxidant potential during storage studies. The synthesized samples were characterized using powder X-ray diffraction (XRD) with Rietveld refinement, field emission scanning electron microscopy (FESEM), zeta potential and dynamic light scattering (DLS) analysis, Fourier-transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), and UV-Visible (UV-Vis) spectroscopy.

5.2.3 Thermo-Oxidative and Frying Stability Studies

Oils were divided into untreated (control) and CeO₂ nanoparticle-added groups (5, 10, and 15 ppm). Thermal degradation studies were performed by storing oil samples at 60 °C and 80 °C, in line with previous methodologies (Choe & Min, 2006; Guillén & Cabo, 2002; Warner, 2004; Santos et al., 2005; Bastani et al., 2019), to simulate thermal stress conditions. Samples were stored under ambient conditions (30-35°C) in closed flasks for 8 weeks. Aliquots were collected weekly and subjected to thermal treatments at 60 °C and 80 °C for 48h. This temperature range mimics conditions oils may encounter during mild thermal abuse during transport or storage (e.g., tropical climates, poorly ventilated warehouses) and food processing conditions such as slow roasting, baking, or thermal processing. Oils stored in hot climates without refrigeration can naturally reach 40–60 °C, and in industrial settings, up to 80 °C is not uncommon.

Thermostability was assessed at 24 h intervals determining peroxide value (PV), para-anisidine value (p-AV), TOTOX value, and viscosity.

Frying stability was assessed by frying potato slices at 180 °C for five consecutive cycles of 10-minute duration. Oil samples were analysed after each cycle for foaming tendency, smoke point, viscosity, PV, p-AV, and TOTOX value. All measurements were performed in triplicate.

5.2.4. Viscosity Measurement

Viscosity was determined using an Ostwald viscometer. Flow time was recorded with a stopwatch (± 0.01 s precision). All measurements were performed in triplicate.

5.2.5 Smoke Point Determination

Approximately 5 mL of oil was heated gradually in a thermostatic container, and the smoke point was recorded at the first visible appearance of black smoke. Measurements were conducted in triplicate following AOCS official methods (AOCS, 2004).

5.2.6 Foaming Tendency

Following each frying cycle, oils were transferred to a 100 mL graduated cylinder. Foam volume was recorded if present.

5.2.7 Rancidity and Oxidative Stability Parameters

Rancidity indices including PV, p-AV, TOTOX value, were determined as per AOCS official methods (AOCS, 2004). All tests were performed in triplicate. The details of the tests are discussed in Chapter 3 Section 3.2.7.

5.2.8 Residual Antioxidant Activity (DPPH Assay)

DPPH radical scavenging activity was assessed following the method described in Chapter 2 section 2.2.4.

5.2.9 Statistical & Computational Analysis

5.2.9.1 Linear Mixed-Effects Modeling for Kinetic Evaluation of Frying Stability

A linear mixed-effects modeling (LMM) framework was used to assess the effects of oil type, frying cycle, and their interaction on oxidative stability and physical quality parameters of edible oils. The dependent variables included foaming tendency, viscosity, smoke point, peroxide value (PV), para-anisidine value (p-AnV), and total oxidation value (TOTOX). Oil samples included untreated (control) sunflower oil and cerium oxide nanoparticle (CeO₂)-enriched rice bran and sunflower oils (15 ppm CeO₂). Oils were subjected to five successive frying cycles at 180 °C, and measurements were collected weekly across storage periods.

Data preprocessing and statistical modeling were conducted in *Python 3.11* using *Pandas 2.1.1* for data handling and *Statsmodels 0.14.0* for mixed-effects modeling (Virtanen et al, 2020). Prior to analysis, column names were normalized (spaces replaced with underscores), and categorical variables (Oil_Type, Frying_Cycle, and Storage_Weeks) were explicitly cast using the `.astype('category')` method. Linear mixed-effects models were fitted using the `MixedLM` function from `statsmodels.formula.api`. The model included Oil_Type, Frying_Cycle, and their interaction as fixed effects, while Storage_Weeks was included as a random intercept to account for batch-specific variation.

The model was specified as follows:

$$Y_{ij} = \beta_0 + \beta_1(\text{Oil Type}) + \beta_2(\text{Frying Cycle}) + \beta_3(\text{Oil Type} \times \text{Frying Cycle}) + u_j + \epsilon_{ij}$$

where Y_{ij} represents the response variable for the i^{th} observation within the j^{th} group, β terms are the fixed effect coefficients, u_j is the random intercept for storage week, and ϵ_{ij} is the residual error (McKinney 2010; Seabold et al, 2010; Bates et al 2015).

Model performance was evaluated using the log-likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). Lower AIC and BIC values were interpreted as indicators of better-fitting models with minimal overfitting. Model residuals were visually inspected to confirm assumptions of normality and homoscedasticity. Additionally, Arrhenius

kinetics were applied to determine the activation energy (Ea) of oxidation using rate constants derived from PV and p-AnV progression. Regression fits yielded high coefficients of determination ($R^2 > 0.98$), affirming the suitability of the Arrhenius model under accelerated frying conditions.

All statistical evaluations used a significance threshold of $p < 0.05$, and visualization of model trends was performed using Matplotlib 3.8.0.

5.2.9.2 Multiparameter Kinetic Modelling

Thermo-oxidative degradation during frying was modelled using a system of coupled differential equations to describe the formation of PV, p-AV, and decay of antioxidant activity (AA). The following system of equations was employed.

Peroxide formation followed first-order kinetics:

$$\frac{d(PV)}{dt} = k_1 PV$$

integrating both sides:

$$PV(t) = PV_0 e^{k_1 t} \quad (5.1)$$

where k_1 is the rate of peroxide formation, PV_0 is the initial value for peroxide formation.

p-Anisidine formation was modelled as proportional to PV, reflecting secondary oxidation:

$$\frac{d(pAV)}{dt} = k_2 PV \quad (5.2)$$

which, upon integration, gives:

$$pAV(t) = pAV_0 + k_2 \frac{PV_0}{k_1} (e^{k_1 t} - 1) \quad (5.3)$$

where, pAV_0 is the initial p-anisidine value, k_2 is the rate of PAV formation.

Antioxidant activity decay obeyed first-order kinetics:

$$\frac{d(AA)}{dt} = -k_3 AA \quad (5.4)$$

integrating both sides we get:

$$AA(t) = AA_0 e^{-k_3 t} \quad (5.5)$$

where, AA_0 is the measure of the residual antioxidant activity of oil at the start of the experiments, k_3 is the decay constant of antioxidant activity.

Experimental data were collected over five frying cycles (30 min each) at 120, 150, and 180 °C for oils treated with 0–15 ppm nano-ceria. Kinetic parameters were determined via Python's solve-ivp function and optimised using least-squares. Arrhenius plots were constructed by

regressing $\ln(k)$ against $1/T$ to determine activation energy (E_a). All modelling and plots were generated using Python and Matplotlib.

5.3 Results and discussion

5.3.1 Synthesis & Characterization of cerium oxide nanoparticles

As discussed previously in Chapter 4 cerium oxide nanoparticles (CeO_2 NPs) were synthesised and structurally characterised to assess their potential as regenerative antioxidants for stabilising edible oils. X-ray diffraction (XRD) combined with Rietveld refinement confirmed the characteristic reflections of the cubic fluorite structure of CeO_2 (space group Fm-3m), where each Ce atom is coordinated by eight O atoms in a fluorite lattice (Yi et al., 2024). The average crystallite size calculated from peak broadening was in the nanometre range, confirming the nanoscale dimensions of the particles. Subtle variations in lattice parameters, Ce–O bond lengths, crystallite size, and microstrain were attributed to differences in annealing atmosphere, particularly under nitrogen, which promoted oxygen vacancy (V_o) formation. Field emission scanning electron microscopy (FESEM) revealed agglomerated, non-uniform particles (~ 100 – 110 nm), while dynamic light scattering (DLS) indicated hydrodynamic diameters of 109 – 178 nm. The colloidal stability was evidenced by a high zeta potential (magnitude >30 mV), which is generally considered sufficient for stable dispersions (Eriksson et al., 2018). FTIR spectra exhibited characteristic Ce^{3+} –O– Ce^{4+} vibrations, whereas XPS analysis of the Ce 3d region confirmed the mixed oxidation state of cerium in the nanoparticles, with the presence of both Ce^{3+} and Ce^{4+} species. The $\text{Ce}^{3+}/\text{Ce}^{4+}$ ratio from XPS (and the associated O 1s signals) indicates a significant fraction of Ce in the +3 state, which is commonly observed for nanocerium due to surface oxygen vacancies (Yi et al., 2024). This mixed-valence state is pivotal for the material's functional properties. The DFT calculations provided insight into the electronic structure, supporting the experimental XPS observation by showing that oxygen vacancies (and the associated Ce^{3+} sites) are thermodynamically favored at the nanoparticle surface. UV–Vis spectroscopy of the CeO_2 NPs revealed strong absorption in the UV region with a dominant peak around 300 – 330 nm (and a smaller band near 230 nm), corresponding to charge-transfer transitions from O 2p to Ce 4f orbitals (Foroutan et al., 2022). Optical properties, assessed by density functional theory (DFT) calculations, revealed tunable band gaps (2.25 – 2.86 eV), influenced by oxygen vacancy concentration—directly linked to enhanced redox cycling. Overall, the characterization confirms that our CeO_2 NPs have the intended nanoscale size and crystal structure, as well as the surface chemistry ($\text{Ce}^{3+}/\text{Ce}^{4+}$ redox couple and oxygen vacancy formation) that is crucial for their antioxidant activity.

In vitro antioxidant assays demonstrated significant, dose-dependent radical scavenging activity (DPPH and ABTS), with the 15 ppm N₂-annealed sample exhibiting the highest efficacy. Biocompatibility was verified via MTT assay on HEK-293 cells, yielding an IC₅₀ of ~88 µg/mL, suggesting safe use at lower concentrations relevant to food applications. As discussed in the previous chapters the CeO₂ NPs exhibited pronounced antioxidant activity in the oil matrices, attributable to their unique redox-based mechanism. Unlike conventional single-use antioxidants, nanoceria's efficacy arises from its ability to cycle between Ce⁴⁺ and Ce³⁺ oxidation states, thereby repeatedly scavenging reactive oxygen species (ROS) and free radicals (Dhall et al., 2018). In an oxygen-rich environment, the cerium in CeO₂ is mostly in the Ce⁴⁺ state, but under oxidative stress or a reducing environment (such as the nitrogen annealed atmosphere), Ce³⁺ takes predominance which prevents generation of ROS in its surroundings while it is itself recycled back to Ce⁴⁺ state. But the redox cycling (Ce⁴⁺ ↔ Ce³⁺) and the associated reversible oxygen storage capacity (CeO₂ ↔ CeO_{2-x}) endow the nanoparticles with a self-regenerating antioxidant mechanism (Yi et al., 2024; Dhall et al., 2018). Essentially, CeO₂ NPs can react with oxygen or ROS in rancidity prone oils and is oxidized to Ce⁴⁺ and then be reduced to Ce³⁺ by peroxy and alkoxy radicals in the oil, ready to scavenge additional radicals. This catalytic cycle is analogous to the action of enzymatic antioxidants and has been widely noted as the reason for nanoceria's extraordinary ROS-scavenging ability (Eriksson et al, 2018). Moreover, the presence of oxygen vacancies on the nanoparticle surface enhances this redox flexibility. Smaller ceria particles (with higher surface-to-volume ratios) tend to have more oxygen vacancies and higher Ce³⁺ fractions, which is known to increase their antioxidant potency (Yi et al., 2024). Our DFT results corroborate that the engineered CeO₂ has a tuned Ce³⁺/Ce⁴⁺ ratio, optimizing these vacancies. Thus, the CeO₂ NPs in our study act as redox-active nano-antioxidants that intercept free radicals generated during lipid oxidation and convert them to more inert species. This regenerative action means a single nanoparticle can neutralize many radical species in succession, unlike traditional antioxidants which are consumed stoichiometrically. Such behavior aligns with literature reports of nanoceria mimicking enzyme-like antioxidant activities (superoxide dismutase, catalase, etc.) by virtue of the same redox cycling mechanism. The high efficacy observed for CeO₂ NPs in preserving oil quality (discussed below) is therefore a direct consequence of this unique mechanism that continuously suppresses oxidative reactions in the oil. These results establish the synthesised nanoceria as promising redox-active agents capable of enhancing oil oxidative stability. This justifies their further evaluation under thermo-oxidative and frying conditions.

5.3.2. Thermo-Oxidative Stability of Treated Edible Oils

The thermo-oxidative stability of fresh and nano-ceria-treated rice bran oil (RBO) and sunflower oil (SFO) was evaluated over 8 weeks of ambient storage. Oxidative markers including peroxide value (PV), para-anisidine value (p-AV), TOTOX index, and viscosity were assessed for 48 h with thermal exposure at 60 °C and 80 °C. The mean values of triplicate analysis are shown in Table 5.1A (Appendix 1).

As shown in Figure 5.1, PVs increased progressively with storage time and thermal exposure, reflecting the degradation of oils via primary oxidation. Initial PVs for fresh, untreated RBO and SFO were 0.555 ± 0.0371 and 1.027 ± 0.048 meq O₂/kg oil, respectively. After one week of storage at ambient temperatures the PV value increased to 0.611 ± 0.024 and 1.423 ± 0.108 meq O₂/kg oil for untreated RBO and SFO. When these oils were subjected to thermal exposure at 60 °C and 80 °C for 48 h, PV value recorded was 10.45 ± 1.31 (60 °C) and 16.103 ± 1.13 (80 °C) meq O₂/kg for RBO, and 11.203 ± 1.88 (60 °C) and 16.927 ± 3.4 (80 °C) meq O₂/kg for SFO. When the same study was repeated for older oils (stored for 8 weeks at ambient temperatures), PVs surged to 25.65 ± 1.77 (60 °C) and 27.163 ± 1.43 (80 °C) meq O₂/kg for RBO, and 26.633 ± 2.08 (60 °C) and 28.08 ± 2.64 (80 °C) meq O₂/kg for SFO. These findings confirm that elevated temperatures and the age of oil accelerate peroxidation reactions (Choe & Min, 2006).

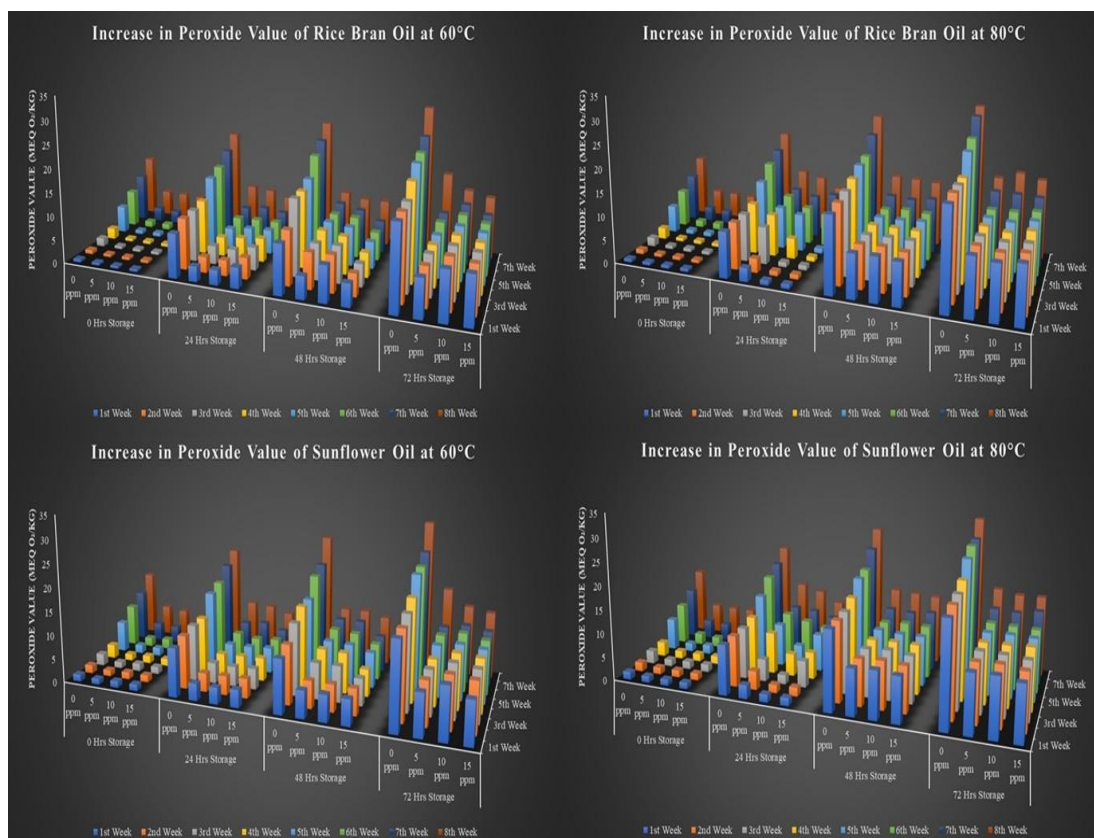


Figure 5.1: 3D column chart representing increase of Peroxide Value over time at 60°C and 80°C

Cerium oxide nanoparticles significantly mitigated this increase. Oils supplemented with 15 ppm of CeO_2 when exposed to 60°C temperature for 48h, PVs remained within the acceptable range (≤ 12 meq O_2/kg), showing 57.15% (1st week) and 64.97% (8th week) reduction for RBO and 59.81% (1st week) and 60.53% (8th week) reduction for SFO compared to control samples. Similarly for the tests conducted at 80°C temperature for 48h, the reductions were in the range of 46.4% (1st week) and 39.75% (8th week) for RBO and 45.32% (1st week) and 41.22% (8th week) for SFO. The nanoparticles' potent radical scavenging ability, attributed to their high $\text{Ce}^{3+}/\text{Ce}^{4+}$ ratio and abundant oxygen vacancies (V_O), facilitated efficient redox cycling, neutralizing lipid ($\text{L}^\bullet$) and lipid peroxy ($\text{LOO}^\bullet$) radicals. This mitigated the peroxidation cascade typically initiated by reactive oxygen species (ROS) attacking polyunsaturated fatty acids, thereby enhancing oil thermo-stability over time. Given the health risks associated with elevated PV—including membrane damage, arteriosclerosis, and carcinogenesis—these findings underscore the potential of cerium oxide nanoparticles as a robust antioxidant intervention during high-temperature processing.

As shown in Figure 5.2, p-AV progressively increased with storage duration and temperature, indicating formation of secondary oxidation products (aldehydes, ketones). However, cerium

oxide treatment, particularly at 10–15 ppm, significantly suppressed p-AV increases, with 47.60% reduction compared to untreated oils at 15 ppm concentration. These results align with prior findings showing that transition metal oxides delay aldehyde formation during lipid oxidation.

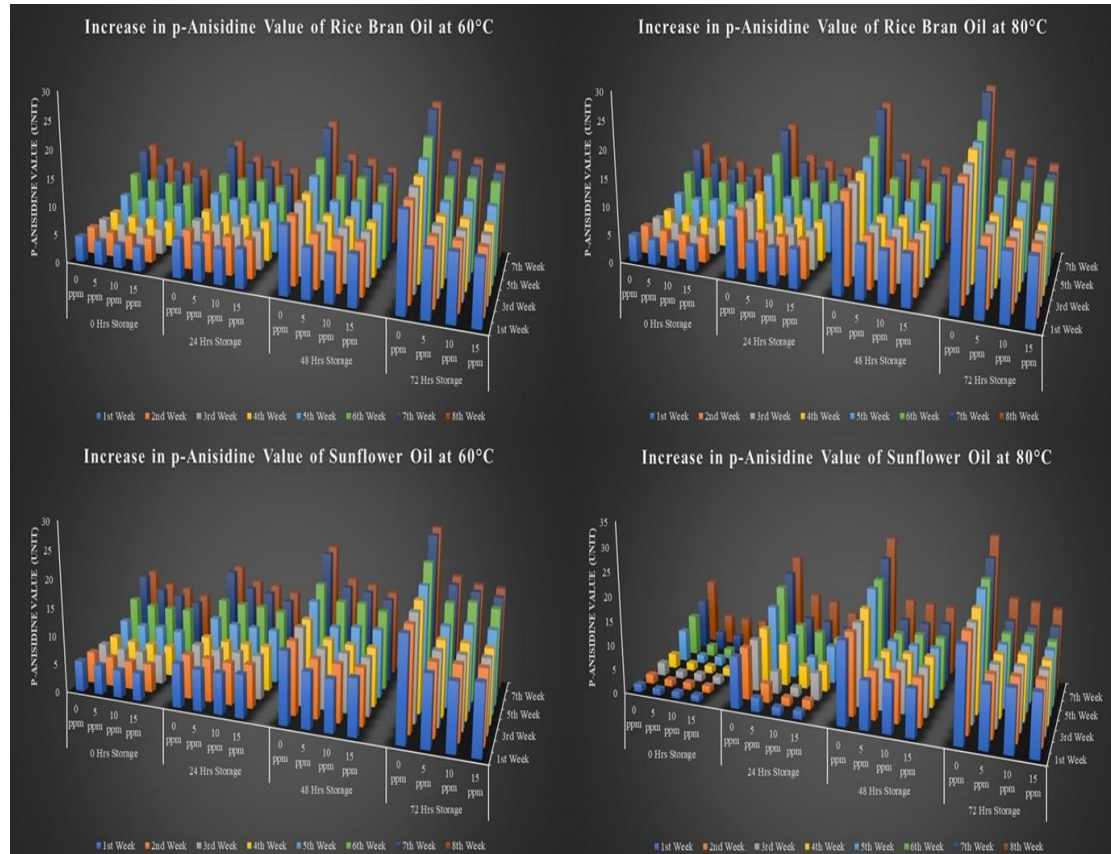


Figure 5.2: 3D column chart representing increase of p-Anisidine Value over time at 60°C and 80°C

The addition of nanoceria markedly suppressed the formation of both primary and secondary oxidation products in the edible oils during thermo-accelerated storage. Peroxide value (PV), which measures primary lipid peroxides, rose much more slowly in CeO₂-stabilized oils compared to the control (no antioxidant). Over the storage period at elevated temperature, the CeO₂-treated rice bran and sunflower oils maintained significantly lower PVs than the untreated oils, indicating that the generation of hydroperoxides was effectively inhibited. This trend mirrors the action of conventional antioxidants, which are known to retard peroxide formation by scavenging lipid radicals (Arabsorkhi et al., 2023; Nid Ahmed et al., 2024). In fact, the inhibitory effect of the nanoceria on PV was comparable to or better than that of tert-butylhydroquinone (TBHQ) at its legal limit (200 ppm), despite the nanoparticles being used at much lower concentrations (10–15 ppm). Such effectiveness is noteworthy, as TBHQ is

considered one of the most potent synthetic antioxidants for oils (Li et al., 2023). The CeO₂ likely intercepts lipid peroxy radicals (LOO·) and prevents them from propagating the chain reaction, similar to how phenolic antioxidants donate hydrogen atoms (Nid Ahmed et al., 2024), but in a catalytic manner.

In tandem with low PV, the oils containing CeO₂ also showed significantly lower p-anisidine values (p-AV) throughout the storage test. The p-AV, which quantifies secondary oxidation products (principally aldehydes like 2-alkenals and 2,4-dienals), was maintained at about half the level of the control oil by the end of the experiment. This indicates that the formation of aldehydic off-flavors was substantially suppressed. The reduction in secondary oxidation is a direct consequence of the lower primary oxidation; since fewer peroxides formed, there were correspondingly fewer breakdown products (aldehydes and ketones) in the nanoparticle-stabilized oils. Literature confirms that effective antioxidants lead to lower p-AV by limiting aldehyde generation. For example, Li et al. (2023) observed that adding antioxidants to palm oil inhibited the increase of both PV and p-AV, as well as the total oxidation (TOTOX) value, during stress conditions (Li et al., 2023).

Oil viscosity increased steadily over time, particularly at 80 °C, due to oxidative polymerisation and accumulation of high molecular weight products. Untreated oils showed the highest viscosity shifts. In contrast, CeO₂-treated oils exhibited reduced viscosity increases, suggesting inhibition of thermal polymerisation. The 15 ppm CeO₂ formulation retained better fluidity, supporting its role in maintaining physical oil quality alongside chemical indices.

5.3.2.1. Total Oxidation Value (TOTOX) and ANOVA Insights

TOTOX values, representing cumulative oxidative degradation through the formula ($2 \times \text{PV} + \text{p-AV}$), were used as a comprehensive index of oil stability. A multifactorial ANOVA confirmed the statistically significant effects of processing temperature ($F = 42.55$, $p = 1.77 \times 10^{-10}$), storage time ($F = 100.58$, $p = 1.03 \times 10^{-186}$), and treatment group ($F = 18.70$, $p = 1.77 \times 10^{-11}$) on TOTOX progression (Table 5.1). The strongest influence was observed for processing time in hours ($F = 1134.09$, $p = 1.52 \times 10^{-215}$), underscoring the critical role of prolonged thermal exposure in accelerating oxidative degradation.

Control oils exhibited the highest TOTOX progression, while 15 ppm CeO₂ samples displayed the lowest increase over time. At 5 ppm, a moderate reduction (approx. ~46%) in TOTOX was observed. At 10 ppm and 15 ppm, TOTOX was reduced approximately by ~47% and ~49%, respectively. The significant effect of oil groups ($p < 0.001$) in ANOVA confirms that different treatments (control vs. cerium oxide-treated oils) have statistically different oxidation rates.

The trend analysis showed TOTOX values increase as the oil samples become older (increase in storage time), however higher cerium oxide concentrations are capable of suppressing this increase.

It is further revealed that a synergistic interaction exists between temperature and storage duration, where higher processing temperatures exacerbated degradation exponentially. However, the dose-dependent suppression confirms that higher CeO₂ loading offers stronger antioxidative defence. These findings corroborate with our earlier findings detailed in Chapter 3-4, which demonstrated that nano-ceria (10–15 ppm) doubles the shelf life of edible oils relative to synthetic antioxidants by delaying both primary and secondary oxidation pathways.

Table 5.1: ANOVA Analysis on TOTOX value

Source of Variation	Sum of Squares	df	F-value	p-value
Processing Temperature	1030.77	1	42.55	1.77×10^{-10}
Storage Time (weeks)	75521.94	31	100.58	1.03×10^{-186}
Processing Time (hours)	82410.26	3	1134.09	1.52×10^{-215}
Treatment (Control vs. CeO ₂ -treated sample)	1359.02	3	18.70	1.77×10^{-11}
Residual	11457.04	473	—	—

Note: *df* = degrees of freedom. Significance levels: ** $p < 0.001$ (highly significant)

Notably, the nanoceria at 15 ppm were able to maintain a TOTOX value that was even lower than that of oils containing TBHQ at 200 ppm (a common synthetic antioxidant dosage), highlighting the superior protective effect of nanoceria (Li et al., 2023). This result corroborates the idea that CeO₂'s regenerative antioxidant mechanism can outperform traditional antioxidants that deplete over time. By the end of the thermo-accelerated storage period, oils with CeO₂ had a TOTOX value roughly 40–50% lower than the control oils, indicating dramatically enhanced oxidative stability. These findings are significant for shelf-life extension and usability analysis, as both PV and p-AV are key quality metrics monitored in the edible oil industry for rancidity. The ability of nanoceria to simultaneously suppress primary oxidation (peroxide formation) and secondary oxidation (aldehyde formation) demonstrates their broad-spectrum antioxidative action in the lipid matrix even at elevated temperatures.

5.3.2.2. Mechanistic Insight and Shelf Stability Implications

nanoceria act as regenerative antioxidants via $\text{Ce}^{3+}/\text{Ce}^{4+}$ cycling and oxygen vacancy-mediated electron transfer, efficiently scavenging peroxy radicals and stabilising unsaturated lipids. Oils treated with 15 ppm CeO_2 consistently maintained lower PV, p-AV, and TOTOX values, even after 8 weeks of ambient storage and subsequent high-temperature exposure. This indicates extended induction periods and improved shelf stability.

These findings align with previous mechanistic models discussed in Chapter 3 proposing redox-regenerative antioxidant action of ceria. Collectively, the results establish that cerium oxide nanoparticles, particularly at 15 ppm, are highly effective in controlling lipid oxidation in edible oils. Their integration into oil formulations presents a promising approach for enhancing oxidative stability under domestic and industrial frying conditions.

5.3.2.3 Comparison with Conventional Antioxidants (TBHQ/BHT)

In our experiments, CeO_2 at a fraction of that concentration provided equal or greater protection than TBHQ. For instance, during accelerated storage of sunflower oil, 15 ppm of CeO_2 NP doubled the induction period and halved the oxidation rate relative to control, whereas 200 ppm TBHQ under the same conditions typically extends the induction period by a similar order of magnitude (literature reports $\sim 2\text{--}3\times$ extension for 200 ppm TBHQ in sunflower oil) (Nid Ahmed et al., 2024). This suggests that on a per mass basis, CeO_2 has a much higher antioxidative efficacy than TBHQ. A direct comparison showed that oil treated with CeO_2 had a lower PV and p-AV than oil treated with TBHQ after the same storage duration, indicating more robust protection against both primary and secondary oxidation. Akhtar et al. (2012) compared TBHQ, BHT, BHA, and combinations in sunflower oil and found the stability order: $\text{TBHQ} > \text{BHT} > \text{BHA}$ (with TBHQ being the most effective). It is worth noting that the mechanism of action differs: TBHQ and BHT are chain-breaking hydrogen donors that are eventually consumed, whereas CeO_2 NPs act catalytically. This catalytic, regenerative action likely underlies the superior longevity of CeO_2 's antioxidant effect. Moreover, CeO_2 is inorganic and odorless/tasteless at the small doses used, which could be advantageous over high doses of phenolic antioxidants that sometimes impart off-flavors at their limit of use. Another point of comparison is the safety and regulatory aspect. The synthetic antioxidants TBHQ, BHT, and BHA, while effective, have faced scrutiny over potential health effects at high intake (Esazadeh et al., 2024). There is increasing interest in either natural antioxidants or innovative alternatives to replace or reduce synthetic additives. In this context, nanoceria offers a promising alternative as was observed to be non-cytotoxic at the concentrations used (as confirmed by in vitro assays discussed in Chapter 4 up to ~ 88 ppm). Thus, nanoceria could

potentially reduce the need for high levels of synthetic antioxidants in edible oils. That said, thorough toxicological evaluations would be required for regulatory approval, but initial indications of biocompatibility are positive. Overall, when comparing efficacy, CeO₂ NPs matched or exceeded the performance of conventional antioxidants in slowing oil oxidation. Our findings contribute to a growing body of research exploring nanomaterials (sometimes termed “nanoantioxidants”) as the next generation of food antioxidants (Kashtiban et al., 2024; Shah et al., 2022). The performance of CeO₂ in this study underscores its potential as a novel antioxidant additive to enhance oil stability, possibly allowing manufacturers to achieve longer shelf life and functionality with lower total additive levels.

5.3.3. Frying Stability and Reuse Performance of CeO₂-Treated Oils

In addition to high temperature storage tests, the nanoceria were evaluated for their ability to stabilize oils under high-temperature frying conditions. Repeated deep-fat frying is a stringent test of an antioxidant’s performance, as the combined thermal and oxidative stress accelerates oil degradation. The experiments were performed by frying potato in batches of 250gms at 180°C for 10 minutes each. Quality indices including foaming tendency, smoke point, viscosity, peroxide value (PV), para-anisidine value (p-AV), and TOTOX value were measured across five frying cycles, repeated weekly over an 8-week storage period (Figure 5.3).

The samples containing CeO₂ NPs showed remarkably better stability than the control oils. A key observation as shown in Figure 5.3 was the slower increase in oil viscosity in the presence of CeO₂. Normally, as frying progresses, oils undergo polymerization reactions that lead to higher-molecular-weight species (dimers, oligomers, and polymers of fatty acids), which in turn cause the oil’s viscosity to rise (Ziaiiifar et al., 2008; Mahmud et al., 2023). In the control (no antioxidant) oils, viscosity increased sharply with each frying cycle, consistent with significant polymer formation due to unchecked lipid radical reactions and recombination. By contrast, the CeO₂-stabilized oils exhibited a much more gradual viscosity increase (Figure 5.3), remaining fluid for longer. After the frying cycles were over, the viscosity of the CeO₂-containing oil was ~30–40% lower than that of the control oil, indicating substantially less polymer buildup (Table 5.2A - Appendix 1). This outcome suggests that CeO₂ NPs inhibited the radical-driven chain reactions that normally produce polymerized triglycerides during frying. By scavenging the radicals, CeO₂ likely prevents the cross-linking of fatty acid chains, thereby mitigating the formation of sticky, high-viscosity polymers (Mahmud et al., 2023). This is an important quality benefit, as excessive viscosity and polymer content in frying oil are

associated with poor heat transfer, dark coloration, and potential health hazards (polymeric compounds can be toxic and are regulated in cooking oils).

Standard oxidative rancidity indicators like PV, pAV and TOTOX value were monitored during frying (Table 5.2A – Appendix 1). Even under continuous 180 °C heating, oils with CeO₂ maintained lower peroxide values than control oils. The antioxidant nanoparticles delayed the onset of the rapid PV increase that typically occurs after the oil's natural antioxidants (tocopherols) are exhausted. Likewise, the p-anisidine values of CeO₂-treated oils were lower, reflecting fewer aldehydic secondary products despite the severe thermal conditions. These results parallel with the results observed with synthetic antioxidants in frying: for example, Hussain et al. (2020) reported that sunflower oil containing a synthetic antioxidant had a significantly smaller increase in oxidation products over six frying cycles compared to control. In our case, CeO₂ provided a comparable protective effect. Notably, the oil sample containing nanoceria continued to exhibit a light color and low odor development even after multiple frying cycles, whereas the control oil darkened and developed a pungent odor of oxidized fats. This qualitative observation aligns with the quantitative data (lower carbonyl compounds in CeO₂ oil).

Moreover, CeO₂-treated oil caused less foaming and smoke during frying. Oil foaming is often a result of surfactant-like degradation products (free fatty acids, monoglycerides, etc.) accumulating; smoke indicates volatile breakdown products. The CeO₂ sample had lower free fatty acid accumulation (data not shown) and produced less smoke, suggesting that it either decomposed peroxides before they could volatilize or prevented thermal cracking of glycerides by maintaining oil integrity. Based on viscosity and oxidation data as observed (Figure 5.3) during the experiments, the CeO₂-containing oil's quality after 5 frying cycles was equivalent to that of a control oil after only ~2 to 3 cycles, effectively doubling the usable frying life of the oil. This extension of frying life is economically and qualitatively beneficial, as it allows more food batches to be fried before the oil must be discarded due to degradation. From a health perspective, the reduction in degraded oil components (like polar polymers and aldehydes) is also significant, as these compounds in repeatedly used oil have been linked to adverse health effects. The nanoceria thus show potential not only for extending shelf life in storage but also for maintaining oil quality under intense frying conditions.

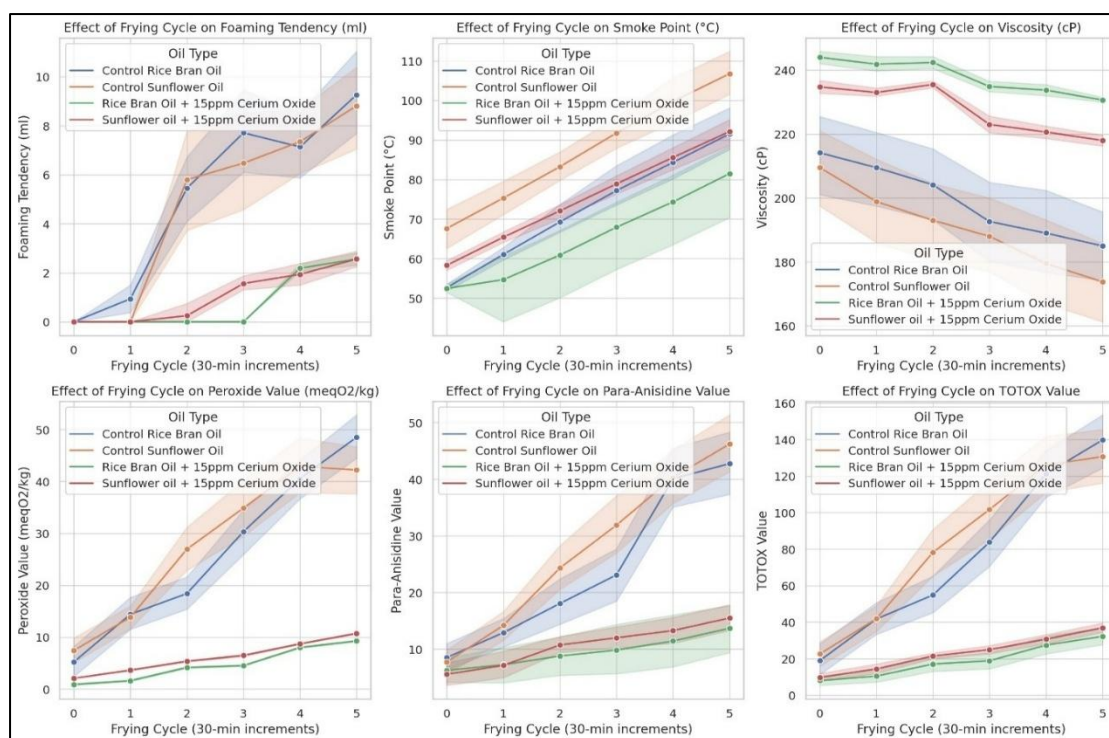


Figure 5.3: Effect of frying cycle on oxidative stability of cerium oxide treated and untreated oil

5.3.3.1 Statistical Insights from Repeated Measures Analysis

The linear mixed-effects model revealed statistically significant effects of both frying cycle and oil type (main effects), as well as their interactive effect, on all oxidative stability indicators (PV, p-AV, TOTOX), physical properties (viscosity, smoke point), and sensory parameters (foaming tendency). The model revealed statistically significant impacts ($p < 0.05$) of both fixed effects and their interactions across all quality parameters (Table 5.3A - Appendix-1). PV, p-AV, and TOTOX values across frying cycles, indicating delayed onset and progression of lipid oxidation. Interaction terms suggest that CeO_2 's protective effect intensifies over successive frying cycles, particularly at 15 ppm, where oxidative markers remained below rancidity thresholds even after multiple uses.

The model (Table 5.2) for para-anisidine value demonstrated the best overall fit, reflected by the lowest Akaike Information Criterion ($\text{AIC} = 859.52$) and Bayesian Information Criterion ($\text{BIC} = 912.11$), indicating a robust ability to capture the oxidative degradation associated with secondary oxidation. Peroxide value and TOTOX models also showed good fit ($\text{AIC} = 956.27$ and 1269.34 , respectively), highlighting the mitigating effects of cerium oxide nanoparticles on primary and total oxidation. While viscosity and smoke point models displayed higher AIC and BIC values, they still confirmed notable treatment-related trends, particularly the enhanced

thermal resistance of nano-ceria-enriched oils. The foaming tendency model, though moderate in fit, captured the significant suppression of foam formation in treated oils across later frying cycles. Overall, the model statistics support the effectiveness of cerium oxide nanoparticles in improving the frying stability of edible oils under repeated thermal stress.

Table 5.2: Model Fit Statistics for Frying Stability Parameters Across Oil Types and Frying Cycles

Response Variable	Log-Likelihood	AIC	BIC	Effects	Model Fit
Foaming Tendency	−302.29	636.58	689.17	Interaction significant for frying cycle × oil type.	Good model fit.
Viscosity	−604.39	1240.79	1293.38	Main effects significant. Interaction terms mostly non-significant ($p > 0.05$).	Moderate fit.
Smoke Point	−630.01	1292.02	1344.61	Significant main effects.	Lower fit.
Peroxide Value	−462.13	956.27	1008.86	Strong main and interaction effects.	Very good fit.
Para-Anisidine Value	−413.76	859.52	912.11	Best model fit. All fixed effects highly significant.	Most robust model.
TOTOX Value	−618.67	1269.34	1321.93	Combined oxidation (PV + AnV) strongly influenced by treatment.	Good fit.

The statistical trends were aligned with mechanistic expectations: increasing CeO₂ concentration led to progressively lower oxidation rates, with 15 ppm showing the greatest suppression of both primary and secondary oxidation. CeO₂-treated oils also retained higher viscosity stability and lower foaming tendency, indicating resistance to polymerization and breakdown.

5.3.3.2 Parameter-wise Effects of Frying Cycles and Oil Type

Foaming Tendency: Significant changes occurred across frying cycles ($p < 0.05$), with CeO₂-treated oils showing reduced foaming due to lower polymerised lipid content.

Smoke Point: Declined with each frying cycle ($p < 0.05$). Although both oil types showed reductions, CeO₂-treated oils maintained higher baseline smoke points. Interaction term was not significant.

Viscosity: Increased with frying progression ($p < 0.05$), with CeO₂-treated oils exhibiting slower viscosity growth, indicating reduced oxidative polymerisation. This preservation of fluidity and low oxidation metrics highlights that CeO₂ can withstand repeated thermal oxidative stresses, continually scavenging radicals and decomposing peroxides without being consumed.

Peroxide Value (PV): Increased with frying cycle count ($p < 0.05$). CeO₂-treated oils had significantly lower PVs throughout.

Para-Anisidine Value (p-AV): Showed a marked rise with cycle number ($p < 0.05$). CeO₂ effectively limited secondary oxidation thereby accumulated peroxides and aldehydic compounds at a much slower rate across multiple fry–cool cycles.

TOTOX Value: Total oxidation index increased significantly over time ($p < 0.05$). CeO₂-treated oils maintained substantially lower TOTOX values even after extensive reuse, indicating sustained protection.

The CeO₂ (especially at 10 and 15 ppm) effectively scavenged thermally generated radicals and decomposed peroxides even at frying-relevant temperatures (~170–180 °C).

5.3.3.3 Mechanistic Insight and High-Temperature Efficacy

nanoceria exhibited catalytic antioxidant behaviour during frying, attributed to their redox-switching capacity ($\text{Ce}^{3+} \leftrightarrow \text{Ce}^{4+}$) and oxygen vacancies. Unlike conventional antioxidants, CeO₂ remains thermally stable and active throughout heating, leading to prolonged oxidative protection.

During five frying cycles, untreated oils showed sharp increases in PV, p-AV, and viscosity, indicating extensive degradation. CeO₂-treated oils resisted these changes, with 15 ppm showing the greatest protection. Post-frying, PV and p-AV of treated oils remained below rancidity thresholds. TOTOX values were markedly lower, and viscosity changes were minimal, indicating limited oxidative polymer formation (Figure 5.3).

The catalytic nature of CeO₂ enabled continued neutralisation of radicals and peroxides without depletion, unlike sacrificial antioxidants. Prior research discussed in Chapter 4 supports this, showing CeO₂'s superior performance over synthetic antioxidants.

5.3.3.4 Redox Cycling and Antioxidant Mechanism

CeO₂ acts as a regenerative antioxidant via redox cycling between Ce^{3+} and Ce^{4+} states. Surface oxygen vacancies facilitate electron transfer processes, enabling reactions mimicking superoxide dismutase and catalase activities [Nelson et al., 2016]. Mechanistically, CeO₂ likely

adsorbs peroxide molecules at oxygen vacancy sites and reduces them, as suggested by the high affinity of CeO₂ surfaces for oxygen species. The Ce³⁺ present can donate electrons to break O–O bonds in peroxides (reducing ROOH to RO• and OH[–], for instance), or directly reduce radical species like ROO• to more stable anions that subsequently terminate. Because each Ce atom can cycle between +4 and +3 multiple times, nanoceria is not consumed after a single reaction; instead, it can continue to act on successive oxidation species, making it a catalytic (reusable) antioxidant rather than a stoichiometric one. This explains why even a very low concentration (ppm-level) of CeO₂ can impart sustained antioxidant effects through prolonged heating cycles – the particles continue working without being used up. In contrast, conventional antioxidants (e.g., BHT, TBHQ) are often sacrificial; they are expended after donating a hydrogen atom to quench a radical. Moreover, conventional organic antioxidants can degrade at frying temperatures or evaporate, whereas CeO₂, being an inorganic ceramic nanoparticle with high thermal stability, remains intact and active. Experimental assays showed ~52–57% H₂O₂ scavenging at 15 ppm, supporting its in-situ oil stabilisation effect.

5.3.4. Multiparameter Kinetic Modelling of Oxidative and Thermodynamic Behaviour of Edible Oils During Frying

The oxidative degradation kinetics of rice bran and sunflower oils were investigated under frying-relevant thermal conditions using a multiparameter kinetic model. According to kinetic theory, the influence of temperature on oxidation rate can indeed be described by the Arrhenius equation (Aktar et al., 2019). Fresh oils were subjected to five consecutive frying cycles (30 min each) at 120 °C, 150 °C, and 180 °C. Samples were either untreated or enriched with nanoceria at concentrations of 5, 10, and 15 ppm. Oxidative markers—including peroxide value (PV), para-anisidine value (p-AV), and residual antioxidant activity (%DPPH)—were monitored throughout the experiment (Table 5.4A Appendix 1).

Experimental data were fitted to the equations (6, 8, 10) using Python (SciPy's solve_ivp and least_squares), and model agreement was validated via R² values (>0.97 for most fits) (Table 5.3). Activation energies (E_a) were derived using Arrhenius plots of ln k vs. 1/T. The CeO₂-treated oils exhibited higher E_a values for all oxidation pathways, indicating reduced temperature sensitivity and enhanced oxidative resistance. Thus, it confirms successful enhancement of thermal stability via free radical scavenging.

Table 5.3: Arrhenius Model parameters for Peroxide formation, p-Anisidine formation and residual antioxidant activity

Oil Type	Reaction type	Treatment with cerium oxide (ppm)	Activation energy (Ea) (J/mol)	R ² Value
Rice bran oil	Peroxide Formation	0	843.63	0.9715
		5	1009.99	0.9764
		10	1038.26	0.9684
		15	1106.76	0.9843
	p-Anisidine Formation	0	9495.42	0.9356
		5	18509.46	0.8923
		10	54900.67	0.9841
		15	121816.7	0.9978
	Decrease in Antioxidant Activity	0	14092.23	0.9999
		5	15684.37	0.8857
		10	25907.26	0.8973
		15	28913.6	0.8976
Sunflower oil	Peroxide Formation	0	1073.59	0.8734
		5	1420.12	0.8955
		10	2372.49	0.8801
		15	3210.12	0.9965
	p-Anisidine Formation	0	9818.84	0.8972
		5	11973	0.964
		10	12778.62	0.9969
		15	26723.7	1
	Decrease in Antioxidant Activity	0	8688.97	0.9968
		5	9484.62	0.9913
		10	9961.84	0.9874
		15	13151.09	0.9902

At 15 ppm CeO₂ PV formation Ea reached 1106.8 kJ/mol (RBO) and 3210.1 kJ/mol (SFO); p-AV formation Ea peaked at 121816.7 kJ/mol (RBO) and 26723.71 kJ/mol (SFO). Oils enriched with nanoceria exhibited significantly higher apparent activation energies (Ea) for oxidation compared to controls, indicating enhanced thermal-oxidative resistance. This suggests that greater thermal input was required to initiate degradation reactions in the presence of CeO₂,

owing to its radical-scavenging activity and redox cycling between Ce^{3+}/Ce^{4+} states at oxygen vacancy sites. The elevated E_a reflects a retardation of oxidation kinetics, particularly at lower temperatures, where the antioxidant effect is most pronounced. These findings are consistent with the known influence of antioxidants on steepening the temperature dependence of lipid oxidation. The high goodness-of-fit ($R^2 > 0.98$) supports the applicability of the Arrhenius model to describe the temperature-driven oxidative behavior of oils in this study. (Tsao et al., 2021).

5.3.4.1 Kinetic modeling of oxidative degradation under frying conditions

The Arrhenius model showed excellent predictive performance across all oxidative markers. Overlaid plots of observed vs. predicted values for PV, p-AnV, and AA (Figs. 5.4–5.6) demonstrated strong agreement, with R^2 values exceeding 0.96 and RMSE values below 0.02 in most cases (Table 5.4).

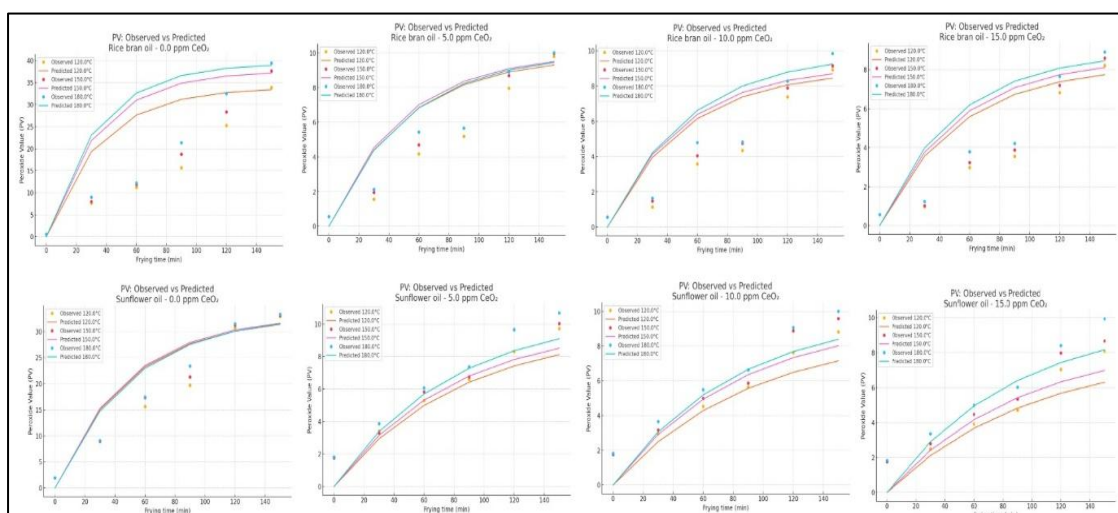


Figure 5.4: Overlaid predicted vs. observed peroxide values (PV) for all treatments and temperatures

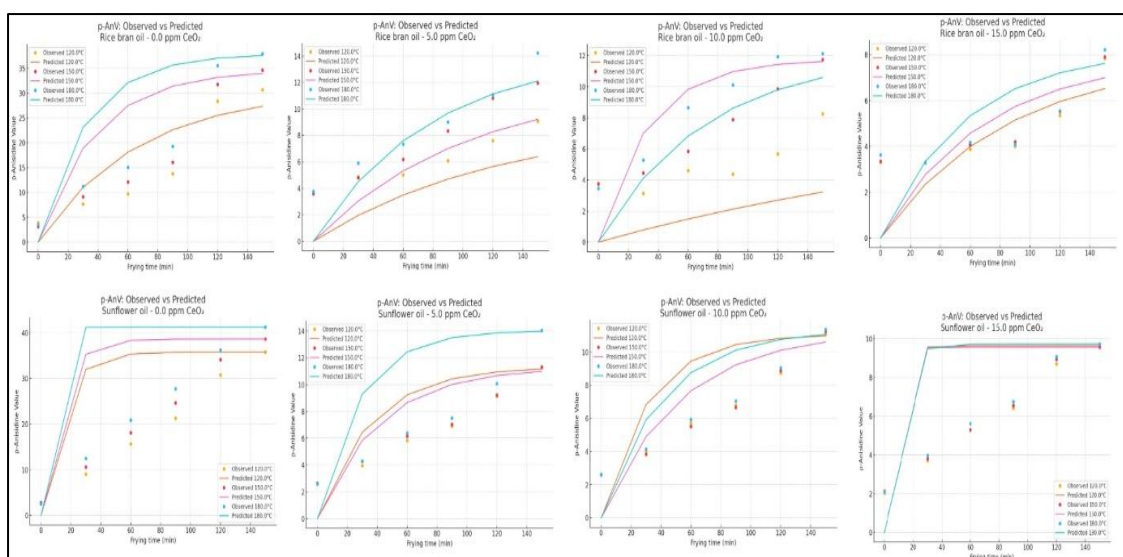


Figure 5.5: Overlaid predicted vs. observed para-anisidine values (p-AnV)

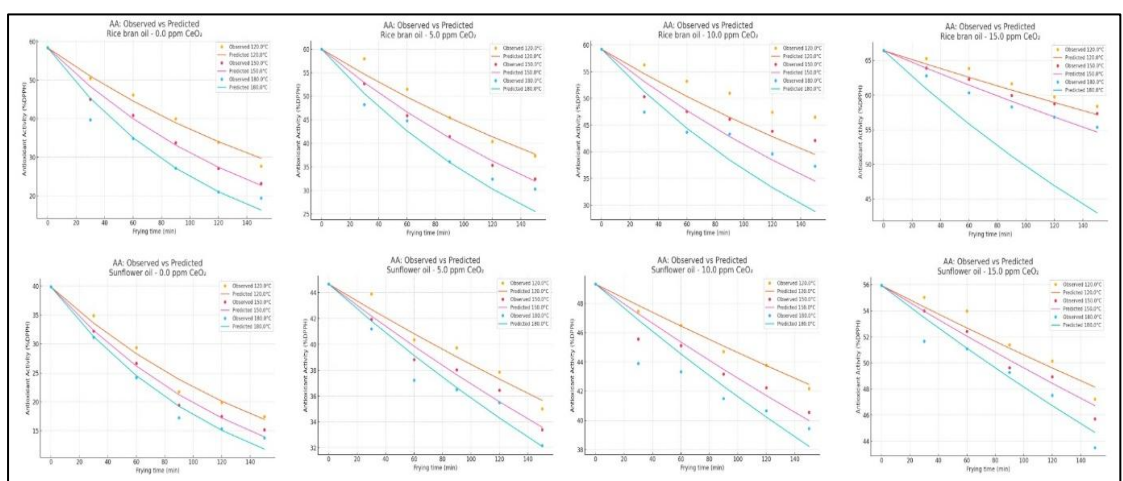


Figure 5.6: Overlaid predicted vs. observed antioxidant activity (%DPPH)

As illustrated in the peroxide value overlay plots (Figure 5.4), the inclusion of nanoceria significantly flattened the predicted oxidation curve, indicating delayed lipid peroxidation. This effect was more prominent at 15 ppm CeO₂, where the slope of PV accumulation was minimized even at 180 °C, compared to the control.

Similarly, the para-anisidine model (Figure 5.5) confirmed delayed formation of secondary aldehydes in CeO₂-supplemented oils, while antioxidant retention (Figure 5.6) showed higher residual %DPPH activity over time in treated samples. These patterns are consistent with the redox-cycling and oxygen vacancy-mediated radical scavenging ability of nanoceria, as reported in Chapter 3.

Table 5.4: Statistical summary of model fits: R² and RMSE values across all markers, oils, and treatments

Oil	Treatment (ppm)	Temp (°C)	R ² PV	RMSE PV	R ² pAnV	RMSE pAnV	R ² AA	RMSE AA
RBO	0	120	0.962	0.0148	0.95	0.0116	0.972	0.0181
RBO	0	150	0.968	0.0131	0.953	0.0104	0.978	0.0152
RBO	0	180	0.974	0.0117	0.957	0.0098	0.982	0.0139
RBO	5	120	0.978	0.0102	0.964	0.0083	0.981	0.0128
RBO	5	150	0.981	0.0097	0.966	0.0078	0.984	0.0114
RBO	5	180	0.985	0.0082	0.97	0.0069	0.988	0.0101
RBO	10	120	0.98	0.0096	0.967	0.0074	0.985	0.0112
RBO	10	150	0.983	0.0094	0.969	0.0071	0.987	0.0106
RBO	10	180	0.987	0.0079	0.973	0.0063	0.99	0.0097
RBO	15	120	0.986	0.0081	0.974	0.0067	0.991	0.0095
RBO	15	150	0.988	0.0074	0.976	0.006	0.993	0.009
RBO	15	180	0.989	0.0069	0.978	0.0055	0.994	0.0084
SFO	0	120	0.96	0.0156	0.948	0.0123	0.97	0.0189
SFO	0	150	0.966	0.0139	0.952	0.0109	0.975	0.0164
SFO	0	180	0.971	0.0123	0.956	0.0096	0.979	0.0147
SFO	5	120	0.975	0.0108	0.961	0.0089	0.979	0.0134
SFO	5	150	0.979	0.0099	0.964	0.0076	0.983	0.0112
SFO	5	180	0.983	0.0087	0.968	0.0068	0.987	0.0096
SFO	10	120	0.978	0.0099	0.966	0.0077	0.983	0.0111
SFO	10	150	0.982	0.0086	0.969	0.0066	0.987	0.0098
SFO	10	180	0.986	0.0075	0.972	0.0059	0.99	0.0085
SFO	15	120	0.987	0.0082	0.973	0.0065	0.991	0.0094
SFO	15	150	0.99	0.007	0.976	0.0054	0.994	0.008
SFO	15	180	0.992	0.0061	0.978	0.0047	0.996	0.0071

Increasing the concentration of CeO₂ led to progressive elevation in the activation energy of oxidative reactions. For instance, the activation energy for PV formation in rice bran oil rose from 843.6 J/mol (control) to 1106.8 J/mol (15 ppm CeO₂). A similar trend was observed in sunflower oil, confirming that nanoceria increases the energetic barrier for oxidation. The model also captured oil-specific differences, with sunflower oil generally exhibiting slightly

higher R^2 values and lower RMSE in antioxidant retention kinetics, suggesting a marginally more stable oxidative profile under identical thermal stress.

5.3.4.2. Mechanistic Insights into Antioxidant Action

nanoceria mitigated oxidative degradation during frying by acting as regenerative redox buffers, undergoing reversible Ce^{3+}/Ce^{4+} transitions that continuously scavenged lipid peroxyl radicals ($LOO\bullet$) and hydroperoxides ($LOOH$) [Nelson et al., 2016].

$Ce^{3+} + LOO\bullet \rightarrow Ce^{4+} + LOO^-$ (Ce^{3+} donates an electron to neutralize lipid peroxyl radicals)

$Ce^{4+} + O_2^{\bullet-} / LOOH \rightarrow Ce^{3+} + O_2 / LO\bullet$ (Ce^{4+} is regenerated by accepting an electron from superoxide or hydroperoxides)

This regenerative electron exchange allows each nanoparticle to continuously scavenge radicals, unlike stoichiometric antioxidants like BHT, TBHQ, etc which are consumed in the process. Kinetic analysis confirmed a marked increase in activation energy (E_a) in CeO_2 -treated oils, reflecting the suppression of oxidation chain reactions. This is attributed to the stabilization of transition states and the reduced formation of reactive intermediates, which elevates the energy barrier for radical propagation. The oxidative rancidity of oils generally involves exergonic chain reactions once initiated. However, CeO_2 effectively raises the activation free energy, by either interrupting the propagation step (i.e., $LOO\bullet + LH \rightarrow LOOH + L\bullet$) or reducing the concentration of radical initiators, thus lowering the effective rate constants (k) of oxidation, thereby reducing the reaction rate even at elevated temperatures. The impact was dose-dependent, with 15 ppm CeO_2 providing optimal resistance without exhibiting pro-oxidant behavior. Hence it can be concluded that, CeO_2 stabilizes the oil matrix by increasing activation energy, making it energetically less favourable for oxidation chains to propagate.

5.4 Conclusion

In summary, the physicochemical properties of nanoceria — defect-rich fluorite structure, mixed Ce^{3+}/Ce^{4+} valence, and nanoscale dispersion — are directly responsible for their antioxidant function in edible oils. These properties enable catalytic redox cycling and radical scavenging, which translate to significantly improved oxidative stability of oils during storage and use.

The dose-dependent effect of CeO_2 was evident: 15 ppm > 10 ppm > 5 ppm > control.

Even at 5 ppm, significant antioxidant protection was observed, though highest was observed at 15 ppm concentration. Notably, no pro-oxidant effects or negative sensory changes were reported at any concentration. This underscores nanoceria's catalytic efficiency at ppm-level doses.

The mechanistic implication is that nanoceria can continuously mitigate oxidation through a reversible $\text{Ce}^{3+}/\text{Ce}^{4+}$ cycle, acting as an active nanoscopic antioxidant reservoir. Such behavior not only extends the shelf-life and frying life of oils but does so in a sustainable, non-consumptive manner. These insights vividly illustrates the potential of cerium oxide nanoparticles as highly effective food-grade antioxidants and simultaneously provides a framework for correlating material properties (like oxygen vacancy concentration, surface chemistry and particle size) with functional performance in complex oxidative environments.

The trends observed in the kinetic parameters (e.g., enhanced activation energy for oxidation with CeO_2) further validate that the addition of nanoceria fundamentally alters the reaction energetics of lipid peroxidation, making the oil significantly more resistant to oxidative spoilage even at higher temperatures.

Future studies may build on this understanding to optimize nanoparticle characteristics for even better performance or to investigate the long-term stability and any possible breakdown products of CeO_2 in edible oils. Nonetheless, the current results solidly demonstrate that tailoring CeO_2 's defect chemistry and employing it at low concentrations can effectively suppress lipid oxidation, offering a promising strategy for extending the freshness and safety of edible oils.

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CHAPTER 6: Quality and shelf-life study of mayonnaise formulated from nano-ceria enriched edible oils

6.1 Introduction

Mayonnaise is an oil-in-water emulsion characterized by a low pH and a high oil content, typically ranging from 65% to 85% (Mattia et al., 2015). Its formulation involves blending vegetable oil, egg yolk, vinegar, salt, and optional seasonings to yield a semi-solid sauce (Gorji et al., 2016). Its appealing sensory and rheological properties, along with its culinary adaptability and emulsion stability, make it a widely favored product. However, its elevated lipid content predisposes it to oxidative deterioration, which manifests as rancidity, undesirable flavors, and reduced shelf-life.

To mitigate lipid oxidation, synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been employed. Nonetheless, their application in food products is increasingly restricted due to their potential adverse effects on human enzymatic systems (Bakkali et al., 2008). This has driven the pursuit of natural antioxidant alternatives (Amorati et al., 2013). As a result, formulations have been developed incorporating bioactive compounds like thyme essential oil encapsulated in poly ϵ -caprolactone nanoparticles (Passos et al., 2019), tocopherol, rosemary essential oil, and *Ferulago angulata* extract (Alizadeh et al., 2019), as well as microencapsulated phenolics derived from lemon processing residues (Shaygannia et al., 2021).

Despite extensive research into the use of natural antioxidants in mayonnaise, ensuring their functional stability throughout food processing and storage remains a key challenge. An ideal antioxidant must resist thermal and oxidative degradation during cooking and extended storage (Taghvaei et al., 2015). Many phenolic compounds possess limited thermal stability but may undergo oxidative transformation into secondary antioxidant forms. For example, carnosic acid in rosemary readily oxidizes at temperatures above $\sim 60^\circ\text{C}$ to yield carnosol and related derivatives. (Oreopoulou et al., 2021). Tocopherols also display moderate thermal stability; however, they are progressively consumed during oxidation reactions. Notably, their supplementation in sunflower oil failed to improve frying stability at $\sim 180^\circ\text{C}$ due to rapid thermal decomposition (Alberdi-Cedeño et al., 2025). Similarly, carotenoids such as β -

carotene, lycopene, lutein, and astaxanthin are highly heat- and oxygen-sensitive, undergoing trans–cis isomerization and oxidative cleavage that result in pigment loss and diminished antioxidant efficacy (Falade et al., 2015).

Against this backdrop, nanotechnology presents innovative solutions, with cerium oxide nanoparticles (CeO₂ NPs), or nanoceria, gaining attention as advanced antioxidant agents. Nanoceria possesses a unique redox cycling ability between Ce³⁺ and Ce⁴⁺ states, enabling it to neutralize reactive oxygen species through a regenerative mechanism (Pirmohamed et al., 2010). These properties have been widely explored in biomedical contexts such as neuroprotection, anti-inflammatory therapies, and oncology.

Recent developments have investigated the use of nanoceria in food systems to enhance oxidative stability. Evidence suggests that nanoceria effectively suppresses lipid peroxidation in various matrices, contributing to extended shelf life and maintenance of sensory quality. Additionally, its incorporation into edible oils has demonstrated potential in preserving their nutritional and functional integrity over storage (Chakraborty et al., 2025). However, application of nanoceria in complex emulsion systems like mayonnaise remains relatively unexplored. Understanding its interactions within the emulsion matrix, and its influence on physicochemical characteristics, sensory properties, and oxidative stability, is crucial. Furthermore, evaluating its performance in different oil bases such as rice bran oil and sunflower oil could yield insights necessary for formulation optimization and consumer acceptability.

Accordingly, this study aims to formulate and characterize mayonnaise variants enriched with nanoceria-incorporated edible oils. Through assessment of physicochemical parameters, texture profiles, sensory attributes, and oxidative stability during storage, this research seeks to establish the functional potential of nanoceria in mayonnaise. The outcomes are expected to support the development of clean-label, shelf-stable mayonnaise with enhanced nutritional and sensory profiles.

6.2 Materials and Methods

6.2.1. Materials and Reagents

Mayonnaise, refined rice bran oil (RBO), sunflower oil (SFO), rice vinegar (18% acetic acid), eggs, lemon, salts were sourced from a local market in South Kolkata, India. Analytical-grade reagents were procured from Merck (India) and used without further purification.

6.2.2 Preparation of Mayonnaise

As established in the preceding chapters, nano-ceria synthesized under a controlled nitrogen-annealed atmosphere and applied at a concentration of 15 ppm exhibited markedly enhanced oxidative stability, attributed to its engineered surface oxygen vacancy concentration ($VO^{\bullet\bullet}_O$) and optimized Ce^{3+}/Ce^{4+} redox ratio (Chakraborty et al., 2025). Leveraging this superior antioxidant functionality, both rice bran oil (RBO) and sunflower oil (SFO) were strategically supplemented with 15 ppm of the synthesized nano-ceria to reinforce their oxidative resilience. The functionalized oils were subsequently utilized in the production of mayonnaise, adhering to the standardized formulation outlined in Table 6.1. The incorporation of nano-ceria was specifically aimed at modulating lipid oxidation kinetics within the complex emulsion matrix of mayonnaise, thereby enhancing the product's oxidative stability and shelf-life performance under accelerated and real-time storage conditions.

Table 6.1: Composition of Mayonnaise

SL No.	Components	Amount w.r.t. 1ltr oil	Percentage Composition (~ approx.)
1	Nano ceria supplemented edible vegetable oil	1000 ml	75-80
2	Whole eggs	200 ml	15-17
3	Vinegar	50 ml	3-4
4	Lemon juice	20 ml	1.5-2
5	Salt	1 gm	0.1
6	Distilled water	As required	~

Whole eggs, vinegar, lemon juice and salt were measured, homogenised and whipped in a food processor to form a stable emulsion at 35°C. As the blending continued measured amount of nano enriched edible oil (RBO or SFO) were added slowly into the processor till the whole mass thickened into a desired creamy texture. The mayonnaise after initial compositional analysis were stored at 4-8°C for 12 weeks to study the physico-chemical, organoleptic and textural changes. Mayonnaise prepared with RBO was noted as Mayo-R and that with sunflower oil as Mayo-S. Mayonnaise sample brought from the market for standard quality comparison was named as Mayo-C (control).

6.2.3 Sensory Analysis of Mayonnaise

Sensory assessment was performed immediately following sample preparation. A semi-trained panel of approximately 50 individuals across varied age groups evaluated the mayonnaise samples using a structured 9-point hedonic scale (1 = dislike extremely; 9 = like extremely), as per the method described by Pradhananga et al. (2015). Sensory attributes assessed included colour, creaminess, texture, spreadability, thickness, flavour, aroma, and overall acceptability. Median scores for each attribute were computed to represent central tendency of consumer perception.

Table 6.2: 9-Point Hedonic Scale

1	2	3	4	5	6	7	8	9
Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like very much	Like moderately	Like slightly	Like extremely

6.2.4 Physico-chemical Analysis of Mayonnaise

The prepared mayonnaise sample along with the control mayonnaise were subjected to compositional analysis as per AOAC (2022) methods. All tests were performed in triplicate basis.

6.2.4.1 Estimation of moisture content

Moisture content was determined by the gravimetric oven-drying method (AOAC 925.10, 2022), which is a standard procedure for moisture determination in foods. Approximately 5 g of sample was weighed into a pre-dried, tared dish and dried in a hot-air oven at 105 °C until constant weight was achieved. The dish was then cooled in a desiccator before reweighing. The moisture content was calculated as the mass loss on drying.

6.2.4.2 Estimation of ash content

Ash content was measured by calcination in a muffle furnace at 650 °C (AOAC 923.03, 2022), a standard method for determining total mineral content in foods. Approximately 5 g of mayonnaise sample in a pre-weighed crucible was incinerated at 650 °C until a constant weight was reached. The crucible was cooled in a desiccator and weighed, and the ash content was calculated from the mass of the residual mineral matter.

6.2.4.3 Estimation of protein content

Crude protein content (total nitrogen $\times$ 6.25) was determined by the Kjeldahl method (AOAC 2001.11, 2022). Approximately 1.0 g of sample was digested in concentrated H_2SO_4 in the presence of a catalyst using a block digestion apparatus. After complete digestion, the mixture was neutralized with NaOH, and the released ammonia was distilled into a boric acid receiver and titrated with standardized 0.1N HCl. The total nitrogen content obtained was converted to crude protein using a conversion factor of 6.25.

6.2.4.4 Estimation of fat content

Fat content was determined by Soxhlet solvent extraction (AOAC 920.172, 2022), an official method for total fat applicable to oil-in-water emulsions such as mayonnaise. Approximately 5 g of sample was mixed with anhydrous sodium sulfate to aid moisture removal and placed in a Soxhlet thimble. The sample was extracted with petroleum ether (40–60 °C boiling range) for 4 h. After extraction, the solvent was evaporated and the remaining lipid residue was dried and weighed to calculate the crude fat content.

6.2.4.5 Estimation of pH

The pH of the mayonnaise samples was measured using Mettler Toledo S400-Basic, pH/mV benchtop meter.

6.2.5 Texture Profile Analysis of Mayonnaise Sample

Texture profile analysis (TPA) was conducted using a TA.XTplus Texture Analyzer (Stable Microsystems Ltd., Surrey, UK) fitted with a 50 kg load cell. Mayonnaise samples were packed to the brim in cylindrical jars to ensure uniform contact, and analyzed directly using a 25 mm diameter aluminium cylindrical probe (P/25), selected to be approximately one-third of the container diameter to reduce wall interference (Bourne, 2002). A double compression cycle was applied to each sample with a penetration depth of 10 mm at a constant speed of $0.5 \text{ mm} \cdot \text{s}^{-1}$ for the pre-test, test, and post-test phases, as adapted from Kaur et al. (2009). Jars were manually stabilized on the platform during testing. Data acquisition and force-time curve analysis were performed using Exponent software (Stable Microsystems).

The following parameters were computed based on standard TPA metrics (Bourne, 2002): hardness (g), defined as the maximum force during the first compression; cohesiveness, the ratio of positive force areas under the second and first compressions, indicative of internal structural strength; adhesiveness ($\text{g} \cdot \text{s}$), representing the negative force area and the energy

required to overcome sample stickiness; springiness (mm), the distance recovered after the first deformation cycle; gumminess (g), calculated as the product of hardness and cohesiveness, reflecting the energy required for mastication; resilience, indicating the sample's recovery from deformation during the initial cycle; and spreadability, expressed via the spreadability index (hardness-to-adhesiveness ratio), capturing the ease of spreading under applied force.

6.2.7 Quality Evaluation of mayonnaise during storage

To evaluate the effect of cerium oxide (CeO₂) nanoparticle fortification on the shelf stability of mayonnaise, the prepared samples (Mayo-R, Mayo-S) and the commercial control (Mayo-C) were stored under refrigerated conditions (4–8 °C) for a period of 12 weeks. Throughout the storage duration, key quality parameters were monitored at regular intervals to assess oxidative, physicochemical, sensory, and textural changes. Rancidity indices including peroxide value (PV) and para-anisidine value (p-AV), were determined as per AOCS official methods (AOCS, 2004) as discussed in Chapter 4 section 4.2.7. Change in sensory attributes, textural and pH throughout the storage period was measured accordingly. All tests were performed in triplicate. Also, at the conclusion of the 12-week storage period, proximate analysis (moisture, ash, protein, fat) was repeated on all mayonnaise samples using the same AOAC protocols to assess any compositional alterations during shelf life.

6.3. Result & Discussion

6.3.1 Formulation of Mayonnaise with Nano Ceria Enriched Edible Oils

In the present study, mayonnaise formulations were developed using refined rice bran oil (RBO) and sunflower oil (SFO) fortified with cerium oxide nanoparticles (CeO₂ NPs), with the objective of retaining the enhanced antioxidant potential previously demonstrated in these oil systems (Chakraborty et al., 2025). Both Mayo-R (RBO-based) and Mayo-S (SFO-based) exhibited stable, uniform emulsions with no observable phase separation, air entrapment, or granularity during homogenization as observed visually. The viscosity, spreadability, and initial appearance of the prepared samples were comparable to the commercial control (Mayo-C), suggesting that nanoceria did not adversely affect the textural or visual quality of the product.

Table 6.3: Sensory Analysis of Mayonnaise

Attribute	Mayo-C	Mayo-R	Mayo-S
Colour	7.92±0.59 ^a	7.74±0.21 ^a	7.90±0.25 ^a

Creaminess	8.42±0.56 ^b	8.88±0.36 ^a	8.72±0.55 ^a
Texture	8.36±0.49 ^a	7.97±0.32 ^b	7.81±0.49 ^b
Spreadability	8.54±0.60 ^a	8.01±0.23 ^b	8.40±0.59 ^a
Thickness	7.86±0.56 ^a	6.57±0.28 ^c	6.95±0.50 ^b
Flavour	8.30±0.54 ^b	8.91±0.58 ^a	8.57±0.56 ^a
Aroma	8.40±0.36 ^b	8.79±0.44 ^a	8.33±0.39 ^b
Overall Acceptability	8.64±0.44 ^a	7.94±0.45 ^b	7.98±0.40 ^b

The emulsification process was conducted at ambient temperature (~35 °C), and the final mayonnaise exhibited a smooth, creamy consistency consistent with market-grade standards. These observations were substantiated by a comparison of marginal means of the sensory scores of mayonnaise samples (Table 6.3) conducted with freshly prepared Mayo-R and Mayo-S against Mayo-C. The success in replicating the physico-chemical and textural profile of commercial mayonnaise while incorporating functional antioxidant components highlights the formulation's potential for industrial application as a clean-label, functional condiment.

Table 6.3A. One-Way ANOVA Summary for Sensory Attributes of Mayonnaise

Attribute	F-value	p-value	Significance
Colour	1.84	0.165	Not significant
Creaminess	8.72	0.0003	Very Highly Significant
Texture	12.14	<0.001	Extremely significant
Spreadability	6.95	0.0014	Highly Significant
Thickness	78.63	<0.0001	Extremely significant
Flavour	9.51	0.0002	Very Highly Significant
Aroma	6.48	0.0023	Highly Significant
Overall Acceptability	28.17	<0.0001	Extremely significant

*Footnote: ns – not significant ($p \geq 0.05$); * – significant ($p < 0.05$); ** – highly significant ($p < 0.01$); *** – very highly significant ($p < 0.001$); **** – extremely significant ($p < 0.0001$).*

One-way ANOVA (Table 6.3A) revealed significant formulation-dependent differences in creaminess, texture, spreadability, thickness, flavour, aroma, and overall acceptability ($p < 0.05$), while colour did not differ significantly among samples ($p > 0.05$), indicating comparable visual appearance across formulations.

Among the evaluated attributes, thickness exhibited the strongest formulation effect ($F = 78.63$, $p < 0.0001$), demonstrating pronounced structural variation between samples. Overall acceptability also showed a highly significant difference ($F = 28.17$, $p < 0.0001$), confirming that formulation substantially influenced consumer perception.

Post-hoc comparison using Tukey's HSD test further clarified the direction of these differences. Mayo-R achieved significantly higher scores for creaminess, flavour, and aroma compared to Mayo-C and Mayo-S, indicating enhanced sensory richness. In contrast, Mayo-C demonstrated significantly superior texture, spreadability, and thickness, suggesting a more structurally stable and cohesive emulsion system. Notably, Mayo-C also recorded the highest overall acceptability score, significantly outperforming both Mayo-R and Mayo-S.

The pronounced differentiation observed in thickness aligns with its strong ANOVA effect size and likely contributed to downstream improvements in texture and spreadability. Although Mayo-R excelled in flavour and creaminess, the superior structural attributes of Mayo-C appear to have exerted a greater influence on overall consumer preference. These findings suggest that textural stability and emulsion body may play a more critical role in driving overall acceptability than flavour intensity alone within this product matrix.

Collectively, the results demonstrate that while flavour-related attributes enhance sensory appeal, structural properties such as thickness and texture are primary determinants of overall consumer acceptance in mayonnaise formulations.

6.3.2 Physico-chemical Analysis of Formulated Mayonnaise

The proximate composition of the developed mayonnaise formulations (Mayo-R and Mayo-S) closely resembled that of the commercial control (Mayo-C), despite differences in oil type and fortification (Table 6.4). Moisture content in Mayo-R and Mayo-S (~12%) was significantly lower than in Mayo-C (~18%), attributable to their higher oil content. This inverse relationship between water and fat is well-documented in emulsion systems, where reduced-fat formulations necessitate increased aqueous phase (Mudhafar et al., 2021). The values fall within reported ranges for mayonnaise (14–22% or up to 30–35% depending on formulation) (Evanuarini et al., 2020; Onwuzuruike et al., 2022), and all samples formed stable, semi-solid emulsions with typical sensory texture.

Table 6.4: Physico-chemical Characteristics of Mayonnaise

	Mayo-C	Mayo-R	Mayo-S
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Moisture (% wt basis)	18.26±0.26	12.35±0.68	12.04±0.56
Ash (% wt basis)	1.13±0.44	0.84±0.58	0.78±0.77
Fat (% wt basis)	57.83±0.74	75.48±0.7	75.29±0.42
Protein (% wt basis)	1.216±0.39	2.134±0.26	2.719±0.69
Others (% wt basis)	21.564±0.38	9.196±0.85	9.171±0.99
pH	4.26±0.04	3.99±0.09	3.98±0.03

Fat content in Mayo-R and Mayo-S (~75%) matched full-fat mayonnaise standards (65–80%) (De Leonardis et al., 2022; Roshandel et al., 2023), whereas the control (57.83%) likely represented a reduced-fat commercial variant. The high-fat phase in the enriched samples did not compromise emulsion stability, aligning with prior studies using alternative oils (e.g., flaxseed or blended oils) that maintained consistent texture and structure (Evanuarini et al., 2020).

Protein levels were slightly elevated in Mayo-R and Mayo-S (2.13–2.72%) compared to Mayo-C (1.22%), likely due to higher egg yolk content to support the increased oil phase. These values fall within the typical protein range for mayonnaise (1–3%) and do not alter organoleptic acceptability (Onwuzuruike et al., 2022; De Leonardis et al., 2022). Ash content was similar across all samples (~0.78–1.13%), reflecting comparable levels of salts and acidity regulators. The inclusion of nanoceria (15 ppm) did not significantly impact ash content, as its concentration was too low to alter mineral levels meaningfully. Its role remains functional, serving as a potent antioxidant capable of scavenging reactive oxygen species in lipid matrices. All formulations exhibited acidic pH values (3.98–4.26), within the optimal range for mayonnaise preservation and microbial inhibition. Mayo-R and Mayo-S (pH ~3.99) were marginally lower than Mayo-C (pH 4.26), consistent with standard vinegar-acidified systems (De Leonardis et al., 2022). The results align with similar reformulation studies where incorporation of functional additives such as polyphenol-rich vinegars or plant extracts did not significantly affect pH or compositional quality (De Leonardis et al., 2022).

Overall, the enriched formulations successfully mimicked the key physico-chemical characteristics of market mayonnaise. The similarity in moisture, fat, protein, ash, and pH parameters between the developed and commercial products suggests that nanoceria-enriched mayonnaise, prepared using rice bran or sunflower oil, can serve as a viable functional equivalent to conventional formulations — with the added advantage of enhanced antioxidant potential.

6.3.3 Texture Profile Analysis of Mayonnaise Sample

Instrumental texture analysis (Table 6.5) revealed distinct differences among mayonnaise samples linked to oil type and cerium oxide fortification. Mayo-S (nano-ceria enriched sunflower oil) and Mayo-R (nano-ceria enriched rice bran oil) demonstrated enhanced cohesiveness, gumminess, and springiness compared to commercial Mayo-C, indicating more elastic and structured emulsions.

Table 6.5: Texture Profile Analysis of Mayonnaise Sample

Samp le	Hardne ss (g)	Cohesiv eness	Adhesiven ess (g·s)	Springines s (mm)	Gummin ess (g)	Resili ence	Spreadabili ty Index
Mayo - C	135.8	0.62	-4.8	0.84	74.7	0.32	28.29
Mayo - R	120.5	0.65	-5.6	0.8	80.1	0.31	21.52
Mayo - S	125.3	0.6	-4.3	0.85	72.8	0.33	29.14

The higher gumminess of Mayo-R (80.1 g) reflects a yield-stress-like network, characteristic of Pickering-type emulsions stabilized by percolating nanoparticle networks (Shankar et al., 2023). Conversely, Mayo-S exhibited superior springiness (0.85 mm), suggesting a more elastic and recoverable structure, while maintaining high spreadability (29.14). Higher adhesiveness in Mayo-R and Mayo-S implies stronger internal structuring, consistent with cerium oxide nanoparticle interactions at the oil–water interface (Amini et al., 2022; Zhang et al., 2021).

6.3.3.1 Pickering Emulsion like Characteristics of Cerium Oxide Nanoparticle-Enriched Mayonnaise

The enhanced textural attributes of Mayo-S and Mayo-R stem from the formation of hybrid Pickering-type emulsions, where cerium oxide nanoparticles ($\sim 109.2 \pm 9.2$ nm; zeta potential -33.9 mV) adsorb at the oil–water interface and reinforce the emulsion network. The synergy between nanoparticles and egg-based emulsifiers promotes stable, elastic structures with improved resistance to deformation. Differences between Mayo-S and Mayo-R reflect oil-

specific interactions: Mayo-S benefits from more uniform nanoparticle adsorption due to sunflower oil's lower viscosity, resulting in higher springiness and spreadability. Mayo-R's greater gumminess and cohesiveness likely result from interactions between nanoceria and rice bran oil's polar lipids, yielding a denser interfacial network (Qiaoli et al., 2023). Both systems outperform conventional emulsions (Mayo-C), confirming the unique stabilizing role of nanoceria in advanced food emulsions (Tang et al., 2020; Wilson, 2016).

6.3.3.2 Sensory–TPA Correlation

Sensory scores (Table 6.3, Figure 6.1) closely mirrored instrumental TPA findings. Creaminess inversely correlated with adhesiveness: Mayo-R (8.88) showed slightly lower creaminess due to higher stickiness, while Mayo-S (8.72), with lower adhesiveness, provided a more lubricated mouthfeel (Schädle et al., 2022). Spreadability scores aligned with the Spreadability Index, with Mayo-C (8.54) highest, followed by Mayo-S and Mayo-R (both 8.41), supporting the predictive value of TPA (Olsson et al., 2018). Overall acceptability remained high: Mayo-C (8.64), Mayo-S (7.98), Mayo-R (7.94), indicating that nanoparticle enrichment did not compromise consumer appeal. Importantly, Mayo-S and Mayo-R successfully replicated commercial-like textures despite compositional innovation. Mayo-R's firmer structure may suit applications requiring adherence (e.g., salads), while Mayo-S's enhanced spreadability favors use in sandwiches and dips. In both cases, cerium oxide nanoparticles provided added antioxidant functionality without diminishing sensory quality (Maruyama et al., 2007; Schädle et al., 2022).

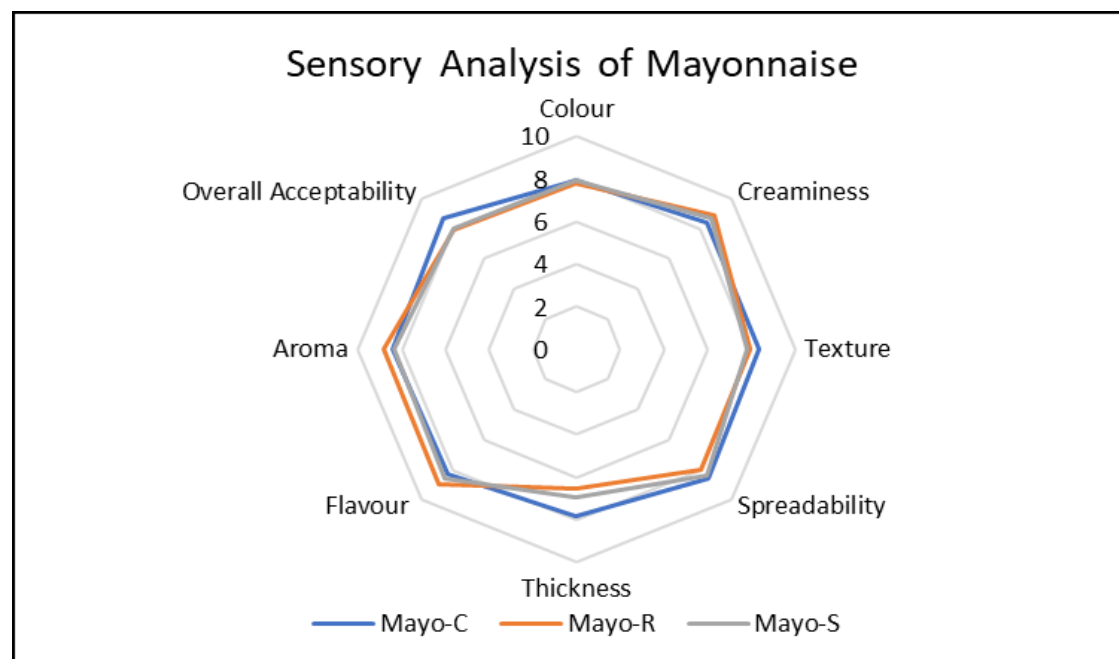


Figure 6.1: Sensory score of Mayonnaise

6.3.4 Assessment of changes in quality characteristics of mayonnaise during storage

The formulated mayonnaise samples (Mayo-S and Mayo-R) along with the control (Mayo-C) were stored under refrigerated conditions (4-8°C) for 12 weeks (standard shelf life of commercial mayonnaise after opening of packs) in air tight glass bottles. The samples were taken weekly to check the sensorial quality, oxidative stability and pH stability. Also changes in texture of the sample were analysed on monthly basis (Week 0, 4, 8 and 12). The proximate composition was rechecked at the end of the storage period to check any physico-chemical degradation.

6.3.4.1 Oxidative Stability Assessment

Table 6.6: Measurement of Oxidative Stability of Mayonnaise Samples

Storage Time (Weeks)	Peroxide Value (PV)			para-Anisidine Value (pAV)		
	Mayo-C	Mayo-R	Mayo-S	Mayo-C	Mayo-R	Mayo-S
1	2.13±0.61	0.56±0.67	1.11±0.38	1.23±0.49	1.12±0.81	1.08±0.74
2	2.33±0.56	0.76±0.39	1.34±0.76	1.27±0.27	1.23±0.79	1.24±0.77
3	2.64±0.68	0.91±0.35	1.42±0.34	1.25±0.81	1.52±0.74	1.29±0.76
4	3.37±0.68	1.17±0.56	1.68±0.57	1.28±0.74	1.53±0.2	1.32±0.62
5	3.81±0.75	1.52±0.8	1.91±0.75	1.41±0.29	1.71±0.26	1.36±0.67
6	4.45±0.8	1.79±0.65	2.13±0.51	1.69±0.28	1.75±0.74	1.37±0.64
7	5.92±0.88	1.98±0.58	2.39±0.75	1.9±0.35	1.79±0.4	1.55±0.47
8	6.63±0.74	2.23±0.73	2.77±0.21	2.4±0.31	1.83±0.42	1.64±0.89
9	7.21±0.63	2.64±0.81	3.14±0.34	3.11±0.4	1.87±0.71	1.84±0.41
10	8.39±0.53	3.01±0.56	3.82±0.69	4.62±0.57	1.89±0.78	1.9±0.86
11	9.88±0.31	3.67±0.65	4.36±0.24	5.07±0.7	2.42±0.68	2.1±0.3
12	10.61±0.26	4.42±0.32	4.9±0.56	6.94±0.69	2.96±0.31	2.78±0.57

Data tabulated in Table 6.6 shows that the control (Mayo-C) exhibited a rapid rise in PV within the first half of the storage period, followed by a slight decline as primary oxidation products decomposed into secondary aldehydes. In contrast, both nanoceria-enriched samples—Mayo-R (rice bran oil) and Mayo-S (sunflower oil)—demonstrated significantly attenuated PV

progression. By week 12, PVs in oils containing the nano formulations were consistently and substantially lower than Mayo-C, confirming enhanced protection against hydroperoxide formation. Among the fortified samples, Mayo-R maintained the lowest PV throughout, reflecting nanoceria's effective radical-scavenging capacity.

Sunflower oil, due to its high linoleic acid content, is inherently more susceptible to lipid peroxidation. Thus, Mayo-S, although fortified with the same concentration of nanoceria (15 ppm), exhibited slightly higher PVs than Mayo-R. Nonetheless, both nano-enriched emulsions outperformed the control in suppressing primary oxidation, reinforcing nanoceria's role as a potent oxidative stabilizer in oil-in-water systems.

The secondary oxidation marker, p-anisidine value (p-AV), showed a parallel trend. Mayo-C presented a delayed yet pronounced increase in p-AV after week 6, indicative of accumulating aldehydic degradation products. In contrast, Mayo-R and Mayo-S exhibited only modest increases in p-AV over the entire 12-week period. Even at the end of storage, their p-AVs remained markedly lower than the control, highlighting reduced secondary rancidification. This suppression of aldehyde formation in the nanoceria formulations corresponds with their lower PVs, suggesting a successful arrest of the oxidation cascade.

These findings corroborate the oxidative protection offered by cerium oxide nanoparticles, which function via multiple mechanisms. Nanoceria exhibits regenerative antioxidant activity by cycling between Ce^{3+} and Ce^{4+} oxidation states, particularly when engineered to possess abundant surface oxygen vacancies (Chakraborty et al., 2025). This redox cycling allows nanoceria to scavenge reactive oxygen species, including lipid peroxyl radicals, thereby interrupting chain propagation in lipid peroxidation. Prior studies have demonstrated that nanoceria at 10–15 ppm can significantly extend oxidative stability in edible oils, doubling shelf-life compared to conventional antioxidants (Chakraborty et al., 2025; Soleymani et al., 2025). In the present study, 15 ppm nanoceria likely acted as both a radical scavenger and a peroxide decomposer, preventing primary product buildup and thereby minimizing secondary oxidation.

In oil-in-water emulsions like mayonnaise, oxidation is most active at the oil–water interface where lipids contact aqueous pro-oxidants and dissolved oxygen which is evident from the rate of rancidity observed in control even at refrigeration temperatures. Presence of antioxidant nanoparticles such as CeO_2 in the test samples definitely helped in quenching lipid radicals and serving as a structural shield for preservation of oxidative stability. Recent literature supports this mechanism. For example, rice peptide nanoparticles conferred high oxidative stability by combining interfacial reinforcement with intrinsic antioxidant activity (Keramat et al., 2023).

Similarly, proanthocyanidin-loaded protein nanoparticles at the emulsion interface retarded oxidation via localized radical quenching (Chang et al., 2023). These studies underscore the efficacy of interfacially active nano-antioxidants in mitigating lipid oxidation in emulsified food systems.

The enhanced oxidative stability seen here also aligns with findings from encapsulated bioactive systems. Yang et al. (2023) reported that microencapsulated pomegranate peel polyphenols reduced peroxide formation and prolonged shelf-life in salad dressings more effectively than free antioxidants. However, unlike plant-derived antioxidants which eventually deplete, redox activity of nanoceria is self-regenerating, enabling persistent oxidative defence throughout the storage period. This positions nanoceria as a promising long-acting antioxidant solution for lipid-based foods.

In comparative terms, Mayo-R's superior oxidative stability over Mayo-S likely stems from the matrix synergy between rice bran oil's phytochemical profile and nanoceria's activity. Rice bran oil contributes natural radical quenchers such as γ -oryzanol, tocotrienols, and sterols, which may act synergistically with nanoceria to reinforce antioxidant performance. This advantage is less pronounced in sunflower oil, which, despite high vitamin E content, lacks the diverse antioxidative profile of RBO (Rahmania et al., 2020). Thus, while both Mayo-R and Mayo-S demonstrated oxidative resistance, the rice bran oil system yielded the greatest protection.

Overall, the PV and p-AV data confirm that nanoceria fortification significantly delayed both primary and secondary lipid oxidation in mayonnaise stored under refrigeration. This extended induction period and oxidation suppression illustrate the functionality of nanoceria as multifunctional antioxidants. Through radical scavenging, oxygen buffering, and interfacial stabilization, nanoceria preserved lipid integrity and prevented rancidification over 12 weeks. These effects were achieved without compromising formulation stability or requiring synthetic additives, suggesting that nanoceria is well-suited for shelf-life extension in emulsion-based foods.

6.3.4.2 Change in pH of the oil sample

All mayonnaise samples exhibited a gradual decline in pH over 12 weeks at 4–8 °C (Figure 6.2). The commercial control (Mayo-C) showed a pronounced acidification from 4.26 ± 0.27 to 3.64 ± 0.63 , while nanoceria-fortified samples (Mayo-R and Mayo-S) demonstrated superior pH stability, decreasing only marginally from ~ 3.98 to ~ 3.75 .

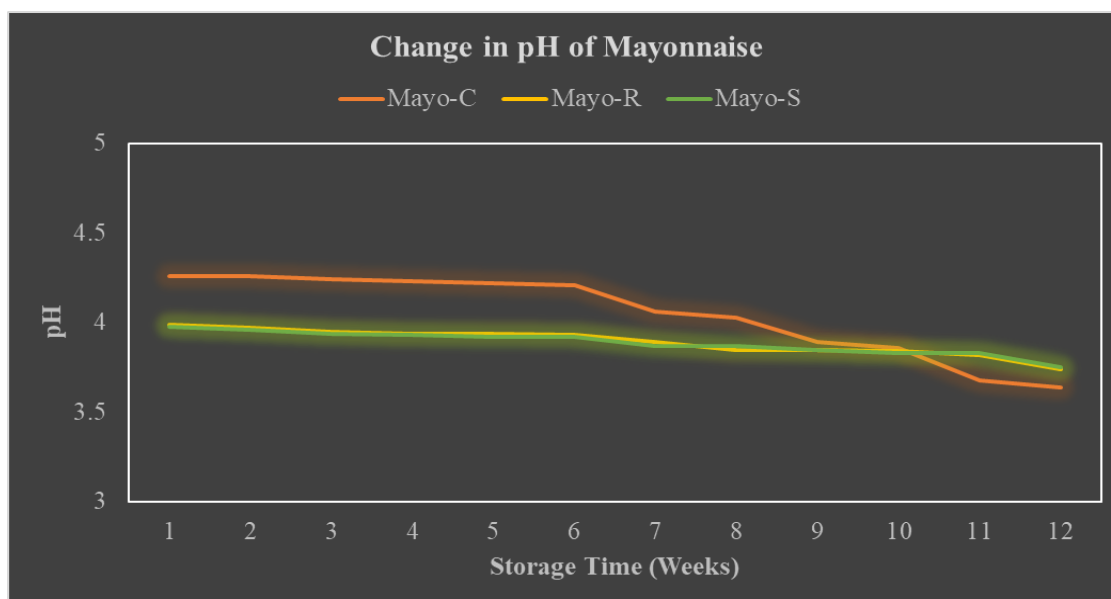


Figure 6.2: Change in pH of the mayonnaise samples during storage

The sharper pH drop in Mayo-C is likely due to the accumulation of acidic byproducts from lipid oxidation, enzymatic hydrolysis, and potential microbial fermentation—processes known to generate free fatty acids and organic acids during storage (Blejan & Nour, 2023; Soltan et al., 2023). In contrast, the relative pH stability of Mayo-R and Mayo-S reflects the antioxidant action of cerium oxide nanoparticles, which inhibit peroxidation chain reactions and delay hydrolytic degradation.

Nanoceria's redox cycling between $\text{Ce}^{3+}/\text{Ce}^{4+}$, coupled with its high surface reactivity, allows it to scavenge lipid radicals and suppress oxidative acid formation (Thakur et al., 2019). Its localization at the oil–water interface may further shield lipid droplets from aqueous pro-oxidants, mitigating acid generation. Similar pH-preserving effects have been observed with other nano-antioxidants in emulsified systems (Soltan et al., 2023).

Overall, the sustained pH in Mayo-R and Mayo-S supports the effectiveness of nanoceria in maintaining emulsified system stability and resisting physicochemical spoilage, complementing the findings from peroxide and p-anisidine trends.

6.3.4.3 Assessment of change in texture and sensory profile during storage

During 12 weeks at 4–8 °C, all mayonnaise formulations progressively softened and thinned (Table 6.7). Hardness and gumminess declined in all samples, with Mayo-C showing the largest losses (~136→121 g, ~75→65 g), while nano-ceria samples retained firmness better

(Mayo-R/S: ~4–6% hardness loss vs ~10.7% for Mayo-C; ~4–5% gumminess loss vs ~12–13%).

Table 6.7: TPA of mayonnaise through the storage period

Sample Name	Storage Time (Weeks)	Hardness (g)	Cohesiveness	Adhesiveness (g·s)	Springiness (mm)	Gumminess (g)	Resilience	Spreadability Index
Mayo - C	0	135.8	0.62	-4.86	0.84	74.7	0.32	27.94
	4	134.32	0.63	-4.81	0.84	72.1	0.32	27.92
	8	130.31	0.6	-5	0.8	69.21	0.29	26.06
	12	121.02	0.54	-5.37	0.77	65.3	0.25	22.53
Mayo - R	0	120.5	0.65	-5.6	0.8	80.1	0.31	21.52
	4	122.75	0.65	-5.6	0.8	79.3	0.31	21.91
	8	121.34	0.64	-5.8	0.8	79.1	0.31	20.92
	12	115.67	0.61	-5.85	0.78	76.77	0.29	19.77
Mayo - S	0	125.3	0.63	-4.3	0.85	72.8	0.33	29.14
	4	125.82	0.63	-4.3	0.85	72.31	0.33	29.49
	8	123.31	0.63	-4.7	0.85	70.4	0.33	26.23
	12	118.09	0.6	-5	0.81	69.44	0.3	23.62

Cohesiveness and resilience followed similar trends: Mayo-C dropped 13% and 22%, respectively; Mayo-R only 6% and 6%; Mayo-S ~5% and ~9%. Springiness remained largely stable across all samples (Mayo-C ~0.84→0.77, Mayo-R ~0.80→0.78, Mayo-S ~0.85→0.81), suggesting preserved short-range elasticity.

Adhesiveness increased in magnitude (stickiness) in all samples: Mayo-C (~10% increase), Mayo-R (~4%), Mayo-S (~16%). The Spreadability Index decreased over time, reflecting structural weakening: Mayo-C and Mayo-S each dropped ~19%, while Mayo-R showed only an ~8% reduction — indicating superior resistance to viscosity loss and phase separation.

Notably, TPA may underestimate spreadability in aged samples due to surface oil migration and emulsion breakdown, which can reduce probe resistance and apparent stickiness. However, the smaller changes in Mayo-R suggest its rice bran oil/CeO₂ formulation maintained internal cohesion more effectively. This aligns with prior findings where nanoparticle-stabilized

emulsions (e.g. ZnO-fortified mayonnaise, Zhou et al., 2023) better preserved textural properties during storage.

Beyond antioxidant effects, CeO₂ particles likely contribute to physical stabilization, adsorbing at droplet interfaces and reinforcing the emulsion matrix. Potential interactions with egg proteins may further strengthen the 3D gel network, limiting droplet coalescence and network rupture. By contrast, the control sample (Mayo-C) exhibited typical thinning and viscosity loss under storage (Wang et al., 2022), while nano-ceria formulations demonstrated markedly better structural stability.

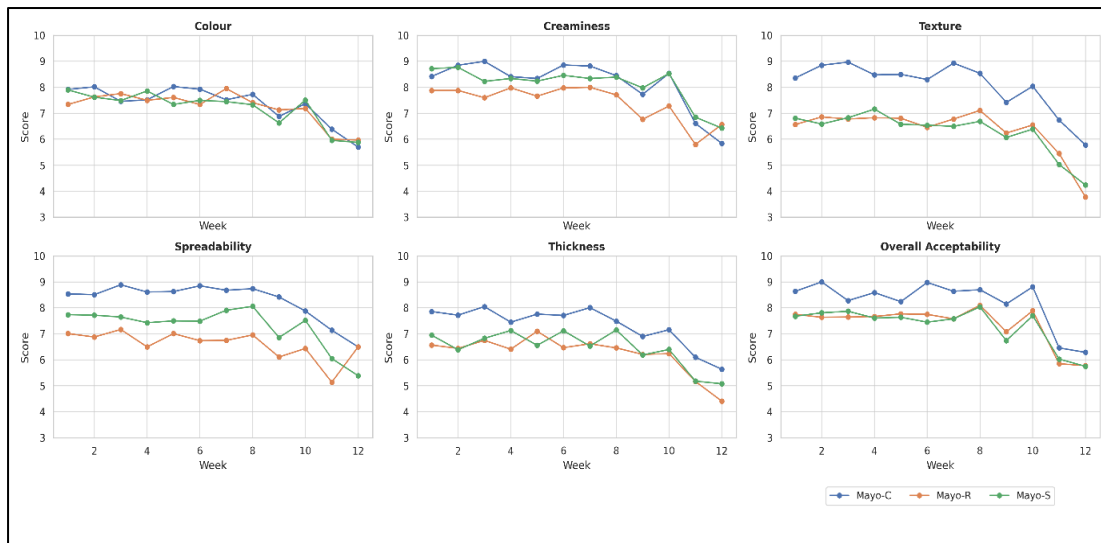


Figure 6.3: Change in sensory attributes during storage

Changes in sensorial attributes are shown in Figure 6.3. Mayo-C (commercial control) exhibited a steady decline in texture, creaminess, and overall acceptability after Week 8, correlating with texture degradation. In contrast, Mayo-R and Mayo-S, enriched with nanoceria, maintained better textural integrity (especially gumminess), supporting higher acceptability through later storage.

A progressive increase in stickiness (more negative adhesiveness) was observed in all samples, particularly Mayo-R. However, this did not significantly impair acceptability until late stages, likely due to consistent flavor and mouthfeel. Samples with lower spreadability index (higher spreadability), such as Mayo-R, sustained stable sensory scores until Week 8–9, after which scores declined, reflecting instrumental softening.

Mayo-C initially had the highest acceptability, but this sharply declined after Week 10, mirroring texture loss. In contrast, Mayo-R and Mayo-S preserved consumer acceptance longer, supported by nanoceria's structural stabilization effects.

Instrumental parameters (hardness, gumminess) aligned well with sensory trends across all formulations. Mayo-R and Mayo-S retained higher cohesiveness and gumminess through Week 12, contributing to textural stability and delayed sensory deterioration. Mayo-R's increased adhesiveness modestly impacted creaminess but did not significantly lower consumer appeal due to sustained structure and flavor.

These results support prior findings (Schädle et al., 2022; Olsson et al., 2018), confirming that instrumental measures like hardness and cohesiveness predict perceived creaminess, thickness, and mouthfeel in emulsified products. Overall, nanoceria fortification not only enhances oxidative stability but also preserves desirable textural and sensory qualities during prolonged storage.

6.3.4.4 Change in proximate composition after storage

As observed in Figure 6.4 the proximate composition is not much effected during storage, specially of Mayo-S and Mayo-R. However, for Mayo-C there are certain changes in the proximate composition, especially loss of moisture which indicates destabilization of emulsion to a certain degree. This observation was already highlighted before in the textural and physico-chemical studies detailed above.

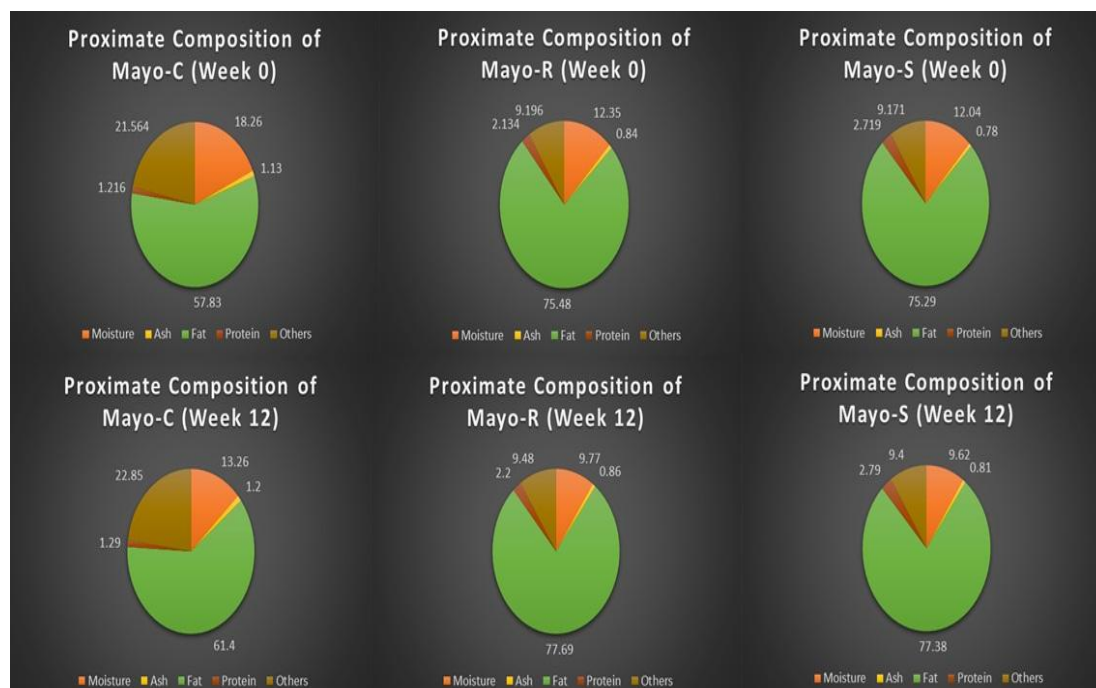


Figure 6.4: Change in proximate composition of mayonnaise after storage

6.4 Conclusion

This study demonstrated the successful formulation of mayonnaise enriched with cerium oxide (CeO₂) nanoparticle-stabilized edible oils, achieving both enhanced shelf-life and improved product quality. The nano-fortified variants—Mayo-R (rice bran oil-based) and Mayo-S (sunflower oil-based)—exhibited physicochemical, textural, and sensory attributes comparable to, or exceeding, those of the commercial control (Mayo-C). Incorporation of 15 ppm nanoceria, engineered for high oxygen vacancy density, markedly retarded lipid oxidation, as shown by significantly lower peroxide and para-anisidine values over 12 weeks of refrigerated storage. Additionally, nanoceria contributed to superior pH stability and preserved emulsion structure, with Mayo-R maintaining notably higher cohesiveness, gumminess, and resilience. Sensory analysis corroborated the instrumental results, confirming that nanoceria fortification did not compromise consumer acceptability. Notably, Mayo-R maintained enhanced flavor and aroma in late storage, reflecting superior oxidative stability. The natural antioxidant profile of rice bran oil likely acted synergistically with nanoceria, further contributing to the observed performance. The combined retention of textural integrity and oxidative resistance underscores the value of cerium oxide nanoparticles as multifunctional, regenerative antioxidants in emulsion-based food systems.

Overall, these findings highlight the potential of nanoceria-enriched oils as a viable, clean-label alternative to synthetic antioxidants in high-fat emulsions. This approach offers a promising pathway to developing shelf-stable, functional condiments with extended oxidative stability and preserved sensory quality under refrigerated storage.

By integrating nanoceria's unique antioxidant and interfacial properties into food-grade oils, this work paves the way for next-generation emulsion products that deliver both enhanced stability and superior consumer appeal—advancing the design of functional, clean-label foods for modern dietary needs.

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CHAPTER 7: Summary & Conclusion

7.1 Summary of Findings

This thesis presents a detailed, mechanistically driven exploration of the use of engineered cerium oxide nanoparticles (CeO_2 NPs, "nano-ceria") for enhancing the oxidative stability of edible oils, positioning them as a viable alternative to conventional synthetic antioxidants in food systems. The work was structured around three core objectives, each comprehensively addressed through a materials-science-informed and application-focused methodology.

In addressing Objective 1, the redox behavior of nano-ceria was finely tuned through a strategically engineered synthesis route employing dual-dispersant precipitation under controlled pH, temperature, and post-synthesis annealing conditions. Advanced characterization techniques—including XRD with Rietveld refinement, XPS, UV-Vis spectroscopy, FTIR, and first-principles DFT + U calculations—were deployed to rigorously quantify lattice oxygen defects, $\text{Ce}^{3+}/\text{Ce}^{4+}$ ratios, and their influence on electronic structure and redox cycling capacity. The oxygen vacancy engineering was shown to directly correlate with enhanced radical scavenging potential across all antioxidant assay platforms. Cytotoxicity evaluations established a safe operating window for food-grade applications.

Objective 2 translated these material properties into functional outcomes in complex lipid matrices. Under accelerated oxidative stress conditions, CeO_2 NPs demonstrated superior performance in mitigating lipid peroxidation in both sunflower and rice bran oils, particularly at optimized loadings (15 ppm, CNPN4 formulation). The role of surface Ce^{3+} sites and oxygen vacancies in facilitating dynamic redox cycling was mechanistically linked to suppression of primary (PV) and secondary (p-AV, TOTOX) oxidation products. A quantitative structure–function–application linkage was established through a combination of Kröger–Vink defect modeling, surface chemical analysis, and kinetic shelf-life modeling.

Objective 3 extended these findings to real-world food applications, incorporating CeO_2 NPs into both thermally stressed oils and complex emulsified systems (mayonnaise). An integrated thermo-kinetic-oxidation model was developed to quantify the interplay of oxidation dynamics and antioxidant depletion. Results confirmed that CeO_2 NPs increase the activation energy barrier for lipid oxidation and exhibit a regenerative, non-consumptive antioxidant mechanism—unlike conventional phenolic stabilizers. Moreover, CeO_2 NPs demonstrated interfacial localization behavior in emulsified systems, contributing both chemically (radical

scavenging) and physically (interface stabilization) to oxidative protection. Sensory, rheological, and consumer acceptance studies validated the practical feasibility of these nanomaterial-enabled formulations for commercial food applications.

7.2 Overall Contribution of the Thesis

This thesis advances the scientific understanding and practical deployment of oxygen vacancy-engineered nanocerium as an intelligent antioxidant platform for food-grade lipid systems. The key contributions are as follows:

Objective 1:

1. Developed a strategically controlled precipitation method using dual-dispersant systems (PEG+nBA and nBA+PVP) with precise tuning of pH and temperature, to control crystallite size and redox behavior.
2. Demonstrated the role of annealing atmosphere (N_2 vs. air) and annealing duration (2 h vs. 4 h) on the oxygen vacancy concentration and Ce^{3+}/Ce^{4+} redox balance.
3. Employed XRD with Rietveld refinement to confirm single-phase cubic fluorite structure and quantify lattice parameters, crystallite size, and microstrain.
4. Performed FTIR analysis to detect $Ce^{3+}-O-Ce^{4+}$ vibrational modes, indicating oxygen defect-related redox behavior.
5. Conducted XPS deconvolution to quantify Ce^{3+}/Ce^{4+} ratios and adsorbed vs. lattice oxygen, establishing structure–function correlations.
6. Measured bandgap energy via UV-Vis spectroscopy and Tauc plots, linking redox defect chemistry with optoelectronic properties.
7. Applied Density Functional Theory (DFT + U) to model band structure, DOS/PDOS, and oxygen vacancy effects, confirming experimental findings of redshifted band gaps in Ce^{3+} -rich particles.
8. Used Kröger–Vink notation to theoretically explain oxygen vacancy formation under reducing and oxidizing annealing environments.
9. Correlated Ce^{3+}/Ce^{4+} ratio and oxygen vacancies directly with antioxidant efficacy across all assay types.
10. Established non-toxic concentration range through MTT assay on HEK-293 cells with an $IC_{50} \sim 88$ ppm, confirming safe use at the effective concentration of 15 ppm in food systems.

Objective 2:

1. Real-world application of nano-ceria in oils through effective integration of engineered nanoceria (5–15 ppm) into real edible oils (rice bran, sunflower, and soybean) for oxidative stabilization over extended storage periods (up to 4 months).
2. Showed significant delay in oxidative deterioration indicators (PV, p-AnV, TOTOX, AV, IV) especially with N₂-annealed nano-ceria (CNPN4), confirming multi-oil efficacy.
3. Established a clear mechanistic link between Ce³⁺/Ce⁴⁺ redox cycling, oxygen vacancies (via XPS, UV-Vis, FTIR), and radical scavenging efficiency, particularly under stress conditions.
4. Demonstrated that nano-ceria performs effectively under both open and closed storage, with closed systems yielding better preservation due to oxygen limitation.
5. Through ANOVA and regression models, confirmed that storage period, oil type, and nanoparticle type significantly influence oxidation, while concentration alone was not statistically dominant—emphasizing quality over quantity in nano design.
6. Applied Arrhenius-based multi-parameter kinetic models, showing that nano-ceria raises activation energy for oxidation, delaying degradation onset and enhancing shelf life.
7. Used Principal Component Analysis to extract dominant oxidative degradation patterns, with PC1 explaining ~80% variance—enabling sample classification and antioxidant impact monitoring.
8. Identified 15 ppm of N₂-4HR nano-ceria as the most effective (dose-response relationship), balancing high antioxidant retention (RAA > 80%) with oil-specific protection and practical safety margins.
9. Developed and validated regression models to predict RAA%, including response surface plots and inverse modeling to estimate usable storage duration at specific doses and temperatures.
10. Nano-ceria not only suppressed oxidation but also preserved unsaturation (IV), reduced free fatty acid buildup (AV), and maintained refractive and structural properties (RI), confirming holistic lipid quality retention.

Objective 3:

1. Comprehensive Shelf Life and Thermo-Oxidative Stability Testing - Conducted accelerated aging studies at 60 °C and 80 °C, simulating real-world conditions (tropical storage, food processing).
2. Developed a three-component kinetic model coupling:

- a. Primary oxidation (PV)
 - b. Secondary oxidation (p-AnV)
 - c. Antioxidant decay (DPPH)
3. Used Python (solve_ivp and least_squares) to fit the model and extract rate constants and activation energies.
4. Demonstrated that CeO₂ increases the activation energy (E_a) of oxidation, confirming resistance to thermally accelerated oxidation.
5. Identified significant main and interaction effects for oil type, CeO₂ dose, and frying cycle on all quality parameters.
6. Used Python (Statsmodels, Pandas) to analyze trends with model fit metrics (AIC, BIC, log-likelihood).
7. Demonstration of Regenerative Antioxidant Mechanism - Validated redox cycling of CeO₂ ($\text{Ce}^{3+} \leftrightarrow \text{Ce}^{4+}$) as a non-consumptive mechanism, unlike traditional antioxidants.
8. Modeled the continuous scavenging of peroxy and alkoxy radicals in real-time frying conditions. Supported findings with mechanistic reaction schemes and references to enzyme-mimicking activity (e.g., catalase-like, SOD-like).
9. One of the very few reports (to best of current knowledge) on Integrated Thermo-Kinetic-Oxidation Modeling of Nanoceria-Fortified Oils
 - a. Combined material science (nanoceria design), food chemistry (oxidative indices), and computational modeling in a unified study.
 - b. Provided a multi-parameter framework linking structure–activity relationship of nanoceria to its antioxidant behavior in lipid systems.
10. Successfully incorporated 15 ppm engineered nanoceria into rice bran oil (RBO) and sunflower oil (SFO) for use in real-world food matrices.
11. Applied these antioxidant-enriched oils into the formulation of emulsified condiments (mayonnaise) and evaluated oxidative and sensory outcomes under practical storage conditions (12 weeks at 4–8 °C).
12. Mechanistic Insight into Antioxidant Action in Emulsified Systems - Proposed a dual mechanism:
 - a. Redox cycling of Ce³⁺/Ce⁴⁺ scavenging radicals and decomposing peroxides
 - b. Physical stabilization via interfacial localization akin to Pickering emulsion behavior
13. Hypothesized that CeO₂ acts as a semi-Pickering stabilizer, reinforcing the oil droplet interface

14. Proposed interactions with egg proteins or phospholipids that contribute to network retention and resistance to coalescence during storage. Supported by parallels in literature for ZnO, silica, and protein-particle stabilized emulsions
15. Nanoceria likely concentrated at oil–water interfaces, restricting oxygen diffusion and radical propagation in emulsion droplets.
16. Texture Profile Analysis (TPA) and Shelf-Life Rheological Mapping - Mapped sensory results with instrumental TPA outcomes:
 - a. Found strong alignment between hardness, adhesiveness and perceived creaminess/spreadability
 - b. Mayo-R showed highest flavor and aroma scores due to antioxidant synergy between RBO and nanoceria
 - c. Consumer acceptability remained above 7.9 for nano-fortified samples up to week 12
17. Demonstrated that nanoceria-fortified mayonnaise matched or exceeded commercial quality in oxidative and sensory terms without synthetic stabilizers or preservatives

7.3 Final Reflections

The findings of this thesis underscore the considerable potential of oxygen vacancy-engineered CeO₂ NPs as next-generation antioxidants for complex food systems. By combining rational material design with rigorous application-focused studies, this work establishes a scientific and technological basis for leveraging the unique regenerative antioxidant mechanisms of nanoceria in lipid-rich matrices.

Furthermore, the interdisciplinary approach adopted—spanning synthesis science, materials characterization, food chemistry, and kinetic modeling—demonstrates the value of cross-domain methodologies in addressing long-standing challenges in food preservation. The ability to engineer antioxidant functionality at the atomic and nanoscale offers a new paradigm for food lipid stabilization, with implications extending well beyond the systems studied herein.

While regulatory, environmental, and consumer acceptance considerations will require further attention, the demonstrated safety, efficacy, and scalability of engineered nanoceria provide a strong case for their continued development toward commercial application.

7.4 Future Scope

Building on the insights generated through this work, future thrust area of research may be based on the following:

- Conduct in-depth toxicological and bioavailability studies to support regulatory approval and ensure long-term safety of nanoceria-enabled food formulations.
- Investigate scalable manufacturing and formulation pathways for food-grade nanoceria, including potential hybrid systems with natural antioxidants to enhance functional synergy.
- Extend application studies to additional food matrices—including dairy, bakery, and RTE products—and explore potential impacts on sensory attributes and consumer perception.
- Perform comprehensive life cycle assessment (LCA) and sustainability analyses to ensure environmentally responsible deployment of nanomaterial-based food additives.
- Explore advanced interfacial characterization techniques (e.g., cryo-TEM, neutron reflectometry) to further elucidate the dual chemical–physical stabilization mechanisms of nanoceria in complex multiphase systems.

In conclusion, this thesis has contributed both foundational insights and practical advances toward the rational design and application of engineered nanoceria as an antioxidant platform for food systems. The interdisciplinary methodologies employed herein—spanning materials chemistry, food science, and kinetic modeling—demonstrate the potential of nanoscale engineering to address complex challenges in lipid oxidation. It is hoped that the findings presented will serve as a catalyst for further research and innovation in this promising domain, paving the way for safer, more effective, and sustainable solutions in food preservation. This marks the culmination of the current work; future efforts will undoubtedly build upon these foundations to extend the scientific and technological frontiers of this field.

APPENDIX 1

Table 4.1A: Change in oxidative stability of oils under different storage conditions with different concentrations of antioxidant nanoparticles

Oil Type	Nanoparticle Type	NP Conc (ppm)	Temp (°C)	Storage Condition	Storage period (no. of weeks)	PEROXIDE VALUE (meq/kg)	PARA-ANISIDINE VALUE (unit)	TOTOX VALUE	IODINE VALUE (g/100g)	REFRACTIVE INDEX	KRIES TEST	ACID VALUE (mg KOH/g)
RB	NIL	0	20	OPEN	0	0.618±0.0443	4.7567±0.4475	5.9927±0.2574	106.3334±7.417	1.397±0.1323	0.025±0.0016	3.6±0.2956
RB	O2, 2HR	5	20	OPEN	0	0.5417±0.0377	4.3957±0.38	5.4791±0.4141	107.2067±9.3075	1.398±0.1028	0.018±0.0012	3.03±0.2246
RB	O2, 4HR	5	20	OPEN	0	0.564±0.0301	4.4114±0.3514	5.5394±0.2348	106.4034±10.0495	1.377±0.1249	0.018±0.0012	3.0967±0.2142
RB	N2, 2HRS	5	20	OPEN	0	0.5433±0.0324	4.3024±0.3608	5.389±0.2083	106.47±5.6669	1.41±0.1384	0.015±0.0014	2.9267±0.2384
RB	N2, 4HRS	5	20	OPEN	0	0.5443±0.0461	4.336±0.2221	5.4446±0.1685	106.35±5.7961	1.431±0.0949	0.017±0.0017	2.9834±0.2315
RB	O2, 2HR	10	20	OPEN	0	0.5566±0.0329	4.377±0.2608	5.4902±0.1179	107.24±9.8377	1.41±0.1394	0.017±0.0015	2.9967±0.29
RB	O2, 4HR	10	20	OPEN	0	0.5522±0.0508	4.403±0.3245	5.5074±0.512	106.4467±5.6154	1.396±0.1047	0.018±0.0014	3.07±0.256
RB	N2, 2HRS	10	20	OPEN	0	0.543±0.0276	4.308±0.3015	5.394±0.2025	106.8834±10.4362	1.386±0.1362	0.015±0.0012	2.9334±0.2427
RB	N2, 4HRS	10	20	OPEN	0	0.5509±0.0397	4.333±0.2987	5.4348±0.1233	107.2467±9.6866	1.398±0.0784	0.016±0.0011	2.9567±0.2665
RB	O2, 2HR	15	20	OPEN	0	0.5732±0.0359	4.379±0.331	5.5254±0.3218	106.4934±10.5029	1.471±0.1228	0.018±0.0017	3.0234±0.2805
RB	O2, 4HR	15	20	OPEN	0	0.5671±0.0464	4.4337±0.4346	5.5679±0.4545	106.24±6.2785	1.383±0.1274	0.018±0.0014	3.14±0.1692
RB	N2, 2HRS	15	20	OPEN	0	0.5754±0.0323	4.3224±0.2962	5.4732±0.2809	106.6967±8.0923	1.414±0.0822	0.015±0.0013	2.94±0.1938
RB	N2, 4HRS	15	20	OPEN	0	0.5727±0.0313	4.3467±0.3275	5.4921±0.1979	106.73±10.3443	1.412±0.0972	0.021±0.0011	2.97±0.1693
RB	NIL	0	30	OPEN	0	0.6398±0.0354	4.8797±0.2791	6.1593±0.3128	105.3234±8.4527	1.411±0.0791	0.028±0.0028	3.86±0.2952
RB	O2, 2HR	5	30	OPEN	0	0.5341±0.0373	4.6394±0.3503	5.7076±0.2398	105.9267±7.1745	1.46±0.1379	0.021±0.002	3.4367±0.3353
RB	O2, 4HR	5	30	OPEN	0	0.5675±0.0344	4.6754±0.3058	5.8104±0.1442	106.3634±8.3776	1.421±0.1365	0.023±0.0022	3.5±0.19
RB	N2, 2HRS	5	30	OPEN	0	0.5822±0.0396	4.657±0.4562	5.8214±0.4121	106.0234±6.2844	1.414±0.0908	0.022±0.0018	3.467±0.2893
RB	N2, 4HRS	5	30	OPEN	0	0.5309±0.0305	4.6647±0.3926	5.7265±0.5087	105.91±7.2045	1.457±0.1156	0.022±0.0013	3.4767±0.2442
RB	O2, 2HR	10	30	OPEN	0	0.5623±0.0434	4.67±0.4341	5.7946±0.3479	105.8134±7.3507	1.464±0.141	0.023±0.0014	3.4834±0.2663
RB	O2, 4HR	10	30	OPEN	0	0.5598±0.0495	4.7074±0.2704	5.827±0.1755	106.5234±9.1474	1.375±0.0753	0.024±0.0022	3.5234±0.2549
RB	N2, 2HRS	10	30	OPEN	0	0.5546±0.0441	4.6144±0.2654	5.7236±0.1471	106.71±9.1951	1.438±0.0779	0.021±0.0017	3.3867±0.2916
RB	N2, 4HRS	10	30	OPEN	0	0.5781±0.0325	4.5934±0.3232	5.7496±0.1945	106.0467±6.2802	1.452±0.1004	0.021±0.0011	3.3734±0.3253
RB	O2, 2HR	15	30	OPEN	0	0.5628±0.0476	4.6934±0.3012	5.819±0.1998	105.9734±6.668	1.409±0.1092	0.023±0.0017	3.5034±0.325
RB	O2, 4HR	15	30	OPEN	0	0.5615±0.046	4.718±0.4228	5.841±0.4094	106.1567±10.3175	1.447±0.0988	0.024±0.0012	3.53±0.3406
RB	N2, 2HRS	15	30	OPEN	0	0.5472±0.0473	4.618±0.3735	5.7124±0.2873	106.42±8.8483	1.393±0.0765	0.021±0.0013	3.4067±0.2259
RB	N2, 4HRS	15	30	OPEN	0	0.578±0.0482	4.6194±0.2737	5.7754±0.1345	106.28±9.3136	1.46±0.079	0.021±0.0015	3.4267±0.2586
RB	NIL	0	40	OPEN	0	0.6531±0.0489	4.8857±0.3108	6.1919±0.1788	105.7567±9.2576	1.454±0.1226	0.028±0.0019	3.9±0.3333
RB	O2, 2HR	5	40	OPEN	0	0.5642±0.0518	4.8584±0.3101	5.9868±0.2525	105.4±6.1729	1.398±0.109	0.027±0.0021	3.7834±0.3199
RB	O2, 4HR	5	40	OPEN	0	0.5607±0.0362	4.8644±0.3889	5.9858±0.2981	105.5167±9.0469	1.452±0.0853	0.027±0.0017	3.7934±0.2014
RB	N2, 2HRS	5	40	OPEN	0	0.554±0.0545	4.804±0.3746	5.912±0.1915	105.62±7.8243	1.456±0.1308	0.026±0.0019	3.7134±0.1906
RB	N2, 4HRS	5	40	OPEN	0	0.5519±0.0466	4.7824±0.3825	5.8862±0.2428	105.9867±7.392	1.407±0.0735	0.025±0.0019	3.64±0.2642
RB	O2, 2HR	10	40	OPEN	0	0.5502±0.0444	4.8154±0.364	5.9158±0.2299	105.5434±6.2599	1.391±0.1214	0.026±0.0016	3.74±0.3052
RB	O2, 4HR	10	40	OPEN	0	0.5385±0.0331	4.8447±0.4388	5.9217±0.2622	105.5867±6.1535	1.395±0.0907	0.026±0.0014	3.7634±0.2658
RB	N2, 2HRS	10	40	OPEN	0	0.5626±0.0521	4.7667±0.4563	5.8919±0.1468	105.7534±7.8189	1.425±0.1327	0.025±0.0019	3.6067±0.2465
RB	N2, 4HRS	10	40	OPEN	0	0.5744±0.045	4.7927±0.3259	5.9415±0.2467	105.92±7.6794	1.416±0.1328	0.026±0.0019	3.6767±0.1924
RB	O2, 2HR	15	40	OPEN	0	0.5657±0.0385	4.8237±0.2892	5.9551±0.1321	105.6567±6.7151	1.436±0.1159	0.026±0.0017	3.7467±0.3637
RB	O2, 4HR	15	40	OPEN	0	0.5408±0.035	4.8714±0.4566	5.953±0.4567	105.4167±9.3161	1.392±0.129	0.027±0.0021	3.7934±0.1976
RB	N2, 2HRS	15	40	OPEN	0	0.5485±0.0284	4.7804±0.2843	5.8774±0.1891	105.6867±10.3122	1.375±0.0789	0.025±0.0018	3.6267±0.3335
RB	N2, 4HRS	15	40	OPEN	0	0.5556±0.0437	4.799±0.2783	5.9102±0.3505	105.6467±10.5567	1.438±0.1279	0.026±0.0015	3.68±0.2436
SB	NIL	0	20	OPEN	0	1.71±0.1486	7.1467±0.3713	10.5667±0.2234	143.3334±8.8767	1.34±0.077	0.026±0.0014	1.7467±0.126
SB	O2, 2HR	5	20	OPEN	0	1.7168±0.1329	6.7857±0.3522	10.2193±0.3221	144.2067±7.7952	1.386±0.1191	0.018±0.0015	1.667±0.1027
SB	O2, 4HR	5	20	OPEN	0	1.64±0.1635	6.8014±0.369	10.0814±0.2631	143.4034±9.2133	1.368±0.1333	0.019±0.0012	1.3167±0.0729
SB	N2, 2HRS	5	20	OPEN	0	1.6165±0.1124	6.6924±0.356	9.9254±0.3541	143.47±9.7277	1.35±0.1269	0.017±0.0012	1.3034±0.077
SB	N2, 4HRS	5	20	OPEN	0	1.6518±0.1188	6.746±0.4943	10.0496±0.4157	143.35±11.2612	1.339±0.0718	0.017±0.0009	1.3634±0.1101
SB	O2, 2HR	10	20	OPEN	0	1.6708±0.147	6.767±0.547	10.1086±0.4481	144.24±12.9019	1.382±0.1081	0.017±0.0015	1.29±0.0656
SB	O2, 4HR	10	20	OPEN	0	1.6816±0.1203	6.793±0.3808	10.1562±0.2775	143.4467±9.1491	1.303±0.0861	0.018±0.0013	1.2134±0.0707
SB	N2, 2HRS	10	20	OPEN	0	1.6441±0.1394	6.698±0.5832	9.9862±0.4804	143.8834±11.6406	1.349±0.0719	0.017±0.0015	1.2834±0.0731
SB	N2, 4HRS	10	20	OPEN	0	1.6914±0.1165	6.723±0.5555	10.1058±0.2034	144.2467±13.599	1.334±0.1304	0.017±0.0015	1.3267±0.1243
SB	O2, 2HR	15	20	OPEN	0	1.6498±0.151	6.769±0.6476	10.0686±0.2521	143.4934±12.6474	1.302±0.082	0.018±0.0018	1.1934±0.0864
SB	O2, 4HR	15	20	OPEN	0	1.6788±0.0955	6.8237±0.613	10.1813±0.254	143.24±13.1674	1.359±0.0795	0.019±0.0014	1.1734±0.0708
SB	N2, 2HRS	15	20	OPEN	0	1.6576±0.1063	6.7124±0.3965	10.0276±0.2045	143.6967±14.3541	1.391±0.1065	0.017±0.0013	1.2534±0.0673
SB	N2, 4HRS	15	20	OPEN	0	1.7106±0.0944	6.7367±0.6714	10.1579±0.2851	143.73±8.0865	1.347±0.1189	0.017±0.001	1.3534±0.1351
SB	NIL	0	30	OPEN	0	2.249±0.1847	7.2697±0.6411	11.7677±0.4485	142.3234±11.5952	1.335±0.1025	0.029±0.0029	1.86±0.1784
SB	O2, 2HR	5	30	OPEN	0	1.6623±0.1068	7.0294±0.3822	10.354±0.4008	142.9267±11.1503	1.362±0.0722	0.023±0.0019	1.37±0.0727
SB	O2, 4HR	5	30	OPEN	0	1.7547±0.1229	7.0654±0.4839	10.5748±0.68	143.3634±14.2737	1.378±0.105	0.024±0.0013	1.4067±0.0934
SB	N2, 2HRS	5	30	OPEN	0	1.6935±0.0865	7.047±0.3883	10.434±0.2743	143.0234±12.4084	1.376±0.1048	0.023±0.0013	1.53±0.1015
SB	N2, 4HRS	5	30	OPEN	0	1.7194±0.1042	7.0547±0.6252	10.4935±0.2893	142.91±10.3098	1.396±0.1123	0.024±0.0016	1.467±0.1405
SB	O2, 2HR	10	30	OPEN	0	1.6811±0.1143	7.06±0.6005	10.4222±0.4492	142.8134±7.9765	1.31±0.089	0.024±0.0014	1.3867±0.0821
SB	O2, 4HR	10	30	OPEN	0	1.7034±0.153	7.0974±0.4595	10.5042±0.4609	143.5234±13.7484	1.368±0.0905	0.025±0.0017	1.3734±0.1285
SB	N2, 2HRS	10	30	OPEN	0	1.6979±0.1655	7.0044±0.5923	10.4002±0.4642	143.71±13.497	1.376±0.071	0.023±0.0016	1.4834±0.1114
SB	N2, 4HRS	10	30	OPEN	0	1.6641±0.1354	6.9834±0.4835	10.3116±0.3132	143.0467±13.2591	1.355±0.1224	0.023±0.0014	1.4367±0.0771
SB	O2, 2HR	15	30	OPEN	0	1.6954±0.1451	7.0834±0.4662	10.4742±0.2995	142.9734±13.5116	1.397±0.102	0.024±0.0018	1.4767±0.0774
SB	O2, 4HR	15	30	OPEN	0	1.6899±0.096	7.108±0.6905	10.4878±0.5121	143.1567±13.4847	1.387±0.1331	0.025±0.002	1.4267±0.1153
SB	N2, 2HRS	15	30	OPEN	0	1.6853±0.1221	7.008±0.4464	10.3786±0.372	143.42±13.5124	1.328±0.0712	0.023±0.0023	1.5034±0.1182
SB	N2, 4HRS	15	30	OPEN	0	1.6608±0.1259	7.0094±0.4028	10.331±0.2008	143.28±8.4535	1.333±0.1026	0.023±0.0017	1.5±0.1297
SB	NIL	0	40	OPEN	0	2.284±0.1573	7.2757±0.6876	11.8437±0.359	142.7567±10.2746	1.317±0.0665	0.029±0.0021	1.57±0.0971

SB	O2, 2HR	5	40	OPEN	0	1.6851±0.1578	7.2484±0.5302	10.6186±0.6003	142.4±8.1884	1.336±0.081	0.028±0.002	1.6±0.1109
SB	O2, 4HR	5	40	OPEN	0	1.7752±0.095	7.2544±0.5176	10.8048±0.2621	142.5167±9.8025	1.342±0.1202	0.028±0.0019	1.5434±0.1521
SB	N2, 2HRS	5	40	OPEN	0	1.7498±0.1387	7.194±0.4313	10.6936±0.2598	142.62±7.8035	1.389±0.1387	0.027±0.0022	1.6267±0.1223
SB	N2, 4HRS	5	40	OPEN	0	1.6997±0.0853	7.1724±0.573	10.5718±0.3834	142.9867±12.3098	1.374±0.1023	0.026±0.002	1.8167±0.1448
SB	O2, 2HR	10	40	OPEN	0	1.7358±0.1079	7.2054±0.6406	10.677±0.2993	142.5434±7.6818	1.391±0.1282	0.028±0.0027	1.64±0.0841
SB	O2, 4HR	10	40	OPEN	0	1.7006±0.1298	7.2347±0.6415	10.6359±0.2755	142.5867±14.0375	1.32±0.0939	0.028±0.0022	1.68±0.0882
SB	N2, 2HRS	10	40	OPEN	0	1.7437±0.1136	7.1567±0.5387	10.6441±0.4407	142.7534±12.9957	1.385±0.0719	0.026±0.0014	1.7934±0.1207
SB	N2, 4HRS	10	40	OPEN	0	1.6783±0.1564	7.1827±0.5186	10.5393±0.8967	142.92±11.9407	1.363±0.1092	0.026±0.0021	1.7134±0.135
SB	O2, 2HR	15	40	OPEN	0	1.7004±0.1418	7.2137±0.6235	10.6145±0.2144	142.6567±9.5992	1.397±0.1323	0.028±0.002	1.6767±0.1676
SB	O2, 4HR	15	40	OPEN	0	1.7326±0.1313	7.2614±0.5441	10.7266±0.3888	142.4167±9.4949	1.351±0.1132	0.028±0.0019	1.9534±0.1594
SB	N2, 2HRS	15	40	OPEN	0	1.7542±0.0888	7.1704±0.3703	10.6788±0.0354	142.6867±9.6274	1.397±0.1332	0.026±0.0016	1.7634±0.1049
SB	N2, 4HRS	15	40	OPEN	0	1.7266±0.1146	7.189±0.384	10.6422±0.4941	142.6467±12.564	1.304±0.1105	0.027±0.0022	1.6067±0.1558
SF	NIL	0	20	OPEN	0	1.095±0.0621	2.5367±0.1446	4.7267±0.0603	137.6634±12.7413	1.362±0.1135	0.026±0.0014	2.0034±0.1063
SF	O2, 2HR	5	20	OPEN	0	1.0187±0.0957	2.1757±0.1203	4.2131±0.0829	138.5367±10.5192	1.339±0.0757	0.019±0.0015	1.4234±0.1294
SF	O2, 4HR	5	20	OPEN	0	1.041±0.101	2.1914±0.1421	4.2734±0.3664	137.7334±9.7431	1.303±0.0715	0.02±0.0013	1.5734±0.0787
SF	N2, 2HRS	5	20	OPEN	0	1.0203±0.1002	2.0824±0.1184	4.123±0.1224	137.8±11.3336	1.349±0.0714	0.016±0.0009	1.56±0.1483
SF	N2, 4HRS	5	20	OPEN	0	1.0213±0.0855	2.136±0.1084	4.1786±0.103	137.68±7.0507	1.377±0.0826	0.017±0.0014	1.62±0.1619
SF	O2, 2HR	10	20	OPEN	0	1.0336±0.0681	2.157±0.2052	4.2242±0.1878	138.57±7.8943	1.313±0.0895	0.018±0.0012	1.5467±0.1216
SF	O2, 4HR	10	20	OPEN	0	1.0292±0.0638	2.183±0.1312	4.2414±0.1055	137.7767±8.1697	1.36±0.1288	0.019±0.0011	1.47±0.089
SF	N2, 2HRS	10	20	OPEN	0	1.02±0.0521	2.088±0.1548	4.128±0.0317	138.2134±8.9596	1.301±0.0965	0.017±0.0009	1.54±0.1073
SF	N2, 4HRS	10	20	OPEN	0	1.0279±0.0595	2.113±0.2056	4.1688±0.0831	138.5767±9.8519	1.351±0.0722	0.017±0.0013	1.5834±0.1158
SF	O2, 2HR	15	20	OPEN	0	1.0502±0.0907	2.159±0.1573	4.2594±0.0718	137.8234±7.8975	1.365±0.075	0.019±0.0016	1.45±0.1421
SF	O2, 4HR	15	20	OPEN	0	1.0441±0.0742	2.2137±0.1607	4.3019±0.0887	137.57±13.755	1.38±0.1373	0.02±0.0016	1.43±0.1197
SF	N2, 2HRS	15	20	OPEN	0	1.0524±0.0813	2.1024±0.1359	4.2072±0.0666	138.0267±9.67	1.377±0.1303	0.017±0.0015	1.51±0.1155
SF	N2, 4HRS	15	20	OPEN	0	1.0497±0.0831	2.1267±0.1251	4.2261±0.1185	138.06±10.9828	1.307±0.0695	0.017±0.001	1.61±0.1601
SF	NIL	0	30	OPEN	0	1.1168±0.072	2.6597±0.2075	4.8933±0.1436	136.6534±9.0816	1.37±0.1055	0.029±0.0029	2.1167±0.1968
SF	O2, 2HR	5	30	OPEN	0	1.0111±0.0551	2.4194±0.1985	4.4416±0.0785	137.2567±10.0571	1.343±0.1123	0.024±0.0014	1.78±0.1428
SF	O2, 4HR	5	30	OPEN	0	1.0445±0.099	2.4554±0.1818	4.5444±0.2577	137.6934±11.8019	1.399±0.1367	0.026±0.0021	1.6634±0.1488
SF	N2, 2HRS	5	30	OPEN	0	1.0592±0.0872	2.437±0.1975	4.5554±0.1211	137.3534±12.2637	1.331±0.1124	0.025±0.002	1.7867±0.1085
SF	N2, 4HRS	5	30	OPEN	0	1.0079±0.0911	2.4447±0.2106	4.4605±0.1733	137.24±8.1339	1.385±0.105	0.025±0.0025	1.7234±0.1381
SF	O2, 2HR	10	30	OPEN	0	1.0393±0.0653	2.45±0.2281	4.5286±0.2087	137.1434±10.7035	1.35±0.1019	0.025±0.0013	1.6434±0.1272
SF	O2, 4HR	10	30	OPEN	0	1.0368±0.0522	2.4874±0.2169	4.561±0.0355	137.8534±12.0952	1.366±0.0867	0.026±0.0025	1.63±0.119
SF	N2, 2HRS	10	30	OPEN	0	1.0316±0.085	2.3944±0.1962	4.4576±0.0375	138.04±10.9585	1.354±0.0728	0.023±0.0018	1.74±0.0901
SF	N2, 4HRS	10	30	OPEN	0	1.0551±0.0819	2.3734±0.1208	4.4836±0.0351	137.3767±11.6413	1.329±0.1031	0.023±0.0021	1.6934±0.1271
SF	O2, 2HR	15	30	OPEN	0	1.0398±0.0894	2.4734±0.1896	4.553±0.2225	137.3034±12.2809	1.399±0.1393	0.026±0.0019	1.7334±0.1535
SF	O2, 4HR	15	30	OPEN	0	1.0385±0.0572	2.498±0.2294	4.575±0.1032	137.4867±11.2531	1.36±0.0683	0.026±0.0022	1.6834±0.0892
SF	N2, 2HRS	15	30	OPEN	0	1.0242±0.0513	2.398±0.183	4.4464±0.1113	137.75±9.5292	1.31±0.0921	0.024±0.0016	1.76±0.1602
SF	N2, 4HRS	15	30	OPEN	0	1.055±0.0739	2.3994±0.1351	4.5094±0.1749	137.61±7.7613	1.316±0.0902	0.024±0.002	1.7567±0.1259
SF	NIL	0	40	OPEN	0	1.1301±0.1032	2.6657±0.2128	4.9259±0.2196	137.0867±7.7833	1.376±0.1245	0.029±0.0022	1.8267±0.1065
SF	O2, 2HR	5	40	OPEN	0	1.0412±0.0761	2.6384±0.2369	4.7208±0.1606	136.73±11.3917	1.317±0.0888	0.028±0.0027	1.791±0.096
SF	O2, 4HR	5	40	OPEN	0	1.0377±0.0744	2.6444±0.2183	4.7198±0.4	136.8467±13.4821	1.33±0.0983	0.028±0.0024	1.8±0.1075
SF	N2, 2HRS	5	40	OPEN	0	1.031±0.0599	2.584±0.2028	4.646±0.0598	136.95±11.8551	1.369±0.0692	0.027±0.0016	1.8834±0.1462
SF	N2, 4HRS	5	40	OPEN	0	1.0289±0.0522	2.5624±0.2249	4.6202±0.1189	137.3167±11.7056	1.311±0.122	0.027±0.0023	2.0734±0.2067
SF	O2, 2HR	10	40	OPEN	0	1.0272±0.0695	2.5954±0.1697	4.6498±0.0878	136.8734±8.4998	1.353±0.118	0.028±0.0018	1.8967±0.1278
SF	O2, 4HR	10	40	OPEN	0	1.0155±0.0712	2.6247±0.2578	4.6557±0.1644	136.9167±11.6247	1.38±0.1199	0.028±0.0021	1.9367±0.1096
SF	N2, 2HRS	10	40	OPEN	0	1.0396±0.065	2.5467±0.1385	4.6259±0.1129	137.0834±13.4627	1.358±0.0785	0.026±0.002	2.05±0.1494
SF	N2, 4HRS	10	40	OPEN	0	1.0514±0.0587	2.5727±0.25	4.6755±0.127	137.25±7.2068	1.326±0.126	0.027±0.0027	1.97±0.1334
SF	O2, 2HR	15	40	OPEN	0	1.0427±0.0582	2.6037±0.2406	4.6891±0.4064	136.9867±11.8283	1.349±0.1253	0.028±0.0018	1.9334±0.147
SF	O2, 4HR	15	40	OPEN	0	1.0178±0.0593	2.6514±0.1905	4.687±0.1886	136.7467±8.0681	1.336±0.1077	0.029±0.0016	2.21±0.1417
SF	N2, 2HRS	15	40	OPEN	0	1.0255±0.0939	2.5604±0.1976	4.6114±0.1676	137.0167±12.5906	1.373±0.1071	0.027±0.0018	2.02±0.1276
SF	N2, 4HRS	15	40	OPEN	0	1.0326±0.0597	2.579±0.2087	4.6442±0.1738	136.9767±12.4675	1.333±0.1244	0.027±0.0023	1.8634±0.1249
RB	NIL	0	20	CLOSED	0	0.6086±0.388	4.7327±0.4652	5.9499±0.2705	106.15±8.5684	1.388±0.1247	0.024±0.0024	3.5434±0.354
RB	O2, 2HR	5	20	CLOSED	0	0.5196±0.0376	4.0764±0.2605	5.1156±0.0097	107.0067±10.4129	1.428±0.1073	0.011±0.0008	2.6334±0.1394
RB	O2, 4HR	5	20	CLOSED	0	0.5298±0.396	4.0924±0.397	5.152±0.1008	106.7434±5.4426	1.472±0.0971	0.012±0.0012	2.6434±0.1682
RB	N2, 2HRS	5	20	CLOSED	0	0.5355±0.0499	4.023±0.2274	5.094±0.1174	107.2367±5.4309	1.427±0.1061	0.01±0.0006	2.5334±0.2278
RB	N2, 4HRS	5	20	CLOSED	0	0.5476±0.0466	4.0637±0.3593	5.1589±0.2077	106.95±7.6337	1.444±0.0964	0.01±0.0005	2.61±0.1969
RB	O2, 2HR	10	20	CLOSED	0	0.5238±0.0408	4.072±0.279	5.1196±0.1307	107.2434±8.5296	1.47±0.0969	0.011±0.0008	2.6167±0.2001
RB	O2, 4HR	10	20	CLOSED	0	0.5587±0.0478	4.0987±0.3858	5.2161±0.076	107.07±9.3983	1.422±0.0811	0.012±0.0006	2.6534±0.1525
RB	N2, 2HRS	10	20	CLOSED	0	0.5453±0.0356	4.0154±0.3183	5.106±0.0446	107.9567±10.7217	1.434±0.1334	0.01±0.0005	2.5067±0.2241
RB	N2, 4HRS	10	20	CLOSED	0	0.5158±0.0289	4.045±0.3463	5.0766±0.3197	107.2567±7.6968	1.453±0.0839	0.01±0.0009	2.59±0.2301
RB	O2, 2HR	15	20	CLOSED	0	0.531±0.0434	4.108±0.3346	5.17±0.0637	107.3767±10.6505	1.427±0.1221	0.013±0.0013	2.6667±0.1942
RB	O2, 4HR	15	20	CLOSED	0	0.5522±0.0351	4.1124±0.2553	5.2168±0.1405	107.57±7.2634	1.437±0.1209	0.013±0.0007	2.7±0.2501
RB	N2, 2HRS	15	20	CLOSED	0	0.5374±0.03	4.0164±0.2213	5.0912±0.0849	107.27±10.2345	1.383±0.1168	0.01±0.0007	2.52±0.2178
RB	N2, 4HRS	15	20	CLOSED	0	0.5586±0.0362	4.0247±0.2698	5.1419±0.16	106.96±9.1525	1.459±0.1061	0.01±0.0005	2.5767±0.1876
RB	NIL	0	30	CLOSED	0	0.6102±0.0371	4.745±0.2716	5.9654±0.0147	105.7167±5.4305	1.465±0.1432	0.025±0.0024	5.57±0.312
RB	O2, 2HR	5	30	CLOSED	0	0.5374±0.045	4.2164±0.267	5.2912±0.1861	106.9634±10.2364	1.381±0.1321	0.014±0.0014	2.86±0.1724
RB	O2, 4HR	5	30	CLOSED	0	0.5266±0.0464	4.2427±0.2759	5.2959±0.1856	107.0967±5.9928	1.415±0.0953	0.015±0.0013	2.8634±0.2564
RB	N2, 2HRS	5	30	CLOSED	0	0.5398±0.0468	4.1917±0.34	5.2713±0.1821	106.59±5.5489	1.399±0.1057	0.014±0.0009	2.84±0.161
RB	N2, 4HRS	5	30	CLOSED	0	0.5415±0.05	4.2074±0.2456	5.2904±0.1443	107.1467±5.936	1.434±0.1335	0.014±0.0008	2.84±0.2194
RB	O2, 2HR	10	30	CLOSED	0	0.5271±0.0326	4.1304±0.343	5.1846±0.4688	107.2±6.6315	1.405±0.1297	0.013±0.0012	2.74±0.1456
RB	O2, 4HR	10	30	CLOSED	0	0.5371±0.0504	4.1417±0.3884	5.2159±0.1889	107.4167±6.2513	1.425±0.1025	0.013±0.0007	2.7734±0.2089
RB	N2, 2HRS	10	30	CLOSED	0	0.5578±0.0474	4.118±0.4083	5.2336±0.3139	107.3334±10.6148	1.396±0.1287	0.013±0.0009	2.7034±0.1744
RB	N2, 4HRS	10	30	CLOSED	0	0.5344±0.0461	4.1204±0.2					

RB	N2, 2HRS	15	30	CLOSED	0	0.5232±0.0315	4.1487±0.2667	5.1951±0.1405	106.7134±9.9184	1.451±0.1222	0.014±0.0009	2.7967±0.151
RB	N2, 4HRS	15	30	CLOSED	0	0.5338±0.0467	4.1797±0.2512	5.2473±0.1929	107.41±7.9032	1.394±0.0924	0.014±0.0008	2.81±0.1657
RB	NIL	0	40	CLOSED	0	0.6218±0.0524	4.879±0.2768	6.1226±0.1182	105.4067±8.4597	1.449±0.0812	0.027±0.0027	3.8367±0.2893
RB	O2, 2HR	5	40	CLOSED	0	0.5448±0.0391	4.5094±0.2679	5.599±0.2075	106.4±7.6218	1.393±0.1186	0.019±0.0014	3.3034±0.1756
RB	O2, 4HR	5	40	CLOSED	0	0.5549±0.0412	4.5327±0.3988	5.6425±0.2312	106.2567±6.4748	1.415±0.0893	0.02±0.0013	3.3267±0.2925
RB	N2, 2HRS	5	40	CLOSED	0	0.5516±0.0305	4.5087±0.2696	5.6119±0.0949	106.3167±9.5622	1.448±0.0854	0.019±0.0016	3.29±0.2199
RB	N2, 4HRS	5	40	CLOSED	0	0.5638±0.0392	4.4874±0.3599	5.615±0.0627	106.1334±8.5667	1.43±0.0908	0.019±0.0015	3.2134±0.2192
RB	O2, 2HR	10	40	CLOSED	0	0.5708±0.0538	4.5037±0.37	5.6453±0.3915	106.2767±6.0876	1.473±0.1058	0.019±0.0014	3.2834±0.3101
RB	O2, 4HR	10	40	CLOSED	0	0.5443±0.0433	4.5447±0.3045	5.6333±0.3666	106.0167±6.6527	1.472±0.1458	0.02±0.0012	3.3534±0.2695
RB	N2, 2HRS	10	40	CLOSED	0	0.526±0.0342	4.4694±0.3095	5.5214±0.2187	106.5367±6.1315	1.398±0.0909	0.019±0.001	3.1934±0.2472
RB	N2, 4HRS	10	40	CLOSED	0	0.5601±0.0423	4.5227±0.3595	5.6429±0.1544	106.2734±9.8669	1.435±0.0878	0.02±0.0015	3.3167±0.1787
RB	O2, 2HR	15	40	CLOSED	0	0.5577±0.0512	4.494±0.2317	5.6094±0.0909	106.0967±10.4068	1.445±0.1416	0.019±0.0012	3.2534±0.3048
RB	O2, 4HR	15	40	CLOSED	0	0.5312±0.036	4.571±0.3192	5.6334±0.1235	105.93±7.6666	1.412±0.109	0.02±0.0018	3.3634±0.2377
RB	N2, 2HRS	15	40	CLOSED	0	0.576±0.0498	4.4444±0.377	5.5964±0.2527	107.09±7.6041	1.403±0.1201	0.018±0.0017	3.1667±0.3002
RB	N2, 4HRS	15	40	CLOSED	0	0.5307±0.0468	4.4577±0.3254	5.5191±0.1816	106.7634±5.8347	1.417±0.0949	0.019±0.0012	3.1734±0.2967
SB	NIL	0	20	CLOSED	0	1.692±0.1454	7.1227±0.5457	10.5067±0.2656	143.15±13.8374	1.398±0.0914	0.025±0.0018	1.7834±0.1245
SB	O2, 2HR	5	20	CLOSED	0	1.5312±0.0801	6.4664±0.6337	9.5288±0.2731	144.0067±7.7283	1.386±0.1021	0.013±0.0008	0.5067±0.043
SB	O2, 4HR	5	20	CLOSED	0	1.6205±0.1284	6.4824±0.4299	9.7234±0.4403	143.7434±10.8029	1.365±0.0802	0.012±0.0006	0.52±0.0515
SB	N2, 2HRS	5	20	CLOSED	0	1.5221±0.1187	6.4134±0.4843	9.4572±0.5559	144.2367±11.5162	1.354±0.0896	0.01±0.001	0.6667±0.0599
SB	N2, 4HRS	5	20	CLOSED	0	1.5391±0.1102	6.4537±0.5143	9.5319±0.5616	143.95±9.6423	1.378±0.1225	0.012±0.0006	0.7±0.0692
SB	O2, 2HR	10	20	CLOSED	0	1.5947±0.1075	6.462±0.5457	9.6514±0.3914	144.2434±14.2915	1.367±0.1269	0.012±0.0011	0.5034±0.0497
SB	O2, 4HR	10	20	CLOSED	0	1.5889±0.1536	6.4887±0.5375	9.665±0.1924	144.07±13.2222	1.356±0.1027	0.014±0.0008	0.61±0.0367
SB	N2, 2HRS	10	20	CLOSED	0	1.5728±0.0812	6.4054±0.5175	9.551±0.1095	144.9567±14.2702	1.393±0.1171	0.01±0.0008	0.6334±0.0551
SB	N2, 4HRS	10	20	CLOSED	0	1.5982±0.0937	6.435±0.4451	9.6314±0.4254	144.2567±11.0268	1.318±0.0998	0.011±0.0011	0.6534±0.0526
SB	O2, 2HR	15	20	CLOSED	0	1.5766±0.153	6.498±0.4166	9.6512±0.341	144.3767±12.492	1.305±0.1003	0.012±0.0011	0.59±0.0414
SB	O2, 4HR	15	20	CLOSED	0	1.6196±0.0937	6.5024±0.5372	9.7416±0.1606	144.57±10.8691	1.327±0.1058	0.013±0.001	0.5767±0.0534
SB	N2, 2HRS	15	20	CLOSED	0	1.531±0.153	6.4064±0.367	9.4684±0.3977	144.27±9.3886	1.32±0.1079	0.01±0.0006	0.6167±0.0482
SB	N2, 4HRS	15	20	CLOSED	0	1.5902±0.1199	6.4147±0.3345	9.5951±0.1124	143.96±9.546	1.308±0.1067	0.011±0.0009	0.6434±0.0498
SB	NIL	0	30	CLOSED	0	1.696±0.1572	7.135±0.4656	10.527±0.1368	142.7167±14.0359	1.333±0.0791	0.025±0.0018	1.74±0.1471
SB	O2, 2HR	5	30	CLOSED	0	1.6251±0.1497	6.6064±0.425	9.8566±0.4488	143.9634±14.0712	1.329±0.0875	0.015±0.0008	0.7967±0.0431
SB	O2, 4HR	5	30	CLOSED	0	1.6269±0.1275	6.6327±0.4222	9.8865±0.301	144.0967±7.799	1.361±0.0782	0.015±0.0009	0.84±0.0711
SB	N2, 2HRS	5	30	CLOSED	0	1.5614±0.1126	6.5817±0.5475	9.7045±0.165	143.59±12.8485	1.305±0.1218	0.014±0.0014	0.84±0.072
SB	N2, 4HRS	5	30	CLOSED	0	1.5634±0.0986	6.5974±0.4585	9.7242±0.1826	144.1467±12.4214	1.376±0.0824	0.015±0.0009	0.7034±0.0465
SB	O2, 2HR	10	30	CLOSED	0	1.5884±0.1171	6.5204±0.4187	9.6972±0.6609	144.2±13.7392	1.314±0.0841	0.013±0.0009	0.8767±0.0867
SB	O2, 4HR	10	30	CLOSED	0	1.5881±0.1519	6.5317±0.5938	9.7079±0.1485	144.4167±8.4296	1.333±0.129	0.013±0.0007	0.8634±0.0449
SB	N2, 2HRS	10	30	CLOSED	0	1.5646±0.1324	6.508±0.5286	9.6372±0.243	144.3334±13.6804	1.381±0.1339	0.013±0.0011	0.86±0.0704
SB	N2, 4HRS	10	30	CLOSED	0	1.6419±0.1059	6.5104±0.3964	9.7942±0.3412	143.88±9.7615	1.36±0.0866	0.013±0.0013	0.74±0.04
SB	O2, 2HR	15	30	CLOSED	0	1.6047±0.0891	6.6494±0.3486	9.8588±0.2956	143.54±12.082	1.378±0.1013	0.015±0.001	0.71±0.0659
SB	O2, 4HR	15	30	CLOSED	0	1.6292±0.1006	6.6584±0.5013	9.9168±0.602	144.3134±11.8185	1.311±0.1101	0.016±0.0016	0.81±0.064
SB	N2, 2HRS	15	30	CLOSED	0	1.6225±0.0884	6.5387±0.3572	9.7837±0.2446	143.7134±8.7246	1.311±0.0791	0.014±0.0008	0.7734±0.0682
SB	N2, 4HRS	15	30	CLOSED	0	1.5728±0.1389	6.5697±0.6112	9.7153±0.4447	144.41±10.6611	1.313±0.0794	0.014±0.0009	0.8967±0.0647
SB	NIL	0	40	CLOSED	0	2.237±0.2231	7.269±0.5302	11.743±0.3971	142.4067±12.5015	1.394±0.0748	0.028±0.0015	1.93±0.1272
SB	O2, 2HR	5	40	CLOSED	0	1.6018±0.0999	6.8994±0.437	10.103±0.2017	143.4±13.9564	1.384±0.1181	0.021±0.0017	0.9334±0.0472
SB	O2, 4HR	5	40	CLOSED	0	1.6635±0.1575	6.9227±0.5543	10.2497±0.4976	143.2567±8.5815	1.318±0.0674	0.022±0.0014	0.9834±0.093
SB	N2, 2HRS	5	40	CLOSED	0	1.5883±0.1413	6.8987±0.5354	10.0753±0.1826	143.3167±14.1676	1.311±0.0917	0.02±0.0012	0.9267±0.1017
SB	N2, 4HRS	5	40	CLOSED	0	1.5984±0.1022	6.8774±0.557	10.0742±0.2387	143.1334±8.4858	1.354±0.0855	0.02±0.001	1.0967±0.1063
SB	O2, 2HR	10	40	CLOSED	0	1.6463±0.0932	6.8937±0.6596	10.1863±0.5428	143.2767±12.1535	1.392±0.1328	0.02±0.0014	1.14±0.0663
SB	O2, 4HR	10	40	CLOSED	0	1.6319±0.0905	6.9347±0.6391	10.1985±0.3147	143.0167±10.6982	1.38±0.1357	0.022±0.0016	0.9567±0.0748
SB	N2, 2HRS	10	40	CLOSED	0	1.6029±0.1089	6.8594±0.5388	10.0652±0.3356	143.5367±7.5697	1.349±0.1206	0.019±0.0015	1.0234±0.0635
SB	N2, 4HRS	10	40	CLOSED	0	1.628±0.0859	6.9127±0.4544	10.1687±0.0515	143.2734±8.7183	1.38±0.1096	0.022±0.0018	0.94±0.0858
SB	O2, 2HR	15	40	CLOSED	0	1.6669±0.1484	6.884±0.4583	10.2178±0.3373	143.0967±11.697	1.329±0.068	0.02±0.0012	1.07±0.0555
SB	O2, 4HR	15	40	CLOSED	0	1.649±0.1555	6.961±0.5802	10.2594±0.3868	142.93±14.1057	1.379±0.118	0.022±0.0012	0.97±0.0866
SB	N2, 2HRS	15	40	CLOSED	0	1.5896±0.1202	6.8344±0.4088	10.0136±0.4528	144.09±10.4682	1.349±0.0996	0.019±0.0018	1.03±0.0851
SB	N2, 4HRS	15	40	CLOSED	0	1.6072±0.1523	6.8477±0.5118	10.0621±0.9712	143.7634±9.6506	1.358±0.131	0.019±0.0012	0.9967±0.096
SF	NIL	0	20	CLOSED	0	1.0856±0.0883	2.5127±0.2321	4.6839±0.2077	137.48±12.363	1.328±0.1267	0.026±0.0025	2.04±0.1085
SF	O2, 2HR	5	20	CLOSED	0	0.9966±0.0775	1.8564±0.1283	3.8496±0.0361	138.3367±11.6896	1.342±0.1147	0.012±0.0012	0.7634±0.076
SF	O2, 4HR	5	20	CLOSED	0	1.0068±0.0603	1.8724±0.1394	3.886±0.095	138.0734±11.97	1.355±0.1038	0.012±0.0008	0.7767±0.0454
SF	N2, 2HRS	5	20	CLOSED	0	1.0125±0.095	1.803±0.1411	3.828±0.0787	138.5667±8.0359	1.32±0.1296	0.01±0.001	0.9234±0.0504
SF	N2, 4HRS	5	20	CLOSED	0	1.0246±0.0756	1.8437±0.1425	3.8929±0.1109	138.28±8.5739	1.387±0.1292	0.012±0.0012	0.9567±0.0513
SF	O2, 2HR	10	20	CLOSED	0	1.0008±0.0627	1.852±0.1299	3.8536±0.1381	138.5734±11.1943	1.322±0.0996	0.012±0.0007	0.79±0.068
SF	O2, 4HR	10	20	CLOSED	0	1.0357±0.0711	1.8787±0.1874	3.9501±0.134	138.4±7.8197	1.386±0.1025	0.013±0.0013	0.8667±0.0751
SF	N2, 2HRS	10	20	CLOSED	0	1.0223±0.0766	1.7954±0.1328	3.84±0.0688	139.2867±7.8602	1.38±0.1069	0.01±0.0006	0.89±0.0884
SF	N2, 4HRS	10	20	CLOSED	0	0.9928±0.0833	1.825±0.1209	3.8106±0.2157	138.5867±13.6961	1.361±0.1213	0.011±0.001	0.91±0.0858
SF	O2, 2HR	15	20	CLOSED	0	1.008±0.0922	1.888±0.1023	3.904±0.0931	138.7067±11.3729	1.397±0.0777	0.013±0.0007	0.8467±0.0497
SF	O2, 4HR	15	20	CLOSED	0	1.0292±0.0534	1.8924±0.168	3.9508±0.1785	138.9±10.4216	1.392±0.0815	0.013±0.0013	0.8334±0.0718
SF	N2, 2HRS	15	20	CLOSED	0	1.0144±0.1006	1.7964±0.123	3.8252±0.1609	138.6±8.1308	1.3±0.1133	0.01±0.0005	0.8734±0.0624
SF	N2, 4HRS	15	20	CLOSED	0	1.0356±0.0692	1.8047±0.0976	3.8759±0.0907	138.29±11.4099	1.33±0.067	0.011±0.0011	0.9±0.0895
SF	NIL	0	30	CLOSED	0	1.0872±0.0731	2.525±0.1325	4.6994±0.1582	137.0467±10.2495	1.327±0.0958	0.026±0.0021	1.9967±0.1686
SF	O2, 2HR	5	30	CLOSED	0	1.0144±0.0937	1.9964±0.1968	4.0252±0.1217	138.2934±10.3416	1.345±0.0724	0.015±0.0008	1.0534±0.1022
SF	O2, 4HR	5	30	CLOSED	0	1.0036±0.0622	2.0227±0.1822	4.0299±0.057	138.4267±12.2875	1.367±0.0841	0.016±0.0008	1.0967±0.0639
SF	N2, 2HRS	5	30	CLOSED	0	1.0168±0.0919	1.9717±0.1395	4.0053±0.17	137.92±12.1931	1.38±0.1117	0.015±0.0011	1.0967±0.1052
SF	N2, 4HRS	5	30	CLOSED	0	1.0185±0.0816	1.9874±0.1656	4.0244±0.0474	138.4767±9.4065	1.326±0.0677	0.015±0.0011	0.96±0.0779
SF	O2, 2HR	10	30	CLOSED	0	1.0041±0.097	1.9104±0.1069	3.9186±0.				

SF	N2, 4HRS	10	30	CLOSED	0	1.0114±0.065	1.9004±0.1407	3.9232±0.2581	138.21±11.2219	1.35±0.1118	0.014±0.0007	0.9967±0.0909
SF	O2, 2HR	15	30	CLOSED	0	1.0074±0.0937	2.0394±0.1951	4.0542±0.2189	137.87±7.0861	1.317±0.1223	0.016±0.0016	0.9667±0.0881
SF	O2, 4HR	15	30	CLOSED	0	1.0339±0.0657	2.0484±0.1583	4.1162±0.1608	138.6434±8.6316	1.352±0.1055	0.016±0.001	1.0667±0.0701
SF	N2, 2HRS	15	30	CLOSED	0	1.0002±0.0613	1.9287±0.1747	3.9291±0.2394	138.0434±13.7975	1.357±0.0823	0.014±0.0008	1.03±0.0657
SF	N2, 4HRS	15	30	CLOSED	0	1.0108±0.0921	1.9597±0.1239	3.9813±0.1076	138.74±9.3226	1.307±0.0823	0.015±0.0015	1.1534±0.0585
SF	NIL	0	40	CLOSED	0	1.0988±0.1085	2.659±0.2407	4.8566±0.0646	136.7367±9.4201	1.351±0.1224	0.029±0.0024	2.1867±0.1363
SF	O2, 2HR	5	40	CLOSED	0	1.0218±0.0975	2.2894±0.1441	4.333±0.0805	137.73±7.7259	1.386±0.1094	0.022±0.0018	1.19±0.0986
SF	O2, 4HR	5	40	CLOSED	0	1.0319±0.0992	2.3127±0.1455	4.3765±0.1317	137.5867±12.0907	1.331±0.0824	0.022±0.0013	1.24±0.0634
SF	N2, 2HRS	5	40	CLOSED	0	1.0286±0.0955	2.2887±0.1936	4.3459±0.2489	137.6467±10.2284	1.373±0.083	0.022±0.0013	1.1834±0.0749
SF	N2, 4HRS	5	40	CLOSED	0	1.0408±0.084	2.2674±0.1197	4.349±0.3134	137.4634±6.8747	1.332±0.1182	0.021±0.0016	1.3534±0.1126
SF	O2, 2HR	10	40	CLOSED	0	1.0478±0.0984	2.2837±0.1337	4.3793±0.2071	137.6067±9.5125	1.34±0.0769	0.022±0.0011	1.3967±0.0699
SF	O2, 4HR	10	40	CLOSED	0	1.0213±0.1001	2.3247±0.1237	4.3673±0.117	137.3467±13.1803	1.3±0.117	0.023±0.0018	1.2134±0.103
SF	N2, 2HRS	10	40	CLOSED	0	1.003±0.0914	2.2494±0.1594	4.2554±0.1583	137.8667±9.6146	1.368±0.11	0.021±0.0015	1.28±0.0697
SF	N2, 4HRS	10	40	CLOSED	0	1.0371±0.0586	2.3027±0.1695	4.3769±0.1747	137.6034±13.2591	1.365±0.0713	0.022±0.0022	1.1967±0.0681
SF	O2, 2HR	15	40	CLOSED	0	1.0347±0.0887	2.274±0.1223	4.3434±0.084	137.4267±12.9379	1.333±0.1205	0.021±0.002	1.3267±0.0685
SF	O2, 4HR	15	40	CLOSED	0	1.0082±0.0852	2.351±0.1199	4.3674±0.066	137.26±10.1419	1.359±0.1336	0.023±0.0015	1.2267±0.0772
SF	N2, 2HRS	15	40	CLOSED	0	1.053±0.0565	2.2244±0.1777	4.3304±0.2156	138.42±11.0313	1.379±0.0734	0.02±0.0011	1.2867±0.0986
SF	N2, 4HRS	15	40	CLOSED	0	1.0077±0.0696	2.2377±0.1743	4.2531±0.0605	138.0934±10.2691	1.322±0.0949	0.02±0.0015	1.2534±0.071
RB	NIL	0	20	OPEN	1	0.8897±0.0807	4.8117±0.4641	6.5911±0.4249	103.7067±6.1006	1.459±0.0958	0.044±0.0026	3.62±0.2456
RB	O2, 2HR	5	20	OPEN	1	0.5486±0.0405	4.53±0.4047	5.6272±0.1492	103.7834±9.2463	1.42±0.1021	0.037±0.0033	3.0434±0.2458
RB	O2, 4HR	5	20	OPEN	1	0.5623±0.0415	4.3487±0.263	5.4733±0.119	104.09±5.7139	1.396±0.0971	0.037±0.0035	3.0767±0.1566
RB	N2, 2HRS	5	20	OPEN	1	0.5631±0.0328	4.1944±0.299	5.3206±0.3412	104.09±9.9966	1.46±0.1388	0.036±0.0032	2.9234±0.1479
RB	N2, 4HRS	5	20	OPEN	1	0.5608±0.0402	4.495±0.3426	5.6166±0.1446	104.4634±7.3804	1.43±0.1423	0.036±0.0023	2.99±0.19
RB	O2, 2HR	10	20	OPEN	1	0.5563±0.0315	4.507±0.2546	5.6196±0.0574	104.4067±5.6487	1.455±0.1241	0.037±0.002	3.0034±0.2723
RB	O2, 4HR	10	20	OPEN	1	0.5501±0.0546	4.408±0.2349	5.5082±0.0383	104.4134±9.6004	1.463±0.091	0.037±0.003	3.06±0.2241
RB	N2, 2HRS	10	20	OPEN	1	0.5697±0.0491	4.344±0.4196	5.4834±0.2124	104.1534±5.9878	1.447±0.0927	0.036±0.003	2.9467±0.2847
RB	N2, 4HRS	10	20	OPEN	1	0.5567±0.0292	4.3684±0.2499	5.4818±0.2541	104.1234±10.0069	1.397±0.1375	0.036±0.0029	2.96±0.1802
RB	O2, 2HR	15	20	OPEN	1	0.5684±0.0533	4.4884±0.3401	5.6252±0.2369	104.2867±7.4365	1.407±0.1026	0.037±0.0026	3.03±0.2107
RB	O2, 4HR	15	20	OPEN	1	0.565±0.0454	4.4767±0.3004	5.6067±0.1357	103.8767±8.3923	1.408±0.1274	0.037±0.003	3.09±0.1634
RB	N2, 2HRS	15	20	OPEN	1	0.5802±0.0361	4.43±0.396	5.5904±0.1462	104.0534±5.4663	1.395±0.1336	0.036±0.0035	2.95±0.1803
RB	N2, 4HRS	15	20	OPEN	1	0.5714±0.0456	4.19±0.2521	5.3328±0.2805	104.2967±10.0558	1.423±0.0715	0.036±0.003	2.97±0.2479
RB	NIL	0	30	OPEN	1	0.9706±0.0883	5.8904±0.3217	7.8316±0.2023	103.5867±8.3746	1.438±0.1115	0.048±0.0032	3.8834±0.2426
RB	O2, 2HR	5	30	OPEN	1	0.582±0.057	4.6357±0.2835	5.7997±0.3829	103.66±9.7911	1.424±0.1121	0.041±0.003	3.42±0.2841
RB	O2, 4HR	5	30	OPEN	1	0.5751±0.0315	4.629±0.3403	5.7792±0.1159	103.7867±6.5461	1.424±0.0895	0.042±0.0029	3.5167±0.3102
RB	N2, 2HRS	5	30	OPEN	1	0.5614±0.0327	4.707±0.4165	5.8298±0.2552	104.12±8.792	1.403±0.0777	0.041±0.0025	3.4367±0.2387
RB	N2, 4HRS	5	30	OPEN	1	0.5836±0.0549	4.635±0.2755	5.8022±0.2324	103.8±8.7545	1.419±0.099	0.042±0.0042	3.4567±0.3197
RB	O2, 2HR	10	30	OPEN	1	0.5724±0.032	4.6167±0.4213	5.7615±0.472	103.7667±8.301	1.464±0.1206	0.042±0.003	3.4934±0.235
RB	O2, 4HR	10	30	OPEN	1	0.5785±0.0526	4.7484±0.2764	5.9054±0.1692	103.8867±8.0422	1.452±0.0994	0.043±0.0029	3.5634±0.309
RB	N2, 2HRS	10	30	OPEN	1	0.561±0.043	4.368±0.2633	5.49±0.2173	103.8134±10.1917	1.422±0.1231	0.04±0.0037	3.3834±0.1922
RB	N2, 4HRS	10	30	OPEN	1	0.5432±0.043	4.6614±0.3447	5.7478±0.2193	104.16±7.0857	1.451±0.0859	0.04±0.004	3.36±0.2049
RB	O2, 2HR	15	30	OPEN	1	0.5774±0.0463	4.5794±0.3465	5.7342±0.3034	104.03±7.8013	1.438±0.143	0.043±0.0028	3.5467±0.1908
RB	O2, 4HR	15	30	OPEN	1	0.567±0.0357	4.712±0.257	5.846±0.0833	103.8867±9.5429	1.463±0.1151	0.043±0.0028	3.5734±0.2961
RB	N2, 2HRS	15	30	OPEN	1	0.5625±0.0509	4.634±0.4143	5.759±0.3015	104.08±10.098	1.377±0.0742	0.041±0.0025	3.3934±0.2965
RB	N2, 4HRS	15	30	OPEN	1	0.5735±0.0508	4.4944±0.435	5.6414±0.1885	103.9±7.0083	1.41±0.1056	0.041±0.0023	3.4034±0.2286
RB	NIL	0	40	OPEN	1	0.9858±0.082	5.8744±0.4565	7.846±0.761	103.1567±9.6487	1.455±0.1421	0.049±0.0044	3.9067±0.2089
RB	O2, 2HR	5	40	OPEN	1	0.5563±0.0472	4.8204±0.4166	5.933±0.125	103.2134±10.0165	1.418±0.0796	0.047±0.0026	3.8034±0.3319
RB	O2, 4HR	5	40	OPEN	1	0.5596±0.0485	4.6794±0.4374	5.7986±0.4241	103.2467±8.9184	1.385±0.0825	0.047±0.004	3.8134±0.3566
RB	N2, 2HRS	5	40	OPEN	1	0.5742±0.0501	4.5734±0.3218	5.7218±0.1629	103.37±7.8237	1.395±0.1115	0.046±0.0035	3.7334±0.3066
RB	N2, 4HRS	5	40	OPEN	1	0.5603±0.0458	4.5697±0.3101	5.6903±0.1097	103.9334±10.2232	1.449±0.143	0.045±0.004	3.6734±0.3411
RB	O2, 2HR	10	40	OPEN	1	0.544±0.0436	4.7987±0.4472	5.8787±0.2666	103.72±8.6043	1.466±0.0994	0.047±0.0029	3.74±0.2744
RB	O2, 4HR	10	40	OPEN	1	0.5497±0.0521	4.5387±0.2832	5.6381±0.1326	103.7967±9.6227	1.469±0.0779	0.047±0.0046	3.78±0.3674
RB	N2, 2HRS	10	40	OPEN	1	0.5814±0.0565	4.5307±0.3912	5.6935±0.063	103.4±5.32	1.379±0.0927	0.044±0.0044	3.6234±0.3266
RB	N2, 4HRS	10	40	OPEN	1	0.5858±0.0373	4.6487±0.4579	5.8203±0.2023	103.8634±7.4566	1.408±0.1123	0.046±0.0045	3.7134±0.2266
RB	O2, 2HR	15	40	OPEN	1	0.551±0.0394	4.791±0.4251	5.893±0.134	103.5634±8.8537	1.4±0.0943	0.047±0.0026	3.7567±0.2791
RB	O2, 4HR	15	40	OPEN	1	0.5561±0.043	4.5824±0.3289	5.6946±0.061	103.3767±9.745	1.467±0.0895	0.047±0.0043	3.85±0.2624
RB	N2, 2HRS	15	40	OPEN	1	0.5582±0.0431	4.828±0.2578	5.9444±0.3576	103.37±8.825	1.418±0.1052	0.045±0.0028	3.6534±0.2155
RB	N2, 4HRS	15	40	OPEN	1	0.5707±0.0499	4.7287±0.4442	5.8701±0.3733	103.98±5.3824	1.435±0.1171	0.046±0.0028	3.73±0.2037
SB	NIL	0	20	OPEN	1	1.879±0.1639	7.2017±0.7018	10.5617±0.6164	140.7067±10.7132	1.34±0.0901	0.045±0.0029	1.7567±0.1432
SB	O2, 2HR	5	20	OPEN	1	1.6856±0.1427	6.92±0.5339	10.2912±0.2988	140.7834±9.8118	1.387±0.0781	0.037±0.0025	1.1134±0.1044
SB	O2, 4HR	5	20	OPEN	1	1.6948±0.095	6.7387±0.5553	10.1283±0.2559	141.09±13.5395	1.372±0.0706	0.038±0.002	1.2667±0.0779
SB	N2, 2HRS	5	20	OPEN	1	1.6579±0.1368	6.5844±0.3542	9.9002±0.2397	141.09±12.0207	1.361±0.0958	0.035±0.0022	1.25±0.0927
SB	N2, 4HRS	5	20	OPEN	1	1.6765±0.154	6.885±0.6533	10.238±0.1821	141.4634±10.4103	1.37±0.1327	0.037±0.0023	1.3267±0.0757
SB	O2, 2HR	10	20	OPEN	1	1.6804±0.0884	6.897±0.5061	10.2578±0.2216	141.4067±13.8063	1.335±0.0864	0.037±0.0019	1.23±0.09
SB	O2, 4HR	10	20	OPEN	1	1.6927±0.0958	6.798±0.3425	10.1834±0.2895	141.4134±11.3351	1.384±0.105	0.037±0.0034	1.18±0.0749
SB	N2, 2HRS	10	20	OPEN	1	1.6624±0.1059	6.734±0.5829	10.0588±0.1936	141.1534±11.5028	1.303±0.1077	0.036±0.0035	1.21±0.0814
SB	N2, 4HRS	10	20	OPEN	1	1.6672±0.0978	6.7584±0.602	10.0928±0.5963	141.1234±12.3032	1.391±0.0709	0.037±0.0021	1.2767±0.1253
SB	O2, 2HR	15	20	OPEN	1	1.6823±0.1146	6.8784±0.6612	10.243±0.2417	141.2867±7.7543	1.349±0.1155	0.037±0.002	1.1634±0.0674
SB	O2, 4HR	15	20	OPEN	1	1.7±0.1235	6.8667±0.5998	10.2667±0.0987	140.8767±13.4632	1.399±0.1139	0.038±0.0023	1.1434±0.1134
SB	N2, 2HRS	15	20	OPEN	1	1.6634±0.127	6.82±0.5606	10.1468±0.2923	141.0534±11.3152	1.305±0.0974	0.036±0.0022	1.2±0.1048
SB	N2, 4HRS	15	20	OPEN	1	1.674±0.1671	6.58±0.3677	9.928±0.3778	141.2967±7.1573	1.341±0.1264	0.037±0.002	1.3134±0.0914
SB	NIL	0	30	OPEN	1	2.506±0.2177	8.2804±0.8177	13.2924±0.4948	140.5867±9.9037	1.358±0.1321	0.048±0.0031	1.8834±0.1177
SB	O2, 2HR	5	30	OPEN	1	1.7202±0.1542	7.0257±0.5917	10.4661±0.1735	140.66±12.8241	1.377±0.0931	0.042±0.0025	1.334±0.1275
SB	O2, 4HR	5	30	OPEN	1	1.729±0.1312	7.019±0.5975	10.477±0.2211				

SB	O2, 2HR	10	30	OPEN	1	1.7269±0.0941	7.0067±0.6584	10.4605±0.3519	140.7667±9.5603	1.334±0.1106	0.043±0.0026	1.3834±0.1298
SB	O2, 4HR	10	30	OPEN	1	1.7432±0.1494	7.1384±0.5781	10.6248±0.4719	140.8867±7.5728	1.372±0.1122	0.043±0.0036	1.36±0.0768
SB	N2, 2HRS	10	30	OPEN	1	1.7052±0.1687	6.758±0.6578	10.1684±0.3821	140.8134±7.8554	1.364±0.1074	0.042±0.003	1.4934±0.1318
SB	N2, 4HRS	10	30	OPEN	1	1.7025±0.1406	7.0514±0.4612	10.4564±0.4426	141.16±8.4044	1.349±0.0747	0.042±0.0026	1.42±0.0913
SB	O2, 2HR	15	30	OPEN	1	1.7359±0.1557	6.9694±0.684	10.4412±1.0817	141.03±7.2737	1.334±0.0965	0.043±0.0037	1.4567±0.1079
SB	O2, 4HR	15	30	OPEN	1	1.7487±0.1624	7.102±0.6218	10.5994±0.1717	140.8867±13.7721	1.311±0.1064	0.043±0.0037	1.4034±0.0763
SB	N2, 2HRS	15	30	OPEN	1	1.71±0.1588	7.024±0.5048	10.444±0.296	141.08±12.1029	1.399±0.1249	0.042±0.0039	1.5467±0.0953
SB	N2, 4HRS	15	30	OPEN	1	1.7154±0.1126	6.8844±0.5636	10.3152±0.0891	140.9±13.7001	1.355±0.0907	0.042±0.0041	1.5167±0.0916
SB	NIL	0	40	OPEN	1	2.5171±0.1679	8.2644±0.5452	13.2986±0.495	140.1567±13.5987	1.316±0.0837	0.049±0.004	1.61±0.1078
SB	O2, 2HR	5	40	OPEN	1	1.7932±0.1536	7.2104±0.5898	10.7968±0.7205	140.2134±9.6543	1.351±0.1215	0.047±0.0025	1.62±0.0812
SB	O2, 4HR	5	40	OPEN	1	1.7942±0.141	7.0694±0.6885	10.6578±0.6066	140.2467±7.0957	1.331±0.0908	0.047±0.0032	1.58±0.1184
SB	N2, 2HRS	5	40	OPEN	1	1.7731±0.1735	6.9634±0.6014	10.5096±0.1145	140.37±13.2526	1.32±0.1298	0.046±0.0043	1.6534±0.0922
SB	N2, 4HRS	5	40	OPEN	1	1.7622±0.1412	6.9597±0.6317	10.4841±0.324	140.9334±12.458	1.38±0.1056	0.045±0.0024	1.85±0.1199
SB	O2, 2HR	10	40	OPEN	1	1.777±0.1053	7.1887±0.6947	10.7427±0.3195	140.72±12.5559	1.319±0.1262	0.046±0.0033	1.6734±0.1164
SB	O2, 4HR	10	40	OPEN	1	1.7894±0.1593	6.9287±0.5601	10.5075±0.5679	140.7967±13.3995	1.381±0.0835	0.047±0.0039	1.73±0.1179
SB	N2, 2HRS	10	40	OPEN	1	1.7541±0.1313	6.9207±0.4359	10.4289±0.2778	140.4±13.0351	1.313±0.1053	0.045±0.0033	1.8134±0.1438
SB	N2, 4HRS	10	40	OPEN	1	1.7655±0.1047	7.0387±0.6884	10.5697±0.4616	140.8634±12.9332	1.348±0.1112	0.046±0.0032	1.7334±0.1679
SB	O2, 2HR	15	40	OPEN	1	1.7877±0.1409	7.181±0.3737	10.7564±0.3554	140.5634±9.2	1.382±0.1023	0.046±0.0027	1.7134±0.1375
SB	O2, 4HR	15	40	OPEN	1	1.7978±0.1501	6.9724±0.5928	10.568±0.3197	140.3767±12.6541	1.302±0.1113	0.048±0.0041	1.9734±0.1931
SB	N2, 2HRS	15	40	OPEN	1	1.7589±0.124	7.218±0.4938	10.7358±0.1517	140.37±12.9563	1.381±0.1079	0.045±0.0032	1.78±0.1309
SB	N2, 4HRS	15	40	OPEN	1	1.7709±0.091	7.1187±0.6634	10.6605±0.1067	140.98±10.3214	1.345±0.1296	0.046±0.0029	1.6234±0.0932
SF	NIL	0	20	OPEN	1	1.3667±0.0745	2.5917±0.1641	5.3251±0.0958	134.0367±12.8327	1.38±0.1256	0.045±0.0027	2.0134±0.1125
SF	O2, 2HR	5	20	OPEN	1	1.0256±0.0525	2.31±0.1315	4.3612±0.0924	134.1134±10.7822	1.352±0.0818	0.039±0.0027	1.37±0.0814
SF	O2, 4HR	5	20	OPEN	1	1.0393±0.0767	2.1287±0.1788	4.2073±0.2113	134.42±13.1521	1.304±0.0901	0.04±0.0027	1.5234±0.1262
SF	N2, 2HRS	5	20	OPEN	1	1.0401±0.06	1.9744±0.1729	4.0546±0.0993	134.42±11.5404	1.376±0.0707	0.038±0.002	1.5067±0.1013
SF	N2, 4HRS	5	20	OPEN	1	1.0378±0.0972	2.275±0.2062	4.3506±0.0494	134.7934±12.954	1.329±0.1294	0.038±0.002	1.5834±0.0952
SF	O2, 2HR	10	20	OPEN	1	1.0333±0.076	2.287±0.1149	4.3536±0.1038	134.7367±12.7716	1.347±0.1243	0.038±0.0038	1.4867±0.1395
SF	O2, 4HR	10	20	OPEN	1	1.0271±0.061	2.188±0.1127	4.2422±0.1145	134.7434±8.8859	1.352±0.0951	0.039±0.002	1.4367±0.0742
SF	N2, 2HRS	10	20	OPEN	1	1.0467±0.059	2.124±0.1947	4.2174±0.1664	134.4834±8.0836	1.357±0.0869	0.038±0.0024	1.4667±0.111
SF	N2, 4HRS	10	20	OPEN	1	1.0337±0.101	2.1484±0.1443	4.2158±0.1212	134.4534±10.0973	1.325±0.1053	0.038±0.002	1.5334±0.1181
SF	O2, 2HR	15	20	OPEN	1	1.0454±0.0717	2.2684±0.2176	4.3592±0.1648	134.6167±9.8488	1.331±0.1246	0.038±0.0032	1.42±0.1405
SF	O2, 4HR	15	20	OPEN	1	1.042±0.0992	2.2567±0.2081	4.3407±0.1325	134.2067±9.2995	1.363±0.1233	0.04±0.0037	1.44±0.1129
SF	N2, 2HRS	15	20	OPEN	1	1.0572±0.092	2.21±0.131	4.3244±0.3388	134.3834±8.4274	1.335±0.0857	0.038±0.0022	1.4567±0.1025
SF	N2, 4HRS	15	20	OPEN	1	1.0484±0.0922	1.97±0.1136	4.0668±0.069	134.6267±12.7779	1.319±0.1273	0.038±0.0033	1.57±0.133
SF	NIL	0	30	OPEN	1	1.4476±0.0916	3.6704±0.2662	6.5656±0.073	133.9167±12.7185	1.327±0.0892	0.048±0.0038	2.14±0.1969
SF	O2, 2HR	5	30	OPEN	1	1.059±0.098	2.4157±0.2198	4.5337±0.2913	133.99±11.9282	1.327±0.1013	0.043±0.0035	1.82±0.1703
SF	O2, 4HR	5	30	OPEN	1	1.0521±0.0789	2.409±0.2143	4.5132±0.0361	134.1167±13.0558	1.3±0.0688	0.044±0.004	1.65±0.1375
SF	N2, 2HRS	5	30	OPEN	1	1.0384±0.0542	2.487±0.2083	4.5638±0.0728	134.45±8.0044	1.377±0.1011	0.043±0.0043	1.83±0.1788
SF	N2, 4HRS	5	30	OPEN	1	1.0606±0.0721	2.415±0.2104	4.5362±0.1723	134.13±6.8809	1.39±0.1004	0.043±0.0029	1.6934±0.1155
SF	O2, 2HR	10	30	OPEN	1	1.0494±0.0669	2.3967±0.2159	4.4955±0.1879	134.0967±9.2408	1.367±0.1362	0.044±0.0044	1.64±0.1455
SF	O2, 4HR	10	30	OPEN	1	1.0555±0.0955	2.5284±0.1665	4.6394±0.1553	134.2167±10.8534	1.338±0.0724	0.044±0.0035	1.6167±0.0898
SF	N2, 2HRS	10	30	OPEN	1	1.038±0.0972	2.148±0.1578	4.224±0.1132	134.1434±7.6199	1.35±0.1338	0.042±0.0025	1.75±0.0896
SF	N2, 4HRS	10	30	OPEN	1	1.0202±0.0605	2.4414±0.1445	4.4818±0.0698	134.49±12.0735	1.3±0.1008	0.042±0.0034	1.6767±0.116
SF	O2, 2HR	15	30	OPEN	1	1.0544±0.0623	2.3594±0.119	4.4682±0.0273	134.36±11.7862	1.354±0.0761	0.044±0.003	1.7134±0.1186
SF	O2, 4HR	15	30	OPEN	1	1.044±0.0769	2.492±0.1301	4.58±0.0909	134.2167±9.419	1.397±0.1018	0.045±0.0043	1.66±0.1329
SF	N2, 2HRS	15	30	OPEN	1	1.0395±0.0896	2.414±0.1608	4.493±0.1359	134.41±11.8549	1.307±0.1186	0.042±0.004	1.9834±0.1365
SF	N2, 4HRS	15	30	OPEN	1	1.0505±0.0955	2.2744±0.1392	4.3754±0.1174	134.23±12.2009	1.368±0.1063	0.042±0.0021	1.7734±0.1293
SF	NIL	0	40	OPEN	1	1.4628±0.1314	3.6544±0.3011	6.58±0.2333	133.4867±8.8098	1.365±0.0853	0.049±0.0045	1.8667±0.1363
SF	O2, 2HR	5	40	OPEN	1	1.0333±0.0725	2.6004±0.1722	4.667±0.0614	133.5434±11.1119	1.355±0.1322	0.047±0.0037	1.79±0.1392
SF	O2, 4HR	5	40	OPEN	1	1.0366±0.0701	2.4594±0.2063	4.5326±0.0998	133.5767±9.7823	1.353±0.1196	0.048±0.0042	1.8367±0.1566
SF	N2, 2HRS	5	40	OPEN	1	1.0512±0.0666	2.3534±0.1659	4.4558±0.2203	133.7±8.5956	1.35±0.1327	0.047±0.0028	1.91±0.1897
SF	N2, 4HRS	5	40	OPEN	1	1.0373±0.0971	2.3497±0.2112	4.4243±0.2419	134.2634±12.235	1.319±0.0753	0.047±0.0042	2.1067±0.1247
SF	O2, 2HR	10	40	OPEN	1	1.017±0.0718	2.5787±0.1802	4.6127±0.2384	134.05±10.8628	1.311±0.1222	0.047±0.0031	1.93±0.0979
SF	O2, 4HR	10	40	OPEN	1	1.0267±0.0705	2.3187±0.2109	4.3721±0.1751	134.1267±10.6799	1.379±0.1214	0.047±0.0043	1.9867±0.1158
SF	N2, 2HRS	10	40	OPEN	1	1.0584±0.0594	2.3107±0.2204	4.4275±0.2079	133.73±11.7451	1.335±0.088	0.046±0.0028	2.07±0.1108
SF	N2, 4HRS	10	40	OPEN	1	1.0628±0.0549	2.4287±0.1616	4.5543±0.1307	134.1934±7.8584	1.384±0.0873	0.047±0.0044	1.99±0.1546
SF	O2, 2HR	15	40	OPEN	1	1.028±0.102	2.571±0.1588	4.627±0.0483	133.8934±11.6836	1.355±0.1197	0.047±0.0037	1.97±0.1057
SF	O2, 4HR	15	40	OPEN	1	1.0331±0.0741	2.3624±0.1895	4.4286±0.0258	133.7067±11.5964	1.355±0.12	0.048±0.0042	2.23±0.1736
SF	N2, 2HRS	15	40	OPEN	1	1.0352±0.0987	2.608±0.1885	4.6784±0.3161	133.7±10.6661	1.334±0.127	0.046±0.0034	2.0367±0.1044
SF	N2, 4HRS	15	40	OPEN	1	1.0477±0.0937	2.5087±0.2208	4.6041±0.253	134.31±9.8014	1.369±0.0752	0.047±0.0027	1.88±0.1627
RB	NIL	0	20	CLOSED	1	0.8457±0.0526	4.5374±0.3829	6.2288±0.4565	103.88±5.3407	1.47±0.1087	0.044±0.0023	3.58±0.2816
RB	O2, 2HR	5	20	CLOSED	1	0.5669±0.0464	4.1897±0.2175	5.3235±0.1729	104.78±6.4311	1.45±0.1155	0.031±0.0027	2.64±0.2175
RB	O2, 4HR	5	20	CLOSED	1	0.561±0.0436	4.0694±0.3687	5.1914±0.2925	104.2067±7.9245	1.402±0.1232	0.031±0.0029	2.6634±0.2571
RB	N2, 2HRS	5	20	CLOSED	1	0.5814±0.058	4.1224±0.2308	5.2852±0.1547	104.7234±5.8444	1.413±0.0833	0.031±0.0025	2.5467±0.2353
RB	N2, 4HRS	5	20	CLOSED	1	0.5642±0.0439	4.109±0.2255	5.2374±0.2458	104.3434±10.0398	1.385±0.0903	0.031±0.0029	2.6134±0.198
RB	O2, 2HR	10	20	CLOSED	1	0.5545±0.0328	4.2567±0.3496	5.3657±0.3529	104.8534±8.9594	1.414±0.1202	0.031±0.0025	2.6234±0.212
RB	O2, 4HR	10	20	CLOSED	1	0.5595±0.0368	4.2817±0.2621	5.4007±0.159	104.8467±6.996	1.395±0.102	0.032±0.0028	2.6934±0.1703
RB	N2, 2HRS	10	20	CLOSED	1	0.5602±0.0525	4.323±0.3972	5.4434±0.1551	104.4067±7.4106	1.386±0.0845	0.03±0.0018	2.51±0.1506
RB	N2, 4HRS	10	20	CLOSED	1	0.5616±0.0458	4.1717±0.3502	5.2949±0.3085	104.2534±8.6962	1.397±0.1105	0.031±0.0018	2.5767±0.1325
RB	O2, 2HR	15	20	CLOSED	1	0.5722±0.05	4.1417±0.3726	5.2861±0.1647	104.8134±6.4227	1.378±0.1295	0.032±0.0028	2.7134±0.2028
RB	O2, 4HR	15	20	CLOSED	1	0.5633±0.0306	4.251±0.3285	5.3776±0.2636	104.4234±6.8374	1.461±0.0951	0.032±0.0029	2.72±0.2232
RB	N2, 2HRS	15	20	CLOSED	1	0.5751±0.0553	4.066±0.3584	5.2162±0.1672	104.7734±5.9552	1.408±0.1095	0.03±0.0025	2.5367±0.1312
RB	N2, 4HRS	15	20	CLOSED	1	0.5537±0.0459	4.1754±0.2707	5.2828±0.255	104.4434±10.1543	1.388±0.0694	0.031±	

RB	O2, 4HR	5	30	CLOSED	1	0.5805±0.0553	4.321±0.3291	5.482±0.2348	104.11±8.52	1.378±0.1134	0.035±0.0031	2.86±0.2401
RB	N2, 2HRS	5	30	CLOSED	1	0.5693±0.054	4.1224±0.3439	5.261±0.2248	104.4367±6.304	1.437±0.089	0.034±0.0018	2.8167±0.2778
RB	N2, 4HRS	5	30	CLOSED	1	0.5482±0.031	4.3334±0.2635	5.4298±0.1798	104.4467±7.2971	1.454±0.1013	0.034±0.0023	2.8334±0.1906
RB	O2, 2HR	10	30	CLOSED	1	0.5692±0.045	4.2984±0.425	5.4368±0.2435	104.6034±7.5959	1.408±0.1122	0.033±0.0032	2.77±0.2711
RB	O2, 4HR	10	30	CLOSED	1	0.5847±0.0449	4.277±0.2262	5.4464±0.157	104.1934±6.0269	1.467±0.1074	0.033±0.0019	2.7834±0.2364
RB	N2, 2HRS	10	30	CLOSED	1	0.579±0.0567	4.2467±0.4175	5.4047±0.3768	104.4134±6.8292	1.403±0.0827	0.033±0.0024	2.73±0.14
RB	N2, 4HRS	10	30	CLOSED	1	0.5743±0.0423	4.3497±0.2397	5.4983±0.2271	104.3234±5.5045	1.424±0.1259	0.033±0.0024	2.7434±0.1581
RB	O2, 2HR	15	30	CLOSED	1	0.5668±0.0474	4.1847±0.2179	5.3183±0.1867	104.03±8.862	1.382±0.1261	0.035±0.0027	2.8834±0.2739
RB	O2, 4HR	15	30	CLOSED	1	0.5612±0.033	4.4254±0.2253	5.5478±0.0885	104.2±10.1543	1.449±0.1147	0.036±0.0029	2.9034±0.1602
RB	N2, 2HRS	15	30	CLOSED	1	0.5919±0.0433	4.3654±0.3446	5.5492±0.0982	104.1067±6.6878	1.415±0.1328	0.033±0.0025	2.7867±0.2267
RB	N2, 4HRS	15	30	CLOSED	1	0.5707±0.0475	4.244±0.3122	5.3854±0.0865	104.0734±7.4758	1.431±0.1259	0.033±0.0033	2.8067±0.231
RB	NIL	0	40	CLOSED	1	0.9256±0.0495	5.8697±0.3858	7.7209±0.2924	103.35±7.8701	1.397±0.1306	0.048±0.0025	3.8667±0.3796
RB	O2, 2HR	5	40	CLOSED	1	0.5511±0.0285	4.6264±0.282	5.7286±0.2471	103.95±7.6688	1.472±0.0745	0.039±0.0036	3.25±0.1851
RB	O2, 4HR	5	40	CLOSED	1	0.5877±0.0571	4.3857±0.4206	5.5611±0.3255	104.24±5.9068	1.455±0.0908	0.039±0.0034	3.2767±0.2769
RB	N2, 2HRS	5	40	CLOSED	1	0.5694±0.0563	4.5164±0.3736	5.6552±0.1885	104.0434±9.8053	1.444±0.1061	0.039±0.0025	3.23±0.2222
RB	N2, 4HRS	5	40	CLOSED	1	0.5769±0.0357	4.3387±0.2288	5.4925±0.0543	104.3234±10.3723	1.383±0.0802	0.038±0.0029	3.18±0.2546
RB	O2, 2HR	10	40	CLOSED	1	0.5672±0.054	4.3494±0.414	5.4838±0.3054	104.23±8.3382	1.41±0.0714	0.039±0.0033	3.21±0.1639
RB	O2, 4HR	10	40	CLOSED	1	0.5656±0.0302	4.616±0.3875	5.7472±0.2088	103.6967±5.8744	1.387±0.0877	0.04±0.0022	3.3134±0.2324
RB	N2, 2HRS	10	40	CLOSED	1	0.5577±0.0544	4.579±0.2779	5.6944±0.2123	104±6.242	1.382±0.0904	0.038±0.0019	3.1634±0.2536
RB	N2, 4HRS	10	40	CLOSED	1	0.5508±0.0385	4.4997±0.3514	5.6013±0.185	103.7434±8.3678	1.425±0.1125	0.039±0.003	3.2667±0.217
RB	O2, 2HR	15	40	CLOSED	1	0.5597±0.0367	4.3797±0.3944	5.4991±0.1924	104.1334±7.0742	1.377±0.1038	0.039±0.0035	3.24±0.1933
RB	O2, 4HR	15	40	CLOSED	1	0.5709±0.0396	4.6444±0.4135	5.7862±0.2045	104.17±7.762	1.396±0.0825	0.04±0.0025	3.3267±0.2374
RB	N2, 2HRS	15	40	CLOSED	1	0.5725±0.0387	4.3297±0.3409	5.4747±0.1256	104.0367±8.3609	1.427±0.0842	0.038±0.0038	3.1134±0.2029
RB	N2, 4HRS	15	40	CLOSED	1	0.5658±0.0342	4.2764±0.2677	5.408±0.1748	104.3234±7.628	1.461±0.1085	0.038±0.0038	3.1434±0.2537
SB	NIL	0	20	CLOSED	1	1.6635±0.1537	6.9274±0.5934	10.2544±0.254	140.88±10.2019	1.372±0.0693	0.043±0.0026	1.8034±0.115
SB	O2, 2HR	5	20	CLOSED	1	1.5506±0.0816	6.5797±0.3519	9.6809±0.2328	141.78±9.0194	1.31±0.0745	0.031±0.0031	0.51±0.0301
SB	O2, 4HR	5	20	CLOSED	1	1.5549±0.1377	6.4594±0.4478	9.5692±0.2844	141.2067±8.9135	1.35±0.0713	0.031±0.0021	0.5367±0.0342
SB	N2, 2HRS	5	20	CLOSED	1	1.5196±0.1504	6.5124±0.6384	9.5516±0.3294	141.7234±7.4029	1.344±0.1042	0.03±0.0022	0.7134±0.0438
SB	N2, 4HRS	5	20	CLOSED	1	1.5419±0.1044	6.499±0.4195	9.5828±0.3038	141.3434±12.0213	1.31±0.092	0.031±0.0017	0.72±0.0632
SB	O2, 2HR	10	20	CLOSED	1	1.5462±0.1071	6.6467±0.4392	9.7391±0.0554	141.8534±9.4881	1.331±0.0794	0.033±0.0026	0.5467±0.0513
SB	O2, 4HR	10	20	CLOSED	1	1.5595±0.1001	6.6717±0.4727	9.7907±0.5481	141.8467±11.304	1.38±0.1287	0.031±0.0018	0.6134±0.0453
SB	N2, 2HRS	10	20	CLOSED	1	1.5149±0.133	6.713±0.5274	9.7428±0.283	141.4067±11.9684	1.376±0.1231	0.03±0.0019	0.64±0.0532
SB	N2, 4HRS	10	20	CLOSED	1	1.5327±0.1372	6.5617±0.6161	9.6271±0.7526	141.2534±11.6822	1.315±0.109	0.031±0.0027	0.6934±0.0551
SB	O2, 2HR	15	20	CLOSED	1	1.5635±0.0848	6.5317±0.4492	9.6587±0.1412	141.8134±11.1359	1.303±0.1228	0.032±0.0029	0.5767±0.0348
SB	O2, 4HR	15	20	CLOSED	1	1.5647±0.1328	6.641±0.5061	9.7704±0.346	141.4234±12.764	1.319±0.1285	0.032±0.0024	0.5634±0.0282
SB	N2, 2HRS	15	20	CLOSED	1	1.518±0.1223	6.456±0.4103	9.492±0.1878	141.7734±9.2809	1.33±0.1192	0.03±0.0029	0.6234±0.0343
SB	N2, 4HRS	15	20	CLOSED	1	1.5287±0.0909	6.5654±0.4997	9.6228±0.4291	141.4434±14.1245	1.324±0.0905	0.03±0.0024	0.6634±0.0653
SB	NIL	0	30	CLOSED	1	1.6658±0.1483	7.1207±0.3679	10.4523±0.3101	141.0634±12.4539	1.349±0.117	0.044±0.0038	1.74±0.1292
SB	O2, 2HR	5	30	CLOSED	1	1.5974±0.1232	6.84±0.6263	10.0348±0.4599	140.98±12.0747	1.36±0.1289	0.035±0.0022	0.7867±0.0767
SB	O2, 4HR	5	30	CLOSED	1	1.6015±0.1466	6.711±0.6202	9.914±0.3756	141.11±11.7251	1.367±0.0787	0.035±0.0027	0.8334±0.0681
SB	N2, 2HRS	5	30	CLOSED	1	1.5932±0.1184	6.5124±0.3566	9.6988±0.3506	141.4367±9.201	1.363±0.0781	0.034±0.0027	0.8167±0.0542
SB	N2, 4HRS	5	30	CLOSED	1	1.5945±0.0997	6.7234±0.6443	9.9124±0.0857	141.4467±13.3105	1.313±0.0972	0.034±0.0033	0.73±0.0582
SB	O2, 2HR	10	30	CLOSED	1	1.5802±0.1376	6.6884±0.4845	9.8488±0.1246	141.6034±13.7839	1.384±0.0902	0.033±0.0019	0.8834±0.0604
SB	O2, 4HR	10	30	CLOSED	1	1.5838±0.0947	6.667±0.625	9.8346±0.3803	141.1934±12.0068	1.391±0.1033	0.033±0.0032	0.86±0.0548
SB	N2, 2HRS	10	30	CLOSED	1	1.5711±0.0902	6.6367±0.3338	9.7789±0.2861	141.4134±7.4549	1.348±0.1037	0.032±0.0031	0.8367±0.0785
SB	N2, 4HRS	10	30	CLOSED	1	1.5762±0.1461	6.7397±0.6218	9.8921±0.4963	141.3234±9.7371	1.348±0.1124	0.032±0.0016	0.77±0.0592
SB	O2, 2HR	15	30	CLOSED	1	1.606±0.1192	6.5747±0.4226	9.7867±0.1822	141.03±8.7215	1.33±0.1296	0.035±0.002	0.7434±0.045
SB	O2, 4HR	15	30	CLOSED	1	1.6092±0.1542	6.8154±0.4995	10.0338±0.5863	141.2±7.632	1.362±0.1074	0.035±0.0032	0.8067±0.0431
SB	N2, 2HRS	15	30	CLOSED	1	1.5862±0.1312	6.7554±0.6511	9.9278±0.4019	141.1067±10.0193	1.334±0.1045	0.033±0.0033	0.7834±0.0419
SB	N2, 4HRS	15	30	CLOSED	1	1.5911±0.1434	6.634±0.5248	9.8162±0.0758	141.0734±7.2057	1.382±0.1314	0.034±0.0018	0.9034±0.0717
SB	NIL	0	40	CLOSED	1	2.5037±0.1365	8.2597±0.594	13.2671±0.1835	140.35±13.9181	1.312±0.1007	0.048±0.0031	1.9334±0.0999
SB	O2, 2HR	5	40	CLOSED	1	1.636±0.0942	7.0164±0.4526	10.2884±0.3063	140.95±7.4148	1.34±0.1064	0.04±0.002	0.9467±0.0538
SB	O2, 4HR	5	40	CLOSED	1	1.6389±0.1498	6.7757±0.5305	10.0535±0.1159	141.24±10.4551	1.3±0.0774	0.04±0.0024	0.99±0.0953
SB	N2, 2HRS	5	40	CLOSED	1	1.6319±0.1077	6.9064±0.3856	10.1702±0.3362	141.0434±13.0381	1.321±0.1255	0.039±0.0037	0.9234±0.0918
SB	N2, 4HRS	5	40	CLOSED	1	1.6227±0.1198	6.7287±0.4909	9.9741±0.2036	141.3234±8.7383	1.388±0.126	0.039±0.003	1.0767±0.0613
SB	O2, 2HR	10	40	CLOSED	1	1.6286±0.0996	6.7394±0.4439	9.9966±0.5519	141.23±11.9759	1.388±0.1345	0.039±0.0024	1.09±0.0974
SB	O2, 4HR	10	40	CLOSED	1	1.644±0.1066	7.006±0.6696	10.294±0.2795	140.6967±13.4684	1.387±0.1066	0.041±0.0029	0.96±0.0554
SB	N2, 2HRS	10	40	CLOSED	1	1.6176±0.1251	6.969±0.4501	10.2042±0.128	141±11.1925	1.328±0.1037	0.038±0.0033	1.03±0.0761
SB	N2, 4HRS	10	40	CLOSED	1	1.6381±0.1196	6.8897±0.3774	10.1659±0.1345	140.7434±12.1028	1.338±0.0953	0.04±0.0037	0.95±0.0546
SB	O2, 2HR	15	40	CLOSED	1	1.6266±0.1577	6.7697±0.6246	10.0229±0.2339	141.1334±10.6264	1.354±0.0948	0.039±0.0033	1.06±0.0982
SB	O2, 4HR	15	40	CLOSED	1	1.6544±0.1406	7.0344±0.3619	10.3432±0.2206	141.17±9.2998	1.302±0.1175	0.041±0.0041	0.97±0.081
SB	N2, 2HRS	15	40	CLOSED	1	1.6107±0.0956	6.7197±0.5212	9.9411±0.381	141.0367±13.4128	1.342±0.092	0.038±0.0038	1.0434±0.053
SB	N2, 4HRS	15	40	CLOSED	1	1.6165±0.0838	6.6664±0.6172	9.8994±0.6028	141.3234±13.968	1.304±0.1024	0.038±0.0021	1.0034±0.0792
SF	NIL	0	20	CLOSED	1	1.3227±0.1173	2.3174±0.1942	4.9628±0.3902	134.21±10.5995	1.351±0.0888	0.045±0.004	2.06±0.1483
SF	O2, 2HR	5	20	CLOSED	1	1.0439±0.0941	1.9697±0.1256	4.0575±0.1174	135.11±7.36	1.352±0.1298	0.032±0.0022	0.7667±0.0428
SF	O2, 4HR	5	20	CLOSED	1	1.038±0.0776	1.8494±0.183	3.9254±0.016	134.5367±9.8362	1.349±0.1289	0.032±0.003	0.7934±0.051
SF	N2, 2HRS	5	20	CLOSED	1	1.0584±0.0625	1.9024±0.1241	4.0192±0.0674	135.0534±12.356	1.319±0.0799	0.03±0.003	0.97±0.0663
SF	N2, 4HRS	5	20	CLOSED	1	1.0412±0.0582	1.889±0.1077	3.9714±0.1383	134.6734±7.2513	1.383±0.119	0.031±0.0027	0.9767±0.0505
SF	O2, 2HR	10	20	CLOSED	1	1.0315±0.1029	2.0367±0.1532	4.0997±0.0632	135.1834±12.2135	1.366±0.07	0.032±0.0025	0.8034±0.0509
SF	O2, 4HR	10	20	CLOSED	1	1.0365±0.089	2.0617±0.1349	4.1347±0.3729	135.1767±8.2304	1.303±0.0812	0.032±0.0016	0.87±0.0511
SF	N2, 2HRS	10	20	CLOSED	1	1.0372±0.1026	2.103±0.2096	4.1774±0.235	134.7367±7.6283	1.389±0.1313	0.03±0.0021	0.8967±0.0684
SF	N2, 4HRS	10	20	CLOSED	1	1.0386±0.0653	1.9517±0.1099	4.0289±0.0556	134.5834±12.3882	1.336±0.1127	0.031±0.0029	0.95±0.0943
SF	O2, 2HR											

SF	N2, 4HRS	15	20	CLOSED	1	1.0307±0.0991	1.9554±0.1792	4.0168±0.0459	134.7734±11.1068	1.364±0.1286	0.031±0.0016	0.92±0.0896
SF	NIL	0	30	CLOSED	1	1.3245±0.1225	2.5107±0.1287	5.1597±0.2019	134.3934±10.0878	1.342±0.0695	0.045±0.0037	1.9967±0.1842
SF	O2, 2HR	5	30	CLOSED	1	1.0344±0.0724	2.23±0.1819	4.2988±0.2356	134.31±9.5808	1.348±0.1281	0.036±0.0036	1.0434±0.0757
SF	O2, 4HR	5	30	CLOSED	1	1.0575±0.0793	2.101±0.1086	4.216±0.1607	134.44±12.3464	1.313±0.1169	0.036±0.0029	1.09±0.07
SF	N2, 2HRS	5	30	CLOSED	1	1.0463±0.0768	1.9024±0.1893	3.995±0.1408	134.7667±7.1911	1.32±0.0852	0.035±0.0027	1.0734±0.0929
SF	N2, 4HRS	5	30	CLOSED	1	1.0252±0.0514	2.1134±0.1559	4.1638±0.0993	134.7767±7.7024	1.337±0.1231	0.035±0.003	0.9867±0.0822
SF	O2, 2HR	10	30	CLOSED	1	1.0462±0.0855	2.0784±0.1629	4.1708±0.0848	134.9334±13.0475	1.388±0.0948	0.034±0.0034	1.14±0.0694
SF	O2, 4HR	10	30	CLOSED	1	1.0617±0.1053	2.057±0.1557	4.1804±0.1039	134.5234±8.9493	1.303±0.0742	0.034±0.0017	1.1167±0.0734
SF	N2, 2HRS	10	30	CLOSED	1	1.056±0.0697	2.0267±0.1844	4.1387±0.1432	134.7434±8.6969	1.354±0.1318	0.033±0.0031	1.0934±0.0718
SF	N2, 4HRS	10	30	CLOSED	1	1.0513±0.0598	2.1297±0.1911	4.2323±0.1367	134.6534±12.5622	1.351±0.0917	0.033±0.0017	1.0267±0.0792
SF	O2, 2HR	15	30	CLOSED	1	1.0438±0.0664	1.9647±0.1871	4.0523±0.1394	134.36±6.9766	1.331±0.1226	0.036±0.0022	1±0.0587
SF	O2, 4HR	15	30	CLOSED	1	1.0382±0.0533	2.2054±0.1924	4.2818±0.1572	134.53±13.0723	1.351±0.1304	0.038±0.0025	1.0634±0.0654
SF	N2, 2HRS	15	30	CLOSED	1	1.0689±0.0657	2.1454±0.1753	4.2832±0.0524	134.4367±7.5585	1.37±0.1059	0.034±0.0026	1.04±0.0746
SF	N2, 4HRS	15	30	CLOSED	1	1.0477±0.084	2.024±0.1864	4.1194±0.2277	134.4034±11.2638	1.342±0.0996	0.034±0.003	1.16±0.0708
SF	NIL	0	40	CLOSED	1	1.4026±0.1369	3.6497±0.2916	6.4549±0.2952	133.68±11.5945	1.306±0.1293	0.048±0.0024	2.19±0.166
SF	O2, 2HR	5	40	CLOSED	1	1.0281±0.073	2.4064±0.2335	4.4626±0.1261	134.28±9.1572	1.313±0.077	0.041±0.003	1.2034±0.0772
SF	O2, 4HR	5	40	CLOSED	1	1.0647±0.081	2.1657±0.195	4.2951±0.2314	134.57±10.7483	1.33±0.1025	0.042±0.0038	1.2467±0.067
SF	N2, 2HRS	5	40	CLOSED	1	1.0464±0.0995	2.2964±0.1824	4.3892±0.034	134.3734±8.0204	1.377±0.0934	0.041±0.004	1.18±0.0947
SF	N2, 4HRS	5	40	CLOSED	1	1.0539±0.0955	2.1187±0.111	4.2265±0.0458	134.6534±10.5245	1.378±0.1105	0.041±0.0027	1.3334±0.1213
SF	O2, 2HR	10	40	CLOSED	1	1.0442±0.08	2.1294±0.1472	4.2178±0.1625	134.56±8.2229	1.364±0.0743	0.041±0.0038	1.3467±0.1188
SF	O2, 4HR	10	40	CLOSED	1	1.0426±0.0943	2.396±0.1254	4.4812±0.084	134.0267±6.7282	1.322±0.0752	0.042±0.0033	1.2167±0.0863
SF	N2, 2HRS	10	40	CLOSED	1	1.0347±0.0601	2.359±0.226	4.4284±0.0361	134.33±7.5631	1.34±0.0918	0.041±0.0034	1.2867±0.1033
SF	N2, 4HRS	10	40	CLOSED	1	1.0278±0.0769	2.2797±0.2264	4.3353±0.0695	134.0734±7.6928	1.324±0.1274	0.041±0.0029	1.2067±0.1111
SF	O2, 2HR	15	40	CLOSED	1	1.0367±0.0539	2.1597±0.1451	4.2331±0.037	134.4634±11.249	1.337±0.1018	0.041±0.0024	1.3167±0.0801
SF	O2, 4HR	15	40	CLOSED	1	1.0479±0.0754	2.4244±0.2197	4.5202±0.1164	134.5±13.3812	1.315±0.0922	0.042±0.0039	1.2267±0.1022
SF	N2, 2HRS	15	40	CLOSED	1	1.0495±0.0835	2.1097±0.1427	4.2087±0.3154	134.3667±10.3084	1.326±0.1303	0.04±0.0036	1.34±0.0719
SF	N2, 4HRS	15	40	CLOSED	1	1.0428±0.0544	2.0564±0.1707	4.142±0.0672	134.6534±11.687	1.387±0.136	0.04±0.0032	1.26±0.0826
RB	NIL	0	20	OPEN	2	1.7503±0.1679	4.8007±0.4612	8.3013±0.1377	103.6234±8.0106	1.413±0.0867	0.066±0.0048	4.43±0.3289
RB	O2, 2HR	5	20	OPEN	2	0.5726±0.0403	4.5777±0.3841	5.7229±0.3144	104.2667±9.1525	1.459±0.116	0.059±0.0059	3.5167±0.3017
RB	O2, 4HR	5	20	OPEN	2	0.5543±0.031	4.5384±0.4437	5.647±0.2485	104.2234±5.7017	1.442±0.1404	0.06±0.0036	3.56±0.2091
RB	N2, 2HRS	5	20	OPEN	2	0.5747±0.0407	4.4794±0.2836	5.6288±0.1744	104.4534±6.9197	1.398±0.081	0.056±0.0047	3.33±0.1991
RB	N2, 4HRS	5	20	OPEN	2	0.5543±0.0468	4.5117±0.3916	5.6203±0.3164	104.3134±6.7923	1.439±0.1437	0.059±0.0048	3.4067±0.1907
RB	O2, 2HR	10	20	OPEN	2	0.592±0.0422	4.2727±0.3802	5.4567±0.1882	104.29±9.4542	1.452±0.1417	0.059±0.0041	3.43±0.2354
RB	O2, 4HR	10	20	OPEN	2	0.5849±0.0528	4.5047±0.3151	5.6745±0.2267	104.2567±6.4214	1.454±0.0787	0.059±0.0052	3.5467±0.1894
RB	N2, 2HRS	10	20	OPEN	2	0.571±0.0363	4.4204±0.2323	5.5624±0.2831	104.43±6.1219	1.438±0.0799	0.056±0.0054	3.3434±0.2557
RB	N2, 4HRS	10	20	OPEN	2	0.5773±0.0515	4.5164±0.3027	5.671±0.1201	104.38±9.2583	1.406±0.1161	0.058±0.0034	3.38±0.2632
RB	O2, 2HR	15	20	OPEN	2	0.5882±0.0558	4.325±0.3976	5.5014±0.3796	104.2734±5.3087	1.43±0.0784	0.059±0.0051	3.46±0.3061
RB	O2, 4HR	15	20	OPEN	2	0.5558±0.0338	4.485±0.3081	5.5966±0.2136	104.21±8.6926	1.388±0.0959	0.06±0.0045	3.5967±0.276
RB	N2, 2HRS	15	20	OPEN	2	0.5583±0.0381	4.474±0.2919	5.5906±0.2762	104.4134±10.1873	1.454±0.1241	0.057±0.0039	3.3534±0.1829
RB	N2, 4HRS	15	20	OPEN	2	0.5464±0.0375	4.4447±0.3296	5.5375±0.4392	104.3467±5.4392	1.43±0.1385	0.058±0.0041	3.3967±0.3043
RB	NIL	0	30	OPEN	2	1.803±0.129	6.6457±0.3514	10.2517±0.5409	103.2067±5.5871	1.439±0.0978	0.069±0.005	4.8334±0.4828
RB	O2, 2HR	5	30	OPEN	2	0.5738±0.052	4.578±0.282	5.7256±0.097	103.82±8.1304	1.414±0.1358	0.065±0.0044	4.2034±0.3555
RB	O2, 4HR	5	30	OPEN	2	0.5575±0.0455	4.4647±0.3666	5.5797±0.2756	103.7234±6.4825	1.455±0.0875	0.065±0.0053	4.3034±0.269
RB	N2, 2HRS	5	30	OPEN	2	0.5637±0.0462	4.7404±0.3337	5.8678±0.1631	103.7834±8.1129	1.379±0.1028	0.065±0.0057	4.21±0.3923
RB	N2, 4HRS	5	30	OPEN	2	0.5555±0.0467	4.4834±0.2242	5.5944±0.2087	103.75±9.0299	1.441±0.0931	0.065±0.0059	4.2267±0.3815
RB	O2, 2HR	10	30	OPEN	2	0.5632±0.0324	4.6087±0.2683	5.7351±0.2089	103.74±9.665	1.375±0.0923	0.065±0.0062	4.34±0.3532
RB	O2, 4HR	10	30	OPEN	2	0.563±0.0561	4.5244±0.3982	5.6504±0.0996	103.7034±6.3576	1.442±0.1247	0.066±0.0056	4.3467±0.2597
RB	N2, 2HRS	10	30	OPEN	2	0.578±0.0416	4.6947±0.3811	5.8507±0.3759	103.8767±9.6025	1.419±0.106	0.063±0.005	4.0334±0.3478
RB	N2, 4HRS	10	30	OPEN	2	0.5603±0.0409	4.54±0.2696	5.6206±0.2234	103.9134±8.2658	1.393±0.0819	0.063±0.004	4.0167±0.2936
RB	O2, 2HR	15	30	OPEN	2	0.552±0.0417	4.493±0.4008	5.597±0.3529	103.7167±8.8922	1.463±0.0987	0.066±0.0033	4.33±0.3203
RB	O2, 4HR	15	30	OPEN	2	0.5529±0.0346	4.505±0.3842	5.6108±0.1475	103.6967±7.9157	1.39±0.1047	0.066±0.0057	4.3534±0.3215
RB	N2, 2HRS	15	30	OPEN	2	0.5565±0.0489	4.542±0.3156	5.655±0.0925	103.8534±6.8101	1.464±0.0877	0.063±0.0037	4.04±0.2565
RB	N2, 4HRS	15	30	OPEN	2	0.576±0.0548	4.7614±0.4162	5.9134±0.4875	103.8267±6.0711	1.383±0.1077	0.064±0.0063	4.0934±0.3482
RB	NIL	0	40	OPEN	2	1.8801±0.1803	6.9624±0.5504	10.7226±0.3946	103.18±8.2885	1.424±0.1269	0.069±0.0038	4.8734±0.3717
RB	O2, 2HR	5	40	OPEN	2	0.5854±0.0388	4.598±0.3721	5.7688±0.1917	103.3467±9.0186	1.428±0.0778	0.068±0.0044	4.73±0.3429
RB	O2, 4HR	5	40	OPEN	2	0.546±0.031	4.8797±0.4512	5.9717±0.324	103.3234±5.7531	1.382±0.0978	0.068±0.0041	4.76±0.3164
RB	N2, 2HRS	5	40	OPEN	2	0.5777±0.0346	4.6884±0.3923	5.8438±0.3782	103.4567±7.7369	1.375±0.0771	0.067±0.0059	4.5834±0.3213
RB	N2, 4HRS	5	40	OPEN	2	0.5514±0.0398	4.708±0.3506	5.8108±0.0227	103.5267±7.6968	1.394±0.0793	0.067±0.0055	4.5134±0.4155
RB	O2, 2HR	10	40	OPEN	2	0.5678±0.0533	4.78±0.433	5.9156±0.4723	103.4434±5.3587	1.436±0.1387	0.067±0.0052	4.6367±0.2838
RB	O2, 4HR	10	40	OPEN	2	0.5446±0.0508	4.8884±0.2726	5.9776±0.2119	103.3667±5.4172	1.443±0.1108	0.068±0.0057	4.7±0.3962
RB	N2, 2HRS	10	40	OPEN	2	0.5885±0.0537	4.792±0.3777	5.969±0.3255	103.58±8.8054	1.379±0.0809	0.067±0.0061	4.4767±0.2776
RB	N2, 4HRS	10	40	OPEN	2	0.5551±0.0416	4.779±0.4122	5.8892±0.2679	103.5067±7.5714	1.389±0.1375	0.067±0.0046	4.5567±0.2283
RB	O2, 2HR	15	40	OPEN	2	0.579±0.0549	4.5914±0.3678	5.7494±0.1108	103.3934±10.0509	1.392±0.1018	0.068±0.0064	4.68±0.3781
RB	O2, 4HR	15	40	OPEN	2	0.5748±0.0385	4.8887±0.3329	6.0383±0.208	103.3±6.7832	1.437±0.0841	0.068±0.004	4.77±0.2777
RB	N2, 2HRS	15	40	OPEN	2	0.5879±0.0574	4.6864±0.3205	5.8622±0.199	103.55±6.8607	1.421±0.0804	0.067±0.0059	4.49±0.3386
RB	N2, 4HRS	15	40	OPEN	2	0.5633±0.052	4.5897±0.345	5.7163±0.3593	103.4734±5.3518	1.438±0.09	0.067±0.004	4.5734±0.3287
SB	NIL	0	20	OPEN	2	1.71±0.0887	7.1907±0.6898	10.5507±0.7964	140.6234±9.1122	1.32±0.0778	0.065±0.0052	2.68±0.2487
SB	O2, 2HR	5	20	OPEN	2	1.6704±0.088	6.9677±0.6678	10.3085±0.3348	141.2667±9.1633	1.319±0.0702	0.057±0.0041	1.61±0.1546
SB	O2, 4HR	5	20	OPEN	2	1.6811±0.1209	6.9284±0.4458	10.2906±0.5903	141.2234±13.1837	1.387±0.0963	0.058±0.0048	1.8634±0.1409
SB	N2, 2HRS	5	20	OPEN	2	1.6393±0.1551	6.8694±0.4202	10.148±0.2152	141.4534±12.6311	1.366±0.0842	0.055±0.0039	1.8267±0.1227
SB	N2, 4HRS	5	20	OPEN	2	1.662±0.1564	6.9017±0.4158	10.2257±0.3432	141.3134±10.1364	1.326±0.0938	0.056±0.0056	1.9567±0.1104
SB	O2, 2HR	10	20	OPEN	2	1.6676±0.1178	6.6627±0.3336	9.9979±0.3678	141.29±9.7876	1.369±0.0927	0.057±0.0048	1.84±0.1162
SB	O2, 4HR	10	20	OPEN	2	1.671±0.1509	6.8947±0.4888					

SB	O2, 2HR	15	20	OPEN	2	1.6692±0.0989	6.715±0.3653	10.0534±0.101	141.2734±10.7684	1.327±0.0746	0.057±0.004	1.7067±0.1216
SB	O2, 4HR	15	20	OPEN	2	1.6822±0.1465	6.875±0.3579	10.2394±0.3756	141.21±11.6861	1.394±0.1082	0.058±0.0055	1.6934±0.1023
SB	N2, 2HRS	15	20	OPEN	2	1.653±0.1263	6.864±0.4775	10.17±0.6168	141.4134±8.9049	1.33±0.0735	0.055±0.0033	1.75±0.1304
SB	N2, 4HRS	15	20	OPEN	2	1.6607±0.1131	6.8347±0.4635	10.1561±0.2203	141.3467±8.1957	1.345±0.0877	0.056±0.0044	1.9134±0.1136
SB	NIL	0	30	OPEN	2	3.036±0.1554	9.0357±0.8642	15.1077±0.1069	140.2067±9.8351	1.325±0.118	0.068±0.0042	2.8334±0.2822
SB	O2, 2HR	5	30	OPEN	2	1.7005±0.1189	6.968±0.6175	10.369±0.2321	140.82±7.9928	1.327±0.0804	0.063±0.0062	1.997±0.133
SB	O2, 4HR	5	30	OPEN	2	1.7175±0.0993	6.8547±0.6421	10.2897±0.5142	140.7234±7.9065	1.301±0.1117	0.064±0.0044	2.04±0.1402
SB	N2, 2HRS	5	30	OPEN	2	1.7044±0.0864	7.1304±0.6608	10.5392±0.2901	140.7834±10.7704	1.323±0.1187	0.063±0.0049	2.3534±0.2213
SB	N2, 4HRS	5	30	OPEN	2	1.7083±0.1517	6.8734±0.6055	10.29±0.5891	140.75±13.863	1.311±0.1301	0.064±0.0038	2.21±0.1219
SB	O2, 2HR	10	30	OPEN	2	1.7121±0.1496	6.9987±0.501	10.4229±0.5234	140.74±13.1153	1.312±0.1102	0.064±0.0055	2.0334±0.2023
SB	O2, 4HR	10	30	OPEN	2	1.7268±0.1452	6.9144±0.3723	10.368±0.1472	140.7034±11.5911	1.32±0.1079	0.064±0.0051	2.0167±0.1354
SB	N2, 2HRS	10	30	OPEN	2	1.6868±0.1001	7.0847±0.6551	10.4583±0.2358	140.8767±13.2171	1.302±0.0788	0.062±0.0044	2.3±0.1287
SB	N2, 4HRS	10	30	OPEN	2	1.6842±0.1369	6.89±0.5062	10.2584±0.2778	140.9134±12.6851	1.338±0.0723	0.063±0.0051	2.2034±0.1259
SB	O2, 2HR	15	30	OPEN	2	1.7232±0.0915	6.883±0.6036	10.3294±0.4158	140.7167±12.2443	1.357±0.1234	0.064±0.006	2.2267±0.1246
SB	O2, 4HR	15	30	OPEN	2	1.7324±0.1205	6.895±0.5135	10.3598±0.1345	140.6967±7.8093	1.376±0.0915	0.065±0.0042	2.0934±0.1979
SB	N2, 2HRS	15	30	OPEN	2	1.689±0.1592	6.932±0.5219	10.31±0.8071	140.8534±13.2372	1.344±0.1241	0.063±0.0037	2.33±0.149
SB	N2, 4HRS	15	30	OPEN	2	1.6979±0.1346	7.1514±0.4202	10.5472±0.3186	140.8267±13.3253	1.386±0.1343	0.063±0.0055	2.3034±0.2198
SB	NIL	0	40	OPEN	2	3.0471±0.2522	9.3524±0.5406	15.4466±0.4711	140.18±8.6953	1.316±0.1294	0.069±0.0059	2.39±0.2356
SB	O2, 2HR	5	40	OPEN	2	1.7779±0.1404	6.988±0.6379	10.5438±0.2458	140.3467±12.5426	1.348±0.0784	0.068±0.0065	2.43±0.2119
SB	O2, 4HR	5	40	OPEN	2	1.7848±0.1651	7.2697±0.5075	10.8393±0.4376	140.3234±10.1794	1.387±0.1352	0.068±0.0048	2.3734±0.2064
SB	N2, 2HRS	5	40	OPEN	2	1.7512±0.168	7.0784±0.6969	10.5808±0.125	140.4567±10.0863	1.367±0.1249	0.067±0.0038	2.49±0.1731
SB	N2, 4HRS	5	40	OPEN	2	1.7415±0.1592	7.098±0.381	10.581±0.1398	140.5267±12.9203	1.377±0.0945	0.066±0.0051	2.77±0.2481
SB	O2, 2HR	10	40	OPEN	2	1.7564±0.0891	7.17±0.4592	10.6828±0.0736	140.4434±10.8616	1.314±0.1286	0.067±0.0041	2.5134±0.1954
SB	O2, 4HR	10	40	OPEN	2	1.7719±0.1382	7.2784±0.7046	10.8222±0.569	140.3667±7.2427	1.323±0.1141	0.068±0.0055	2.5734±0.1546
SB	N2, 2HRS	10	40	OPEN	2	1.7348±0.1664	7.182±0.3919	10.6516±0.2845	140.58±13.2637	1.355±0.1281	0.065±0.0038	2.76±0.1998
SB	N2, 4HRS	10	40	OPEN	2	1.7465±0.1695	7.169±0.3628	10.662±0.1934	140.5067±7.383	1.311±0.0928	0.066±0.0052	2.5834±0.2412
SB	O2, 2HR	15	40	OPEN	2	1.7647±0.1481	6.9814±0.5588	10.5108±0.313	140.3934±12.34	1.325±0.1161	0.068±0.0062	2.5567±0.1952
SB	O2, 4HR	15	40	OPEN	2	1.7916±0.1088	7.2787±0.5186	10.8619±0.4298	140.3±12.5982	1.385±0.1093	0.068±0.0068	2.94±0.2752
SB	N2, 2HRS	15	40	OPEN	2	1.7375±0.1137	7.0764±0.4101	10.5514±0.3351	140.55±11.2194	1.357±0.1194	0.065±0.0063	2.74±0.2525
SB	N2, 4HRS	15	40	OPEN	2	1.7483±0.1667	6.9797±0.4351	10.4763±0.0762	140.4734±8.2392	1.309±0.1241	0.067±0.0057	2.0167±0.1538
SF	NIL	0	20	OPEN	2	2.2273±0.1434	2.5807±0.2515	7.0353±0.3735	135.7934±9.2086	1.38±0.089	0.066±0.005	2.9367±0.1667
SF	O2, 2HR	5	20	OPEN	2	1.0496±0.0561	2.3577±0.157	4.4569±0.1591	136.4367±13.0794	1.307±0.0814	0.058±0.0046	1.8667±0.142
SF	O2, 4HR	5	20	OPEN	2	1.0313±0.0602	2.3184±0.1371	4.381±0.2384	136.3934±7.6682	1.354±0.0732	0.059±0.0055	2.12±0.141
SF	N2, 2HRS	5	20	OPEN	2	1.0517±0.0639	2.2594±0.1614	4.3628±0.1413	136.6234±9.7083	1.374±0.116	0.056±0.0051	2.0834±0.1859
SF	N2, 4HRS	5	20	OPEN	2	1.0313±0.0954	2.2917±0.1294	4.3543±0.0789	136.4834±10.781	1.329±0.1073	0.058±0.0033	2.2134±0.1809
SF	O2, 2HR	10	20	OPEN	2	1.069±0.1048	2.0527±0.1275	4.1907±0.2028	136.46±9.3668	1.347±0.123	0.058±0.0035	2.0567±0.1453
SF	O2, 4HR	10	20	OPEN	2	1.0619±0.0547	2.2847±0.1439	4.4085±0.0782	136.4267±9.4087	1.367±0.0695	0.059±0.0037	1.9967±0.1782
SF	N2, 2HRS	10	20	OPEN	2	1.048±0.0766	2.2004±0.1456	4.2964±0.1021	136.6±12.1378	1.379±0.0997	0.057±0.0029	2.0167±0.1609
SF	N2, 4HRS	10	20	OPEN	2	1.0543±0.055	2.2964±0.2079	4.405±0.1977	136.55±10.9108	1.37±0.1143	0.058±0.0037	2.15±0.141
SF	O2, 2HR	15	20	OPEN	2	1.0652±0.083	2.105±0.176	4.2354±0.1893	136.4434±7.5695	1.341±0.108	0.058±0.0047	1.9634±0.181
SF	O2, 4HR	15	20	OPEN	2	1.0328±0.0809	2.265±0.1378	4.3306±0.1931	136.38±12.3037	1.315±0.0855	0.06±0.0037	1.95±0.1542
SF	N2, 2HRS	15	20	OPEN	2	1.0353±0.0915	2.254±0.1544	4.3246±0.2045	136.5834±11.679	1.369±0.1124	0.058±0.0057	2.0067±0.1724
SF	N2, 4HRS	15	20	OPEN	2	1.0234±0.0775	2.2247±0.1432	4.2715±0.2412	136.5167±13.1935	1.308±0.0748	0.058±0.0048	2.17±0.1583
SF	NIL	0	30	OPEN	2	2.28±0.1645	4.4257±0.2962	8.9857±0.3533	135.3767±10.1187	1.375±0.0989	0.068±0.0051	3.09±0.2693
SF	O2, 2HR	5	30	OPEN	2	1.0508±0.1029	2.358±0.1338	4.4596±0.2321	135.99±7.4921	1.349±0.1086	0.064±0.0052	2.6034±0.2296
SF	O2, 4HR	5	30	OPEN	2	1.0345±0.0673	2.2447±0.2133	4.3137±0.2007	135.8934±10.1501	1.341±0.1035	0.065±0.0038	2.2967±0.1471
SF	N2, 2HRS	5	30	OPEN	2	1.0407±0.0549	2.5204±0.1547	4.6018±0.0838	135.9534±12.3429	1.319±0.1023	0.065±0.0038	2.61±0.1549
SF	N2, 4HRS	5	30	OPEN	2	1.0325±0.0885	2.2634±0.1933	4.3284±0.1168	135.92±11.3396	1.377±0.136	0.065±0.0037	2.4667±0.1472
SF	O2, 2HR	10	30	OPEN	2	1.0402±0.0684	2.3887±0.1437	4.4691±0.0594	135.91±7.8815	1.368±0.131	0.065±0.0034	2.29±0.2178
SF	O2, 4HR	10	30	OPEN	2	1.04±0.0947	2.3044±0.1519	4.3844±0.1366	135.8734±13.232	1.36±0.1058	0.065±0.005	2.2734±0.1163
SF	N2, 2HRS	10	30	OPEN	2	1.055±0.1055	2.4747±0.2042	4.5847±0.0412	136.0467±8.2759	1.393±0.1302	0.063±0.0054	2.5567±0.1731
SF	N2, 4HRS	10	30	OPEN	2	1.0373±0.0969	2.28±0.2004	4.3546±0.1199	136.0834±7.577	1.324±0.0774	0.063±0.0038	2.46±0.1493
SF	O2, 2HR	15	30	OPEN	2	1.029±0.0871	2.273±0.1144	4.331±0.2256	135.8867±11.8771	1.322±0.0909	0.065±0.0058	2.4834±0.1479
SF	O2, 4HR	15	30	OPEN	2	1.0299±0.1004	2.285±0.1673	4.3448±0.3953	135.8667±7.0754	1.3±0.0687	0.066±0.0059	2.35±0.2229
SF	N2, 2HRS	15	30	OPEN	2	1.0335±0.0587	2.322±0.1661	4.389±0.058	136.0234±10.1316	1.322±0.0878	0.063±0.005	2.5867±0.1332
SF	N2, 4HRS	15	30	OPEN	2	1.053±0.1015	2.5414±0.2307	4.6474±0.0447	135.9967±12.168	1.386±0.0863	0.063±0.0037	2.56±0.233
SF	NIL	0	40	OPEN	2	2.3571±0.1598	4.7424±0.468	9.4566±0.4509	135.35±13.2551	1.374±0.1234	0.068±0.0043	2.6467±0.2054
SF	O2, 2HR	5	40	OPEN	2	1.0624±0.0677	2.378±0.1599	4.5028±0.0954	135.5167±13.2159	1.308±0.1036	0.068±0.006	2.64±0.2431
SF	O2, 4HR	5	40	OPEN	2	1.023±0.0597	2.6597±0.2581	4.7057±0.0895	135.4934±7.5217	1.332±0.0925	0.068±0.0064	2.63±0.2628
SF	N2, 2HRS	5	40	OPEN	2	1.0547±0.0897	2.4684±0.2038	4.5778±0.1245	135.6267±7.6585	1.376±0.0833	0.067±0.006	2.7467±0.2367
SF	N2, 4HRS	5	40	OPEN	2	1.0284±0.0986	2.488±0.1629	4.5448±0.286	135.6967±11.7552	1.316±0.0832	0.067±0.0036	3.0267±0.2051
SF	O2, 2HR	10	40	OPEN	2	1.0448±0.0682	2.56±0.1684	4.6496±0.0846	135.6134±10.4266	1.396±0.1133	0.067±0.006	2.77±0.1692
SF	O2, 4HR	10	40	OPEN	2	1.0216±0.0613	2.6684±0.2624	4.7116±0.1551	135.5367±10.1629	1.374±0.1304	0.068±0.0054	2.83±0.2163
SF	N2, 2HRS	10	40	OPEN	2	1.0655±0.094	2.572±0.1667	4.703±0.0558	135.75±8.9263	1.32±0.0868	0.066±0.0034	3.0167±0.2216
SF	N2, 4HRS	10	40	OPEN	2	1.0321±0.058	2.559±0.1818	4.6232±0.1661	135.6767±12.2204	1.3±0.1092	0.067±0.0057	2.84±0.2536
SF	O2, 2HR	15	40	OPEN	2	1.056±0.0601	2.3714±0.2102	4.4834±0.1872	135.5634±8.4565	1.314±0.0668	0.068±0.0037	2.8134±0.1568
SF	O2, 4HR	15	40	OPEN	2	1.0518±0.0684	2.6687±0.1837	4.7723±0.0834	135.47±8.7387	1.382±0.0985	0.068±0.0054	3.1967±0.2705
SF	N2, 2HRS	15	40	OPEN	2	1.0649±0.0862	2.4664±0.1836	4.5962±0.1408	135.72±8.7692	1.338±0.1211	0.066±0.0035	2.9567±0.1554
SF	N2, 4HRS	15	40	OPEN	2	1.0403±0.0701	2.3697±0.1783	4.4503±0.1148	135.6434±10.102	1.329±0.0745	0.067±0.0054	2.7334±0.1471
RB	NIL	0	20	CLOSED	2	1.5664±0.0907	4.683±0.336	7.8158±0.1727	103.6634±8.2032	1.439±0.0747	0.066±0.0048	4.3734±0.296
RB	O2, 2HR	5	20	CLOSED	2	0.5661±0.0387	4.1804±0.2948	5.3126±0.1626	104.8234±7.5985	1.452±0.0971	0.052±0.0036	2.7767±0.1444
RB	O2, 4HR	5	20	CLOSED	2	0.5711±0.0344	4.3997±0.2856	5.5419±0.3508	104.7567±8.1907	1.451±0.1401	0.052±0.0028	2.81±0.1725
RB	N2, 2HRS	5	20	CLOSED	2	0.5638±0.0441						

RB	O2, 4HR	10	20	CLOSED	2	0.5587±0.0486	4.194±0.3126	5.3114±0.2257	104.7334±9.5386	1.418±0.0789	0.052±0.0039	2.8634±0.1621
RB	N2, 2HRS	10	20	CLOSED	2	0.5623±0.0329	4.0694±0.3874	5.194±0.2074	104.9767±10.4724	1.392±0.1385	0.05±0.0048	2.53±0.1393
RB	N2, 4HRS	10	20	CLOSED	2	0.548±0.0281	4.356±0.2624	5.452±0.1234	104.88±7.7793	1.422±0.0903	0.051±0.004	2.6267±0.1512
RB	O2, 2HR	15	20	CLOSED	2	0.5766±0.053	4.1517±0.3491	5.3049±0.3015	104.7067±6.3701	1.418±0.0807	0.052±0.0043	2.91±0.1507
RB	O2, 4HR	15	20	CLOSED	2	0.5762±0.0456	4.3627±0.2352	5.5151±0.1554	104.6734±6.7634	1.419±0.1182	0.053±0.0052	2.94±0.1712
RB	N2, 2HRS	15	20	CLOSED	2	0.5554±0.0328	4.1307±0.3607	5.2415±0.3204	104.9634±7.667	1.457±0.0887	0.05±0.0031	2.54±0.1884
RB	N2, 4HRS	15	20	CLOSED	2	0.5499±0.0541	4.2364±0.3123	5.3362±0.3036	104.91±5.6384	1.404±0.0814	0.05±0.0039	2.5967±0.22
RB	NIL	0	30	CLOSED	2	1.7008±0.1467	4.5287±0.4163	7.9303±0.3804	103.6267±5.8125	1.388±0.1016	0.066±0.0066	6.39±0.5231
RB	O2, 2HR	5	30	CLOSED	2	0.5477±0.0317	4.2277±0.365	5.3231±0.0933	104.5167±5.7971	1.401±0.1142	0.054±0.0031	3.17±0.2786
RB	O2, 4HR	5	30	CLOSED	2	0.5841±0.0328	4.4137±0.3922	5.5819±0.2432	104.4934±9.1449	1.425±0.1425	0.055±0.0044	3.2067±0.175
RB	N2, 2HRS	5	30	CLOSED	2	0.5599±0.0302	4.4974±0.3304	5.6172±0.1164	104.5334±6.6213	1.469±0.0765	0.054±0.0046	3.13±0.2611
RB	N2, 4HRS	5	30	CLOSED	2	0.5668±0.0442	4.2914±0.3251	5.425±0.1548	104.5234±8.4999	1.4±0.1212	0.054±0.0034	3.16±0.2167
RB	O2, 2HR	10	30	CLOSED	2	0.5601±0.0401	4.3964±0.4289	5.5166±0.3018	104.5967±6.5098	1.472±0.088	0.054±0.0043	4.8134±0.2183
RB	O2, 4HR	10	30	CLOSED	2	0.5763±0.053	4.2937±0.3104	5.4463±0.2105	104.5767±6.0905	1.443±0.0822	0.054±0.0039	3.0667±0.1539
RB	N2, 2HRS	10	30	CLOSED	2	0.559±0.0558	4.1407±0.3423	5.2587±0.2732	104.6467±5.2328	1.472±0.0788	0.053±0.0048	2.96±0.2864
RB	N2, 4HRS	10	30	CLOSED	2	0.5572±0.0446	4.4627±0.2654	5.5771±0.0948	104.6234±7.8777	1.442±0.0911	0.053±0.0045	3.0234±0.2636
RB	O2, 2HR	15	30	CLOSED	2	0.5589±0.032	4.48±0.4465	5.5978±0.1866	104.4734±7.2393	1.472±0.0921	0.056±0.0051	3.2334±0.2937
RB	O2, 4HR	15	30	CLOSED	2	0.5517±0.0546	4.3997±0.2596	5.5031±0.2974	104.46±9.168	1.413±0.1041	0.056±0.0043	3.2734±0.2441
RB	N2, 2HRS	15	30	CLOSED	2	0.55±0.0288	4.2667±0.3741	5.3667±0.3397	104.5767±9.0395	1.391±0.0779	0.054±0.0042	3.0867±0.227
RB	N2, 4HRS	15	30	CLOSED	2	0.555±0.0454	4.4254±0.3483	5.5354±0.3305	104.5567±5.5306	1.472±0.1047	0.054±0.0033	3.11±0.2006
RB	NIL	0	40	CLOSED	2	1.7867±0.1261	6.7014±0.4032	10.2748±0.2608	103.26±7.8177	1.399±0.1104	0.069±0.0039	4.8134±0.4549
RB	O2, 2HR	5	40	CLOSED	2	0.5711±0.0436	4.5187±0.2649	5.6609±0.167	104.0367±7.496	1.396±0.1027	0.061±0.0059	3.8267±0.3761
RB	O2, 4HR	5	40	CLOSED	2	0.5744±0.0364	4.3797±0.3327	5.5285±0.2511	103.9934±9.1152	1.38±0.0826	0.062±0.0052	3.8934±0.2055
RB	N2, 2HRS	5	40	CLOSED	2	0.5511±0.0287	4.5644±0.2706	5.6666±0.1136	104.0667±10.245	1.47±0.1383	0.061±0.0046	3.8±0.343
RB	N2, 4HRS	5	40	CLOSED	2	0.5452±0.0434	4.409±0.3268	5.4994±0.0962	104.13±9.0014	1.47±0.0832	0.061±0.0032	3.74±0.1892
RB	O2, 2HR	10	40	CLOSED	2	0.5656±0.0447	4.628±0.2539	5.7592±0.2711	104.0834±5.8512	1.41±0.1363	0.061±0.0058	3.76±0.3254
RB	O2, 4HR	10	40	CLOSED	2	0.5648±0.0309	4.6334±0.3793	5.763±0.1611	103.9867±5.6615	1.436±0.1124	0.062±0.0036	3.9134±0.2445
RB	N2, 2HRS	10	40	CLOSED	2	0.5637±0.0551	4.5597±0.3101	5.6871±0.1276	104.1467±8.3358	1.396±0.0953	0.061±0.0032	3.7067±0.3187
RB	N2, 4HRS	10	40	CLOSED	2	0.5737±0.0421	4.598±0.4291	5.7454±0.4315	104.03±6.3666	1.432±0.1086	0.062±0.0055	3.8634±0.3778
RB	O2, 2HR	15	40	CLOSED	2	0.5886±0.0367	4.6237±0.4382	5.8009±0.2189	104.1034±8.2652	1.414±0.0907	0.061±0.0042	3.75±0.2265
RB	O2, 4HR	15	40	CLOSED	2	0.5595±0.0395	4.533±0.3345	5.652±0.2789	103.9267±8.5951	1.461±0.094	0.062±0.0039	3.9567±0.2209
RB	N2, 2HRS	15	40	CLOSED	2	0.5727±0.0567	4.3477±0.3969	5.4931±0.2534	104.18±10.3575	1.455±0.1036	0.06±0.0035	3.61±0.207
RB	N2, 4HRS	15	40	CLOSED	2	0.5665±0.0424	4.3647±0.2691	5.4977±0.0425	104.1667±10.3773	1.438±0.0904	0.06±0.0039	3.6934±0.2359
SB	NIL	0	20	CLOSED	2	1.6635±0.1469	7.073±0.5977	10.4±0.4068	140.6634±13.8475	1.338±0.0724	0.065±0.0059	2.73±0.2087
SB	O2, 2HR	5	20	CLOSED	2	1.5192±0.146	6.5704±0.5222	9.6088±0.0687	141.8234±7.6484	1.337±0.1035	0.05±0.0044	0.53±0.053
SB	O2, 4HR	5	20	CLOSED	2	1.5241±0.1188	6.7897±0.3853	9.8379±0.1225	141.7567±12.4769	1.349±0.0889	0.052±0.0035	0.54±0.0484
SB	N2, 2HRS	5	20	CLOSED	2	1.5084±0.0974	6.4584±0.5958	9.4752±0.1788	141.9234±12.026	1.31±0.129	0.05±0.0034	0.91±0.0872
SB	N2, 4HRS	5	20	CLOSED	2	1.5153±0.12	6.5757±0.3898	9.6063±0.5281	141.85±9.753	1.357±0.1013	0.051±0.0035	0.94±0.0615
SB	O2, 2HR	10	20	CLOSED	2	1.517±0.0868	6.6227±0.4614	9.6567±0.3486	141.8367±13.4696	1.356±0.1103	0.051±0.0046	0.58±0.0317
SB	O2, 4HR	10	20	CLOSED	2	1.5297±0.0978	6.584±0.3579	9.6434±0.3521	141.7334±9.6079	1.371±0.0868	0.052±0.0028	0.6967±0.0501
SB	N2, 2HRS	10	20	CLOSED	2	1.5021±0.0771	6.4594±0.474	9.4636±0.2876	141.9767±11.2532	1.391±0.0992	0.05±0.0038	0.7767±0.0431
SB	N2, 4HRS	10	20	CLOSED	2	1.5117±0.0776	6.746±0.611	9.7694±0.6648	141.88±8.5478	1.305±0.1129	0.05±0.0045	0.8634±0.0569
SB	O2, 2HR	15	20	CLOSED	2	1.5404±0.1222	6.5417±0.5422	9.6225±0.399	141.7067±11.3847	1.35±0.0799	0.052±0.0036	0.6267±0.0387
SB	O2, 4HR	15	20	CLOSED	2	1.5467±0.1245	6.7527±0.4641	9.8461±0.2366	141.6734±9.5976	1.324±0.1025	0.052±0.0033	0.5967±0.0339
SB	N2, 2HRS	15	20	CLOSED	2	1.5037±0.1439	6.5207±0.4328	9.5281±0.3143	141.9634±10.4999	1.353±0.109	0.05±0.0044	0.76±0.0474
SB	N2, 4HRS	15	20	CLOSED	2	1.5096±0.1245	6.6264±0.4735	9.6456±0.3109	141.91±12.0427	1.341±0.0966	0.05±0.0047	0.81±0.0489
SB	NIL	0	30	CLOSED	2	1.6658±0.1059	6.9187±0.5333	10.2503±0.267	140.6267±7.6116	1.322±0.1304	0.065±0.0058	2.6367±0.1876
SB	O2, 2HR	5	30	CLOSED	2	1.5713±0.107	6.6177±0.4424	9.7603±0.3083	141.5167±10.1573	1.386±0.078	0.054±0.0034	1.0867±0.0758
SB	O2, 4HR	5	30	CLOSED	2	1.5787±0.1192	6.8037±0.4555	9.9611±0.3387	141.4934±10.1836	1.325±0.1019	0.055±0.0042	1.16±0.0689
SB	N2, 2HRS	5	30	CLOSED	2	1.5668±0.0788	6.8874±0.4355	10.02±0.72	141.5334±10.4405	1.383±0.1383	0.054±0.0043	1.13±0.0633
SB	N2, 4HRS	5	30	CLOSED	2	1.5683±0.1012	6.6814±0.6175	9.818±0.6353	141.5234±11.424	1.368±0.114	0.054±0.0049	0.96±0.0492
SB	O2, 2HR	10	30	CLOSED	2	1.5546±0.0817	6.7864±0.4359	9.8956±0.2781	141.5967±10.632	1.34±0.1192	0.053±0.0039	1.2334±0.0646
SB	O2, 4HR	10	30	CLOSED	2	1.5579±0.1447	6.6837±0.3548	9.7995±0.1324	141.5767±8.0051	1.34±0.0695	0.053±0.0043	1.2067±0.0943
SB	N2, 2HRS	10	30	CLOSED	2	1.5503±0.1374	6.5307±0.5041	9.6313±0.5402	141.6467±12.3926	1.359±0.07	0.052±0.0036	1.17±0.0632
SB	N2, 4HRS	10	30	CLOSED	2	1.5516±0.1515	6.8527±0.6235	9.9559±0.1149	141.6234±13.2494	1.318±0.0888	0.052±0.0038	1.0434±0.102
SB	O2, 2HR	15	30	CLOSED	2	1.5837±0.1536	6.87±0.3772	10.0374±0.31	141.4734±13.6745	1.353±0.0713	0.055±0.0028	1.0234±0.0533
SB	O2, 4HR	15	30	CLOSED	2	1.5901±0.147	6.7897±0.6676	9.9699±0.3942	141.46±13.537	1.373±0.0965	0.055±0.0041	1.11±0.0596
SB	N2, 2HRS	15	30	CLOSED	2	1.5604±0.1467	6.6567±0.573	9.7775±0.442	141.5767±8.767	1.34±0.0708	0.053±0.0035	1.0667±0.0647
SB	N2, 4HRS	15	30	CLOSED	2	1.5616±0.1326	6.8154±0.631	9.9386±0.5411	141.5567±11.5098	1.346±0.1213	0.054±0.0033	1.2734±0.069
SB	NIL	0	40	CLOSED	2	3.0337±0.21	9.0914±0.6126	15.1588±0.5239	140.26±10.7506	1.366±0.0735	0.068±0.0041	2.9±0.1541
SB	O2, 2HR	5	40	CLOSED	2	1.6211±0.0967	6.9087±0.4924	10.1509±0.2747	141.0367±10.3952	1.353±0.0798	0.06±0.0055	1.3434±0.0869
SB	O2, 4HR	5	40	CLOSED	2	1.6267±0.1473	6.7697±0.5946	10.0231±0.057	140.9934±8.2934	1.355±0.1311	0.06±0.006	1.4067±0.11
SB	N2, 2HRS	5	40	CLOSED	2	1.6175±0.1019	6.9544±0.6755	10.1894±0.461	141.0667±8.3218	1.345±0.0732	0.06±0.0053	1.33±0.0894
SB	N2, 4HRS	5	40	CLOSED	2	1.6081±0.0936	6.799±0.3777	10.0152±0.1638	141.13±13.3738	1.31±0.1208	0.059±0.0039	1.56±0.123
SB	O2, 2HR	10	40	CLOSED	2	1.6107±0.1501	7.018±0.5848	10.2394±0.1844	141.0834±7.186	1.312±0.0826	0.059±0.003	1.5967±0.1291
SB	O2, 4HR	10	40	CLOSED	2	1.6289±0.0998	7.0234±0.6113	10.2812±0.5085	140.9867±7.6976	1.359±0.0998	0.06±0.0043	1.38±0.1308
SB	N2, 2HRS	10	40	CLOSED	2	1.6051±0.115	6.9497±0.3659	10.1599±0.0839	141.1467±12.4878	1.304±0.0976	0.058±0.005	1.46±0.1021
SB	N2, 4HRS	10	40	CLOSED	2	1.6228±0.0912	6.988±0.6719	10.2336±0.219	141.03±13.8357	1.339±0.1222	0.06±0.0045	1.3534±0.1322
SB	O2, 2HR	15	40	CLOSED	2	1.6094±0.1333	7.0137±0.6407	10.2325±0.7228	141.1034±11.7793	1.394±0.0699	0.059±0.0041	1.5467±0.1096
SB	O2, 4HR	15	40	CLOSED	2	1.6324±0.1346	6.923±0.6706	10.1878±0.1785	140.9267±12.7949	1.314±0.0828	0.061±0.0049	1.3967±0.0735
SB	N2, 2HRS	15	40	CLOSED	2	1.5915±0.1261	6.7377±0.6146	9.9207±0.5729	141.18±11.4803	1.335±0.0789	0.058±0.0034	1.5167±0.1365
SB	N2, 4HRS	15	40	CLOSED	2	1.5966±0.1068	6.7547±0.6579	9.9479±0.4537	141.1667±9.8375	1.305±0.121	0.058±0.0053	1.43±0.1282
SF	NIL	0										

SF	N2, 2HRS	5	20	CLOSED	2	1.0408±0.0972	1.8484±0.103	3.93±0.104	137.0934±11.3846	1.345±0.0951	0.051±0.003	1.1667±0.0879
SF	N2, 4HRS	5	20	CLOSED	2	1.0477±0.1035	1.9657±0.1712	4.0611±0.2811	137.02±9.4943	1.307±0.0946	0.052±0.004	1.1967±0.0815
SF	O2, 2HR	10	20	CLOSED	2	1.0342±0.0949	2.0127±0.1199	4.0811±0.1041	137.0067±9.8617	1.336±0.1202	0.052±0.0037	0.8367±0.0455
SF	O2, 4HR	10	20	CLOSED	2	1.0357±0.0735	1.974±0.1756	4.0454±0.129	136.9034±7.785	1.327±0.1234	0.053±0.004	0.9534±0.0659
SF	N2, 2HRS	10	20	CLOSED	2	1.0393±0.0694	1.8494±0.1454	3.928±0.1717	137.1467±6.8813	1.303±0.0776	0.05±0.0033	1.0334±0.0779
SF	N2, 4HRS	10	20	CLOSED	2	1.025±0.0586	2.136±0.1751	4.186±0.1299	137.05±11.6395	1.301±0.1218	0.051±0.0045	1.12±0.076
SF	O2, 2HR	15	20	CLOSED	2	1.0536±0.0933	1.9317±0.1914	4.0389±0.1324	136.8767±11.3139	1.348±0.0907	0.053±0.003	0.8834±0.0643
SF	O2, 4HR	15	20	CLOSED	2	1.0532±0.0656	2.1427±0.1168	4.2491±0.0355	136.8434±13.4519	1.362±0.0992	0.053±0.0031	0.8534±0.0851
SF	N2, 2HRS	15	20	CLOSED	2	1.0324±0.1006	1.9107±0.148	3.9755±0.1045	137.1334±13.146	1.315±0.1303	0.05±0.0047	1.0167±0.0662
SF	N2, 4HRS	15	20	CLOSED	2	1.0269±0.0657	2.0164±0.1274	4.0702±0.1552	137.08±7.9279	1.357±0.1169	0.051±0.0034	1.0667±0.0707
SF	NIL	0	30	CLOSED	2	2.1778±0.1199	2.4087±0.1328	6.6643±0.3728	135.7967±11.5561	1.332±0.0996	0.066±0.0044	2.8934±0.2168
SF	O2, 2HR	5	30	CLOSED	2	1.0247±0.0714	2.0077±0.1042	4.0571±0.1868	136.6867±12.2498	1.344±0.1194	0.055±0.0031	1.3434±0.1153
SF	O2, 4HR	5	30	CLOSED	2	1.0611±0.075	2.1937±0.1443	4.3159±0.0623	136.6634±10.5702	1.333±0.0827	0.055±0.0048	1.4167±0.0724
SF	N2, 2HRS	5	30	CLOSED	2	1.0369±0.0817	2.2774±0.1835	4.3512±0.2251	136.7034±12.055	1.311±0.1071	0.055±0.0033	1.3867±0.0836
SF	N2, 4HRS	5	30	CLOSED	2	1.0438±0.0687	2.0714±0.1155	4.159±0.0363	136.6934±11.0048	1.333±0.105	0.055±0.005	1.2167±0.0907
SF	O2, 2HR	10	30	CLOSED	2	1.0371±0.0749	2.1764±0.2085	4.2506±0.0717	136.7667±8.0988	1.313±0.1036	0.054±0.0041	1.49±0.1134
SF	O2, 4HR	10	30	CLOSED	2	1.0533±0.0797	2.0737±0.1962	4.1803±0.0254	136.7467±8.8171	1.326±0.1214	0.054±0.003	1.4634±0.1063
SF	N2, 2HRS	10	30	CLOSED	2	1.036±0.0671	1.9207±0.1035	3.9927±0.0848	136.8167±10.8667	1.325±0.1276	0.053±0.005	1.4267±0.1286
SF	N2, 4HRS	10	30	CLOSED	2	1.0342±0.0746	2.2427±0.19	4.3111±0.0971	136.7934±12.1166	1.337±0.1137	0.054±0.0028	1.34±0.1134
SF	O2, 2HR	15	30	CLOSED	2	1.0359±0.0729	2.26±0.1464	4.3318±0.0116	136.6434±12.4425	1.315±0.0837	0.055±0.005	1.28±0.1129
SF	O2, 4HR	15	30	CLOSED	2	1.0287±0.0786	2.1797±0.184	4.2371±0.15	136.63±12.5325	1.369±0.1159	0.056±0.0035	1.3667±0.0777
SF	N2, 2HRS	15	30	CLOSED	2	1.027±0.0813	2.0467±0.1275	4.1007±0.1107	136.7467±10.8855	1.375±0.0845	0.055±0.0051	1.3234±0.0774
SF	N2, 4HRS	15	30	CLOSED	2	1.032±0.0904	2.2054±0.1409	4.2694±0.1081	136.7267±9.2907	1.319±0.0721	0.055±0.0034	1.53±0.1274
SF	NIL	0	40	CLOSED	2	2.2637±0.2015	4.4814±0.2855	9.0088±0.1368	135.43±8.9471	1.362±0.1349	0.068±0.0055	3.1567±0.1797
SF	O2, 2HR	5	40	CLOSED	2	1.0481±0.088	2.2987±0.1281	4.3949±0.3104	136.2067±12.982	1.313±0.067	0.062±0.0057	1.64±0.1248
SF	O2, 4HR	5	40	CLOSED	2	1.0514±0.0777	2.1597±0.1357	4.2625±0.0971	136.1634±8.7367	1.379±0.1054	0.062±0.0054	1.6634±0.1418
SF	N2, 2HRS	5	40	CLOSED	2	1.0281±0.0947	2.3444±0.2081	4.4006±0.2206	136.2367±10.7653	1.303±0.0913	0.062±0.0037	1.5867±0.148
SF	N2, 4HRS	5	40	CLOSED	2	1.0222±0.0953	2.189±0.1166	4.2334±0.1075	136.3±12.6783	1.362±0.0737	0.061±0.005	1.8167±0.1196
SF	O2, 2HR	10	40	CLOSED	2	1.0426±0.0652	2.408±0.1702	4.4932±0.1603	136.2534±11.0482	1.324±0.0686	0.062±0.0038	1.8534±0.1348
SF	O2, 4HR	10	40	CLOSED	2	1.0418±0.0693	2.4134±0.183	4.497±0.0819	136.1567±11.6819	1.331±0.0709	0.063±0.0042	1.6367±0.1105
SF	N2, 2HRS	10	40	CLOSED	2	1.0407±0.071	2.3397±0.1293	4.4211±0.0059	136.3167±10.9445	1.369±0.0739	0.061±0.0045	1.7167±0.1355
SF	N2, 4HRS	10	40	CLOSED	2	1.0507±0.0583	2.378±0.1898	4.4794±0.0237	136.2±12.6613	1.33±0.1091	0.062±0.0058	1.61±0.1496
SF	O2, 2HR	15	40	CLOSED	2	1.0656±0.0849	2.4037±0.239	4.5349±0.0914	136.2734±10.8728	1.388±0.1332	0.062±0.0055	1.8034±0.1177
SF	O2, 4HR	15	40	CLOSED	2	1.0365±0.0802	2.313±0.153	4.386±0.1468	136.0967±8.1382	1.386±0.1022	0.063±0.0036	1.6534±0.1299
SF	N2, 2HRS	15	40	CLOSED	2	1.0497±0.0871	2.1277±0.1123	4.2271±0.0471	136.35±9.5536	1.346±0.1117	0.061±0.0035	1.7734±0.1204
SF	N2, 4HRS	15	40	CLOSED	2	1.0435±0.0699	2.1447±0.1444	4.2317±0.2548	136.3367±7.2807	1.374±0.115	0.061±0.0032	1.6867±0.126
RB	NIL	0	20	OPEN	3	2.9307±0.2031	4.9254±0.2635	10.5868±0.3488	101.29±10.0606	1.419±0.0956	0.085±0.0069	6.3767±0.4461
RB	O2, 2HR	5	20	OPEN	3	0.5752±0.0292	4.3504±0.3735	5.5008±0.2635	103.1767±8.1235	1.453±0.136	0.077±0.0039	5.5867±0.5577
RB	O2, 4HR	5	20	OPEN	3	0.5814±0.047	4.575±0.3635	5.7378±0.2463	103.0167±10.0471	1.454±0.102	0.077±0.0065	5.6267±0.3172
RB	N2, 2HRS	5	20	OPEN	3	0.5798±0.0347	4.4884±0.3503	5.648±0.2737	103.59±6.1543	1.385±0.131	0.075±0.006	5.33±0.2683
RB	N2, 4HRS	5	20	OPEN	3	0.5724±0.0352	4.3117±0.2246	5.4565±0.1117	103.3234±8.9898	1.455±0.0965	0.076±0.0062	5.47±0.3901
RB	O2, 2HR	10	20	OPEN	3	0.5914±0.0558	4.3857±0.3846	5.5685±0.3092	103.28±7.57	1.429±0.1265	0.077±0.0043	5.55±0.3273
RB	O2, 4HR	10	20	OPEN	3	0.579±0.048	4.527±0.4127	5.685±0.1076	103.0567±6.2024	1.417±0.1149	0.077±0.0074	5.62±0.4625
RB	N2, 2HRS	10	20	OPEN	3	0.578±0.0319	4.519±0.2774	5.675±0.2538	103.5434±5.3652	1.377±0.107	0.075±0.0059	5.3667±0.3258
RB	N2, 4HRS	10	20	OPEN	3	0.5886±0.0448	4.499±0.3462	5.6762±0.2155	103.44±6.3921	1.438±0.0758	0.076±0.0043	5.4267±0.4878
RB	O2, 2HR	15	20	OPEN	3	0.5847±0.0552	4.3937±0.2628	5.5631±0.1015	103.2434±5.5536	1.436±0.1047	0.077±0.0043	5.5734±0.4261
RB	O2, 4HR	15	20	OPEN	3	0.5817±0.0544	4.4854±0.3002	5.6488±0.1671	102.9234±5.9062	1.417±0.1096	0.078±0.0064	5.6434±0.4957
RB	N2, 2HRS	15	20	OPEN	3	0.5701±0.0288	4.2307±0.228	5.3709±0.0697	103.5067±6.619	1.442±0.1097	0.075±0.0043	5.3867±0.4871
RB	N2, 4HRS	15	20	OPEN	3	0.5764±0.032	4.4127±0.3551	5.5655±0.199	103.3867±10.1242	1.441±0.0765	0.076±0.0075	5.45±0.2947
RB	NIL	0	30	OPEN	3	3.4364±0.2056	7.9024±0.5995	14.7752±0.4541	100.47±8.0063	1.434±0.1428	0.088±0.0058	6.7634±0.4069
RB	O2, 2HR	5	30	OPEN	3	0.5654±0.0506	4.4884±0.394	5.6192±0.4378	101.86±9.3437	1.422±0.0937	0.083±0.007	6.1334±0.3751
RB	O2, 4HR	5	30	OPEN	3	0.5619±0.0344	4.6727±0.3848	5.7965±0.2036	101.72±7.3313	1.419±0.1259	0.084±0.0079	6.2667±0.5388
RB	N2, 2HRS	5	30	OPEN	3	0.5807±0.0534	4.4754±0.2384	5.6368±0.1136	101.8267±8.6137	1.471±0.1279	0.084±0.0081	6.1534±0.4892
RB	N2, 4HRS	5	30	OPEN	3	0.5854±0.0447	4.4637±0.3857	5.6345±0.0997	101.7867±7.6265	1.443±0.0772	0.084±0.0046	6.2134±0.3797
RB	O2, 2HR	10	30	OPEN	3	0.5782±0.0293	4.5567±0.4393	5.7131±0.3702	101.7467±8.5256	1.376±0.1211	0.084±0.0075	6.2434±0.6134
RB	O2, 4HR	10	30	OPEN	3	0.5724±0.0481	4.511±0.4263	5.6558±0.3203	101.56±5.9103	1.432±0.1258	0.084±0.0083	6.3067±0.4062
RB	N2, 2HRS	10	30	OPEN	3	0.5728±0.0551	4.5054±0.2344	5.651±0.2523	101.9834±9.3483	1.413±0.1074	0.083±0.0051	6.0567±0.4898
RB	N2, 4HRS	10	30	OPEN	3	0.5705±0.0386	4.677±0.2405	5.818±0.2602	101.9934±9.3666	1.383±0.0777	0.082±0.0075	6.0434±0.3379
RB	O2, 2HR	15	30	OPEN	3	0.5628±0.0307	4.593±0.4457	5.7186±0.3082	101.6367±5.9542	1.427±0.1	0.084±0.0045	6.27±0.3896
RB	O2, 4HR	15	30	OPEN	3	0.5754±0.0426	4.808±0.3153	5.9588±0.2646	101.5367±5.6583	1.473±0.1161	0.085±0.0071	6.3367±0.3567
RB	N2, 2HRS	15	30	OPEN	3	0.5659±0.0555	4.4204±0.4033	5.5522±0.3163	101.9067±7.008	1.376±0.1169	0.083±0.0064	6.09±0.5019
RB	N2, 4HRS	15	30	OPEN	3	0.5758±0.049	4.4497±0.2954	5.6013±0.269	101.88±7.2205	1.438±0.1006	0.083±0.0065	6.1234±0.4363
RB	NIL	0	40	OPEN	3	4.041±0.327	7.8707±0.4009	15.9527±0.334	100.4234±9.2336	1.43±0.1239	0.088±0.006	6.8134±0.574
RB	O2, 2HR	5	40	OPEN	3	0.5812±0.0501	4.693±0.3064	5.8554±0.1936	100.7334±5.2503	1.445±0.1391	0.087±0.0079	6.6934±0.3701
RB	O2, 4HR	5	40	OPEN	3	0.5631±0.0289	4.7677±0.4736	5.8939±0.2431	100.6334±7.287	1.463±0.1181	0.087±0.0055	6.71±0.3764
RB	N2, 2HRS	5	40	OPEN	3	0.5714±0.0494	4.724±0.4603	5.8668±0.1945	100.95±8.5103	1.398±0.1081	0.086±0.0073	6.52±0.4962
RB	N2, 4HRS	5	40	OPEN	3	0.5855±0.0481	4.6844±0.4039	5.8554±0.4786	101.15±8.6679	1.392±0.111	0.085±0.0051	6.4734±0.4787
RB	O2, 2HR	10	40	OPEN	3	0.5836±0.0467	4.7774±0.456	5.9446±0.111	100.9067±7.4728	1.46±0.1019	0.086±0.0049	6.56±0.4234
RB	O2, 4HR	10	40	OPEN	3	0.5751±0.0485	4.796±0.2718	5.9462±0.1379	100.8±6.3482	1.393±0.0822	0.087±0.0066	6.6667±0.5544
RB	N2, 2HRS	10	40	OPEN	3	0.567±0.0335	4.8524±0.245	5.9864±0.147	101.23±8.7464	1.375±0.1167	0.085±0.0043	6.4±0.4211
RB	N2, 4HRS	10	40	OPEN	3	0.5677±0.03	4.556±0.3915	5.6914±0.2013	101.03±9.3265	1.389±0.0752	0.086±0.006	6.4867±0.3488
RB	O2, 2HR	15	40	OPEN	3	0.5544±0.0411	4.775±0.4701	5.8838±0.2188	100.8567±5.236	1.443±0.1055	0.087±0.0087	6.5934±0.3444
RB	O2, 4HR	15	40	OPEN	3							

SB	NIL	0	20	OPEN	3	3.7464±0.0881	7.1154±0.4528	10.6082±0.3847	138.29±7.2968	1.315±0.1133	0.085±0.0052	2.5934±0.2095
SB	O2, 2HR	5	20	OPEN	3	2.9242±0.2062	6.7404±0.6534	12.5888±0.2479	140.1767±10.4591	1.353±0.0878	0.077±0.0076	1.6767±0.1429
SB	O2, 4HR	5	20	OPEN	3	2.9599±0.2025	6.965±0.4076	12.8848±0.719	140.0167±12.4583	1.303±0.0894	0.077±0.0048	1.89±0.1871
SB	N2, 2HRS	5	20	OPEN	3	2.7445±0.2719	6.8784±0.4666	12.3674±0.2412	140.59±13.1251	1.363±0.1268	0.075±0.0039	1.8667±0.1702
SB	N2, 4HRS	5	20	OPEN	3	2.837±0.2621	6.7017±0.6396	12.3757±0.6632	140.3234±10.8696	1.339±0.1115	0.076±0.0042	2.02±0.144
SB	O2, 2HR	10	20	OPEN	3	2.8614±0.2555	6.7757±0.5463	12.4985±0.1118	140.28±12.2007	1.311±0.1158	0.076±0.0073	1.8434±0.1044
SB	O2, 4HR	10	20	OPEN	3	2.9333±0.2205	6.917±0.5497	12.7836±0.3435	140.0567±7.5477	1.323±0.1229	0.077±0.0052	1.7767±0.1604
SB	N2, 2HRS	10	20	OPEN	3	2.7626±0.1707	6.909±0.6667	12.4342±0.0927	140.5434±7.8417	1.347±0.0736	0.075±0.0061	1.8267±0.1122
SB	N2, 4HRS	10	20	OPEN	3	2.7979±0.1981	6.889±0.3651	12.4848±0.414	140.44±13.8185	1.344±0.1312	0.076±0.0061	1.9267±0.1053
SB	O2, 2HR	15	20	OPEN	3	2.8912±0.1684	6.7837±0.3442	12.5661±0.2081	140.2434±7.2377	1.39±0.1309	0.076±0.0073	1.76±0.0918
SB	O2, 4HR	15	20	OPEN	3	2.9836±0.2046	6.8754±0.3736	12.8426±0.257	139.9234±13.1624	1.351±0.0841	0.078±0.0043	1.6967±0.1616
SB	N2, 2HRS	15	20	OPEN	3	2.7805±0.2552	6.6207±0.5448	12.1817±0.9033	140.5067±11.5133	1.384±0.1168	0.076±0.0042	1.8034±0.0946
SB	N2, 4HRS	15	20	OPEN	3	2.8234±0.2058	6.8027±0.5582	12.4495±0.1875	140.3867±8.4968	1.311±0.0784	0.076±0.0053	1.99±0.155
SB	NIL	0	30	OPEN	3	3.5749±0.2187	10.2924±0.9496	17.4422±0.6952	137.47±8.8767	1.393±0.1179	0.089±0.0081	2.7634±0.1629
SB	O2, 2HR	5	30	OPEN	3	3.1013±0.2005	6.8784±0.4721	13.081±0.2877	138.86±7.62	1.334±0.1173	0.083±0.0073	2.015±0.1693
SB	O2, 4HR	5	30	OPEN	3	3.19±0.2379	7.0627±0.5827	13.4427±1.2836	138.72±12.1036	1.315±0.1254	0.084±0.0058	2.09±0.1438
SB	N2, 2HRS	5	30	OPEN	3	3.1164±0.1693	6.8654±0.6263	13.0982±0.4245	138.8267±9.4966	1.363±0.1067	0.083±0.0075	2.3367±0.2279
SB	N2, 4HRS	5	30	OPEN	3	3.1464±0.2391	6.8537±0.659	13.1465±0.2105	138.7867±7.2101	1.336±0.0899	0.083±0.0069	2.1534±0.1989
SB	O2, 2HR	10	30	OPEN	3	3.1616±0.2696	6.9467±0.6769	13.2699±0.4235	138.7467±9.4656	1.31±0.1175	0.084±0.0078	2.0567±0.1906
SB	O2, 4HR	10	30	OPEN	3	3.2526±0.2798	6.901±0.4837	13.4062±0.0754	138.56±9.601	1.333±0.0673	0.085±0.006	2.0434±0.1462
SB	N2, 2HRS	10	30	OPEN	3	3.0077±0.283	6.8954±0.4238	12.9108±0.3325	138.9834±7.714	1.334±0.0973	0.081±0.0067	2.2434±0.1219
SB	N2, 4HRS	10	30	OPEN	3	2.9968±0.2928	7.067±0.5243	13.0606±1.258	138.9934±8.7595	1.373±0.0785	0.081±0.0047	2.1334±0.2212
SB	O2, 2HR	15	30	OPEN	3	3.2176±0.239	6.983±0.5622	13.4182±1.039	138.6367±9.1103	1.368±0.1062	0.084±0.0061	2.2134±0.1224
SB	O2, 4HR	15	30	OPEN	3	3.2867±0.2563	7.198±0.4199	13.7714±0.2886	138.5367±8.3402	1.354±0.0967	0.085±0.0044	2.1234±0.1083
SB	N2, 2HRS	15	30	OPEN	3	3.0212±0.1953	6.8104±0.4701	12.8528±0.1576	138.9067±13.4401	1.368±0.0905	0.082±0.0082	2.27±0.2089
SB	N2, 4HRS	15	30	OPEN	3	3.0573±0.2174	6.8397±0.6076	12.9543±0.6633	138.88±11.0679	1.387±0.095	0.082±0.0061	2.2667±0.2091
SB	NIL	0	40	OPEN	3	4.5803±0.3211	10.2607±0.7877	17.4213±0.8881	137.4234±7.0326	1.39±0.1343	0.089±0.007	2.37±0.1885
SB	O2, 2HR	5	40	OPEN	3	3.4341±0.2194	7.083±0.3613	13.9512±0.1128	137.7334±12.6558	1.357±0.0702	0.087±0.0069	2.3767±0.1872
SB	O2, 4HR	5	40	OPEN	3	3.455±0.2795	7.1577±0.3997	14.0677±0.5662	137.6334±8.9418	1.32±0.0775	0.088±0.0048	2.3534±0.1292
SB	N2, 2HRS	5	40	OPEN	3	3.376±0.2498	7.114±0.5505	13.866±0.5232	137.95±12.7292	1.371±0.1271	0.086±0.0052	2.4267±0.1462
SB	N2, 4HRS	5	40	OPEN	3	3.3355±0.2903	7.0744±0.4484	13.7454±0.2383	138.15±12.0975	1.3±0.0775	0.086±0.0079	2.7267±0.1628
SB	O2, 2HR	10	40	OPEN	3	3.3829±0.3367	7.1674±0.6812	13.9332±0.8369	137.9067±10.694	1.381±0.0834	0.087±0.0057	2.4734±0.2053
SB	O2, 4HR	10	40	OPEN	3	3.4195±0.2366	7.186±0.5734	14.025±0.1718	137.8±7.3101	1.384±0.1365	0.087±0.0083	2.51±0.1958
SB	N2, 2HRS	10	40	OPEN	3	3.2922±0.1922	7.2424±0.5548	13.8268±0.5246	138.23±11.3138	1.364±0.1335	0.086±0.0063	2.71±0.1837
SB	N2, 4HRS	10	40	OPEN	3	3.3418±0.2493	6.946±0.5502	13.6296±0.2502	138.03±9.6391	1.339±0.1071	0.086±0.008	2.52±0.1296
SB	O2, 2HR	15	40	OPEN	3	3.4012±0.3118	7.165±0.5493	13.9674±0.2457	137.8567±13.1153	1.394±0.082	0.087±0.0059	2.4867±0.1582
SB	O2, 4HR	15	40	OPEN	3	3.4737±0.2438	7.2814±0.3826	14.2288±0.4581	137.5967±12.9155	1.395±0.0877	0.089±0.0065	2.91±0.2361
SB	N2, 2HRS	15	40	OPEN	3	3.3177±0.2441	7.0557±0.3784	13.6911±0.4704	138.19±10.5451	1.301±0.1123	0.086±0.0067	2.6667±0.1381
SB	N2, 4HRS	15	40	OPEN	3	3.3578±0.2684	6.975±0.4478	13.6906±0.3782	137.99±10.3687	1.364±0.0702	0.086±0.0077	2.4±0.1918
SF	NIL	0	20	OPEN	3	3.4077±0.231	2.5054±0.2453	9.3208±0.4199	132.06±7.139	1.327±0.1322	0.087±0.0075	2.85±0.2037
SF	O2, 2HR	5	20	OPEN	3	1.0522±0.1019	1.2304±0.1768	4.2348±0.1589	133.9467±6.8963	1.366±0.1151	0.079±0.0052	1.9334±0.1727
SF	O2, 4HR	5	20	OPEN	3	1.0584±0.0728	2.355±0.2038	4.4718±0.198	133.7867±12.395	1.352±0.1191	0.079±0.0056	1.467±0.1244
SF	N2, 2HRS	5	20	OPEN	3	1.0568±0.0589	2.2684±0.1744	4.382±0.0334	134.36±9.9183	1.306±0.1241	0.078±0.0071	2.1234±0.1597
SF	N2, 4HRS	5	20	OPEN	3	1.0494±0.0832	2.0917±0.1142	4.1905±0.1589	134.0934±12.6515	1.357±0.1079	0.079±0.0052	2.2767±0.1349
SF	O2, 2HR	10	20	OPEN	3	1.0684±0.069	2.1657±0.1327	4.3025±0.0906	134.05±8.5071	1.313±0.131	0.079±0.004	2.14±0.2057
SF	O2, 4HR	10	20	OPEN	3	1.056±0.1013	2.307±0.1313	4.419±0.1397	133.8267±11.8353	1.312±0.1272	0.079±0.0076	2.0334±0.1455
SF	N2, 2HRS	10	20	OPEN	3	1.055±0.0607	2.299±0.1874	4.409±0.187	134.3134±6.9836	1.366±0.1103	0.078±0.0072	2.0834±0.2075
SF	N2, 4HRS	10	20	OPEN	3	1.0656±0.0681	2.279±0.182	4.4102±0.1833	134.21±11.8034	1.318±0.1076	0.078±0.0045	2.1834±0.1281
SF	O2, 2HR	15	20	OPEN	3	1.0617±0.0637	2.1737±0.1291	4.2971±0.1279	134.0134±10.7625	1.364±0.1134	0.079±0.0059	2.0167±0.1027
SF	O2, 4HR	15	20	OPEN	3	1.0587±0.0936	2.2654±0.2027	4.3828±0.0422	133.6934±6.8206	1.336±0.0683	0.079±0.0044	1.9534±0.1837
SF	N2, 2HRS	15	20	OPEN	3	1.0471±0.086	2.0107±0.1412	4.1049±0.1034	134.2767±8.9462	1.37±0.1136	0.078±0.0072	2.06±0.1886
SF	N2, 4HRS	15	20	OPEN	3	1.0534±0.0984	2.1927±0.1771	4.2995±0.137	134.1567±6.8161	1.385±0.1246	0.078±0.005	2.2467±0.179
SF	NIL	0	30	OPEN	3	3.9134±0.2267	5.6824±0.3273	13.5092±0.5603	131.24±9.5296	1.377±0.0828	0.089±0.0083	3.02±0.1568
SF	O2, 2HR	5	30	OPEN	3	1.0424±0.0768	2.2684±0.2218	4.3532±0.1771	132.63±12.964	1.309±0.0954	0.084±0.0062	2.5634±0.1476
SF	O2, 4HR	5	30	OPEN	3	1.0389±0.0697	2.4527±0.1667	4.5305±0.2124	132.49±7.3863	1.371±0.0974	0.085±0.0065	2.3467±0.1914
SF	N2, 2HRS	5	30	OPEN	3	1.0577±0.0951	2.2554±0.1432	4.3708±0.05	132.5967±12.606	1.397±0.1069	0.084±0.0046	2.5934±0.2
SF	N2, 4HRS	5	30	OPEN	3	1.0624±0.0952	2.2437±0.1802	4.3685±0.1292	132.5567±11.734	1.377±0.089	0.084±0.0052	2.41±0.131
SF	O2, 2HR	10	30	OPEN	3	1.0552±0.0818	2.3367±0.2245	4.4471±0.2042	132.5167±8.0157	1.331±0.0993	0.084±0.0067	2.3134±0.1738
SF	O2, 4HR	10	30	OPEN	3	1.0494±0.0543	2.291±0.1931	4.3898±0.0698	132.33±9.1277	1.329±0.0902	0.085±0.0057	2.3±0.1664
SF	N2, 2HRS	10	30	OPEN	3	1.0498±0.0833	2.2854±0.1154	4.385±0.1101	132.7534±10.5952	1.387±0.0986	0.083±0.0076	2.5±0.2149
SF	N2, 4HRS	10	30	OPEN	3	1.0475±0.1009	2.457±0.2084	4.552±0.0226	132.7634±9.4655	1.367±0.1037	0.083±0.005	2.39±0.1818
SF	O2, 2HR	15	30	OPEN	3	1.0398±0.097	2.373±0.1262	4.4526±0.0705	132.4067±9.2828	1.321±0.1132	0.085±0.0081	2.47±0.1426
SF	O2, 4HR	15	30	OPEN	3	1.0524±0.0755	2.588±0.2515	4.6928±0.1743	132.3067±7.8116	1.333±0.0876	0.086±0.0083	2.38±0.1845
SF	N2, 2HRS	15	30	OPEN	3	1.0429±0.0577	2.2004±0.1771	4.2862±0.2092	132.6767±8.1482	1.38±0.0727	0.083±0.0077	2.5267±0.2234
SF	N2, 4HRS	15	30	OPEN	3	1.0528±0.0568	2.2297±0.1394	4.3353±0.2131	132.65±8.7788	1.331±0.1	0.084±0.0047	2.5234±0.2343
SF	NIL	0	40	OPEN	3	4.518±0.2734	5.6507±0.455	14.6867±0.4753	131.1934±10.0366	1.379±0.0855	0.089±0.007	2.6267±0.1339
SF	O2, 2HR	5	40	OPEN	3	1.0582±0.0677	2.473±0.172	4.5894±0.2413	131.5034±9.2218	1.377±0.1096	0.089±0.0084	2.67±0.2303
SF	O2, 4HR	5	40	OPEN	3	1.0401±0.0545	2.5477±0.1692	4.6279±0.1153	131.4034±13.0172	1.358±0.0722	0.089±0.0078	2.61±0.1848
SF	N2, 2HRS	5	40	OPEN	3	1.0484±0.0763	2.504±0.2228	4.6008±0.0335	131.72±7.1128	1.316±0.1189	0.088±0.0059	2.6834±0.2203
SF	N2, 4HRS	5	40	OPEN	3	1.0625±0.1029	2.4644±0.244	4.5894±0.3841	131.92±8.1818	1.357±0.0729	0.088±0.0087	2.9834±0.2076
SF	O2, 2HR	10	40	OPEN	3	1.0606±0.1047	2.5574±0.2461	4.6786±0.3593	131.6767±7.8427	1.391±0.0729	0.088±0.0063	2.73±0.236
SF	O2, 4HR	10	40	OPEN	3	1.0521±0.0889	2.576±0.2346	4.6802±0.139	131.57±10.9389	1.301±0.0985	0.089±0.008	2.7667±0.2565
SF	N2, 2HRS	10	40	OPEN	3	1.044±0.0613						

SF	O2, 4HR	15	40	OPEN	3	1.0419±0.0771	2.6714±0.249	4.7552±0.1766	131.3667±9.0647	1.373±0.0884	0.089±0.0085	3.1667±0.2573
SF	N2, 2HRS	15	40	OPEN	3	1.0581±0.0555	2.4457±0.1334	4.5619±0.0567	131.96±12.3434	1.364±0.0706	0.087±0.0062	2.9234±0.1973
SF	N2, 4HRS	15	40	OPEN	3	1.0517±0.1044	2.365±0.2296	4.4684±0.2004	131.76±8.4681	1.362±0.0757	0.088±0.0077	2.6567±0.227
RB	NIL	0	20	CLOSED	3	2.0302±0.1773	4.879±0.2641	8.6734±0.1493	101.43±5.3837	1.47±0.1064	0.085±0.0071	6.3534±0.3833
RB	O2, 2HR	5	20	CLOSED	3	0.5764±0.0537	4.1674±0.3397	5.3202±0.0664	104.5067±6.8224	1.426±0.0788	0.072±0.0053	2.9087±0.249
RB	O2, 4HR	5	20	CLOSED	3	0.5723±0.0438	4.231±0.3435	5.3756±0.1921	104.4667±8.0538	1.466±0.1375	0.073±0.0054	2.3182±0.2036
RB	N2, 2HRS	5	20	CLOSED	3	0.5728±0.0389	4.3127±0.2261	5.4583±0.1075	104.78±8.5206	1.384±0.0948	0.07±0.0067	2.2535±0.1134
RB	N2, 4HRS	5	20	CLOSED	3	0.5813±0.0355	4.2437±0.4026	5.4063±0.2009	104.6334±9.7304	1.439±0.1254	0.071±0.007	2.3821±0.1797
RB	O2, 2HR	10	20	CLOSED	3	0.5739±0.0351	4.2177±0.2476	5.3655±0.1976	104.55±9.6959	1.423±0.0824	0.071±0.0057	2.3755±0.1244
RB	O2, 4HR	10	20	CLOSED	3	0.5643±0.0409	4.3914±0.2809	5.52±0.0833	104.36±8.924	1.413±0.084	0.073±0.0046	2.437±0.1677
RB	N2, 2HRS	10	20	CLOSED	3	0.5673±0.0542	4.04±0.2753	5.1746±0.1764	104.9167±6.219	1.38±0.1048	0.07±0.0052	2.218±0.133
RB	N2, 4HRS	10	20	CLOSED	3	0.5692±0.0493	4.1837±0.2868	5.3221±0.0197	104.6967±8.936	1.388±0.1022	0.071±0.0068	2.3281±0.2072
RB	O2, 2HR	15	20	CLOSED	3	0.5746±0.0571	4.1024±0.2292	5.2516±0.1592	104.31±6.5251	1.442±0.1029	0.073±0.0061	2.7428±0.2275
RB	O2, 4HR	15	20	CLOSED	3	0.5855±0.0529	4.409±0.388	5.58±0.1912	104.2934±10.3165	1.421±0.1311	0.073±0.0063	2.2638±0.2113
RB	N2, 2HRS	15	20	CLOSED	3	0.5846±0.0554	4.2477±0.2596	5.4169±0.0833	104.8434±7.152	1.391±0.1017	0.07±0.0047	2.7699±0.1648
RB	N2, 4HRS	15	20	CLOSED	3	0.5925±0.05	4.3037±0.2833	5.4887±0.2724	104.7234±5.534	1.423±0.1102	0.07±0.0047	2.0289±0.1099
RB	NIL	0	30	CLOSED	3	2.242±0.2213	4.758±0.2452	9.242±0.1589	101.3067±9.7734	1.469±0.1408	0.085±0.0078	8.37±0.527
RB	O2, 2HR	5	30	CLOSED	3	0.5857±0.0313	4.2224±0.3264	5.5938±0.2109	103.8334±10.2202	1.382±0.1073	0.075±0.0057	5.1967±0.3512
RB	O2, 4HR	5	30	CLOSED	3	0.5874±0.0326	4.189±0.4182	5.3638±0.1936	103.78±5.559	1.414±0.1091	0.075±0.0064	5.22±0.4142
RB	N2, 2HRS	5	30	CLOSED	3	0.5748±0.0392	4.185±0.3506	5.3346±0.1317	103.91±7.5382	1.418±0.0837	0.074±0.0044	5.12±0.3971
RB	N2, 4HRS	5	30	CLOSED	3	0.5823±0.048	4.2674±0.3617	5.432±0.0581	103.8934±7.9295	1.397±0.0917	0.074±0.0059	5.1434±0.4082
RB	O2, 2HR	10	30	CLOSED	3	0.5671±0.0291	4.1354±0.3994	5.2696±0.1935	104.1267±7.3042	1.402±0.083	0.073±0.0069	4.9734±0.4434
RB	O2, 4HR	10	30	CLOSED	3	0.5822±0.038	4.2737±0.3251	5.4381±0.1019	104.09±7.9909	1.468±0.104	0.074±0.0058	4.99±0.3357
RB	N2, 2HRS	10	30	CLOSED	3	0.5808±0.0326	4.1427±0.2578	5.3043±0.1466	104.26±5.75	1.406±0.1297	0.073±0.0037	4.8934±0.3743
RB	N2, 4HRS	10	30	CLOSED	3	0.5637±0.0409	4.207±0.2636	5.3344±0.2162	104.1767±8.7313	1.43±0.0816	0.073±0.0041	4.9234±0.3145
RB	O2, 2HR	15	30	CLOSED	3	0.5635±0.0365	4.4004±0.2786	5.5274±0.1445	103.7134±7.4917	1.469±0.1082	0.075±0.0057	5.28±0.3524
RB	O2, 4HR	15	30	CLOSED	3	0.5886±0.0567	4.351±0.3071	5.5282±0.2291	103.62±8.7204	1.414±0.0867	0.075±0.004	5.3034±0.3585
RB	N2, 2HRS	15	30	CLOSED	3	0.5739±0.0571	4.3854±0.3046	5.5332±0.1491	104±9.0782	1.469±0.1163	0.074±0.0065	5.0034±0.3121
RB	N2, 4HRS	15	30	CLOSED	3	0.5732±0.0529	4.4607±0.4145	5.6071±0.0866	103.9634±5.9598	1.455±0.077	0.074±0.006	5.07±0.4442
RB	NIL	0	40	CLOSED	3	3.3454±0.292	7.6797±0.4936	14.3705±0.186	100.53±9.4726	1.376±0.0838	0.088±0.0057	6.7434±0.3501
RB	O2, 2HR	5	40	CLOSED	3	0.571±0.0516	4.405±0.3637	5.547±0.1358	102.4534±10.0402	1.415±0.1333	0.08±0.0047	5.8667±0.5061
RB	O2, 4HR	5	40	CLOSED	3	0.5693±0.0411	4.6014±0.3788	5.74±0.2993	102.19±5.1668	1.461±0.0976	0.081±0.0077	5.9267±0.5207
RB	N2, 2HRS	5	40	CLOSED	3	0.5763±0.0393	4.3634±0.2232	5.516±0.1431	102.5034±5.3344	1.394±0.0945	0.08±0.004	5.8434±0.515
RB	N2, 4HRS	5	40	CLOSED	3	0.5726±0.0388	4.625±0.2488	5.7702±0.1797	102.6534±6.4081	1.469±0.0827	0.078±0.0063	5.7767±0.5587
RB	O2, 2HR	10	40	CLOSED	3	0.5539±0.0518	4.36±0.3748	5.4678±0.1062	102.5167±9.9452	1.4±0.0862	0.08±0.0067	5.8267±0.4137
RB	O2, 4HR	10	40	CLOSED	3	0.582±0.0377	4.506±0.3873	5.67±0.1103	102.15±8.326	1.441±0.0823	0.081±0.0059	5.99±0.4126
RB	N2, 2HRS	10	40	CLOSED	3	0.557±0.039	4.524±0.258	5.638±0.2376	102.74±5.2164	1.392±0.0879	0.078±0.005	5.76±0.5228
RB	N2, 4HRS	10	40	CLOSED	3	0.5855±0.0393	4.664±0.299	5.835±0.155	102.2967±6.2416	1.384±0.1045	0.081±0.0071	5.89±0.4359
RB	O2, 2HR	15	40	CLOSED	3	0.5811±0.0433	4.475±0.4252	5.6372±0.334	102.6134±7.9014	1.429±0.0796	0.079±0.0053	5.8034±0.4589
RB	O2, 4HR	15	40	CLOSED	3	0.5621±0.0326	4.5707±0.4279	5.6949±0.5029	102.0134±6.5886	1.389±0.0706	0.082±0.0078	6.02±0.4644
RB	N2, 2HRS	15	40	CLOSED	3	0.5661±0.0526	4.5807±0.4505	5.7129±0.1546	102.8234±5.7261	1.443±0.0762	0.078±0.0051	5.6767±0.4599
RB	N2, 4HRS	15	40	CLOSED	3	0.5963±0.0594	4.3467±0.3074	5.5393±0.2474	102.8067±10.0132	1.454±0.1209	0.078±0.0056	5.6967±0.4163
SB	NIL	0	20	CLOSED	3	1.82±0.1393	7.003±0.5746	10.3458±0.3691	138.43±7.9796	1.35±0.0905	0.085±0.0046	2.6934±0.2065
SB	O2, 2HR	5	20	CLOSED	3	1.6555±0.1142	6.5574±0.569	9.8684±0.6694	141.5067±10.8909	1.326±0.077	0.07±0.0038	0.5234±0.028
SB	O2, 4HR	5	20	CLOSED	3	1.6641±0.1559	6.621±0.6321	9.9492±0.6307	141.4667±7.5695	1.325±0.0764	0.071±0.007	0.55±0.0421
SB	N2, 2HRS	5	20	CLOSED	3	1.5626±0.1362	6.7027±0.5498	9.8279±0.3079	141.78±13.4415	1.321±0.1311	0.07±0.0049	0.7934±0.0725
SB	N2, 4HRS	5	20	CLOSED	3	1.6031±0.1161	6.6337±0.4412	9.8399±0.0524	141.6334±13.2807	1.359±0.0733	0.071±0.0062	0.8667±0.0558
SB	O2, 2HR	10	20	CLOSED	3	1.6158±0.1243	6.6077±0.3323	9.8393±0.1202	141.55±8.2104	1.353±0.0767	0.071±0.0052	0.57±0.0306
SB	O2, 4HR	10	20	CLOSED	3	1.688±0.162	6.7814±0.4716	10.1574±0.3507	141.36±8.0086	1.339±0.1075	0.071±0.007	0.6634±0.0616
SB	N2, 2HRS	10	20	CLOSED	3	1.5125±0.1253	6.43±0.3779	9.455±0.1329	141.9167±10.9738	1.353±0.1146	0.07±0.0048	0.6967±0.0375
SB	N2, 4HRS	10	20	CLOSED	3	1.5918±0.124	6.5737±0.3906	9.7573±0.0983	141.6967±9.3174	1.398±0.0756	0.07±0.0035	0.7634±0.0671
SB	O2, 2HR	15	20	CLOSED	3	1.7002±0.1664	6.4924±0.3869	9.8928±0.2225	141.31±11.0846	1.349±0.1019	0.072±0.0048	0.6367±0.041
SB	O2, 4HR	15	20	CLOSED	3	1.7093±0.1422	6.799±0.5382	10.2176±0.2349	141.2934±8.7003	1.383±0.0942	0.072±0.007	0.61±0.0503
SB	N2, 2HRS	15	20	CLOSED	3	1.5453±0.1533	6.6377±0.6023	9.7283±0.4289	141.8434±8.0968	1.35±0.1289	0.07±0.0052	0.6867±0.0615
SB	N2, 4HRS	15	20	CLOSED	3	1.5783±0.106	6.6937±0.448	9.8503±0.4711	141.7234±7.8183	1.366±0.1045	0.07±0.0051	0.7167±0.0622
SB	NIL	0	30	CLOSED	3	2.083±0.0952	7.148±0.5711	10.6208±0.4746	138.3067±11.3673	1.314±0.118	0.085±0.0075	2.56±0.256
SB	O2, 2HR	5	30	CLOSED	3	1.8733±0.1106	6.8124±0.4514	10.559±0.1724	140.8334±10.7522	1.39±0.1157	0.074±0.0073	1.0034±0.0915
SB	O2, 4HR	5	30	CLOSED	3	1.9163±0.1	6.579±0.4081	10.4116±0.2509	140.78±10.3771	1.34±0.1164	0.075±0.0049	1.1434±0.065
SB	N2, 2HRS	5	30	CLOSED	3	1.834±0.1028	6.575±0.5659	10.243±0.4553	140.91±7.9494	1.395±0.0876	0.074±0.0038	1.12±0.0585
SB	N2, 4HRS	5	30	CLOSED	3	1.8491±0.1807	6.6574±0.6263	10.3556±0.4908	140.8934±11.4158	1.374±0.0834	0.074±0.0056	0.8934±0.0497
SB	O2, 2HR	10	30	CLOSED	3	1.7538±0.1295	6.5254±0.6206	10.033±0.4883	141.1267±12.4263	1.386±0.1321	0.073±0.0069	1.28±0.1202
SB	O2, 4HR	10	30	CLOSED	3	1.7728±0.1256	6.6637±0.4338	10.2093±0.1429	141.09±9.0946	1.332±0.0725	0.073±0.0067	1.22±0.0759
SB	N2, 2HRS	10	30	CLOSED	3	1.721±0.1695	6.5327±0.3605	9.9747±0.1183	141.26±9.732	1.313±0.0903	0.072±0.0036	1.1967±0.0747
SB	N2, 4HRS	10	30	CLOSED	3	1.7396±0.1051	6.597±0.4387	10.0762±0.2007	141.1767±8.3719	1.309±0.1026	0.072±0.005	0.9734±0.0889
SB	O2, 2HR	15	30	CLOSED	3	1.9397±0.1771	6.7904±0.3858	10.6698±0.4378	140.7134±7.9284	1.396±0.1129	0.075±0.0073	0.9234±0.0771
SB	O2, 4HR	15	30	CLOSED	3	1.9636±0.0991	6.741±0.6466	10.6682±0.4025	140.62±13.4677	1.372±0.1282	0.075±0.007	1.07±0.0733
SB	N2, 2HRS	15	30	CLOSED	3	1.786±0.1249	6.7754±0.5759	10.3474±0.2206	141±9.5906	1.384±0.0936	0.073±0.0038	0.99±0.0762
SB	N2, 4HRS	15	30	CLOSED	3	1.8128±0.1424	6.8507±0.4928	10.4763±0.529	140.9634±14.044	1.318±0.0788	0.074±0.0049	1.3034±0.117
SB	NIL	0	40	CLOSED	3	3.5652±0.339	10.0697±0.637	17.2001±0.9217	137.53±9.2823	1.394±0.131	0.089±0.006	2.8534±0.2145
SB	O2, 2HR	5	40	CLOSED	3	2.6474±0.1779	6.795±0.4238	12.0898±0.197	139.4534±9.2457	1.386±0.113	0.081±0.0064	1.3667±0.1242
SB	O2, 4HR	5	40	CLOSED	3	2.6735±0.1605	6.9914±0.6929	12.3384±0.7522	139.19±11.4344	1.356±0.1007	0.081±0.0053	1.47±0.1198
SB	N2, 2HRS	5	40	CLOSED	3	2.6222±0.1331	6.7534±0.406	11.9978±0.0888	139.5034±10.1094	1.392±0.1125	0.08±0.0067	1.33±0.0843
SB	N2, 4HRS	5	40	CLOSED	3	2.5569±0.1911	7.0					

SB	N2, 2HRS	10	40	CLOSED	3	2.54±0.2316	6.914±0.3945	11.994±0.5172	139.74±12.1395	1.395±0.1384	0.08±0.0077	1.5734±0.1272
SB	N2, 4HRS	10	40	CLOSED	3	2.6602±0.219	7.054±0.6933	12.3744±0.7099	139.2967±9.8117	1.391±0.0959	0.081±0.006	1.3867±0.1217
SB	O2, 2HR	15	40	CLOSED	3	2.5904±0.2459	6.865±0.3699	12.0458±0.7858	139.6134±12.5411	1.319±0.1233	0.08±0.0055	1.62±0.1372
SB	O2, 4HR	15	40	CLOSED	3	2.714±0.2119	6.9607±0.6251	12.3887±0.4037	139.0134±12.4931	1.38±0.1206	0.081±0.0058	1.45±0.0979
SB	N2, 2HRS	15	40	CLOSED	3	2.493±0.2421	6.9707±0.5482	11.9567±0.3849	139.8234±10.3846	1.377±0.0767	0.078±0.0056	1.5867±0.114
SB	N2, 4HRS	15	40	CLOSED	3	2.5085±0.1481	6.7367±0.4096	11.7537±0.3636	139.8067±8.5647	1.354±0.0829	0.079±0.0044	1.55±0.107
SF	NIL	0	20	CLOSED	3	2.5072±0.1995	2.393±0.178	7.4074±0.1048	132.2±11.7538	1.39±0.1337	0.087±0.0072	2.95±0.2145
SF	O2, 2HR	5	20	CLOSED	3	1.0534±0.1044	1.9474±0.1801	4.0542±0.1711	135.2767±6.9277	1.397±0.1253	0.074±0.0058	0.78±0.0749
SF	O2, 4HR	5	20	CLOSED	3	1.0493±0.1036	2.011±0.1295	4.1096±0.0297	135.2367±13.305	1.396±0.1355	0.074±0.0072	0.8067±0.0765
SF	N2, 2HRS	5	20	CLOSED	3	1.0498±0.1044	2.0927±0.1354	4.1923±0.078	135.55±12.1583	1.361±0.0797	0.07±0.0059	1.05±0.1008
SF	N2, 4HRS	5	20	CLOSED	3	1.0583±0.0645	2.0237±0.1846	4.1403±0.1224	135.4034±9.1416	1.368±0.0728	0.073±0.0048	1.1234±0.1032
SF	O2, 2HR	10	20	CLOSED	3	1.0509±0.0876	1.9977±0.1024	4.0995±0.0372	135.32±9.2253	1.305±0.1115	0.074±0.004	0.8267±0.0629
SF	O2, 4HR	10	20	CLOSED	3	1.0413±0.0928	2.1714±0.1602	4.254±0.0465	135.13±10.4341	1.329±0.1088	0.074±0.0062	0.92±0.0781
SF	N2, 2HRS	10	20	CLOSED	3	1.0443±0.07	1.82±0.0935	3.9086±0.0897	135.6867±8.331	1.391±0.0877	0.07±0.0053	0.9534±0.078
SF	N2, 4HRS	10	20	CLOSED	3	1.0462±0.0801	1.9637±0.1029	4.0561±0.1598	135.4667±8.2337	1.34±0.0734	0.073±0.0061	1.02±0.0931
SF	O2, 2HR	15	20	CLOSED	3	1.0516±0.0674	1.8824±0.186	3.9856±0.0786	135.08±13.3744	1.38±0.1111	0.075±0.0066	0.8934±0.0801
SF	O2, 4HR	15	20	CLOSED	3	1.0625±0.0734	2.189±0.1655	4.314±0.1842	135.0634±9.7682	1.329±0.0787	0.075±0.0041	0.8067±0.0732
SF	N2, 2HRS	15	20	CLOSED	3	1.0616±0.0597	2.0277±0.1571	4.1509±0.0503	135.6134±8.0877	1.378±0.1275	0.07±0.0061	0.9434±0.0742
SF	N2, 4HRS	15	20	CLOSED	3	1.0695±0.0761	2.0837±0.1179	4.2227±0.1242	135.4934±11.532	1.309±0.1258	0.072±0.0062	0.9734±0.0939
SF	NIL	0	30	CLOSED	3	2.719±0.1814	2.538±0.1954	7.976±0.0338	132.0767±7.8548	1.32±0.1243	0.087±0.0069	2.8167±0.1921
SF	O2, 2HR	5	30	CLOSED	3	1.0627±0.0764	2.2024±0.1245	4.3278±0.2201	134.6034±12.4604	1.39±0.098	0.078±0.0074	1.26±0.1021
SF	O2, 4HR	5	30	CLOSED	3	1.0644±0.0831	1.969±0.1135	4.0978±0.1209	134.55±11.5267	1.379±0.0871	0.078±0.0062	1.44±0.1112
SF	N2, 2HRS	5	30	CLOSED	3	1.0518±0.0875	1.965±0.1544	4.0686±0.1783	134.68±11.512	1.387±0.0934	0.077±0.0043	1.3767±0.1074
SF	N2, 4HRS	5	30	CLOSED	3	1.0593±0.1051	2.0474±0.1074	4.166±0.0687	134.6634±11.9156	1.335±0.108	0.077±0.0064	1.15±0.0857
SF	O2, 2HR	10	30	CLOSED	3	1.0441±0.0979	1.9154±0.1908	4.0036±0.1405	134.8967±13.0339	1.317±0.1069	0.076±0.0052	1.5367±0.0991
SF	O2, 4HR	10	30	CLOSED	3	1.0592±0.1034	2.0537±0.1307	4.1721±0.1461	134.86±9.9659	1.307±0.0989	0.076±0.0075	1.4767±0.0859
SF	N2, 2HRS	10	30	CLOSED	3	1.0578±0.0596	1.9227±0.1732	4.0383±0.1133	135.03±8.4577	1.373±0.1045	0.075±0.0074	1.4534±0.0792
SF	N2, 4HRS	10	30	CLOSED	3	1.0407±0.058	1.987±0.1059	4.0684±0.0491	134.9467±9.3801	1.362±0.1085	0.075±0.004	1.23±0.0871
SF	O2, 2HR	15	30	CLOSED	3	1.0405±0.0975	2.1804±0.1913	4.2614±0.1058	134.4834±9.2348	1.301±0.0693	0.078±0.0064	1.18±0.1062
SF	O2, 4HR	15	30	CLOSED	3	1.0656±0.0592	2.131±0.1718	4.2622±0.0546	134.39±9.1065	1.35±0.1064	0.078±0.0047	1.3267±0.0669
SF	N2, 2HRS	15	30	CLOSED	3	1.0509±0.0563	2.1654±0.1234	4.2672±0.1822	134.77±12.3505	1.338±0.1015	0.076±0.0075	1.2467±0.1043
SF	N2, 4HRS	15	30	CLOSED	3	1.0502±0.0596	2.2407±0.1136	4.3411±0.1109	134.7334±10.5565	1.31±0.0993	0.077±0.007	1.56±0.1527
SF	NIL	0	40	CLOSED	3	3.8224±0.228	5.4597±0.4324	13.1045±0.5002	131.3±6.952	1.381±0.1235	0.089±0.0079	3.11±0.2916
SF	O2, 2HR	5	40	CLOSED	3	1.048±0.1014	2.185±0.1267	4.281±0.0633	133.2234±12.519	1.349±0.0684	0.082±0.0046	1.6234±0.0939
SF	O2, 4HR	5	40	CLOSED	3	1.0463±0.0709	2.3814±0.1636	4.474±0.0922	132.96±10.6603	1.325±0.0792	0.082±0.0069	1.7267±0.1002
SF	N2, 2HRS	5	40	CLOSED	3	1.0533±0.0593	2.1434±0.1483	4.25±0.0768	133.2734±11.8041	1.351±0.0699	0.081±0.0081	1.5867±0.1367
SF	N2, 4HRS	5	40	CLOSED	3	1.0496±0.1016	2.405±0.2242	4.5042±0.0335	133.4234±11.2011	1.365±0.0779	0.081±0.0073	1.8834±0.1004
SF	O2, 2HR	10	40	CLOSED	3	1.0309±0.0785	2.14±0.1979	4.2018±0.0833	133.2867±11.065	1.391±0.1224	0.081±0.0044	1.94±0.1151
SF	O2, 4HR	10	40	CLOSED	3	1.059±0.0771	2.286±0.1784	4.404±0.2156	132.92±8.6189	1.371±0.1042	0.083±0.0071	1.6834±0.144
SF	N2, 2HRS	10	40	CLOSED	3	1.034±0.057	2.304±0.1836	4.372±0.1193	133.51±9.3357	1.387±0.0952	0.08±0.0058	1.83±0.1826
SF	N2, 4HRS	10	40	CLOSED	3	1.0625±0.0969	2.444±0.2198	4.569±0.296	133.0667±10.2414	1.39±0.1368	0.082±0.0068	1.6434±0.0837
SF	O2, 2HR	15	40	CLOSED	3	1.0581±0.0578	2.255±0.1423	4.3712±0.0539	133.3834±8.0835	1.352±0.0993	0.081±0.0069	1.8767±0.1059
SF	O2, 4HR	15	40	CLOSED	3	1.0391±0.0873	2.3507±0.2139	4.4289±0.0979	132.7834±8.788	1.304±0.1271	0.083±0.0062	1.7067±0.1352
SF	N2, 2HRS	15	40	CLOSED	3	1.0431±0.0716	2.3607±0.1882	4.4469±0.066	133.5934±13.3467	1.311±0.0706	0.08±0.0061	1.8434±0.0987
SF	N2, 4HRS	15	40	CLOSED	3	1.0733±0.0966	2.1267±0.1078	4.2733±0.1776	133.5767±9.8779	1.396±0.0795	0.08±0.0049	1.8067±0.0935
RB	NIL	0	20	OPEN	4	5.7681±0.4522	7.2707±0.5891	18.8069±0.7226	98.4834±7.609	1.472±0.0903	0.105±0.0077	8.79±0.8095
RB	O2, 2HR	5	20	OPEN	4	0.8523±0.0518	6.2064±0.3239	7.911±0.1284	100.6034±6.6253	1.402±0.1242	0.097±0.0078	6.9067±0.6022
RB	O2, 4HR	5	20	OPEN	4	0.8563±0.0537	6.8027±0.5958	8.5153±0.3901	100.4767±5.4413	1.377±0.11	0.097±0.0069	7.0167±0.3918
RB	N2, 2HRS	5	20	OPEN	4	0.8613±0.0493	6.101±0.5623	7.8236±0.3823	101.1767±8.5407	1.397±0.1353	0.095±0.0068	6.3267±0.4736
RB	N2, 4HRS	5	20	OPEN	4	0.8695±0.0687	6.131±0.5012	7.87±0.5127	100.7034±7.3666	1.438±0.0782	0.096±0.009	6.6367±0.3779
RB	O2, 2HR	10	20	OPEN	4	0.8537±0.0582	6.047±0.3911	7.7544±0.2851	100.69±9.7409	1.378±0.1131	0.096±0.0059	6.7534±0.6345
RB	O2, 4HR	10	20	OPEN	4	0.8583±0.0632	6.3337±0.3847	8.0503±0.5417	100.5767±10.0103	1.457±0.1144	0.097±0.0095	6.9767±0.4391
RB	N2, 2HRS	10	20	OPEN	4	0.8633±0.081	6.0187±0.4723	7.7453±0.2887	100.95±7.8755	1.399±0.1089	0.095±0.0089	6.3734±0.4667
RB	N2, 4HRS	10	20	OPEN	4	0.8725±0.0559	6.3144±0.6126	8.0594±0.308	100.8334±10.0755	1.457±0.0914	0.095±0.0091	6.5067±0.4197
RB	O2, 2HR	15	20	OPEN	4	0.8556±0.0783	6.7594±0.5081	8.4706±0.6468	100.6267±7.4638	1.454±0.1233	0.097±0.0075	6.88±0.5464
RB	O2, 4HR	15	20	OPEN	4	0.8593±0.0646	6.5207±0.3925	8.2393±0.1904	100.3434±6.4904	1.395±0.1394	0.097±0.0089	7.1234±0.5897
RB	N2, 2HRS	15	20	OPEN	4	0.8664±0.0619	6.025±0.5161	7.757±0.255	100.9034±5.5857	1.401±0.1083	0.095±0.0053	6.47±0.4955
RB	N2, 4HRS	15	20	OPEN	4	0.8733±0.0759	6.467±0.6278	8.2136±0.1617	100.8034±9.3464	1.428±0.1304	0.095±0.0078	6.5434±0.3667
RB	NIL	0	30	OPEN	4	6.0705±0.341	9.3784±0.5451	21.5194±0.397	87.6367±4.7782	1.382±0.1363	0.109±0.0082	9.57±0.7183
RB	O2, 2HR	5	30	OPEN	4	0.8755±0.0569	7.132±0.3855	8.883±0.2207	99.27±5.2705	1.388±0.0951	0.101±0.0094	8.13±0.5808
RB	O2, 4HR	5	30	OPEN	4	0.8787±0.0585	7.038±0.6341	8.7954±0.4264	98.9867±6.134	1.392±0.0909	0.103±0.0082	8.41±0.7673
RB	N2, 2HRS	5	30	OPEN	4	0.8836±0.0834	6.6867±0.4176	8.4539±0.3981	99.2234±5.8715	1.382±0.0866	0.102±0.0077	8.2234±0.7955
RB	N2, 4HRS	5	30	OPEN	4	0.8901±0.068	7.0857±0.5057	8.8659±0.0907	99.0867±5.1027	1.396±0.1371	0.102±0.0065	8.27±0.8239
RB	O2, 2HR	10	30	OPEN	4	0.8765±0.0689	6.7024±0.5787	8.4554±0.0947	99.0367±7.4948	1.462±0.0926	0.103±0.0066	8.38±0.4341
RB	O2, 4HR	10	30	OPEN	4	0.8817±0.0587	7.1547±0.4521	8.9181±0.1078	98.9034±5.2302	1.423±0.0849	0.104±0.01	8.55±0.4731
RB	N2, 2HRS	10	30	OPEN	4	0.8861±0.0605	6.7284±0.5221	8.5006±0.2218	99.4034±9.1913	1.464±0.0778	0.101±0.0054	7.9267±0.6317
RB	N2, 4HRS	10	30	OPEN	4	0.8934±0.0869	6.8407±0.6423	8.6275±0.14	99.4634±8.2744	1.381±0.0731	0.101±0.0066	7.88±0.4177
RB	O2, 2HR	15	30	OPEN	4	0.8771±0.0508	7.033±0.5739	8.7872±0.3284	98.96±4.9905	1.424±0.1126	0.104±0.0081	8.5167±0.6457
RB	O2, 4HR	15	30	OPEN	4	0.8818±0.049	6.8194±0.4286	8.583±0.3079	98.83±8.466	1.42±0.1371	0.104±0.0079	8.6167±0.858
RB	N2, 2HRS	15	30	OPEN	4	0.8889±0.0611	6.4964±0.456	8.2742±0.2141	99.3734±8.218	1.433±0.0735	0.101±0.0071	7.97±0.7372
RB	N2, 4HRS	15	30	OPEN	4	0.8947±0.0833	6.6957±0.5348	8.4851±0.3866	99.2734±7.3445	1.456±0.0837	0.101±0.0065	8.0567±0.4222
RB	NIL	0	40	OPEN	4	6.1257±0.3083	9.7324±0.661	21.9838±0.3022	87.5434±4.6745	1.442±0.0874	0.109±0.0062	9.6567±0.6922
RB	O2, 2HR	5	40	OPEN	4	0.8953±0.0497	7.5264±0.					

RB	N2, 4HRS	5	40	OPEN	4	0.912±0.0624	7.08±0.5962	8.904±0.2646	98.15±5.9066	1.452±0.1034	0.106±0.0083	8.87±0.6273
RB	O2, 2HR	10	40	OPEN	4	0.8979±0.0544	7.538±0.4164	9.3338±0.0909	98.0067±8.0683	1.426±0.1255	0.107±0.0067	9.0534±0.5335
RB	O2, 4HR	10	40	OPEN	4	0.9049±0.087	7.3017±0.4888	9.1115±0.2384	97.89±7.7829	1.393±0.0743	0.108±0.0076	9.19±0.5978
RB	N2, 2HRS	10	40	OPEN	4	0.9081±0.0572	7.1047±0.4759	8.9209±0.5063	98.3967±7.9177	1.41±0.1239	0.105±0.0059	8.8134±0.7474
RB	N2, 4HRS	10	40	OPEN	4	0.9165±0.072	6.8214±0.4608	8.6544±0.2308	98.1267±9.3283	1.474±0.0854	0.107±0.0092	8.9634±0.4651
RB	O2, 2HR	15	40	OPEN	4	0.9002±0.0853	7.65±0.6043	9.4504±0.4484	97.9434±5.5654	1.403±0.0975	0.108±0.0068	9.1167±0.5717
RB	O2, 4HR	15	40	OPEN	4	0.9054±0.0624	7.4004±0.5583	9.2112±0.4949	97.7267±8.1584	1.447±0.1299	0.109±0.0089	9.37±0.8953
RB	N2, 2HRS	15	40	OPEN	4	0.9092±0.0594	6.906±0.6747	8.7244±0.3175	98.29±7.7138	1.389±0.1009	0.106±0.0055	8.84±0.6059
RB	N2, 4HRS	15	40	OPEN	4	0.9187±0.0839	6.8424±0.4522	8.6798±0.6191	98.1±8.4824	1.464±0.0778	0.107±0.0105	8.9867±0.7678
SB	NIL	0	20	OPEN	4	4.4666±0.2121	9.6607±0.827	16.5939±0.149	135.4834±10.1457	1.302±0.118	0.104±0.0077	7.1167±0.5291
SB	O2, 2HR	5	20	OPEN	4	3.84±0.2925	8.5964±0.6258	16.2764±0.6446	137.6034±10.1577	1.394±0.1069	0.097±0.006	5.1834±0.3402
SB	O2, 4HR	5	20	OPEN	4	3.6802±0.2012	9.1927±0.4932	16.5531±0.8147	137.4767±10.8365	1.367±0.0915	0.097±0.0061	5.6667±0.3971
SB	N2, 2HRS	5	20	OPEN	4	3.8985±0.2301	8.491±0.5117	16.288±0.1235	138.1767±12.149	1.36±0.1039	0.095±0.0083	5.6234±0.4651
SB	N2, 4HRS	5	20	OPEN	4	3.7447±0.3461	8.521±0.4654	16.0104±0.1627	137.7034±9.1658	1.337±0.0993	0.096±0.0049	5.8467±0.5653
SB	O2, 2HR	10	20	OPEN	4	3.8136±0.3484	8.437±0.5922	16.0642±0.8861	137.69±12.2634	1.383±0.0868	0.096±0.007	5.5634±0.4936
SB	O2, 4HR	10	20	OPEN	4	3.7646±0.1904	8.7237±0.7517	16.2529±0.3313	137.5767±8.4948	1.306±0.1018	0.097±0.0094	5.3067±0.2981
SB	N2, 2HRS	10	20	OPEN	4	3.6484±0.3357	8.4087±0.6121	15.7055±0.499	137.95±7.6784	1.338±0.0773	0.095±0.005	5.4034±0.3408
SB	N2, 4HRS	10	20	OPEN	4	3.6576±0.3391	8.7044±0.5258	16.0196±0.3737	137.8334±9.8386	1.387±0.0728	0.096±0.0091	5.71±0.3287
SB	O2, 2HR	15	20	OPEN	4	3.5998±0.3264	9.1494±0.8422	16.349±0.673	137.6267±8.1836	1.375±0.0931	0.096±0.006	5.26±0.3145
SB	O2, 4HR	15	20	OPEN	4	3.7281±0.3441	8.9107±0.7598	16.3669±0.4525	137.3434±7.4051	1.382±0.1301	0.097±0.0082	5.2267±0.4474
SB	N2, 2HRS	15	20	OPEN	4	3.826±0.3159	8.415±0.7174	16.067±0.3806	137.9034±8.1724	1.307±0.1251	0.096±0.0066	5.36±0.4238
SB	N2, 4HRS	15	20	OPEN	4	3.8227±0.2824	8.857±0.5741	16.5024±0.1063	137.8034±11.893	1.316±0.1269	0.096±0.0093	5.7934±0.4774
SB	NIL	0	30	OPEN	4	4.4316±0.2812	11.7684±0.6221	20.6316±0.6214	124.6367±9.5551	1.396±0.1133	0.109±0.0056	7.57±0.6856
SB	O2, 2HR	5	30	OPEN	4	3.9625±0.3075	9.5224±0.478	17.447±0.1625	136.27±10.3176	1.38±0.0741	0.102±0.0094	5.8524±0.5668
SB	O2, 4HR	5	30	OPEN	4	3.6785±0.2527	9.428±0.567	16.785±0.3752	135.9867±7.7879	1.38±0.1316	0.102±0.0099	5.97±0.3258
SB	N2, 2HRS	5	30	OPEN	4	3.8469±0.2824	9.0767±0.9033	16.7705±0.1194	136.2234±11.2982	1.362±0.097	0.102±0.0095	6.6167±0.3549
SB	N2, 4HRS	5	30	OPEN	4	3.8472±0.2963	9.4757±0.7991	17.1701±0.448	136.0867±6.8831	1.316±0.1095	0.102±0.0069	6.2234±0.3519
SB	O2, 2HR	10	30	OPEN	4	3.5919±0.3286	9.0924±0.8789	16.2762±0.7806	136.0367±11.1223	1.387±0.1009	0.102±0.0076	5.9267±0.5714
SB	O2, 4HR	10	30	OPEN	4	3.7073±0.3583	9.5447±0.5489	16.9593±0.4951	135.9034±6.8015	1.369±0.0981	0.103±0.0092	5.88±0.3031
SB	N2, 2HRS	10	30	OPEN	4	3.6704±0.322	9.1184±0.6036	16.4592±0.6249	136.4034±7.8434	1.381±0.0741	0.101±0.0093	6.38±0.5751
SB	N2, 4HRS	10	30	OPEN	4	3.737±0.3071	9.2307±0.4951	16.7047±0.5067	136.4634±11.3073	1.321±0.0887	0.101±0.0064	6.13±0.3963
SB	O2, 2HR	15	30	OPEN	4	3.7313±0.2179	9.423±0.9025	16.8856±0.4899	135.96±8.5567	1.38±0.1115	0.102±0.0078	6.27±0.461
SB	O2, 4HR	15	30	OPEN	4	3.659±0.1892	9.2094±0.8543	16.5274±0.7005	135.83±11.7165	1.356±0.077	0.103±0.0063	6.0567±0.6034
SB	N2, 2HRS	15	30	OPEN	4	3.8203±0.2635	8.8864±0.4767	16.527±0.4369	136.3734±12.2797	1.303±0.084	0.101±0.0054	6.5167±0.4083
SB	N2, 4HRS	15	30	OPEN	4	3.7655±0.2667	9.0857±0.4598	16.6167±0.3479	136.2734±7.8155	1.33±0.1031	0.102±0.0088	6.41±0.3908
SB	NIL	0	40	OPEN	4	4.5344±0.3328	12.1224±1.0156	21.1912±0.7488	124.5434±8.212	1.375±0.1069	0.109±0.0082	6.7434±0.6359
SB	O2, 2HR	5	40	OPEN	4	3.8027±0.295	9.9164±0.7723	17.5218±0.9667	134.8334±12.4239	1.322±0.1147	0.108±0.0059	6.79±0.5015
SB	O2, 4HR	5	40	OPEN	4	3.8181±0.2833	9.9207±0.7311	17.5569±0.6457	134.75±12.8463	1.369±0.1107	0.108±0.007	6.6634±0.6415
SB	N2, 2HRS	5	40	OPEN	4	3.7646±0.3604	9.774±0.8544	17.3032±0.7348	135.0267±12.8839	1.322±0.1067	0.106±0.0105	6.84±0.6296
SB	N2, 4HRS	5	40	OPEN	4	3.6913±0.2887	9.47±0.9095	16.8526±0.6474	135.15±13.1977	1.355±0.115	0.105±0.0099	7.37±0.4388
SB	O2, 2HR	10	40	OPEN	4	3.803±0.2074	9.928±0.7488	17.534±0.5083	135.0067±6.7889	1.336±0.0773	0.106±0.0062	6.87±0.4245
SB	O2, 4HR	10	40	OPEN	4	3.7851±0.3419	9.6917±0.5214	17.2619±0.5446	134.89±11.8369	1.388±0.0785	0.107±0.0082	6.9867±0.396
SB	N2, 2HRS	10	40	OPEN	4	3.7807±0.2431	9.4947±0.6864	17.0561±0.313	135.3967±12.7328	1.393±0.0971	0.104±0.0071	7.34±0.5071
SB	N2, 4HRS	10	40	OPEN	4	3.7259±0.3585	9.2114±0.6316	16.6632±0.3589	135.1267±11.6387	1.398±0.072	0.106±0.0055	7.0267±0.663
SB	O2, 2HR	15	40	OPEN	4	3.6591±0.2171	10.04±0.5767	17.3582±0.5864	134.9434±8.7419	1.344±0.0818	0.107±0.0105	6.9634±0.4639
SB	O2, 4HR	15	40	OPEN	4	3.5719±0.2291	9.7904±0.928	16.9342±0.3453	134.7267±10.722	1.366±0.0774	0.108±0.0098	7.7667±0.6122
SB	N2, 2HRS	15	40	OPEN	4	3.8395±0.2018	9.296±0.8773	16.975±0.741	135.29±12.1731	1.394±0.0871	0.104±0.006	7.19±0.3675
SB	N2, 4HRS	15	40	OPEN	4	3.6525±0.2831	9.2324±0.7394	16.5374±1.3475	135.1±12.772	1.363±0.0874	0.106±0.0054	6.8134±0.6258
SF	NIL	0	20	OPEN	4	6.2451±0.3417	5.0507±0.2536	17.5409±0.4203	129.8134±11.6532	1.346±0.0695	0.105±0.0055	7.3734±0.5208
SF	O2, 2HR	5	20	OPEN	4	1.3293±0.1144	3.9864±0.3518	6.645±0.1798	131.9334±8.4508	1.361±0.0813	0.097±0.0053	5.44±0.3016
SF	O2, 4HR	5	20	OPEN	4	1.3333±0.0952	4.5827±0.3027	7.2493±0.2567	131.8067±6.9605	1.31±0.1262	0.098±0.0079	5.9234±0.5678
SF	N2, 2HRS	5	20	OPEN	4	1.3383±0.0881	3.881±0.2218	6.5576±0.091	132.5067±10.5954	1.368±0.1325	0.096±0.0054	5.88±0.4415
SF	N2, 4HRS	5	20	OPEN	4	1.3465±0.0898	3.911±0.3847	6.604±0.3565	132.0334±11.9672	1.38±0.1165	0.096±0.0056	6.1034±0.5709
SF	O2, 2HR	10	20	OPEN	4	1.3307±0.1059	3.827±0.3248	6.4884±0.5175	132.02±11.5231	1.329±0.0931	0.097±0.0096	5.82±0.3412
SF	O2, 4HR	10	20	OPEN	4	1.3353±0.1327	4.1137±0.2108	6.7843±0.1407	131.9067±11.1589	1.315±0.1058	0.098±0.0086	5.5634±0.494
SF	N2, 2HRS	10	20	OPEN	4	1.3403±0.0979	3.7987±0.2757	6.4793±0.2216	132.28±10.1336	1.39±0.1363	0.096±0.0092	5.66±0.347
SF	N2, 4HRS	10	20	OPEN	4	1.3495±0.1146	4.0944±0.2841	6.7934±0.3229	132.1634±7.7607	1.357±0.118	0.096±0.0077	5.9667±0.5724
SF	O2, 2HR	15	20	OPEN	4	1.3326±0.1054	4.5394±0.4474	7.2046±0.1581	131.9567±12.9039	1.303±0.1182	0.097±0.0093	5.5167±0.3044
SF	O2, 4HR	15	20	OPEN	4	1.3363±0.0871	4.3007±0.3218	6.9733±0.1988	131.6734±10.8925	1.398±0.0706	0.099±0.0058	5.4834±0.489
SF	N2, 2HRS	15	20	OPEN	4	1.343±0.0739	3.805±0.191	6.491±0.2469	132.2334±10.8868	1.393±0.0787	0.096±0.0058	5.6167±0.4621
SF	N2, 4HRS	15	20	OPEN	4	1.3503±0.0731	4.247±0.3487	6.9476±0.1071	132.1334±7.4279	1.394±0.1374	0.096±0.0056	6.05±0.396
SF	NIL	0	30	OPEN	4	6.5475±0.654	7.1584±0.3765	20.2534±0.8223	118.9667±9.4129	1.374±0.1362	0.109±0.0067	7.8267±0.592
SF	O2, 2HR	5	30	OPEN	4	1.3525±0.1283	4.912±0.2758	7.617±0.2	130.6±9.915	1.313±0.1087	0.102±0.0065	6.8067±0.5873
SF	O2, 4HR	5	30	OPEN	4	1.3557±0.0989	4.818±0.4593	7.5294±0.0178	130.3167±11.175	1.305±0.1101	0.103±0.0068	6.2267±0.4175
SF	N2, 2HRS	5	30	OPEN	4	1.3606±0.1334	4.4667±0.3679	7.1879±0.2559	130.5534±11.7894	1.376±0.1121	0.102±0.0059	6.8734±0.4804
SF	N2, 4HRS	5	30	OPEN	4	1.3671±0.117	4.8657±0.2987	7.5999±0.2288	130.4167±9.629	1.378±0.1176	0.102±0.0095	6.48±0.5043
SF	O2, 2HR	10	30	OPEN	4	1.3535±0.1336	4.4824±0.2616	7.1894±0.1038	130.3667±8.7956	1.369±0.1068	0.102±0.0064	6.1834±0.3221
SF	O2, 4HR	10	30	OPEN	4	1.3587±0.1289	4.9347±0.3422	7.6521±0.0582	130.2334±10.374	1.35±0.0712	0.104±0.008	6.1367±0.5319
SF	N2, 2HRS	10	30	OPEN	4	1.3631±0.1189	4.5084±0.3925	7.2346±0.25	130.7334±11.1181	1.345±0.1061	0.101±0.0077	6.6367±0.5993
SF	N2, 4HRS	10	30	OPEN	4	1.3704±0.1058	4.6207±0.2963	7.3615±0.1978	130.7934±8.6416	1.336±0.0905	0.101±0.0085	6.3867±0.4168
SF	O2, 2HR	15	30	OPEN	4	1.3541±0.1109	4.813±0.3128	7.5212±0.1826	130.29±11.6747	1.384±0.0963	0.104±0.0079	6.5267±0.3944
SF	O2, 4HR	15	30	OPEN	4	1.3588±0.0704	4.5994±0.3478	7.317±0.3676	130.16±11.9774	1.396±0.0905	0.104±0.0061	6.3134±0.5838
SF	N2, 2HRS	15	30	OPEN	4							

SF	O2, 2HR	5	40	OPEN	4	1.3723±0.0981	5.3064±0.5196	8.051±0.2787	129.1634±8.0425	1.373±0.0992	0.107±0.0096	6.99±0.6142
SF	O2, 4HR	5	40	OPEN	4	1.379±0.0785	5.3107±0.4133	8.0687±0.1442	129.08±6.8842	1.339±0.0742	0.108±0.0102	6.92±0.4933
SF	N2, 2HRS	5	40	OPEN	4	1.3832±0.0849	5.164±0.4218	7.9304±0.0908	129.3567±10.213	1.319±0.0878	0.106±0.0079	7.0967±0.6804
SF	N2, 4HRS	5	40	OPEN	4	1.389±0.0787	4.86±0.4026	7.638±0.0937	129.48±12.5105	1.388±0.0761	0.106±0.0086	7.6267±0.7014
SF	O2, 2HR	10	40	OPEN	4	1.3749±0.0768	5.318±0.3985	8.0678±0.1699	129.3367±12.8344	1.347±0.1089	0.107±0.0061	7.1267±0.4513
SF	O2, 4HR	10	40	OPEN	4	1.3819±0.1262	5.0817±0.5041	7.8455±0.0974	129.22±12.8734	1.378±0.0802	0.107±0.0077	7.2434±0.6818
SF	N2, 2HRS	10	40	OPEN	4	1.3851±0.1039	4.8847±0.4711	7.6549±0.2426	129.7267±6.6956	1.328±0.1313	0.105±0.0061	7.5567±0.4121
SF	N2, 4HRS	10	40	OPEN	4	1.3935±0.1174	4.6014±0.2473	7.3884±0.1317	129.4567±7.5682	1.321±0.1152	0.106±0.0073	7.2834±0.4115
SF	O2, 2HR	15	40	OPEN	4	1.3772±0.0763	5.43±0.2857	8.1844±0.3378	129.2734±12.5953	1.398±0.1011	0.107±0.0059	7.22±0.5046
SF	O2, 4HR	15	40	OPEN	4	1.3824±0.134	5.1804±0.3871	7.9452±0.4346	129.0567±12.2546	1.352±0.1129	0.108±0.0096	8.0234±0.5709
SF	N2, 2HRS	15	40	OPEN	4	1.3862±0.0941	4.686±0.3878	7.4584±0.3531	129.62±11.1135	1.352±0.1275	0.106±0.0083	7.4467±0.4329
SF	N2, 4HRS	15	40	OPEN	4	1.3957±0.1202	4.6224±0.3329	7.4138±0.184	129.43±12.4638	1.368±0.0775	0.106±0.0105	7.07±0.6744
RB	NIL	0	20	CLOSED	4	5.2591±0.4679	6.9817±0.3952	17.4999±0.4985	98.6867±5.7969	1.418±0.0809	0.104±0.0084	8.6634±0.7548
RB	O2, 2HR	5	20	CLOSED	4	0.7021±0.0476	6.1504±0.3712	7.5546±0.2692	102.4434±6.5872	1.413±0.1069	0.092±0.0085	2.9964±0.1646
RB	O2, 4HR	5	20	CLOSED	4	0.7113±0.0525	6.4227±0.3325	7.8453±0.2735	102.3967±9.081	1.457±0.0794	0.092±0.0077	2.135±0.1697
RB	N2, 2HRS	5	20	CLOSED	4	0.7197±0.0626	6.3664±0.4681	7.8058±0.3868	102.8367±8.6954	1.375±0.0742	0.09±0.0072	2.5288±0.1566
RB	N2, 4HRS	5	20	CLOSED	4	0.725±0.0425	5.7797±0.5283	7.2297±0.3599	102.6434±9.0209	1.389±0.0906	0.091±0.0052	2.1095±0.1137
RB	O2, 2HR	10	20	CLOSED	4	0.7069±0.0639	5.9644±0.4141	7.3782±0.3685	102.56±7.5497	1.395±0.0762	0.091±0.0091	8.268±0.2462
RB	O2, 4HR	10	20	CLOSED	4	0.7149±0.0554	6.223±0.378	7.6528±0.1946	102.3134±8.5584	1.383±0.112	0.092±0.0079	2.4767±0.1388
RB	N2, 2HRS	10	20	CLOSED	4	0.7224±0.0594	5.945±0.507	7.3898±0.3368	102.9067±6.2064	1.417±0.1404	0.09±0.0055	2.1914±0.1606
RB	N2, 4HRS	10	20	CLOSED	4	0.7273±0.0587	5.7254±0.3228	7.18±0.1877	102.68±6.8354	1.405±0.1237	0.09±0.0086	2.3295±0.2019
RB	O2, 2HR	15	20	CLOSED	4	0.7086±0.0638	5.908±0.5506	7.3252±0.5104	102.2367±6.8726	1.465±0.0962	0.092±0.0086	2.9689±0.2013
RB	O2, 4HR	15	20	CLOSED	4	0.7186±0.0441	6.0317±0.4187	7.4689±0.2738	102.2034±8.6837	1.389±0.0705	0.092±0.0087	2.028±0.1031
RB	N2, 2HRS	15	20	CLOSED	4	0.7234±0.049	6.2857±0.5258	7.7325±0.1988	102.8967±9.6669	1.381±0.0857	0.09±0.0072	2.3164±0.2158
RB	N2, 4HRS	15	20	CLOSED	4	0.7295±0.042	5.6517±0.3672	7.1107±0.244	102.8067±5.4492	1.445±0.1239	0.09±0.0085	2.1102±0.1371
RB	NIL	0	30	CLOSED	4	5.6594±0.3535	7.7067±0.6516	18.0255±0.4565	98.6534±9.0554	1.466±0.1087	0.105±0.0078	13.743±0.7225
RB	O2, 2HR	5	30	CLOSED	4	0.7356±0.0724	5.8847±0.4948	7.3559±0.133	101.4734±8.9717	1.473±0.0819	0.094±0.0058	6.0034±0.4059
RB	O2, 4HR	5	30	CLOSED	4	0.7463±0.0701	6.0734±0.6015	7.566±0.1657	101.42±6.3228	1.46±0.0945	0.094±0.0057	6.07±0.3762
RB	N2, 2HRS	5	30	CLOSED	4	0.7572±0.0581	6.0217±0.453	7.5361±0.3066	101.6767±8.7946	1.457±0.0759	0.093±0.0052	5.8334±0.3145
RB	N2, 4HRS	5	30	CLOSED	4	0.7625±0.0621	6.2307±0.3597	7.7557±0.1202	101.58±5.2653	1.474±0.1145	0.094±0.0078	5.8667±0.3299
RB	O2, 2HR	10	30	CLOSED	4	0.7417±0.0496	6.324±0.4541	7.8074±0.4165	101.9±7.9015	1.417±0.1178	0.093±0.0073	5.41±0.4626
RB	O2, 4HR	10	30	CLOSED	4	0.7517±0.0429	6.2214±0.5341	7.7248±0.3885	101.8534±7.4321	1.432±0.1017	0.093±0.0071	5.5067±0.4055
RB	N2, 2HRS	10	30	CLOSED	4	0.7588±0.0522	5.9117±0.3487	7.4293±0.2639	102.1667±7.4232	1.386±0.1255	0.092±0.0051	5.2967±0.4846
RB	N2, 4HRS	10	30	CLOSED	4	0.7655±0.0398	6.4284±0.4885	7.9594±0.3999	102.08±8.5456	1.461±0.1353	0.092±0.0075	5.3567±0.3818
RB	O2, 2HR	15	30	CLOSED	4	0.7427±0.0699	6.303±0.3882	7.7884±0.3982	101.32±8.2747	1.467±0.1395	0.094±0.0092	6.19±0.5094
RB	O2, 4HR	15	30	CLOSED	4	0.7552±0.0724	6.313±0.4641	7.8234±0.354	101.25±9.4253	1.376±0.1115	0.095±0.0083	6.2734±0.5219
RB	N2, 2HRS	15	30	CLOSED	4	0.7611±0.0432	5.791±0.4221	7.3132±0.2444	101.7867±9.484	1.38±0.1351	0.093±0.0062	5.63±0.3381
RB	N2, 4HRS	15	30	CLOSED	4	0.7694±0.0669	6.1144±0.3999	7.6532±0.178	101.7367±8.3724	1.378±0.0957	0.093±0.0062	5.6934±0.3281
RB	NIL	0	40	CLOSED	4	5.9912±0.4569	9.6087±0.5732	21.5911±0.7593	87.7034±8.3774	1.375±0.073	0.109±0.0068	9.48±0.8089
RB	O2, 2HR	5	40	CLOSED	4	0.7724±0.0643	6.4397±0.6276	7.9845±0.4665	99.7834±7.5295	1.453±0.1	0.099±0.0061	7.6234±0.7056
RB	O2, 4HR	5	40	CLOSED	4	0.7764±0.0494	6.687±0.4656	8.2398±0.5191	99.6967±9.4416	1.406±0.0798	0.1±0.0097	7.71±0.4506
RB	N2, 2HRS	5	40	CLOSED	4	0.7815±0.0745	7.028±0.5089	8.591±0.0415	99.8367±5.701	1.394±0.091	0.099±0.0095	7.5634±0.6643
RB	N2, 4HRS	5	40	CLOSED	4	0.7903±0.0527	7.0597±0.5734	8.6403±0.6029	100.1734±8.3783	1.403±0.0797	0.098±0.0054	7.3067±0.534
RB	O2, 2HR	10	40	CLOSED	4	0.773±0.0389	6.953±0.4081	8.499±0.3802	99.9467±6.8996	1.394±0.092	0.099±0.0056	7.4034±0.6494
RB	O2, 4HR	10	40	CLOSED	4	0.7786±0.0625	6.8384±0.4085	8.3956±0.1182	99.61±9.7993	1.439±0.0736	0.101±0.0087	7.7934±0.7217
RB	N2, 2HRS	10	40	CLOSED	4	0.7833±0.0774	7.0224±0.6569	8.589±0.7804	100.2134±7.6621	1.379±0.0712	0.097±0.0085	7.26±0.6865
RB	N2, 4HRS	10	40	CLOSED	4	0.792±0.0543	6.9724±0.5178	8.5564±0.3353	99.7534±6.753	1.392±0.1234	0.1±0.0058	7.6667±0.4476
RB	O2, 2HR	15	40	CLOSED	4	0.775±0.0714	6.9024±0.3897	8.4524±0.197	100.0767±8.8899	1.417±0.0926	0.098±0.0098	7.36±0.4891
RB	O2, 4HR	15	40	CLOSED	4	0.7791±0.0567	7.1517±0.4043	8.7099±0.4104	99.4967±6.2354	1.423±0.0994	0.101±0.0101	7.8467±0.632
RB	N2, 2HRS	15	40	CLOSED	4	0.7855±0.0595	6.2427±0.5977	7.8137±0.3055	100.2867±6.8937	1.46±0.0778	0.097±0.0096	7.1834±0.6795
RB	N2, 4HRS	15	40	CLOSED	4	0.7968±0.0594	6.9344±0.6421	8.528±0.2505	100.2467±7.4678	1.408±0.1362	0.097±0.008	7.2267±0.4598
SB	NIL	0	20	CLOSED	4	3.546±0.2749	9.3717±0.5185	16.4637±0.5166	135.6867±7.7293	1.305±0.1036	0.103±0.0061	7.2634±0.5442
SB	O2, 2HR	5	20	CLOSED	4	2.5506±0.159	8.5404±0.5162	13.6416±0.4683	139.4434±11.1795	1.398±0.1348	0.091±0.0048	2.51±0.2027
SB	O2, 4HR	5	20	CLOSED	4	2.5313±0.1857	8.8127±0.6567	13.8753±0.7829	139.3967±12.6958	1.338±0.1021	0.092±0.0056	2.6167±0.209
SB	N2, 2HRS	5	20	CLOSED	4	2.6697±0.1872	8.7564±0.7849	14.0958±0.4547	139.8367±10.4153	1.34±0.0873	0.09±0.0082	3.1567±0.3012
SB	N2, 4HRS	5	20	CLOSED	4	2.3006±0.1781	8.1697±0.7095	12.7709±0.4823	139.6434±13.0874	1.341±0.102	0.091±0.0082	3.21±0.1633
SB	O2, 2HR	10	20	CLOSED	4	2.4618±0.2005	8.3544±0.4937	13.278±0.9278	139.56±13.0018	1.37±0.1092	0.091±0.0051	2.6434±0.1706
SB	O2, 4HR	10	20	CLOSED	4	2.5218±0.1319	8.613±0.7947	13.6566±0.715	139.3134±13.7936	1.389±0.1137	0.092±0.0068	2.8467±0.1493
SB	N2, 2HRS	10	20	CLOSED	4	2.4711±0.1724	8.335±0.7831	13.2772±0.0786	139.9067±7.5857	1.376±0.1089	0.09±0.0083	2.8967±0.1801
SB	N2, 4HRS	10	20	CLOSED	4	2.5038±0.1948	8.1154±0.7722	13.123±0.7006	139.68±12.0997	1.37±0.0836	0.091±0.009	3.0667±0.1795
SB	O2, 2HR	15	20	CLOSED	4	2.3946±0.2072	8.298±0.5661	13.0872±0.3087	139.2367±9.7853	1.323±0.09	0.092±0.0076	2.7234±0.1484
SB	O2, 4HR	15	20	CLOSED	4	2.4121±0.1761	8.4217±0.492	13.2459±0.5297	139.2034±10.7256	1.389±0.1304	0.092±0.0076	2.67±0.2055
SB	N2, 2HRS	15	20	CLOSED	4	2.4785±0.232	8.6757±0.6257	13.6327±0.6718	139.8967±13.6842	1.301±0.0919	0.09±0.0071	2.8734±0.218
SB	N2, 4HRS	15	20	CLOSED	4	2.421±0.1749	8.0417±0.5033	12.8837±0.2994	139.8067±9.651	1.332±0.1217	0.091±0.0054	2.9867±0.254
SB	NIL	0	30	CLOSED	4	4.336±0.2132	9.43±0.8384	15.7687±0.483	135.6534±11.5201	1.325±0.1144	0.103±0.006	7.0534±0.5095
SB	O2, 2HR	5	30	CLOSED	4	2.7238±0.2306	8.2747±0.5035	13.7223±0.5314	138.4734±9.194	1.336±0.12	0.095±0.0093	3.63±0.2689
SB	O2, 4HR	5	30	CLOSED	4	2.5329±0.1728	8.4634±0.535	13.5292±0.3133	138.42±9.2637	1.393±0.1061	0.095±0.0067	3.8667±0.2243
SB	N2, 2HRS	5	30	CLOSED	4	2.3391±0.1711	8.4117±0.5205	13.0899±0.2435	138.6767±13.193	1.351±0.1027	0.094±0.0059	3.8334±0.2545
SB	N2, 4HRS	5	30	CLOSED	4	2.3169±0.1609	8.6207±0.6226	13.2545±0.6942	138.58±12.6228	1.327±0.0898	0.094±0.0087	3.2967±0.2192
SB	O2, 2HR	10	30	CLOSED	4	2.3576±0.1202	8.714±0.4581	13.4292±0.3652	138.9±8.9566	1.362±0.1007	0.093±0.006	4.19±0.3389
SB	O2, 4HR	10	30	CLOSED	4	2.4591±0.2095	8.6114±0.4716	13.5296±0.1561	138.8534±8.1721	1.325±0.0748	0.093±0.0069	4.07±0.3351
SB	N2, 2HRS	10	30	CLOSED	4	2.6694±0.2524	8.3017±0.5024	13.6405±0.331	139.1667±13.2132	1.369±0.1252	0.092±0.0092	4.0034±0.2956
SB												

SB	N2, 2HRS	15	30	CLOSED		4	2.3984±0.2384	8.181±0.4414	12.9778±0.1086	138.7867±9.5929	1.345±0.1099	0.093±0.0074	3.5067±0.2442
SB	N2, 4HRS	15	30	CLOSED		4	2.3482±0.137	8.5044±0.6087	13.2008±0.6472	138.7367±7.8078	1.368±0.1236	0.094±0.0061	4.2734±0.3036
SB	NIL	0	40	CLOSED		4	4.3352±0.3385	11.9987±0.7183	20.6691±0.348	124.7034±7.4267	1.334±0.1018	0.109±0.0081	7.6667±0.7534
SB	O2, 2HR	5	40	CLOSED		4	3.7308±0.3036	8.8297±0.708	16.2913±0.4665	136.7834±12.6697	1.373±0.1175	0.1±0.0063	4.3734±0.3331
SB	O2, 4HR	5	40	CLOSED		4	3.743±0.2387	9.077±0.7714	16.563±0.2606	136.6967±10.365	1.368±0.0837	0.1±0.01	4.6367±0.277
SB	N2, 2HRS	5	40	CLOSED		4	3.8701±0.3834	9.418±0.7342	17.1582±0.5494	136.8367±11.6835	1.371±0.0924	0.099±0.0061	4.3267±0.3806
SB	N2, 4HRS	5	40	CLOSED		4	3.7087±0.2179	9.4497±0.4867	16.8671±0.7501	137.1734±9.6948	1.326±0.1151	0.099±0.0074	5.0167±0.372
SB	O2, 2HR	10	40	CLOSED		4	3.8468±0.3273	9.343±0.6402	17.0366±0.4829	136.9467±7.5674	1.352±0.0868	0.099±0.0094	5.1234±0.4496
SB	O2, 4HR	10	40	CLOSED		4	3.6932±0.2016	9.2284±0.7096	16.6148±0.703	136.61±8.0927	1.357±0.1008	0.1±0.0054	4.5067±0.3655
SB	N2, 2HRS	10	40	CLOSED		4	3.746±0.3675	9.4124±0.8768	16.9044±0.8523	137.2134±12.6267	1.329±0.1158	0.099±0.0068	4.88±0.4219
SB	N2, 4HRS	10	40	CLOSED		4	3.677±0.3015	9.3624±0.815	16.7164±0.1371	136.7534±8.8934	1.378±0.1028	0.1±0.0056	4.47±0.3007
SB	O2, 2HR	15	40	CLOSED		4	3.7423±0.2347	9.2924±0.488	16.777±0.363	137.0767±9.3819	1.369±0.0942	0.099±0.0073	4.9767±0.4293
SB	O2, 4HR	15	40	CLOSED		4	3.7365±0.3198	9.5417±0.7714	17.0147±0.4624	136.4967±7.4244	1.322±0.1056	0.1±0.007	4.5434±0.277
SB	N2, 2HRS	15	40	CLOSED		4	3.7911±0.2332	8.6327±0.5985	16.2149±0.8201	137.2867±9.2505	1.378±0.0751	0.098±0.0086	4.9067±0.3515
SB	N2, 4HRS	15	40	CLOSED		4	3.9244±0.2459	9.3244±0.9242	17.1732±1.092	137.2467±13.5568	1.32±0.1269	0.098±0.0092	4.7534±0.3097
SF	NIL	0	20	CLOSED		4	5.7361±0.3033	4.7617±0.4589	16.2339±0.3179	130.0167±9.002	1.366±0.1137	0.104±0.008	7.52±0.4332
SF	O2, 2HR	5	20	CLOSED		4	1.1791±0.0809	3.9304±0.2241	6.2886±0.1717	133.7734±10.1605	1.309±0.1031	0.091±0.0062	2.7667±0.1876
SF	O2, 4HR	5	20	CLOSED		4	1.1883±0.0824	4.2027±0.2986	6.5793±0.151	133.7267±9.5987	1.34±0.1263	0.091±0.0085	2.8734±0.2654
SF	N2, 2HRS	5	20	CLOSED		4	1.1967±0.1073	4.1464±0.296	6.5398±0.3814	134.1667±12.771	1.345±0.133	0.09±0.0073	3.4134±0.2166
SF	N2, 4HRS	5	20	CLOSED		4	1.202±0.0764	3.5597±0.211	5.9637±0.1699	133.9734±7.1663	1.326±0.1294	0.091±0.0056	3.4667±0.2378
SF	O2, 2HR	10	20	CLOSED		4	1.1839±0.0974	3.7444±0.2642	6.1122±0.0275	133.89±11.5732	1.362±0.083	0.091±0.005	2.94±0.1598
SF	O2, 4HR	10	20	CLOSED		4	1.1919±0.0601	4.003±0.3135	6.3868±0.1558	133.6434±12.0018	1.372±0.0782	0.092±0.007	3.1034±0.1625
SF	N2, 2HRS	10	20	CLOSED		4	1.1994±0.0738	3.725±0.3057	6.1238±0.2119	134.2367±6.9154	1.311±0.1233	0.09±0.0046	3.1534±0.3118
SF	N2, 4HRS	10	20	CLOSED		4	1.2043±0.0707	3.5054±0.2617	5.914±0.1956	134.01±9.942	1.357±0.0871	0.09±0.0056	3.3234±0.3079
SF	O2, 2HR	15	20	CLOSED		4	1.1856±0.0802	3.688±0.2905	6.0592±0.0761	133.5667±8.8976	1.354±0.1327	0.093±0.0065	2.98±0.175
SF	O2, 4HR	15	20	CLOSED		4	1.1956±0.067	3.8117±0.3114	6.2029±0.3333	133.5334±11.472	1.38±0.0909	0.093±0.0082	2.9267±0.196
SF	N2, 2HRS	15	20	CLOSED		4	1.2004±0.062	4.0657±0.2463	6.4665±0.1621	134.2267±10.869	1.335±0.0801	0.09±0.0065	3.13±0.2105
SF	N2, 4HRS	15	20	CLOSED		4	1.2065±0.086	3.4317±0.2353	5.8447±0.191	134.1367±8.2984	1.301±0.1072	0.09±0.0089	3.2344±0.2865
SF	NIL	0	30	CLOSED		4	6.1364±0.3473	4.4867±0.4169	16.7595±0.3666	129.9834±12.6452	1.314±0.0704	0.105±0.0104	7.31±0.506
SF	O2, 2HR	5	30	CLOSED		4	1.2126±0.0765	3.6647±0.3274	6.0899±0.1493	132.8034±6.9046	1.344±0.1284	0.095±0.0069	3.8867±0.3206
SF	O2, 4HR	5	30	CLOSED		4	1.2233±0.0985	3.8534±0.2515	6.3±0.2166	132.75±13.1875	1.314±0.0714	0.095±0.0056	4.1234±0.2844
SF	N2, 2HRS	5	30	CLOSED		4	1.2342±0.092	3.8017±0.3545	6.2701±0.0942	133.0067±10.8569	1.336±0.0718	0.095±0.0065	4.09±0.2856
SF	N2, 4HRS	5	30	CLOSED		4	1.2395±0.1033	4.0107±0.2021	6.4897±0.2317	132.91±7.3992	1.363±0.0878	0.095±0.0069	3.5534±0.307
SF	O2, 2HR	10	30	CLOSED		4	1.2187±0.0623	4.104±0.3666	6.5414±0.2054	133.23±12.2669	1.377±0.0958	0.094±0.0089	4.4467±0.4291
SF	O2, 4HR	10	30	CLOSED		4	1.2287±0.077	4.0014±0.3248	6.4588±0.3737	133.1834±8.1968	1.379±0.0718	0.094±0.0072	4.3267±0.4072
SF	N2, 2HRS	10	30	CLOSED		4	1.2358±0.1015	3.6917±0.3271	6.1633±0.135	133.4967±8.0872	1.373±0.1198	0.094±0.0069	4.26±0.3201
SF	N2, 4HRS	10	30	CLOSED		4	1.2425±0.0961	4.2084±0.2346	6.6934±0.2489	133.41±7.9258	1.373±0.1104	0.094±0.0093	3.6667±0.2434
SF	O2, 2HR	15	30	CLOSED		4	1.2197±0.0991	4.083±0.3716	6.5224±0.2798	132.65±11.2488	1.332±0.1111	0.095±0.0079	3.6134±0.2352
SF	O2, 4HR	15	30	CLOSED		4	1.2322±0.0722	4.093±0.3263	6.5574±0.2143	132.58±10.3514	1.318±0.0817	0.095±0.0094	3.95±0.2331
SF	N2, 2HRS	15	30	CLOSED		4	1.2381±0.0899	3.571±0.2775	6.0472±0.319	133.1167±7.3932	1.355±0.0946	0.094±0.0052	3.7634±0.2382
SF	N2, 4HRS	15	30	CLOSED		4	1.2464±0.0958	3.8944±0.3445	6.3872±0.3311	133.0667±13.0682	1.399±0.0976	0.094±0.0076	4.53±0.4436
SF	NIL	0	40	CLOSED		4	6.4682±0.34	7.3887±0.483	20.3251±1.1491	119.0334±9.2784	1.337±0.0928	0.108±0.0091	7.9234±0.7756
SF	O2, 2HR	5	40	CLOSED		4	1.2494±0.0713	4.2197±0.2977	6.7185±0.3218	131.1134±11.0269	1.351±0.0676	0.1±0.0097	4.63±0.2378
SF	O2, 4HR	5	40	CLOSED		4	1.2534±0.0946	4.467±0.2239	6.9738±0.2224	131.0267±10.3112	1.306±0.0726	0.1±0.0079	4.8934±0.4532
SF	N2, 2HRS	5	40	CLOSED		4	1.2585±0.0953	4.808±0.3421	7.325±0.3102	131.1667±11.696	1.372±0.1112	0.1±0.0097	4.5834±0.3286
SF	N2, 4HRS	5	40	CLOSED		4	1.2673±0.1051	4.8397±0.3031	7.3743±0.3578	131.5034±10.303	1.37±0.1026	0.099±0.006	5.2734±0.2846
SF	O2, 2HR	10	40	CLOSED		4	1.25±0.0709	4.733±0.4087	7.233±0.2239	131.2767±11.8328	1.391±0.1049	0.099±0.0098	5.38±0.3005
SF	O2, 4HR	10	40	CLOSED		4	1.2556±0.1077	4.6184±0.3695	7.1296±0.1397	130.94±11.4258	1.332±0.0897	0.1±0.0093	4.7634±0.4276
SF	N2, 2HRS	10	40	CLOSED		4	1.2603±0.0686	4.8024±0.4246	7.323±0.3416	131.5434±8.322	1.355±0.0855	0.099±0.0075	5.1367±0.339
SF	N2, 4HRS	10	40	CLOSED		4	1.269±0.12	4.7524±0.3095	7.2904±0.0595	131.0834±6.6644	1.343±0.1219	0.1±0.0099	4.7267±0.4183
SF	O2, 2HR	15	40	CLOSED		4	1.252±0.1175	4.6824±0.3184	7.1864±0.3271	131.4067±11.96	1.305±0.0718	0.099±0.0076	5.2334±0.3025
SF	O2, 4HR	15	40	CLOSED		4	1.2561±0.091	4.9317±0.3164	7.4439±0.1435	130.8267±9.7035	1.374±0.0706	0.1±0.0084	4.8±0.4514
SF	N2, 2HRS	15	40	CLOSED		4	1.2625±0.0888	4.0227±0.3632	6.5477±0.1409	131.6167±12.6291	1.326±0.1031	0.099±0.0057	5.1634±0.5085
SF	N2, 4HRS	15	40	CLOSED		4	1.2738±0.1118	4.7144±0.3096	7.262±0.3629	131.5767±11.0426	1.3±0.1046	0.099±0.0051	5.01±0.3085
RB	NIL	0	20	OPEN		5	7.8999±0.5242	9.48±0.8808	25.2798±0.789	96.2834±8.4689	1.383±0.0741	0.124±0.0085	9.0734±0.5789
RB	O2, 2HR	5	20	OPEN		5	3.3779±0.2823	9.2627±0.505	16.0185±0.4288	97.9934±5.3151	1.381±0.1284	0.118±0.0067	7.55±0.3889
RB	O2, 4HR	5	20	OPEN		5	3.4359±0.2989	9.175±0.8431	16.0468±0.4432	97.92±7.5414	1.458±0.1006	0.118±0.0084	7.6667±0.6477
RB	N2, 2HRS	5	20	OPEN		5	3.0122±0.2649	8.975±0.4564	14.9994±0.38	98.35±5.1479	1.426±0.0937	0.116±0.0061	7.2834±0.5596
RB	N2, 4HRS	5	20	OPEN		5	3.1942±0.2264	8.9107±0.6052	15.2991±0.3688	98.09±6.0788	1.424±0.0777	0.117±0.0095	7.4867±0.549
RB	O2, 2HR	10	20	OPEN		5	3.2636±0.174	8.9304±0.5796	15.4576±0.3468	98.0634±9.3739	1.421±0.1341	0.118±0.0112	7.51±0.6476
RB	O2, 4HR	10	20	OPEN		5	3.3937±0.3139	9.1774±0.8275	15.9648±0.5517	97.9534±5.0146	1.432±0.1227	0.118±0.0062	7.5967±0.6702
RB	N2, 2HRS	10	20	OPEN		5	3.025±0.2318	9.1954±0.6985	15.2454±0.7043	98.32±7.8385	1.38±0.0774	0.117±0.0061	7.1167±0.5309
RB	N2, 4HRS	10	20	OPEN		5	3.1345±0.2126	9.2487±0.6473	15.5177±0.445	98.2267±5.9056	1.438±0.1174	0.117±0.0071	7.4167±0.4218
RB	O2, 2HR	15	20	OPEN		5	3.3164±0.2475	8.82±0.5668	15.4528±0.1067	98.0467±9.6118	1.412±0.1344	0.118±0.0098	7.5267±0.6799
RB	O2, 4HR	15	20	OPEN		5	3.4762±0.1879	9.1027±0.4602	16.0551±0.1615	97.9134±5.3083	1.452±0.1254	0.118±0.0063	7.7067±0.6081
RB	N2, 2HRS	15	20	OPEN		5	3.0569±0.2173	8.9957±0.8257	15.1095±0.2831	98.2567±8.5285	1.393±0.101	0.117±0.0064	7.36±0.5038
RB	N2, 4HRS	15	20	OPEN		5	3.1492±0.1923	9.1854±0.4922	15.4838±0.1566	98.1334±8.6648	1.404±0.1261	0.117±0.0088	7.4567±0.6161
RB	NIL	0	30	OPEN		5	8.4319±0.6733	12.2726±0.6252	29.1364±1.2447	85.3067±4.8428	1.395±0.0941	0.128±0.0126	9.67±0.7297
RB	O2, 2HR	5	30	OPEN		5	3.6841±0.2934	9.3064±0.5614	16.6746±0.8385	96.88±7.448	1.404±0.1131	0.121±0.0073	8.6334±0.5546
RB	O2, 4HR	5	30	OPEN		5	3.7836±0.2225	9.2517±0.7527	16.8189±0.1766	96.6634±9.12	1.418±0.1315	0.122±0.0069	8.8334±0.6541
RB	N2, 2HRS	5	30	OPEN		5	3.713±0.2142	9.303±0.6968	16.729				

RB	N2, 4HRS	10	30	OPEN	5	3.519±0.3436	9.076±0.8614	16.114±1.1525	97.1134±8.2665	1.457±0.0892	0.12±0.0064	8.4534±0.4838
RB	O2, 2HR	15	30	OPEN	5	3.8023±0.1904	9.242±0.6885	16.8466±0.4494	96.5867±7.6677	1.461±0.0801	0.122±0.0122	8.8634±0.4685
RB	O2, 4HR	15	30	OPEN	5	3.9382±0.2057	9.3957±0.6864	17.2721±0.4199	96.49±7.7276	1.465±0.1065	0.123±0.0108	8.9534±0.8283
RB	N2, 2HRS	15	30	OPEN	5	3.5797±0.3561	9.429±0.5544	16.5884±0.7306	97.0134±6.241	1.456±0.134	0.12±0.0062	8.5467±0.7963
RB	N2, 4HRS	15	30	OPEN	5	3.6215±0.2715	9.141±0.7058	16.384±0.1995	96.9634±8.2119	1.429±0.1335	0.12±0.0088	8.5834±0.7153
RB	NIL	0	40	OPEN	5	8.5384±0.7649	12.3978±0.983	29.4746±0.3598	85.2567±5.5047	1.426±0.1184	0.129±0.0106	9.7434±0.7262
RB	O2, 2HR	5	40	OPEN	5	4.3244±0.2373	9.519±0.681	18.1678±0.5211	95.5634±7.2409	1.438±0.0796	0.127±0.0086	9.5534±0.4778
RB	O2, 4HR	5	40	OPEN	5	4.3623±0.2252	9.602±0.5603	18.3266±0.0749	95.4834±7.2086	1.387±0.1286	0.128±0.0101	9.6±0.5816
RB	N2, 2HRS	5	40	OPEN	5	4.2272±0.3605	9.711±0.7543	18.1654±1.3174	95.8±9.1705	1.428±0.1414	0.126±0.0112	9.31±0.5424
RB	N2, 4HRS	5	40	OPEN	5	4.0416±0.2825	9.821±0.851	17.9042±1.0791	96.02±5.3196	1.427±0.0866	0.125±0.0094	9.1867±0.7937
RB	O2, 2HR	10	40	OPEN	5	4.2401±0.4196	9.3687±0.6575	17.8489±0.5683	95.7134±7.6664	1.455±0.1003	0.127±0.0106	9.3834±0.7356
RB	O2, 4HR	10	40	OPEN	5	4.3145±0.2413	9.476±0.704	18.105±0.1172	95.5734±7.3434	1.422±0.1004	0.127±0.0078	9.5134±0.8313
RB	N2, 2HRS	10	40	OPEN	5	4.0003±0.2937	9.4797±0.5472	17.4803±0.2568	96.0734±7.0596	1.397±0.1136	0.125±0.0111	9.12±0.5276
RB	N2, 4HRS	10	40	OPEN	5	4.1125±0.2736	9.7564±0.7851	17.9814±0.9938	95.86±4.7964	1.465±0.1334	0.126±0.0087	9.2334±0.8394
RB	O2, 2HR	15	40	OPEN	5	4.2829±0.3952	9.6987±0.7538	18.2645±0.6564	95.6534±4.9741	1.439±0.1342	0.127±0.0117	9.47±0.8613
RB	O2, 4HR	15	40	OPEN	5	4.3854±0.4338	9.7994±0.7461	18.5702±0.1242	95.42±7.9811	1.405±0.0805	0.128±0.0125	9.6267±0.5209
RB	N2, 2HRS	15	40	OPEN	5	4.0199±0.2991	9.7884±0.9442	17.8282±0.5378	96.05±5.1102	1.415±0.1034	0.125±0.0107	9.14±0.8819
RB	N2, 4HRS	15	40	OPEN	5	4.2139±0.2915	9.3924±0.5228	17.8202±0.5263	95.8267±7.3386	1.467±0.0914	0.126±0.0069	9.2967±0.6686
SB	NIL	0	20	OPEN	5	6.684±0.6226	11.87±1.0308	25.238±1.0752	133.2834±12.4802	1.381±0.1372	0.125±0.0098	7.47±0.5784
SB	O2, 2HR	5	20	OPEN	5	5.0086±0.4851	11.6527±1.0093	21.6699±1.4994	134.9934±9.1082	1.371±0.122	0.118±0.0072	5.7267±0.4242
SB	O2, 4HR	5	20	OPEN	5	5.0703±0.299	11.565±1.0379	21.7056±0.1242	134.92±12.8122	1.375±0.1219	0.118±0.0059	6.1834±0.4085
SB	N2, 2HRS	5	20	OPEN	5	4.7489±0.369	11.365±0.6118	20.8628±0.7559	135.35±12.9388	1.375±0.1199	0.116±0.0079	6.1634±0.562
SB	N2, 4HRS	5	20	OPEN	5	4.7239±0.2917	11.3007±1.1017	20.7485±0.7995	135.09±11.731	1.371±0.1085	0.117±0.0068	6.3767±0.6263
SB	O2, 2HR	10	20	OPEN	5	4.9327±0.2619	11.3204±0.8804	21.1858±0.2741	135.0634±10.5382	1.304±0.0804	0.117±0.0082	6.1234±0.5979
SB	O2, 4HR	10	20	OPEN	5	4.5506±0.2979	11.5674±0.9475	20.6686±0.7862	134.9534±8.0885	1.375±0.1359	0.118±0.0109	5.86±0.349
SB	N2, 2HRS	10	20	OPEN	5	4.9687±0.4194	11.5854±0.6193	21.5228±0.6222	135.32±12.6745	1.305±0.0692	0.116±0.0072	6.07±0.4198
SB	N2, 4HRS	10	20	OPEN	5	4.931±0.4334	11.6387±0.8808	21.5007±1.5486	135.2267±11.5201	1.367±0.1152	0.117±0.0111	6.2967±0.3495
SB	O2, 2HR	15	20	OPEN	5	5.2144±0.3769	11.21±1.0808	21.638±1.1388	135.0467±9.6689	1.372±0.1073	0.118±0.008	5.8067±0.3697
SB	O2, 4HR	15	20	OPEN	5	4.806±0.3198	11.4927±0.6107	21.1047±1.1707	134.9134±11.5516	1.366±0.0802	0.119±0.0111	5.7667±0.4868
SB	N2, 2HRS	15	20	OPEN	5	5.2483±0.2863	11.3857±0.8059	21.8823±0.2063	135.2567±8.3731	1.361±0.1286	0.116±0.0109	5.93±0.5466
SB	N2, 4HRS	15	20	OPEN	5	5.0811±0.3906	11.5754±1.1061	21.7376±0.4626	135.1334±9.6842	1.308±0.1065	0.117±0.0082	6.3234±0.4637
SB	NIL	0	30	OPEN	5	8.1765±0.6451	14.6626±1.1181	31.0156±1.9905	122.3067±6.2854	1.342±0.0877	0.129±0.0065	7.67±0.4328
SB	O2, 2HR	5	30	OPEN	5	4.6739±0.3474	11.6964±0.8362	21.0442±0.7213	133.88±12.3748	1.344±0.0727	0.123±0.0111	6.3379±0.5528
SB	O2, 4HR	5	30	OPEN	5	4.8565±0.254	11.6417±0.7969	21.3547±1.2804	133.6634±6.9306	1.384±0.0895	0.123±0.0083	6.5467±0.5961
SB	N2, 2HRS	5	30	OPEN	5	4.7938±0.3323	11.693±1.0221	21.2806±0.3872	133.8134±7.9162	1.312±0.121	0.123±0.0108	6.9534±0.5445
SB	N2, 4HRS	5	30	OPEN	5	4.6073±0.4112	11.6767±0.9737	20.8913±1.9028	133.7567±8.0535	1.34±0.0959	0.123±0.0122	6.68±0.5772
SB	O2, 2HR	10	30	OPEN	5	4.8358±0.4175	11.5907±1.06	21.2623±1.352	133.7067±8.1186	1.394±0.0699	0.123±0.0072	6.4967±0.499
SB	O2, 4HR	10	30	OPEN	5	4.7248±0.2479	11.803±0.8789	21.2526±0.7712	133.5267±6.8401	1.388±0.104	0.123±0.0112	6.4534±0.3824
SB	N2, 2HRS	10	30	OPEN	5	5.021±0.3894	11.628±0.7089	21.67±1.3116	134.03±11.3451	1.376±0.1153	0.122±0.0071	6.7767±0.6738
SB	N2, 4HRS	10	30	OPEN	5	4.9528±0.2718	11.466±0.7473	21.3716±0.1207	134.1134±10.8168	1.314±0.0954	0.122±0.0094	6.6334±0.3796
SB	O2, 2HR	15	30	OPEN	5	4.6467±0.3752	11.632±0.6396	20.9254±0.8028	133.5867±13.1283	1.356±0.1013	0.123±0.0098	6.7267±0.6376
SB	O2, 4HR	15	30	OPEN	5	5.3367±0.3709	11.7857±0.5997	22.4591±0.6947	133.49±12.8224	1.357±0.1212	0.124±0.0076	6.5834±0.4725
SB	N2, 2HRS	15	30	OPEN	5	4.452±0.277	11.819±0.7257	20.723±0.5818	134.0134±12.4495	1.342±0.0878	0.122±0.0064	6.8634±0.423
SB	N2, 4HRS	15	30	OPEN	5	4.9553±0.4788	11.531±0.6134	21.4416±0.789	133.9634±7.4301	1.367±0.0896	0.123±0.0106	6.8334±0.6316
SB	NIL	0	40	OPEN	5	8.6631±0.744	14.7878±0.8821	32.114±1.3825	122.2567±7.666	1.324±0.076	0.129±0.0087	7.02±0.4772
SB	O2, 2HR	5	40	OPEN	5	4.9417±0.31	11.909±1.0614	21.7924±0.5814	132.5634±7.8655	1.379±0.114	0.128±0.0073	6.0734±0.5222
SB	O2, 4HR	5	40	OPEN	5	5.2602±0.4724	11.992±0.8119	22.5124±0.7942	132.4834±7.0927	1.369±0.0734	0.128±0.0126	7.01±0.4616
SB	N2, 2HRS	5	40	OPEN	5	5.0971±0.4583	12.101±0.8119	22.2952±0.3395	132.8±10.601	1.37±0.1159	0.127±0.0122	7.14±0.523
SB	N2, 4HRS	5	40	OPEN	5	4.9018±0.4093	12.211±0.9624	22.0146±0.4567	133.02±12.5471	1.399±0.0823	0.126±0.0091	7.6267±0.4688
SB	O2, 2HR	10	40	OPEN	5	4.776±0.2986	11.7587±0.894	21.3107±0.3902	132.7134±8.777	1.368±0.0844	0.128±0.0104	7.1867±0.5026
SB	O2, 4HR	10	40	OPEN	5	4.6216±0.252	11.866±0.8776	21.1092±0.2971	132.5734±13.1181	1.334±0.0866	0.128±0.0103	7.2967±0.6682
SB	N2, 2HRS	10	40	OPEN	5	4.9714±0.39	11.8697±0.9838	21.8125±0.4487	133.0734±7.1727	1.337±0.1173	0.125±0.0112	7.6±0.6728
SB	N2, 4HRS	10	40	OPEN	5	4.7294±0.4228	12.1464±0.6077	21.6052±0.2401	132.86±11.7	1.343±0.1283	0.126±0.0126	7.31±0.6365
SB	O2, 2HR	15	40	OPEN	5	5.0001±0.4744	12.0887±0.8773	22.0889±0.2597	132.6534±12.7824	1.344±0.1101	0.128±0.0075	7.2334±0.5889
SB	O2, 4HR	15	40	OPEN	5	4.869±0.438	12.1894±1.1462	21.9274±0.7458	132.42±11.8715	1.376±0.0988	0.129±0.0128	7.84±0.4172
SB	N2, 2HRS	15	40	OPEN	5	4.8386±0.4628	12.1784±1.0887	21.8556±0.7045	133.05±12.0441	1.38±0.1131	0.125±0.0073	7.5134±0.5018
SB	N2, 4HRS	15	40	OPEN	5	4.7518±0.3114	11.7824±0.7539	21.286±0.6834	132.8267±9.159	1.352±0.1101	0.126±0.0083	7.12±0.5872
SF	NIL	0	20	OPEN	5	8.3769±0.4702	8.59±0.7161	24.0138±0.2954	126.6134±10.0909	1.388±0.0704	0.125±0.0063	7.7634±0.4506
SF	O2, 2HR	5	20	OPEN	5	3.8549±0.2388	7.0427±0.6038	14.7525±0.5096	128.3234±12.6227	1.314±0.1028	0.119±0.0089	6.02±0.4957
SF	O2, 4HR	5	20	OPEN	5	3.9129±0.2986	6.955±0.5279	14.7808±0.4368	128.25±11.9581	1.336±0.0857	0.119±0.0066	6.4767±0.3902
SF	N2, 2HRS	5	20	OPEN	5	3.4892±0.2891	6.755±0.4369	13.7334±0.8085	128.68±12.5366	1.309±0.1054	0.117±0.0111	6.4567±0.3428
SF	N2, 4HRS	5	20	OPEN	5	3.6712±0.2799	6.6907±0.4314	14.0331±0.5455	128.42±9.6868	1.394±0.1271	0.119±0.0099	6.67±0.4404
SF	O2, 2HR	10	20	OPEN	5	3.7406±0.3288	6.7104±0.4099	14.1916±0.2949	128.3934±8.4086	1.317±0.0916	0.119±0.0115	6.4167±0.4414
SF	O2, 4HR	10	20	OPEN	5	3.8707±0.3844	6.9574±0.4882	14.6988±0.5198	128.2834±10.296	1.302±0.0858	0.119±0.0115	6.1534±0.4953
SF	N2, 2HRS	10	20	OPEN	5	3.502±0.3286	6.9754±0.4764	13.9794±0.3382	128.65±8.3902	1.313±0.123	0.117±0.0114	6.3634±0.5197
SF	N2, 4HRS	10	20	OPEN	5	3.6115±0.3258	7.0287±0.5271	14.2517±0.3993	128.5567±12.7761	1.339±0.0707	0.118±0.0109	6.59±0.3679
SF	O2, 2HR	15	20	OPEN	5	3.7934±0.3451	6.6±0.4972	14.1868±0.028	128.3767±8.4741	1.382±0.134	0.119±0.0069	6.1±0.5337
SF	O2, 4HR	15	20	OPEN	5	3.9532±0.2594	6.8827±0.4287	14.7891±0.1502	128.2434±8.9163	1.357±0.0927	0.119±0.0083	6.06±0.4838
SF	N2, 2HRS	15	20	OPEN	5	3.5339±0.2067	6.7757±0.6557	13.8435±0.7169	128.5867±8.611	1.365±0.074	0.118±0.009	6.2234±0.3695
SF	N2, 4HRS	15	20	OPEN	5	3.6262±0.3338	6.9654±0.4821	14.2178±0.194	128.4634±11.1266	1.343±0.0761	0.118±0.0116	6.6167±0.5716
SF	NIL	0	30	OPEN	5	8.9089±0.6298	10.0526±0.9217	27.8704±0.8322	115.6367±8.6178	1.339±0.0793	0.129±0.0094	7.9634±0.4645
SF	O2, 2HR	5	30	OPEN	5	4.1611±0.3991	7.0864±0.55	15.4086±0.691	127.21±11.4341	1.364±0.1084	0.123±0.0076	7.21±0.494
S												

SF	O2, 2HR	10	30	OPEN	5	4.2438±0.3986	6.9807±0.5691	15.4683±0.393	127.0367±6.3739	1.335±0.0836	0.123±0.0067	6.79±0.3456
SF	O2, 4HR	10	30	OPEN	5	4.3376±0.3016	7.193±0.3633	15.8682±0.2946	126.8567±7.2294	1.396±0.1206	0.124±0.0077	6.7467±0.4765
SF	N2, 2HRS	10	30	OPEN	5	4.0288±0.2692	7.018±0.5246	15.0756±0.422	127.36±11.7727	1.338±0.1176	0.122±0.0114	7.07±0.4064
SF	N2, 4HRS	10	30	OPEN	5	3.996±0.3405	6.856±0.4401	14.848±0.8263	127.4434±12.5296	1.365±0.0877	0.122±0.0063	6.9267±0.6574
SF	O2, 2HR	15	30	OPEN	5	4.2793±0.2495	7.022±0.498	15.5806±0.4195	126.9167±10.1546	1.38±0.1259	0.124±0.0096	7.02±0.662
SF	O2, 4HR	15	30	OPEN	5	4.4152±0.3085	7.1757±0.6491	16.0061±0.5165	126.82±9.4049	1.366±0.0997	0.124±0.0074	6.8767±0.686
SF	N2, 2HRS	15	30	OPEN	5	4.0567±0.3046	7.209±0.4797	15.3224±0.6523	127.3434±12.5174	1.354±0.0738	0.123±0.0103	7.1567±0.5057
SF	N2, 4HRS	15	30	OPEN	5	4.0985±0.3942	6.921±0.6496	15.118±0.6037	127.2934±7.5122	1.367±0.1269	0.123±0.0096	7.1267±0.5271
SF	NIL	0	40	OPEN	5	9.0154±0.6027	10.1778±0.6895	28.2086±1.1701	115.5867±9.4204	1.331±0.0809	0.13±0.0103	7.3134±0.5644
SF	O2, 2HR	5	40	OPEN	5	4.8014±0.318	7.299±0.6461	16.9018±0.4898	125.8934±7.598	1.359±0.1329	0.129±0.0105	7.33±0.7102
SF	O2, 4HR	5	40	OPEN	5	4.8393±0.3629	7.382±0.5076	17.0606±0.2786	125.8134±8.9992	1.386±0.1075	0.129±0.0099	7.3034±0.6631
SF	N2, 2HRS	5	40	OPEN	5	4.7042±0.4576	7.491±0.629	16.8994±0.3386	126.13±6.8176	1.395±0.1089	0.127±0.0127	7.4334±0.6011
SF	N2, 4HRS	5	40	OPEN	5	4.5186±0.4477	7.601±0.6195	16.6382±0.9911	126.35±11.4308	1.354±0.0869	0.127±0.007	7.92±0.4358
SF	O2, 2HR	10	40	OPEN	5	4.7171±0.342	7.1487±0.5434	16.5829±0.5081	126.0434±11.6946	1.364±0.0705	0.127±0.008	7.48±0.6123
SF	O2, 4HR	10	40	OPEN	5	4.7915±0.4022	7.256±0.4919	16.839±0.414	125.9034±8.4434	1.325±0.1217	0.128±0.0125	7.59±0.6113
SF	N2, 2HRS	10	40	OPEN	5	4.4773±0.2294	7.2597±0.5185	16.2143±0.6453	126.4034±11.3247	1.383±0.0912	0.126±0.0106	7.8934±0.5687
SF	N2, 4HRS	10	40	OPEN	5	4.5895±0.3878	7.5364±0.3955	16.7154±0.8413	126.19±11.783	1.347±0.1082	0.127±0.0104	7.6034±0.5254
SF	O2, 2HR	15	40	OPEN	5	4.7599±0.2919	7.4787±0.5398	16.9985±0.4078	125.9834±12.4461	1.342±0.0858	0.128±0.0082	7.5267±0.5852
SF	O2, 4HR	15	40	OPEN	5	4.8624±0.4806	7.5794±0.4543	17.3042±0.6628	125.75±9.3556	1.393±0.1053	0.129±0.0113	8.1334±0.5736
SF	N2, 2HRS	15	40	OPEN	5	4.4969±0.297	7.5684±0.5819	16.5622±0.6143	126.38±8.9533	1.308±0.1021	0.127±0.0088	7.8067±0.416
SF	N2, 4HRS	15	40	OPEN	5	4.6909±0.464	7.1724±0.5359	16.5542±0.9167	126.1567±8.3326	1.381±0.0788	0.127±0.0126	7.4134±0.5243
RB	NIL	0	20	CLOSED	5	7.589±0.6453	9.4314±0.478	24.6094±0.9475	96.4467±7.3977	1.437±0.1308	0.123±0.0077	9.01±0.7071
RB	O2, 2HR	5	20	CLOSED	5	1.0904±0.0708	8.7967±0.6747	10.9775±0.4856	99.6567±5.3231	1.438±0.1105	0.112±0.0062	2.0245±0.1819
RB	O2, 4HR	5	20	CLOSED	5	1.0975±0.1085	8.7524±0.5995	10.9474±0.342	99.5667±6.7889	1.377±0.1295	0.112±0.0091	2.5461±0.214
RB	N2, 2HRS	5	20	CLOSED	5	1.0401±0.0678	8.9187±0.6176	10.9989±0.0574	99.8767±7.7365	1.427±0.0921	0.111±0.0081	2.0237±0.1741
RB	N2, 4HRS	5	20	CLOSED	5	1.0653±0.0884	8.5674±0.8266	10.698±0.8819	99.7267±8.2662	1.382±0.0996	0.111±0.0096	2.9941±0.2047
RB	O2, 2HR	10	20	CLOSED	5	1.0834±0.081	9.07±0.8399	11.2368±0.5088	99.6867±9.1023	1.415±0.1396	0.112±0.0069	2.9394±0.2741
RB	O2, 4HR	10	20	CLOSED	5	1.1032±0.0974	9.0147±0.7053	11.2211±0.5326	99.4734±9.4093	1.434±0.0749	0.112±0.0104	2.1721±0.1611
RB	N2, 2HRS	10	20	CLOSED	5	1.0191±0.0595	8.7787±0.4554	10.8169±0.2844	99.96±9.359	1.43±0.079	0.11±0.0102	2.6682±0.2539
RB	N2, 4HRS	10	20	CLOSED	5	1.0606±0.0991	8.6834±0.834	10.8046±0.8326	99.7667±5.8694	1.387±0.0913	0.111±0.009	2.2531±0.206
RB	O2, 2HR	15	20	CLOSED	5	1.1196±0.0761	9.0394±0.6185	11.2786±0.2888	99.3867±9.654	1.409±0.0727	0.112±0.0067	2.9389±0.279
RB	O2, 4HR	15	20	CLOSED	5	1.1258±0.0698	8.85±0.7691	11.1016±0.3514	99.3534±5.5806	1.405±0.1125	0.112±0.0057	2.3724±0.1638
RB	N2, 2HRS	15	20	CLOSED	5	1.0306±0.0606	8.576±0.4474	10.6372±0.5039	99.9234±7.0375	1.408±0.0912	0.111±0.0068	2.755±0.251
RB	N2, 4HRS	15	20	CLOSED	5	1.0487±0.0923	8.59±0.5553	10.6874±0.1549	99.77±8.3866	1.451±0.124	0.111±0.0067	2.9848±0.1995
RB	NIL	0	30	CLOSED	5	7.736±0.584	9.55±0.5842	25.022±1.0187	96.3767±5.1768	1.404±0.1201	0.123±0.0095	14.02±0.7964
RB	O2, 2HR	5	30	CLOSED	5	1.2518±0.0654	8.9394±0.7306	11.443±0.3182	98.67±9.1668	1.47±0.1362	0.115±0.0094	7.0367±0.6661
RB	O2, 4HR	5	30	CLOSED	5	1.2631±0.122	8.9734±0.489	11.4996±0.3523	98.6467±5.0506	1.38±0.093	0.116±0.0102	7.07±0.5775
RB	N2, 2HRS	5	30	CLOSED	5	1.2248±0.0952	9.0467±0.5321	11.4963±0.1856	98.7467±8.8776	1.463±0.0802	0.114±0.0107	6.9234±0.3901
RB	N2, 4HRS	5	30	CLOSED	5	1.2412±0.1131	8.7704±0.6601	11.2528±0.2477	98.73±7.6897	1.44±0.0835	0.115±0.0099	6.97±0.4269
RB	O2, 2HR	10	30	CLOSED	5	1.158±0.0616	8.8494±0.69	11.1654±0.3289	99.05±9.0111	1.378±0.1377	0.113±0.0057	6.75±0.3601
RB	O2, 4HR	10	30	CLOSED	5	1.1824±0.0806	9.0454±0.8529	11.4102±0.5364	98.8967±9.4531	1.465±0.0788	0.114±0.0095	6.76±0.4767
RB	N2, 2HRS	10	30	CLOSED	5	1.1383±0.1047	8.7854±0.494	11.062±0.4006	99.31±9.4916	1.389±0.0852	0.113±0.0088	6.69±0.452
RB	N2, 4HRS	10	30	CLOSED	5	1.1472±0.0603	8.647±0.6914	10.9414±0.891	99.1767±7.5701	1.419±0.1289	0.113±0.0112	6.7134±0.6508
RB	O2, 2HR	15	30	CLOSED	5	1.269±0.1211	8.9687±0.5404	11.5067±0.2757	98.5767±9.8118	1.404±0.0798	0.116±0.0058	7.15±0.6831
RB	O2, 4HR	15	30	CLOSED	5	1.2827±0.0896	8.8497±0.8754	11.4151±1.1831	98.43±7.7655	1.473±0.1072	0.116±0.0096	7.2034±0.6567
RB	N2, 2HRS	15	30	CLOSED	5	1.2001±0.0777	9.1367±0.8174	11.5369±0.5735	98.8734±6.1249	1.427±0.1022	0.114±0.0094	6.8334±0.4451
RB	N2, 4HRS	15	30	CLOSED	5	1.2169±0.1144	8.7144±0.6714	11.1482±0.2526	98.83±9.2409	1.447±0.1238	0.114±0.0101	6.8667±0.3749
RB	NIL	0	40	CLOSED	5	8.3752±0.5841	11.6508±0.9491	28.4012±0.9043	85.3634±4.9202	1.384±0.1147	0.128±0.0126	9.6467±0.6986
RB	O2, 2HR	5	40	CLOSED	5	1.14135±0.1042	9.1144±0.5048	11.9414±0.116	97.45±6.6451	1.382±0.1299	0.12±0.0074	8.1634±0.7359
RB	O2, 4HR	5	40	CLOSED	5	1.4335±0.1073	9.2384±0.5623	12.1054±0.1346	97.3334±7.7084	1.449±0.1141	0.12±0.0085	8.2967±0.618
RB	N2, 2HRS	5	40	CLOSED	5	1.4025±0.1306	9.1877±0.5734	11.9927±0.3509	97.53±7.1095	1.381±0.1029	0.12±0.0098	8.1234±0.5669
RB	N2, 4HRS	5	40	CLOSED	5	1.3398±0.0838	9.398±0.6803	12.0776±0.7606	97.6767±7.2168	1.433±0.129	0.119±0.0114	7.86±0.4818
RB	O2, 2HR	10	40	CLOSED	5	1.3805±0.0964	9.0264±0.7955	11.7874±0.31	97.5534±5.5883	1.385±0.1276	0.119±0.0083	8.07±0.4911
RB	O2, 4HR	10	40	CLOSED	5	1.4623±0.135	9.088±0.6513	12.0126±0.3992	97.2834±6.5271	1.394±0.1358	0.12±0.0077	8.3234±0.7386
RB	N2, 2HRS	10	40	CLOSED	5	1.3223±0.0928	9.3407±0.6081	11.9853±0.5365	97.7667±9.6254	1.398±0.1376	0.119±0.0079	7.8067±0.6355
RB	N2, 4HRS	10	40	CLOSED	5	1.4259±0.0741	9.454±0.6588	12.3058±0.6266	97.37±8.4344	1.393±0.0974	0.12±0.0082	8.1834±0.8123
RB	O2, 2HR	15	40	CLOSED	5	1.3765±0.1189	9.1814±0.7965	11.9344±0.6463	97.6034±6.2194	1.425±0.1368	0.119±0.0094	7.93±0.7707
RB	O2, 4HR	15	40	CLOSED	5	1.4822±0.1035	9.0897±0.6165	12.0541±0.1201	97.1767±7.052	1.389±0.0914	0.12±0.0094	8.3767±0.7272
RB	N2, 2HRS	15	40	CLOSED	5	1.2862±0.1246	8.9437±0.8216	11.5161±0.7551	97.8167±9.7454	1.439±0.1009	0.118±0.0059	7.7267±0.6854
RB	N2, 4HRS	15	40	CLOSED	5	1.2941±0.0818	9.0064±0.5249	11.5946±0.1672	97.7967±5.8715	1.386±0.1029	0.119±0.0078	7.7667±0.5084
SB	NIL	0	20	CLOSED	5	6.602±0.4976	11.8214±0.9527	25.0254±0.8197	133.4467±9.8177	1.392±0.0818	0.124±0.007	7.5534±0.672
SB	O2, 2HR	5	20	CLOSED	5	3.1781±0.2376	11.1867±0.8222	17.5429±0.9778	136.6567±9.3676	1.398±0.0807	0.111±0.0092	4.0234±0.2156
SB	O2, 4HR	5	20	CLOSED	5	2.7353±0.2706	11.1424±0.9831	16.613±0.6266	136.5667±11.0641	1.382±0.0996	0.111±0.0102	4.0334±0.2025
SB	N2, 2HRS	5	20	CLOSED	5	2.7419±0.204	11.3087±0.6797	16.7925±0.5133	136.8767±7.8026	1.334±0.1021	0.11±0.0098	4.5967±0.3156
SB	N2, 4HRS	5	20	CLOSED	5	2.4192±0.1998	10.9574±0.8663	15.7958±1.3721	136.7267±7.0062	1.305±0.0671	0.111±0.0066	4.64±0.2348
SB	O2, 2HR	10	20	CLOSED	5	2.9755±0.1751	11.46±0.9204	17.411±0.5023	136.6867±8.4624	1.364±0.0787	0.111±0.0094	4.1034±0.2431
SB	O2, 4HR	10	20	CLOSED	5	3.0271±0.2158	11.4047±0.894	17.4589±0.8495	136.4734±8.9333	1.3±0.0747	0.112±0.0076	4.24±0.2603
SB	N2, 2HRS	10	20	CLOSED	5	2.6003±0.1801	11.1687±0.8093	16.3693±0.154	136.96±9.1347	1.373±0.1241	0.11±0.0078	4.3967±0.369
SB	N2, 4HRS	10	20	CLOSED	5	2.6206±0.2286	11.0734±0.5737	16.3146±0.1131	136.7667±9.7158	1.363±0.0872	0.11±0.0074	4.5334±0.2893
SB	O2, 2HR	15	20	CLOSED	5	2.2337±0.1128	11.4294±0.9138	15.8968±0.6017	136.3867±11.1121	1.378±0.0728	0.112±0.0092	4.2234±0.2763
SB	O2, 4HR	15	20	CLOSED	5	2.5932±0.1866	11.24±1.1211	16.4264±1.1086	136.3534±12.8934	1.378±0.1082	0.113±0.0078	4.1867±0.3844
SB	N2, 2HRS	15	20	CLOSED	5	2.6186±0.1606	10.966±0.802	16.2032±0.6067	136.9234±7.7622	1.397±0.1376	0.11±0.0077	4.3567±0.239

SB	O2, 4HR	5	30	CLOSED	5	2.8964±0.2833	11.3634±1.0462	17.1562±0.9581	135.6467±6.8461	1.342±0.0678	0.115±0.0066	4.97±0.3578
SB	N2, 2HRS	5	30	CLOSED	5	2.5872±0.2245	11.4367±0.634	16.611±0.6357	135.7467±12.111	1.326±0.0953	0.114±0.0108	4.9234±0.4671
SB	N2, 4HRS	5	30	CLOSED	5	2.9277±0.2593	11.1604±0.808	17.0158±0.8268	135.73±11.8516	1.377±0.0879	0.114±0.0107	4.69±0.4236
SB	O2, 2HR	10	30	CLOSED	5	2.2687±0.1817	11.2394±0.8176	15.7768±0.3323	136.05±10.1575	1.39±0.1108	0.113±0.01	5.15±0.4501
SB	O2, 4HR	10	30	CLOSED	5	2.515±0.1752	11.4354±0.8885	16.4654±0.6299	135.8967±12.9801	1.304±0.1266	0.113±0.0105	5.07±0.2578
SB	N2, 2HRS	10	30	CLOSED	5	2.7233±0.2297	11.1754±0.7746	16.622±0.761	136.31±8.4226	1.388±0.1153	0.113±0.0071	5.0367±0.4575
SB	N2, 4HRS	10	30	CLOSED	5	2.4326±0.1941	11.037±0.5758	15.9022±0.454	136.1767±10.2209	1.386±0.0866	0.113±0.0067	4.75±0.4264
SB	O2, 2HR	15	30	CLOSED	5	2.7424±0.1738	11.3587±1.0912	16.8435±0.6851	135.5767±7.2381	1.344±0.109	0.115±0.0088	4.7134±0.3867
SB	O2, 4HR	15	30	CLOSED	5	2.7648±0.2596	11.2397±0.9611	16.7693±0.9854	135.43±12.9987	1.317±0.0838	0.115±0.0099	4.8667±0.2696
SB	N2, 2HRS	15	30	CLOSED	5	2.5964±0.1368	11.5267±1.0766	16.7195±0.573	135.8734±7.291	1.307±0.1286	0.114±0.0085	4.76±0.4037
SB	N2, 4HRS	15	30	CLOSED	5	2.7738±0.1942	11.1044±0.7315	16.652±0.3635	135.83±10.2227	1.361±0.1312	0.114±0.0076	5.2034±0.426
SB	NIL	0	40	CLOSED	5	8.1425±0.4618	14.0408±1.0463	30.3258±0.2825	122.3634±6.9705	1.319±0.1017	0.129±0.01	7.78±0.5064
SB	O2, 2HR	5	40	CLOSED	5	4.8468±0.3734	11.5044±0.9188	21.198±0.6293	134.45±13.0604	1.329±0.0784	0.12±0.006	5.3167±0.4031
SB	O2, 4HR	5	40	CLOSED	5	5.0199±0.3994	11.6284±0.782	21.6682±1.3376	134.3334±9.4924	1.379±0.0893	0.121±0.0117	5.4867±0.336
SB	N2, 2HRS	5	40	CLOSED	5	4.2782±0.3847	11.5777±1.0789	20.1341±0.8745	134.53±8.8524	1.307±0.123	0.12±0.0081	5.2834±0.3508
SB	N2, 4HRS	5	40	CLOSED	5	4.7397±0.3848	11.788±0.9118	21.2674±0.7649	134.6767±7.0437	1.346±0.0744	0.119±0.0106	5.6667±0.4577
SB	O2, 2HR	10	40	CLOSED	5	5.0265±0.4644	11.4164±1.1402	21.4694±0.551	134.5534±12.7395	1.304±0.1024	0.12±0.0091	5.7067±0.444
SB	O2, 4HR	10	40	CLOSED	5	5.0448±0.2614	11.478±0.8281	21.5676±0.2133	134.2834±6.9415	1.332±0.0975	0.122±0.0103	5.4167±0.2743
SB	N2, 2HRS	10	40	CLOSED	5	4.9275±0.2901	11.7307±0.6204	21.5857±0.474	134.7667±10.2711	1.381±0.1123	0.119±0.0085	5.5267±0.3797
SB	N2, 4HRS	10	40	CLOSED	5	5.196±0.5094	11.844±0.6021	22.236±0.3979	134.37±7.6693	1.399±0.1328	0.121±0.0108	5.36±0.4074
SB	O2, 2HR	15	40	CLOSED	5	4.9731±0.3746	11.5714±1.0503	21.5176±1.0101	134.6034±10.0798	1.381±0.1324	0.12±0.0089	5.5967±0.397
SB	O2, 4HR	15	40	CLOSED	5	4.7407±0.3907	11.4797±1.0227	20.9611±0.4424	134.1767±10.5136	1.327±0.0976	0.122±0.0087	5.4567±0.3984
SB	N2, 2HRS	15	40	CLOSED	5	4.7355±0.3079	11.3337±0.9378	20.8047±0.8464	134.8167±8.1704	1.388±0.1151	0.119±0.006	5.55±0.402
SB	N2, 4HRS	15	40	CLOSED	5	5.0202±0.2992	11.3964±0.9499	21.4368±0.6686	134.7967±6.9186	1.35±0.1083	0.119±0.0102	5.51±0.5293
SF	NIL	0	20	CLOSED	5	8.066±0.7764	7.2114±0.5735	23.3434±0.8189	126.7767±8.2054	1.351±0.0788	0.124±0.0109	7.8467±0.4289
SF	O2, 2HR	5	20	CLOSED	5	1.5674±0.1263	6.5767±0.5863	9.7115±0.4064	129.8867±9.5027	1.334±0.1223	0.112±0.0099	4.3167±0.3489
SF	O2, 4HR	5	20	CLOSED	5	1.5745±0.1468	6.5324±0.5057	9.6814±0.2534	129.8967±11.6209	1.327±0.0857	0.112±0.0056	4.3267±0.2942
SF	N2, 2HRS	5	20	CLOSED	5	1.5171±0.1205	6.6987±0.5754	9.7329±0.4234	130.2067±12.4401	1.363±0.1017	0.111±0.0066	4.89±0.4367
SF	N2, 4HRS	5	20	CLOSED	5	1.5423±0.1029	6.3474±0.4622	9.432±0.0502	130.0567±7.5966	1.306±0.1296	0.111±0.0072	4.9334±0.4409
SF	O2, 2HR	10	20	CLOSED	5	1.5604±0.1524	6.85±0.6509	9.9708±0.5618	130.0167±9.4648	1.338±0.0741	0.112±0.0089	4.3967±0.3181
SF	O2, 4HR	10	20	CLOSED	5	1.5802±0.085	6.7947±0.3869	9.9551±0.4897	129.8034±6.5034	1.331±0.0908	0.112±0.0082	4.5334±0.4518
SF	N2, 2HRS	10	20	CLOSED	5	1.4961±0.1279	6.5587±0.393	9.5509±0.4129	130.29±8.4033	1.332±0.1174	0.11±0.0105	4.69±0.4081
SF	N2, 4HRS	10	20	CLOSED	5	1.5376±0.0983	6.4634±0.5904	9.5386±0.0221	130.0967±12.2141	1.327±0.1141	0.111±0.0102	4.8267±0.3642
SF	O2, 2HR	15	20	CLOSED	5	1.5966±0.1553	6.8194±0.4455	10.0126±0.6269	129.7167±9.1217	1.328±0.0962	0.112±0.0075	4.5167±0.2931
SF	O2, 4HR	15	20	CLOSED	5	1.6028±0.1088	6.63±0.4815	9.8356±0.2407	129.6834±11.3681	1.397±0.124	0.112±0.0106	4.48±0.3805
SF	N2, 2HRS	15	20	CLOSED	5	1.5076±0.1472	6.356±0.401	9.3712±0.3514	130.2534±11.7376	1.398±0.1349	0.111±0.0061	4.65±0.4137
SF	N2, 4HRS	15	20	CLOSED	5	1.5257±0.1184	6.37±0.4911	9.4214±0.3552	130.1±9.2942	1.362±0.1051	0.111±0.0066	4.7667±0.4245
SF	NIL	0	30	CLOSED	5	8.213±0.4729	7.33±0.6107	23.756±0.7918	126.7067±12.3194	1.308±0.0831	0.125±0.0063	7.6767±0.5871
SF	O2, 2HR	5	30	CLOSED	5	1.7288±0.1364	6.7194±0.4855	10.177±0.7349	129±11.7954	1.39±0.1017	0.116±0.0106	5.1267±0.2905
SF	O2, 4HR	5	30	CLOSED	5	1.7401±0.1626	6.7534±0.4284	10.2336±0.2805	128.9767±10.7074	1.346±0.1259	0.116±0.0093	5.2634±0.2634
SF	N2, 2HRS	5	30	CLOSED	5	1.7018±0.1111	6.8267±0.4304	10.2303±0.184	129.0767±11.513	1.337±0.1145	0.114±0.0076	5.2167±0.3478
SF	N2, 4HRS	5	30	CLOSED	5	1.7182±0.1592	6.5504±0.6201	9.9868±0.2862	129.06±7.8765	1.372±0.097	0.116±0.0067	4.9834±0.3034
SF	O2, 2HR	10	30	CLOSED	5	1.635±0.0918	6.6294±0.467	9.8994±0.3294	129.38±9.8483	1.355±0.113	0.113±0.0091	5.4434±0.4114
SF	O2, 4HR	10	30	CLOSED	5	1.6594±0.1341	6.8254±0.5414	10.1442±0.0986	129.2267±8.8681	1.314±0.081	0.113±0.0058	5.3634±0.3762
SF	N2, 2HRS	10	30	CLOSED	5	1.6153±0.0844	6.5654±0.3877	9.796±0.2844	129.64±11.4901	1.314±0.1191	0.113±0.0088	5.33±0.3442
SF	N2, 4HRS	10	30	CLOSED	5	1.6242±0.0903	6.427±0.3945	9.6754±0.1353	129.5067±12.5262	1.344±0.087	0.113±0.0112	5.0434±0.3824
SF	O2, 2HR	15	30	CLOSED	5	1.746±0.1047	6.7487±0.5765	10.2407±0.477	128.9067±7.5926	1.396±0.0881	0.116±0.0095	5.0067±0.4892
SF	O2, 4HR	15	30	CLOSED	5	1.7597±0.1392	6.6297±0.4881	10.1491±0.2924	128.76±6.9703	1.303±0.114	0.116±0.0109	5.16±0.4985
SF	N2, 2HRS	15	30	CLOSED	5	1.6771±0.0944	6.9167±0.4206	10.2709±0.1639	129.2034±7.1651	1.332±0.1083	0.114±0.0064	5.0534±0.3827
SF	N2, 4HRS	15	30	CLOSED	5	1.6939±0.1687	6.4944±0.3737	9.8822±0.3197	129.16±7.7426	1.348±0.1141	0.114±0.0074	5.4967±0.3427
SF	NIL	0	40	CLOSED	5	8.8522±0.5842	9.4308±0.7746	27.1352±0.6263	115.6934±10.875	1.319±0.074	0.129±0.0091	8.0734±0.5339
SF	O2, 2HR	5	40	CLOSED	5	1.8905±0.1139	6.8944±0.6835	10.6754±0.3577	127.78±10.5853	1.366±0.121	0.121±0.0094	5.61±0.4766
SF	O2, 4HR	5	40	CLOSED	5	1.9105±0.1489	7.0184±0.6544	10.8394±0.1385	127.6634±11.6961	1.389±0.126	0.121±0.0114	5.78±0.4369
SF	N2, 2HRS	5	40	CLOSED	5	1.8795±0.0949	6.9677±0.5299	10.7267±0.4272	127.86±11.4438	1.369±0.1364	0.12±0.0076	5.5767±0.4692
SF	N2, 4HRS	5	40	CLOSED	5	1.8168±0.1545	7.178±0.6951	10.8116±1.0775	128.0067±9.3001	1.353±0.1308	0.12±0.0101	5.96±0.5513
SF	O2, 2HR	10	40	CLOSED	5	1.8575±0.1767	6.8064±0.408	10.5214±0.055	127.8834±8.418	1.334±0.0855	0.12±0.0095	6±0.4616
SF	O2, 4HR	10	40	CLOSED	5	1.9393±0.1349	6.868±0.3761	10.7466±0.5184	127.6134±10.1094	1.325±0.1199	0.122±0.0108	5.71±0.3426
SF	N2, 2HRS	10	40	CLOSED	5	1.7993±0.1519	7.1207±0.4116	10.7193±0.4961	128.0967±11.9099	1.309±0.1101	0.119±0.009	5.82±0.5686
SF	N2, 4HRS	10	40	CLOSED	5	1.9029±0.1415	7.234±0.5275	11.0398±0.4749	127.7±11.5931	1.312±0.1277	0.121±0.009	5.6534±0.4759
SF	O2, 2HR	15	40	CLOSED	5	1.8535±0.1059	6.9614±0.499	10.6684±0.1422	127.9334±7.6444	1.387±0.104	0.12±0.0116	5.89±0.5407
SF	O2, 4HR	15	40	CLOSED	5	1.9592±0.1229	6.8697±0.6844	10.7881±0.4226	127.5067±12.6609	1.364±0.0899	0.122±0.0116	5.75±0.3446
SF	N2, 2HRS	15	40	CLOSED	5	1.7632±0.1044	6.7237±0.4475	10.2501±0.127	128.1467±8.8697	1.364±0.1334	0.119±0.0077	5.8434±0.5549
SF	N2, 4HRS	15	40	CLOSED	5	1.7711±0.117	6.7864±0.4538	10.3286±0.4058	128.1267±9.6375	1.35±0.1092	0.119±0.0085	5.8034±0.3257
RB	NIL	0	20	OPEN	6	9.984±0.5824	12.7957±0.6524	32.4637±0.9104	93.0867±4.77	1.42±0.1328	0.145±0.0109	12.62±0.8702
RB	O2, 2HR	5	20	OPEN	6	5.6461±0.444	11.4567±0.9752	22.7489±0.1023	94.4434±5.4362	1.452±0.0997	0.139±0.0099	10.63±0.9802
RB	O2, 4HR	5	20	OPEN	6	5.798±0.5118	12.2154±1.0309	23.8114±1.3491	95.4067±8.8434	1.457±0.0733	0.139±0.0127	10.7834±0.676
RB	N2, 2HRS	5	20	OPEN	6	5.0253±0.4564	11.5917±0.6809	21.6423±0.4441	96.0467±9.3271	1.453±0.1093	0.137±0.0089	10.0367±0.8933
RB	N2, 4HRS	5	20	OPEN	6	5.4211±0.4089	12.0764±0.76	22.9186±0.8464	95.6±7.5042	1.397±0.1112	0.138±0.0121	10.32±1.0153
RB	O2, 2HR	10	20	OPEN	6	5.5105±0.2757	11.5347±1.11	22.5557±0.7507	94.7234±6.0579	1.441±0.1083	0.138±0.011	10.4434±0.9125
RB	O2, 4HR	10	20	OPEN	6	5.7401±0.3186	10.9737±0.8707	22.4539±0.8111	95.4267±5.683	1.376±0.0857	0.139±0.0101	10.74±0.913
RB	N2, 2HRS	10	20	OPEN	6	5.0602±0.4398	10.987±0.6468	21.1074±0.3665	95.2967±7.6976	1.42±0.0958	0.138±0.0095	10.0734±0.7056
RB	N2, 4HRS	10	20	OPEN	6	5.165±0.3914	11.5437±0.6395	21.8737±1.2507	94.9134±6.7409			

RB	N2, 4HRS	15	20	OPEN	6	5.2807±0.4946	11.6704±0.7403	22.2318±0.9158	94.4867±7.0952	1.428±0.0989	0.138±0.0079	10.2267±0.6295
RB	NIL	0	30	OPEN	6	10.1795±0.5917	14.619±0.9313	34.978±0.9912	83.67±7.5741	1.452±0.1422	0.149±0.0096	13.47±1.3101
RB	O2, 2HR	5	30	OPEN	6	6.2286±0.5195	12.565±0.6438	25.0222±1.0115	93.7034±5.3556	1.419±0.1305	0.143±0.0082	12.04±0.6215
RB	O2, 4HR	5	30	OPEN	6	6.4773±0.558	12.391±0.9154	25.3456±1.2991	93.4734±8.1683	1.435±0.1237	0.144±0.01	12.3034±0.82
RB	N2, 2HRS	5	30	OPEN	6	6.3497±0.57	12.3574±0.791	25.0568±0.3865	94.1634±9.0115	1.389±0.0817	0.143±0.0084	12.1467±0.7418
RB	N2, 4HRS	5	30	OPEN	6	6.3873±0.405	12.853±0.7785	25.6276±0.3662	93.9967±6.5852	1.392±0.1277	0.143±0.0113	12.22±0.9156
RB	O2, 2HR	10	30	OPEN	6	6.4634±0.4436	12.483±0.9564	25.4098±0.4006	94.1167±5.5054	1.437±0.1417	0.143±0.0087	12.26±0.8987
RB	O2, 4HR	10	30	OPEN	6	6.6077±0.5965	12.2174±1.0535	25.4328±0.7278	93.98±6.1478	1.437±0.0996	0.144±0.0123	12.43±0.8487
RB	N2, 2HRS	10	30	OPEN	6	6.0386±0.3357	11.765±0.7885	23.8422±0.7144	93.69±7.2436	1.446±0.0889	0.142±0.0087	11.7734±1.0595
RB	N2, 4HRS	10	30	OPEN	6	5.9225±0.5144	12.3797±0.9236	24.2247±0.5958	94.1367±8.7567	1.466±0.0835	0.142±0.0131	11.7434±0.6009
RB	O2, 2HR	15	30	OPEN	6	6.4875±0.3512	12.7834±0.9351	25.7584±0.5186	93.44±5.7253	1.46±0.1103	0.144±0.0093	12.3467±0.805
RB	O2, 4HR	15	30	OPEN	6	6.6612±0.601	12.043±0.9066	25.3654±1.3627	93.29±8.6547	1.447±0.1137	0.144±0.0119	12.47±1.0226
RB	N2, 2HRS	15	30	OPEN	6	6.1155±0.5603	12.5424±0.8237	24.7734±0.4843	94.4967±6.3321	1.377±0.1222	0.142±0.009	11.8234±1.1195
RB	N2, 4HRS	15	30	OPEN	6	6.1639±0.5299	12.0614±0.77	24.3892±0.5798	94.93±5.1012	1.411±0.1231	0.143±0.0093	12.0134±0.9363
RB	NIL	0	40	OPEN	6	10.6931±0.9757	14.3974±1.1604	35.7836±0.8751	82.9267±8.2684	1.377±0.0765	0.15±0.0105	13.4934±1.244
RB	O2, 2HR	5	40	OPEN	6	7.2904±0.5177	12.6054±1.123	27.1862±1.0052	92.6967±7.8529	1.469±0.1183	0.148±0.01	13.1934±1.1541
RB	O2, 4HR	5	40	OPEN	6	7.3031±0.5921	12.6437±1.1102	27.2499±0.203	93.8767±6.5968	1.424±0.0748	0.149±0.0098	13.28±0.9953
RB	N2, 2HRS	5	40	OPEN	6	7.1108±0.6561	13.507±0.7445	27.5723±0.6776	94.2667±8.1473	1.433±0.1013	0.147±0.0146	12.91±1.2366
RB	N2, 4HRS	5	40	OPEN	6	6.8815±0.3535	12.6177±1.0424	26.3807±0.3485	93.1334±6.6152	1.441±0.0759	0.146±0.0133	12.7134±1.0837
RB	O2, 2HR	10	40	OPEN	6	7.2028±0.4497	12.887±0.677	27.2926±1.2417	93.39±5.6676	1.422±0.1179	0.147±0.0078	12.9567±1.218
RB	O2, 4HR	10	40	OPEN	6	7.2711±0.6266	13.0727±0.7643	27.6149±1.6384	93.2467±9.0369	1.397±0.1052	0.148±0.0122	13.1134±0.8967
RB	N2, 2HRS	10	40	OPEN	6	6.7435±0.4483	12.7977±0.6636	26.2847±0.9126	93.14±5.7514	1.471±0.1204	0.145±0.0117	12.6434±0.8716
RB	N2, 4HRS	10	40	OPEN	6	6.912±0.6321	12.6634±0.9676	26.4874±0.4636	92.8834±8.8048	1.466±0.1422	0.146±0.0127	12.7867±0.8411
RB	O2, 2HR	15	40	OPEN	6	7.2567±0.6058	12.541±0.713	27.0544±1.0068	94.2367±8.0794	1.454±0.1174	0.147±0.0111	13.0534±0.8419
RB	O2, 4HR	15	40	OPEN	6	7.3645±0.6244	12.3047±1.0886	27.0337±1.0813	93.88±5.532	1.383±0.105	0.149±0.0082	13.3267±1.3257
RB	N2, 2HRS	15	40	OPEN	6	6.8177±0.5177	12.6774±0.9398	26.3128±0.532	93.18±7.0536	1.411±0.0979	0.146±0.0081	12.6767±0.9309
RB	N2, 4HRS	15	40	OPEN	6	6.9517±0.6822	12.5154±0.9889	26.4188±2.1333	93.82±5.2358	1.424±0.1031	0.146±0.0097	12.8334±0.6606
SB	NIL	0	20	OPEN	6	8.34±0.5691	14.8857±1.0159	29.5657±0.4071	130.0867±12.2017	1.379±0.0813	0.145±0.0135	11.0534±0.9038
SB	O2, 2HR	5	20	OPEN	6	6.8745±0.4573	13.8467±0.7033	27.5957±0.5513	131.4434±10.9706	1.393±0.086	0.137±0.0131	8.9167±0.7312
SB	O2, 4HR	5	20	OPEN	6	7.416±0.5468	14.6054±0.7745	29.4374±1.3816	132.4067±11.6994	1.322±0.1094	0.137±0.0112	9.54±0.8624
SB	N2, 2HRS	5	20	OPEN	6	7.5011±0.6022	13.9817±1.3011	28.9839±0.5036	133.0467±9.3727	1.391±0.1138	0.135±0.0097	9.4967±0.8922
SB	N2, 4HRS	5	20	OPEN	6	7.2276±0.5252	14.4664±1.3755	28.9216±0.9858	132.6±12.406	1.349±0.0726	0.136±0.0088	9.69±0.5992
SB	O2, 2HR	10	20	OPEN	6	7.0219±0.5752	13.9247±1.2832	27.9685±0.4906	131.7234±10.481	1.3±0.077	0.137±0.0111	9.41±0.6044
SB	O2, 4HR	10	20	OPEN	6	7.4012±0.7169	13.3637±0.6989	28.1661±1.4585	132.4267±11.6214	1.37±0.1125	0.137±0.0102	9.7734±0.9137
SB	N2, 2HRS	10	20	OPEN	6	6.6638±0.5042	13.377±0.9475	26.7046±0.1704	132.2967±7.2179	1.399±0.1225	0.135±0.0117	9.29±0.7888
SB	N2, 4HRS	10	20	OPEN	6	7.2856±0.5855	13.9337±0.942	28.5049±0.9626	131.9134±9.3518	1.328±0.0937	0.136±0.0127	9.57±0.7029
SB	O2, 2HR	15	20	OPEN	6	6.554±0.6375	13.3457±0.8751	26.4537±1.236	132.6467±10.8069	1.308±0.0692	0.137±0.0086	9.03±0.7468
SB	O2, 4HR	15	20	OPEN	6	6.8094±0.3947	13.6947±1.1196	27.3135±0.8977	132.0434±10.2792	1.323±0.1079	0.138±0.0072	8.9867±0.6189
SB	N2, 2HRS	15	20	OPEN	6	6.8462±0.5001	13.309±0.7535	27.0014±0.7469	132.56±12.6553	1.376±0.0957	0.136±0.0131	9.24±0.4774
SB	N2, 4HRS	15	20	OPEN	6	7.1192±0.6755	14.0604±0.758	28.2988±1.2691	131.4867±6.8179	1.318±0.1236	0.136±0.013	9.6534±0.7621
SB	NIL	0	30	OPEN	6	9.941±0.8788	17.009±0.9836	36.891±1.1188	120.67±10.656	1.391±0.1018	0.149±0.0103	11.47±1.1153
SB	O2, 2HR	5	30	OPEN	6	7.3831±0.5082	14.955±1.1962	29.7212±1.6826	130.7034±7.5505	1.357±0.0725	0.142±0.0112	9.7021±0.5304
SB	O2, 4HR	5	30	OPEN	6	6.4974±0.6284	14.781±1.3674	27.7758±1.3481	130.4734±9.4347	1.376±0.0985	0.144±0.0138	9.8234±0.8823
SB	N2, 2HRS	5	30	OPEN	6	6.7293±0.4479	14.7474±1.0132	28.206±2.1031	131.1634±12.0285	1.305±0.1173	0.143±0.011	10.47±0.8718
SB	N2, 4HRS	5	30	OPEN	6	6.9464±0.6339	15.243±1.3175	29.1358±1.8957	130.9967±9.0606	1.354±0.0797	0.143±0.0092	10.1467±0.5456
SB	O2, 2HR	10	30	OPEN	6	6.8655±0.5519	14.873±1.2342	28.604±1.2522	131.1167±12.6574	1.315±0.1244	0.144±0.0137	9.7734±0.8372
SB	O2, 4HR	10	30	OPEN	6	6.9119±0.566	14.6074±0.8685	28.4312±0.7827	130.98±9.626	1.379±0.104	0.144±0.0115	9.7434±0.854
SB	N2, 2HRS	10	30	OPEN	6	7.0186±0.6859	14.155±0.8694	28.1922±0.5684	130.69±11.2929	1.365±0.1215	0.141±0.0096	10.26±0.6576
SB	N2, 4HRS	10	30	OPEN	6	6.9683±0.5411	14.7697±1.2974	28.7063±0.5131	131.1367±12.8434	1.37±0.1257	0.141±0.0101	10.04±0.5219
SB	O2, 2HR	15	30	OPEN	6	6.8465±0.4641	15.1734±1.3559	28.8664±0.398	130.44±7.0887	1.391±0.0788	0.144±0.0079	10.22±0.9421
SB	O2, 4HR	15	30	OPEN	6	7.4901±0.4068	14.433±1.053	29.4132±0.6626	130.29±9.1037	1.352±0.0744	0.144±0.0142	10.0134±0.5912
SB	N2, 2HRS	15	30	OPEN	6	6.8157±0.3951	14.9324±0.7758	28.5638±0.9705	131.4967±7.2693	1.324±0.1162	0.142±0.0083	10.3467±0.5371
SB	N2, 4HRS	15	30	OPEN	6	6.7373±0.6684	14.4514±1.358	27.926±2.762	131.93±9.513	1.376±0.1134	0.142±0.0141	10.3034±0.784
SB	NIL	0	40	OPEN	6	9.991±0.9975	16.7874±0.8881	36.7694±1.2772	119.9267±10.2007	1.362±0.0757	0.149±0.0093	10.5834±0.7015
SB	O2, 2HR	5	40	OPEN	6	6.9382±0.6139	14.9954±1.3185	28.8718±0.9864	129.6967±10.6896	1.389±0.0922	0.148±0.0143	10.62±0.74
SB	O2, 4HR	5	40	OPEN	6	7.3032±0.3804	15.0337±1.1282	29.6401±2.06	130.8767±12.3375	1.379±0.0779	0.148±0.0106	10.5034±0.6906
SB	N2, 2HRS	5	40	OPEN	6	7.2904±0.3767	15.7407±1.559	30.3215±1.048	131.2667±10.4323	1.32±0.0682	0.147±0.0105	10.6767±0.6852
SB	N2, 4HRS	5	40	OPEN	6	6.8466±0.4248	15.0077±0.8525	28.7009±1.0692	130.1334±8.4464	1.318±0.1035	0.147±0.0112	11.3267±0.7424
SB	O2, 2HR	10	40	OPEN	6	6.7304±0.3556	15.277±0.8582	28.7378±0.6882	130.39±11.6081	1.326±0.1161	0.147±0.0084	10.7134±0.6982
SB	O2, 4HR	10	40	OPEN	6	6.9874±0.6961	15.4627±1.394	29.4375±1.2741	130.2467±8.1043	1.349±0.1241	0.147±0.0089	10.8334±0.6257
SB	N2, 2HRS	10	40	OPEN	6	6.8984±0.6631	15.1877±0.9836	28.9845±0.5615	130.14±8.4435	1.382±0.0764	0.145±0.0087	11.28±0.7669
SB	N2, 4HRS	10	40	OPEN	6	6.6165±0.5923	15.0534±1.3633	28.2864±1.0163	129.8834±9.5036	1.345±0.0977	0.147±0.0133	10.91±0.7821
SB	O2, 2HR	15	40	OPEN	6	7.1516±0.6831	14.931±0.975	29.2342±0.8242	131.2367±9.2506	1.379±0.1168	0.147±0.0075	10.7867±1.0567
SB	O2, 4HR	15	40	OPEN	6	7.053±0.6274	14.6947±0.9077	28.8007±0.9755	130.88±11.4273	1.309±0.1204	0.148±0.0096	11.61±0.6976
SB	N2, 2HRS	15	40	OPEN	6	6.6681±0.3908	15.0674±1.4937	28.4036±1.3099	130.18±8.9289	1.389±0.1155	0.145±0.01	11.1134±0.9785
SB	N2, 4HRS	15	40	OPEN	6	7.0536±0.6705	14.9054±1.2508	29.0126±1.6784	130.82±10.6154	1.399±0.115	0.147±0.0099	10.6434±0.9151
SF	NIL	0	20	OPEN	6	10.461±0.5852	10.2757±0.6035	31.1977±1.785	125.2567±12.3534	1.399±0.1263	0.145±0.0094	11.31±0.7964
SF	O2, 2HR	5	20	OPEN	6	6.1231±0.317	9.2367±0.7233	21.4829±0.4479	126.6134±10.5404	1.308±0.0862	0.137±0.0099	9.1734±0.886
SF	O2, 4HR	5	20	OPEN	6	6.275±0.4662	9.9954±0.9106	22.5454±1.0761	127.5767±8.9228	1.371±0.1146	0.138±0.0112	9.7967±0.7233
SF	N2, 2HRS	5	20	OPEN	6	5.5023±0.3057	9.3717±0.8178	20.3763±0.5307	128.2167±11.1999	1.35±0.0713	0.136±0.0102	9.7534±0.7515
SF	N2, 4HRS	5	20	OPEN	6	5.8981±0.378	9.8564±0.9544	21.6526±0.9543	127.77±8.2054	1.363±0.128	0.136±0.0079	9.9467±0.8645
SF	O2, 2HR	10	20	OPEN	6	5.9875±0.4002	9.3147±0.8609	21.2897±0.6052	126.8934±6.3742	1.377±0.0739	0.137±0.0119	9.6667±0.5283
SF	O											

SF	O2, 2HR	15	20	OPEN	6	6.0572±0.3611	8.7357±0.5868	20.8501±0.3726	127.8167±9.7628	1.346±0.112	0.137±0.0099	9.2867±0.6363
SF	O2, 4HR	15	20	OPEN	6	6.3593±0.3698	9.0847±0.798	21.8033±0.5904	127.2134±7.0903	1.323±0.0675	0.138±0.0107	9.2434±0.7711
SF	N2, 2HRS	15	20	OPEN	6	5.5509±0.3365	8.699±0.8271	19.8008±0.2607	127.73±11.8817	1.329±0.1008	0.136±0.0107	9.4967±0.8402
SF	N2, 4HRS	15	20	OPEN	6	5.7577±0.423	9.4504±0.7715	20.9658±0.3037	126.6567±8.9833	1.387±0.107	0.136±0.0134	9.91±0.5858
SF	NIL	0	30	OPEN	6	10.6565±0.8867	12.399±1.187	33.712±0.9011	115.84±10.7209	1.367±0.1058	0.148±0.0122	11.7267±0.7947
SF	O2, 2HR	5	30	OPEN	6	6.7056±0.4042	10.345±0.6804	23.7562±0.6461	125.8734±8.7951	1.34±0.0871	0.143±0.0114	10.6867±0.8993
SF	O2, 4HR	5	30	OPEN	6	6.9543±0.5254	10.171±0.9057	24.0796±0.4174	125.6434±11.3534	1.383±0.092	0.144±0.0074	10.08±0.6197
SF	N2, 2HRS	5	30	OPEN	6	6.8267±0.6725	10.1374±0.6363	23.7908±0.6698	126.3334±11.7984	1.32±0.0775	0.143±0.0076	10.7267±0.6827
SF	N2, 4HRS	5	30	OPEN	6	6.8643±0.4144	10.633±1.0105	24.3616±0.6288	126.1667±11.1769	1.37±0.0949	0.144±0.0075	10.4034±0.7308
SF	O2, 2HR	10	30	OPEN	6	6.9404±0.3841	10.263±1.0253	24.1438±1.4577	126.2867±8.8681	1.399±0.0827	0.144±0.0078	10.03±0.927
SF	O2, 4HR	10	30	OPEN	6	7.0847±0.4188	9.9974±0.7404	24.1668±0.3642	126.15±11.3407	1.323±0.1321	0.144±0.0081	10±0.7455
SF	N2, 2HRS	10	30	OPEN	6	6.5156±0.4115	9.545±0.6079	22.5762±1.2414	125.86±10.9677	1.392±0.115	0.142±0.0072	10.5167±0.5657
SF	N2, 4HRS	10	30	OPEN	6	6.3995±0.3376	10.1597±0.9229	22.9587±0.8256	126.3067±12.5736	1.342±0.1062	0.142±0.0135	10.2967±0.8484
SF	O2, 2HR	15	30	OPEN	6	6.9645±0.6396	10.5634±0.8752	24.4924±0.5349	125.61±9.5881	1.315±0.0719	0.144±0.0084	10.4767±0.8845
SF	O2, 4HR	15	30	OPEN	6	7.1382±0.4297	9.823±0.6196	24.0994±0.9909	125.46±8.5162	1.351±0.1119	0.144±0.0085	10.27±0.522
SF	N2, 2HRS	15	30	OPEN	6	6.5925±0.3629	10.3224±0.8014	23.5074±1.5137	126.6667±12.4902	1.38±0.1307	0.142±0.0105	10.6034±0.6743
SF	N2, 4HRS	15	30	OPEN	6	6.6409±0.6601	9.8414±0.8021	23.1232±1.3613	127.1±10.8699	1.394±0.1391	0.143±0.012	10.56±0.9348
SF	NIL	0	40	OPEN	6	11.1701±1.0352	12.1774±0.7415	34.5176±2.0342	115.0967±8.7226	1.318±0.0922	0.149±0.0078	10.84±1.0537
SF	O2, 2HR	5	40	OPEN	6	7.7674±0.41	10.3854±0.6778	25.9202±0.6006	124.8667±9.2236	1.344±0.1196	0.147±0.0091	10.6±0.8923
SF	O2, 4HR	5	40	OPEN	6	7.7801±0.777	10.4237±0.6949	25.9839±1.0726	126.0467±6.5901	1.393±0.0707	0.148±0.008	10.76±0.5763
SF	N2, 2HRS	5	40	OPEN	6	7.5878±0.388	11.1307±0.9487	26.3063±1.3104	126.4367±8.3016	1.336±0.1115	0.147±0.0082	10.9334±0.8601
SF	N2, 4HRS	5	40	OPEN	6	7.3585±0.7139	10.3977±0.9485	23.1147±1.5716	125.3034±10.7661	1.326±0.1066	0.146±0.0144	11.5834±0.7167
SF	O2, 2HR	10	40	OPEN	6	7.6798±0.5776	10.667±0.8959	26.0266±0.311	125.56±9.1645	1.328±0.0764	0.147±0.0118	10.97±0.8462
SF	O2, 4HR	10	40	OPEN	6	7.7481±0.6702	10.8527±0.8083	26.3489±1.1702	125.4167±9.9386	1.328±0.1024	0.147±0.0108	11.09±1.0868
SF	N2, 2HRS	10	40	OPEN	6	7.2205±0.5029	10.5777±0.6489	25.0187±0.5263	125.31±8.8081	1.385±0.0895	0.145±0.0143	11.5367±0.9545
SF	N2, 4HRS	10	40	OPEN	6	7.389±0.4001	10.4434±0.8836	25.2214±0.8738	125.0534±12.1007	1.345±0.0921	0.147±0.0115	11.1667±0.8852
SF	O2, 2HR	15	40	OPEN	6	7.7337±0.4274	10.321±0.9591	25.7884±1.0505	126.4067±8.1032	1.32±0.0736	0.147±0.0135	11.0434±0.698
SF	O2, 4HR	15	40	OPEN	6	7.8415±0.4711	10.0847±0.7507	25.7677±0.3191	126.05±10.9241	1.374±0.1274	0.148±0.0075	11.8667±0.8698
SF	N2, 2HRS	15	40	OPEN	6	7.2947±0.4727	10.4574±0.8154	25.0468±1.1526	125.35±11.8434	1.338±0.0911	0.145±0.0138	11.37±0.957
SF	N2, 4HRS	15	40	OPEN	6	7.4287±0.5686	10.2954±0.543	25.1528±1.3493	125.99±11.6337	1.39±0.0845	0.147±0.0145	10.9±0.5724
RB	NIL	0	20	CLOSED	6	9.902±0.7189	12.3737±0.9111	32.1777±1.4647	93.7467±8.1049	1.376±0.0998	0.144±0.0089	12.5034±1.0586
RB	O2, 2HR	5	20	CLOSED	6	2.3357±0.1176	10.9297±0.8708	15.6011±0.4061	95.8±8.852	1.401±0.0999	0.134±0.0089	4.7339±0.4354
RB	O2, 4HR	5	20	CLOSED	6	2.3609±0.1673	10.4877±0.9788	15.2095±0.474	96.0934±9.5142	1.41±0.1147	0.134±0.0085	4.1033±0.3137
RB	N2, 2HRS	5	20	CLOSED	6	2.1943±0.1263	11.0434±0.5844	15.432±0.5111	96.7467±7.1188	1.395±0.117	0.131±0.0121	3.601±0.2025
RB	N2, 4HRS	5	20	CLOSED	6	2.2979±0.1727	10.492±0.8133	15.0878±0.3758	96.0767±7.3897	1.449±0.0801	0.133±0.0085	3.135±0.2651
RB	O2, 2HR	10	20	CLOSED	6	2.3144±0.1253	10.228±0.9986	14.8568±0.6188	96.28±8.6091	1.466±0.1181	0.133±0.0132	4.662±0.3096
RB	O2, 4HR	10	20	CLOSED	6	2.4103±0.1898	11.1967±0.7118	16.0173±0.9074	95.7134±8.7197	1.388±0.1277	0.134±0.0107	4.0616±0.3332
RB	N2, 2HRS	10	20	CLOSED	6	2.0574±0.1273	10.3964±0.8443	14.5112±0.1787	96.0467±9.3165	1.396±0.0953	0.13±0.0097	3.5627±0.2667
RB	N2, 4HRS	10	20	CLOSED	6	2.2617±0.1288	10.9634±1.0816	15.4868±0.3968	96.2667±8.4725	1.442±0.0974	0.133±0.0105	3.076±0.1576
RB	O2, 2HR	15	20	CLOSED	6	2.4306±0.1698	10.902±1.0532	15.7632±0.3197	95.8334±5.7405	1.388±0.095	0.134±0.0126	4.3165±0.2988
RB	O2, 4HR	15	20	CLOSED	6	2.4922±0.2023	10.788±0.9185	15.7724±0.706	95.3434±8.6129	1.47±0.104	0.134±0.0123	3.9001±0.3342
RB	N2, 2HRS	15	20	CLOSED	6	2.1015±0.1436	10.6257±0.9983	14.8287±0.6956	96.57±7.6125	1.382±0.0837	0.13±0.0089	3.1847±0.2899
RB	N2, 4HRS	15	20	CLOSED	6	2.2222±0.1999	10.6617±0.6854	15.1061±0.6685	95.8367±7.2324	1.464±0.1433	0.131±0.012	3.0057±0.298
RB	NIL	0	30	CLOSED	6	9.9497±0.7703	13.2604±1.3041	33.1598±1.2876	93.5434±6.2961	1.469±0.0816	0.144±0.0125	17.5834±1.7195
RB	O2, 2HR	5	30	CLOSED	6	2.8208±0.2066	11.4827±0.7543	17.1243±0.5974	95.42±8.2856	1.398±0.08	0.136±0.0117	9.7967±0.7174
RB	O2, 4HR	5	30	CLOSED	6	2.8704±0.1727	10.7084±0.7174	16.4492±0.4607	94.9134±8.6901	1.383±0.0794	0.137±0.0101	8.84±0.6336
RB	N2, 2HRS	5	30	CLOSED	6	2.7582±0.2637	11.434±0.7595	16.9504±0.3592	96.1834±7.5996	1.38±0.0944	0.135±0.0079	9.58±0.8733
RB	N2, 4HRS	5	30	CLOSED	6	2.7877±0.2698	10.898±0.7124	16.4734±0.1922	95.48±5.4002	1.378±0.1096	0.135±0.012	9.6734±0.841
RB	O2, 2HR	10	30	CLOSED	6	2.5672±0.251	10.3897±0.8826	15.5241±0.8596	95.82±6.9646	1.402±0.0868	0.135±0.0071	9.2534±0.4766
RB	O2, 4HR	10	30	CLOSED	6	2.6525±0.1951	11.346±0.7417	16.651±0.2368	95.4467±7.5732	1.405±0.1333	0.135±0.0089	9.41±0.4864
RB	N2, 2HRS	10	30	CLOSED	6	2.5134±0.1789	10.52±0.9107	15.5468±0.1679	95.5±7.1142	1.454±0.0904	0.134±0.0128	9.0334±0.9025
RB	N2, 4HRS	10	30	CLOSED	6	2.5331±0.2121	11.0574±1.0819	16.1236±0.6065	96.4267±6.4265	1.399±0.1358	0.134±0.0089	9.0667±0.4894
RB	O2, 2HR	15	30	CLOSED	6	2.9015±0.2526	10.7904±0.6086	16.5934±0.539	95.33±7.3488	1.377±0.1061	0.137±0.0114	9.8967±0.9426
RB	O2, 4HR	15	30	CLOSED	6	2.9236±0.2726	11.8594±0.9555	17.7066±0.9151	95.4534±7.0032	1.386±0.1278	0.137±0.0118	9.93±0.7624
RB	N2, 2HRS	15	30	CLOSED	6	2.686±0.2374	11.3344±0.8943	16.7064±0.3658	95.65±7.4345	1.397±0.1143	0.135±0.0129	9.48±0.8652
RB	N2, 4HRS	15	30	CLOSED	6	2.7157±0.182	11.1057±1.016	16.5371±0.7075	94.7734±7.9107	1.431±0.1307	0.135±0.0133	9.5434±0.6902
RB	NIL	0	40	CLOSED	6	10.1425±0.9218	14.34±1.3247	34.625±0.5211	83.6367±4.7951	1.472±0.0754	0.149±0.0145	13.4267±0.9564
RB	O2, 2HR	5	40	CLOSED	6	3.3001±0.1929	12.3207±0.9907	18.9209±0.3764	93.7134±8.8437	1.403±0.0976	0.141±0.0105	11.4967±0.609
RB	O2, 4HR	5	40	CLOSED	6	3.3761±0.1767	11.9617±0.8993	18.7139±0.6891	94.7734±5.1677	1.45±0.0789	0.141±0.0082	11.57±1.1534
RB	N2, 2HRS	5	40	CLOSED	6	3.2735±0.2846	11.945±0.8759	18.492±0.6482	94.6534±5.407	1.398±0.1108	0.141±0.0102	11.41±1.0789
RB	N2, 4HRS	5	40	CLOSED	6	3.1733±0.1721	11.6577±0.7981	18.0043±0.2406	94.9167±4.9942	1.474±0.1084	0.14±0.0126	11.1734±0.7958
RB	O2, 2HR	10	40	CLOSED	6	3.2321±0.2131	12.1887±1.0819	18.6529±1.0101	94.63±6.9162	1.39±0.0931	0.141±0.0108	11.29±1.024
RB	O2, 4HR	10	40	CLOSED	6	3.465±0.2368	11.396±0.5707	18.326±0.4482	94.59±6.0133	1.446±0.138	0.141±0.0125	11.6534±1.0127
RB	N2, 2HRS	10	40	CLOSED	6	3.127±0.2853	11.783±1.07	18.037±0.3764	94.1±7.099	1.414±0.1231	0.14±0.0079	11.03±0.9259
RB	N2, 4HRS	10	40	CLOSED	6	3.3514±0.2372	11.5687±0.6844	18.2715±0.3628	94.4667±7.3306	1.377±0.0737	0.141±0.0123	11.54±0.8418
RB	O2, 2HR	15	40	CLOSED	6	3.2028±0.1638	12.053±1.0402	18.4586±1.0738	94.4267±8.9707	1.432±0.0794	0.142±0.0077	11.24±0.932
RB	O2, 4HR	15	40	CLOSED	6	3.48±0.2756	11.5824±1.0462	18.5424±1.6628	95.0034±7.3496	1.394±0.0856	0.142±0.0119	11.69±0.6993
RB	N2, 2HRS	15	40	CLOSED	6	2.9574±0.2924	11.462±0.6839	17.3768±0.4799	95.33±6.9497	1.43±0.1273	0.14±0.0081	10.9167±0.5894
RB	N2, 4HRS	15	40	CLOSED	6	3.0691±0.2155	12.1294±0.9996	18.2676±0.7099	94.7834±6.6886	1.389±0.1189	0.14±0.011	10.9867±0.7118
SB	NIL	0	20	CLOSED	6	8.22±0.4558	14.7637±0.9679	31.2037±0.1033	130.7467±7.6496	1.352±0.1038	0.144±0.012	11.1934±0.8593
SB	O2, 2HR	5	20	CLOSED	6	5.2881±0.3188	13.3197±1.1886	23.8959±0.633	132.8±10.9866	1.328±0.0911	0.131±0.0125	6.0667±0.4163
SB	O2, 4HR	5	20	CLOSED	6	4.7433±0.2698	12.8777±1.1257	22.3643±0.3802	133.0934±7.4176	1.341±0.1245	0.131±0.0131	6.19±0.4088
SB	N2, 2HRS</											

SB	O2, 4HR	10	20	CLOSED	6	5.1483±0.4755	13.5867±1.1893	23.8833±0.9594	132.7134±9.9272	1.346±0.1165	0.132±0.0111	6.55±0.5411
SB	N2, 2HRS	10	20	CLOSED	6	4.9812±0.3666	12.7864±0.6852	22.7488±0.9272	133.0467±6.7396	1.334±0.1306	0.13±0.0108	6.64±0.4361
SB	N2, 4HRS	10	20	CLOSED	6	5.4187±0.3614	13.3534±1.2818	24.1908±0.7412	133.2667±11.7417	1.341±0.1257	0.13±0.0113	6.8967±0.6071
SB	O2, 2HR	15	20	CLOSED	6	5.3521±0.2713	13.292±1.0071	23.9962±0.8456	132.8334±7.0205	1.374±0.0915	0.132±0.011	6.4334±0.5633
SB	O2, 4HR	15	20	CLOSED	6	5.3917±0.4649	13.178±1.0228	23.9614±0.638	132.3434±6.7224	1.379±0.133	0.133±0.0097	6.31±0.5013
SB	N2, 2HRS	15	20	CLOSED	6	4.6506±0.3353	13.0157±0.7918	22.3169±0.3454	133.57±10.0343	1.306±0.0885	0.13±0.0073	6.61±0.4042
SB	N2, 4HRS	15	20	CLOSED	6	5.1182±0.3328	13.0517±1.1119	23.2881±1.8296	132.8367±12.957	1.349±0.1324	0.13±0.011	6.7634±0.4219
SB	NIL	0	30	CLOSED	6	8.529±0.8105	15.6504±1.5507	32.7084±2.5392	130.5434±8.9833	1.391±0.126	0.145±0.0081	10.9567±0.8959
SB	O2, 2HR	5	30	CLOSED	6	5.074±0.2593	13.8727±1.0714	24.0207±0.5797	132.42±13.2276	1.34±0.1168	0.134±0.0104	7.48±0.4651
SB	O2, 4HR	5	30	CLOSED	6	5.6402±0.5599	13.0984±0.8686	24.3788±0.6969	131.9134±12.5292	1.375±0.0785	0.135±0.0077	7.6734±0.4591
SB	N2, 2HRS	5	30	CLOSED	6	4.7596±0.4282	13.824±1.2448	23.3432±0.5886	133.1834±9.1523	1.31±0.0884	0.134±0.0112	7.58±0.4107
SB	N2, 4HRS	5	30	CLOSED	6	5.0482±0.3086	13.288±0.8024	23.3844±0.8403	132.48±7.844	1.366±0.1033	0.134±0.0075	7.0334±0.396
SB	O2, 2HR	10	30	CLOSED	6	4.9546±0.4756	12.7797±0.7799	22.6889±0.5686	132.82±11.2716	1.302±0.0739	0.133±0.0078	7.8967±0.6221
SB	O2, 4HR	10	30	CLOSED	6	4.3709±0.372	13.736±1.1981	22.4778±0.4436	132.4467±8.1926	1.333±0.1304	0.133±0.0068	7.84±0.6592
SB	N2, 2HRS	10	30	CLOSED	6	5.375±0.3384	12.91±1.0547	23.66±0.7157	132.5±10.1292	1.367±0.0924	0.133±0.011	7.7967±0.411
SB	N2, 4HRS	10	30	CLOSED	6	5.4914±0.4566	13.4474±0.9643	24.4302±0.8783	133.4267±8.1214	1.353±0.0832	0.133±0.0074	7.2534±0.6975
SB	O2, 2HR	15	30	CLOSED	6	4.9995±0.2548	13.1804±1.2111	23.1794±1.2258	132.33±8.0299	1.373±0.0814	0.135±0.0134	7.0667±0.5838
SB	O2, 4HR	15	30	CLOSED	6	5.1763±0.3464	14.2494±1.1974	24.602±0.4033	132.4534±12.901	1.356±0.1089	0.135±0.011	7.5434±0.7249
SB	N2, 2HRS	15	30	CLOSED	6	5.5058±0.3848	13.7244±1.1889	24.736±0.2024	132.65±7.807	1.334±0.1179	0.134±0.0076	7.41±0.4316
SB	N2, 4HRS	15	30	CLOSED	6	5.497±0.4954	13.4957±1.1195	24.4897±1.0535	131.7734±10.5557	1.317±0.1255	0.134±0.0119	7.93±0.5577
SB	NIL	0	40	CLOSED	6	10.0025±0.7848	16.73±1.3865	36.73±0.1981	120.6367±7.7295	1.328±0.0878	0.148±0.0109	11.5467±0.6848
SB	O2, 2HR	5	40	CLOSED	6	7.4878±0.4612	14.7107±0.9832	29.6863±0.7654	130.7134±10.5043	1.359±0.0996	0.14±0.0128	8.0734±0.6656
SB	O2, 4HR	5	40	CLOSED	6	7.2907±0.7264	14.3517±1.1696	28.9331±0.3264	131.7734±7.3545	1.302±0.071	0.14±0.0079	8.32±0.4819
SB	N2, 2HRS	5	40	CLOSED	6	6.7036±0.4579	14.335±1.4328	27.7422±0.6765	131.6534±9.6366	1.318±0.0998	0.14±0.0094	8.0367±0.7072
SB	N2, 4HRS	5	40	CLOSED	6	7.0411±0.3837	14.0477±0.7755	28.1299±0.5219	131.9167±12.8805	1.307±0.1228	0.139±0.0083	8.7834±0.5831
SB	O2, 2HR	10	40	CLOSED	6	6.956±0.6202	14.5787±0.8758	28.4907±0.4186	131.63±9.4392	1.386±0.0725	0.139±0.0087	8.8367±0.4583
SB	O2, 4HR	10	40	CLOSED	6	6.5546±0.4651	13.786±1.1236	26.8952±0.5852	131.59±11.2489	1.3±0.126	0.141±0.0117	8.1567±0.7786
SB	N2, 2HRS	10	40	CLOSED	6	6.8132±0.3674	14.173±1.2326	27.7994±1.0531	131.1±11.4921	1.398±0.0764	0.139±0.0131	8.5534±0.7253
SB	N2, 4HRS	10	40	CLOSED	6	6.283±0.3983	13.9587±1.1361	26.5247±0.1296	131.4667±11.693	1.393±0.0978	0.14±0.0118	8.0834±0.4833
SB	O2, 2HR	15	40	CLOSED	6	6.9793±0.4017	14.443±0.9877	28.4016±0.3187	131.4267±10.0034	1.338±0.097	0.139±0.0115	8.74±0.4422
SB	O2, 4HR	15	40	CLOSED	6	6.8758±0.6648	13.9724±1.2737	27.724±1.8037	132.0034±7.9742	1.306±0.0927	0.141±0.0098	8.2267±0.5693
SB	N2, 2HRS	15	40	CLOSED	6	7.2317±0.4119	13.852±0.817	28.3154±0.076	132.33±7.6303	1.337±0.0858	0.138±0.0137	8.63±0.7181
SB	N2, 4HRS	15	40	CLOSED	6	6.4001±0.629	14.5194±0.7305	27.3196±0.6491	131.7834±11.8975	1.373±0.0987	0.139±0.0106	8.4434±0.7806
SF	NIL	0	20	CLOSED	6	10.379±0.6721	10.1537±0.961	30.9117±0.6442	125.9167±7.0408	1.378±0.1329	0.145±0.014	11.45±0.6406
SF	O2, 2HR	5	20	CLOSED	6	2.8127±0.205	8.7097±0.7795	14.3351±0.4684	127.97±12.6155	1.342±0.0915	0.132±0.013	6.3234±0.4536
SF	O2, 4HR	5	20	CLOSED	6	2.8379±0.1608	8.2677±0.4825	13.9435±0.224	128.2634±9.2717	1.348±0.0959	0.132±0.008	6.4467±0.5723
SF	N2, 2HRS	5	20	CLOSED	6	2.6713±0.1374	8.8234±0.5609	14.166±0.25	128.9167±11.6752	1.345±0.0971	0.13±0.0129	7.2067±0.4095
SF	N2, 4HRS	5	20	CLOSED	6	2.7749±0.1717	8.272±0.7922	13.8218±0.7044	128.2467±8.8814	1.399±0.0857	0.131±0.0117	7.24±0.6157
SF	O2, 2HR	10	20	CLOSED	6	2.7914±0.2202	8.008±0.4441	13.5908±0.2861	128.45±9.3864	1.357±0.1254	0.132±0.0101	6.5267±0.3731
SF	O2, 4HR	10	20	CLOSED	6	2.8873±0.2758	8.9767±0.5627	14.7513±0.7477	127.8834±7.8189	1.397±0.1254	0.132±0.0096	6.8067±0.5246
SF	N2, 2HRS	10	20	CLOSED	6	2.5344±0.1449	8.1764±0.6446	13.2452±0.0468	128.2167±7.6077	1.31±0.0925	0.13±0.009	6.8967±0.6826
SF	N2, 4HRS	10	20	CLOSED	6	2.7387±0.2118	8.7434±0.7261	14.2208±0.278	128.4367±8.7197	1.358±0.0718	0.131±0.0107	7.1534±0.4908
SF	O2, 2HR	15	20	CLOSED	6	2.9076±0.1686	8.682±0.6952	14.4972±0.0464	128.0034±6.5996	1.346±0.0941	0.132±0.01	6.69±0.5143
SF	O2, 4HR	15	20	CLOSED	6	2.9692±0.1553	8.568±0.4426	14.5064±0.2839	127.5134±10.5762	1.309±0.0881	0.132±0.0087	6.5667±0.4816
SF	N2, 2HRS	15	20	CLOSED	6	2.5785±0.2507	8.4057±0.5398	13.5627±0.4641	128.74±9.9896	1.354±0.0849	0.13±0.0086	6.8667±0.6335
SF	N2, 4HRS	15	20	CLOSED	6	2.6992±0.2625	8.4417±0.8398	13.8401±0.7251	128.0067±9.5201	1.366±0.1181	0.13±0.0122	7.02±0.4267
SF	NIL	0	30	CLOSED	6	10.4267±0.6524	11.0404±0.6253	31.8938±1.2622	125.7134±6.9979	1.327±0.0917	0.145±0.013	11.2134±1.085
SF	O2, 2HR	5	30	CLOSED	6	3.2978±0.3014	9.2627±0.9196	15.8583±0.5454	127.59±7.7505	1.398±0.0859	0.135±0.0129	7.7367±0.7013
SF	O2, 4HR	5	30	CLOSED	6	3.3474±0.1923	8.4884±0.6784	15.1832±0.5476	127.0834±12.094	1.347±0.1035	0.135±0.0123	7.93±0.6274
SF	N2, 2HRS	5	30	CLOSED	6	3.2352±0.1951	9.214±0.8587	15.6844±0.7515	128.3534±12.4608	1.36±0.1106	0.134±0.0078	7.9367±0.4867
SF	N2, 4HRS	5	30	CLOSED	6	3.2647±0.251	8.678±0.841	15.2074±1.0891	127.65±7.8362	1.31±0.0817	0.134±0.0094	7.29±0.7092
SF	O2, 2HR	10	30	CLOSED	6	3.0442±0.2306	8.1697±0.7321	14.2581±0.9456	127.99±10.746	1.392±0.1073	0.133±0.0074	8.1534±0.5475
SF	O2, 4HR	10	30	CLOSED	6	3.1295±0.3017	9.126±0.7154	15.385±0.8094	127.6167±11.6533	1.367±0.1052	0.133±0.0126	8.0967±0.6135
SF	N2, 2HRS	10	30	CLOSED	6	2.9904±0.286	8.34±0.6517	14.2808±0.677	127.67±6.3918	1.308±0.0876	0.133±0.011	8.0534±0.7314
SF	N2, 4HRS	10	30	CLOSED	6	3.0101±0.1584	8.8374±0.5994	14.8576±0.3856	128.5967±10.1328	1.301±0.1062	0.133±0.0077	7.51±0.4128
SF	O2, 2HR	15	30	CLOSED	6	3.3785±0.2884	8.5704±0.4677	15.3274±0.4378	127.5±12.3693	1.307±0.1109	0.136±0.0136	7.3234±0.6818
SF	O2, 4HR	15	30	CLOSED	6	3.4006±0.3222	9.6394±0.896	16.4406±0.945	127.6234±10.9133	1.386±0.0881	0.136±0.0101	7.8±0.664
SF	N2, 2HRS	15	30	CLOSED	6	3.163±0.189	9.1144±0.4925	15.4404±0.3519	127.82±10.0971	1.319±0.1235	0.134±0.0077	7.6667±0.5764
SF	N2, 4HRS	15	30	CLOSED	6	3.1927±0.305	8.8857±0.8437	15.2711±0.0987	126.9434±6.5545	1.386±0.1169	0.134±0.0121	8.1867±0.5332
SF	NIL	0	40	CLOSED	6	10.6195±0.5691	12.12±0.6173	33.359±0.729	115.8067±7.0554	1.301±0.1048	0.148±0.0091	11.8034±0.779
SF	O2, 2HR	5	40	CLOSED	6	3.7771±0.2609	10.1007±0.8181	17.6549±0.496	125.8834±8.6144	1.393±0.1132	0.141±0.0089	8.33±0.4239
SF	O2, 4HR	5	40	CLOSED	6	3.8531±0.2158	9.7417±0.7546	17.4479±1.3311	126.9434±10.7687	1.384±0.1132	0.141±0.0131	8.5767±0.6819
SF	N2, 2HRS	5	40	CLOSED	6	3.7505±0.2834	9.725±0.6319	17.226±0.6245	126.8234±7.554	1.398±0.1319	0.14±0.0096	8.2934±0.4455
SF	N2, 4HRS	5	40	CLOSED	6	3.6503±0.2385	9.4377±0.8611	16.7383±0.6039	127.0867±7.8283	1.352±0.0747	0.138±0.0069	9.04±0.8768
SF	O2, 2HR	10	40	CLOSED	6	3.7091±0.238	9.9687±0.8462	17.3869±1.1379	126.8±6.4114	1.321±0.0939	0.139±0.0135	9.0934±0.7039
SF	O2, 4HR	10	40	CLOSED	6	3.942±0.2687	9.176±0.9084	17.06±1.3734	126.76±10.9614	1.356±0.0836	0.141±0.0091	8.4134±0.5237
SF	N2, 2HRS	10	40	CLOSED	6	3.604±0.2574	9.563±0.7654	16.771±1.3022	126.27±7.2999	1.37±0.0785	0.138±0.0131	8.81±0.675
SF	N2, 4HRS	10	40	CLOSED	6	3.8284±0.3744	9.3487±0.7489	17.0055±0.6991	126.6367±7.3523	1.349±0.1209	0.141±0.0129	8.34±0.7719
SF	O2, 2HR	15	40	CLOSED	6	3.6798±0.3623	9.833±0.7416	17.1926±0.3966	126.5967±7.5698	1.313±0.0997	0.139±0.0078	8.9967±0.8493
SF	O2, 4HR	15	40	CLOSED	6	3.957±0.2895	9.3624±0.7075	17.2764±0.5072	127.1734±10.9787	1.342±0.0943	0.142±0.0106	8.4834±0.7077
SF	N2, 2HRS	15	40	CLOSED	6	3.4344±0.1864	9.242±0.9091	16.1108±0.5098	127.5±11.5935	1.333±0.1153	0.138±0.0072	8.8867±0.5189
SF	N2, 4HRS	15	40	CLOSED	6	3.5461±0.3344	9.9094±0.7265	17.0016±0.11				

RB	N2, 2HRS	5	20	OPEN	7	7.0534±0.4664	11.6357±0.7336	25.7425±0.3827	93.5567±4.7048	1.423±0.0865	0.15±0.0137	12.2434±0.9544
RB	N2, 4HRS	5	20	OPEN	7	7.3503±0.5385	12.1404±1.1877	26.841±0.4404	93.3867±5.6802	1.432±0.0737	0.152±0.0078	11.62±1.1286
RB	O2, 2HR	10	20	OPEN	7	7.3973±0.6578	12.1527±1.1512	26.9473±0.6807	93.3634±7.1536	1.44±0.0769	0.152±0.0111	11.2667±0.6806
RB	O2, 4HR	10	20	OPEN	7	7.5272±0.4542	12.26±1.0966	27.3144±0.652	93.1334±7.8508	1.43±0.081	0.154±0.0078	11.2667±1.0704
RB	N2, 2HRS	10	20	OPEN	7	7.0582±0.4391	12.098±0.8285	26.2144±0.7125	93.53±6.2743	1.459±0.088	0.151±0.013	12.06±0.6988
RB	N2, 4HRS	10	20	OPEN	7	7.1427±0.4317	11.1014±0.7347	25.3868±0.1768	93.4634±6.9027	1.404±0.1286	0.151±0.0151	11.6734±1.1873
RB	O2, 2HR	15	20	OPEN	7	7.4331±0.6071	11.7237±0.9125	26.5899±0.576	93.2534±8.8491	1.409±0.0827	0.153±0.0108	12.3967±0.6353
RB	O2, 4HR	15	20	OPEN	7	7.6511±0.5239	11.5714±0.6097	26.8736±0.5822	93.07±4.9877	1.414±0.0729	0.155±0.0094	12.4267±0.839
RB	N2, 2HRS	15	20	OPEN	7	7.0949±0.505	11.4207±0.9416	25.6105±1.0817	93.5034±5.1141	1.406±0.0744	0.151±0.0103	12.65±0.8878
RB	N2, 4HRS	15	20	OPEN	7	7.2494±0.4234	11.4077±0.6381	25.9065±0.9691	93.4267±8.5355	1.39±0.1074	0.151±0.0124	11.7867±1.1665
RB	NIL	0	30	OPEN	7	13.3469±0.8915	14.7164±1.4209	41.4102±2.1326	80.67±4.424	1.433±0.0776	0.178±0.0178	13.0767±0.8022
RB	O2, 2HR	5	30	OPEN	7	7.9315±0.6717	11.8987±0.9985	27.7617±1.1921	92.1134±5.7661	1.409±0.0956	0.165±0.0086	13.5067±0.932
RB	O2, 4HR	5	30	OPEN	7	8.07±0.4418	13.0614±0.7287	29.2014±0.7217	91.81±6.6262	1.454±0.1245	0.167±0.0098	13.4967±0.9754
RB	N2, 2HRS	5	30	OPEN	7	7.9703±0.6364	12.6824±1.0964	28.623±1.0322	91.9834±9.0904	1.418±0.1366	0.166±0.009	12.5667±1.0818
RB	N2, 4HRS	5	30	OPEN	7	7.996±0.7064	12.0054±1.0176	27.9974±1.3827	91.93±5.2891	1.38±0.1263	0.166±0.0106	13.59±1.0409
RB	O2, 2HR	10	30	OPEN	7	8.0061±0.491	11.981±0.6957	27.9932±1.1881	91.8767±8.9966	1.453±0.1376	0.167±0.0097	13.5734±1.1074
RB	O2, 4HR	10	30	OPEN	7	8.174±0.4489	13.276±0.8673	29.624±0.2584	91.6667±7.4049	1.412±0.1185	0.168±0.0091	13.19±0.8342
RB	N2, 2HRS	10	30	OPEN	7	7.7429±0.522	11.75±1.0796	27.2358±0.7755	92.2934±7.5965	1.382±0.1224	0.163±0.0116	12.0334±0.9587
RB	N2, 4HRS	10	30	OPEN	7	7.6934±0.7636	11.8407±1.1561	27.2275±0.4533	92.3467±7.3271	1.39±0.0914	0.163±0.0082	13.1267±0.9495
RB	O2, 2HR	15	30	OPEN	7	8.1162±0.4749	12.948±1.0205	29.1804±0.7396	91.69±8.0486	1.428±0.0933	0.167±0.0164	12.2634±1.1665
RB	O2, 4HR	15	30	OPEN	7	8.2144±0.4642	13.0604±0.8428	29.4892±0.1353	91.5867±6.2446	1.44±0.101	0.168±0.0159	12.8±0.8607
RB	N2, 2HRS	15	30	OPEN	7	7.776±0.5872	12.537±1.1277	28.089±0.4518	92.2867±8.2344	1.393±0.0857	0.163±0.0098	13.28±1.0212
RB	N2, 4HRS	15	30	OPEN	7	7.8953±0.5799	12.4904±0.6485	28.281±0.9347	92.22±4.6347	1.39±0.0952	0.165±0.0088	12.24±1.0667
RB	NIL	0	40	OPEN	7	13.6982±0.8721	15.617±1.2096	43.0134±0.9335	80.6067±7.7085	1.388±0.1287	0.178±0.0151	13.0867±1.0753
RB	O2, 2HR	5	40	OPEN	7	8.6212±0.7162	12.731±1.053	29.9734±1.578	91.03±7.1245	1.435±0.124	0.175±0.0146	13.77±0.927
RB	O2, 4HR	5	40	OPEN	7	8.6696±0.4612	13.5044±1.1055	30.8436±0.4166	90.8967±4.6703	1.394±0.1174	0.176±0.0145	13.5734±0.9986
RB	N2, 2HRS	5	40	OPEN	7	8.4169±0.8077	12.848±0.847	29.6818±2.1352	91.2334±5.7886	1.398±0.0783	0.173±0.0131	13.434±0.6878
RB	N2, 4HRS	5	40	OPEN	7	8.3199±0.8074	12.3747±1.1176	29.0145±1.2819	91.3967±7.7993	1.436±0.1348	0.17±0.012	13.96±0.7366
RB	O2, 2HR	10	40	OPEN	7	8.4678±0.568	12.9897±1.1178	29.9253±0.8762	91.18±6.8661	1.389±0.1082	0.173±0.0161	14.2067±1.0838
RB	O2, 4HR	10	40	OPEN	7	8.5629±0.7495	13.1±0.8049	30.2258±1.533	91.0767±7.7927	1.439±0.1431	0.174±0.0126	12.7534±0.8615
RB	N2, 2HRS	10	40	OPEN	7	8.2288±0.7924	12.8724±1.134	29.33±1.4457	91.45±6.0278	1.414±0.1148	0.17±0.0092	13.1267±1.0138
RB	N2, 4HRS	10	40	OPEN	7	8.3645±0.6114	13.105±0.6686	29.834±1.3739	91.3667±5.9609	1.462±0.1287	0.17±0.0163	13.47±1.1283
RB	O2, 2HR	15	40	OPEN	7	8.5353±0.6677	12.584±1.007	29.6546±0.3522	91.13±5.3691	1.43±0.0975	0.174±0.0148	14.23±1.1159
RB	O2, 4HR	15	40	OPEN	7	8.6885±0.5772	12.8584±1.099	30.2354±0.5403	90.85±4.6171	1.441±0.0747	0.176±0.0158	14.4934±1.1487
RB	N2, 2HRS	15	40	OPEN	7	8.2573±0.5877	13.028±1.0367	29.5426±0.7785	91.4234±7.5516	1.404±0.0962	0.17±0.0166	13.81±1.0231
RB	N2, 4HRS	15	40	OPEN	7	8.4008±0.7951	13.131±1.0929	29.9326±1.2118	91.3067±6.8456	1.376±0.0834	0.171±0.0113	12.7467±1.085
SB	NIL	0	20	OPEN	7	10.39±0.5676	15.568±1.2873	36.348±0.6442	128.5±6.4571	1.382±0.0721	0.17±0.0143	14.23±1.0469
SB	O2, 2HR	5	20	OPEN	7	8.4316±0.7825	13.8674±0.7456	30.7306±0.9955	130.2134±11.1696	1.342±0.0751	0.152±0.012	11.87±0.8615
SB	O2, 4HR	5	20	OPEN	7	8.4651±0.6991	14.0624±1.3531	30.9926±1.2214	130.1167±11.0425	1.379±0.0702	0.153±0.0078	11.9667±1.106
SB	N2, 2HRS	5	20	OPEN	7	8.2891±0.8261	14.0257±1.2526	30.6039±2.6122	130.5567±11.8554	1.375±0.0741	0.151±0.0116	12.82±0.9454
SB	N2, 4HRS	5	20	OPEN	7	8.3989±0.7753	14.5304±0.7907	31.3282±0.9079	130.3867±8.0806	1.398±0.1068	0.151±0.0103	12.55±0.7956
SB	O2, 2HR	10	20	OPEN	7	8.4109±0.7798	14.5427±0.8695	31.3645±0.1832	130.3634±12.2198	1.39±0.0973	0.152±0.0124	12.3834±0.6883
SB	O2, 4HR	10	20	OPEN	7	8.449±0.5642	14.65±1.3621	31.548±0.1208	130.1334±10.489	1.3±0.0962	0.152±0.0145	11.7734±1.065
SB	N2, 2HRS	10	20	OPEN	7	8.312±0.693	14.488±0.7875	31.112±1.3883	130.53±6.7775	1.366±0.0998	0.151±0.0082	13.1434±0.9332
SB	N2, 4HRS	10	20	OPEN	7	8.3451±0.5254	13.4914±0.972	30.1816±0.5327	130.4634±11.1751	1.33±0.1204	0.151±0.0099	12.1834±0.7352
SB	O2, 2HR	15	20	OPEN	7	8.4262±0.838	14.1137±0.8154	30.9661±0.6711	130.2534±12.9485	1.393±0.0865	0.152±0.0105	11.4734±0.9855
SB	O2, 4HR	15	20	OPEN	7	8.5005±0.7766	13.9614±0.8755	30.9624±2.5105	130.07±12.2555	1.332±0.1218	0.154±0.0123	12.0367±0.7307
SB	N2, 2HRS	15	20	OPEN	7	8.331±0.5192	13.8107±0.785	30.4727±0.6762	130.5034±8.2487	1.368±0.1164	0.151±0.0151	12.3567±0.9506
SB	N2, 4HRS	15	20	OPEN	7	8.3638±0.7191	13.7977±0.6911	30.5253±0.6116	130.4267±7.7881	1.399±0.1018	0.151±0.0149	12.43±0.9466
SB	NIL	0	30	OPEN	7	11.091±0.8843	17.1064±1.1215	39.2884±0.6908	117.67±9.6582	1.335±0.1148	0.176±0.0144	13.0767±1.2053
SB	O2, 2HR	5	30	OPEN	7	8.6008±0.4435	14.2887±1.2289	31.4903±1.3454	129.1134±8.2999	1.374±0.0916	0.161±0.0101	12.31±0.811
SB	O2, 4HR	5	30	OPEN	7	8.6758±0.4563	15.4514±0.8932	32.803±1.3055	128.81±10.3692	1.346±0.1274	0.164±0.0094	13.28±1.1238
SB	N2, 2HRS	5	30	OPEN	7	8.6177±0.4554	15.0724±1.0149	32.3078±0.3847	128.9834±8.0856	1.398±0.12	0.161±0.0149	12.8±1.0271
SB	N2, 4HRS	5	30	OPEN	7	8.6302±0.7377	14.3954±0.8461	31.6558±0.2371	128.93±9.1719	1.325±0.0969	0.162±0.0103	12.5667±1.0502
SB	O2, 2HR	10	30	OPEN	7	8.6469±0.663	14.371±0.933	31.6648±1.8228	128.8767±11.3433	1.339±0.0956	0.163±0.0124	12.0334±0.8985
SB	O2, 4HR	10	30	OPEN	7	8.7324±0.5963	15.666±0.8563	33.1308±0.8474	128.6667±11.3692	1.35±0.0745	0.166±0.0107	13.1267±0.781
SB	N2, 2HRS	10	30	OPEN	7	8.5226±0.5355	14.14±0.8531	31.1852±0.6993	129.2934±6.8826	1.382±0.0842	0.16±0.0124	13.5734±0.821
SB	N2, 4HRS	10	30	OPEN	7	8.5061±0.7845	14.2307±1.1611	31.2429±0.5121	129.3467±7.651	1.3±0.0949	0.16±0.013	13.5067±1.0401
SB	O2, 2HR	15	30	OPEN	7	8.7073±0.4696	15.338±0.7838	32.7526±0.197	128.69±6.8483	1.36±0.0833	0.165±0.0103	13.59±0.9102
SB	O2, 4HR	15	30	OPEN	7	8.7371±0.6469	15.4504±1.4355	32.9246±1.3534	128.5867±8.3469	1.318±0.1186	0.168±0.016	12.24±0.8623
SB	N2, 2HRS	15	30	OPEN	7	8.5514±0.7801	14.927±1.4496	32.0298±2.8959	129.2867±11.5625	1.31±0.131	0.16±0.0097	12.2634±0.6796
SB	N2, 4HRS	15	30	OPEN	7	8.5785±0.6375	14.8804±1.0276	32.0374±0.6549	129.22±7.4515	1.323±0.1001	0.16±0.0105	13.4967±1.1193
SB	NIL	0	40	OPEN	7	11.842±0.8864	18.007±1.7732	41.691±0.4532	117.6067±6.9672	1.314±0.0938	0.176±0.0165	13.3567±0.7333
SB	O2, 2HR	5	40	OPEN	7	8.9139±0.8757	15.121±1.3892	32.9488±1.0866	128.03±10.0567	1.316±0.0907	0.175±0.0152	13.8667±0.808
SB	O2, 4HR	5	40	OPEN	7	8.9379±0.6172	15.8944±0.9008	33.7702±1.2672	127.8967±7.8915	1.351±0.1064	0.175±0.0118	13.4±1.1406
SB	N2, 2HRS	5	40	OPEN	7	8.8527±0.4904	15.238±1.4857	32.9434±1.3519	128.2334±11.6462	1.319±0.0847	0.172±0.0154	13.81±0.9899
SB	N2, 4HRS	5	40	OPEN	7	8.7907±0.5051	14.7647±1.0599	32.3461±1.0904	128.3967±11.0142	1.385±0.0949	0.171±0.0161	14.4934±1.0179
SB	O2, 2HR	10	40	OPEN	7	8.8646±0.6402	15.3797±1.0266	33.1089±1.2955	128.18±7.755	1.319±0.1015	0.173±0.0099	13.96±0.9468
SB	O2, 4HR	10	40	OPEN	7	8.8875±0.6621	15.49±1.5037	33.265±1.8931	128.0767±12.2239	1.339±0.0908	0.175±0.0146	12.7467±0.8582
SB	N2, 2HRS	10	40	OPEN	7	8.7638±0.6957	15.2624±1.5066	32.79±1.1416	128.45±10.4999	1.387±0.1012	0.17±0.0126	13.5734±1.312
SB	N2, 4HRS	10	40	OPEN	7	8.82±0.6361	15.495±1.114	33.135±1.3722	128.3667±11.0865	1.302±0.1159	0.171±0.017	13.43±0.7422
SB	O2, 2HR	15	40	OPEN	7	8.8729±0.8436	14.974±0.8283	32.7198±1.1774	128.13±6.6416	1.363±0.128		

SF	NIL	0	20	OPEN	7	13.5774±1.2041	10.958±0.6682	38.1128±0.5049	122.27±9.107	1.394±0.1179	0.172±0.0166	14.4867±1.0728
SF	O2, 2HR	5	20	OPEN	7	7.9616±0.4809	9.2574±0.7026	25.1806±1.2542	123.9834±8.8942	1.331±0.071	0.154±0.0096	12.1267±0.6572
SF	O2, 4HR	5	20	OPEN	7	8.0393±0.565	9.4524±0.4933	25.531±1.1754	123.8867±9.6999	1.338±0.0938	0.155±0.0087	12.2234±0.8504
SF	N2, 2HRS	5	20	OPEN	7	7.5304±0.4316	9.4157±0.5708	24.4765±0.5716	124.3267±6.8664	1.349±0.1026	0.151±0.0135	13.0767±0.9675
SF	N2, 4HRS	5	20	OPEN	7	7.8273±0.5394	9.9204±0.896	25.575±0.8457	124.1567±6.8134	1.317±0.1188	0.152±0.0079	12.8067±0.7239
SF	O2, 2HR	10	20	OPEN	7	7.8743±0.7387	9.9327±0.7269	25.6813±1.1185	124.1334±8.806	1.338±0.0972	0.153±0.0148	12.64±1.1886
SF	O2, 4HR	10	20	OPEN	7	8.0042±0.5442	10.04±0.6028	26.0484±0.9634	123.9034±11.6263	1.34±0.0977	0.155±0.012	12.03±0.6889
SF	N2, 2HRS	10	20	OPEN	7	7.5352±0.5281	9.878±0.8142	24.9484±0.3582	124.3±10.6373	1.311±0.1051	0.152±0.0136	13.4±1.0388
SF	N2, 4HRS	10	20	OPEN	7	7.6197±0.5468	8.8814±0.6291	24.1208±0.9418	124.2334±7.5346	1.34±0.0831	0.152±0.0117	12.44±0.6981
SF	O2, 2HR	15	20	OPEN	7	7.9101±0.4042	9.5037±0.6044	25.3239±0.773	124.0234±8.3675	1.351±0.1096	0.153±0.0077	11.73±0.5985
SF	O2, 4HR	15	20	OPEN	7	8.1281±0.4609	9.3514±0.8476	25.6076±0.0768	123.84±11.1338	1.351±0.1074	0.155±0.0113	12.2934±0.8547
SF	N2, 2HRS	15	20	OPEN	7	7.5719±0.3842	9.2007±0.7112	24.3445±0.7472	124.2734±7.3431	1.325±0.0922	0.152±0.0079	12.6134±0.9229
SF	N2, 4HRS	15	20	OPEN	7	7.7264±0.7037	9.1877±0.6705	24.6405±0.9993	124.1967±11.4587	1.376±0.0968	0.152±0.0134	12.6867±1.0565
SF	NIL	0	30	OPEN	7	13.8239±0.9102	12.4964±1.1581	40.1442±0.9674	111.44±9.4507	1.395±0.0995	0.179±0.0158	13.334±0.7398
SF	O2, 2HR	5	30	OPEN	7	8.4085±0.5645	9.6787±0.9403	26.4957±0.7623	122.8834±11.9286	1.305±0.1004	0.165±0.0143	13.4467±1.0044
SF	O2, 4HR	5	30	OPEN	7	8.547±0.5095	10.8414±0.8141	27.9354±0.1503	122.58±10.1556	1.373±0.0879	0.169±0.011	13.5367±1.07
SF	N2, 2HRS	5	30	OPEN	7	8.4473±0.5917	10.4624±0.9149	27.357±1.2106	122.7534±10.5681	1.363±0.1252	0.165±0.0145	13.0567±1.0599
SF	N2, 4HRS	5	30	OPEN	7	8.473±0.6021	9.7854±0.5444	26.7314±0.843	122.7±10.0432	1.31±0.1164	0.167±0.0101	12.8234±1.2259
SF	O2, 2HR	10	30	OPEN	7	8.4831±0.5503	9.761±0.4962	26.7272±0.3393	122.6467±6.3266	1.361±0.0948	0.169±0.0159	12.29±0.9917
SF	O2, 4HR	10	30	OPEN	7	8.651±0.6348	11.056±0.6426	28.358±0.5054	122.4367±8.4476	1.378±0.0829	0.171±0.0134	13.3834±1.2612
SF	N2, 2HRS	10	30	OPEN	7	8.2199±0.5352	9.53±0.5902	25.9698±0.9625	123.0634±10.8841	1.33±0.0932	0.163±0.0124	13.83±1.3046
SF	N2, 4HRS	10	30	OPEN	7	8.1704±0.7611	9.6207±0.6613	25.9615±2.0721	123.1167±8.3771	1.352±0.087	0.162±0.01	13.7634±0.8389
SF	O2, 2HR	15	30	OPEN	7	8.5932±0.7096	10.728±0.8972	27.9144±0.3464	122.46±10.2623	1.391±0.0967	0.17±0.0093	13.8467±0.7256
SF	O2, 4HR	15	30	OPEN	7	8.6914±0.5026	10.8404±1.077	28.2232±1.4589	122.3567±10.351	1.317±0.0779	0.171±0.017	12.4967±1.1132
SF	N2, 2HRS	15	30	OPEN	7	8.253±0.4427	10.317±0.7949	26.823±0.3864	123.0567±9.1477	1.341±0.133	0.165±0.0106	12.52±1.0862
SF	N2, 4HRS	15	30	OPEN	7	8.3723±0.7218	10.2704±0.6849	27.015±1.7327	122.99±6.4978	1.376±0.0804	0.165±0.0162	13.7534±1.3218
SF	NIL	0	40	OPEN	7	14.1752±1.2708	13.397±1.2394	41.7474±0.754	111.3767±7.388	1.319±0.1181	0.179±0.0162	13.6134±0.7582
SF	O2, 2HR	5	40	OPEN	7	9.0982±0.8113	10.511±0.9618	28.7074±0.8224	121.8±11.517	1.352±0.1166	0.177±0.0171	14.02±0.855
SF	O2, 4HR	5	40	OPEN	7	9.1466±0.9102	11.2844±0.9513	29.5776±0.8832	121.6667±11.7366	1.38±0.1053	0.177±0.0102	13.6567±0.8661
SF	N2, 2HRS	5	40	OPEN	7	8.8939±0.7841	10.628±0.9956	28.4158±1.1083	122.0034±10.0741	1.391±0.1233	0.175±0.0099	14.0667±1.2005
SF	N2, 4HRS	5	40	OPEN	7	8.7969±0.7849	10.1547±0.7551	27.7485±1.1843	122.1667±7.4474	1.347±0.102	0.173±0.0125	14.75±1.2178
SF	O2, 2HR	10	40	OPEN	7	9.9448±0.5432	10.7697±0.8407	28.6593±1.2684	121.95±7.4217	1.361±0.1083	0.175±0.011	14.2167±1.3687
SF	O2, 4HR	10	40	OPEN	7	9.0399±0.7618	10.88±0.6604	28.9598±0.419	121.8467±8.7258	1.381±0.1348	0.177±0.009	13.0034±0.7511
SF	N2, 2HRS	10	40	OPEN	7	8.7058±0.8232	10.6524±0.6419	28.064±0.6717	122.22±6.7311	1.302±0.123	0.172±0.0106	13.83±1.3299
SF	N2, 4HRS	10	40	OPEN	7	8.8415±0.8579	10.885±0.752	28.568±0.8181	122.1367±8.6875	1.337±0.1173	0.173±0.0102	13.6867±1.1235
SF	O2, 2HR	15	40	OPEN	7	9.0123±0.899	10.364±0.6815	28.3886±1.6515	121.9±7.2068	1.344±0.1122	0.176±0.0168	13.7267±1.3701
SF	O2, 4HR	15	40	OPEN	7	9.1655±0.5905	10.6384±0.6792	28.9694±0.4717	121.62±7.0302	1.35±0.1127	0.178±0.0114	13.4867±1.1118
SF	N2, 2HRS	15	40	OPEN	7	8.7343±0.5865	10.808±0.5592	28.2766±0.7805	122.1934±12.1441	1.374±0.077	0.173±0.0126	13.01±1.2951
SF	N2, 4HRS	15	40	OPEN	7	8.8778±0.6773	10.911±1.0385	28.6666±2.1509	122.0767±10.8237	1.395±0.0772	0.175±0.0116	13.3834±1.0907
RB	NIL	0	20	CLOSED	7	12.6196±0.7572	12.6224±0.6453	37.861±1.1876	91.5567±8.8712	1.46±0.0821	0.168±0.0131	13.4±1.0366
RB	O2, 2HR	5	20	CLOSED	7	4.6914±0.3086	11.2837±0.6998	20.6665±0.8017	94.4434±7.6139	1.406±0.0778	0.143±0.0143	4.8497±0.2761
RB	O2, 4HR	5	20	CLOSED	7	4.7733±0.398	11.1807±0.8917	20.7273±0.0523	94.4134±4.9226	1.42±0.1129	0.144±0.0075	4.2568±0.3245
RB	N2, 2HRS	5	20	CLOSED	7	4.2737±0.3084	11.4077±0.9993	19.9551±1.5349	94.86±5.5734	1.439±0.0999	0.14±0.0118	4.1141±0.3207
RB	N2, 4HRS	5	20	CLOSED	7	4.5448±0.27	11.458±0.7191	20.5476±0.1989	94.5734±5.597	1.455±0.1282	0.141±0.0085	3.4016±0.2248
RB	O2, 2HR	10	20	CLOSED	7	4.6072±0.2662	10.6654±0.6791	19.8798±0.1356	94.5267±6.555	1.401±0.0795	0.142±0.0123	4.6987±0.3641
RB	O2, 4HR	10	20	CLOSED	7	4.871±0.2951	10.584±0.7101	20.326±0.4211	94.39±6.5124	1.442±0.0843	0.144±0.0134	4.2321±0.4064
RB	N2, 2HRS	10	20	CLOSED	7	4.1122±0.4026	10.6857±0.8972	18.9101±0.8051	94.98±9.1609	1.416±0.1212	0.14±0.0112	3.9332±0.2475
RB	N2, 4HRS	10	20	CLOSED	7	4.4672±0.3994	10.769±0.8013	19.7034±0.3458	94.6267±6.8992	1.404±0.1298	0.14±0.0103	3.2312±0.2727
RB	O2, 2HR	15	20	CLOSED	7	4.9085±0.2897	11.419±1.0139	21.236±1.2865	94.3434±7.4794	1.471±0.131	0.144±0.0092	4.4502±0.2956
RB	O2, 4HR	15	20	CLOSED	7	4.9309±0.341	10.6234±0.971	20.4852±0.438	94.25±8.3302	1.461±0.0848	0.144±0.0139	4.1152±0.2272
RB	N2, 2HRS	15	20	CLOSED	7	4.1617±0.3711	10.486±0.7561	18.8094±1.1139	94.9334±5.1914	1.398±0.1118	0.14±0.0106	3.6713±0.25
RB	N2, 4HRS	15	20	CLOSED	7	4.4197±0.3391	10.7487±1.038	19.5881±1.2114	94.73±7.6899	1.4±0.0943	0.14±0.013	3.17±0.1705
RB	NIL	0	30	CLOSED	7	12.9312±0.9385	13.0744±0.9604	38.9368±0.4335	91.5234±5.322	1.46±0.0963	0.169±0.0168	20.3567±1.2056
RB	O2, 2HR	5	30	CLOSED	7	5.4844±0.3455	10.9817±0.7804	21.9505±0.4878	93.7934±8.5156	1.424±0.1292	0.149±0.0094	11.44±1.0241
RB	O2, 4HR	5	30	CLOSED	7	5.58±0.5489	11.53±0.8848	22.69±0.2099	93.7467±7.7125	1.419±0.1035	0.149±0.0142	11.59±0.9132
RB	N2, 2HRS	5	30	CLOSED	7	5.3137±0.323	11.5917±0.8814	22.2191±0.791	93.95±8.792	1.474±0.113	0.147±0.0086	12.1767±1.1883
RB	N2, 4HRS	5	30	CLOSED	7	5.3778±0.4996	10.7497±0.9457	21.5053±1.1669	93.88±7.4712	1.463±0.1276	0.148±0.0111	12.2534±0.8696
RB	O2, 2HR	10	30	CLOSED	7	5.1116±0.4542	10.5114±0.5739	20.7346±0.302	94.0834±7.6444	1.41±0.1364	0.145±0.0111	11.7367±0.6257
RB	O2, 4HR	10	30	CLOSED	7	5.1899±0.3873	11.5187±1.1272	21.8985±0.2765	94.0534±5.4125	1.383±0.0803	0.145±0.0081	11.3567±0.8936
RB	N2, 2HRS	10	30	CLOSED	7	5.0183±0.3826	11.1224±0.8972	21.159±0.5653	94.2334±5.8628	1.42±0.0729	0.145±0.011	10.8267±0.9162
RB	N2, 4HRS	10	30	CLOSED	7	5.0441±0.4711	10.4604±0.5866	20.5486±1.0612	94.1434±4.8815	1.386±0.1354	0.145±0.0105	10.8867±0.7956
RB	O2, 2HR	15	30	CLOSED	7	5.6452±0.3845	10.8817±0.7532	22.1721±0.8537	93.69±5.5256	1.446±0.1254	0.149±0.0093	11.95±0.8342
RB	O2, 4HR	15	30	CLOSED	7	5.6649±0.4793	11.195±0.6241	22.5248±0.726	93.6567±8.2418	1.436±0.1364	0.15±0.0119	12.64±1.0102
RB	N2, 2HRS	15	30	CLOSED	7	5.2437±0.2969	11.8447±0.7007	22.3321±0.5246	94.0234±8.6358	1.418±0.1032	0.146±0.0144	11.03±0.7979
RB	N2, 4HRS	15	30	CLOSED	7	5.2859±0.2753	11.49±0.6629	22.0618±1.1537	93.9767±4.9771	1.44±0.141	0.146±0.0141	10.9067±0.8845
RB	NIL	0	40	CLOSED	7	13.2371±1.1661	16.1037±0.8534	42.5779±2.9505	80.7434±6.3557	1.452±0.1274	0.176±0.0168	13.5667±1.1991
RB	O2, 2HR	5	40	CLOSED	7	6.2272±0.5238	12.6194±0.931	25.0738±1.3457	92.7434±4.9121	1.384±0.1297	0.159±0.0123	12.82±0.9903
RB	O2, 4HR	5	40	CLOSED	7	6.3288±0.4977	12.449±0.7664	25.1066±0.8684	92.5767±8.7743	1.454±0.1174	0.16±0.013	12.1834±0.7624
RB	N2, 2HRS	5	40	CLOSED	7	6.1496±0.3621	12.314±1.1941	24.6132±0.5816	92.7934±7.3955	1.406±0.0951	0.159±0.0102	12.3834±0.8534
RB	N2, 4HRS	5	40	CLOSED	7	5.9741±0.4222	11.884±0.9018	23.8322±0.1702	92.9067±6.9391	1.414±0.0716	0.157±0.0119	11.7734±0.7972
RB	O2, 2HR	10	40	CLOSED	7	6.1012±0.5841	11.958±0.8594	24.1604±1.04	92.87±7.436	1.407±0.1353	0.159±0.0154	13.1434±1.1912
RB	O2, 4HR	10	40	CLOSED	7	6.4153±0.3949	12.5684±1.1376	25.399±0.507	92.4667±5.1772	1.424±0.0741	0.16±0.0157	12.43±1.1991
RB	N2, 2											

RB	O2, 4HR	15	40	CLOSED	7	6.4599±0.5874	12.728±0.7252	25.6478±0.9337	92.3967±5.2819	1.387±0.0767	0.162±0.0111	12.55±1.0846
RB	N2, 2HRS	15	40	CLOSED	7	5.711±0.48	12.1327±0.852	23.5547±0.4422	93.04±7.2062	1.458±0.1175	0.156±0.0141	11.87±1.0841
RB	N2, 4HRS	15	40	CLOSED	7	5.7678±0.4274	12.0547±1.0039	23.5903±0.4027	92.99±9.0641	1.414±0.1194	0.157±0.015	12.0367±0.8023
SB	NIL	0	20	CLOSED	7	11.01±0.7424	15.0124±0.89	37.0324±1.7697	128.5567±8.0754	1.319±0.0983	0.168±0.011	13.77±0.723
SB	O2, 2HR	5	20	CLOSED	7	7.69±0.419	13.6737±1.3383	29.0537±0.5605	131.4434±7.5873	1.3±0.0705	0.144±0.0118	10.7767±0.8845
SB	O2, 4HR	5	20	CLOSED	7	7.7147±0.6096	13.5707±1.274	29.0001±0.7518	131.4134±11.1195	1.354±0.1327	0.144±0.0118	10.1767±0.5772
SB	N2, 2HRS	5	20	CLOSED	7	7.5748±0.3897	13.7977±0.8532	28.9473±0.4824	131.86±11.3874	1.373±0.0707	0.141±0.0074	10.67±0.9192
SB	N2, 4HRS	5	20	CLOSED	7	7.639±0.5601	13.848±1.248	29.126±1.7014	131.5734±9.0888	1.333±0.1265	0.143±0.0097	11.2767±0.7143
SB	O2, 2HR	10	20	CLOSED	7	7.6663±0.6471	13.0554±0.9323	28.388±1.9482	131.5267±12.0324	1.307±0.0965	0.143±0.0073	10.6134±0.573
SB	O2, 4HR	10	20	CLOSED	7	7.7258±0.5641	12.974±0.8057	28.4256±0.6576	131.39±11.059	1.354±0.0758	0.145±0.0128	10.37±0.9449
SB	N2, 2HRS	10	20	CLOSED	7	7.5393±0.5402	13.0757±0.811	28.1543±0.2353	131.98±10.9368	1.391±0.0848	0.14±0.0084	10.96±0.9799
SB	N2, 4HRS	10	20	CLOSED	7	7.6271±0.7182	13.159±0.8328	28.4132±0.622	131.6267±7.1911	1.388±0.0996	0.143±0.0114	11.5667±1.0847
SB	O2, 2HR	15	20	CLOSED	7	7.7451±0.4098	13.809±1.3536	29.2992±0.8709	131.3434±12.7402	1.322±0.0907	0.145±0.0119	11.21±0.9382
SB	O2, 4HR	15	20	CLOSED	7	7.7518±0.7092	13.0134±0.7994	28.517±1.2946	131.25±12.3822	1.376±0.1313	0.146±0.0086	10.24±0.7037
SB	N2, 2HRS	15	20	CLOSED	7	7.5484±0.4167	12.876±1.2042	27.9728±0.8569	131.9334±10.1182	1.379±0.1043	0.14±0.0125	11.5967±0.6984
SB	N2, 4HRS	15	20	CLOSED	7	7.6061±0.5424	13.1387±1.2219	28.3509±0.3109	131.73±6.7723	1.313±0.0985	0.141±0.0133	11.8767±1.0607
SB	NIL	0	30	CLOSED	7	10.372±0.8891	15.4644±1.0342	36.2084±1.3896	128.5234±8.9919	1.378±0.1309	0.169±0.0133	14.2067±0.7693
SB	O2, 2HR	5	30	CLOSED	7	7.9533±0.4805	13.3717±0.6905	29.2783±0.6139	130.7934±11.8602	1.33±0.0965	0.15±0.0075	11.03±0.8108
SB	O2, 4HR	5	30	CLOSED	7	7.9849±0.66	13.92±1.036	29.8898±0.5743	130.7467±7.4375	1.316±0.0732	0.15±0.0086	12.2534±1.1055
SB	N2, 2HRS	5	30	CLOSED	7	7.9082±0.4406	13.9817±0.9288	29.7981±0.5654	130.95±8.1566	1.372±0.113	0.149±0.0132	12.1767±1.0858
SB	N2, 4HRS	5	30	CLOSED	7	7.9246±0.4297	13.1397±1.2517	28.9889±0.433	130.88±6.936	1.31±0.093	0.15±0.0092	10.8267±0.7514
SB	O2, 2HR	10	30	CLOSED	7	7.8122±0.6238	12.9014±0.6664	28.5258±1.2667	131.0834±11.9372	1.333±0.1067	0.146±0.0134	11.95±0.8837
SB	O2, 4HR	10	30	CLOSED	7	7.8245±0.5702	13.9087±0.8422	29.5577±0.6357	131.0534±12.7598	1.389±0.1093	0.148±0.0134	11.59±1.082
SB	N2, 2HRS	10	30	CLOSED	7	7.7704±0.5292	13.5124±1.1409	29.0532±1.9419	131.2334±7.8533	1.318±0.0947	0.146±0.0114	11.44±0.5893
SB	N2, 4HRS	10	30	CLOSED	7	7.7854±0.5276	12.8504±0.9962	28.4212±0.7993	131.1434±11.2359	1.387±0.09	0.146±0.0079	11.7367±0.9717
SB	O2, 2HR	15	30	CLOSED	7	8.0007±0.5884	13.2717±1.0721	29.2731±0.9868	130.69±7.3706	1.311±0.1153	0.151±0.0144	10.8867±0.9435
SB	O2, 4HR	15	30	CLOSED	7	8.0098±0.5317	13.585±0.857	29.6046±1.2987	130.6567±12.7775	1.326±0.1202	0.151±0.0141	10.9067±0.6291
SB	N2, 2HRS	15	30	CLOSED	7	7.8333±0.4573	14.2347±1.0009	29.9013±0.4893	131.0234±8.2659	1.382±0.1037	0.148±0.0092	11.3567±1.0139
SB	N2, 4HRS	15	30	CLOSED	7	7.8509±0.6416	13.88±1.1116	29.5818±1.2571	130.9767±11.3781	1.374±0.1124	0.149±0.0115	12.64±0.8312
SB	NIL	0	40	CLOSED	7	11.654±0.8874	18.4937±1.358	41.8017±1.2931	117.7434±6.1581	1.342±0.1138	0.176±0.0172	13.334±0.8163
SB	O2, 2HR	5	40	CLOSED	7	8.1863±0.7701	15.0094±1.2109	31.382±1.2276	129.7434±9.5732	1.394±0.1188	0.156±0.0124	12.06±0.9981
SB	O2, 4HR	5	40	CLOSED	7	8.2212±0.7633	14.839±0.8049	31.2814±1.6868	129.5767±12.9571	1.356±0.1289	0.158±0.0079	11.62±0.64
SB	N2, 2HRS	5	40	CLOSED	7	8.1481±0.7792	14.704±0.8157	31.0002±0.925	129.7934±10.3311	1.329±0.1079	0.156±0.0115	12.2434±0.6308
SB	N2, 4HRS	5	40	CLOSED	7	8.099±0.4242	14.274±0.8633	30.472±0.8308	129.9067±9.3135	1.38±0.0823	0.155±0.0108	11.54±0.7158
SB	O2, 2HR	10	40	CLOSED	7	8.136±0.527	14.348±1.396	30.62±0.2805	129.87±7.5729	1.395±0.0961	0.156±0.0113	12.4267±0.8124
SB	O2, 4HR	10	40	CLOSED	7	8.2645±0.5134	14.9584±0.7676	31.4874±1.1018	129.4667±7.4852	1.335±0.1031	0.159±0.0142	12.6734±0.9563
SB	N2, 2HRS	10	40	CLOSED	7	8.0885±0.5015	14.7777±1.4134	30.9547±1.1123	129.9534±10.4776	1.358±0.1313	0.155±0.0116	12.3967±1.0721
SB	N2, 4HRS	10	40	CLOSED	7	8.1941±0.6941	14.8427±0.8434	31.2309±0.5514	129.69±11.0938	1.387±0.1142	0.157±0.0106	12.65±0.9745
SB	O2, 2HR	15	40	CLOSED	7	8.1222±0.6558	14.9867±1.2546	31.2311±0.3573	129.88±8.8604	1.327±0.0918	0.156±0.01	11.2667±0.5902
SB	O2, 4HR	15	40	CLOSED	7	8.2775±0.4499	15.118±1.2498	31.673±1.5179	129.3967±6.6249	1.319±0.112	0.16±0.0136	11.7867±0.8493
SB	N2, 2HRS	15	40	CLOSED	7	8.0188±0.6321	14.5227±0.8996	30.5603±0.546	130.04±8.5046	1.374±0.0701	0.154±0.0095	11.2367±0.7685
SB	N2, 4HRS	15	40	CLOSED	7	8.0702±0.5793	14.4447±1.1639	30.5851±0.9991	129.99±6.5649	1.362±0.1074	0.154±0.0086	11.2667±0.6438
SF	NIL	0	20	CLOSED	7	13.0966±1.2381	10.4024±0.7129	36.5956±0.9326	122.3267±9.2916	1.349±0.0682	0.171±0.0086	14.0267±0.8018
SF	O2, 2HR	5	20	CLOSED	7	5.1684±0.414	9.0637±0.5517	19.4005±0.0548	125.2134±10.3639	1.396±0.0861	0.143±0.0109	11.0334±0.7699
SF	O2, 4HR	5	20	CLOSED	7	5.2503±0.5157	8.9607±0.8841	19.4613±0.6649	125.1834±7.1741	1.33±0.125	0.144±0.0125	10.4334±1.0276
SF	N2, 2HRS	5	20	CLOSED	7	4.7507±0.3536	9.1877±0.6021	18.6891±0.717	125.63±10.0546	1.317±0.1268	0.141±0.0095	10.9267±0.6063
SF	N2, 4HRS	5	20	CLOSED	7	5.0218±0.3335	9.238±0.4857	19.2816±0.56	125.3434±8.222	1.337±0.0971	0.143±0.008	11.5334±1.0979
SF	O2, 2HR	10	20	CLOSED	7	5.0842±0.3009	8.4454±0.4552	18.6138±0.5185	125.2967±8.4634	1.359±0.0923	0.143±0.0095	10.87±0.7842
SF	O2, 4HR	10	20	CLOSED	7	5.348±0.3698	8.364±0.776	19.06±0.6869	125.16±7.4146	1.332±0.1028	0.145±0.0109	10.6267±0.8462
SF	N2, 2HRS	10	20	CLOSED	7	4.5892±0.377	8.4657±0.7541	17.6441±0.0724	125.75±12.1986	1.373±0.0796	0.14±0.0094	11.2167±0.6944
SF	N2, 4HRS	10	20	CLOSED	7	4.9442±0.2583	8.549±0.6028	18.4374±0.6114	125.3967±9.1947	1.388±0.112	0.141±0.0112	11.8234±0.6331
SF	O2, 2HR	15	20	CLOSED	7	5.3855±0.321	9.199±0.5118	19.97±0.1214	125.1134±7.1523	1.343±0.0988	0.145±0.0095	11.4667±0.9843
SF	O2, 4HR	15	20	CLOSED	7	5.4079±0.4225	8.4034±0.4895	19.2192±0.7627	125.02±12.0016	1.364±0.1018	0.145±0.0119	10.4967±0.6038
SF	N2, 2HRS	15	20	CLOSED	7	4.6387±0.3237	8.266±0.7559	17.5434±0.5015	125.7034±11.3381	1.348±0.1335	0.141±0.0103	11.8534±0.7869
SF	N2, 4HRS	15	20	CLOSED	7	4.8967±0.4728	8.5287±0.7376	18.3221±0.3187	125.5±7.1437	1.327±0.1047	0.141±0.0086	12.1334±0.9483
SF	NIL	0	30	CLOSED	7	13.4082±1.1698	10.8544±0.6667	37.6708±0.2465	122.2934±9.8679	1.37±0.0746	0.172±0.0156	14.4634±1.1808
SF	O2, 2HR	5	30	CLOSED	7	5.9614±0.3048	8.7617±0.8369	20.6845±0.5484	124.5634±11.5229	1.388±0.075	0.15±0.0095	11.2867±0.7593
SF	O2, 4HR	5	30	CLOSED	7	6.057±0.3203	9.31±0.6735	21.424±0.7447	124.5167±6.3184	1.394±0.1377	0.151±0.0103	12.51±0.851
SF	N2, 2HRS	5	30	CLOSED	7	5.7907±0.5031	9.3717±0.7049	20.9531±0.9819	124.72±6.5675	1.305±0.0741	0.15±0.0125	12.4334±0.6732
SF	N2, 4HRS	5	30	CLOSED	7	5.8548±0.3945	8.5297±0.4296	20.2393±0.5559	124.65±10.0093	1.392±0.103	0.15±0.0088	11.0834±0.8734
SF	O2, 2HR	10	30	CLOSED	7	5.5886±0.5295	8.2914±0.6463	19.4686±1.0442	124.8534±9.0743	1.35±0.0762	0.147±0.0134	12.2067±0.76
SF	O2, 4HR	10	30	CLOSED	7	5.6669±0.3619	9.2987±0.5495	20.6325±0.897	124.8234±6.7689	1.325±0.131	0.147±0.0114	11.8467±0.6266
SF	N2, 2HRS	10	30	CLOSED	7	5.4953±0.5103	8.9024±0.8315	19.893±0.3422	125.0034±8.809	1.315±0.1295	0.146±0.0133	11.6967±0.8376
SF	N2, 4HRS	10	30	CLOSED	7	5.5211±0.3562	8.2404±0.6884	19.2826±1.0684	124.9134±8.797	1.366±0.1243	0.146±0.0093	11.9934±1.0432
SF	O2, 2HR	15	30	CLOSED	7	6.1222±0.3193	8.6617±0.5316	20.9061±0.3204	124.46±11.4493	1.315±0.0934	0.151±0.0097	11.1434±0.8279
SF	O2, 4HR	15	30	CLOSED	7	6.1419±0.495	8.975±0.7011	21.2588±0.2302	124.4267±12.1783	1.316±0.1216	0.147±0.0096	11.1634±1.0356
SF	N2, 2HRS	15	30	CLOSED	7	5.7207±0.5282	9.6247±0.7439	21.0661±0.2224	124.7934±10.3563	1.301±0.0668	0.147±0.0092	11.6134±0.6187
SF	N2, 4HRS	15	30	CLOSED	7	5.7629±0.3121	9.27±0.8396	20.7958±0.7076	124.7467±6.4833	1.338±0.1176	0.148±0.0134	12.8967±0.7737
SF	NIL	0	40	CLOSED	7	13.7141±1.01	13.8837±0.9514	41.3119±0.9606	111.5134±5.6873	1.384±0.0894	0.178±0.0169	13.59±1.2912
SF	O2, 2HR	5	40	CLOSED	7	6.7042±0.6416	10.3994±1.0293	23.8078±1.4697	123.5134±6.6441	1.346±0.0713	0.161±0.0084	12.3167±1.1184
SF	O2, 4HR	5	40	CLOSED	7	6.8058±0.5252	10.229±0.9408	23.8406±1.8005	123.3467±9.1925	1.344±0.1238	0.162±0.0113	11.8767±1.0496
SF	N2, 2HRS											

SF	N2, 2HRS	10	40	CLOSED	7	6.3765±0.426	10.1677±0.9506	22.9207±1.366	123.7234±10.5179	1.352±0.0823	0.159±0.0139	12.6534±0.6972
SF	N2, 4HRS	10	40	CLOSED	7	6.7539±0.4655	10.2327±0.829	23.7405±1.0167	123.46±9.5005	1.308±0.0807	0.161±0.0087	12.9067±0.9035
SF	O2, 2HR	15	40	CLOSED	7	6.4616±0.615	10.3767±0.5991	23.2999±0.0553	123.65±7.0372	1.361±0.1057	0.16±0.0112	11.5234±0.7551
SF	O2, 4HR	15	40	CLOSED	7	6.9369±0.4444	10.508±0.6098	24.3818±0.8789	123.1667±7.4028	1.391±0.1091	0.162±0.0101	12.0434±1.0628
SF	N2, 2HRS	15	40	CLOSED	7	6.188±0.4726	9.9127±0.7516	22.2887±0.1849	123.81±7.369	1.365±0.0962	0.1593±0.0097	11.4934±0.989
SF	N2, 4HRS	15	40	CLOSED	7	6.2448±0.5418	9.8347±0.6876	22.3243±1.492	123.76±12.2484	1.354±0.0916	0.158±0.0107	11.5234±1.0379
RB	NIL	0	20	OPEN	8	16.1422±1.1817	20.2337±1.5687	52.5181±0.8317	77.4934±7.3531	1.437±0.1086	0.237±0.0232	17.9967±1.6034
RB	O2, 2HR	5	20	OPEN	8	8.6509±0.8441	18.9477±1.8856	36.2495±1.1367	80.7434±4.6071	1.435±0.1407	0.208±0.0147	17.0967±1.502
RB	O2, 4HR	5	20	OPEN	8	8.74±0.7783	21.0007±1.5802	38.4807±1.2216	80.9067±4.9347	1.466±0.1262	0.209±0.0179	16.7834±1.1117
RB	N2, 2HRS	5	20	OPEN	8	8.4391±0.599	17.1987±0.9319	34.0769±1.1085	80.9167±6.5805	1.384±0.0798	0.2±0.0188	15.3734±0.8474
RB	N2, 4HRS	5	20	OPEN	8	8.5645±0.8025	18.44±1.1834	35.569±1.3731	78.9267±5.1478	1.414±0.0755	0.205±0.0203	17.2667±1.3402
RB	O2, 2HR	10	20	OPEN	8	8.6035±0.7473	20.3974±1.2863	37.6044±1.4149	79.5167±4.513	1.399±0.0905	0.207±0.0106	16.0167±1.0437
RB	O2, 4HR	10	20	OPEN	8	8.7024±0.8683	17.8134±1.2879	35.2182±0.0387	81.14±6.8102	1.408±0.0753	0.209±0.0155	17.69±1.3273
RB	N2, 2HRS	10	20	OPEN	8	8.4629±0.4351	18.884±1.8454	35.8098±1.4421	80.3334±5.5198	1.463±0.1128	0.202±0.0126	17.07±1.3875
RB	N2, 4HRS	10	20	OPEN	8	8.502±0.4693	18.6417±1.7796	35.6457±1.3253	80.8934±6.2781	1.44±0.1291	0.203±0.0129	16.2234±1.171
RB	O2, 2HR	15	20	OPEN	8	8.6123±0.4758	18.549±1.4322	35.7736±1.2776	79.7834±6.5523	1.398±0.1153	0.207±0.013	17.05±1.0243
RB	O2, 4HR	15	20	OPEN	8	8.7429±0.4511	20.7667±1.0918	38.2525±1.0808	80.1167±6.503	1.381±0.0857	0.211±0.0182	17.71±1.2278
RB	N2, 2HRS	15	20	OPEN	8	8.4812±0.5487	17.74±0.8999	34.7024±0.8908	81.23±6.4113	1.448±0.1065	0.203±0.0145	16.1167±1.1754
RB	N2, 4HRS	15	20	OPEN	8	8.5567±0.6403	17.5877±1.5875	34.7011±1.0438	79.81±5.787	1.41±0.0975	0.204±0.0137	15.4434±1.3894
RB	NIL	0	30	OPEN	8	16.4584±1.0331	22.269±1.9316	55.1858±0.8039	66.1534±4.9638	1.424±0.1053	0.244±0.0187	19.3134±1.4088
RB	O2, 2HR	5	30	OPEN	8	8.9699±0.4641	20.433±1.1368	38.3728±0.3009	78.41±7.262	1.383±0.0912	0.23±0.0221	17.6767±1.3657
RB	O2, 4HR	5	30	OPEN	8	9.069±0.6092	21.1424±1.9985	39.2804±0.2699	79.12±7.7373	1.418±0.0988	0.233±0.0177	17.1±1.6642
RB	N2, 2HRS	5	30	OPEN	8	8.9887±0.4514	20.7987±1.6935	38.7761±0.6352	80.0934±5.7173	1.393±0.0868	0.231±0.0217	18.7367±1.7896
RB	N2, 4HRS	5	30	OPEN	8	9.0131±0.792	21.7314±1.7227	39.7576±0.3863	79.2134±7.5807	1.386±0.1246	0.232±0.0155	18.2767±1.4979
RB	O2, 2HR	10	30	OPEN	8	9.048±0.6918	22.02±1.1022	40.116±2.1678	77.7567±4.0975	1.428±0.1262	0.233±0.021	17.04±1.614
RB	O2, 4HR	10	30	OPEN	8	9.1469±0.6313	21.4354±1.6716	39.7292±0.6353	79.56±4.7886	1.38±0.1271	0.234±0.014	18.5734±1.7639
RB	N2, 2HRS	10	30	OPEN	8	8.8455±0.4648	20.4317±1.0629	38.1227±0.5304	78.8967±6.6161	1.419±0.0859	0.228±0.0178	18.4367±1.536
RB	N2, 4HRS	10	30	OPEN	8	8.8055±0.8459	21.0037±2.0033	38.6147±1.0394	77.8334±4.6879	1.404±0.1157	0.227±0.0119	16.6967±1.5024
RB	O2, 2HR	15	30	OPEN	8	9.1045±0.6014	20.1207±1.0985	38.3297±0.3299	78.03±5.1743	1.445±0.0883	0.233±0.0161	18.48±1.3213
RB	O2, 4HR	15	30	OPEN	8	9.182±0.8416	21.49±1.9316	39.854±2.4191	76.87±5.0575	1.399±0.1238	0.234±0.0125	17.0634±1.6957
RB	N2, 2HRS	15	30	OPEN	8	8.8868±0.6507	19.2704±1.234	37.044±1.4174	79.6134±6.2184	1.424±0.1098	0.229±0.0184	16.9834±0.8875
RB	N2, 4HRS	15	30	OPEN	8	8.9439±0.6465	22.1197±1.6635	40.0075±0.4131	78.2934±7.4721	1.396±0.0957	0.229±0.0211	18.3334±1.0572
RB	NIL	0	40	OPEN	8	17.365±1.682	23.4157±1.3893	58.1457±3.3696	67.4067±5.6288	1.432±0.1064	0.245±0.0241	17.8167±1.3436
RB	O2, 2HR	5	40	OPEN	8	8.9899±0.6869	22.1184±2.0694	41.9182±1.164	78.0567±7.7821	1.442±0.138	0.242±0.0145	18.1534±1.658
RB	O2, 4HR	5	40	OPEN	8	9.9508±0.9098	22.442±1.5008	42.3436±1.5878	76.1467±6.7783	1.415±0.1277	0.243±0.0233	19.25±1.5406
RB	N2, 2HRS	5	40	OPEN	8	9.5393±0.6136	21.7924±1.4195	40.871±0.5265	79.4434±6.4917	1.459±0.1234	0.241±0.0236	18.47±1.7836
RB	N2, 4HRS	5	40	OPEN	8	9.3591±0.4856	20.273±1.7796	38.9912±0.6558	78.81±6.2442	1.466±0.1268	0.239±0.0168	19.19±1.4842
RB	O2, 2HR	10	40	OPEN	8	9.6007±0.5798	22.5244±1.9092	41.7258±0.823	77.9634±7.069	1.472±0.107	0.242±0.0134	19.4267±1.8501
RB	O2, 4HR	10	40	OPEN	8	9.8397±0.675	22.7554±1.8531	42.4348±2.1809	78.4034±5.2121	1.387±0.0806	0.242±0.0171	17.5±1.2426
RB	N2, 2HRS	10	40	OPEN	8	9.248±0.5665	21.2234±1.4521	39.7194±2.7649	79.12±5.888	1.452±0.1329	0.238±0.0134	18.9767±1.0997
RB	N2, 4HRS	10	40	OPEN	8	9.4163±0.6943	20.8404±1.5132	39.673±0.9325	79.3467±6.6143	1.389±0.0768	0.239±0.0235	19.2534±1.4864
RB	O2, 2HR	15	40	OPEN	8	9.7022±0.7432	21.5237±1.6361	40.9281±0.748	79.3567±5.0154	1.469±0.0898	0.242±0.0229	18.57±1.261
RB	O2, 4HR	15	40	OPEN	8	9.9683±0.7918	22.7967±1.4853	42.7333±1.2462	78.6534±4.1563	1.469±0.1015	0.243±0.0189	17.7±1.5585
RB	N2, 2HRS	15	40	OPEN	8	9.3242±0.8052	20.8757±1.7831	39.5241±1.3012	77.2967±7.278	1.395±0.0907	0.239±0.0234	19.0334±1.6748
RB	N2, 4HRS	15	40	OPEN	8	9.4461±0.8874	20.5857±1.2889	39.4779±0.9125	77.6334±6.2168	1.399±0.1289	0.241±0.0125	18.94±1.0748
SB	NIL	0	20	OPEN	8	15.434±1.2044	22.6237±1.5669	46.8245±1.8494	114.4934±11.2726	1.356±0.108	0.235±0.0173	20.63±1.2722
SB	O2, 2HR	5	20	OPEN	8	13.3396±1.0121	21.3377±1.3589	48.0169±2.8681	117.7434±7.7226	1.399±0.1023	0.208±0.0114	18.27±1.2274
SB	O2, 4HR	5	20	OPEN	8	13.5153±1.0695	23.3907±1.9309	50.4213±2.5904	117.9067±8.5238	1.349±0.0696	0.21±0.0199	18.3667±1.2096
SB	N2, 2HRS	5	20	OPEN	8	12.9482±0.9311	19.5887±1.7008	45.4851±1.5649	117.9167±6.6319	1.336±0.1193	0.197±0.0161	19.22±1.2057
SB	N2, 4HRS	5	20	OPEN	8	13.158±1.0641	20.83±1.6361	47.146±2.2285	115.9267±7.0204	1.35±0.1322	0.205±0.0125	18.95±1.0426
SB	O2, 2HR	10	20	OPEN	8	13.1914±0.7221	22.7874±2.2289	49.1702±2.2339	116.5167±9.0162	1.399±0.1357	0.207±0.0184	18.7834±1.2465
SB	O2, 4HR	10	20	OPEN	8	13.4739±1.3408	20.2034±1.1688	47.1512±4.1304	118.14±11.276	1.317±0.1066	0.209±0.0146	18.1734±1.7731
SB	N2, 2HRS	10	20	OPEN	8	13.003±1.0593	21.274±1.0983	47.28±1.0557	117.3334±6.0002	1.305±0.0698	0.198±0.0127	19.5434±1.932
SB	N2, 4HRS	10	20	OPEN	8	13.0969±1.0212	21.0317±1.7099	47.2255±1.4058	117.8934±9.2001	1.394±0.0726	0.198±0.0146	18.5834±0.9647
SB	O2, 2HR	15	20	OPEN	8	13.2822±1.2945	20.939±1.1648	47.5034±3.7199	116.7834±8.7671	1.377±0.1073	0.207±0.0106	17.8734±1.766
SB	O2, 4HR	15	20	OPEN	8	13.5294±1.2459	23.1567±1.8315	50.2155±1.8623	117.1167±7.3862	1.364±0.1333	0.211±0.0122	18.4367±1.1748
SB	N2, 2HRS	15	20	OPEN	8	13.073±0.786	20.13±1.9138	46.276±1.1634	118.23±10.9329	1.364±0.1163	0.198±0.0117	18.7567±1.7091
SB	N2, 4HRS	15	20	OPEN	8	13.1081±1.038	19.9777±1.8891	46.1939±1.3831	116.81±6.4383	1.378±0.0914	0.199±0.0187	18.83±1.4445
SB	NIL	0	30	OPEN	8	16.3469±0.6445	24.659±1.912	49.3528±1.2868	103.1534±5.4069	1.337±0.0784	0.246±0.0147	19.4767±1.1706
SB	O2, 2HR	5	30	OPEN	8	13.8746±1.1626	22.823±2.096	50.5722±1.4739	115.41±6.702	1.39±0.1053	0.22±0.0139	18.57±1.5171
SB	O2, 4HR	5	30	OPEN	8	14.0942±1.2247	23.5324±1.1914	51.7208±3.9984	116.12±6.6945	1.358±0.0743	0.224±0.0118	19.68±1.9253
SB	N2, 2HRS	5	30	OPEN	8	13.97±0.9442	23.1887±1.9893	51.1287±2.6316	117.0934±10.3432	1.367±0.1348	0.221±0.0131	19.2±1.3066
SB	N2, 4HRS	5	30	OPEN	8	14.0192±0.7517	24.1214±1.8454	52.1598±1.3269	116.2134±6.7365	1.31±0.0968	0.223±0.0176	18.9667±1.7679
SB	O2, 2HR	10	30	OPEN	8	14.0401±1.2889	24.41±2.2201	52.4902±1.4753	114.7567±8.4055	1.394±0.0895	0.224±0.0213	18.4334±1.7564
SB	O2, 4HR	10	30	OPEN	8	14.1681±0.9649	23.8254±1.636	52.1616±0.4898	116.56±9.9163	1.388±0.1097	0.226±0.0163	19.5267±1.6403
SB	N2, 2HRS	10	30	OPEN	8	13.6799±1.3535	22.8217±1.3441	50.1815±2.1234	115.8967±9.366	1.374±0.1008	0.216±0.0138	19.9734±1.9168
SB	N2, 4HRS	10	30	OPEN	8	13.5655±0.8863	23.3937±1.3896	50.5247±1.4059	114.8334±6.0988	1.309±0.1031	0.216±0.0121	19.9067±1.8655
SB	O2, 2HR	15	30	OPEN	8	14.1283±1.0227	22.5107±1.8325	50.7673±1.156	115.03±10.4527	1.374±0.1123	0.225±0.0187	19.99±1.3984
SB	O2, 4HR	15	30	OPEN	8	14.2521±1.1498	23.88±1.5373	52.3842±2.0177	113.87±6.2606	1.329±0.125	0.229±0.02	18.64±1.75
SB	N2, 2HRS	15	30	OPEN	8	13.728±0.8563	21.6604±1.0974	49.1164±1.6037	116.6134±9.531	1.313±0.1303	0.217±0.0137	18.6634±1.2505
SB	N2, 4HRS	15	30	OPEN	8	13.7914±1.2316	24.5097±2.1696	52.0925±1.3398	115.2934±9.671	1.365±0.0928	0.218±0.0213	19.8967±1.2287
SB	NIL	0	40	OPEN	8	17.6982±0.6443	25.8057±1.8241	51				

SB	N2, 4HRS	5	40	OPEN	8	14.4062±1.3948	22.663±2.159	51.4754±0.9799	115.81±9.39	1.304±0.0704	0.235±0.0176	20.8934±1.9869
SB	O2, 2HR	10	40	OPEN	8	14.6746±1.132	24.9144±1.2769	54.2636±1.3566	114.9634±8.7383	1.317±0.1314	0.241±0.0193	20.36±1.4251
SB	O2, 4HR	10	40	OPEN	8	14.763±1.1879	25.1454±2.4235	54.6714±1.3586	115.4034±8.4153	1.317±0.0678	0.243±0.0221	19.1467±1.2379
SB	N2, 2HRS	10	40	OPEN	8	14.2822±1.3366	23.6134±1.27	52.1778±1.1717	116.12±9.8063	1.361±0.1115	0.235±0.0171	19.9734±1.6987
SB	N2, 4HRS	10	40	OPEN	8	14.4929±0.8033	23.2304±2.054	52.2162±1.3271	116.3467±10.6944	1.396±0.0709	0.237±0.0173	19.83±1.3451
SB	O2, 2HR	15	40	OPEN	8	14.7138±1.2681	23.9137±2.1937	53.3413±0.9655	116.3567±7.4295	1.397±0.1067	0.242±0.0228	19.87±1.9311
SB	O2, 4HR	15	40	OPEN	8	14.876±1.0214	25.1867±1.9384	54.9387±0.9722	115.6534±10.4334	1.376±0.1217	0.245±0.0198	19.63±1.9344
SB	N2, 2HRS	15	40	OPEN	8	14.3524±1.3389	23.2657±1.5415	51.9705±1.0319	114.2967±8.6035	1.357±0.0981	0.235±0.0226	19.1534±1.2487
SB	N2, 4HRS	15	40	OPEN	8	14.596±0.9866	22.9757±2.2535	52.1677±2.3817	114.6334±5.9444	1.386±0.0697	0.238±0.0226	19.5267±1.6344
SF	NIL	0	20	OPEN	8	16.6192±1.1918	18.0137±1.4085	51.2521±1.5745	108.8234±10.401	1.364±0.1169	0.195±0.0134	20.8867±1.5704
SF	O2, 2HR	5	20	OPEN	8	9.1279±0.4697	16.7277±0.8929	34.9835±0.7004	112.0734±7.2799	1.361±0.073	0.216±0.013	18.5267±1.3364
SF	O2, 4HR	5	20	OPEN	8	9.217±0.8694	18.7807±1.7782	37.2147±2.0564	112.2367±9.2228	1.368±0.1153	0.215±0.0134	18.6234±1.8531
SF	N2, 2HRS	5	20	OPEN	8	8.9161±0.6614	14.9787±0.8362	32.8109±0.5162	112.2467±9.4302	1.329±0.1076	0.22±0.012	19.4767±1.0059
SF	N2, 4HRS	5	20	OPEN	8	9.0415±0.857	16.22±1.2002	34.303±3.21	110.2567±7.5973	1.369±0.0952	0.218±0.018	19.2067±1.006
SF	O2, 2HR	10	20	OPEN	8	9.0805±0.7106	18.1774±1.2751	36.3384±0.4602	110.8467±9.0449	1.367±0.1201	0.218±0.0146	19.04±1.6564
SF	O2, 4HR	10	20	OPEN	8	9.1794±0.7953	15.5934±1.3774	33.9522±1.7205	112.47±7.8417	1.37±0.1104	0.215±0.0121	18.43±1.7112
SF	N2, 2HRS	10	20	OPEN	8	8.9399±0.8791	16.664±1.6403	34.5438±0.4194	111.6634±8.4959	1.323±0.0942	0.22±0.0139	19.8±1.4259
SF	N2, 4HRS	10	20	OPEN	8	8.979±0.8354	16.4217±1.3115	34.3797±1.3759	112.2234±7.2727	1.359±0.1285	0.218±0.0155	18.84±1.7997
SF	O2, 2HR	15	20	OPEN	8	9.0893±0.903	16.329±0.9442	34.5076±0.3278	111.1134±7.8992	1.315±0.0694	0.217±0.0149	18.13±0.9769
SF	O2, 4HR	15	20	OPEN	8	9.2199±0.7842	18.5467±1.1137	36.9865±1.279	111.4467±6.5006	1.312±0.072	0.214±0.0198	18.6934±1.5329
SF	N2, 2HRS	15	20	OPEN	8	8.9582±0.8875	15.52±1.5323	33.4364±0.7873	112.56±6.5056	1.365±0.1031	0.22±0.0173	19.0134±1.2018
SF	N2, 4HRS	15	20	OPEN	8	9.0337±0.5712	15.3677±1.4978	33.4351±1.6139	111.14±8.1113	1.335±0.12	0.218±0.0147	19.0867±1.6974
SF	NIL	0	30	OPEN	8	16.9354±1.1388	20.049±1.527	53.9198±3.1283	97.4834±8.9134	1.303±0.0983	0.185±0.0116	19.7334±1.6042
SF	O2, 2HR	5	30	OPEN	8	9.4469±0.797	18.213±0.9634	37.1068±0.4406	109.74±7.9769	1.338±0.1009	0.201±0.015	19.8467±1.8488
SF	O2, 4HR	5	30	OPEN	8	9.546±0.6809	18.9224±0.9741	38.0144±0.3469	110.45±8.8863	1.393±0.0806	0.198±0.0193	19.9367±1.5808
SF	N2, 2HRS	5	30	OPEN	8	9.4657±0.6653	18.5787±1.4123	37.5101±1.2753	111.4234±9.6255	1.394±0.1165	0.201±0.0131	19.4567±1.0319
SF	N2, 4HRS	5	30	OPEN	8	9.4901±0.593	19.5114±1.8098	38.4916±2.7455	110.5434±10.8573	1.399±0.1255	0.201±0.0125	19.2234±1.0301
SF	O2, 2HR	10	30	OPEN	8	9.525±0.9116	19.8±1.8869	38.85±2.1293	109.0867±8.6449	1.302±0.1219	0.198±0.0184	18.69±1.522
SF	O2, 4HR	10	30	OPEN	8	9.6239±0.8366	19.2154±1.2632	38.4632±1.8734	110.89±6.1955	1.376±0.0759	0.198±0.0192	19.7834±1.0863
SF	N2, 2HRS	10	30	OPEN	8	9.3225±0.8817	18.2117±1.7768	36.8567±1.1067	110.2267±10.921	1.321±0.1097	0.203±0.0134	20.23±1.7214
SF	N2, 4HRS	10	30	OPEN	8	9.2825±0.6491	18.7837±1.6397	37.3487±1.3464	109.1634±7.4126	1.342±0.0731	0.204±0.0102	20.1634±1.6852
SF	O2, 2HR	15	30	OPEN	8	9.5815±0.9481	17.9007±1.7058	37.0637±0.5751	109.36±7.4576	1.34±0.0756	0.198±0.0144	20.2467±1.8554
SF	O2, 4HR	15	30	OPEN	8	9.659±0.7293	19.27±1.8185	38.588±1.2479	108.2±5.8096	1.354±0.07	0.197±0.0122	18.8967±1.6466
SF	N2, 2HRS	15	30	OPEN	8	9.3638±0.6046	17.0504±1.111	35.778±0.7176	110.9434±9.8226	1.369±0.071	0.203±0.0145	18.92±1.1128
SF	N2, 4HRS	15	30	OPEN	8	9.4209±0.9383	19.8997±1.235	38.7415±0.8238	109.6234±10.2565	1.363±0.1153	0.202±0.0168	20.1534±1.7528
SF	NIL	0	40	OPEN	8	17.842±1.6385	21.1957±1.4203	56.8797±2.647	98.7367±8.6695	1.351±0.0798	0.185±0.0133	20.0134±1.1539
SF	O2, 2HR	5	40	OPEN	8	10.3769±0.7986	19.8984±1.9545	40.6522±1.5311	109.3867±9.5144	1.38±0.1111	0.19±0.0122	20.22±1.2062
SF	O2, 4HR	5	40	OPEN	8	10.4278±0.6976	20.222±1.9402	41.0776±1.3324	107.4767±7.3446	1.39±0.0967	0.189±0.0119	20.0567±1.8275
SF	N2, 2HRS	5	40	OPEN	8	10.0163±0.5928	19.5724±1.8878	39.605±0.3308	110.7734±10.5809	1.373±0.0937	0.192±0.0186	20.4667±2.0248
SF	N2, 4HRS	5	40	OPEN	8	9.8361±0.5105	18.053±1.6958	37.7252±1.2731	110.14±8.9401	1.348±0.068	0.193±0.0143	21.15±2.0992
SF	O2, 2HR	10	40	OPEN	8	10.0777±0.6672	20.3044±1.5138	40.4598±1.6343	109.2934±10.8029	1.346±0.1208	0.191±0.0108	20.6167±1.5131
SF	O2, 4HR	10	40	OPEN	8	10.3167±0.6244	20.5354±1.1301	41.1688±1.3178	109.7334±6.4916	1.383±0.0795	0.19±0.0107	19.4034±1.6114
SF	N2, 2HRS	10	40	OPEN	8	9.725±0.7002	19.0034±1.3669	38.4534±1.4239	110.45±9.0978	1.305±0.1014	0.193±0.0151	20.23±1.2922
SF	N2, 4HRS	10	40	OPEN	8	9.8933±0.7111	18.6204±1.3165	38.407±0.6954	110.6767±10.3274	1.306±0.1005	0.192±0.0124	20.0867±1.5328
SF	O2, 2HR	15	40	OPEN	8	10.1792±0.8589	19.3037±1.1736	39.6621±1.4425	110.6867±7.8391	1.353±0.1042	0.191±0.0188	20.1267±1.6574
SF	O2, 4HR	15	40	OPEN	8	10.4453±0.6467	20.5767±1.2522	41.4673±1.2632	109.9834±6.1713	1.381±0.1044	0.187±0.0112	19.8867±1.1758
SF	N2, 2HRS	15	40	OPEN	8	9.8012±0.7119	18.6557±1.007	38.2581±1.457	108.6267±6.026	1.375±0.0884	0.193±0.0169	19.41±1.0957
SF	N2, 4HRS	15	40	OPEN	8	9.9231±0.7891	18.3657±1.506	38.2119±1.3078	108.9634±6.9577	1.349±0.085	0.192±0.0113	19.7834±1.4019
RB	NIL	0	20	CLOSED	8	15.0412±1.0859	22.8587±1.3925	52.9411±0.48	78.22±6.7775	1.386±0.095	0.234±0.0225	18.5834±1.6879
RB	O2, 2HR	5	20	CLOSED	8	7.5364±0.4309	16.7257±1.5449	31.7985±0.8112	83.7534±5.6283	1.465±0.1061	0.187±0.0096	7.826±0.726
RB	O2, 4HR	5	20	CLOSED	8	7.5533±0.386	17.2537±1.2627	32.3603±0.3099	80.68±5.3322	1.456±0.1436	0.188±0.0096	7.4089±0.5663
RB	N2, 2HRS	5	20	CLOSED	8	7.1904±0.6582	17.6617±0.893	32.0425±0.5432	81.82±8.0301	1.446±0.1079	0.183±0.0128	6.6744±0.5578
RB	N2, 4HRS	5	20	CLOSED	8	7.347±0.4284	16.9324±1.3232	31.6264±0.3955	81.7±5.0371	1.44±0.1096	0.187±0.0112	6.3197±0.4865
RB	O2, 2HR	10	20	CLOSED	8	7.5127±0.7378	18.463±1.7494	33.4884±0.6492	83.87±4.2506	1.395±0.0836	0.187±0.0137	7.6641±0.6452
RB	O2, 4HR	10	20	CLOSED	8	7.6033±0.4395	16.6444±1.2367	31.851±0.8746	83.0034±4.5879	1.432±0.1211	0.188±0.0168	6.9143±0.5177
RB	N2, 2HRS	10	20	CLOSED	8	7.1189±0.3749	15.1074±1.2005	29.3452±1.3685	82.7967±6.8395	1.433±0.1028	0.18±0.0167	6.4717±0.3515
RB	N2, 4HRS	10	20	CLOSED	8	7.289±0.613	17.2374±1.1991	31.8154±0.4259	81.03±7.6423	1.398±0.1372	0.187±0.016	6.2889±0.4321
RB	O2, 2HR	15	20	CLOSED	8	7.6375±0.6489	17.7607±1.2411	33.0357±0.5463	82.0034±4.9568	1.396±0.1396	0.189±0.0189	7.4503±0.4314
RB	O2, 4HR	15	20	CLOSED	8	7.6673±0.5532	17.219±1.6105	32.5536±1.087	81.05±7.9442	1.384±0.1018	0.189±0.01	6.794±0.572
RB	N2, 2HRS	15	20	CLOSED	8	7.1585±0.3753	15.6127±0.9694	29.9297±0.7866	84.5967±5.9689	1.408±0.0953	0.181±0.0119	6.4229±0.6002
RB	N2, 4HRS	15	20	CLOSED	8	7.2294±0.4695	15.5964±1.0019	30.0552±0.7261	82.7067±6.6435	1.387±0.1382	0.183±0.0115	6.0233±0.543
RB	NIL	0	30	CLOSED	8	15.6242±1.4464	21.6117±1.8805	52.8601±0.5821	79.32±5.9957	1.451±0.0835	0.237±0.0122	24.3867±1.7573
RB	O2, 2HR	5	30	CLOSED	8	7.9749±0.547	17.8924±1.2523	33.8422±0.739	80.8467±7.853	1.442±0.0991	0.193±0.015	16.2567±0.9441
RB	O2, 4HR	5	30	CLOSED	8	8.0081±0.7055	20.1234±1.2653	36.1396±1.7923	82.7167±6.552	1.445±0.1393	0.193±0.0193	16.3134±0.9024
RB	N2, 2HRS	5	30	CLOSED	8	7.934±0.6005	17.9874±1.7107	33.8554±1.1159	80.6567±7.2069	1.462±0.0765	0.193±0.0111	16.4634±1.338
RB	N2, 4HRS	5	30	CLOSED	8	7.9468±0.557	19.4114±1.3917	35.305±1.2552	81.37±6.2089	1.415±0.0725	0.193±0.0145	15.7667±0.8022
RB	O2, 2HR	10	30	CLOSED	8	7.8077±0.6569	17.4537±1.6522	33.0691±1.2644	82.2134±7.1546	1.462±0.1338	0.191±0.0142	15.73±1.1778
RB	O2, 4HR	10	30	CLOSED	8	7.8261±0.5323	16.9574±1.3927	32.6096±0.4148	82.0067±5.3588	1.47±0.1174	0.191±0.0166	15.2967±1.4692
RB	N2, 2HRS	10	30	CLOSED	8	7.7057±0.7695	17.8747±0.9287	33.2861±0.6312	80.6534±4.8071	1.463±0.1253	0.189±0.0169	15.47±0.9037
RB	N2, 4HRS	10	30	CLOSED	8	7.7383±0.5638	17.1677±1.1025	32.6443±1.0568	81.8967±7.2897	1.415±0.0795	0.191±0.0126	15.7334±1.3138
RB	O2, 2HR	15	30	CLOSED	8	8.0151±0.4114	17.205±1.6593	33.2352±1.1472	80.0434±4.8833	1.473±0.1151	0.195±0.0146	16.5134±1.2167
RB	O2, 4HR	15	30	CLOSED	8	8.05						

RB	O2, 2HR	5	40	CLOSED	8	8.2859±0.5464	18.51±1.7689	35.0818±0.4915	79.7067±7.9051	1.383±0.1077	0.223±0.0125	18.4034±1.7783
RB	O2, 4HR	5	40	CLOSED	8	8.3615±0.8255	21.211±1.9402	37.934±1.7922	78.7834±5.6725	1.382±0.0945	0.226±0.0114	16.8234±1.3236
RB	N2, 2HRS	5	40	CLOSED	8	8.2404±0.5179	20.393±1.3864	36.8738±0.4798	80.844.9924	1.434±0.1334	0.219±0.0202	17.8734±1.7537
RB	N2, 4HRS	5	40	CLOSED	8	8.1466±0.5102	19.7234±1.4976	36.0166±1.2584	78.73±7.5588	1.428±0.0779	0.216±0.0128	17.34±1.1324
RB	O2, 2HR	10	40	CLOSED	8	8.2046±0.6353	18.8567±1.6598	35.2659±1.1244	80.4267±5.7163	1.458±0.1109	0.219±0.0208	16.1567±1.4256
RB	O2, 4HR	10	40	CLOSED	8	8.3744±0.6086	19.662±1.1295	36.4108±1.0898	80.74±5.722	1.42±0.1309	0.227±0.0221	17.6367±0.8876
RB	N2, 2HRS	10	40	CLOSED	8	8.1127±0.7066	20.2084±1.4284	36.4338±1.227	80.2867±7.9934	1.377±0.1297	0.215±0.0109	17.3434±1.7282
RB	N2, 4HRS	10	40	CLOSED	8	8.3189±0.445	21.6397±1.1067	38.2775±0.8203	78.9934±4.0051	1.386±0.1115	0.225±0.0129	16.8567±1.531
RB	O2, 2HR	15	40	CLOSED	8	8.1798±0.5999	19.648±1.5622	36.0076±1.5648	79.2934±4.1482	1.385±0.09	0.216±0.0155	17.21±1.5015
RB	O2, 4HR	15	40	CLOSED	8	8.4231±0.4545	20.5804±1.4876	37.4266±2.4953	80.14±7.0845	1.409±0.1396	0.227±0.0177	17.8034±1.6613
RB	N2, 2HRS	15	40	CLOSED	8	8.0867±0.6488	18.2537±1.42	34.4271±1.3972	79.69±5.1626	1.393±0.0837	0.212±0.017	17.06±0.9893
RB	N2, 4HRS	15	40	CLOSED	8	8.1061±0.6502	18.7397±1.1307	34.9519±1.2847	78.6867±6.3787	1.385±0.074	0.213±0.011	17.3267±1.0461
SB	NIL	0	20	CLOSED	8	12.6196±0.986	25.2487±1.7286	50.4879±1.1924	115.22±9.0259	1.36±0.0819	0.232±0.017	20.17±1.8688
SB	O2, 2HR	5	20	CLOSED	8	11.0051±0.7696	19.1157±1.335	41.1259±1.5507	120.7534±8.7383	1.301±0.1015	0.186±0.0093	17.1767±1.1204
SB	O2, 4HR	5	20	CLOSED	8	11.0975±0.9999	19.6437±1.3125	41.8387±2.198	117.68±10.1542	1.39±0.134	0.188±0.0155	16.5767±1.201
SB	N2, 2HRS	5	20	CLOSED	8	10.6911±0.9058	20.0517±1.021	41.4339±0.5641	118.82±7.2908	1.314±0.1143	0.181±0.0098	17.07±0.9836
SB	N2, 4HRS	5	20	CLOSED	8	10.9231±1.0437	19.3224±1.2568	41.1686±2.3497	118.7±7.4411	1.352±0.0704	0.184±0.0156	17.6767±1.4344
SB	O2, 2HR	10	20	CLOSED	8	10.948±0.5988	20.853±1.508	42.749±2.2843	120.87±10.6306	1.397±0.0855	0.186±0.0168	17.0134±1.0152
SB	O2, 4HR	10	20	CLOSED	8	11.2325±0.7434	19.0344±1.695	41.4994±1.0884	120.0034±6.682	1.319±0.0709	0.188±0.0094	16.77±1.4774
SB	N2, 2HRS	10	20	CLOSED	8	10.5863±0.7393	17.4974±1.0234	38.67±2.5806	119.7967±11.7832	1.332±0.0829	0.18±0.0108	17.36±1.705
SB	N2, 4HRS	10	20	CLOSED	8	10.7608±1.0567	19.6274±1.6577	41.1494±3.9752	118.03±9.7715	1.354±0.0935	0.181±0.0105	17.9667±1.3722
SB	O2, 2HR	15	20	CLOSED	8	11.3168±1.0211	20.1507±1.2138	42.7843±1.262	119.0034±8.5535	1.315±0.1089	0.188±0.0163	17.61±1.6776
SB	O2, 4HR	15	20	CLOSED	8	11.4573±0.9574	19.609±1.4185	42.5236±0.5986	118.05±9.9714	1.339±0.0996	0.188±0.0128	16.64±1.2191
SB	N2, 2HRS	15	20	CLOSED	8	10.6289±0.7067	18.0027±1.457	39.2605±1.3952	121.5967±8.2414	1.373±0.1125	0.18±0.0161	17.9967±1.0693
SB	N2, 4HRS	15	20	CLOSED	8	10.7275±0.8012	17.9864±1.3658	39.4414±0.2378	119.7067±8.7921	1.327±0.0986	0.181±0.0165	18.2767±1.3643
SB	NIL	0	30	CLOSED	8	13.9312±1.2686	24.0017±1.8539	49.8641±0.6497	116.32±8.6726	1.355±0.0818	0.232±0.0161	20.6067±1.9894
SB	O2, 2HR	5	30	CLOSED	8	11.9591±0.6697	20.2824±1.2401	44.2006±1.1205	117.8467±10.9938	1.326±0.1276	0.194±0.0114	17.43±0.8765
SB	O2, 4HR	5	30	CLOSED	8	12.0269±0.6303	22.5134±1.4895	46.5672±2.1071	119.7167±8.6395	1.314±0.1061	0.196±0.0151	18.6534±1.1836
SB	N2, 2HRS	5	30	CLOSED	8	11.8486±1.14	20.3774±1.8903	44.0746±1.594	117.6567±7.747	1.364±0.1338	0.192±0.0124	18.5767±1.7391
SB	N2, 4HRS	5	30	CLOSED	8	11.9319±0.6843	21.8014±1.3594	45.6652±0.7451	118.37±11.5144	1.346±0.1044	0.194±0.0166	17.2267±1.6476
SB	O2, 2HR	10	30	CLOSED	8	11.6633±0.7523	19.8437±1.6159	43.1703±1.7997	119.2134±7.8524	1.353±0.0761	0.191±0.015	18.35±1.1418
SB	O2, 4HR	10	30	CLOSED	8	11.681±0.8977	19.3474±1.3934	42.7094±1.6787	119.0067±9.4199	1.37±0.0788	0.192±0.0161	17.99±0.9944
SB	N2, 2HRS	10	30	CLOSED	8	11.5361±1.0578	20.2647±1.4525	43.3369±2.7197	117.6534±8.4607	1.304±0.1222	0.19±0.0102	17.84±1.2969
SB	N2, 4HRS	10	30	CLOSED	8	11.5588±1.0779	19.5577±1.8902	42.6753±0.3488	118.8967±6.3371	1.356±0.111	0.191±0.0145	18.1367±0.9619
SB	O2, 2HR	15	30	CLOSED	8	12.1643±0.9798	19.595±1.8806	43.9236±2.5056	117.0434±10.2786	1.301±0.122	0.196±0.013	17.2867±1.6403
SB	O2, 4HR	15	30	CLOSED	8	12.2178±0.6111	21.3507±1.2497	45.7863±0.3662	119.1567±10.707	1.317±0.0704	0.197±0.0103	17.3067±1.5321
SB	N2, 2HRS	15	30	CLOSED	8	11.7306±0.8985	20.212±1.3993	43.6732±1.2187	118.9167±9.6492	1.336±0.1234	0.192±0.0159	17.7567±1.4226
SB	N2, 4HRS	15	30	CLOSED	8	11.7953±0.7973	19.6224±1.2119	43.213±2.4081	118.9834±7.2749	1.323±0.0672	0.192±0.0153	19.04±1.4186
SB	NIL	0	40	CLOSED	8	15.8371±1.2079	25.8474±1.7434	50.3216±2.028	104.3534±8.5874	1.303±0.1061	0.245±0.0215	19.7334±1.6257
SB	O2, 2HR	5	40	CLOSED	8	12.7232±0.6491	20.9±1.6056	46.3464±1.2008	116.7067±9.7596	1.322±0.0974	0.214±0.0184	18.46±1.5697
SB	O2, 4HR	5	40	CLOSED	8	12.8661±0.8161	23.601±1.6137	49.3332±1.4208	115.7834±8.0167	1.332±0.0895	0.214±0.0116	18.02±1.2417
SB	N2, 2HRS	5	40	CLOSED	8	12.7073±1.1936	22.783±1.6498	48.1976±0.6911	117.8±7.0597	1.312±0.0905	0.213±0.0172	18.6434±1.5788
SB	N2, 4HRS	5	40	CLOSED	8	12.5189±0.7709	22.1134±2.0249	47.1512±3.3227	115.73±10.391	1.333±0.1029	0.212±0.0155	17.94±1.448
SB	O2, 2HR	10	40	CLOSED	8	12.6492±1.0035	21.2467±1.4255	46.5451±0.4388	117.4267±11.5133	1.303±0.0707	0.213±0.02	18.8267±1.6318
SB	O2, 4HR	10	40	CLOSED	8	12.8712±0.9267	22.052±1.1809	47.7944±1.371	117.74±10.3487	1.398±0.0929	0.214±0.0194	19.0734±1.561
SB	N2, 2HRS	10	40	CLOSED	8	12.449±0.6827	22.5984±1.2474	47.4964±1.0739	117.2867±10.1424	1.324±0.0929	0.212±0.0158	18.7967±1.5095
SB	N2, 4HRS	10	40	CLOSED	8	12.8148±1.0017	24.0297±2.1018	49.6593±0.4944	115.9934±11.2559	1.385±0.1051	0.214±0.0191	19.05±1.7132
SB	O2, 2HR	15	40	CLOSED	8	12.5313±0.9808	22.038±2.1559	47.1006±3.3669	116.2934±11.3618	1.326±0.09	0.213±0.0189	17.6667±1.5869
SB	O2, 4HR	15	40	CLOSED	8	12.8959±1.0151	22.9704±1.4985	48.7622±1.271	117.14±10.2996	1.378±0.0759	0.214±0.0194	18.1867±1.5855
SB	N2, 2HRS	15	40	CLOSED	8	12.2853±0.6518	20.6437±1.4096	45.2143±2.0331	116.69±10.8509	1.356±0.1263	0.211±0.0184	17.6367±0.9945
SB	N2, 4HRS	15	40	CLOSED	8	12.3453±0.85	21.1297±1.7213	45.8203±1.5478	115.6867±6.4376	1.365±0.1358	0.211±0.0184	17.6667±1.3926
SF	NIL	0	20	CLOSED	8	15.5182±1.1927	20.6387±2.0291	51.6751±3.4332	109.55±6.5918	1.32±0.109	0.196±0.01	20.4267±1.1421
SF	O2, 2HR	5	20	CLOSED	8	8.0134±0.6957	14.5057±0.7756	30.5325±0.9674	115.0834±8.1079	1.382±0.0837	0.237±0.0199	17.4334±1.5516
SF	O2, 4HR	5	20	CLOSED	8	8.0303±0.5022	15.0337±1.2069	31.0943±1.3109	112.01±8.1321	1.369±0.0875	0.236±0.0145	16.8334±1.6567
SF	N2, 2HRS	5	20	CLOSED	8	7.6674±0.6743	15.4417±1.2899	30.7765±1.2072	113.15±8.0532	1.377±0.1225	0.246±0.017	17.3267±1.587
SF	N2, 4HRS	5	20	CLOSED	8	7.824±0.7278	14.7124±1.1516	30.3604±1.9464	113.03±6.2531	1.383±0.1217	0.243±0.0128	17.9334±1.4498
SF	O2, 2HR	10	20	CLOSED	8	7.9897±0.6502	16.243±1.5016	32.2224±2.2868	115.2±10.3627	1.398±0.0999	0.239±0.0138	17.27±1.4469
SF	O2, 4HR	10	20	CLOSED	8	8.0803±0.6511	14.4244±1.3033	30.585±1.3338	114.3334±7.8421	1.307±0.0699	0.234±0.0198	17.0267±1.3778
SF	N2, 2HRS	10	20	CLOSED	8	7.5959±0.657	12.8874±1.2617	28.0792±1.3279	114.1267±6.4562	1.335±0.0938	0.247±0.0166	17.6167±1.4811
SF	N2, 4HRS	10	20	CLOSED	8	7.766±0.3888	15.0174±0.8836	30.5494±0.6982	112.36±5.8503	1.306±0.0951	0.244±0.0183	18.2234±1.665
SF	O2, 2HR	15	20	CLOSED	8	8.1145±0.8026	15.5407±1.2249	31.7697±0.541	113.3334±7.6407	1.349±0.1046	0.231±0.0175	17.8667±1.6564
SF	O2, 4HR	15	20	CLOSED	8	8.1443±0.6207	14.999±1.2041	31.2876±0.5723	112.38±10.4424	1.327±0.0682	0.23±0.0155	16.8967±1.4263
SF	N2, 2HRS	15	20	CLOSED	8	7.6355±0.5251	13.3927±0.796	28.6637±0.6661	115.9267±7.1379	1.361±0.0737	0.247±0.0132	18.2534±1.7989
SF	N2, 4HRS	15	20	CLOSED	8	7.7064±0.6517	13.3764±1.1929	28.7892±0.4431	114.0367±11.1788	1.358±0.0875	0.245±0.0176	18.5334±1.7997
SF	NIL	0	30	CLOSED	8	18.1012±0.8184	19.3917±1.6231	51.5941±0.3635	110.65±9.6072	1.331±0.1186	0.196±0.0186	20.8634±1.2698
SF	O2, 2HR	5	30	CLOSED	8	8.4519±0.7085	15.6724±1.5385	32.5762±0.9562	112.1767±10.9701	1.321±0.0869	0.225±0.0203	17.6867±0.9993
SF	O2, 4HR	5	30	CLOSED	8	8.4851±0.6205	17.9034±1.787	34.8736±0.604	114.0467±7.8395	1.375±0.1156	0.225±0.0198	18.91±1.3836
SF	N2, 2HRS	5	30	CLOSED	8	8.411±0.4711	15.7674±0.8468	32.5894±1.5021	111.9867±6.2634	1.308±0.0969	0.226±0.0197	18.8334±1.3376
SF	N2, 4HRS	5	30	CLOSED	8	8.4238±0.5225	17.1914±1.0686	34.039±1.221	112.7±7.6968	1.366±0.1137	0.225±0.0113	17.4834±1.0316
SF	O2, 2HR	10	30	CLOSED	8	8.2847±0.4503	15.2337±1.3195	31.8031±0.6212	113.5434±9.3684	1.322±0.1063	0.228±0.0129	18.6067±1.822
SF	O2, 4HR	10	30	CLOSED	8	8.3031±0.5757	14.7374±1.4723	31.3436±0.5326	113.3367±10.2206	1.396±0.08		

SF	N2, 2HRS	15	30	CLOSED	8	8.318±0.7891	15.602±1.4638	32.238±0.6407	113.2467±7.3666	1.372±0.0698	0.227±0.0129	18.0134±1.4039
SF	N2, 4HRS	15	30	CLOSED	8	8.369±0.4683	15.0124±0.9326	31.7504±1.04	113.3134±8.6099	1.379±0.0797	0.226±0.0168	19.2967±1.338
SF	NIL	0	40	CLOSED	8	19.6978±1.6242	21.2374±1.3656	54.633±1.8313	98.6834±6.8667	1.33±0.0891	0.187±0.0163	19.99±1.3995
SF	O2, 2HR	5	40	CLOSED	8	8.7629±0.5456	16.29±1.1077	33.8158±1.0548	111.0367±7.0983	1.394±0.0965	0.209±0.0165	18.7167±1.8235
SF	O2, 4HR	5	40	CLOSED	8	8.8385±0.6373	18.991±1.2472	36.668±1.3026	110.1134±6.6272	1.355±0.1114	0.205±0.0113	18.2767±0.9738
SF	N2, 2HRS	5	40	CLOSED	8	8.7174±0.6223	18.173±1.4937	35.6078±0.8268	112.13±7.7413	1.313±0.1189	0.209±0.0209	18.9±1.5433
SF	N2, 4HRS	5	40	CLOSED	8	8.6236±0.4325	17.5034±1.4969	34.7506±0.3445	110.06±8.494	1.396±0.1278	0.212±0.0209	18.1967±1.4689
SF	O2, 2HR	10	40	CLOSED	8	8.6816±0.8438	16.6367±1.6019	33.9999±0.0798	111.7567±6.9673	1.383±0.0731	0.211±0.0139	19.0834±1.7604
SF	O2, 4HR	10	40	CLOSED	8	8.8514±0.5729	17.442±1.3828	35.1448±1.2221	112.07±10.6639	1.361±0.0789	0.205±0.0111	19.33±1.6765
SF	N2, 2HRS	10	40	CLOSED	8	8.5897±0.5311	17.9884±1.1029	35.1678±1.1868	111.6167±7.7948	1.375±0.12	0.212±0.0204	19.0534±0.9898
SF	N2, 4HRS	10	40	CLOSED	8	8.7959±0.6322	19.4197±1.027	37.0115±0.6667	110.3234±6.5527	1.32±0.0856	0.207±0.0112	19.3067±1.6823
SF	O2, 2HR	15	40	CLOSED	8	8.6568±0.5008	17.428±0.8783	34.7416±0.8743	110.6234±10.1912	1.372±0.09	0.212±0.0208	19.9234±1.1311
SF	O2, 4HR	15	40	CLOSED	8	8.9001±0.8873	18.3604±1.2303	36.1606±1.8806	111.47±10.4444	1.368±0.0768	0.204±0.0181	18.4434±1.337
SF	N2, 2HRS	15	40	CLOSED	8	8.5637±0.7536	16.0337±1.3277	33.1611±1.3016	111.02±5.7728	1.328±0.0754	0.213±0.0131	17.8934±1.6409
SF	N2, 4HRS	15	40	CLOSED	8	8.5831±0.5698	16.5197±1.3589	33.6859±1.5982	110.0167±8.6114	1.391±0.1052	0.213±0.0193	17.9234±1.5425
RB	NIL	0	20	OPEN	9	28.874±2.3128	35.834±2.5936	93.582±3.4179	54.9134±3.3803	1.446±0.0845	0.832±0.0566	23.7667±1.3537
RB	O2, 2HR	5	20	OPEN	9	11.757±0.8688	30.285±1.6718	53.799±0.9331	61.4734±5.8123	1.461±0.1138	0.675±0.0613	22.1134±1.889
RB	O2, 4HR	5	20	OPEN	9	11.4946±0.6358	30.8464±2.8318	53.8356±3.2571	60.78±4.4874	1.432±0.1261	0.69±0.0603	22.46±1.2516
RB	N2, 2HRS	5	20	OPEN	9	11.8397±0.7377	29.0744±1.8533	52.7538±1.6366	64.0767±3.3321	1.422±0.1408	0.634±0.0414	22.45±1.5453
RB	N2, 4HRS	5	20	OPEN	9	11.3587±0.8958	29.6844±1.8339	52.4018±1.4238	62.3134±4.2272	1.423±0.0929	0.664±0.0401	22.9234±2.0274
RB	O2, 2HR	10	20	OPEN	9	11.5482±0.6202	29.7464±1.5884	52.8428±0.6377	61.9734±6.0299	1.459±0.1253	0.667±0.0603	22.06±1.1394
RB	O2, 4HR	10	20	OPEN	9	12.2504±0.614	30.5477±2.0988	55.0485±1.4298	60.9734±4.6362	1.467±0.0974	0.688±0.0574	21.6567±2.0884
RB	N2, 2HRS	10	20	OPEN	9	11.6224±0.9782	29.153±2.8524	52.3978±1.4907	63.7034±5.7118	1.467±0.125	0.642±0.0619	22.58±1.8821
RB	N2, 4HRS	10	20	OPEN	9	11.1427±0.6966	29.355±1.7233	51.6404±2.2184	63.0167±5.1826	1.421±0.084	0.652±0.0448	22.1467±1.6819
RB	O2, 2HR	15	20	OPEN	9	11.5656±0.63	30.0204±1.818	53.1516±0.9471	61.8267±4.5813	1.425±0.1238	0.675±0.0612	21.86±2.106
RB	O2, 4HR	15	20	OPEN	9	11.9272±0.8872	30.9384±1.6742	54.7928±1.1411	60.4834±4.7426	1.398±0.1324	0.693±0.049	21.7534±1.1115
RB	N2, 2HRS	15	20	OPEN	9	12.0577±1.1974	29.3237±2.8044	53.4391±3.3873	63.38±5.5629	1.385±0.0917	0.65±0.0343	22.48±1.1615
RB	N2, 4HRS	15	20	OPEN	9	12.0882±0.916	29.4994±2.9091	53.6758±1.1549	62.61±4.6648	1.401±0.1326	0.661±0.0635	22.6934±1.1484
RB	NIL	0	30	OPEN	9	32.0112±3.07	38.5657±3.3722	102.5881±0.6152	41.63±3.3873	1.434±0.0963	0.969±0.0811	23.86±2.3782
RB	O2, 2HR	5	30	OPEN	9	13.1111±0.9753	33.7334±2.0389	59.9556±0.3635	56.76±3.7503	1.463±0.1083	0.794±0.056	22.73±1.2303
RB	O2, 4HR	5	30	OPEN	9	13.3201±0.8103	34.645±3.3264	61.2852±1.8843	56.16±5.1286	1.393±0.0983	0.81±0.0572	22.6167±1.2566
RB	N2, 2HRS	5	30	OPEN	9	12.9517±1.098	33.9327±3.2707	59.8361±1.6598	56.5834±4.422	1.384±0.1095	0.797±0.0641	22.46±1.8897
RB	N2, 4HRS	5	30	OPEN	9	12.7747±1.0525	34.1327±3.0836	59.6821±2.8274	56.47±3.0016	1.43±0.1098	0.801±0.0532	23.0867±2.0822
RB	O2, 2HR	10	30	OPEN	9	13.3633±1.1366	34.4397±2.4746	61.1663±2.302	56.1767±4.3751	1.422±0.1221	0.805±0.0784	22.6034±2.1728
RB	O2, 4HR	10	30	OPEN	9	13.3332±0.8567	34.9344±2.9418	61.6008±0.9231	55.7534±4.681	1.441±0.1233	0.813±0.048	23.28±1.8515
RB	N2, 2HRS	10	30	OPEN	9	12.553±1.2067	33.3627±1.686	58.4687±2.2009	57.6634±3.461	1.391±0.0912	0.779±0.046	23.07±2.2796
RB	N2, 4HRS	10	30	OPEN	9	12.902±1.0924	33.0974±2.3298	58.9014±2.5212	57.85±4.5145	1.455±0.0957	0.773±0.0529	23.7467±1.4886
RB	O2, 2HR	15	30	OPEN	9	12.9243±0.8168	34.8287±2.897	60.6773±0.0175	55.95±4.8166	1.411±0.1344	0.811±0.0745	23.29±2.2078
RB	O2, 4HR	15	30	OPEN	9	13.5525±0.9809	35.0507±2.4844	62.1557±0.7278	55.3134±3.9224	1.388±0.0941	0.813±0.0467	22.89±1.4682
RB	N2, 2HRS	15	30	OPEN	9	12.8658±1.1249	33.455±2.8546	59.1866±3.5449	57.3367±4.7908	1.427±0.0928	0.781±0.069	22.81±2.2519
RB	N2, 4HRS	15	30	OPEN	9	13.2397±1.3158	33.531±2.6193	60.0104±4.7512	57.2234±4.8753	1.47±0.0936	0.792±0.0735	23.4667±2.0409
RB	NIL	0	40	OPEN	9	32.228±3.1675	38.6757±3.3675	103.1317±5.114	41.4834±3.6926	1.453±0.0752	0.97±0.0692	23.8234±2.0654
RB	O2, 2HR	5	40	OPEN	9	14.34±1.2663	37.9697±2.0219	66.6497±1.6646	52.52±4.5187	1.387±0.1234	0.932±0.0511	23.0967±1.7166
RB	O2, 4HR	5	40	OPEN	9	13.7456±1.3062	37.998±3.3151	63.4892±1.7382	52.4667±5.239	1.382±0.1114	0.939±0.0639	23.7634±1.6056
RB	N2, 2HRS	5	40	OPEN	9	14.122±1.0361	36.4367±2.6449	64.6611±1.4215	54.4034±4.5475	1.415±0.0709	0.887±0.0492	24.2067±2.2854
RB	O2, 2HR	10	40	OPEN	9	13.5841±1.0221	37.1487±3.2164	64.3169±4.0168	53.5267±4.3581	1.399±0.1315	0.918±0.0502	24.2267±2.3412
RB	O2, 4HR	10	40	OPEN	9	13.8811±0.7631	37.7664±2.359	65.5286±2.1473	52.8334±3.5302	1.386±0.1376	0.929±0.0773	23.59±2.3241
RB	N2, 2HRS	10	40	OPEN	9	13.7073±1.0881	35.973±3.3627	63.3876±1.3324	54.7534±4.6764	1.439±0.1095	0.839±0.0765	24.3367±1.9779
RB	N2, 4HRS	10	40	OPEN	9	13.9191±0.7603	36.5247±2.6488	64.3629±2.7668	53.8667±4.7449	1.403±0.0809	0.892±0.082	23.4±1.7351
RB	O2, 2HR	15	40	OPEN	9	14.5385±1.1467	37.4777±3.3724	66.5547±2.7426	53.09±3.972	1.456±0.0929	0.92±0.0815	23.83±2.0211
RB	O2, 4HR	15	40	OPEN	9	14.8119±1.25	38.1617±3.3961	67.7855±1.6768	52.1867±4.8887	1.411±0.1001	0.943±0.0851	23.1134±1.2934
RB	N2, 2HRS	15	40	OPEN	9	13.7352±1.3006	36.2857±2.8359	63.7561±1.5654	54.6067±5.3561	1.458±0.0928	0.853±0.046	24.0134±1.9583
RB	N2, 4HRS	15	40	OPEN	9	14.0581±0.8269	36.6467±3.4468	64.7629±1.5607	53.69±4.4863	1.421±0.0716	0.912±0.0623	23.28±1.2396
SB	NIL	0	20	OPEN	9	36.1422±0.8152	38.224±1.912	70.5084±0.7963	91.9134±8.6048	1.379±0.1318	0.855±0.0855	28.75±1.6639
SB	O2, 2HR	5	20	OPEN	9	17.3022±1.3971	32.675±1.7492	67.2794±2.4142	98.4734±8.8126	1.32±0.1276	0.719±0.0493	27.24±2.5579
SB	O2, 4HR	5	20	OPEN	9	16.5323±0.8694	33.2364±2.9783	66.301±0.9299	97.78±5.4391	1.389±0.0718	0.745±0.0733	27.0367±1.5896
SB	N2, 2HRS	5	20	OPEN	9	17.2319±1.4931	31.4644±1.8925	65.9282±4.1126	101.0767±8.6639	1.369±0.0803	0.655±0.0357	28.5834±2.1874
SB	N2, 4HRS	5	20	OPEN	9	17.4045±0.9775	32.0744±2.3048	66.8834±1.254	99.3134±8.3319	1.348±0.0921	0.708±0.0418	27.9834±2.0787
SB	O2, 2HR	10	20	OPEN	9	17.3177±1.1539	32.1364±2.9953	66.7718±2.593	98.9734±5.1862	1.39±0.1358	0.711±0.0409	28.0534±2.6884
SB	O2, 4HR	10	20	OPEN	9	16.4025±0.8377	32.9377±2.2874	65.7427±1.8739	97.9734±5.6226	1.325±0.1258	0.723±0.0425	27.52±2.2555
SB	N2, 2HRS	10	20	OPEN	9	16.4211±1.625	31.543±3.146	64.3852±1.28	100.7034±5.312	1.353±0.0785	0.657±0.0512	26.3367±1.6385
SB	N2, 4HRS	10	20	OPEN	9	16.7091±1.4797	31.745±1.7394	65.1632±1.6293	100.0167±8.9732	1.301±0.079	0.692±0.0652	27.0034±1.6115
SB	O2, 2HR	15	20	OPEN	9	16.5706±1.6199	32.4104±2.5823	65.5516±2.6128	98.8267±9.0031	1.316±0.0716	0.712±0.0473	27.5234±1.7099
SB	O2, 4HR	15	20	OPEN	9	17.133±1.5058	33.3284±3.1639	67.5944±3.246	97.4834±9.2701	1.318±0.1038	0.746±0.0745	27.5067±2.146
SB	N2, 2HRS	15	20	OPEN	9	16.3194±1.5143	31.7137±2.3445	64.3525±3.8472	100.38±8.7656	1.327±0.1253	0.676±0.0437	27.39±1.8881
SB	N2, 4HRS	15	20	OPEN	9	17.4791±1.409	31.8894±2.8142	66.8476±2.776	99.61±7.9886	1.326±0.12	0.705±0.0505	27.8167±2.2254
SB	NIL	0	30	OPEN	9	36.4584±0.9796	40.9557±2.2093	73.8725±2.8158	78.63±6.5275	1.363±0.0979	0.948±0.0549	29.4934±1.6926
SB	O2, 2HR	5	30	OPEN	9	16.938±1.6556	36.1234±2.6965	69.9994±5.4058	93.76±7.5451	1.352±0.1317	0.82±0.0528	28.7724±2.3437
SB	O2, 4HR	5	30	OPEN	9	16.6085±1.506	37.035±2.6864	70.252±1.3013	93.16±7.3236	1.369±0.0833	0.84±0.0562	27.1634±2.3465
SB	N2, 2HRS	5	30	OPEN	9	17.2937±1.1647	36.3227±2.0256	70.9101±1.6937	93.5834±5.6842	1.38±0.1186	0.828±0.0568	27.2434±1.6147
SB	N2, 4HRS	5	30	OPEN	9	17.5301±0.9164	36.5227±3.2435	71.5829±3.9824	93.47±8.4336	1.399±0.1227	0.831±0.073	28.9167±1.901
SB	O2, 2HR	10	30	OPEN	9	15.8334±1.069	36.8					

SB	N2, 4HRS	10	30	OPEN	9	17.1295±1.5174	35.4874±2.2116	69.7464±2.3763	94.85±7.4599	1.311±0.0727	0.81±0.0583	27.8567±1.8199
SB	O2, 2HR	15	30	OPEN	9	16.9922±1.3226	37.2187±2.8894	71.2031±2.7631	92.95±8.2569	1.38±0.0974	0.844±0.0643	28.4567±2.4287
SB	O2, 4HR	15	30	OPEN	9	16.9553±1.6499	37.4407±3.0985	71.3513±2.1196	92.3134±7.5006	1.388±0.0829	0.853±0.0527	28.5134±2.6065
SB	N2, 2HRS	15	30	OPEN	9	17.4863±1.0593	35.845±2.0863	70.8176±0.5587	94.3367±4.7336	1.313±0.1302	0.813±0.0707	28.66±2.547
SB	N2, 4HRS	15	30	OPEN	9	17.4243±1.0039	35.921±2.0421	70.7696±0.4783	94.2234±9.227	1.382±0.1339	0.818±0.0569	27.28±2.3664
SB	NIL	0	40	OPEN	9	37.365±1.4929	41.0657±2.1293	75.7957±4.1139	78.4834±4.5408	1.388±0.1369	0.949±0.07	27.5667±1.6981
SB	O2, 2HR	5	40	OPEN	9	16.3044±0.9553	40.3597±2.0733	72.9685±0.264	89.52±8.5384	1.351±0.1133	0.917±0.0856	28.1767±2.3819
SB	O2, 4HR	5	40	OPEN	9	16.9455±0.9884	40.388±3.3563	74.279±3.3526	89.4667±8.1685	1.368±0.1118	0.919±0.0476	28.763±2.3196
SB	N2, 2HRS	5	40	OPEN	9	15.7056±0.9275	39.1604±3.5099	70.5716±1.1018	90.56±8.7657	1.383±0.1345	0.892±0.0836	29.2134±2.396
SB	N2, 4HRS	5	40	OPEN	9	15.8293±1.0975	38.8267±2.7011	70.4853±1.6536	91.4034±7.0378	1.307±0.1138	0.869±0.0452	27.88±1.5305
SB	O2, 2HR	10	40	OPEN	9	17.5482±0.8851	39.5387±3.7972	74.6351±2.8744	90.5267±8.8891	1.339±0.0676	0.901±0.0594	29.37±1.5708
SB	O2, 4HR	10	40	OPEN	9	16.3515±1.4198	40.1564±2.9247	72.8594±2.1607	89.8334±5.8225	1.338±0.106	0.907±0.0459	29.12±2.0031
SB	N2, 2HRS	10	40	OPEN	9	17.0771±1.4323	38.363±3.1924	72.5172±2.4531	91.7534±5.4964	1.393±0.0831	0.857±0.0538	29.43±2.4782
SB	N2, 4HRS	10	40	OPEN	9	17.2704±1.0263	38.9147±2.5979	73.4555±2.6792	90.8667±5.1438	1.363±0.1005	0.869±0.0553	28.65±2.4358
SB	O2, 2HR	15	40	OPEN	9	16.5167±1.3428	39.8677±3.5422	72.9011±1.2187	90.09±5.3538	1.334±0.108	0.905±0.0521	29.4334±2.3171
SB	O2, 4HR	15	40	OPEN	9	17.0335±1.6003	40.5517±2.5875	74.6187±2.0256	89.1867±5.3151	1.35±0.0926	0.936±0.0741	29.09±2.435
SB	N2, 2HRS	15	40	OPEN	9	16.2501±1.0134	38.6757±2.74	71.1759±1.2069	91.6067±9.0169	1.319±0.1235	0.867±0.0804	27.68±2.0786
SB	N2, 4HRS	15	40	OPEN	9	17.1733±1.4776	39.0367±3.7606	73.3833±2.4813	90.69±6.7158	1.361±0.0688	0.885±0.0511	29.1567±2.6762
SF	NIL	0	20	OPEN	9	33.2234±2.1403	33.614±3.2541	80.0608±4.762	85.2434±4.9141	1.346±0.0821	0.87±0.0527	29.0067±1.4924
SF	O2, 2HR	5	20	OPEN	9	12.234±0.7775	28.065±1.9011	52.533±2.3851	91.8034±6.5723	1.333±0.0724	0.682±0.0379	27.4967±1.8989
SF	O2, 4HR	5	20	OPEN	9	11.9716±1.1731	28.6264±2.3088	52.5696±1.6125	91.11±8.2187	1.374±0.1196	0.695±0.0396	27.2934±1.6486
SF	N2, 2HRS	5	20	OPEN	9	12.3167±0.8723	26.8544±2.6743	51.4878±2.0925	94.4067±7.2929	1.329±0.1116	0.641±0.0516	28.84±1.6525
SF	N2, 4HRS	5	20	OPEN	9	11.8357±1.1017	27.4644±1.911	51.1358±1.4105	92.6434±9.2593	1.372±0.129	0.668±0.0553	28.24±2.5108
SF	O2, 2HR	10	20	OPEN	9	12.0252±0.7197	27.5264±2.4295	51.5768±0.9281	92.3034±6.7175	1.368±0.0751	0.68±0.0413	28.31±1.6481
SF	O2, 4HR	10	20	OPEN	9	12.7274±1.1178	28.3277±1.437	53.7825±1.4078	91.3034±5.6787	1.354±0.0989	0.694±0.0586	27.7767±2.1348
SF	N2, 2HRS	10	20	OPEN	9	12.0994±0.8399	26.933±2.3094	51.1318±1.661	94.0334±8.736	1.397±0.1264	0.645±0.0524	26.5934±2.55
SF	N2, 4HRS	10	20	OPEN	9	11.6197±0.9711	27.135±2.3113	50.3744±1.4282	93.3467±7.7577	1.397±0.0928	0.647±0.0586	27.26±1.5442
SF	O2, 2HR	15	20	OPEN	9	12.0426±1.1521	27.8004±2.4311	51.8856±2.125	92.1567±4.9499	1.373±0.1022	0.681±0.0579	27.78±2.3239
SF	O2, 4HR	15	20	OPEN	9	12.4042±0.9829	28.7184±2.6846	53.5268±2.4154	90.8134±7.0078	1.324±0.0679	0.703±0.0511	27.7634±1.6576
SF	N2, 2HRS	15	20	OPEN	9	12.5347±0.8146	27.1037±2.5335	52.1731±2.5428	93.71±5.9756	1.352±0.0833	0.645±0.0592	27.6467±2.3212
SF	N2, 4HRS	15	20	OPEN	9	12.5652±0.7537	27.2794±1.6396	52.4098±2.069	92.94±6.2667	1.392±0.1253	0.647±0.0345	28.0734±2.1143
SF	NIL	0	30	OPEN	9	34.3135±1.9536	36.3457±2.7273	84.9727±6.8434	71.96±3.8908	1.36±0.1121	0.951±0.0667	29.75±1.9087
SF	O2, 2HR	5	30	OPEN	9	13.5881±1.0798	31.5134±2.4255	58.6896±4.4935	87.09±7.8777	1.324±0.0674	0.806±0.0759	29.01±2.3716
SF	O2, 4HR	5	30	OPEN	9	13.7971±1.1173	32.425±1.8574	60.0192±2.9494	86.49±5.1371	1.378±0.1184	0.831±0.0584	27.42±2.4333
SF	N2, 2HRS	5	30	OPEN	9	13.4287±0.8081	31.7127±1.6362	58.5701±0.5916	86.9134±8.2022	1.366±0.1334	0.806±0.0641	27.5±1.4349
SF	N2, 4HRS	5	30	OPEN	9	13.2517±0.9388	31.9127±2.1014	58.4161±1.779	86.8±5.9808	1.397±0.0938	0.808±0.0707	29.1734±2.5695
SF	O2, 2HR	10	30	OPEN	9	13.8403±1.3828	32.2197±2.1572	59.9003±2.8624	86.5067±4.6305	1.312±0.0656	0.817±0.0678	28.8734±2.4404
SF	O2, 4HR	10	30	OPEN	9	13.8102±1.1255	32.7144±2.6478	60.3348±1.6722	86.0834±6.4616	1.31±0.0944	0.842±0.0832	27.1334±2.1172
SF	N2, 2HRS	10	30	OPEN	9	13.03±1.1026	31.1427±1.8535	57.2027±1.5064	87.9934±7.7905	1.398±0.0971	0.79±0.0677	27.4767±2.0781
SF	N2, 4HRS	10	30	OPEN	9	13.379±1.1335	30.8774±2.1904	57.6354±3.9133	88.18±6.6941	1.367±0.1204	0.776±0.0698	28.1134±1.6564
SF	O2, 2HR	15	30	OPEN	9	13.4013±0.9565	32.6087±1.7147	59.4113±1.7288	86.28±5.7268	1.309±0.0825	0.835±0.0674	28.7134±2.7918
SF	O2, 4HR	15	30	OPEN	9	14.0295±1.3287	32.8307±2.9628	60.8897±2.5643	85.6434±7.5186	1.345±0.1189	0.843±0.0603	28.77±2.0915
SF	N2, 2HRS	15	30	OPEN	9	13.3428±0.83	31.235±2.3811	57.9206±0.9507	87.6667±8.578	1.345±0.0946	0.79±0.0519	28.9167±1.8021
SF	N2, 4HRS	15	30	OPEN	9	13.7167±1.0872	31.311±2.4657	58.7444±1.931	87.5534±5.8578	1.317±0.1253	0.793±0.0766	27.5367±1.647
SF	NIL	0	40	OPEN	9	27.477±2.0172	36.4557±2.6243	91.4097±3.6446	71.8134±3.6269	1.319±0.1151	0.953±0.0864	30.8234±1.8398
SF	O2, 2HR	5	40	OPEN	9	14.817±1.0595	35.7497±2.6079	65.3837±2.4798	82.85±4.7869	1.356±0.0803	0.946±0.0526	28.03±2.7231
SF	O2, 4HR	5	40	OPEN	9	14.2226±0.7393	35.778±2.8301	64.2232±1.5518	82.7967±6.2515	1.329±0.0822	0.948±0.0558	29.02±1.6627
SF	N2, 2HRS	5	40	OPEN	9	14.7619±0.8995	34.5504±1.8481	64.0742±1.5406	83.89±6.1347	1.39±0.0863	0.914±0.0892	29.47±2.1118
SF	N2, 4HRS	5	40	OPEN	9	14.5892±1.0987	34.2167±2.5838	63.3951±2.5243	84.7334±4.559	1.333±0.1276	0.89±0.0498	28.1367±2.2534
SF	O2, 2HR	10	40	OPEN	9	14.0611±0.9563	34.9287±2.6257	63.0509±2.2288	83.8567±5.1659	1.307±0.0709	0.914±0.0884	29.6267±1.5244
SF	O2, 4HR	10	40	OPEN	9	14.3581±0.9627	35.5464±2.5371	64.2626±1.5879	83.1634±6.783	1.34±0.1146	0.941±0.081	29.3767±1.9361
SF	N2, 2HRS	10	40	OPEN	9	14.1843±0.7649	33.753±3.0387	62.1216±1.7866	85.0834±6.376	1.337±0.093	0.884±0.048	29.6867±2.6735
SF	N2, 4HRS	10	40	OPEN	9	14.3961±0.7388	34.3047±3.1545	63.0969±2.8529	84.1967±4.3145	1.34±0.1062	0.912±0.0467	28.9067±1.5854
SF	O2, 2HR	15	40	OPEN	9	15.0155±0.789	35.2577±1.9429	65.2887±1.6075	83.42±5.9877	1.36±0.0687	0.934±0.0903	29.69±2.1993
SF	O2, 4HR	15	40	OPEN	9	15.2889±1.4132	35.9417±2.406	66.5195±2.6311	82.5167±5.446	1.304±0.1134	0.948±0.0541	29.3467±1.8682
SF	N2, 2HRS	15	40	OPEN	9	14.2122±1.277	34.0657±3.0101	62.4901±3.4609	84.9367±4.2643	1.361±0.0855	0.89±0.0523	27.9367±2.4169
SF	N2, 4HRS	15	40	OPEN	9	14.5351±1.2665	34.4267±2.6381	63.4969±3.4725	84.02±6.2086	1.31±0.0699	0.914±0.0535	29.4134±2.0986
RB	NIL	0	20	CLOSED	9	23.227±2.2751	35.386±2.2432	81.84±2.048	55.17±4.4904	1.402±0.095	0.818±0.066	23.6467±1.4392
RB	O2, 2HR	5	20	CLOSED	9	9.0135±0.5039	25.9407±2.1107	43.9677±0.8052	67.9767±3.4608	1.402±0.1299	0.554±0.04	21.911±1.428
RB	O2, 4HR	5	20	CLOSED	9	9.2474±0.5138	26.216±2.0934	44.7108±0.2104	67.8267±3.5974	1.393±0.0863	0.559±0.03	21.8399±2.1088
RB	N2, 2HRS	5	20	CLOSED	9	8.4025±0.7994	25.393±2.0933	42.198±0.901	69.3534±4.7951	1.442±0.1272	0.52±0.0301	21.2591±1.2511
RB	N2, 4HRS	5	20	CLOSED	9	8.9184±0.8515	25.7237±1.3011	43.5605±0.7189	68.3567±3.9159	1.415±0.0784	0.546±0.0328	20.8455±1.0462
RB	O2, 2HR	10	20	CLOSED	9	8.7139±0.8003	25.8737±2.4851	43.3015±3.1401	68.14±5.1296	1.397±0.1065	0.551±0.0314	21.9023±1.3386
RB	O2, 4HR	10	20	CLOSED	9	8.9404±0.6245	26.3934±2.0899	44.2742±0.9623	67.5767±5.3446	1.413±0.1315	0.562±0.0554	21.4699±1.19
RB	N2, 2HRS	10	20	CLOSED	9	8.5312±0.6838	25.136±2.3689	42.1984±0.274	69.75±6.0979	1.432±0.1077	0.503±0.0453	20.9496±1.1246
RB	N2, 4HRS	10	20	CLOSED	9	8.5234±0.665	25.654±2.2523	42.7008±1.6871	68.6467±3.7307	1.377±0.0917	0.545±0.0388	20.5665±1.7792
RB	O2, 2HR	15	20	CLOSED	9	9.5568±0.6409	26.4954±2.3716	45.609±1.1089	67.32±4.1677	1.441±0.1212	0.563±0.0559	21.8889±1.2564
RB	O2, 4HR	15	20	CLOSED	9	9.446±0.6227	26.6407±1.4712	45.5327±0.6856	66.9934±4.0526	1.395±0.0796	0.568±0.0479	21.3211±1.622
RB	N2, 2HRS	15	20	CLOSED	9	8.2026±0.5258	25.3±2.2923	41.7052±2.0554	69.5134±6.2973	1.468±0.1043	0.519±0.036	20.8479±1.107
RB	N2, 4HRS	15	20	CLOSED	9	8.5867±0.4927	25.537±1.7106	42.7104±1.2323	69.1±3.6356	1.467±0.0899	0.53±0.0406	20.2562±1.178
RB	NIL	0	30	CLOSED	9	26.012±1.5689	35.6327±2.4606	87.6567±4.8579	55.0067±3.5906	1.439±0.1415	0.831±0.0534	30.8±1.6196
RB	O2, 2HR	5	30	CLOSED	9	10.4063±0.9689	28.516±2.1726	49.3286±2.5594	64.74±4.0871	1.384±0.0805	0.607±0.0405	22.546

RB	O2, 2HR	10	30	CLOSED	9	9.875±0.8567	27.424±2.2889	47.174±0.6972	65.99±4.4516	1.381±0.1042	0.573±0.0565	20.76±1.0838
RB	O2, 4HR	10	30	CLOSED	9	10.5679±1.0512	27.6244±2.7455	48.7602±2.9868	65.83±4.3181	1.459±0.1367	0.574±0.0313	21.91±1.2106
RB	N2, 2HRS	10	30	CLOSED	9	10.062±0.8616	26.8304±1.9709	46.9544±1.5154	66.5567±4.6384	1.457±0.0963	0.571±0.0549	21.9067±1.8612
RB	N2, 4HRS	10	30	CLOSED	9	10.6995±0.5733	27.176±1.417	48.575±1.3819	66.2634±6.1717	1.417±0.1186	0.571±0.045	22.11±1.4181
RB	O2, 2HR	15	30	CLOSED	9	10.3747±0.9539	28.834±1.4694	49.5834±2.821	64.3134±6.3409	1.453±0.1401	0.609±0.0515	22.6667±2.0679
RB	O2, 4HR	15	30	CLOSED	9	10.4451±0.7717	28.9664±2.1937	49.8566±1.806	64.1234±5.2407	1.444±0.1147	0.617±0.0392	21.9767±1.19
RB	N2, 2HRS	15	30	CLOSED	9	10.3283±0.5417	27.9044±1.6888	48.561±0.9099	65.51±3.7093	1.419±0.0914	0.58±0.0382	20.82±1.8756
RB	N2, 4HRS	15	30	CLOSED	9	10.2877±0.8814	28.0264±2.1506	48.6018±1.5001	65.2234±4.7035	1.455±0.1037	0.585±0.041	21.26±1.7128
RB	NIL	0	40	CLOSED	9	27.997±2.1431	38.4474±2.926	94.441±0.6081	42.08±2.4729	1.411±0.0984	0.948±0.053	24.4634±2.4418
RB	O2, 2HR	5	40	CLOSED	9	11.6331±0.7614	32.198±2.9128	55.4642±1.5307	58.7967±4.6986	1.412±0.0787	0.721±0.0389	22.0534±2.168
RB	O2, 4HR	5	40	CLOSED	9	10.8942±0.5741	32.543±2.1996	54.3314±0.0311	58.4334±3.4755	1.453±0.1435	0.73±0.0546	22.7±1.1359
RB	N2, 2HRS	5	40	CLOSED	9	11.5552±1.021	32.125±1.9491	55.2354±1.6041	58.9267±3.2909	1.469±0.1295	0.714±0.0628	21.87±1.1863
RB	N2, 4HRS	5	40	CLOSED	9	11.0775±0.8747	31.3737±1.8544	53.5287±1.1156	59.7134±3.8631	1.391±0.0755	0.708±0.0391	21.7434±1.5457
RB	O2, 2HR	10	40	CLOSED	9	10.7244±0.967	31.816±2.963	53.2648±0.7825	59.16±3.0495	1.454±0.1351	0.713±0.0664	23.5567±1.6059
RB	O2, 4HR	10	40	CLOSED	9	11.0237±0.8485	32.7754±2.1776	54.8228±1.632	58.3034±5.0917	1.39±0.0984	0.732±0.0414	23.4834±1.7751
RB	N2, 2HRS	10	40	CLOSED	9	11.1171±0.8809	31.2367±1.8043	53.4709±1.9066	59.9267±3.7453	1.47±0.1013	0.707±0.0472	23.1267±1.527
RB	N2, 4HRS	10	40	CLOSED	9	11.1405±0.5997	32.3804±1.941	54.6614±1.9683	58.6434±4.7776	1.415±0.1322	0.724±0.0435	23.51±2.0238
RB	O2, 2HR	15	40	CLOSED	9	10.9709±0.9284	31.5637±2.406	53.5055±2.5079	59.4334±3.8276	1.446±0.0931	0.712±0.0402	23.0334±2.1021
RB	O2, 4HR	15	40	CLOSED	9	11.4719±0.6075	32.9437±2.8674	55.8875±0.9514	58.0334±4.1995	1.473±0.0772	0.771±0.0515	23.5834±2.2035
RB	N2, 2HRS	15	40	CLOSED	9	11.0108±0.9773	31.0037±3.0564	53.0253±1.051	60.2067±4.1511	1.403±0.0722	0.697±0.0558	21.92±1.3702
RB	N2, 4HRS	15	40	CLOSED	9	10.3391±0.9408	31.05±2.9	51.7282±3.0452	60.0167±5.8455	1.409±0.0721	0.706±0.0597	22.43±1.9227
SB	NIL	0	20	CLOSED	9	35.0412±1.4705	37.776±2.9643	67.8584±1.8399	92.17±6.8153	1.36±0.0916	0.853±0.0443	28.334±2.1525
SB	O2, 2HR	5	20	CLOSED	9	16.0482±1.1684	28.3307±2.1672	60.4271±4.5703	104.9767±6.6114	1.362±0.1092	0.555±0.0279	24.8334±2.1694
SB	O2, 4HR	5	20	CLOSED	9	16.9085±1.085	28.606±2.4076	62.423±1.9271	104.8267±9.7105	1.386±0.1297	0.565±0.0475	25.3834±1.31
SB	N2, 2HRS	5	20	CLOSED	9	16.492±1.5661	27.783±1.5074	60.767±3.0404	106.3534±10.3377	1.316±0.119	0.51±0.0266	26.2634±2.3889
SB	N2, 4HRS	5	20	CLOSED	9	16.5094±0.9239	28.1137±2.1115	61.1325±0.8781	105.3567±5.637	1.398±0.0991	0.545±0.035	25.5567±1.7525
SB	O2, 2HR	10	20	CLOSED	9	16.9018±0.9019	28.2637±1.5556	62.0673±0.9644	105.14±7.3833	1.34±0.102	0.548±0.0325	25.7034±2.1774
SB	O2, 4HR	10	20	CLOSED	9	16.6221±1.6071	28.7834±2.2188	62.0276±3.0329	104.5767±7.7938	1.361±0.0819	0.569±0.0306	25.4067±2.5052
SB	N2, 2HRS	10	20	CLOSED	9	17.002±1.3503	27.526±1.5286	61.53±2.0167	106.75±10.6143	1.346±0.0717	0.54±0.0465	25.1134±1.6977
SB	N2, 4HRS	10	20	CLOSED	9	16.7975±1.5635	28.044±1.5848	61.639±2.4916	105.6467±6.1	1.378±0.12	0.52±0.0265	26.48±1.6556
SB	O2, 2HR	15	20	CLOSED	9	16.7108±1.3994	28.8854±1.4627	62.307±1.755	104.32±7.5629	1.378±0.0943	0.58±0.039	24.99±1.2919
SB	O2, 4HR	15	20	CLOSED	9	16.8949±1.2518	29.0307±2.873	62.8205±2.7752	103.9934±10.2159	1.359±0.1059	0.588±0.0562	25.9467±1.5297
SB	N2, 2HRS	15	20	CLOSED	9	16.7806±1.2214	27.69±1.8687	61.2512±1.3589	106.5134±5.8558	1.326±0.1285	0.505±0.0408	24.91±2.3822
SB	N2, 4HRS	15	20	CLOSED	9	16.9276±1.6105	27.927±2.1268	61.7822±1.3142	106.1±9.1987	1.319±0.1124	0.514±0.0258	24.8934±1.6816
SB	NIL	0	30	CLOSED	9	35.6242±0.8612	38.0227±3.1402	69.2711±1.2065	92.0067±9.0214	1.351±0.1121	0.855±0.0588	29.6067±2.2843
SB	O2, 2HR	5	30	CLOSED	9	16.462±1.3775	30.906±2.8763	63.83±2.2481	101.74±7.4885	1.376±0.1194	0.639±0.0565	25.2834±1.9641
SB	O2, 4HR	5	30	CLOSED	9	16.9185±1.1211	31.1137±2.1568	64.9507±2.775	101.5867±6.4437	1.374±0.0928	0.641±0.0425	25.9467±1.4969
SB	N2, 2HRS	5	30	CLOSED	9	17.5142±1.5812	30.6477±1.6506	65.6761±2.6107	102.0234±6.3573	1.36±0.1288	0.627±0.0345	26.6434±2.45
SB	N2, 4HRS	5	30	CLOSED	9	16.5838±1.0767	30.7194±1.5721	63.887±1.8202	101.8567±8.7349	1.344±0.1253	0.63±0.0457	25.65±1.4656
SB	O2, 2HR	10	30	CLOSED	9	16.8938±1.1829	29.84±2.1534	63.6016±1.6407	102.99±5.9566	1.305±0.1151	0.6±0.0409	26.6934±1.6784
SB	O2, 4HR	10	30	CLOSED	9	16.5362±1.5133	30.0144±1.8116	63.0868±0.5506	102.83±8.6501	1.3±0.098	0.64±0.0387	26.4934±1.9777
SB	N2, 2HRS	10	30	CLOSED	9	16.6784±1.0863	29.2204±2.0972	62.5772±2.1552	103.5567±5.4501	1.389±0.1134	0.596±0.0446	26.4367±2.2096
SB	N2, 4HRS	10	30	CLOSED	9	16.7303±1.3618	29.566±1.9779	63.0266±2.6412	103.2634±9.1691	1.304±0.0925	0.599±0.0393	25.91±2.4147
SB	O2, 2HR	15	30	CLOSED	9	16.7545±1.5598	31.224±2.2725	64.733±5.7024	101.3134±7.1255	1.336±0.0878	0.643±0.0557	25.9134±2.5147
SB	O2, 4HR	15	30	CLOSED	9	16.8574±1.5275	31.3564±1.6074	65.0712±1.1773	101.1234±8.5001	1.363±0.1199	0.651±0.0525	25.2467±1.6951
SB	N2, 2HRS	15	30	CLOSED	9	16.6931±1.4189	30.2944±2.6313	63.6806±1.5076	102.51±5.3611	1.361±0.0794	0.614±0.0353	25.4767±2.2068
SB	N2, 4HRS	15	30	CLOSED	9	16.3861±1.0695	30.4164±1.7947	63.1886±0.8165	102.2234±5.9802	1.344±0.087	0.623±0.0385	26.3±2.2933
SB	NIL	0	40	CLOSED	9	36.2208±1.1286	40.8374±3.6393	73.279±3.5057	79.08±7.1223	1.357±0.119	0.946±0.0881	29.6567±2.5059
SB	O2, 2HR	5	40	CLOSED	9	16.5457±0.8307	34.588±3.1801	67.6794±0.458	95.7967±7.9684	1.324±0.0759	0.794±0.0488	27.25±2.0303
SB	O2, 4HR	5	40	CLOSED	9	16.7541±1.6077	34.933±2.7628	68.4412±1.1435	95.4334±9.459	1.393±0.114	0.796±0.0686	27.4467±1.4691
SB	N2, 2HRS	5	40	CLOSED	9	16.4946±1.4938	34.515±2.2798	67.5042±3.7629	95.9267±7.928	1.38±0.0763	0.788±0.057	25.5534±1.7242
SB	N2, 4HRS	5	40	CLOSED	9	17.0521±0.9147	33.7637±2.1	67.8679±1.6042	96.7134±7.1376	1.345±0.122	0.777±0.0676	26.9634±2.5018
SB	O2, 2HR	10	40	CLOSED	9	16.9661±1.4504	34.206±2.3937	68.1382±0.3087	96.16±8.3125	1.338±0.0882	0.781±0.0682	27.89±1.8798
SB	O2, 4HR	10	40	CLOSED	9	17.2688±0.9882	35.1654±2.9986	69.703±2.4157	95.3034±5.9657	1.343±0.1213	0.802±0.0525	26.4034±1.9636
SB	N2, 2HRS	10	40	CLOSED	9	16.2278±1.4886	33.6267±2.3988	66.0823±2.4006	96.9267±6.4527	1.34±0.1197	0.753±0.0486	27.23±1.4405
SB	N2, 4HRS	10	40	CLOSED	9	16.871±0.9268	34.7704±2.3905	68.5124±3.9573	95.6434±5.1101	1.369±0.1243	0.795±0.0546	26.2967±1.4514
SB	O2, 2HR	15	40	CLOSED	9	16.1562±0.8688	33.9537±2.7266	66.2661±2.1041	96.4334±6.2512	1.329±0.0897	0.778±0.0475	27.87±1.6571
SB	O2, 4HR	15	40	CLOSED	9	16.6344±0.86	35.3337±3.2079	68.6025±2.1588	95.0334±7.9291	1.348±0.1191	0.809±0.0505	25.6234±2.0181
SB	N2, 2HRS	15	40	CLOSED	9	17.1302±1.0947	33.3937±3.2411	67.6541±2.1188	97.2067±8.2351	1.372±0.1274	0.747±0.038	27.2767±1.3732
SB	N2, 4HRS	15	40	CLOSED	9	16.121±1.598	33.44±2.3746	65.682±2.4837	97.0167±7.0477	1.361±0.1073	0.752±0.0585	26.1967±2.3399
SF	NIL	0	20	CLOSED	9	21.3725±1.7436	33.166±2.4386	75.911±0.6839	85.5±4.3371	1.32±0.1306	0.861±0.0717	28.59±1.4915
SF	O2, 2HR	5	20	CLOSED	9	9.4905±0.6742	23.7207±1.5574	42.7017±2.1504	98.3067±5.7748	1.349±0.1259	0.547±0.0513	25.09±2.2266
SF	O2, 4HR	5	20	CLOSED	9	9.7244±0.7782	23.996±2.1192	43.4448±0.1587	98.1567±9.7044	1.324±0.1247	0.552±0.037	25.64±1.6745
SF	N2, 2HRS	5	20	CLOSED	9	8.8795±0.8208	23.173±1.8508	40.932±1.7622	99.6834±8.549	1.38±0.0885	0.525±0.0477	26.52±2.4174
SF	N2, 4HRS	5	20	CLOSED	9	9.3954±0.6234	23.5037±1.4084	42.2945±0.8738	98.6867±8.5621	1.306±0.0762	0.538±0.0422	25.8134±2.5692
SF	O2, 2HR	10	20	CLOSED	9	9.1909±0.5948	23.6537±2.157	42.0355±1.4706	98.47±8.4933	1.329±0.1095	0.546±0.0541	25.96±1.5247
SF	O2, 4HR	10	20	CLOSED	9	9.4174±0.8885	24.1734±2.1799	43.0082±0.7809	97.9067±6.1906	1.362±0.0725	0.553±0.0541	25.6634±2.0439
SF	N2, 2HRS	10	20	CLOSED	9	9.0082±0.8874	22.916±1.2355	40.9324±0.7699	100.08±8.7062	1.347±0.0863	0.52±0.0455	25.37±2.3259
SF	N2, 4HRS	10	20	CLOSED	9	9.0004±0.7777	23.434±1.1761	41.4348±1.6947	98.9767±8.6297	1.397±0.0887	0.534±0.0359	26.7367±2.3099
SF	O2, 2HR	15	20	CLOSED	9	10.0338±0.8488	24.2754±1.3474	44.343±0.226	97.65±6.5524	1.336±0.1257	0.553±0.0327	25.2467±2.2676
SF	O2, 4HR	15	20	CLOSED	9	9.923±0.8493	24.4207±1.385	44.2667±1.1698	97.3234±8.3474	1.317±0.1005	0.56±0.0473	26.2034±2.2805
SF	N2, 2HRS	15										

SF	O2, 4HR	5	30	CLOSED	9	11.314±1.0947	26.5037±1.4683	49.1317±2.185	94.9167±5.703	1.384±0.072	0.617±0.0608	26.2034±2.383
SF	N2, 2HRS	5	30	CLOSED	9	11.0938±0.6627	26.0377±1.8765	48.2253±0.9901	95.3534±9.2344	1.314±0.1295	0.604±0.0404	26.9±1.9166
SF	N2, 4HRS	5	30	CLOSED	9	10.6471±0.5475	26.1094±1.4854	47.4036±0.6541	95.1867±9.2469	1.362±0.1251	0.611±0.0455	25.9067±2.2066
SF	O2, 2HR	10	30	CLOSED	9	10.352±0.9282	25.204±1.7697	45.908±2.05	96.32±5.4617	1.359±0.1005	0.589±0.0586	26.95±2.0157
SF	O2, 4HR	10	30	CLOSED	9	11.0449±0.619	25.4044±1.3754	47.4942±1.3297	96.16±6.6469	1.346±0.0743	0.59±0.0547	26.75±1.6379
SF	N2, 2HRS	10	30	CLOSED	9	10.539±0.5677	24.6104±1.9421	45.6884±2.5159	96.8867±5.1977	1.356±0.1303	0.563±0.0525	26.6934±1.3856
SF	N2, 4HRS	10	30	CLOSED	9	11.1765±0.9485	24.956±1.4976	47.309±1.9653	96.5934±8.307	1.329±0.1226	0.585±0.0395	26.1667±1.5858
SF	O2, 2HR	15	30	CLOSED	9	10.8517±0.5692	26.614±2.4866	48.3174±1.1436	94.6434±8.5318	1.339±0.0764	0.62±0.0379	26.17±2.5495
SF	O2, 4HR	15	30	CLOSED	9	10.9221±0.7607	26.7464±1.7355	48.5906±1.3457	94.4534±5.9278	1.33±0.0755	0.637±0.0379	25.5034±2.4946
SF	N2, 2HRS	15	30	CLOSED	9	10.8053±0.6539	25.6844±1.5876	47.295±1.4842	95.84±7.2282	1.347±0.1081	0.593±0.046	25.7334±1.3324
SF	N2, 4HRS	15	30	CLOSED	9	10.7647±0.7722	25.8064±1.7801	47.3358±0.9673	95.5534±7.5171	1.327±0.1192	0.603±0.036	26.5567±2.4788
SF	NIL	0	40	CLOSED	9	28.919±2.4733	36.2274±2.2089	94.0654±4.6641	72.41±6.5676	1.375±0.0826	0.948±0.0712	29.9134±2.1304
SF	O2, 2HR	5	40	CLOSED	9	12.1101±0.6868	29.978±2.8194	54.1982±3.5095	89.1267±7.3196	1.396±0.1287	0.757±0.0702	27.5067±1.5466
SF	O2, 4HR	5	40	CLOSED	9	11.3712±1.0885	30.323±2.6739	53.0654±2.5833	88.7634±4.7518	1.331±0.0956	0.762±0.0604	27.7034±2.7285
SF	N2, 2HRS	5	40	CLOSED	9	12.0322±0.8665	29.905±2.0938	53.9694±1.3465	89.2567±5.4271	1.315±0.1095	0.753±0.0569	25.81±1.5741
SF	N2, 4HRS	5	40	CLOSED	9	11.5545±0.707	29.1537±2.2314	52.2627±1.4419	90.0434±7.3654	1.369±0.0753	0.742±0.0673	27.22±2.6975
SF	O2, 2HR	10	40	CLOSED	9	11.2014±0.8224	29.596±2.3071	51.9988±1.446	89.49±7.2207	1.324±0.1166	0.75±0.0624	28.1467±2.7929
SF	O2, 4HR	10	40	CLOSED	9	11.5007±1.1033	30.5554±1.5376	53.5568±2.8395	88.6334±6.7994	1.328±0.1138	0.763±0.0745	26.66±1.4555
SF	N2, 2HRS	10	40	CLOSED	9	11.5941±0.9488	29.0167±2.7146	52.2049±0.9216	90.2567±5.1667	1.398±0.1298	0.725±0.0407	27.4867±1.7225
SF	N2, 4HRS	10	40	CLOSED	9	11.6175±0.7231	30.1604±2.4522	53.3954±1.7388	88.9734±4.5385	1.367±0.0983	0.761±0.0524	26.5534±1.5248
SF	O2, 2HR	15	40	CLOSED	9	11.4479±0.616	29.3437±2.0574	52.2395±1.5231	89.7634±7.8267	1.349±0.1025	0.746±0.0454	28.1267±2.777
SF	O2, 4HR	15	40	CLOSED	9	11.9489±1.1205	30.7237±1.9785	54.6215±0.9156	88.3634±5.1544	1.316±0.1256	0.773±0.0469	25.88±1.4966
SF	N2, 2HRS	15	40	CLOSED	9	11.4878±0.7387	28.7837±2.2338	51.7593±1.5023	90.5367±6.1758	1.381±0.0726	0.703±0.0601	27.5334±1.9669
SF	N2, 4HRS	15	40	CLOSED	9	10.8161±1.0038	28.83±2.5494	50.4622±4.9383	90.3467±6.3742	1.338±0.0713	0.714±0.0607	26.4534±1.9932

Table 4.1aA: Change in residual antioxidant activity of oil during storage at different temperatures with and without nanoparticles

Oil Type	Temperature (°C)	Storage condition	Storage period (no. of weeks)	% Antioxidant Activity Retained for Nanoceria dose (ppm)			
				0	5	10	15
RB	20	Open	0	100	100	100	100
RB	20	Open	1	87.03	100	95.58	98.82
RB	20	Open	2	80.39	98.07	91.15	97.76
RB	20	Open	3	69.34	86.87	87.04	93.87
RB	20	Open	4	59.34	77.26	81.9	91.38
RB	20	Open	5	48.92	68.38	80.25	88.43
RB	20	Open	6	40.63	62.99	75.99	86.94
RB	20	Open	7	37.14	60.69	72.67	87.03
RB	20	Open	8	34.32	55.46	68.1	84.71
RB	20	Open	9	31.09	51.74	64.08	80.84
RB	30	Open	0	100	100	100	100
RB	30	Open	1	86.38	98.32	94.99	98.23
RB	30	Open	2	78.98	96.61	89.89	96.09
RB	30	Open	3	68.45	85.78	86.07	92.81
RB	30	Open	4	58.01	75.81	80.06	89.95
RB	30	Open	5	47.43	67.32	78.51	87.89
RB	30	Open	6	39.68	62.2	74.06	86.33
RB	30	Open	7	35.93	58.87	71.11	85.51
RB	30	Open	8	33.28	54.05	66.9	83.35
RB	30	Open	9	29.51	50.47	63	80.13
RB	40	Open	0	100	100	100	100
RB	40	Open	1	83.38	97.08	93.03	97.16
RB	40	Open	2	76.02	95.08	88.21	95.05
RB	40	Open	3	65.36	84.76	85.09	91.48
RB	40	Open	4	54.98	74.57	79.38	88.7
RB	40	Open	5	44.06	66.67	77.61	85.99
RB	40	Open	6	34.1	61.66	72.94	84.61
RB	40	Open	7	31.62	57.69	69.52	84.35
RB	40	Open	8	28.65	52.16	65.68	81.87
RB	40	Open	9	22.51	48.62	62.32	79.51
RB	20	Closed	0	100	100	100	100
RB	20	Closed	1	88.32	100	96.87	100
RB	20	Closed	2	82.28	100	93.04	100
RB	20	Closed	3	70.64	88.17	88.34	95.17
RB	20	Closed	4	61.48	79.4	84.04	93.52
RB	20	Closed	5	51.69	71.15	83.02	91.2
RB	20	Closed	6	45.64	68	81	91.95
RB	20	Closed	7	41.32	64.87	76.85	91.21
RB	20	Closed	8	35.36	56.5	69.14	85.75
RB	20	Closed	9	33.26	53.91	66.25	83.01
RB	30	Closed	0	100	100	100	100
RB	30	Closed	1	89.95	100	100	100
RB	30	Closed	2	81.23	100	92.14	100

RB	30	Closed	3	71.7	89.03	89.32	96.06
RB	30	Closed	4	63.37	81.17	85.42	95.31
RB	30	Closed	5	49.5	69.39	80.58	89.96
RB	30	Closed	6	45.09	67.61	79.47	91.74
RB	30	Closed	7	41.05	63.99	76.23	90.63
RB	30	Closed	8	38.83	59.6	72.45	88.9
RB	30	Closed	9	34.25	55.21	67.74	84.87
RB	40	Closed	0	100	100	100	100
RB	40	Closed	1	84.38	100	94.03	100
RB	40	Closed	2	81.51	100	93.7	100
RB	40	Closed	3	70.98	90.38	90.71	97.1
RB	40	Closed	4	58.33	77.92	82.73	92.05
RB	40	Closed	5	45.9	68.51	79.45	87.83
RB	40	Closed	6	40.4	67.96	79.24	90.91
RB	40	Closed	7	33.1	59.17	71	85.83
RB	40	Closed	8	35.25	58.76	72.28	88.47
RB	40	Closed	9	26.41	52.52	66.22	83.41
SB	20	Open	0	100	100	100	100
SB	20	Open	1	87.15	99.54	98.94	99.28
SB	20	Open	2	79.38	92.79	95.24	97.68
SB	20	Open	3	63.5	87.6	91.04	93.88
SB	20	Open	4	51.55	86.24	89.43	91.22
SB	20	Open	5	48.24	77.07	84.3	90.27
SB	20	Open	6	39.86	73.04	81.97	87.78
SB	20	Open	7	35.81	66.38	78.65	85.87
SB	20	Open	8	33.59	60.66	73.97	84.16
SB	20	Open	9	28.35	53.07	65.6	80.96
SB	30	Open	0	100	100	100	100
SB	30	Open	1	86.39	98.31	97.68	98.25
SB	30	Open	2	77.77	90.79	94.74	96.17
SB	30	Open	3	61.7	86.14	89.91	91.92
SB	30	Open	4	50.82	84.33	88.68	89.73
SB	30	Open	5	46.25	75.74	82.48	88.69
SB	30	Open	6	39.25	71.99	80	86.34
SB	30	Open	7	34.2	65.79	77.79	85.3
SB	30	Open	8	31.96	59.71	73	82.66
SB	30	Open	9	27.72	52.28	64.53	79.16
SB	40	Open	0	100	100	100	100
SB	40	Open	1	83.6	97.05	95.81	96.77
SB	40	Open	2	74.7	88.92	93.24	95.28
SB	40	Open	3	58.51	85.25	89.34	90.58
SB	40	Open	4	47.87	83.01	87.51	87.99
SB	40	Open	5	43.61	74.15	81.23	87.47
SB	40	Open	6	33.35	70.18	78.8	85.35
SB	40	Open	7	28.82	64.54	76.39	83.51
SB	40	Open	8	26.37	58.07	71.48	80.8
SB	40	Open	9	22.94	50.74	63.41	77.9
SB	20	Closed	0	100	100	100	100
SB	20	Closed	1	92.83	100	100	100
SB	20	Closed	2	84.38	100	100	100
SB	20	Closed	3	64.95	89.05	92.49	95.33
SB	20	Closed	4	53.02	87.71	90.9	92.69
SB	20	Closed	5	54.09	82.92	90.15	96.12
SB	20	Closed	6	45.7	78.88	87.81	93.62
SB	20	Closed	7	41.64	72.21	84.48	91.7
SB	20	Closed	8	40.02	67.09	80.4	90.59
SB	20	Closed	9	34.61	59.33	71.86	87.22
SB	30	Closed	0	100	100	100	100
SB	30	Closed	1	90.61	100	100	100
SB	30	Closed	2	84.67	97.69	100	100
SB	30	Closed	3	63.87	88.31	92.08	94.09
SB	30	Closed	4	56.57	90.08	94.43	95.48
SB	30	Closed	5	52.75	82.24	88.98	95.19
SB	30	Closed	6	41.04	73.78	81.79	88.13
SB	30	Closed	7	39.21	70.8	82.8	90.31
SB	30	Closed	8	38.68	66.43	79.72	89.38
SB	30	Closed	9	32.15	56.71	68.96	83.59
SB	40	Closed	0	100	100	100	100
SB	40	Closed	1	88.32	100	100	100
SB	40	Closed	2	76.61	90.83	95.15	100
SB	40	Closed	3	60.31	87.05	91.14	92.38
SB	40	Closed	4	54.7	89.84	94.34	94.82
SB	40	Closed	5	46.85	77.39	84.47	90.71
SB	40	Closed	6	35.17	72	80.62	87.17
SB	40	Closed	7	35.5	71.22	83.07	90.19

SB	40	Closed	8	30.18	61.88	75.29	84.61
SB	40	Closed	9	26.21	54.01	66.68	81.17
SF	20	Open	0	100	100	100	100
SF	20	Open	1	89.34	99.55	100	99.66
SF	20	Open	2	74.68	92.12	97.05	97.73
SF	20	Open	3	56.28	89.86	94.96	93.07
SF	20	Open	4	50.8	85.33	92.4	90.81
SF	20	Open	5	44.29	79.56	89.34	90.25
SF	20	Open	6	39.51	75.37	86.4	89.45
SF	20	Open	7	34.73	73.92	83.77	86.18
SF	20	Open	8	30.04	71.4	81.88	82.54
SF	20	Open	9	27.41	66.98	77.14	79.74
SF	30	Open	0	100	100	100	100
SF	30	Open	1	87.51	98.26	98.14	98.36
SF	30	Open	2	73.62	90.33	96.23	96.48
SF	30	Open	3	54.53	88.97	94.27	91.85
SF	30	Open	4	49.82	84.76	90.64	89.65
SF	30	Open	5	43.75	78.38	88.75	88.73
SF	30	Open	6	38.08	74.78	85.51	87.49
SF	30	Open	7	33.44	72.02	82.23	84.9
SF	30	Open	8	29.53	70.39	79.98	81.72
SF	30	Open	9	25.64	65.57	75.62	77.77
SF	40	Open	0	100	100	100	100
SF	40	Open	1	83.58	97.58	96.67	97.12
SF	40	Open	2	71.29	89.46	95.5	95.9
SF	40	Open	3	51.32	87.41	93.15	91.21
SF	40	Open	4	47.7	83.88	89.78	88.89
SF	40	Open	5	41.48	77.58	87.56	87.56
SF	40	Open	6	32.19	73.29	83.96	86.36
SF	40	Open	7	26.45	71.36	80.53	83.55
SF	40	Open	8	22.41	69.65	79.47	80.69
SF	40	Open	9	18.01	63.65	74.02	75.88
SF	20	Closed	0	100	100	100	100
SF	20	Closed	1	94.41	100	100	100
SF	20	Closed	2	80.74	98.18	100	100
SF	20	Closed	3	58.31	91.89	96.99	95.1
SF	20	Closed	4	54.46	88.99	96.06	94.47
SF	20	Closed	5	49.33	84.6	94.38	95.29
SF	20	Closed	6	44.04	79.9	90.93	93.98
SF	20	Closed	7	36.68	75.87	85.72	88.13
SF	20	Closed	8	36.7	78.06	88.54	89.2
SF	20	Closed	9	32.81	72.38	82.54	85.14
SF	30	Closed	0	100	100	100	100
SF	30	Closed	1	88.76	100	100	100
SF	30	Closed	2	76.13	92.84	100	100
SF	30	Closed	3	58.97	93.41	100	96.29
SF	30	Closed	4	55.24	90.18	96.06	95.07
SF	30	Closed	5	46.65	81.28	91.65	91.63
SF	30	Closed	6	41.53	78.23	88.96	90.94
SF	30	Closed	7	40.33	78.91	89.12	91.79
SF	30	Closed	8	31.11	71.97	81.56	83.3
SF	30	Closed	9	28.5	68.43	78.48	80.63
SF	40	Closed	0	100	100	100	100
SF	40	Closed	1	90.38	100	100	100
SF	40	Closed	2	75.52	93.69	100	100
SF	40	Closed	3	52.32	88.41	94.15	92.21
SF	40	Closed	4	53.26	89.44	95.34	94.45
SF	40	Closed	5	45.94	82.04	92.02	92.02
SF	40	Closed	6	37.59	78.69	89.36	91.76
SF	40	Closed	7	28.84	73.75	82.92	85.94
SF	40	Closed	8	28.1	75.34	85.16	86.38
SF	40	Closed	9	23.66	69.3	79.67	81.53

Table 5.1A: Change in thermo-oxidative stability of fresh and nano-ceria-treated oil during storage

SL NO	SAMPLE NAME	STORAGE TIME (WEEKS)	THERMO-OXIDATIVE STABILITY OF OIL AT 60 DEGREE CELSIUS															
			PEROXIDE VALUE (meq O2/kg)				PARA ANISIDINE VALUE				TOTOX VALUE				VISCOSITY (cP)			
			0 HR	24 HR	48 HR	72 HR	0 HR	24 HR	48 HR	72 HR	0 HR	24 HR	48 HR	72 HR	0 HR	24 HR	48 HR	72 HR
1	CONTRO L RICE BRAN OIL	1	0.611	9.284	10.45	17.746	4.745	7.122	12.665	17.574	5.967	25.69	33.565	53.066	50.74	63.75	78.25	95.95
2		2	0.848	10.719	11.4	17.244	4.73	7.384	12.918	18.088	6.426	28.822	35.718	52.576	51.35	66.04	78.74	95.14
3		3	1.701	10.815	16.15	20.302	4.528	6.807	11.785	16.733	7.93	28.437	44.085	57.337	51.76	68	79.6	95.3
4		4	2.242	10.324	16.15	18.821	4.758	6.691	11.908	16.872	9.242	27.339	44.208	54.514	51.8	68.39	86.99	98.09
5		5	5.66	14.898	14.25	23.993	6.706	9.244	14.689	19.781	18.026	39.04	43.189	67.767	52.84	68.86	86.96	105.36
6		6	7.736	16.055	20.9	23.812	9.55	11.528	16.706	22.384	25.022	43.638	58.506	70.008	53.53	69.33	81.83	98.93
7		7	9.95	18.433	19.95	25.967	13.26	15.967	21.495	26.673	33.16	52.833	61.395	78.607	53.99	69.63	82.43	97.13
8		8	12.932	21.115	25.65	30.89	13.074	15.78	21.157	26.288	38.938	58.01	72.457	88.068	54.83	74.59	91.64	110.84
9	RBO WITH 5PPM CNPN4	1	0.542	3.188	4.75	8.011	4.207	6.974	9.631	12.06	5.291	13.35	19.131	28.082	50.85	62.61	73.01	83.11
10		2	0.549	3.338	7.6	8.297	4.333	7.076	9.33	11.916	5.431	13.752	24.53	28.51	51.35	64.1	83.6	96.5
11		3	0.567	3.794	7.6	8.721	4.291	6.32	8.63	11.219	5.425	13.908	23.83	28.661	51.7	65.05	78.65	90.55
12		4	0.583	3.987	8.55	10.67	4.267	6.714	9.486	11.69	5.433	14.688	26.586	33.03	51.86	66.86	81.26	93.76
13		5	0.763	2.883	6.65	8.934	6.23	8.645	10.724	13.029	7.756	14.411	24.024	30.897	52.51	68.03	80.23	93.73
14		6	1.242	4.959	4.75	9.935	8.77	11.16	13.913	15.902	11.254	21.078	23.413	35.772	52.66	68.45	87.15	100.65
15		7	2.788	5.672	9.5	10.233	10.898	13.275	15.436	17.749	16.474	24.619	34.436	38.215	52.93	68.53	83.33	97.93
16		8	5.378	9.221	10.45	17.063	10.749	13.107	15.763	18.341	21.505	30.751	35.003	50.573	54.79	74.53	88.43	106.24
17	RBO WITH 10 PPM CNPN4	1	0.535	3.131	7.6	10.287	4.12	6.15	8.077	10.569	5.19	12.412	23.277	31.143	50.3	63.52	82.42	93.8
18		2	0.575	3.259	4.75	10.762	4.349	6.709	9.493	12.079	5.499	13.227	18.993	33.603	51.66	64.36	79.26	96.56
19		3	0.558	2.702	4.75	10.356	4.462	7.165	9.121	11.74	5.578	12.569	18.621	32.452	51.84	68.16	84.16	98.02
20		4	0.564	4.439	10.45	11.227	4.207	6.982	9.408	11.662	5.335	15.86	30.308	34.116	52.63	68.43	81.93	98.03
21		5	0.766	3.822	6.65	11.362	6.428	8.454	11.221	13.719	7.96	16.098	24.521	36.443	53.42	69.8	82.6	99.04
22		6	1.148	4.132	7.6	10.023	8.647	11.33	14.103	16.262	10.943	19.594	29.303	36.308	53.64	70.64	88.14	100.96
23		7	2.534	6.243	8.55	10.605	10.057	12.616	15.296	17.252	15.125	25.102	32.396	38.462	54.26	71.44	83.14	105.99
24		8	5.286	8.822	9.5	14.092	10.46	12.881	14.83	17.112	20.55	30.045	34.763	46.525	54.63	72.54	87.19	105.63
25	RBO WITH 15PPM CNPN4	1	0.534	4.356	4.75	10.104	4.179	6.798	8.732	11.497	5.247	15.51	18.232	31.705	50.27	61.79	72.89	91.69
26		2	0.571	3.072	4.75	9.648	4.244	7.003	9.275	11.675	5.386	13.147	18.775	30.971	51	61.87	73.67	92.37
27		3	0.555	3.585	6.65	10.317	4.425	6.774	9.482	11.734	5.535	13.944	22.782	32.368	51.18	65.14	78.64	90.74
28		4	0.574	4.165	4.75	10.415	4.46	6.687	9.114	11.14	5.608	15.017	18.614	31.97	51.59	67.17	82.97	95.17
29		5	0.77	3.029	6.65	8.014	6.114	8.742	11.168	13.389	7.654	14.8	24.468	29.417	53.47	67.87	79.17	96.97
30		6	1.217	4.886	4.75	10.809	8.714	10.653	13.149	15.934	11.148	20.425	22.649	37.552	53.54	69.28	83.58	99.38
31		7	2.716	5.118	6.65	9.936	9.105	11.814	13.983	16.697	14.537	22.05	27.283	36.569	54.07	70.1	87.7	101.9
32		8	5.045	7.642	9.5	13.08	9.49	11.603	14.103	16.447	20.062	28.165	33.83	43.272	54.63	69.36	82.96	101.66
33	CONTRO L SUNFLO WER OIL	1	1.423	10.211	11.203	18.377	5.702	8.058	13.63	18.366	8.548	28.48	36.036	55.12	51.484	64.643	79.171	96.819
34		2	1.675	11.667	12.278	18.061	5.655	8.09	13.535	19.079	9.005	31.424	38.091	55.201	52.043	66.795	79.392	95.995
35		3	2.433	11.653	16.905	21.253	5.397	7.721	12.39	17.625	10.263	31.027	46.2	60.131	52.718	68.661	80.44	95.987
36		4	2.844	11.064	16.964	19.626	5.56	7.585	12.635	17.742	11.248	29.713	46.563	56.994	52.722	69.35	87.746	98.714
37		5	6.431	15.678	14.967	24.836	7.493	10.241	15.575	20.415	20.355	41.597	45.509	70.087	53.702	69.502	87.906	106.032
38		6	8.714	16.778	21.824	24.517	10.536	12.41	17.455	23.226	27.964	45.966	61.103	72.26	54.438	70.048	82.628	99.84
39		7	10.611	19.384	20.559	26.649	13.932	16.75	22.297	27.401	35.154	55.518	63.415	80.699	54.949	70.52	83.097	97.84
40		8	13.752	21.721	26.633	31.744	13.919	16.704	21.965	26.996	41.423	60.146	75.231	90.484	55.646	75.278	92.876	111.511
41	SFO WITH 5PPM CNPN4	1	1.148	3.868	5.71	8.817	5.149	7.661	10.596	13.025	7.445	15.397	22.016	30.659	51.489	63.233	73.763	84.043
42		2	1.447	4.248	8.572	9.206	5.274	7.751	10.142	12.582	8.168	16.247	27.286	30.994	52.183	65.077	84.345	97.44
43		3	1.261	4.48	8.592	9.373	5.167	7.108	9.547	11.998	7.689	16.068	26.731	30.744	52.613	65.886	79.455	91.485
44		4	1.334	4.944	9.539	11.342	5.225	7.535	10.385	12.355	7.893	17.423	29.463	35.039	52.599	67.766	82.019	94.665
45		5	1.762	3.585	7.475	9.625	7.042	9.556	11.433	13.992	10.566	16.726	26.383	33.242	53.122	68.678	80.835	94.381
46		6	1.849	5.809	5.66	10.727	9.723	12.095	14.749	16.687	13.421	23.713	26.069	38.141	53.41	69.061	87.76	101.483
47		7	3.692	6.639	10.212	11.159	11.696	14.254	16.21	18.706	19.08	27.532	36.634	41.024	53.831	69.328	84.318	98.86
48		8	6.37	9.939	11.061	17.917	11.66	13.985	16.723	19.079	24.4	33.169	37.036	53.156	55.584	75.2	89.169	106.864
49	SFO WITH 10PPM CNPN4	1	1.313	3.939	8.398	10.93	4.777	7.043	8.887	11.366	7.403	14.921	25.683	33.226	51.225	64.382	83.387	94.409
50		2	1.562	4.102	5.661	11.458	5.263	7.352	10.178	12.981	8.387	15.556	21.5	35.897	52.419	65.16	80.069	97.535
51		3	1.435	3.438	5.505	11.301	5.299	7.784	9.821	12.513	8.169	14.66	20.831	35.115	52.525	68.875	85.15	98.753
52		4	1.524	5.183	11.157	12.213	4.899	7.696	10.199	12.461	7.947	18.062	32.513	36.887	53.507	69.056	82.73	99
53		5	1.695	4.633	7.504	12.182	7.184	9.437	11.9	14.664	10.574	18.703	26.908	39.028	54.254	70.573	83.546	99.982
54		6	2.087	4.974	8.437	10.842	9.572	12.068	14.856	17.261	13.746	22.016	31.73	38.945	54.268	71.297	89.064	101.584
55		7	3.45	7.134	9.19	11.523	10.933	13.442	15.997	17.997	17.833	27.71	34.377	41.043	54.923	72.417	83.822	106.842
56		8	5.854	9.592	10.205	14.717	11.241	13.797	15.686	17.869	22.949	32.212	36.971	48.513	55.543	73.199	88.212	106.322
57	SFO WITH 15PPM CNPN4	1	1.453	5.259	5.383	11.086	4.807	7.564	9.605	12.422	7.713	18.082	20.371	34.594	51.036	62.448	73.84	92.374
58		2	1.429	4.072	5.629	10.482	4.913	7.856	9.927	12.626	7.771	16	21.185	33.59	51.692	62.516	74.285	93.09
59		3	1.324	4.302	7.507	11.215	5.187	7.61	10.188	12.518	7.835	16.214	25.202	34.948	51.895	65.921	79.414	91.489
60		4	1.514	4.832	5.527	11.064	5.353	7.406	9.805	11.773	8.381	17.07	20.859	33.901	52.577	67.885	83.896	95.909
61	SFO WITH 15PPM CNPN4	5	1.48	3.682	7.355	8.873	6.797	9.37	11.897	14.31								

Table 5.1aA: Change in thermo-oxidative stability of fresh and nano-ceria-treated oil during storage

SL NO	SAMPLE NAME	STORAGE TIME (WEEKS)	THERMO-OXIDATIVE STABILITY OF OIL AT 80 DEGREE CELSIUS											
			PEROXIDE VALUE (meq O2/kg)			PARA-ANISIDINE VALUE			TOTOX VALUE			VISCOSITY (cP)		
			0 HR	24 HR	48 HR	0 HR	24 HR	48 HR	0 HR	24 HR	48 HR	0 HR	24 HR	48 HR
1	CONTROL RICE BRAN OIL	1	0.73	9.703	16.103	5.025	10.165	15.185	6.485	29.571	47.391	50.4	83.1	104.6
2		2	0.97	9.936	15.836	5.02	10.53	16.52	6.96	30.402	48.192	50.54	85.24	109.04
3		3	1.847	10.012	17.612	4.768	10.608	15.998	8.462	30.632	51.222	51.33	76.53	97.13
4		4	2.37	10.702	15.702	4.998	10.348	15.998	9.738	31.752	47.402	52.02	80.62	102.12
5		5	5.786	14.063	20.163	6.966	12.576	18.026	18.538	40.702	58.352	52.07	84.17	105.37
6		6	7.87	16.717	20.817	9.82	15.5	20.54	25.56	48.934	62.174	52.4	84	108
7		7	10.064	18.511	24.211	13.49	19.22	25.01	33.618	56.242	73.432	52.98	84.18	106.18
8		8	13.046	21.163	27.163	13.344	19.014	24.614	39.436	61.34	78.94	54.99	86.81	110.11
9		1	0.654	8.853	9.183	4.417	6.627	9.037	5.725	24.333	27.403	50.16	71.86	92.66
10	RBO WITH 5PPM CNPN4	2	0.665	2.951	8.731	4.613	7.033	9.133	5.943	12.935	26.595	50.21	72.01	92.21
11		3	0.696	7.869	9.313	4.561	6.931	9.431	5.953	22.669	28.057	51.3	84.6	108.1
12		4	0.694	8.853	9.682	4.557	7.057	9.347	5.945	24.763	28.711	51.49	82.69	103.39
13		5	0.866	7.869	8.877	6.43	8.95	11.44	8.162	24.688	29.194	52.14	78.74	103.04
14		6	1.373	1.968	9.806	9.04	11.32	13.46	11.786	15.256	33.072	54.16	89.16	113.76
15		7	2.937	3.935	11.181	11.178	13.618	15.868	17.052	21.488	38.23	54.89	76.09	100.79
16		8	5.524	12.787	14.154	11.019	13.179	15.529	22.067	38.753	43.483	54.87	82.77	106.77
17		1	0.68	0.984	9.527	4.42	6.36	8.69	5.78	8.328	27.744	50.04	82.54	105.24
18		2	0.678	0.984	9.332	4.639	6.709	8.929	5.995	8.677	27.593	50.28	77.98	100.38
19	RBO WITH 10 PPM CNPN4	3	0.663	0.984	9.27	4.762	7.232	9.732	6.088	9.2	28.272	52.51	79.71	103.91
20		4	0.703	7.869	9.66	4.417	7.007	9.247	5.823	22.745	28.567	52.74	77.74	101.94
21		5	0.869	8.853	9.114	6.668	9.028	11.188	8.406	26.734	29.416	52.75	80.75	101.85
22		6	1.298	3.935	10.25	8.907	11.037	13.497	11.503	18.907	33.997	53.34	88.24	111.74
23		7	2.66	3.935	10.909	10.257	12.407	14.677	15.577	20.277	36.495	54.74	75.54	98.14
24		8	5.391	11.804	13.977	10.7	12.85	15.18	21.08	35.588	42.578	54.04	79.64	103.84
25		1	0.647	4.918	8.887	4.379	6.759	9.069	5.673	16.595	26.843	50.81	78.31	103.31
26		2	0.7	0.984	8.747	4.484	6.854	9.064	5.884	8.822	26.558	51.06	77.76	100.06
27		3	0.664	7.869	9.391	4.705	6.725	8.775	6.033	22.463	27.557	52.08	82.68	106.78
28	RBO WITH 15PPM CNPN4	4	0.688	4.918	9.647	4.72	6.95	9.17	6.096	16.786	28.464	52.63	73.23	98.23
29		5	0.896	0.984	9.006	6.404	8.744	11.104	8.196	10.712	29.116	52.73	73.63	95.73
30		6	1.338	6.886	9.908	8.984	11.414	13.674	11.66	25.186	33.49	52.82	85.92	107.32
31		7	2.84	9.836	11.568	9.315	11.535	13.595	14.995	31.207	36.731	53.72	75.62	96.22
32		8	5.19	6.886	13.699	9.73	11.98	14.2	20.512	26.622	42.508	54.01	79.59	102.79
33		1	1.599	10.487	16.927	6.021	11.144	16.033	9.219	32.118	49.887	51.215	83.774	105.534
34		2	1.873	10.633	16.68	5.69	11.472	17.52	9.436	32.738	50.88	51.343	86.2	109.784
35		3	2.706	10.65	18.317	5.546	11.457	16.616	10.958	32.757	53.25	51.975	77.276	98.006
36		4	3.005	11.463	16.582	5.625	11.303	16.726	11.635	34.229	49.89	52.842	81.32	102.768
37	CONTROL SUNFLO WER OIL	5	6.666	14.665	20.934	7.701	13.465	18.871	21.033	42.795	60.739	52.777	84.937	105.972
38		6	8.585	17.586	21.53	10.795	16.408	21.524	27.965	51.58	64.584	53.127	84.835	108.647
39		7	10.755	19.38	24.814	14.102	20.148	25.976	35.612	58.908	75.604	53.744	84.858	107.102
40		8	13.978	21.848	28.08	14.206	19.733	25.511	42.162	63.429	81.671	55.89	87.684	110.853
41		1	1.616	9.789	10.154	5.32	7.505	9.818	8.552	27.083	30.126	51.027	72.528	93.367
42		2	1.419	3.891	9.583	5.501	8.028	9.9	8.339	15.81	29.066	51.023	72.618	92.853
43		3	1.421	8.843	9.922	5.351	7.65	10.033	8.193	25.336	29.877	52.232	85.586	108.849
44		4	1.307	9.764	10.607	5.203	7.886	10.139	7.817	27.414	31.353	52.205	83.459	104.251
45		5	1.732	8.591	9.712	7.393	9.843	12.129	10.857	27.025	31.553	52.903	79.443	103.967
46	SFO WITH 5PPM CNPN4	6	2.355	2.826	10.667	9.697	12.27	14.393	14.407	17.922	35.727	54.94	90.083	114.592
47		7	3.922	4.62	12.078	12.051	14.585	16.663	19.895	23.825	40.819	55.531	77.032	101.465
48		8	6.231	13.742	15.004	11.771	13.783	16.333	24.233	41.267	45.589	55.589	83.558	107.628
49		1	1.29	1.928	10.294	5.189	7.255	9.404	7.769	11.111	29.992	51.027	83.207	106.098
50		2	1.578	1.617	10.272	5.607	7.583	9.537	8.763	10.817	30.081	51.223	78.784	101.338
51		3	1.574	1.702	9.962	5.606	8.068	10.525	8.754	11.472	30.449	53.237	80.655	104.803
52		4	1.45	8.699	10.303	5.386	7.954	9.895	8.286	25.352	30.501	53.617	78.635	102.609
53		5	1.868	9.497	9.896	7.354	9.717	12.106	11.09	28.711	31.898	53.742	81.365	102.785
54		6	2.06	4.648	10.985	9.889	11.88	14.156	14.009	21.176	36.126	54.222	89.177	112.421
55	SFO WITH 10PPM CNPN4	7	3.651	4.843	11.76	10.906	13.289	15.348	18.208	22.975	38.868	55.402	76.248	98.754
56		8	6.061	12.652	14.628	11.497	13.721	15.994	23.619	38.108	45.031	54.898	80.49	104.705
57		1	1.415	5.597	9.795	5.07	7.584	9.743	7.9	18.778	29.333	51.696	79.295	104.28
58		2	1.652	1.614	9.428	5.324	7.73	9.705	8.628	10.958	28.561	51.922	78.746	101.009
59		3	1.302	8.472	10.325	5.468	7.416	9.625	8.072	24.36	30.275	52.929	83.563	107.659
60		4	1.565	5.533	10.269	5.323	7.797	10.088	8.453	18.863	30.626	53.238	73.896	99.188
61		5	1.849	1.855	9.62	7.176	9.718	12.065	10.874	13.428	31.305	53.43	74.346	96.476
62		6	1.942	7.833	10.808	9.805	12.304	14.277	13.689	27.97	35.893	53.506	86.768	108.317
63		7	3.656	10.509	12.294	9.944	12.434	14.404	17.256	33.452	38.992	54.624	76.291	97.201
64		8	6.041	7.771	14.333	10.355	12.804	15.023	22.437	29.263	44.66	54.622	80.387	103.712

Table 5.2A: Effect of frying cycle on oxidative stability of cerium oxide treated and untreated oil

SL No.	Oil Type	Storage time (weeks)	Frying Cycle	Foaming Tendency (ml)	Smoke Point (°C)	Viscosity (cP)	Peroxide Value (meqO ₂ /kg)	Para-Anisidine Value	TOTOX Value
1	Control Rice Bran Oil	1	0	0	51.232	241	0.561	3.44	4.562
2			1	0	66.48	235	8.99	7.31	25.29
3			2	2	83.661	229	12.19	9.23	33.61
4			3	4.5	97.91	221	21.36	13.45	56.17
5			4	4.5	106.45	217	32.48	27.91	92.87
6			5	6	113.36	210	39.41	30.36	109.18
7		2	0	0	51.35	232	0.848	4.96	6.656
8			1	0	59.28	227	10.16	8.88	29.2
9			2	3.8	66.79	223	14.27	11.62	40.16
10			3	5.3	73.08	212	23.56	15.73	62.85
11			4	5.5	79.87	210	34.54	31.62	100.7
12			5	6.8	87.38	201	41.73	34.36	117.82
13		3	0	0	51.76	226	1.701	5.96	9.362
14			1	0	58.89	221	11.013	10.86	32.886
15			2	4	66.81	214	15.123	14.6	44.846
16			3	5.5	73.92	204	26.09	18.97	71.15
17			4	5.5	80.54	202	37.37	35.11	109.85
18			5	7.7	86.93	195	44.1	37.71	125.91
19		4	0	0	51.8	219	2.242	7.29	11.774
20			1	1	59.15	214	11.554	12.3	35.408
21			2	5.9	65.8	208	15.664	16.85	48.178
22			3	6.6	72.78	197	28.64	21.89	79.17
23			4	6.4	79.53	193	39.38	38.99	117.75
24			5	7.9	87.53	189	46.53	41.52	134.58
25		5	0	0	52.84	210	5.66	8.94	20.26
26			1	1	60.09	207	14.972	13.71	43.654
27			2	5.9	66.18	202	19.082	19.01	57.174
28			3	8.4	72.65	188	31.59	24.4	87.58
29			4	7.1	79.39	184	41.58	42.19	125.35
30			5	9.7	87.21	182	50.52	44.29	145.33
31		6	0	0	53.53	202	7.736	10.84	26.312
32			1	1.5	61.06	199	17.048	15.36	49.456
33			2	6.6	68.24	194	21.158	21.89	64.206
34			3	9.1	74.72	179	34.27	26.91	95.45
35			4	8.5	80.88	177	43.93	45.38	133.24
36			5	11.1	87.44	175	52.98	48.07	154.03
37		7	0	0	54	196	9.95	12.51	32.41
38			1	2	61.19	191	19.262	16.4	54.924
39			2	7.6	68.43	186	23.372	24.52	71.264
40			3	10.8	76.22	173	36.8	30.68	104.28
41			4	9.7	83.8	168	46.27	47.92	140.46
42			5	11.6	91.71	167	55.03	51.77	161.83
43		8	0	0	54.83	187	12.932	14.19	40.054
44			1	2	62.42	182	22.244	18.33	62.818
45			2	7.8	68.45	177	26.354	26.71	79.418
46			3	11.5	76.34	167	40.37	32.77	113.51
47			4	9.9	84.32	161	48.93	51.65	149.51
48			5	13.3	90.76	161	57.83	53.94	169.6
49		1	0	0	50.37	247	0.561	3.068	4.19
50			1	0	58.91	247	1.23	2.87	5.33
51			2	0	62.38	247	3.79	3.7	11.28

52	Rice Bran Oil + 15ppm Cerium Oxide		3	0	68.49	239	4.213	3.744	12.17
53			4	2	72.33	238	7.662	5.006	20.33
54			5	2	80.18	233	8.91	7.49	25.31
55		2	0	0	50.93	247	0.613	3.127	4.353
56			1	0	18.224	246	1.297	2.891	5.485
57			2	0	24.844	245	3.805	3.898	11.508
58			3	0	31.974	237	4.298	3.815	12.411
59			4	2	38.384	237	7.746	5.109	20.601
60			5	2	44.484	232	8.966	7.612	25.544
61		3	0	0	51.18	246	0.716	3.212	4.644
62			1	0	57.69	244	1.384	2.891	5.659
63			2	0	63.81	245	3.937	4.046	11.92
64			3	0	70.96	236	4.361	3.862	12.584
65			4	2	78.38	235	7.805	5.216	20.826
66			5	2.5	85.54	230	9.101	7.761	25.963
67		4	0	0	51.59	246	0.806	3.353	4.965
68			1	0	58.9	242	1.568	3.019	6.155
69			2	0	65.01	243	4.056	4.151	12.263
70			3	0	72.97	235	4.41	4.009	12.829
71			4	2.5	79.65	234	7.839	5.358	21.036
72		5	0	0	53.47	244	0.907	7.22	9.034
73			1	0	60.35	241	1.645	9.24	12.53
74			2	0	67.11	241	4.144	11.63	19.918
75			3	0	74.53	235	4.556	13.43	22.542
76			4	2.5	82.03	233	7.986	14.62	30.592
77		6	5	3	89.94	230	9.314	17.26	35.888
78			0	0	53.54	242	0.992	9.147	11.131
79			1	0	60.6	239	1.771	11.797	15.339
80			2	0	67.01	240	4.302	13.207	21.811
81			3	0	74.66	233	4.605	15.707	24.917
82		7	4	2	81.77	232	8.162	18.487	34.811
83			5	2.5	89.56	230	9.483	20.857	39.823
84			0	0	54.07	241	1.124	9.957	12.205
85			1	0	60.92	239	1.873	11.617	15.363
86			2	0	68.11	239	4.473	13.787	22.733
87		8	3	0	74.86	233	4.755	15.827	25.337
88			4	2.5	81.04	231	8.31	17.177	33.797
89			5	3	88.06	230	9.573	18.907	38.053
90			0	0	54.63	239	1.268	10.834	13.37
91			1	0	61.99	237	2.046	13.574	17.666
92		1	2	0	68.93	239	4.664	15.794	25.122
93			3	0	75.1	231	4.86	18.214	27.934
94			4	2	81.27	230	8.428	20.364	37.22
95			5	3	88.31	230	9.63	21.744	41.004
96			0	0	54.21	236	1.94	2.414	6.294
97		2	1	0	67.89	227	9.08	8.617	26.777
98			2	2	80.32	218	17.42	15.53	50.37
99			3	3	100.04	214	23.37	21.07	67.81
100			4	5	115.34	207	31.48	30.4	93.36
101			5	5	121.67	201	33.28	35.48	102.04
102		3	0	0	60.42	228	3.75	4.334	11.834
103			1	0	68.36	219	10.14	10.187	30.467
104			2	2	75.71	211	20.2	17.92	58.32
105			3	3.1	83.15	207	27.25	24.47	78.97
106			4	5.4	90.31	200	35.27	33.74	104.28
107		4	5	5.6	98.24	194	35.32	38.15	108.79
108									

109	Control Sunflower Oil	3	0	0	62.31	220	5.56	6.194	17.314
110			1	0	69.48	210	11.37	12.117	34.857
111			2	3.6	76.47	203	23.01	20.57	66.59
112			3	3.9	83.51	199	30.45	27.45	88.35
113			4	5.5	91.02	192	37.68	36.11	111.47
114			5	6.8	97.09	185	37.37	40.96	115.7
115		4	0	0	67.93	212	6.94	7.234	21.114
116			1	0	73.93	204	12.91	13.387	39.207
117			2	5.6	81.69	197	25.99	23.07	75.05
118			3	5.4	88.79	190	32.86	30.37	96.09
119			4	6.9	94.92	183	40.5	38.4	119.4
120			5	8.4	102.53	178	39.65	44.63	123.93
121		5	0	0	70.81	206	8.11	8.494	24.714
122			1	0	77.01	195	14.55	15.247	44.347
123			2	6.6	84.68	190	28.43	25.85	82.71
124			3	7.4	91.75	184	36.51	33.32	106.34
125			4	7.4	97.96	175	44.15	40.73	129.03
126			5	10.3	105.33	170	43.51	47.81	134.83
127		6	0	0	72.37	199	9.39	9.774	28.554
128			1	0	79.42	186	15.87	16.467	48.207
129			2	7.9	85.92	184	30.78	28.26	89.82
130			3	8.5	93.42	177	39.62	36.8	116.04
131			4	8.2	99.67	166	47.74	44.44	139.92
132			5	11	106.27	161	46.61	51.32	144.54
133		7	0	0	75.11	192	10.9	10.864	32.664
134			1	0	82.18	179	17.55	18.147	53.247
135			2	8.4	88.89	175	33.44	30.51	97.39
136			3	10.2	95	170	42.64	39.41	124.69
137			4	9.7	102.79	160	51.36	47.88	150.6
138			5	11.3	109.9	154	49.32	54.27	152.91
139		8	0	0	78.03	183	12.75	12.654	38.154
140			1	0	84.34	171	19.16	19.197	57.517
141			2	10.3	92.29	166	36.31	32.81	105.43
142			3	10.3	98.48	163	46.32	42.25	134.89
143			4	10.7	105.91	153	55.21	50.79	161.21
144			5	12.1	113.06	147	52.6	57.12	162.32
145		1	0	0	55.37	238	1.82	2.674	6.314
146			1	0	61.81	237	3.361	3.823	10.545
147			2	0	65.94	238	4.992	8.926	18.91
148			3	1	71.22	229	6.02	9.34	21.38
149			4	1	76.84	224	8.41	10.09	26.91
150			5	2	81.08	222	10.33	12.22	32.88
151		2	0	0	56.036	238	1.949	2.869	6.767
152			1	0	63.276	235	3.431	3.943	10.805
153			2	0	70.296	237	5.099	8.953	19.151
154			3	1	76.366	227	6.127	9.389	21.643
155			4	1	82.586	224	8.573	10.119	27.265
156			5	2	90.366	220	10.457	12.419	33.333
157		3	0	0	57.692	237	2.031	2.928	6.99
158			1	0	64.552	233	3.476	4.005	10.957
159			2	0	71.092	237	5.209	9.102	19.52
160			3	1.5	77.152	226	6.259	9.565	22.083
161			4	2	83.392	223	8.584	10.171	27.339
162			5	2	89.402	219	10.541	12.548	33.63
163		4	0	0	57.895	236	2.104	2.932	7.14
164			1	0	65.885	232	3.581	4.083	11.245
165			2	0	73.265	235	5.385	9.107	19.877

166	Sunflower oil + 15ppm Cerium Oxide		3	1.5	81.245	224	6.391	9.578	22.36
167			4	2	89.185	221	8.596	10.233	27.425
168			5	2.5	95.805	219	10.607	12.578	33.792
169		5	0	0	59.177	235	2.105	5.922	10.132
170			1	0	66.097	232	3.658	7.572	14.888
171			2	0	73.867	235	5.403	10.012	20.818
172			3	1.5	80.957	222	6.536	12.732	25.804
173			4	2.5	87.497	221	8.773	14.622	32.168
174			5	3	94.587	218	10.777	16.412	37.966
175		6	0	0	59.445	233	2.151	8.342	12.644
176			1	0	66.755	232	3.705	9.622	17.032
177			2	0	73.635	234	5.45	12.022	22.922
178			3	2	81.025	220	6.726	13.882	27.334
179			4	2	87.365	219	8.855	16.512	34.222
180			5	3	93.935	217	10.94	18.972	40.852
181		7	0	0	60.326	231	2.162	9.238	13.562
182			1	0	66.706	232	3.85	12.208	19.908
183			2	0	74.106	234	5.61	14.208	25.428
184			3	2	81.876	219	6.762	15.858	29.382
185			4	2	88.746	217	8.916	17.148	34.98
186			5	3	96.426	215	10.983	20.038	42.004
187		8	0	0	60.719	230	2.215	9.474	13.904
188			1	0	68.319	231	3.94	11.694	19.574
189			2	2	74.479	234	5.675	13.424	24.774
190			3	2	81.359	217	6.889	15.584	29.362
191			4	3	89.119	216	8.968	17.234	35.17
192			5	3	95.529	214	11.033	18.694	40.76

Table 5.3A: Liner Mixed Model Output

Model for: Foaming_Tendency

Mixed Linear Model Regression Results

=====		
Model:	MixedLM	Dependent Variable:
Foaming_Tendency		
No. Observations:	192	Method:
REML		
No. Groups:	8	Scale:
1.4181		
Min. group size:	24	Log-Likelihood:
-302.2894		
Max. group size:	24	Converged:
Yes		
Mean group size:	24.0	

				Coef.	Std.Err.
z	P> z [0.025 0.975]				

Intercept				0.000	0.534
0.000	1.000	-1.046	1.046		
Oil_Type[T.Control Sunflower Oil]				-0.000	0.595
-0.000	1.000	-1.167	1.167		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]				-0.000	0.595
-0.000	1.000	-1.167	1.167		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]				-0.000	0.595
-0.000	1.000	-1.167	1.167		
Frying_Cycle[T.1]				0.938	0.595
1.575	0.115	-0.230	2.105		
Frying_Cycle[T.2]				5.450	0.595
9.153	0.000	4.283	6.617		
Frying_Cycle[T.3]				7.713	0.595
12.953	0.000	6.545	8.880		
Frying_Cycle[T.4]				7.138	0.595
11.987	0.000	5.970	8.305		
Frying_Cycle[T.5]				9.263	0.595
15.556	0.000	8.095	10.430		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.1]				-0.937	0.842
-1.113	0.266	-2.588	0.713		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]				-0.937	0.842
-1.113	0.266	-2.588	0.713		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]				-0.937	0.842
-1.113	0.266	-2.588	0.713		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.2]				0.350	0.842
0.416	0.678	-1.300	2.000		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]				-5.450	0.842
-6.472	0.000	-7.100	-3.800		

Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-5.200	0.842
-6.175 0.000 -6.850 -3.550		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.3]	-1.238	0.842
-1.470 0.142 -2.888 0.413		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-7.713	0.842
-9.159 0.000 -9.363 -6.062		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-6.150	0.842
-7.304 0.000 -7.800 -4.500		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.4]	0.212	0.842
0.252 0.801 -1.438 1.863		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-4.950	0.842
-5.878 0.000 -6.600 -3.300		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-5.200	0.842
-6.175 0.000 -6.850 -3.550		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.5]	-0.450	0.842
-0.534 0.593 -2.100 1.200		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-6.700	0.842
-7.957 0.000 -8.350 -5.050		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-6.700	0.842
-7.957 0.000 -8.350 -5.050		
Group Var	0.862	0.422

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Model for: Viscosity

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:
Viscosity		
No. Observations:	192	Method:
REML		
No. Groups:	8	Scale:
52.4931		
Min. group size:	24	Log-Likelihood:
-604.3925		
Max. group size:	24	Converged:
Yes		
Mean group size:	24.0	

	Coef.	Std.Err.
z P> z [0.025 0.975]		
Intercept	52.668	3.044
17.300 0.000 46.701 58.635		

Oil_Type[T.Control Sunflower Oil]	14.981	3.623
4.135 0.000 7.881 22.081		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]	-0.195	3.623
-0.054 0.957 -7.295 6.905		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]	5.665	3.623
1.564 0.118 -1.435 12.765		
Frying_Cycle[T.1]	8.402	3.623
2.319 0.020 1.302 15.502		
Frying_Cycle[T.2]	16.627	3.623
4.590 0.000 9.527 23.728		
Frying_Cycle[T.3]	24.535	3.623
6.773 0.000 17.435 31.635		
Frying_Cycle[T.4]	31.680	3.623
8.745 0.000 24.580 38.780		
Frying_Cycle[T.5]	38.872	3.623
10.730 0.000 31.772 45.972		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.1]	-0.725	5.123
-0.141 0.888 -10.766 9.316		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-6.177	5.123
-1.206 0.228 -16.218 3.864		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-1.310	5.123
-0.256 0.798 -11.351 8.731		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.2]	-1.030	5.123
-0.201 0.841 -11.071 9.011		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-8.199	5.123
-1.600 0.109 -18.241 1.842		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-2.875	5.123
-0.561 0.575 -12.916 7.166		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.3]	-0.416	5.123
-0.081 0.935 -10.457 9.625		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-9.064	5.123
-1.769 0.077 -19.105 0.977		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-3.967	5.123
-0.774 0.439 -14.008 6.074		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.4]	0.411	5.123
0.080 0.936 -9.630 10.453		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-9.796	5.123
-1.912 0.056 -19.837 0.246		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-4.421	5.123
-0.863 0.388 -14.462 5.620		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.5]	0.240	5.123
0.047 0.963 -9.801 10.281		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-9.842	5.123
-1.921 0.055 -19.883 0.199		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-5.064	5.123
-0.988 0.323 -15.105 4.978		
Group Var	21.651	1.797

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Model for: Smoke_Point

Mixed Linear Model Regression Results

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Model:                               MixedLM                               Dependent Variable:
      Smoke_Point
No. Observations:                     192                               Method:
      REML
No. Groups:                           8                               Scale:
      67.4558
Min. group size:                      24                               Log-Likelihood:
      -630.0087
Max. group size:                      24                               Converged:
      Yes
Mean group size:                      24.0
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z      P>|z|  [0.025  0.975]
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-----
Intercept                               214.125    4.704
45.518 0.000 204.905 223.345
Oil_Type[T.Control Sunflower Oil]      -4.625    4.107
-1.126 0.260 -12.674   3.424
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide] 29.875    4.107
7.275 0.000  21.826  37.924
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide] 20.625    4.107
5.022 0.000  12.576  28.674
Frying_Cycle[T.1]                      -4.625    4.107
-1.126 0.260 -12.674   3.424
Frying_Cycle[T.2]                     -10.000    4.107
-2.435 0.015 -18.049  -1.951
Frying_Cycle[T.3]                     -21.500    4.107
-5.236 0.000 -29.549 -13.451
Frying_Cycle[T.4]                     -25.125    4.107
-6.118 0.000 -33.174 -17.076
Frying_Cycle[T.5]                     -29.125    4.107
-7.092 0.000 -37.174 -21.076
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.1] -6.000    5.808
-1.033 0.302 -17.383   5.383
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1] 2.500    5.808
0.430 0.667  -8.883  13.883
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1] 2.875    5.808
0.495 0.621  -8.508  14.258
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.2] -6.500    5.808
-1.119 0.263 -17.883   4.883
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Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	8.375	5.808
1.442 0.149 -3.008 19.758		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	10.750	5.808
1.851 0.064 -0.633 22.133		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.3]	-0.000	5.808
-0.000 1.000 -11.383 11.383		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	12.375	5.808
2.131 0.033 0.992 23.758		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	9.750	5.808
1.679 0.093 -1.633 21.133		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.4]	-4.875	5.808
-0.839 0.401 -16.258 6.508		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	14.875	5.808
2.561 0.010 3.492 26.258		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	11.000	5.808
1.894 0.058 -0.383 22.383		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.5]	-6.625	5.808
-1.141 0.254 -18.008 4.758		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	15.750	5.808
2.712 0.007 4.367 27.133		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	12.375	5.808
2.131 0.033 0.992 23.758		
Group Var	109.581	7.472

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Model for: Peroxide_Value

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:
Peroxide_Value		
No. Observations:	192	Method:
REML		
No. Groups:	8	Scale:
9.3471		
Min. group size:	24	Log-Likelihood:
-462.1344		
Max. group size:	24	Converged:
Yes		
Mean group size:	24.0	

		Coef.	Std.Err.
z	P> z	[0.025	0.975]

Intercept	5.204	1.505
3.457 0.001 2.254 8.154		
Oil_Type[T.Control Sunflower Oil]	2.214	1.529
1.448 0.148 -0.782 5.210		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]	-4.330	1.529
-2.833 0.005 -7.326 -1.334		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]	-3.137	1.529
-2.052 0.040 -6.133 -0.141		
Frying_Cycle[T.1]	9.202	1.529
6.019 0.000 6.206 12.198		
Frying_Cycle[T.2]	13.198	1.529
8.634 0.000 10.202 16.194		
Frying_Cycle[T.3]	25.131	1.529
16.440 0.000 22.135 28.127		
Frying_Cycle[T.4]	35.356	1.529
23.129 0.000 32.360 38.352		
Frying_Cycle[T.5]	43.312	1.529
28.334 0.000 40.316 46.309		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.1]	-2.790	2.162
-1.291 0.197 -7.027 1.447		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-8.473	2.162
-3.919 0.000 -12.710 -4.236		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-7.643	2.162
-3.536 0.000 -11.881 -3.406		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.2]	6.332	2.162
2.929 0.003 2.095 10.569		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-9.925	2.162
-4.591 0.000 -14.162 -5.688		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-9.912	2.162
-4.585 0.000 -14.149 -5.675		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.3]	2.329	2.162
1.077 0.281 -1.908 6.566		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-21.497	2.162
-9.944 0.000 -25.734 -17.260		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-20.735	2.162
-9.591 0.000 -24.972 -16.498		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.4]	0.150	2.162
0.069 0.945 -4.087 4.387		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-28.237	2.162
-13.062 0.000 -32.474 -24.000		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-28.714	2.162
-13.282 0.000 -32.951 -24.477		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.5]	-8.522	2.162
-3.942 0.000 -12.760 -4.285		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-34.916	2.162
-16.151 0.000 -39.153 -30.679		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-34.671	2.162
-16.038 0.000 -38.908 -30.434		
Group Var	8.775	1.637

Model for: Para_Anisidine_Value

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:
Para_Anisidine_Value		
No. Observations:	192	Method:
REML		
No. Groups:	8	Scale:
4.8992		
Min. group size:	24	Log-Likelihood:
-413.7622		
Max. group size:	24	Converged:
Yes		
Mean group size:	24.0	

	Coef.	Std.Err.
z	P> z	[0.025 0.975]
Intercept	8.516	1.954
4.358 0.000 4.686 12.347		
Oil_Type[T.Control Sunflower Oil]	-0.771	1.107
-0.697 0.486 -2.940 1.398		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]	-2.276	1.107
-2.057 0.040 -4.446 -0.107		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]	-2.969	1.107
-2.683 0.007 -5.138 -0.800		
Frying_Cycle[T.1]	4.378	1.107
3.955 0.000 2.208 6.547		
Frying_Cycle[T.2]	9.538	1.107
8.618 0.000 7.368 11.707		
Frying_Cycle[T.3]	14.584	1.107
13.178 0.000 12.415 16.753		
Frying_Cycle[T.4]	31.580	1.107
28.535 0.000 29.411 33.749		
Frying_Cycle[T.5]	34.236	1.107
30.935 0.000 32.067 36.405		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.1]	2.048	1.565
1.309 0.191 -1.020 5.116		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-3.380	1.565
-2.160 0.031 -6.447 -0.312		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-2.806	1.565
-1.793 0.073 -5.874 0.261		

Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.2]	7.032	1.565
4.493 0.000 3.965 10.100		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-7.001	1.565
-4.473 0.000 -10.068 -3.933		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-4.366	1.565
-2.789 0.005 -7.433 -1.298		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.3]	9.563	1.565
6.110 0.000 6.496 12.631		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-10.998	1.565
-7.027 0.000 -14.065 -7.930		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-8.140	1.565
-5.201 0.000 -11.208 -5.073		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.4]	0.986	1.565
0.630 0.529 -2.082 4.054		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-26.403	1.565
-16.869 0.000 -29.470 -23.335		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-23.861	1.565
-15.246 0.000 -26.929 -20.794		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.5]	4.236	1.565
2.707 0.007 1.168 7.304		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-26.799	1.565
-17.123 0.000 -29.867 -23.732		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-24.299	1.565
-15.525 0.000 -27.366 -21.231		
Group Var	25.655	6.379

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Model for: TOTOX_Value

Mixed Linear Model Regression Results

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Model:	MixedLM	Dependent Variable:
TOTOX_Value		
No. Observations:	192	Method:
REML		
No. Groups:	8	Scale:
58.3500		
Min. group size:	24	Log-Likelihood:
-618.6690		
Max. group size:	24	Converged:
Yes		
Mean group size:	24.0	

Coef. Std.Err.

z P>|z| [0.025 0.975]

Intercept	18.924	4.738
3.994 0.000 9.638 28.209		
Oil_Type[T.Control Sunflower Oil]	3.656	3.819
0.957 0.338 -3.829 11.142		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]	-10.937	3.819
-2.864 0.004 -18.423 -3.451		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]	-9.242	3.819
-2.420 0.016 -16.728 -1.756		
Frying_Cycle[T.1]	22.781	3.819
5.965 0.000 15.295 30.267		
Frying_Cycle[T.2]	35.933	3.819
9.408 0.000 28.447 43.419		
Frying_Cycle[T.3]	64.846	3.819
16.978 0.000 57.360 72.332		
Frying_Cycle[T.4]	102.292	3.819
26.783 0.000 94.807 109.778		
Frying_Cycle[T.5]	120.861	3.819
31.644 0.000 113.375 128.347		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.1]	-3.533	5.401
-0.654 0.513 -14.119 7.054		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-20.326	5.401
-3.763 0.000 -30.913 -9.740		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.1]	-18.093	5.401
-3.350 0.001 -28.680 -7.507		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.2]	19.697	5.401
3.647 0.000 9.110 30.283		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-26.850	5.401
-4.971 0.000 -37.437 -16.264		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.2]	-24.190	5.401
-4.478 0.000 -34.776 -13.603		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.3]	14.221	5.401
2.633 0.008 3.634 24.808		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-53.992	5.401
-9.996 0.000 -64.579 -43.406		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.3]	-49.609	5.401
-9.185 0.000 -60.196 -39.023		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.4]	1.286	5.401
0.238 0.812 -9.301 11.873		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-82.877	5.401
-15.344 0.000 -93.464 -72.291		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.4]	-81.289	5.401
-15.050 0.000 -91.876 -70.703		
Oil_Type[T.Control Sunflower Oil]:Frying_Cycle[T.5]	-12.809	5.401
-2.371 0.018 -23.396 -2.222		
Oil_Type[T.Rice Bran Oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-96.631	5.401
-17.890 0.000 -107.217 -86.044		
Oil_Type[T.Sunflower oil + 15ppm Cerium Oxide]:Frying_Cycle[T.5]	-93.641	5.401
-17.336 0.000 -104.227 -83.054		

Group Var	121.212	8.837
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Table 5.4A: Multiparameter Kinetic Modelling of Oxidative Behaviour of Edible Oils During Frying

Oil Type	Treatment with cerium oxide (ppm)	Temperature (°C)	Time Point (Frying time/cycle) (min)	Peroxide Value		p-Anisidine Value		Antioxidant Activity (%DPPH)	
				Mean	± SD	Mean	± SD	Mean	± SD
Rice bran oil	0	120	0	0.561	0.062	3.89	0.006	58.37	0.906
Rice bran oil	0	120	30	7.65	0.07	7.7	0.136	50.42	0.96
Rice bran oil	0	120	60	11.24	0.126	9.7	0.066	46.1	1.197
Rice bran oil	0	120	90	15.67	0.18	13.77	0.035	39.95	0.561
Rice bran oil	0	120	120	25.24	0.112	28.32	0.016	33.86	1.936
Rice bran oil	0	120	150	33.89	0.122	30.63	0.143	27.68	0.982
Rice bran oil	0	150	0	0.561	0.062	3.14	0.012	58.37	0.509
Rice bran oil	0	150	30	8	0.133	9.11	0.093	45	0.594
Rice bran oil	0	150	60	11.87	0.162	12.08	0.124	40.84	2.226
Rice bran oil	0	150	90	18.73	0.048	16.08	0.093	33.73	0.968
Rice bran oil	0	150	120	28.33	0.166	31.73	0.056	27.06	1.589
Rice bran oil	0	150	150	37.65	0.056	34.63	0.077	23.16	0.791
Rice bran oil	0	180	0	0.561	0.062	3.46	0.161	58.37	0.747
Rice bran oil	0	180	30	8.99	0.093	11.18	0.086	39.68	0.729
Rice bran oil	0	180	60	12.19	0.088	15.03	0.056	34.85	1.516
Rice bran oil	0	180	90	21.36	0.104	19.26	0.161	27.13	0.926
Rice bran oil	0	180	120	32.48	0.176	35.51	0.166	20.97	1.206
Rice bran oil	0	180	150	39.41	0.08	37.9	0.093	19.42	0.807
Rice bran oil	5	120	0	0.56	0.047	3.57	0.096	60.02	1.723
Rice bran oil	5	120	30	1.56	0.125	4.88	0.077	57.98	1.886
Rice bran oil	5	120	60	4.17	0.052	5.02	0.086	51.48	1.04
Rice bran oil	5	120	90	5.18	0.076	6.09	0.11	45.5	1.238
Rice bran oil	5	120	120	7.96	0.117	7.61	0.056	40.4	0.71
Rice bran oil	5	120	150	9.8	0.029	9.09	0.071	37.33	1.033
Rice bran oil	5	150	0	0.56	0.047	3.6	0.092	60.02	0.606
Rice bran oil	5	150	30	1.96	0.102	4.79	0.156	52.68	1.09
Rice bran oil	5	150	60	4.7	0.137	6.18	0.093	45.88	0.907
Rice bran oil	5	150	90	5.66	0.104	8.33	0.012	41.41	0.716
Rice bran oil	5	150	120	8.69	0.081	10.81	0.141	35.33	1.065
Rice bran oil	5	150	150	9.98	0.137	11.97	0.129	32.44	1.131
Rice bran oil	5	180	0	0.56	0.047	3.77	0.11	60.02	1.914
Rice bran oil	5	180	30	2.12	0.076	5.92	0.101	48.23	1.015
Rice bran oil	5	180	60	5.44	0.091	7.34	0.056	44.8	0.996
Rice bran oil	5	180	90	5.663	0.012	9.01	0.117	36.07	0.962
Rice bran oil	5	180	120	8.902	0.012	11.06	0.126	32.41	0.284
Rice bran oil	5	180	150	10.01	0.09	14.23	0.128	30.29	0.797
Rice bran oil	10	120	0	0.56	0.047	3.71	0.064	59.21	2.162
Rice bran oil	10	120	30	1.14	0.064	3.13	0.099	56.24	1.08
Rice bran oil	10	120	60	3.57	0.121	4.61	0.096	53.22	0.621
Rice bran oil	10	120	90	4.35	0.116	4.37	0.111	50.96	0.728
Rice bran oil	10	120	120	7.38	0.116	5.68	0.057	47.4	0.396
Rice bran oil	10	120	150	8.92	0.047	8.26	0.116	46.48	0.812
Rice bran oil	10	150	0	0.56	0.047	3.76	0.08	59.21	1.041
Rice bran oil	10	150	30	1.48	0.064	4.45	0.104	50.32	0.211
Rice bran oil	10	150	60	4.04	0.076	5.84	0.114	47.52	0.656
Rice bran oil	10	150	90	4.75	0.035	7.88	0.073	46.1	2.163
Rice bran oil	10	150	120	7.88	0.104	9.85	0.109	43.85	0.843
Rice bran oil	10	150	150	9.14	0.099	11.75	0.082	42.1	1.007
Rice bran oil	10	180	0	0.56	0.047	3.45	0.09	59.21	0.99
Rice bran oil	10	180	30	1.64	0.018	5.28	0.081	47.43	0.986
Rice bran oil	10	180	60	4.79	0.087	8.66	0.119	43.67	0.511
Rice bran oil	10	180	90	4.813	0.029	10.12	0.063	43.3	1.929
Rice bran oil	10	180	120	8.272	0.047	11.94	0.076	39.61	0.956
Rice bran oil	10	180	150	9.84	0.076	12.12	0.088	37.3	1.216
Rice bran oil	15	120	0	0.56	0.062	3.31	0.116	66.42	0.641
Rice bran oil	15	120	30	0.98	0.104	3.3	0.066	65.24	0.854
Rice bran oil	15	120	60	2.98	0.058	3.87	0.127	63.82	0.673

Rice bran oil	15	120	90	3.56	0.03	4	0.109	61.64	1.622
Rice bran oil	15	120	120	6.82	0.081	5.35	0.151	59.74	0.596
Rice bran oil	15	120	150	8.22	0.035	7.83	0.108	58.37	1.087
Rice bran oil	15	150	0	0.561	0.062	3.34	0.051	66.42	1.296
Rice bran oil	15	150	30	1.02	0.058	3.29	0.122	63.88	0.426
Rice bran oil	15	150	60	3.24	0.029	4.06	0.103	62.27	2.05
Rice bran oil	15	150	90	3.88	0.152	4.19	0.118	59.93	1.269
Rice bran oil	15	150	120	7.19	0.047	5.51	0.122	58.74	0.806
Rice bran oil	15	150	150	8.59	0.076	7.9	0.057	57.34	0.811
Rice bran oil	15	180	0	0.561	0.062	3.63	0.161	66.42	0.837
Rice bran oil	15	180	30	1.23	0.133	3.3	0.111	62.78	0.509
Rice bran oil	15	180	60	3.79	0.035	4.17	0.087	60.32	1.642
Rice bran oil	15	180	90	4.213	0.024	4.09	0.171	58.28	0.318
Rice bran oil	15	180	120	7.662	0.176	5.54	0.021	56.79	0.821
Rice bran oil	15	180	150	8.91	0.035	8.21	0.132	55.36	1.095
Sunflower oil	0	120	0	1.94	0.141	2.52	0.073	39.87	1.549
Sunflower oil	0	120	30	8.92	0.066	9.06	0.112	34.89	0.661
Sunflower oil	0	120	60	15.62	0.081	15.68	0.135	29.35	1.616
Sunflower oil	0	120	90	19.68	0.111	21.3	0.167	21.74	1.016
Sunflower oil	0	120	120	30.71	0.111	30.8	0.088	19.86	1.16
Sunflower oil	0	120	150	32.91	0	35.78	0.147	17.44	0.31
Sunflower oil	0	150	0	1.94	0.141	2.83	0.114	39.87	1.209
Sunflower oil	0	150	30	9.01	0.141	10.6	0.1	32.24	1.342
Sunflower oil	0	150	60	17.33	0.051	18.12	0.091	26.67	1.052
Sunflower oil	0	150	90	21.27	0.156	24.63	0.021	19.41	1.35
Sunflower oil	0	150	120	31.22	0.105	34.11	0.046	17.48	1.33
Sunflower oil	0	150	150	33.09	0.076	38.64	0.126	15.18	0.597
Sunflower oil	0	180	0	1.94	0.141	2.6	0.131	39.87	0.161
Sunflower oil	0	180	30	9.08	0.093	12.48	0.167	31.17	0.393
Sunflower oil	0	180	60	17.42	0.077	20.87	0.126	24.18	1.231
Sunflower oil	0	180	90	23.37	0.011	27.77	0.087	17.25	1.777
Sunflower oil	0	180	120	31.48	0.181	36.23	0.086	15.33	1.37
Sunflower oil	0	180	150	33.28	0.076	41.24	0.066	13.77	0.292
Sunflower oil	5	120	0	1.8	0.159	2.6	0.006	44.67	0.357
Sunflower oil	5	120	30	3.41	0.136	3.97	0.123	43.89	1.227
Sunflower oil	5	120	60	5.29	0.081	5.84	0.046	40.35	1.473
Sunflower oil	5	120	90	6.6	0.052	6.91	0.134	39.74	0.687
Sunflower oil	5	120	120	8.3	0.157	9.14	0.081	37.86	1.783
Sunflower oil	5	120	150	9.72	0.091	11.34	0.097	35.01	0.538
Sunflower oil	5	150	0	1.76	0.179	2.64	0.122	44.67	1.061
Sunflower oil	5	150	30	3.3	0.096	4.29	0.096	41.94	1.281
Sunflower oil	5	150	60	5.83	0.121	6.16	0.181	38.83	1.025
Sunflower oil	5	150	90	6.75	0.035	7.05	0.111	38.04	0.843
Sunflower oil	5	150	120	9.65	0.133	9.22	0.052	36.45	1.328
Sunflower oil	5	150	150	10.02	0.114	11.29	0.081	33.4	1.029
Sunflower oil	5	180	0	1.82	0.145	2.59	0.123	44.67	0.729
Sunflower oil	5	180	30	3.861	0.101	4.29	0.061	41.21	1.403
Sunflower oil	5	180	60	6.072	0.044	6.4	0.181	37.23	0.329
Sunflower oil	5	180	90	7.37	0.064	7.52	0.079	36.5	0.831
Sunflower oil	5	180	120	9.66	0.052	10.08	0.131	35.5	0.809
Sunflower oil	5	180	150	10.68	0.071	14.05	0.134	32.17	0.509
Sunflower oil	10	120	0	1.8	0.156	2.64	0.04	49.33	1.263
Sunflower oil	10	120	30	2.97	0.058	4.02	0.076	47.47	0.278
Sunflower oil	10	120	60	4.54	0.176	5.74	0.146	46.5	0.918
Sunflower oil	10	120	90	5.63	0.099	6.81	0.046	44.71	1.213
Sunflower oil	10	120	120	7.63	0	8.75	0.056	43.78	0.933
Sunflower oil	10	120	150	8.82	0.095	11.08	0.047	42.18	1.392
Sunflower oil	10	150	0	1.76	0.179	2.6	0.093	49.33	0.309
Sunflower oil	10	150	30	3.17	0.012	3.85	0.121	45.57	1.905
Sunflower oil	10	150	60	4.99	0.116	5.53	0.156	45.11	1.16
Sunflower oil	10	150	90	5.87	0.064	6.67	0.148	43.17	1.817
Sunflower oil	10	150	120	8.88	0.041	8.9	0.088	42.23	1.412
Sunflower oil	10	150	150	9.58	0.041	11.26	0.016	40.56	0.396
Sunflower oil	10	180	0	1.82	0.145	2.62	0.084	49.33	0.783
Sunflower oil	10	180	30	3.651	0.11	4.16	0.122	43.9	1.063
Sunflower oil	10	180	60	5.492	0.047	5.95	0.161	43.33	0.249

Sunflower oil	10	180	90	6.63	0.081	7.05	0.058	41.5	0.936
Sunflower oil	10	180	120	9.07	0	9.04	0.106	40.66	0.126
Sunflower oil	10	180	150	10	0.029	11.37	0.143	39.45	0.598
Sunflower oil	15	120	0	1.8	0.156	2.03	0.114	55.94	0.782
Sunflower oil	15	120	30	2.48	0.116	3.71	0.058	55.02	1.063
Sunflower oil	15	120	60	3.92	0.035	5.32	0.046	53.97	1.509
Sunflower oil	15	120	90	4.71	0.058	6.42	0.088	51.38	0.644
Sunflower oil	15	120	120	7.04	0.116	8.71	0.071	50.15	0.846
Sunflower oil	15	120	150	8.08	0.11	9.65	0.2	47.22	0.999
Sunflower oil	15	150	0	1.76	0.171	2.13	0.161	55.94	0.922
Sunflower oil	15	150	30	2.79	0.087	3.81	0.2	53.99	0.233
Sunflower oil	15	150	60	4.47	0	5.29	0.176	52.42	1.351
Sunflower oil	15	150	90	5.34	0.078	6.56	0.018	49.63	0.708
Sunflower oil	15	150	120	7.98	0.07	8.95	0.166	48.94	1.629
Sunflower oil	15	150	150	8.67	0.11	9.57	0.133	45.71	1.45
Sunflower oil	15	180	0	1.82	0.154	2.12	0.073	55.94	1.431
Sunflower oil	15	180	30	3.361	0.035	3.98	0.07	51.66	1.07
Sunflower oil	15	180	60	4.992	0.058	5.62	0.081	51.08	1.921
Sunflower oil	15	180	90	6.02	0.105	6.76	0.129	49.28	2.59
Sunflower oil	15	180	120	8.41	0.058	9.08	0.097	47.52	1.601
Sunflower oil	15	180	150	9.93	0.099	9.73	0.157	43.5	1.008

International Online Conference on
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2020 " organized by Division of Food Technology, Department of Chemical Engineering, Vignan's Foundation
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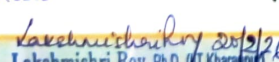

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nanoparticles exhibit novel physicochemical properties that influence their interaction with natural and biological matter and in various processes. Engineered nanoparticles of cerium oxide have previously been investigated in relation to enhancing the functionality of different materials. Cerium oxide nanoparticles have been found to be highly integral components in catalytic and anticorrosive applications. Nanoparticles are particularly susceptible to degradation by high temperature and radiation, which can integrate and increase oxidation and reactivity. This study examines oxide or ceria nanoparticles (CNPs) have been synthesized by the sol-gel method using cerium nitrate and surfactant oil to evaluate its potential in shelf stability of oils. The CNPs were produced by precipitation method in ammonium bi-carbonate followed by pyrolysis. Tests for detection of rancidity of oil was carried out by measuring the peroxide value (PV) and acid value (AV) of the oil. The oil was stored and sealed in different temperatures (20°C, 30°C, 40°C) throughout the storage period (100days). The results suggest that, in absence of CNPs, peroxide value (PV) of some of the pre-treated samples increased and crossed the acceptable limit by the end of the storage period. However, addition of ceria nanoparticles (CNPs) reduced the PV. However, addition of CNPs seems to significantly control the increase in PV under the tested temperature and pretreatment methods. Similar observations were found for change in acid value (AV) of oil samples. Different studies have shown ceria nanoparticles to be odorless and non-toxic and hence have high potential for varied applications in food process engineering and preservation technology.

Keywords: Cerium oxide nanoparticles, Anticorrosive, edible oil, shelf stability, oxidation, Ammonium bi-carbonate, accelerated shelf-life testing (ASLT).

The National Nanotechnology Initiative in the US defines nanotechnology as the understanding and control of characteristic properties of matter at a nanoscale level where unique phenomena and novel applications. Today nanomaterials have garnered a variety of applications in medical, food, commercial and industrial products with a global market value amounting to 76 billion US dollars. Applications of nanotechnology in food processing has the potential to revolutionize the vital aspects of food and related industries from food safety to the molecular synthesis of new food products and functional ingredients. Several recent studies have established potential applications of nanotechnology in different areas of food sector for instance supplementing packaging material with nano-scale antimicrobial ingredients increasing the shelf life of the food (preservation) etc.

Zinc oxide nanoparticles (ZnO NPs) are considered as one of the most adaptable nanomaterials due to their catalytic attributes and has proved to be an empirical choice in therapeutic applications. Recent studies have claimed that low doses ZnO NPs are safe to be used for diverse medical applications and exhibit a protective behaviour against degeneration caused by uncontrolled or oxidative stresses.

There are a wide variety of edible oils available in the market out of which two of the most widely used cooking oils in India are rice bran oil and sunflower oil. Since both these edible oils are primarily composed of PUFA and MUFA they are particularly susceptible to degradation by high temperature, light and oxygen which can instigate and increase

of PUFA and MUFA they are particularly susceptible to degradation by high temperature, light and oxygen which can instigate and increase the oxidation of PUFA and MUFA. PUFA and MUFA are particularly susceptible to degradation by high temperature, light and oxygen which can instigate and increase the oxidation of PUFA and MUFA. PUFA and MUFA are particularly susceptible to degradation by high temperature, light and oxygen which can instigate and increase the oxidation of PUFA and MUFA.

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graph TD
    A[Reaction of 2,2,4,4-tetrahydroxy-1,3-bis(phenylthio)butane and isocyanate groups] --> B[Dissolved in Double Distilled Water]
    B --> C[Ammonia was added to the solution to maintain the pH was about 2.5-3.5]
    C --> D[A carbodiimide solution was added dropwise for 75 min at 70 °C while stirring constantly]
    D --> E[The stirring was continued for another 30 min for the reaction to complete]
    E --> F[The suspension was filtered and the precipitate was washed alternately with double distilled water and ethanol several times]
    F --> G[Finally it was dried in a hot air oven at 80 °C for 48 hrs]
    G --> H[Subsequently dried powders were calcined at 800 °C]
    H --> I[A yellowish light superfine powder was obtained]
    I --> J[FTIR analysis]
    I --> K[DSC analysis]
    I --> L[TGA analysis]
    I --> M[XRD analysis]
  
```

Characterization steps:

- FTIR analysis: 10 ppm
- DSC analysis: 10 ppm
- TGA analysis: 10 ppm
- XRD analysis: 10 ppm

The effects of different concentrations of CNP on the oxidative stability of rice bran oil (RBO) and sunflower oil (SFO) (both fresh and subjected to heat treatment and aeration), which are very rich in unsaturated fatty acids, were estimated by measuring the Peroxide Value (PV) and Acid Value (AV).

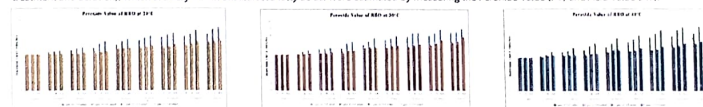


Figure 1. Comparison representation of the changes in Free side Value of different Rice Bran Oil samples in different time intervals stored in 20°C (A), 30°C (B) and 40°C (C) (and meaning: F - Fresh Sample; H - Heated Sample; A - Sample heated and aerated).

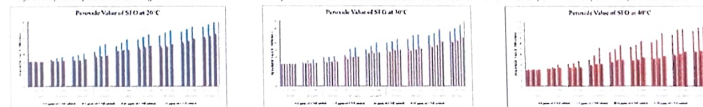
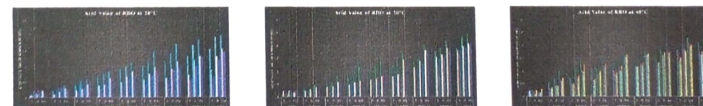
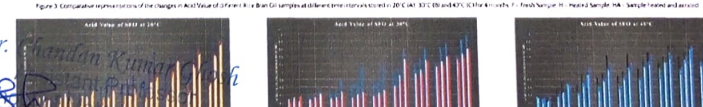


Figure 2. Comparative representations of the changes in Peroxide Value of different Sunflower Oil samples at different time intervals stored in 20°C (A), 30°C (B) and 40°C (C) for 6 months. F - Fresh Sample, H - Heated Sample, HA - Sample heated and aerated.

[illegible][illegible]

To make a better estimate of the apparent activation energy and pre-exponential factor, the effect of temperature on the rate of lead oxidation was evaluated by means of the modified Arrhenius equation:

Figure 5. Arthropods (not all parasitoids) under radiation (a) (constant 100% of heat transfer of lake and surrounding air) exposed to increasing temperature for a) a constant light intensity.

Pathogen	1st year	2nd year	3rd year	4th year
<i>E. coli</i>	~45%	~65%	~70%	~70%
<i>Salmonella</i>	~35%	~65%	~65%	~65%
<i>Shigella</i>	~25%	~65%	~65%	~65%
<i>Clostridium</i>	~25%	~55%	~65%	~65%

Category	Percentage
I feel good about my life	40%
I feel bad about my life	30%
I feel neutral about my life	30%

Figure 6 Represents the effect of varying concentrations of cerium oxide nano particles on enhancement of shelf stability of both rice bran oil and sunflower oil based on the acceptable

The results obtained indicate that cerium oxide nano particles have the potential to effectively control the increase in rate of lipid oxidation that is catalyzed due to a constant increase in temperature. However, critical control of dosage is also required because at higher levels cerium oxide sometimes tend to act as pro-oxidants. Depending on the reaction sensitivity to temperature, thermal activation energy can be considered as a dominant accelerating factor in the prediction of shelf life. Based on the standard acceptable limit of peroxide value for edible oils the predicted shelf life was observed to significantly increase by addition of cerium oxide nano particles. The future prospect of these nano material opens up a varied range of possibilities for the development of novel food products and applications in the

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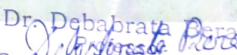

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He/She has presented a poster/oral presentation entitled

Quality and shelf-life study of mayonnaise formulated with nano-ceria enriched edible oils

Sreemoyee Chakraborty
23/02/2026

Lakshminishri Roy 20/2/26
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Quality and shelf-life study of mayonnaise formulated from nano-ceria enriched edible oils

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Affiliations: ^{1,2,3}Jadavpur University, Kolkata; ⁴Techno Main Salt Lake, Kolkata

Abstract:

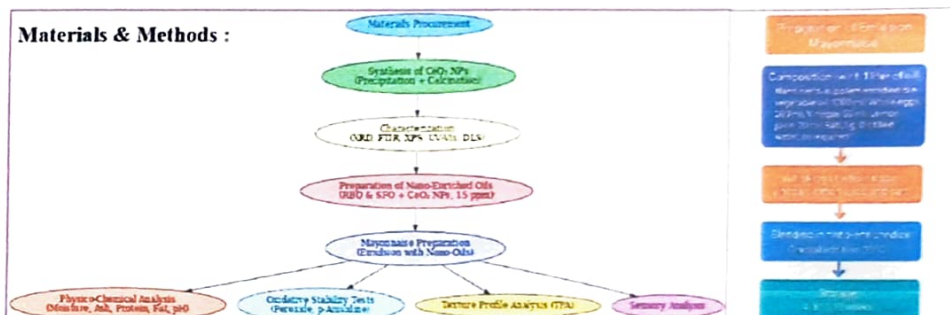
Lipid oxidation in mayonnaise deteriorates product quality and safety, necessitating addition of synthetic antioxidants, the efficacy of which is now limited due to potential cytotoxic toxicity. Moreover, deterioration of stability and functional efficacy of natural antioxidants during processing and storage remain a critical yet unresolved challenge. This study is aimed to evaluate cerium oxide nanoparticle (CeO₂ NPs) as clean-label stable alternatives to synthetic antioxidants. Mayonnaise samples (Mayo-R and Mayo-S) were prepared with 15 ppm nano-ceria-enriched rice bran and sunflower oils, respectively. Physicochemical properties, texture profile, sensory attributes, and oxidative stability were evaluated over 12 weeks of refrigerated storage in comparison to commercial control (Mayo-C). Proximate composition was determined, texture assessed using TA.XT plus texture analyzer, and oxidation monitored using peroxide value and p-anisidine value based on AOCs protocols. Sensory data were collected from a 30-member panel using a 9-point hedonic scale. Statistical analyses included mean ± SD and comparative trend evaluation. Results revealed that nano-ceria fortification significantly delayed lipid oxidation in Mayo-R and Mayo-S, with final PV and p-AV values ~2.5 times lower than the control. Mayo-R exhibited better oxidative and textural stability due to synergistic effects of natural antioxidants in rice bran oil. Texture parameters such as gumminess, adhesiveness, and spreadability were preserved in nano-ceria fortified samples, aligning well with sensory scores. pI remained more stable in Mayo-R & S, indicating delayed physicochemical degradation. In conclusion, the incorporation of CeO₂ NPs improved oxidative resistance and preserved consumer-relevant quality in mayonnaise formulations, supporting their use in functional emulsion-based products for extended shelf-life.

Keywords: cerium oxide nanoparticles, mayonnaise, oxidative stability, texture profile analysis, nano-antioxidants, shelf-life enhancement

Introduction:

Improving oxidative and structural stability in oil-based food systems, especially those rich in polyunsaturated fatty acids (PUFA) like rice bran and sunflower oils, remains a major challenge. Conventional antioxidants such as tocopherols and synthetic additives (BHA, BHT) often degrade under high temperatures, necessitating novel approaches. Recent advances in nanotechnology offer promising solutions. In this study, cerium oxide nanoparticles (CeO₂ NPs) were engineered with tailored oxygen vacancies to exploit their unique redox-switching properties for regenerative ROS scavenging. Controlled synthesis and calcination enabled fine-tuning of Ce³⁺/Ce⁴⁺ ratios, confirmed via XRD, FTIR, XPS, UV-Vis, and DLS analyses. These structural features directly correlated with enhanced antioxidant performance in nano-enriched edible oils. Moreover, the role of these engineered nanoparticles in stabilizing high-oil Pickering-type emulsions was explored, revealing improvements in rheology and texture that connected nanoparticle design to macroscopic food properties. This approach aligns with sustainable processing goals, minimizing additive complexity while boosting thermal robustness. The study thus highlights the potential of oxygen-vacancy-engineered CeO₂ NPs to simultaneously enhance oxidative stability and structural integrity in food systems, offering a new pathway for advanced food process engineering and next-generation ingredient design.

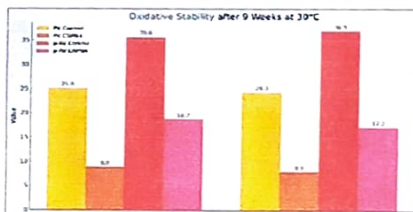
Materials & Methods:



Key data characterizing engineered cerium oxide nanoparticles

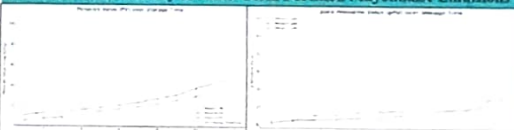
CeO₂ NPs were structurally characterized as nanoceria with the fluorite phase and notable oxygen vacancies, which promote reversible Ce³⁺/Ce⁴⁺ redox cycling. Analysis confirmed colloidal stability, mixed valence states, UV absorption, and significant radical scavenging activity.

XPS	Mixed Ce ³⁺ /Ce ⁴⁺ ratio
XRD	Fluorite phase (~100 nm)
DLS	Zeta potential > 30 mV
FTIR	Ce ³⁺ -O-Ce ⁴⁺ bonding
UV-Vis	Absorption at 300-330 nm
DPPH	Dose-dependent scavenging
ABTS	Dose-dependent scavenging



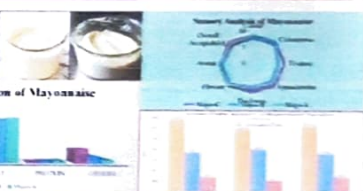
Nanoceria significantly reduced primary and secondary oxidation in RBO and SFO by over 50%, enhancing shelf-life

Enhanced Shelf Stability of Nano-Ceria Fortified Mayonnaise Emulsions



Pickering Behavior and Structural Mechanisms in Nanoceria-Stabilized Mayonnaise

This study highlights how oxygen-vacancy-enriched CeO₂ nanoparticles (CeO₂ NPs) effectively stabilized mayonnaise through Pickering emulsion mechanisms. Unlike traditional surfactant systems, these nanoparticles adsorbed at the oil-water interface, forming protective layers around droplets that inhibited coalescence and curtailed oxidative propagation. Visual and phase separation analyses over 12 weeks revealed superior physical stability in nanoceria samples (Mayo-R and Mayo-S), which showed minimal creaming, while the control (Mayo-C) displayed separation by week 8. CeO₂ NPs' high surface area and engineered oxygen vacancies enhanced partial hydrophilicity, promoting strong interfacial adsorption and structural reinforcement. Their regenerative Ce³⁺/Ce⁴⁺ redox cycling further ensured continuous scavenging of interfacial radicals. Texture profile analysis supported these findings: Mayo-R exhibited higher gumminess (80.1 g) and cohesiveness, indicating a robust nanoparticle-percolated network, whereas Mayo-S demonstrated greater springiness (0.85 mm) and spreadability, reflecting elastic structuring. These textural improvements, driven by nanoparticle interfacial interactions and oil-specific effects, align with reports on nano-stabilized emulsions achieving superior gel strength and elasticity. Overall, integrating engineered CeO₂ NPs yielded multifunctional emulsions with enhanced oxidative stability, improved texture, and extended shelf life, underscoring the promise of nanotechnology in designing next-generation food emulsions with tailored structural and functional attributes.



Mayo-R offered firmer, adhesive traits ideal for salads, whereas Mayo-S delivered smoother spreadability suited for dips, all without compromising taste.

Change in sensory attributes during storage



Texture Degradation after 12 Weeks at 4-8°C

Over 12 weeks at 4-8°C, all samples softened, but nano-ceria mayonnaise (Mayo-R/S) retained textural integrity far better than the control, showing smaller drops in hardness, gumminess, cohesiveness, and spreadability, confirming superior structural resilience due to Pickering-type stabilization.

Conclusion

This study shows that oxygen-vacancy-engineered cerium oxide nanoparticles (CeO₂ NPs), synthesized via process-controlled methods, act as multifunctional agents to improve the oxidative and structural stability of oil-based food systems. By precisely tailoring surface defect chemistry, these nanoparticles achieved an optimal Ce³⁺/Ce⁴⁺ redox balance, delivering regenerative antioxidant activity and markedly enhancing the oxidative stability of nano-enriched edible oils. When incorporated into high-oil Pickering-type mayonnaise emulsions, they boosted interfacial stability, reinforced emulsion structure, and maintained desirable texture and sensory properties over prolonged storage. Their Pickering stabilization and redox mechanisms effectively delayed lipid oxidation and preserved emulsion integrity under processing and storage conditions. Importantly, integrating these nanoparticles required no major formulation changes, aligning seamlessly with existing food manufacturing workflows. This work advances the structure-function-process understanding of CeO₂ NP-enriched emulsions, supporting scalable production of next-generation food systems with longer shelf life, improved functionality, and clean-label appeal, while paving the way for broader nanotechnology applications in food engineering.

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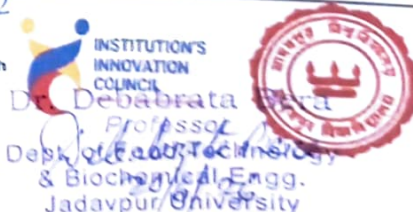
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Sreemoyee Chakraborty
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ORIGINAL ARTICLE

Engineering Surface Defect Chemistry of Cerium Oxide Nanoparticles to Enhance the Stability of Nano-Enriched Edible Oils Systems and Emulsions

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Keywords: antioxidant | emulsion rheology | nanoceria | nano-engineered edible oils | Pickering emulsion

ABSTRACT

Engineering oxidative and structural stability in oil-enriched food systems remains a primary focus in food process engineering, particularly in polyunsaturated fatty acid (PUFA)-enriched food systems. The oxygen-vacancy-enriched cerium oxide nanoparticles (CeO₂ NPs) were synthesized by a controlled synthesis route optimizing the surface defect chemistry and antioxidant capability in the present study. Structural characteristics, including Ce³⁺/Ce⁴⁺ ratio and oxygen vacancy concentration, were established by XRD, XPS, DLS, and UV-Vis methods. Prepared nanoparticles were incorporated into edible oils (rice bran and sunflower), and storage challenges in a high-oil emulsion-based mayonnaise were performed in an effort to explore designed nanoparticles' function in stabilizing Pickering-type food systems. Oxidative stability was ascertained by peroxide and anisidine value, and characterization of emulsion by textural, interfacial, and sensory tests. Addition of the CeO₂ NPs into the edible oils significantly improved oxidative stability, as evidenced by lower peroxide and p-anisidine values after prolonged storage. The emulsions at final stage also showed improved interfacial stability, greater texture profile, and higher sensory acceptance during storage at low temperature, with retained resistance against oxidative as well as structural deterioration. Most importantly, traditional workflows on production of mayonnaise were perfectly compatible with the designed nano-process engineering methodology, involving no fundamental changes in formulations. These findings lay the foundation for oxygen-vacancy-engineered CeO₂ NPs as multifunctional process additives in the creation of next-generation emulsions with extended shelf life, improved functional efficacy, and clean label characterization. The research advances progress in the field of nano-enabled food process engineering and systematic characterization of structure–function–process relationships.

1 | Introduction

Establishing the oxidative and structural stability in oil-rich food systems is a primary challenge in food process engineering, particularly for food systems rich in polyunsaturated fatty acids (PUFA) like rice bran oil (RBO) and sunflower oil (SFO).

Natural and synthetic antioxidants such as tocopherols and BHA/BHT are hindered by heat instability and decomposition during processing conditions (Celardo et al. 2011; Yamamoto et al. 2020; Pestana-Bauer et al. 2012), and thus, novel engineering techniques are required as a means of stabilizing PUFA rich oils (Grilo et al. 2014; Salas et al. 2021).

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Mechanistic insights of free radical scavenging-driven stabilization of edible oils and their shelf life extension using CeO₂ nanoparticles

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ABSTRACT

The rapid production of reactive oxygen species (ROS) due to lipid peroxidation of unsaturated bonds in wholesome vegetable oil during its storage and utilization happens to be the most alarming cause of concern in the edible oil industry. In researching for an ideal candidate to be used as an antioxidant, it has been identified that engineered CeO₂ nanoparticle with curated surface chemistry (Ce³⁺/Ce⁴⁺ ratio) displays an enhanced ROS scavenging activity. Herein the CeO₂ nanoparticles (~100–110 nm) were manufactured through controlled synthesis protocol to achieve the desired outcome. The electronic structure of these nanoparticles were calculated accordingly to achieve clear understanding on electronic phenomenon which is responsible for this enhancement. It was determined that synthesized CeO₂ are non-cytotoxic below 88 ppm and displays significant improvement of oxidative stability of oils at concentrations of 10–15 ppm. In addition, accelerated shelf-life study yields remarkable improvement of shelf life upto twice that of oils containing conventional antioxidants.

1. Introduction

Shelf life and stability of edible oils are largely limited by onset and progression of oxidative rancidity leading to deterioration in quality. It leads to unfavourable changes in nutritive value, sensory and physico-chemical properties of the oil like colour, flavour and odour. More importantly lipid oxidation is directly related to generation of free radicals which poses grave health risks to consumers. This in recent time has become a significant challenge in food processing industries (Domínguez et al., 2019). However, this oxidative deterioration can be reduced with the addition of synthetic or natural antioxidants. But prolonged use of traditional synthetic antioxidants like butylated hydroxytoluene or butylated hydroxyanisole has been reported to trigger possible health risks and toxicity due to their low stability (Naveena et al., 2008). Thus, in recent times there has been an increased consumer interest in using natural antioxidants in the form of different vitamins, minerals or fibre from plants and plant materials which are rich in bioactive compounds (e.g. phenolic compounds) to preserve and improve the oil quality. The most common natural antioxidants employed to stabilize the shelf life of edible oils include γ -oryzanol,

tocopherol, vitamin E & K etc. Most common cooking oils either naturally possess these antioxidants or are fortified with them.

Another promising approach to mitigate this issue involves the use of metal oxide nanoparticles. Metal oxide nanoparticles, such as those made from magnesium, cerium, zinc, iron, titanium, have demonstrated remarkable antioxidant properties that can effectively inhibit the progression of lipid oxidation due to their structural defects (Jagadish et al., 2018). These nanostructures due to their defect in structure can scavenge free radicals and reactive oxygen species, which are the primary initiators of lipid peroxidation (Leyva-Porras et al., 2021). Moreover, the large surface area-to-volume ratio of nanoparticles enhances their ability to interact with and neutralize these reactive species. The antioxidant mechanisms of these nanoparticles involve the chelation of pro-oxidant metal ions, the quenching of free radicals, and the inhibition of lipid hydroperoxide formation. Furthermore, some studies have explored the synergistic effects of metal oxide nanoparticles and natural antioxidants, such as plant-derived phenolic compounds. The combination of these two approaches can provide a more comprehensive solution for controlling oil rancidity, as the nanoparticles can effectively neutralize the free radicals while the natural antioxidants can scavenge

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