# *Development of a Banana peel fortified product, its analysis and comparison with unfortified product*

*A thesis submitted towards the partial fulfilment of the requirements for the degree of Master of Technology in Food Technology and Biochemical Engineering course affiliated to Faculty of Engineering and Technology, Jadavpur University*

*Submitted by*

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# *CERTIFICATE OF RECOMMENDATION*

I hereby recommend the thesis entitled "***Development of a Banana peel fortified product, its analysis and comparison with unfortified product***" carried out under my supervision by Aritra Ganguly of Registration No- 163699 of 2022-2023. The thesis has been evaluated by me and found satisfactory. It is therefore, being accepted in partial fulfilment of the requirement for awarding the degree of Master of Technology in Food Technology and Biochemical Engineering course affiliated to Faculty of Engineering and Technology, Jadavpur University.

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# *CERTIFICATE OF APPROVAL*

The foregoing thesis is hereby approved as a creditable study in **Master of Technology in Food Technology and Biochemical Engineering** and presented in a manner satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein but approve the thesis only for the purpose for which it is submitted.

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# *DECLARATION OF ORIGINALITY AND COMPLIANCE OF ACADEMIC ETHICS*

I hereby declare that this thesis contains literature survey and original research work by the undersigned candidate, as part of my Master of Technology in Food Technology and Biochemical Engineering.
All information in this document have been obtained and presented in accordance with academic rules and ethical conduct.
I also declare that, as required by these rules and conduct, I have fully cited and referred all material and results that are not original to this work.

Name: Aritra Ganguly
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# ABSTRACT

The food product sector is searching more and more for foods that have nutritive qualities and can improve health. Another issue facing the food sector is making use of all raw materials. These factors make banana peel, a raw ingredient from banana (Musa spp.) fruit, a promising candidate for the creation of novel culinary products. Banana peel might be a desirable option for the creation of powders with high antioxidant qualities, as evidenced by the blends prepared with banana peel having higher antioxidant capabilities.

Asian noodles often have a high glycemic index, and obesity and weight growth have been associated with an imbalanced diet high in carbohydrates. Noodles made from Green banana peel flour and water, are well-known for their numerous health advantages and capacity to increase fullness. However, because of its low energy content, it gives very little nutritious value. The present study demonstrated the viability of incorporating green banana flour (GBF), an underutilized subproduct with minimal commercial value and relevance in the food industry, to make low-calorie, gluten-free noodles with enhanced nutritional value. The ideal Green Banana Fortified noodles had an increase in fiber content of 5.4%, a decrease in carbohydrate content of 13%, and an increase in ash content of 2%. Compared to store-bought yellow alkaline wheat noodles, the ash content and hardness were 80% (based on texture profile analysis). This study illustrated Green Banana Flour's potential as a functional food component for improving nutrition and product processing.

# LIST OF ABBREVIATIONS

RT – Room Temperature

DW- Distilled Water

CY- Cooking Yeild

CL- Cooking Loss

WAC- Water Absoption Capacity

OA- Overall Acceptability

µg- neu molar

mg- milligram

gm- gram

ml- millilitre

°C- Degree centrigrade

RSM- Response Surface Methodology

GBPF – Green Banana Peel Flour

WF- Wheat Flour

CCD- Central composite design

# INTRODUCTION

In the food sector, the creation of new products is strategically important. Food products with a high nutritional content and extra health advantages are in high demand from consumers. Functional foods, which are usually referred to as "foods that resemble conventional foods and are consumed as part of a normal diet and have demonstrated physiological benefits and/or reduce the risk of chronic disease beyond basic nutritional functions," are products of this sort.

A climacteric fruit, bananas are eaten in many tropical nations when they are fully mature. During commercialization, a significant amount of bananas are lost as a result of poor postharvest treatment. On the other hand, unripe banana fruit keeps well on the shelf and is a good source of indigestible carbs.
The peel of unripe bananas is high in lignin, cellulose, hemicellulose, and starch. Several writers have claimed in recent years that unripe bananas' starch and fiber have nutritional and nutraceutical potential. The fruit's affordability and abundance offer excellent promise for the cost-effective manufacture of dietary fiber ingredients for food and food products with appealing chemical and functional properties.

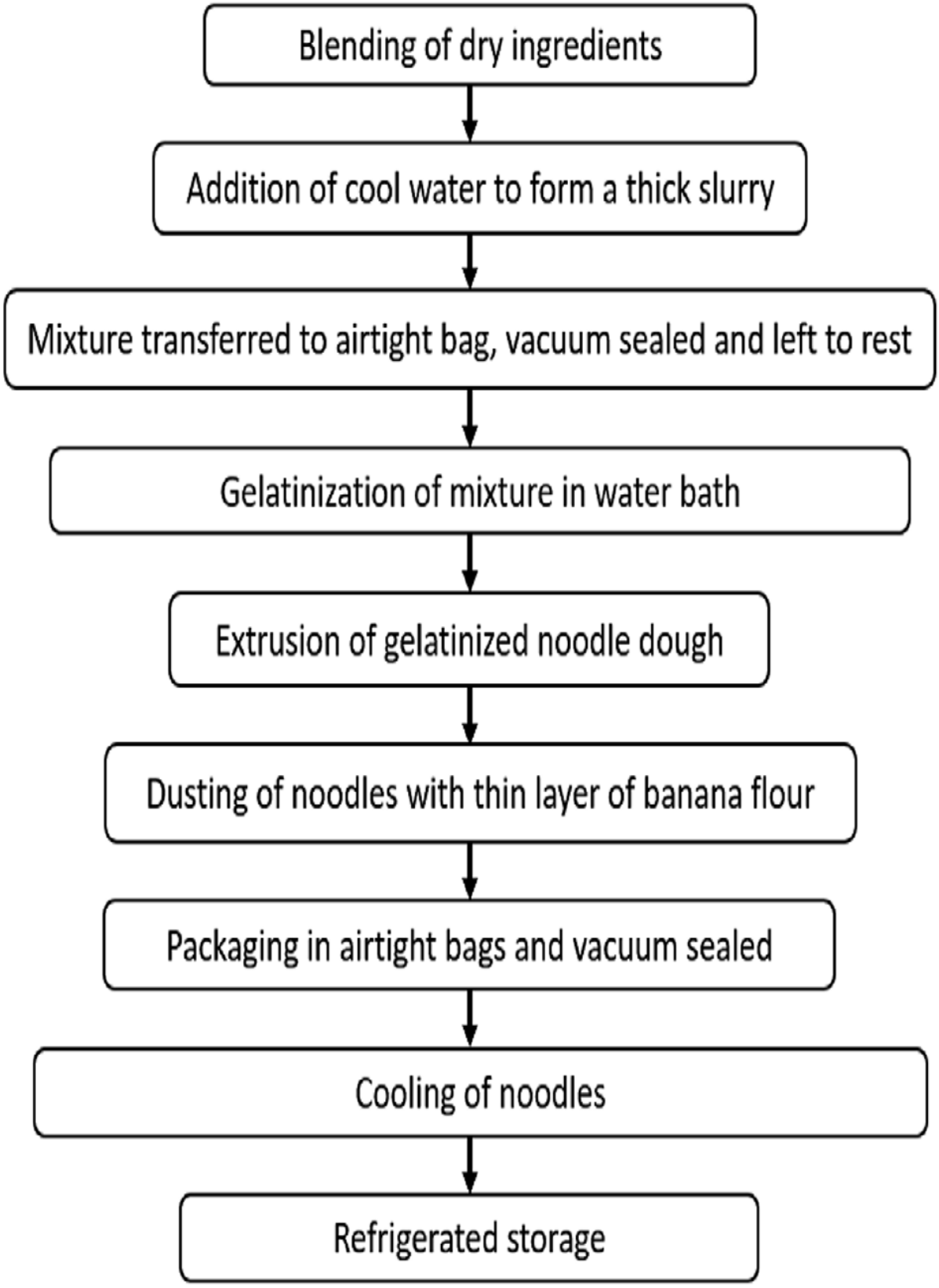
In this thesis work we have tried to demonstrate the use of unripe banana peel by peeling it and converting it to peel powder with the help of tray drying technology and eventually using the banana peel powder as a fortifying agent by mixing it with whole wheat flour and making noodles out of the mixture of whole wheat flour fortified with banana peel flour.

Response Surface Methodology (RSM) was used as a statistical tool to get the best optimised result out of various proportionate noodles made with using different combination of whole wheat flour along with unripe banana peel flour and water mixed in 13 different ratios and the best suitable and optimised result was analysed after 13 runs. Three repetitions and a fully randomized design were used to set up the studies. The standard deviation and mean were used to express the findings. Tukey's test ($p<0.05$) was run after a one-way analysis of variance (ANOVA) was used to compare the means.

For every physical and qualitative property under investigation, the means (based on a minimum of four replicates) and standard deviations were ascertained. One-way analysis of variance (ANOVA) was used to determine the significant difference between their mean values, and the Fisher least significant difference (LSD) method (significant threshold was then applied p50.05) utilizing the Windows program Minitab 14.



# GREEN BANANA PEEL FLOUR FORTIFIED NOODLES MAKING PROCESS


Blending of dry ingredients
Addition of cool water to form a thick slurry
Mixture transferred to airtight bag, vacuum sealed and left to rest
Gelatinization of mixture in water bath
Extrusion of gelatinized noodle dough
Dusting of noodles with thin layer of banana flour
Packaging in airtight bags and vacuum sealed
Cooling of noodles
Refrigerated storage

# PROCESS STEPS IN DETAILS

The noodles were prepared using Response Surface Methodology as a statistical tool to analyse, optimse, develop and improve the process flow and get the desired product. The RSM methodology was made to run based on four specifications precisely: Cooking Yeild, Cooking Loss, Water Absoption Capacity (WAC) and Acceptibility.

Following the equation – y = f(x) | where – y = response output which depends on x= variable input

The mentioned above parameters on which RSM was based is discussed in details on the next portion of the thesis.

The quantity of wheat flour was taken as a constant of 80gm and the amount of water and green banana peel flour was taken as variables based on the percentage conversion of wheat flour constant value. The proportionate table is shown below

| Amount of Wheat Flour taken = 80gm (constant) | % of Green banana peel flour (variable) | % of water (variable) | % to mg conversion for GBPF | % to ml conversion for water |
|---|---|---|---|---|
| 80 | 10 | 60 | 8 | 48 |
| 80 | 30 | 60 | 24 | 48 |
| 80 | 10 | 94 | 8 | 75.2 |
| 80 | 30 | 94 | 24 | 75.2 |
| 80 | 10 | 77 | 8 | 61.6 |
| 80 | 30 | 77 | 24 | 61.6 |
| 80 | 20 | 60 | 16 | 48 |
| 80 | 20 | 94 | 16 | 75.2 |
| 80 | 20 | 77 | 16 | 61.6 |
| 80 | 20 | 77 | 16 | 61.6 |
| 80 | 20 | 77 | 16 | 61.6 |
| 80 | 20 | 77 | 16 | 61.6 |
| 80 | 20 | 77 | 16 | 61.6 |

**Materials Required**- Potassium Meta-bisulphate (KMS), NaCl, Guar Gum, Tray drier, Extruder, Motar & Pestle, water, Green banana peel powder, Peeler, Wheat Flour

**Method**

- Fresh Green unripe banana were taken from the market with no skin spots.
- Washing and Peeling of the skin was done carefully such that the banana flesh is not taken out while peeling.
- Peeling was followed by hot water blanching to restrict the enzymatic activities and prevention of browning. Blanching of the green banana peels was done with Potassium Meta-bisulphite (KMS) taken in the ratio of 1:10 with the sample (10gm sample and 1gm KMS) along with 100ml of water
- 10-15 mins of blanching was followed by drying of the green banana peel
- Drying was done with the help of a Tray dryer for an approximate period of 4hrs at 60°C
- After drying the crisp peels were taken and milled into powder forming Green Banana peel flour
- The peel flour obtained is mixed with refined wheat flour and the fortification was done according to the specific various proportions mentioned in the table. The raw materials were exactly mixed as mentioned in the table and out of all the models obtained again RSM was done to obtain the most optimised model accordingly.
- Specific amount of water along with wheat flour and particular amount of green banana peel flour was mixed along with 2gm of salt to taste and 0.2gm of Guar Gum all mixed kneaded in a mixer for 2-6 mins at medium speed to make a dough formation.
- After mixing, the dough was sheeted in noodle making machine at 3mm gap, then it was folded and passed through the rolls of noodle making machine twice again
- The dough sheet obtained after sheeting was rested 1hr and then again rolled through the sheeting rolls three times at progessively smaller gaps of 2.40mm, 1.85mm, 1.30mm
- The dough sheet was then subjected to cutting into noodle strand by machine

**STORAGE – Noodles was stored in air tight zip bags at 4°c for 24hrs untill cooked.**

# Cooking Yeild, Cooking Loss, Water Absorption Capacity & Acceptability

The Noodles prepared according to the specifications obtained through RSM table were further segregated on specific 4 parameters to get the one best optimised result out of the 13 runs in the previous RSM table. The parameters are:

- Cooking Yeild
- Cooking Loss
- Water Absorption Capacity
- Acceptability

***COOKING YEILD*** - Cooking quality of green banana peel fortified noodles was determined using AACC approved method 66-50. GBPF Noodles (10 g) was cooked in 300mL of boiling water for 12 min. Cooked weight (g) was determined as the weight of cooked noodles after it was drained for 2 min.

Cooking Yeild % = **{Weight of cooked noodles / Weight of dried noodles}×100**

***COOKING LOSS*** - Cooking loss (% total solids weight) was measured by evaporating the cooking water over night to dryness in a forced-air drying oven at 110 °C

Cooking Loss % = **{Weight of dried Residue / Weight of dry noodles before cooked}× 100**

***WATER ABSORPTION CAPACITY***- WAC of noodles was measured by the centrifugation method of Sosulski. About 3gm of finely powdered sample was dispersed in 25ml of distilled water and placed in pre-weighted centrifuge tubes. The dispersion was stirred occasionally for about 30 mins followed by centrifugation at 3000 g for 25 mins. The supernatant was decanted, the excess moisture was removed from centrifuge tube by drying at 50°c for 25 mins in hot air oven and the sample was re-weighted.

WAC % = **{{Wet sample weight – Dry sample weight} / Dry sample weight}× 100**

Cooking Yield, Cooking Loss, Water Absorption and Overall Acceptability of all the 13 models was calculated using the formulas obtained previously shown in the table below:

| Amount of Wheat Flour in gm (constant) | % of GBPF (variable) | % of water (variable) | Cooking Yield % | Cooking Loss % | WAC % | Overall Acceptability |
|---|---|---|---|---|---|---|
| 80 | 10 | 60 | 31 | 4 | 2.3 | 7.5 |
| 80 | 30 | 60 | 25 | 8 | 2.7 | 5.5 |
| 80 | 10 | 94 | 55 | 4 | 1.7 | 7.7 |
| 80 | 30 | 94 | 40 | 7 | 2.7 | 5.8 |
| 80 | 10 | 77 | 45 | 3 | 1.1 | 7.7 |
| 80 | 30 | 77 | 29 | 8 | 2.8 | 5.8 |
| 80 | 20 | 60 | 41 | 6 | 2.8 | 7.2 |
| 80 | 20 | 94 | 31 | 6 | 2.2 | 7 |
| 80 | 20 | 77 | 34 | 6 | 2.2 | 7.2 |
| 80 | 20 | 77 | 34 | 6 | 2.2 | 7.2 |
| 80 | 20 | 77 | 34 | 6 | 2.2 | 7.2 |
| 80 | 20 | 77 | 34 | 6 | 2.2 | 7.2 |
| 80 | 20 | 77 | 34 | 6 | 2.2 | 7.2 |

# RESPONSE SURFACE METHODOLOGY (RSM)

The experimental design made advantage of the well-liked second order design known as CCD. Design-expert 7.0 was used to apply the four-factor, five-level complete factorial RSM based on CCD. Based on preliminary research, two independent variables, j x1- % of Green Banana Peel Flour and x2- % of water in used in the Process, were coded at five levels between -1 and +1. As needed by many design techniques, four factor designed experiments were expanded with six replicates at the design center to assess the pure error. The experiments were also conducted in a random order. Linear and quadratic models in the experimental design provide for a straightforward relationship between the response and selected parameters. The following quadratic equation explains how the process behaves.

$$Y = \beta_o + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} x_i^2 + \sum_{i=1}^{k} \sum_{j=1}^{k} \beta_{ij} x_i x_j + \varepsilon$$

where βo is the free or offset term known as the intercept term, βi is the first-order (linear) main effect, βii is the quadratic (squared) effect, βij is the interaction effect, and ε is the random error between predicted and measured values. Y is the process response or output (dependent variable). To determine the interaction between the answer and the process variables, analysis of variance (ANOVA) was employed. The coefficient of determination $R^2$, modified R2, and F-test were used to assess the statistical significance of the polynomial model fit.

The experimental design was structured on basis of the table obtained after calculation of Cooking Yeild, Cooking Loss, Water Absoption Capacity and Acceptability. Each parameters were again linked to CCD experimental design and all graphs plotted to get a exact understanding of a perfect optimised value after 13 odd runs.

Following are the structured data and analysis based on CCD experimental design of RSM on the following four parameters:

- Cooking Yeild
- Cooking Loss
- WAC
- Acceptibility

# CENTRAL COMPOSITE DESIGN (CCD)

## Build Information

| | | | |
|---|---|---|---|
| **File Version** | 13.0.5.0 | | |
| **Study Type** | Response Surface | **Subtype** | Randomized |
| **Design Type** | Central Composite | **Runs** | 13.00 |
| **Design Model** | Quadratic | **Blocks** | No Blocks |
| **Build Time (ms)** | 1.0000 | | |

## FACTORS

| Factor | Name | Units | Type | SubType | Minimum | Maximum | Coded Low | Coded High | Mean | Std. Dev. |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Green Banana Peel Powder | % | Numeric | Continuous | 10.00 | 30.00 | -1 ↔ 10.00 | +1 ↔ 30.00 | 20.00 | 7.07 |
| | | | | | | | | | | |
| B | Amount of Water | % | Numeric | Continuous | 60.00 | 94.00 | -1 ↔ 60.00 | +1 ↔ 94.00 | 77.00 | 12.02 |

**Non- Center point = 8**

**Center point = 5 | Run = 13 | Alpha= 1**

| | | | X1 | X2 | **Response 1** | **Response 2** | **Response 3** | **Response 4** |
|---|---|---|---|---|---|---|---|---|
| Std | Run | Space Type | A:Green Banana Peel Powder | B:Amount of Water | Water Absorption Power | Cooking Yield | Cooking Loss | Overall Acceptability |
| | | | % | % | % | % | % | |
| 1 | 10 | Factorial | 10 | 60 | 2.3 | 31 | 4 | 7.5 |
| 2 | 12 | Factorial | 30 | 60 | 2.7 | 25 | 8 | 5.5 |
| 3 | 7 | Factorial | 10 | 94 | 1.7 | 55 | 4 | 7.7 |
| 4 | 5 | Factorial | 30 | 94 | 2.7 | 40 | 7 | 5.8 |
| 5 | 13 | Axial | 10 | 77 | 1.1 | 45 | 3 | 7.7 |
| 6 | 9 | Axial | 30 | 77 | 2.8 | 29 | 8 | 5.8 |
| 7 | 2 | Axial | 20 | 60 | 2.8 | 41 | 6 | 7.2 |
| 8 | 6 | Axial | 20 | 94 | 2.2 | 31 | 6 | 7 |
| 9 | 4 | Center | 20 | 77 | 2.2 | 34 | 6 | 7.2 |
| 10 | 8 | Center | 20 | 77 | 2.2 | 34 | 6 | 7.2 |
| 11 | 11 | Center | 20 | 77 | 2.2 | 34 | 6 | 7.2 |
| 12 | 1 | Center | 20 | 77 | 2.2 | 34 | 6 | 7.2 |
| 13 | 3 | Center | 20 | 77 | 2.2 | 34 | 6 | 7.2 |

## ANOVA FOR QUADRATIC MODEL

### *RESPONSE 1 – Water Absorption Power*

| Source | Sum of Squares | df | Mean Square | F-value | p-value | |
|---|---|---|---|---|---|---|
| **Model** | 2.28 | 5 | 0.4564 | 8.63 | 0.0066 | significant |
| A-Green Banana Peel Powder | 1.60 | 1 | 1.60 | 30.28 | 0.0009 | Significant |
| B-Amount of Water | 0.2400 | 1 | 0.2400 | 4.54 | 0.0707 | Not Significant |
| AB | 0.0900 | 1 | 0.0900 | 1.70 | 0.2333 | Not Significant |
| $A^2$ | 0.1124 | 1 | 0.1124 | 2.12 | 0.1883 | Not Significant |
| $B^2$ | 0.3350 | 1 | 0.3350 | 6.33 | 0.0400 | Significant |
| **Residual** | 0.3702 | 7 | 0.0529 | | | |
| Lack of Fit | 0.3702 | 3 | 0.1234 | | | |
| Pure Error | 0.0000 | 4 | 0.0000 | | | |
| **Cor Total** | 2.65 | 12 | | | | |

Factor coding is **Coded**.
Sum of squares is **Type III - Partial**

The **Model F-value** of 8.63 implies the model is significant. There is only a 0.66% chance that an F-value this large could occur due to noise.

**P-values** less than 0.0500 indicate model terms are significant. In this case A, $B^2$ are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

### Fit Statistics

| | | | |
|---|---|---|---|
| **Std. Dev.** | 0.2300 | **$R^2$** | 0.9404 |
| **Mean** | 2.25 | **Adjusted $R^2$** | 0.9607 |
| **C.V. %** | 10.20 | **Predicted $R^2$** | 0.9125 |
| | | **Adequate Precision** | 9.1740 |

A negative **Predicted $R^2$** implies that the overall mean may be a better predictor of your response than the current model. In some cases, a higher order model may also predict better

## Coefficients in Terms of Coded Factors

| Factor | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|---|---|---|---|---|---|---|
| Intercept | 2.19 | 1 | 0.0955 | 1.96 | 2.41 | |
| A-Green Banana Peel Powder | 0.5167 | 1 | 0.0939 | 0.2947 | 0.7387 | 1.0000 |
| B-Amount of Water | -0.2000 | 1 | 0.0939 | -0.4220 | 0.0220 | 1.0000 |
| AB | 0.1500 | 1 | 0.1150 | -0.1219 | 0.4219 | 1.0000 |
| $A^2$ | -0.2017 | 1 | 0.1384 | -0.5289 | 0.1255 | 1.17 |
| $B^2$ | 0.3483 | 1 | 0.1384 | 0.0211 | 0.6755 | 1.17 |

The coefficient estimate represents the expected change in response per unit change in factor value when all remaining factors are held constant. The intercept in an orthogonal design is the overall average response of all the runs. The coefficients are adjustments around that average based on the factor settings. When the factors are orthogonal the VIFs are 1; VIFs greater than 1 indicate multi-co-linearity, the higher the VIF the more severe the correlation of factors. As a rough rule, VIFs less than 10 are tolerable.

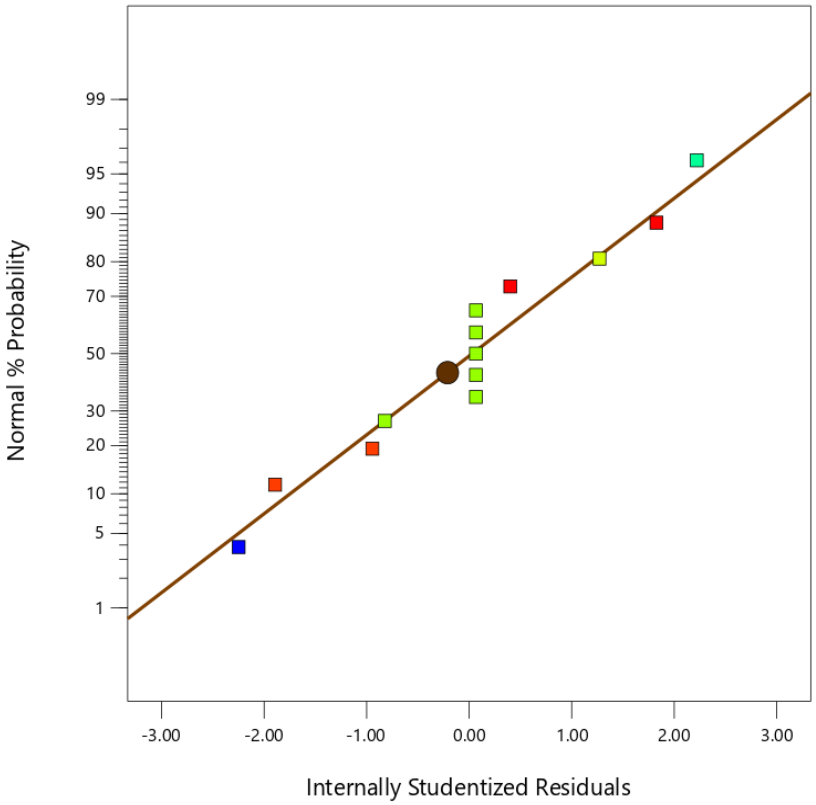
## Final Equation in Terms of Coded Factors

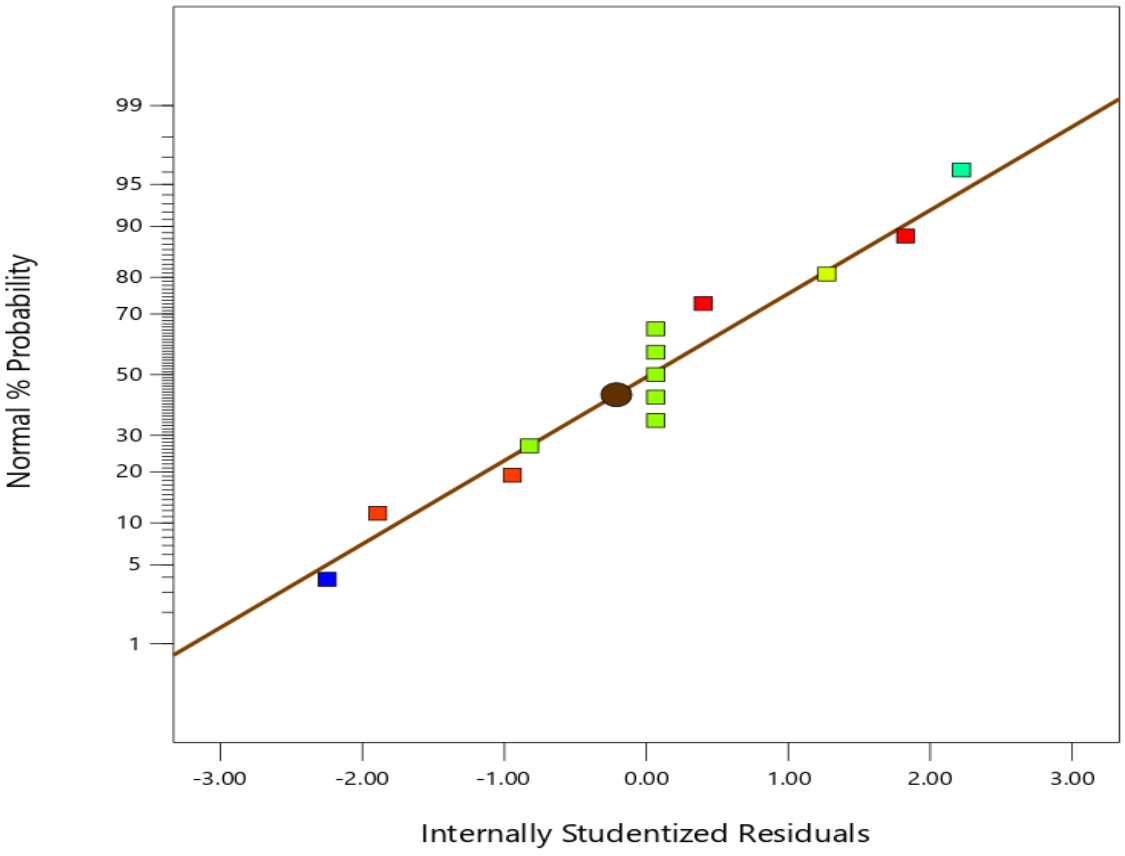
| Water Absorption Power | = |
|---|---|
| +2.19 | |
| +0.5167 | **A** |
| -0.2000 | **B** |
| +0.1500 | **AB** |
| -0.2017 | **$A^2$** |
| +0.3483 | **$B^2$** |

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

**Water Absorption Power**

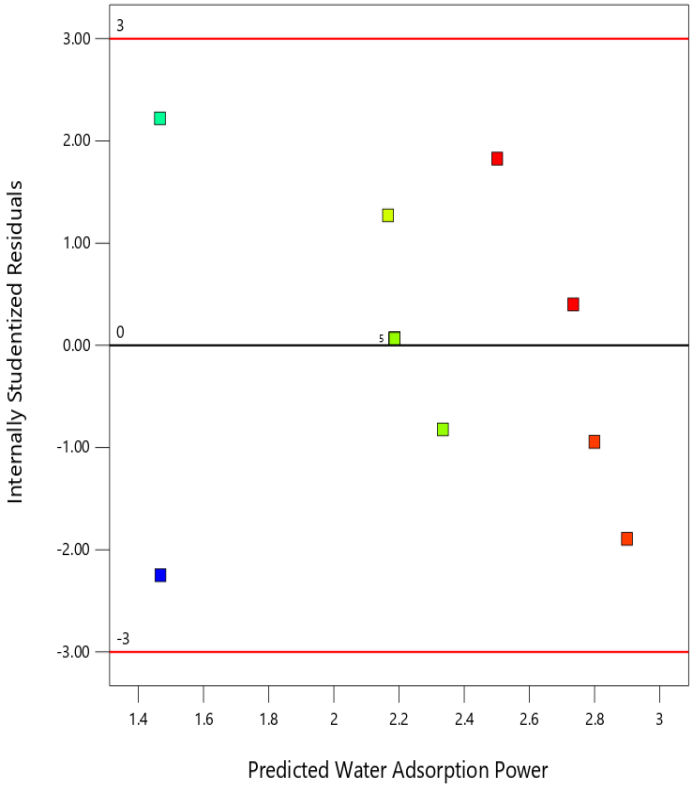
Color points by value of
Water Absorption Power:
1.1 2.8



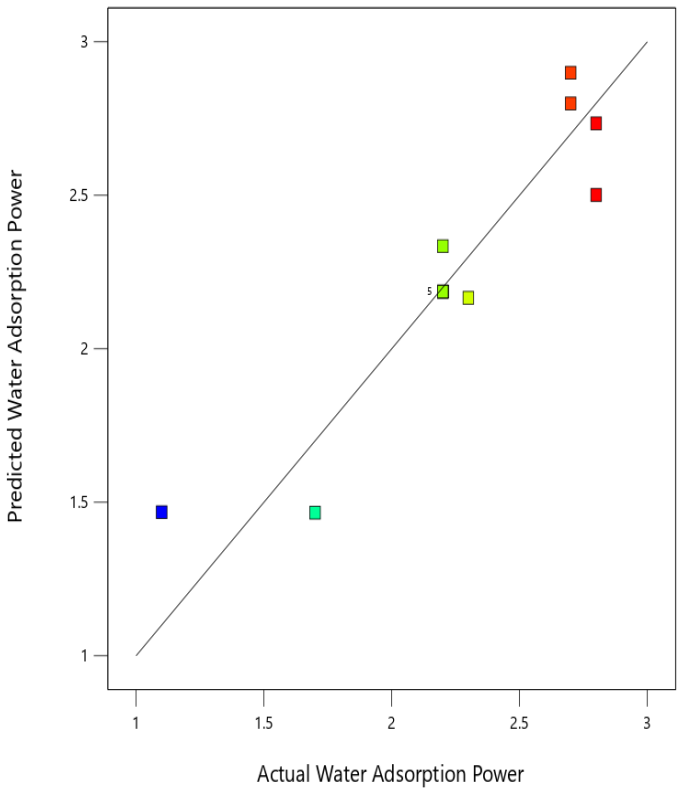
**Water Absorption Power**

Color points by value of
Water Absorption Power:
1.1 2.8




**Water Absorption Power**

Color points by value of
Water Absorption Power:
1.1 2.8



# REPORT FOR WAC – RESPONSE 1

| Run order | Actual Value | Predicted value | Residual Value | Internally studentized Residual | Externally studentized residual | Leverage value | Influence on fitted value | Standard order | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.20 | 2.19 | 0.0138 | 0.066 | 0.061 | 0.172 | 0.028 | 12 | |
| 2 | 2.80 | 2.73 | 0.0655 | 0.401 | 0.375 | 0.494 | 0.371 | 7 | |
| 3 | 2.20 | 2.19 | 0.0138 | 0.066 | 0.061 | 0.172 | 0.028 | 13 | |
| 4 | 2.20 | 2.19 | 0.0138 | 0.066 | 0.061 | 0.172 | 0.028 | 9 | |
| 5 | 2.70 | 2.80 | -0.0994 | -0.944 | -0.935 | 0.790 | -1.816 | 4 | |
| 6 | 2.20 | 2.33 | -0.1345 | -0.822 | -0.801 | 0.494 | -0.792 | 8 | |
| 7 | 1.70 | 1.47 | 0.2339 | 2.221 | 3.782 | 0.790 | 7.341(1) | 3 | |
| 8 | 2.20 | 2.19 | 0.0138 | 0.066 | 0.061 | 0.172 | 0.028 | 10 | |
| 9 | 2.80 | 2.50 | 0.2989 | 1.827 | 2.339 | 0.494 | 2.312(1) | 6 | |
| 10 | 2.30 | 2.17 | 0.1339 | 1.271 | 1.342 | 0.790 | 2.605(1) | 1 | |
| 11 | 2.20 | 2.19 | 0.0138 | 0.066 | 0.061 | 0.172 | 0.028 | 11 | |
| 12 | 2.70 | 2.90 | -0.1994 | -1.893 | -2.509 | 0.790 | -4.871(1) | 2 | |
| 13 | 1.10 | 1.47 | -0.3678 | -2.249 | -3.953 | 0.494 | -3.908(1) | 5 | |

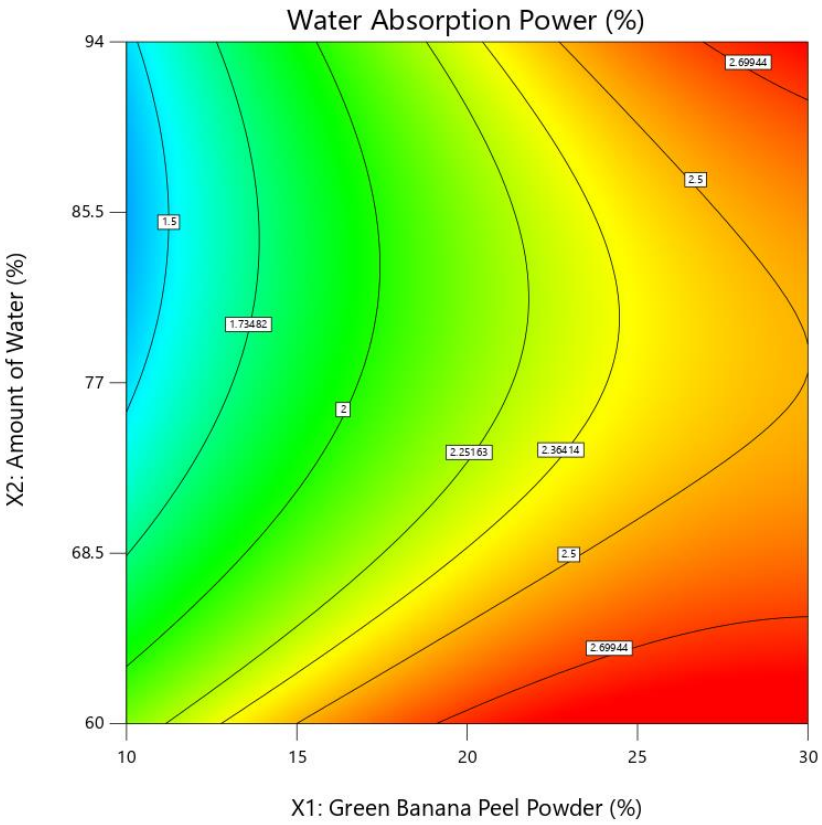
Factor Coding: Actual

**Water Absorption Power (%)**

1.1 2.8

X1 = A

X2 = B



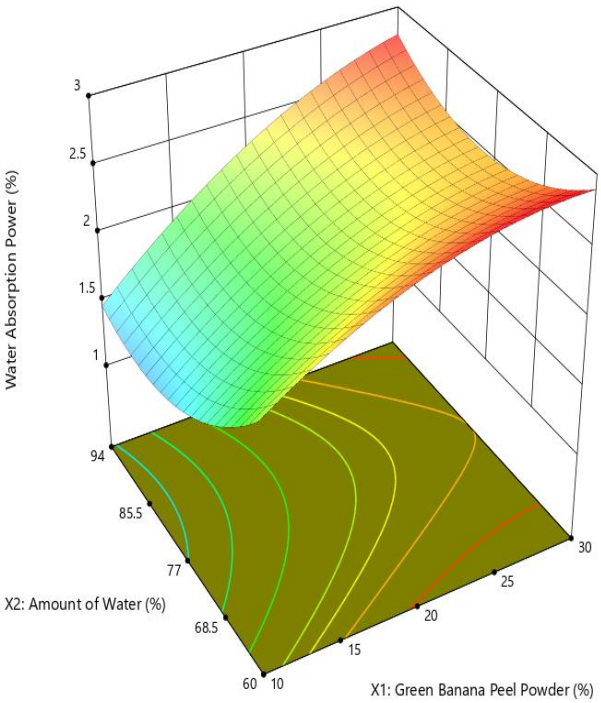

Factor Coding: Actual

**Water Absorption Power (%)**

1.1 2.8

X1 = A

X2 = B



# ANOVA FOR QUADRATIC MODEL

***RESPONSE 2- COOKING YEILD***

| Source | Sum of Squares | df | Mean Square | F-value | p-value | |
|---|---|---|---|---|---|---|
| **Model** | 1.68 | 5 | 0.4334 | 7.96 | 0.0022 | significant |
| A-Green Banana Peel Powder | 1.17 | 1 | 1.17 | 40.30 | 0.0448 | significant |
| B-Amount of Water | 0.1700 | 1 | 0.1700 | 3.26 | 0.1141 | Not Significant |
| AB | 0.0250 | 1 | 0.0250 | 1.47 | 0.5148 | Not Significant |
| $A^2$ | 0.1086 | 1 | 0.1086 | 2.36 | 0.5629 | Not Significant |
| $B^2$ | 0.3902 | 1 | 0.3902 | 2.12 | 0.7339 | Not Significant |
| **Residual** | 0.6415 | 7 | 0.1325 | | | |
| Lack of Fit | 0.4241 | 3 | 0.1257 | | | |
| Pure Error | 0.0000 | 4 | 0.0000 | | | |
| **Cor Total** | 3.92 | 12 | | | | |

Factor coding is **Coded**.
Sum of squares is **Type III - Partial**

The **Model F-value** of 7.96 implies the model is significant. There is a 0.63% chance that an F-value this large could occur due to noise.

**P-values** less than 0.0500 indicate model terms are significant. In this case there are A significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

## Fit Statistics

| | | | | |
|---|---|---|---|---|
| **Std. Dev.** | 0.56 | | **$R^2$** | 0.8833 |
| **Mean** | 2.92 | | **Adjusted $R^2$** | 0.8857 |
| **C.V. %** | 12.26 | | **Predicted $R^2$** | 0.9177 |
| | | | **Adequate Precision** | 4.9364 |

A negative **Predicted $R^2$** 0.9377 implies that the overall mean may be a better predictor of your response than the current model. In some cases, a higher order model may also predict better.

## Coefficients in Terms of Coded Factors

| Factor | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|---|---|---|---|---|---|---|
| Intercept | 34.17 | 1 | 2.72 | 27.73 | 40.61 | |
| A-Green Banana Peel Powder | -6.17 | 1 | 2.68 | -12.50 | 0.1661 | 1.0000 |
| B-Amount of Water | 4.83 | 1 | 2.68 | -1.50 | 11.17 | 1.0000 |
| AB | -2.25 | 1 | 3.28 | -10.01 | 5.51 | 1.0000 |
| $A^2$ | 2.40 | 1 | 3.95 | -6.94 | 11.73 | 1.17 |
| $B^2$ | 1.40 | 1 | 3.95 | -7.94 | 10.73 | 1.17 |

The coefficient estimate represents the expected change in response per unit change in factor value when all remaining factors are held constant. The intercept in an orthogonal design is the overall average response of all the runs. The coefficients are adjustments around that average based on the factor settings. When the factors are orthogonal the VIFs are 1; VIFs greater than 1 indicate multi-colinearity, the higher the VIF the more severe the correlation of factors. As a rough rule, VIFs less than 10 are tolerable.

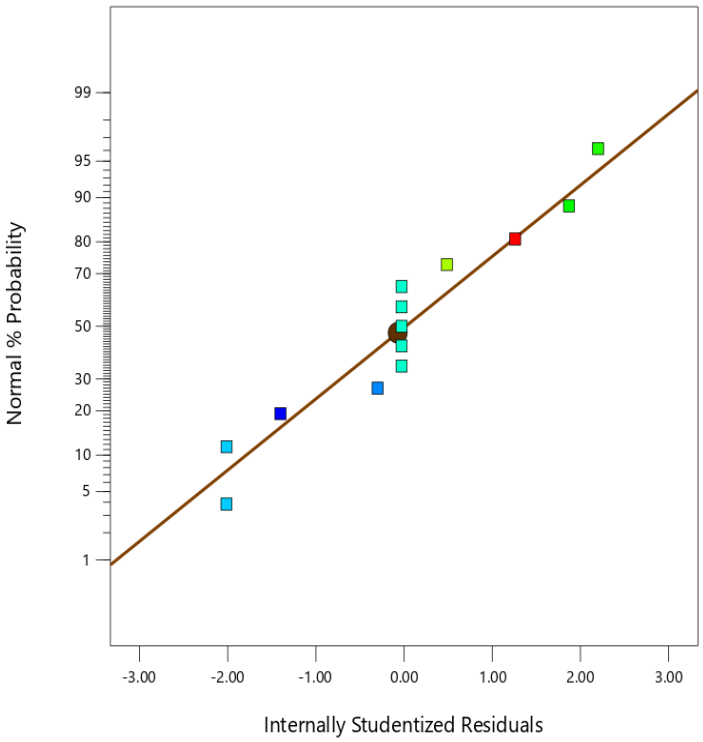
## Final Equation in Terms of Coded Factors

| Cooking Yield | = |
|---|---|
| +4.17 | |
| -0.1712 | A |
| +0.8302 | B |
| -0.2510 | AB |
| +0.4024 | $A^2$ |
| +0.4026 | $B^2$ |

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

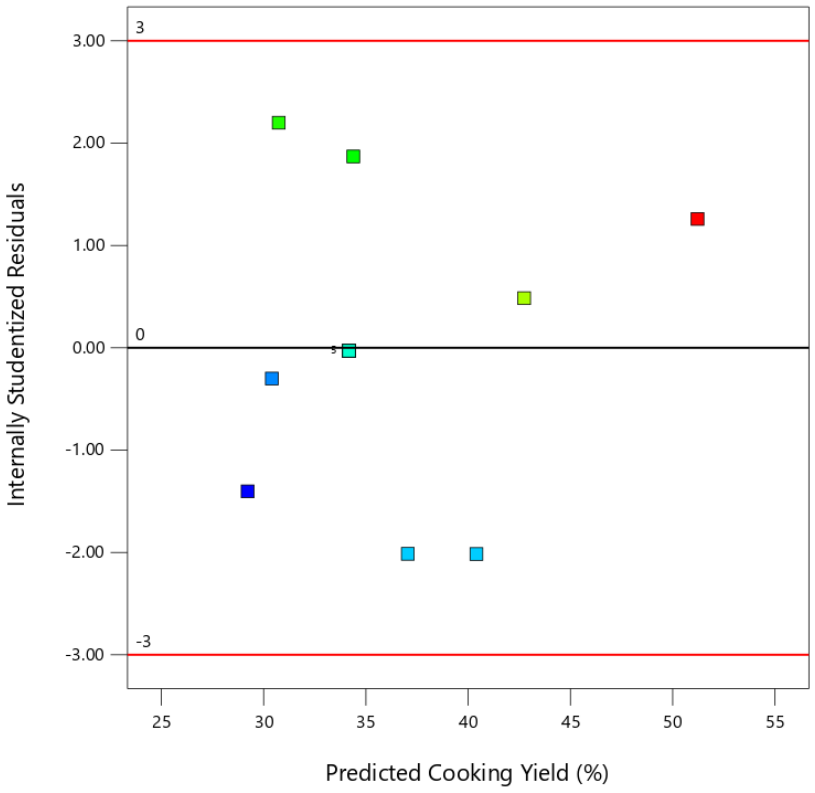
**Cooking Yield**

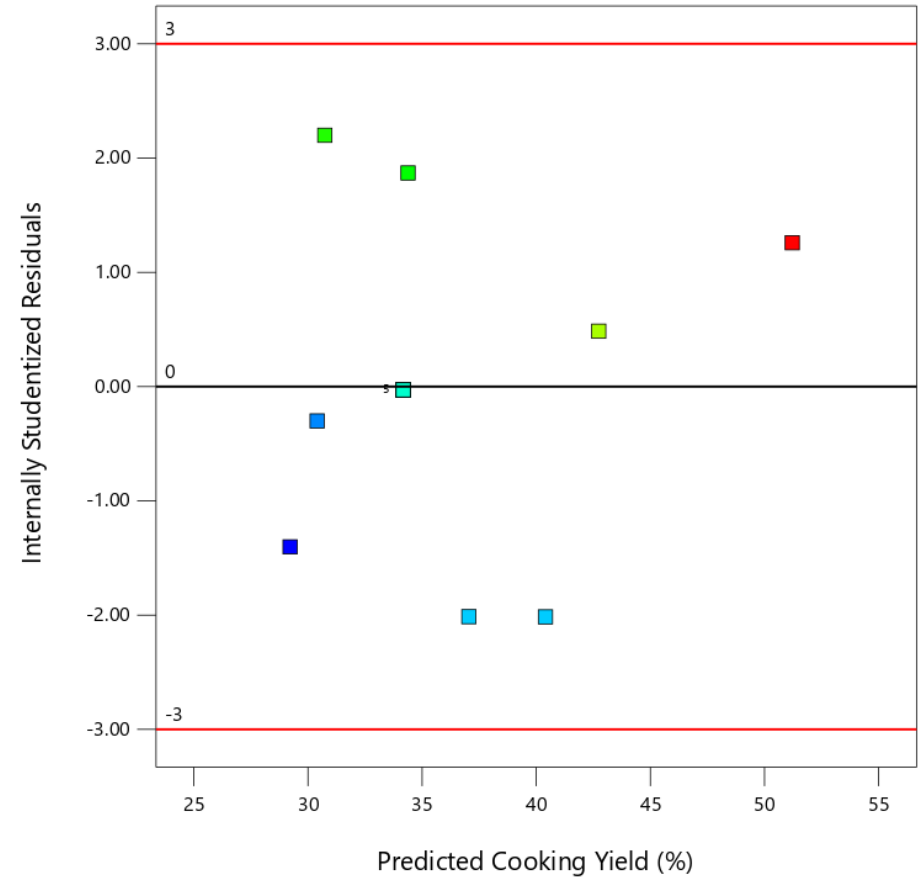
Color points by value of
Cooking Yield:
25 55

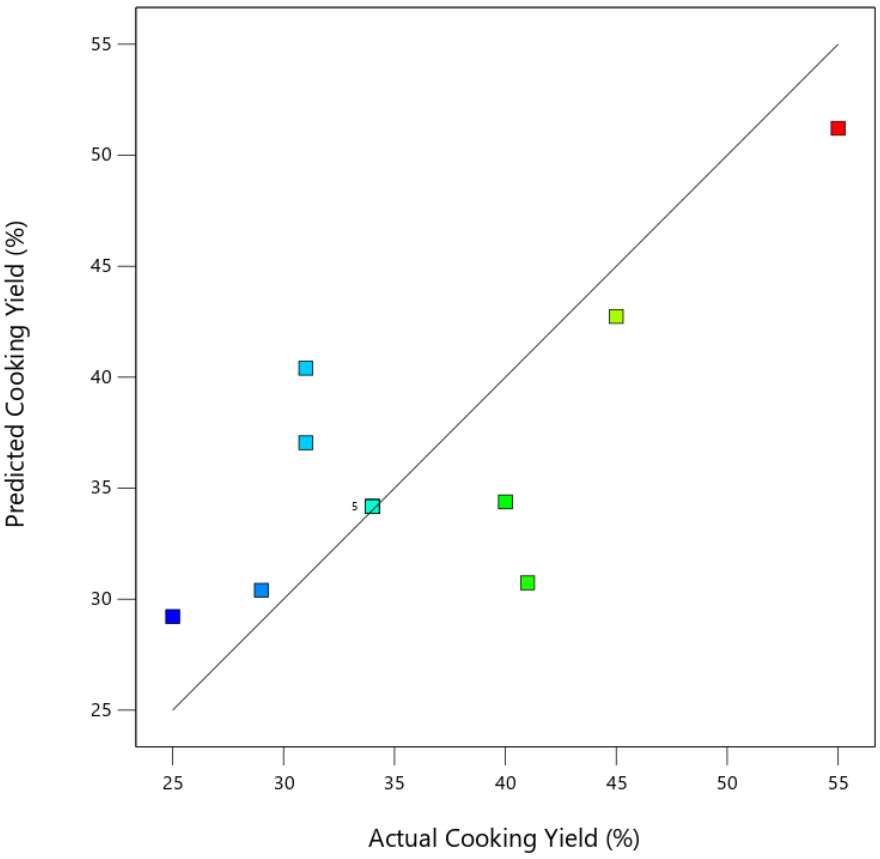



**Cooking Yield**

Color points by value of
Cooking Yield:
25 55




Internally Studentized Residuals
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
3
0
-3
25
30
35
40
45
50
55
Predicted Cooking Yield (%)


Predicted Cooking Yield (%)
55
50
45
40
35
30
25
25
30
35
40
45
50
55
Actual Cooking Yield (%)

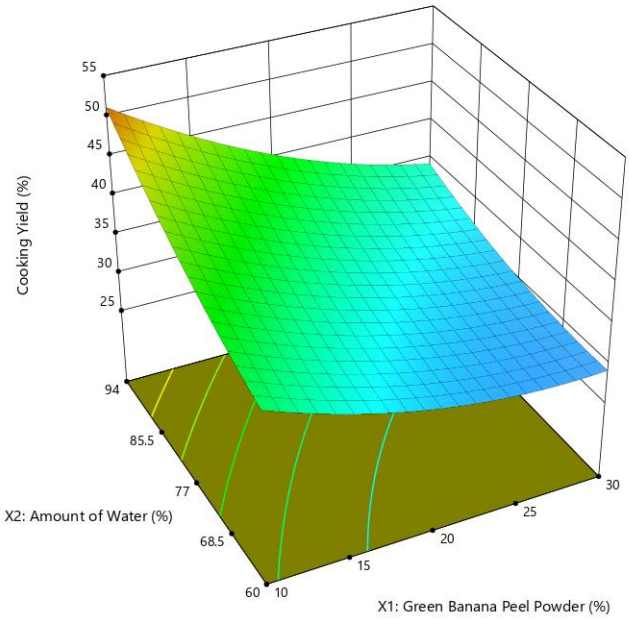
Factor Coding: Actual

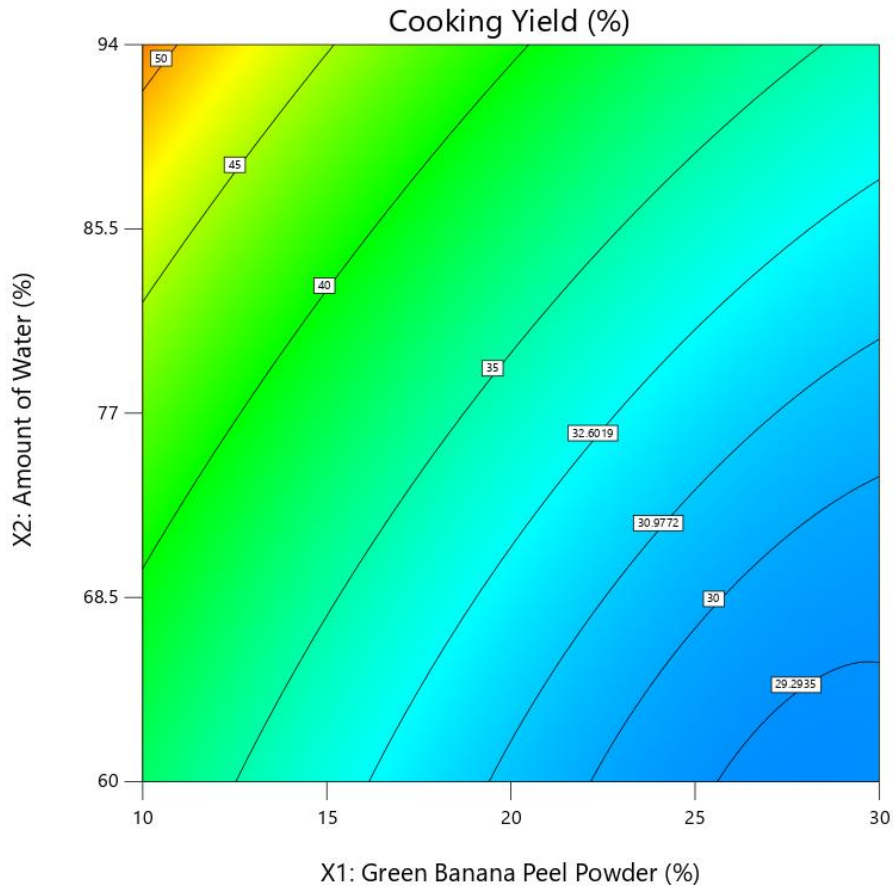
**Cooking Yield (%)**

25 55

X1 = A

X2 = B



# REPORT FOR COOKING YIELD – RESPONSE 2

| Run order | Actual Value | Predicted value | Residual Value | Internally studentized Residual | Externally studentized residual | Leverage value | Influence on fitted value | Standard order | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 34.00 | 34.17 | -0.1724 | -0.029 | -0.027 | 0.172 | -0.012 | 12 | |
| 2 | 41.00 | 40.74 | 0.26 | 2.200 | 3.668 | 0.494 | 3.626(1) | 7 | |
| 3 | 34.00 | 34.17 | -0.1724 | -0.029 | -0.027 | 0.172 | -0.012 | 13 | |
| 4 | 34.00 | 34.17 | -0.1724 | -0.029 | -0.027 | 0.172 | -0.012 | 9 | |
| 5 | 40.00 | 37.38 | 2.62 | 1.870 | 2.447 | 0.790 | 4.749(1) | 4 | |
| 6 | 31.00 | 34.40 | -3.40 | -2.015 | -2.880 | 0.494 | -2.847(1) | 8 | |
| 7 | 55.00 | 51.22 | 3.78 | 1.260 | 1.326 | 0.790 | 2.574(1) | 3 | |
| 8 | 34.00 | 34.17 | -0.1724 | -0.029 | -0.027 | 0.172 | -0.012 | 10 | |
| 9 | 29.00 | 30.40 | -1.40 | -0.301 | -0.280 | 0.494 | -0.277 | 6 | |
| 10 | 31.00 | 34.05 | -3.05 | -2.013 | -2.873 | 0.790 | -5.576(1) | 1 | |
| 11 | 34.00 | 34.17 | -0.1724 | -0.029 | -0.027 | 0.172 | -0.012 | 11 | |
| 12 | 25.00 | 27.22 | -2.22 | -1.403 | -1.532 | 0.790 | -2.974(1) | 2 | |
| 13 | 45.00 | 42.74 | 2.26 | 0.485 | 0.457 | 0.494 | 0.452 | 5 | |

# ANOVA for QUADRATIC MODEL

## *Response 3- Cooking Loss*

| Source | Sum of Squares | df | Mean Square | F-value | p-value | |
|---|---|---|---|---|---|---|
| **Model** | 24.82 | 5 | 4.96 | 39.64 | < 0.0001 | significant |
| A-Green Banana Peel Powder | 24.00 | 1 | 24.00 | 191.69 | < 0.0001 | Significant |
| B-Amount of Water | 0.1667 | 1 | 0.1667 | 1.33 | 0.2865 | Not Significant |
| AB | 0.2500 | 1 | 0.2500 | 2.00 | 0.2005 | Not Significant |
| $A^2$ | 0.3974 | 1 | 0.3974 | 3.17 | 0.1180 | Not Significant |
| $B^2$ | 0.0402 | 1 | 0.0402 | 0.3213 | 0.5885 | Not Significant |
| **Residual** | 0.8764 | 7 | 0.1252 | | | |
| Lack of Fit | 0.8764 | 3 | 0.2921 | | | |
| Pure Error | 0.0000 | 4 | 0.0000 | | | |
| **Cor Total** | 25.69 | 12 | | | | |

Factor coding is **Coded**.
Sum of squares is **Type III - Partial**

The **Model F-value** of 39.64 implies the model is significant. There is only a 0.01% chance that an F-value this large could occur due to noise.

**P-values** less than 0.0500 indicate model terms are significant. In this case A is a significant model term. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

**Fit Statistics**

| | | | | |
|---|---|---|---|---|
| **Std. Dev.** | 0.3538 | | **$R^2$** | 0.9659 |
| **Mean** | 5.85 | | **Adjusted $R^2$** | 0.9415 |
| **C.V. %** | 6.05 | | **Predicted $R^2$** | 0.9583 |
| | | | **Adequate Precision** | 18.8750 |

The **Predicted $R^2$** of 0.9583 is not as close to the **Adjusted $R^2$** of 0.9415 as one might normally expect; i.e. the difference is more than 0.2. This may indicate a large block effect or a possible problem with your model and/or data. Things to consider are model reduction, response transformation, outliers, etc. All empirical models should be tested by doing confirmation runs.

## Coefficients in Terms of Coded Factors

| Factor | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|---|---|---|---|---|---|---|
| Intercept | 5.97 | 1 | 0.1469 | 5.62 | 6.31 | |
| A-Green Banana Peel Powder | 2.00 | 1 | 0.1445 | 1.66 | 2.34 | 1.0000 |
| B-Amount of Water | -0.1667 | 1 | 0.1445 | -0.5083 | 0.1749 | 1.0000 |
| AB | -0.2500 | 1 | 0.1769 | -0.6684 | 0.1684 | 1.0000 |
| $A^2$ | -0.3793 | 1 | 0.2129 | -0.8828 | 0.1242 | 1.17 |
| $B^2$ | 0.1207 | 1 | 0.2129 | -0.3828 | 0.6242 | 1.17 |

The coefficient estimate represents the expected change in response per unit change in factor value when all remaining factors are held constant. The intercept in an orthogonal design is the overall average response of all the runs. The coefficients are adjustments around that average based on the factor settings. When the factors are orthogonal the VIFs are 1; VIFs greater than 1 indicate multi-colinearity, the higher the VIF the more severe the correlation of factors. As a rough rule, VIFs less than 10 are tolerable.

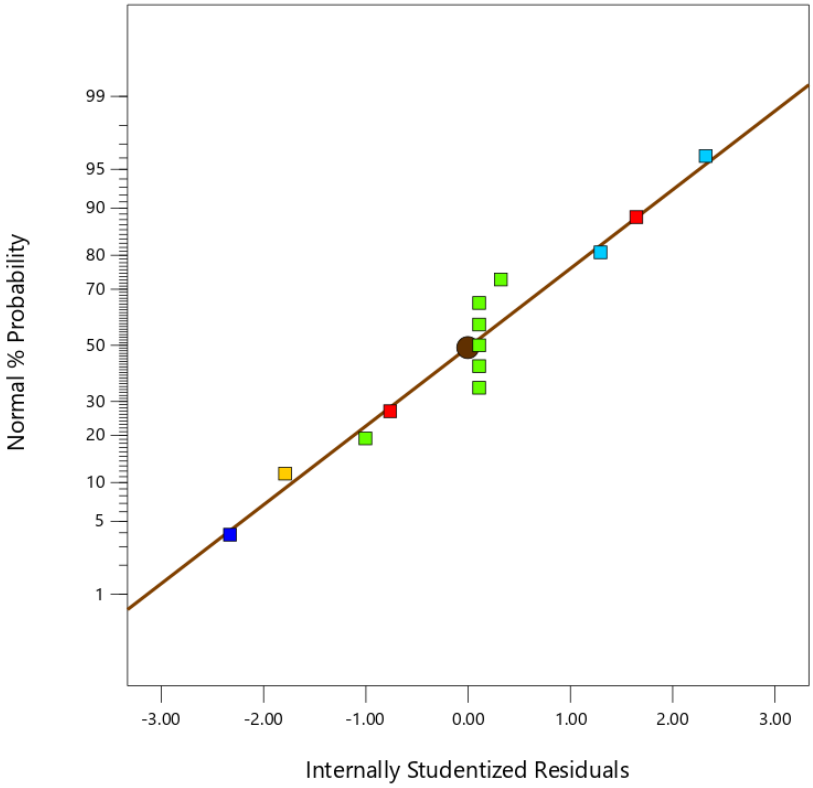
## Final Equation in Terms of Coded Factors

| Cooking Loss | = |
|---|---|
| +5.97 | |
| +2.00 | A |
| -0.1667 | B |
| -0.2500 | AB |
| -0.3793 | $A^2$ |
| +0.1207 | $B^2$ |

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

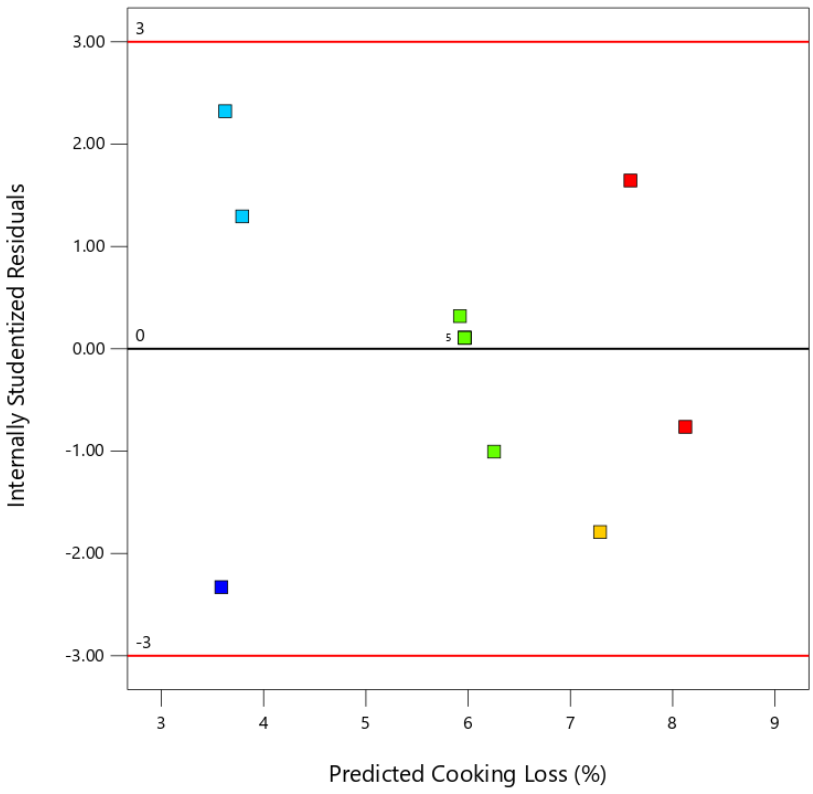
**Cooking Loss**

Color points by value of
Cooking Loss:
3 8



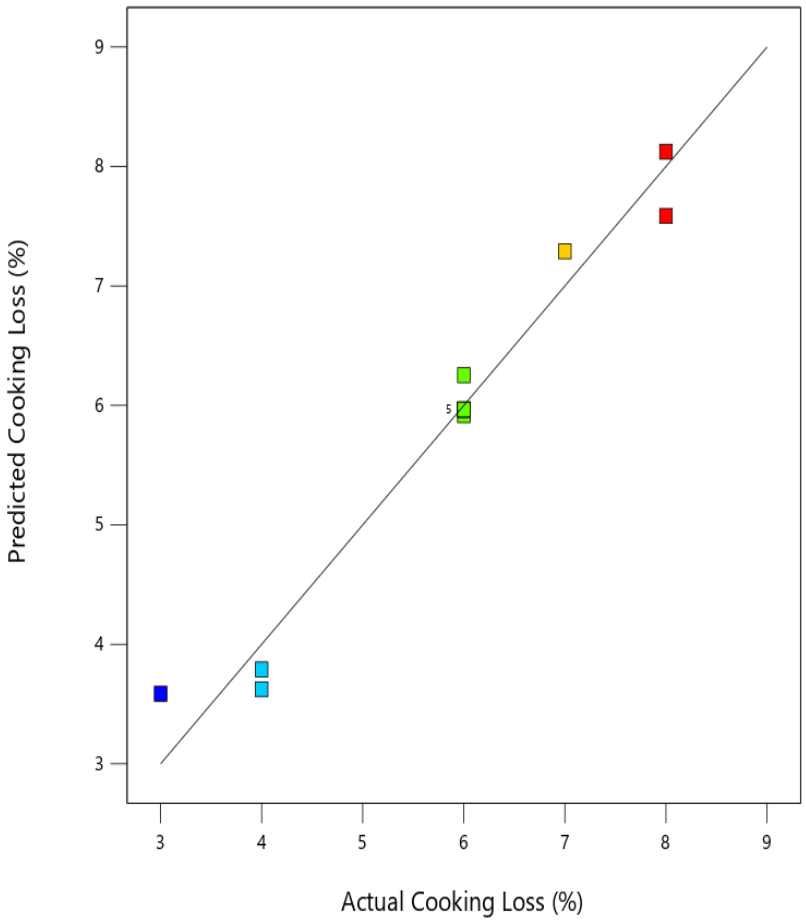

**Cooking Loss**

Color points by value of
Cooking Loss:
3 8



**Cooking Loss**

Color points by value of
Cooking Loss:
3 8



# REPORT FOR COOKING LOSS – RESPONSE 3

| Run order | Actual Value | Predicted value | Residual Value | Internally studentized Residual | Externally studentized residual | Leverage value | Influence on fitted value | Standard order | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.00 | 5.97 | 0.0345 | 0.107 | 0.099 | 0.172 | 0.045 | 12 | |
| 2 | 6.00 | 6.25 | -0.2529 | -1.005 | -1.006 | 0.494 | -0.994 | 7 | |
| 3 | 6.00 | 5.97 | 0.0345 | 0.107 | 0.099 | 0.172 | 0.045 | 13 | |
| 4 | 6.00 | 5.97 | 0.0345 | 0.107 | 0.099 | 0.172 | 0.045 | 9 | |
| 5 | 7.00 | 7.29 | -0.2902 | -1.791 | -2.252 | 0.790 | -4.372(1) | 4 | |
| 6 | 6.00 | 5.92 | 0.0805 | 0.320 | 0.298 | 0.494 | 0.295 | 8 | |
| 7 | 4.00 | 3.79 | 0.2098 | 1.294 | 1.374 | 0.790 | 2.667(1) | 3 | |
| 8 | 6.00 | 5.97 | 0.0345 | 0.107 | 0.099 | 0.172 | 0.045 | 10 | |
| 9 | 8.00 | 7.59 | 0.4138 | 1.644 | 1.943 | 0.494 | 1.921 | 6 | |
| 10 | 4.00 | 3.62 | 0.3764 | 2.323 | 4.492 | 0.790 | 8.718(1) | 1 | |
| 11 | 6.00 | 5.97 | 0.0345 | 0.107 | 0.099 | 0.172 | 0.045 | 11 | |
| 12 | 8.00 | 8.12 | -0.1236 | -0.762 | -0.737 | 0.790 | -1.431 | 2 | |
| 13 | 3.00 | 3.59 | -0.5862 | -2.330 | -4.549 | 0.494 | -4.497(1) | 5 | |

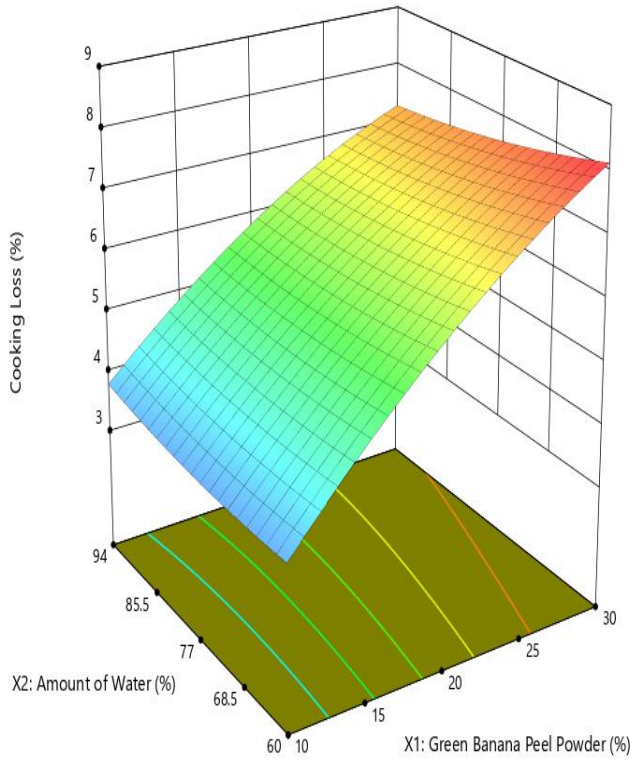
Factor Coding: Actual

**Cooking Loss (%)**

3 8

X1 = A

X2 = B



# ANOVA for QUADRATIC MODEL

***Response 4: Overall Acceptability***

| Source | Sum of Squares | df | Mean Square | F-value | p-value | |
|---|---|---|---|---|---|---|
| **Model** | 6.48 | 5 | 1.30 | 131.97 | < 0.0001 | significant |
| A-Green Banana Peel Powder | 5.61 | 1 | 5.61 | 570.74 | < 0.0001 | significant |
| B-Amount of Water | 0.0150 | 1 | 0.0150 | 1.53 | 0.2564 | Not significant |
| AB | 0.0025 | 1 | 0.0025 | 0.2545 | 0.6294 | Not significant |
| $A^2$ | 0.5897 | 1 | 0.5897 | 60.03 | 0.0001 | significant |
| $B^2$ | 0.0347 | 1 | 0.0347 | 3.53 | 0.1023 | Not significant |
| **Residual** | 0.0688 | 7 | 0.0098 | | | |
| Lack of Fit | 0.0688 | 3 | 0.0229 | | | |
| Pure Error | 0.0000 | 4 | 0.0000 | | | |
| **Cor Total** | 6.55 | 12 | | | | |

Factor coding is **Coded**.
Sum of squares is **Type III - Partial**

The **Model F-value** of 131.97 implies the model is significant. There is only a 0.01% chance that an F-value this large could occur due to noise.

**P-values** less than 0.0500 indicate model terms are significant. In this case A, $A^2$ are significant model terms. Values greater than 0.1000 indicate the model terms are not significant. If there are many insignificant model terms (not counting those required to support hierarchy), model reduction may improve your model.

## Fit Statistics

| | | | | |
|---|---|---|---|---|
| **Std. Dev.** | 0.0991 | | **$R^2$** | 0.9895 |
| **Mean** | 6.94 | | **Adjusted $R^2$** | 0.9820 |
| **C.V. %** | 1.43 | | **Predicted $R^2$** | 0.9323 |
| | | | **Adequate Precision** | 31.4906 |

The **Predicted $R^2$** of 0.9233 is in reasonable agreement with the **Adjusted $R^2$** of 0.9820

## Coefficients in Terms of Coded Factors

| Factor | Coefficient Estimate | df | Standard Error | 95% CI Low | 95% CI High | VIF |
|---|---|---|---|---|---|---|
| Intercept | 7.20 | 1 | 0.0412 | 7.11 | 7.30 | |
| A-Green Banana Peel Powder | -0.9667 | 1 | 0.0405 | -1.06 | -0.8710 | 1.0000 |
| B-Amount of Water | 0.0500 | 1 | 0.0405 | -0.0457 | 0.1457 | 1.0000 |
| AB | 0.0250 | 1 | 0.0496 | -0.0922 | 0.1422 | 1.0000 |
| $A^2$ | -0.4621 | 1 | 0.0596 | -0.6031 | -0.3210 | 1.17 |
| $B^2$ | -0.1121 | 1 | 0.0596 | -0.2531 | 0.0290 | 1.17 |

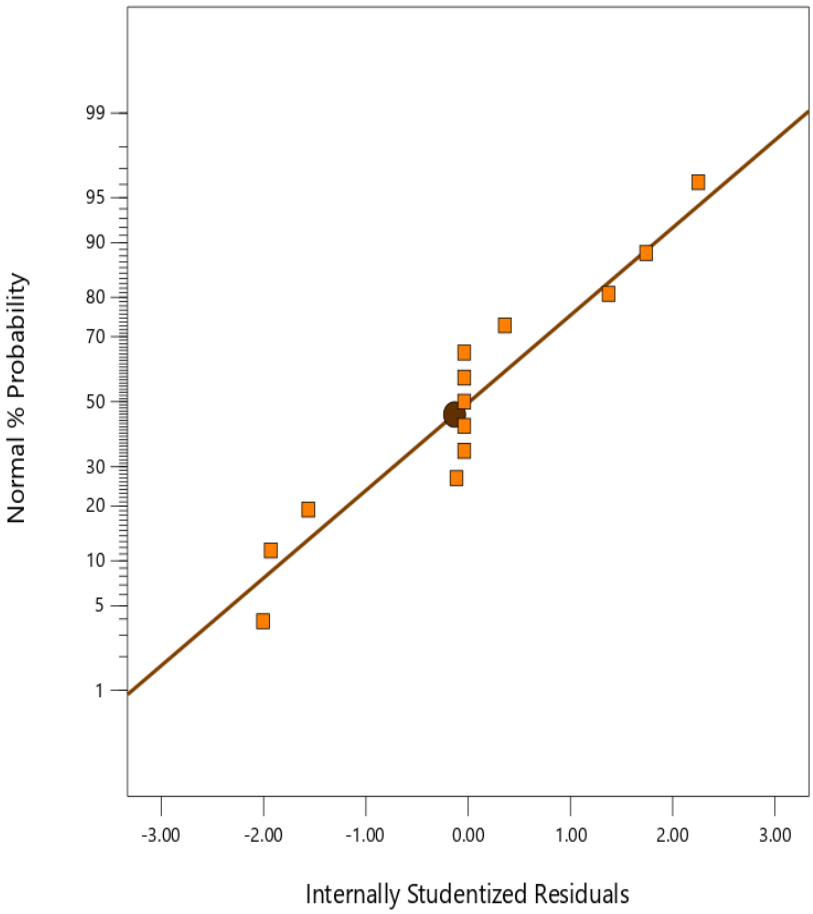
The coefficient estimate represents the expected change in response per unit change in factor value when all remaining factors are held constant. The intercept in an orthogonal design is the overall average response of all the runs. The coefficients are adjustments around that average based on the factor settings. When the factors are orthogonal the VIFs are 1; VIFs greater than 1 indicate multi-colinearity, the higher the VIF the more severe the correlation of factors. As a rough rule, VIFs less than 10 are tolerable.

## Final Equation in Terms of Coded Factors

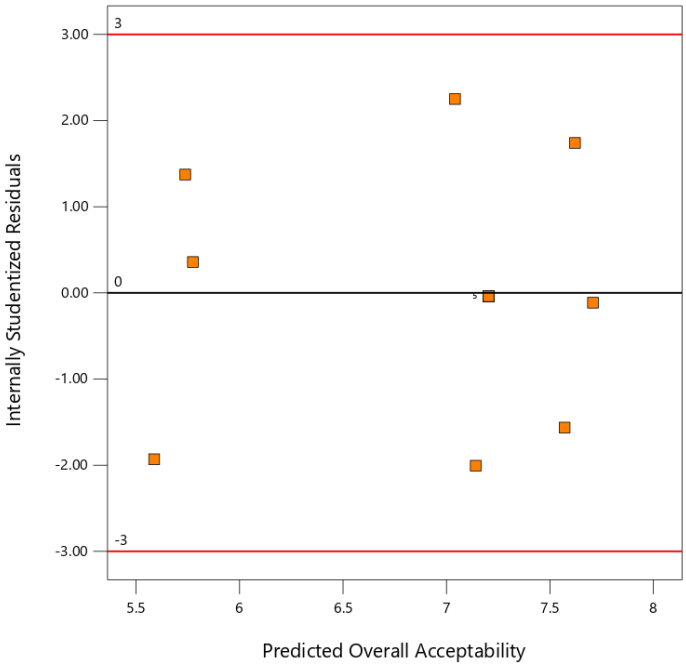
| Overall Acceptability | = |
|---|---|
| +7.20 | |
| -0.9667 | A |
| +0.0500 | B |
| +0.0250 | AB |
| -0.4621 | $A^2$ |
| -0.1121 | $B^2$ |

The equation in terms of coded factors can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

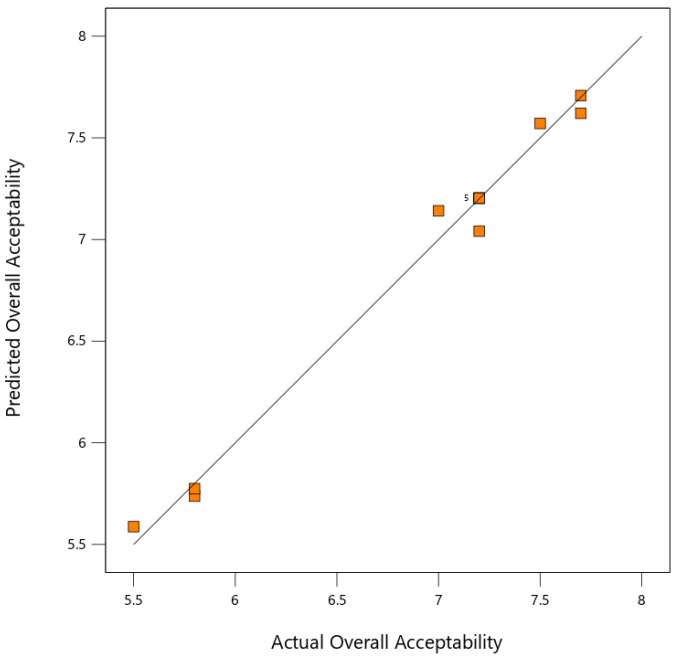
**Overall Acceptability**



**Overall Acceptability**




**Overall Acceptability**



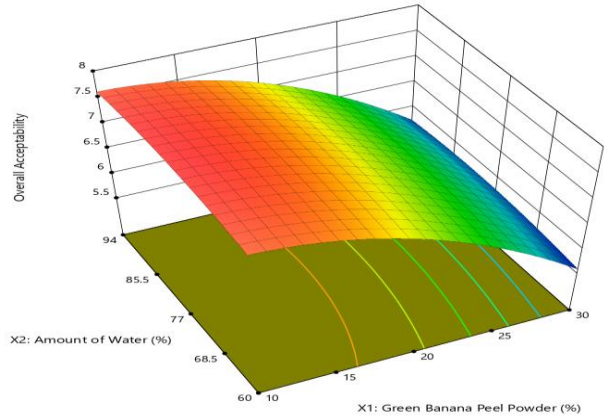
Factor Coding: Actual

**Overall Acceptability**

5.5 7.7

X1 = A

X2 = B



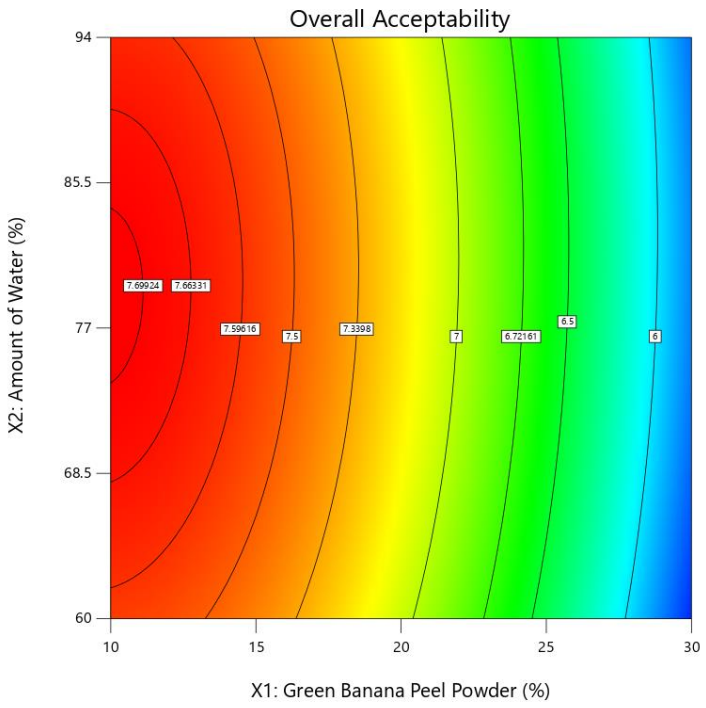

Factor Coding: Actual

**Overall Acceptability**

5.5 7.7

X1 = A

X2 = B



## REPORT FOR OVERALL ACCEPTABILITY – RESPONSE 4

| Run order | Actual Value | Predicted value | Residual Value | Internally studentized Residual | Externally studentized residual | Leverage value | Influence on fitted value | Standard order | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 7.20 | 7.20 | -0.0034 | -0.038 | -0.035 | 0.172 | -0.016 | 12 | |
| 2 | 7.20 | 7.04 | 0.1586 | 2.250 | 3.962 | 0.494 | 3.917[1] | 7 | |
| 3 | 7.20 | 7.20 | -0.0034 | -0.038 | -0.035 | 0.172 | -0.016 | 13 | |
| 4 | 7.20 | 7.20 | -0.0034 | -0.038 | -0.035 | 0.172 | -0.016 | 9 | |
| 5 | 5.80 | 5.74 | 0.0624 | 1.374 | 1.488 | 0.790 | 2.888[1] | 4 | |
| 6 | 7.00 | 7.14 | -0.1414 | -2.006 | -2.848 | 0.494 | -2.815[1] | 8 | |
| 7 | 7.70 | 7.62 | 0.0790 | 1.741 | 2.140 | 0.790 | 4.154[1] | 3 | |
| 8 | 7.20 | 7.20 | -0.0034 | -0.038 | -0.035 | 0.172 | -0.016 | 10 | |
| 9 | 5.80 | 5.77 | 0.0253 | 0.359 | 0.335 | 0.494 | 0.331 | 6 | |
| 10 | 7.50 | 7.57 | -0.0710 | -1.564 | -1.794 | 0.790 | -3.483[1] | 1 | |
| 11 | 7.20 | 7.20 | -0.0034 | -0.038 | -0.035 | 0.172 | -0.016 | 11 | |
| 12 | 5.50 | 5.59 | -0.0876 | -1.931 | -2.614 | 0.790 | -5.074[1] | 2 | |
| 13 | 7.70 | 7.71 | -0.0080 | -0.114 | -0.106 | 0.494 | -0.105 | 5 | |

# RESULT AND DISCUSSION OF RSM

After the experimental design and analysis using RSM as a statistical tool and using the four responses (Cooking yield, Cooking loss, WAC, Acceptability) as variables we have reached the optimised values to be considered for noodle preparation out of the 13 odd runs through the RSM methodology. According to the data we have obtained as the ideal optimised condition we have considered that model noodle for our next step of proximate analysis.

The cooking yield obtained was close to the maximum range and considering the other factors this model sample has the least cooking loss as well as the least water absorption capacity which makes this sample a perfect amongst the other models developed in all aspects. The acceptability score is also done with a satisfactory score of 7.7. So overall this is the best model which can be a best fit sample.

The model noodle which we have considered has the optimised value as follows:

| Amount of WF (constant) | % of GBPF | % of water | Amount of GBPF | Amount of Water | Cooking Yeild % | Cooking Loss % | Water Absorption Capacity % | Overall Acceptability |
|---|---|---|---|---|---|---|---|---|
| 80gm | 10 | 77 | 8gm | 61.6ml | 45 | 3 | 1.1 | 7.7 |

# PROXIMATE ANALYSIS OF THE RESULT OBTAINED FROM RSM

**OBJECTIVE –** To understand the characteristics of the optimised sample and conduct the proximate analysis of the fortified and also the unfortified sample.

**ANALYSIS CONDUCTED-** Proximal Analysis of the model Green banana peel fortified noodle was done and compared with unfortified wheat flour noodles in the following part. The analysis on the basis of which the comparison was done are:

- **Moisture Content**
- **Ash Content**
- **Fat Content**
- **Protein Content**
- **Carbohydrate Content**
- **Crude Fibre Content**
- **Antioxidant content**
- **Flavonoid Content**
- **Texture Profile Analysis**
- **Colour analysis**

# MATERIALS AND METHODS

# DETERMINATION OF MOISTURE CONTENT

**AIM – To analyse the moisture content of the sample.**

**Materials Required –**

- 5 gm of powdered fortified noodle Sample
- Petri dish
- Hot air oven
- Digital weighing balance

**Method-**

- Weigh 5 gm of sample using a weighing balance
- Put the sample in a petri dish and also note the weigh of sample along with the petri dish
- Place the petri dish containing the sample in the hot air oven
- Set the temperature of hot air oven to 105°C and keep the sample inside the hot air oven for a duration of 3hrs
- After 3hrs take out the petri dish and allow it to cool by keeping it inside a desiccator
- Weigh the petri dish along with the sample to note the weight after it has cooled down.

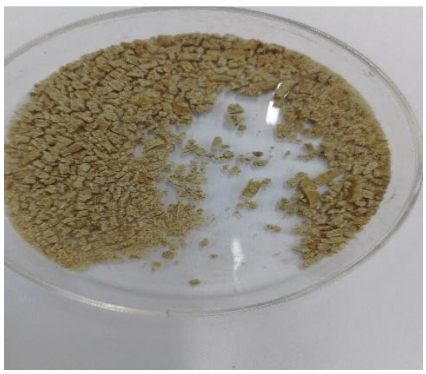
**Calculation** –

$$\textbf{Moisture Content \%} = \frac{W_s - (W_2 - W_1)}{W_s} \times 100$$

Ws = Weight of the Sample

$W_1$ = Weight of Petri dish

$W_2$ = Weight of petri dish + sample (after drying)



# DETERMINATION OF ASH CONTENT

**AIM** – To determine the Ash content of the sample

**Materials Required** –

- 2-5 gm of fortified noodle sample
- Crucible
- Muffle furnace
- Digital Weighing balance

**Method** –

- Weigh 2gm of sample using a weighing balance
- Take the weight of an empty crucible
- Place the sample inside the crucible and cover the crucible with a lid
- Place the crucible which contains the sample inside the muffle furnace.
- Set the temperature of the muffle furnace at 550°C for a duration of 4hrs
- After 4hrs allow the crucible to cool down by placing it into a desiccator and then measure the final weight of the crucible containing the sample.

**Calculation –**

$$\textbf{Ash content \%} = \frac{W_2 - W_1}{W_s} \times 100$$

$W_S$ = Weight of the sample

$W_1$ = Weight of the crucible

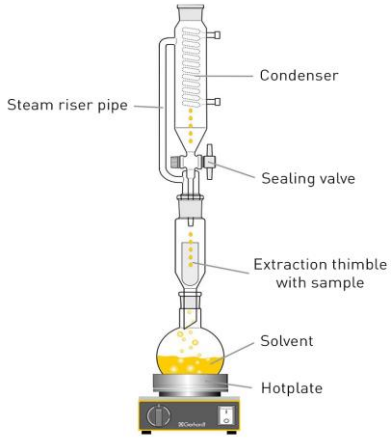
$W_2$ = Weight of the crucible + Ash

# DETERMINATION OF FAT CONTENT

**AIM –** To determine the Fat content in the sample by using Soxhlet method

**Materials Required** –

- Soxhlet Apparatus
- Thimble
- Sample of 5gm weight in powdered form
- Round Bottom Flask
- Heater
- Petroleum Ether – used as a solvent
- Cotton wool

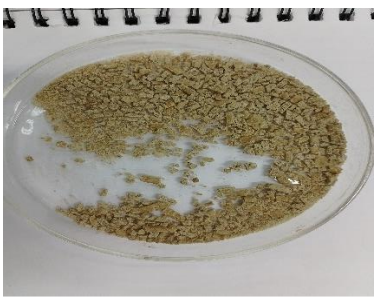



**Method –**

- Accurately weigh 5 gm of sample into the thimble/flask
- Dry the sample in an oven at 105ºC for 3 hrs
- Insert the thimble in a Soxhlet extractor
- Accurately weigh a clean, dry 150 ml round bottom flash and put about 90 ml of petroleum ether in the flask
- Assemble the extraction unit over in an electric heating mantle
- Heat the solvent in the flask until it boils
- Continue the extraction process for 12 cycles.
- Remove the extraction unit from the heat source and detach the extractor and condenser (Replace the flask on the heat source and evaporate off the solvent)
- Place the flask in a water bath at 40ºC & dry the contents until constant weight is obtain (for 1 to 2 hr).
- Cool the flask in a desiccator & weigh the flask with contents.

**Calculations - % Crude fat = (W2 – W1) x 100/S**

W1 = Weight of Empty Flask
W2 = Weight of Flask + extracted fat
S = Weight of Sample



# DETERMINATION OF CRUDE FIBRE CONTENT

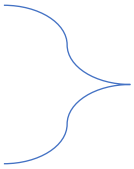
**AIM** – To determine the crude fibre content of the sample

**Materials & Reagents Required –**

- Sulphuric Acid
- Sodium Hydroxide
- Muffle Furnace
- Hot air oven
- Hot Plate
- Crucible
- Measuring cylinder
- Conical Flask
- Ash free Filter Paper
- Funnel
- 2 gm of sample

**Method –**

STEP 1 – Boiling in Acid
STEP 2 - Boiling in Base
STEP 3- Drying of Fibre
STEP 4- Incineration of Fibre



**Preparation of the Reagents** - 0.128 M $H_2SO_4$ & 0.313 M NaOH

- 0.128M $H_2SO_4$ – Dilute 3.49ml of $H_2SO_4$ in 500 ml DW
- 0.313M NaOH – Dissolve 6.25gm of NaOH in 500ml DW

**Boiling in Acid**

- Measure 200ml of 0.128M $H_2SO_4$ with a measuring cylinder
- Pour that 200ml of 0.128M sulphuric Acid in a conical flask
- Take 2gm sample in 200ml conical flask which has 0.128M $H_2SO_4$ acid
- Place the conical on a hot plate and boil for 30 mins with stirring
- Take a funnel with a filter paper and filter the boiling mixture after 30 mins

**Boiling in Base**

- Measure 200ml of 0.313M NaOH with a measuring cylinder
- Pour NaOH solution into the conical flask washing the filtrate obtained previously
- Put the flask on hot plate for boiling for 30mins
- Filter the sample using a ash less filter paper
- Collect the filtrate in a clean dry crucible

**Drying of Fibre**

- Place the crucible in hot air oven for 105°C for 2 hrs
- Take out the crucible and let it cool inside a desiccator
- Take weight of the crucible containing the fibre

**Incineration of Fibre**

- Place the crucible inside the muffle furnace set at a temperature of 550°C for 2-3 hrs
- Cool it down inside a desiccator
- Note the weight of the crucible with ash

**Calculation –**

$$\textbf{Crude Fibre \%} = \frac{W_1 - W_2}{W_S} \times 100$$

$W_1$ = Weight of crucible with Fibre
$W_2$ = Weight of crucible with Ash
$W_S$ = Weight of Sample

# DETERMINATION OF PROTEIN CONTENT

**AIM** – To estimate the protein content of the sample

**Materials Required-**

- Digestion bench placed in digestion chamber
- Kjeldahl Distillation Unit
- Kjeldhal flask
- Burette
- Conical flask V
- Volumetric flask
- Measuring cylinder
- Weighing Balance
- Pipettes
- Potassium sulphate
- Copper sulphate
- Sodium hydroxide (NaOH)
- Commercial sulphuric acid (H2SO4)
- Methyl red Indicator
- Glass beads
- 1gm of Sample

**Method –**

The method of estimation of nitrogen by Kjeldhal method includes three steps;

1- Digestion
2- Distillation
3- Titration

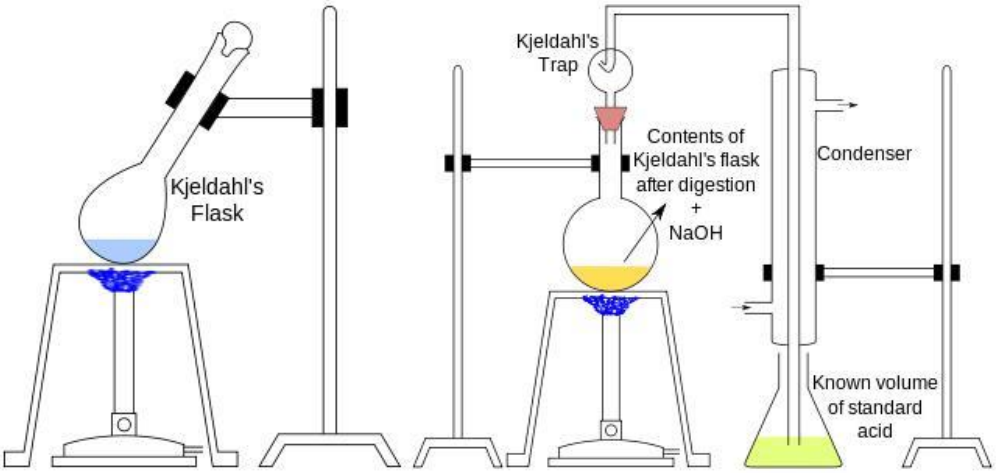
Accurately weigh the sample (1 g) and place in digestion tube. Add 7 g catalyst, 3 to 5 anti-bumping granules and 20 ml of cone $H_2SO_4$. Also prepare a tube containing the above chemicals as blank. Cover tube with exhaust manifold and place tube in the preheated digestor and digest at about 110-130°C for 15 mins (ignore this process if non liquid sample is to be digested). Turn the digestor to digestion temperature normally around 420°C and digest the sample until the solution is light green and then a further 15 mins. Remove tube and leave to stand until sample is cooled. Add cautiously 60 ml distilled water. Switch on distillation apparatus and pre-wash for 10 mins. Dispense 25 ml 4% boric acid into a 250 ml conical flask and place the flask under the condenser, ensuring that the condenser tip is immersed in the boric acid solution. Connect the digestion tube containing the sample digest to the distillation apparatus. Dispense 60 ml 40% NaOH carefully into digested sample. Immediately turn on the steam supply valve to initiate the distillation. Heat for 4 mins until all ammonia has passed over

into the boric acid. Lower the conical flask ensuring the condenser tip is not immersed in solution and continue heating for further 1 min. Collect approximately 120 ml distillate. Wash tip of condenser with distilled water. Place conical flask containing ammonia distillate on magnetic stirrer. Add 1 ml indicator and titrate the sample with standard 0.1N sulphuric acid until the solution change from green to pinkish. Read volume of acid used for titration.

**Calculations –**

$$\textbf{\% Protein} = \frac{(b-a) \times 0.1 \times 14}{W} \times 100 \times \frac{6.25}{1000}$$

$W_S$ = Weight of the sample
a = volume (ml) of 0.1N H2SO4 used in blank titration
b = volume (ml) of 0.1N H2SO4 used in sample titration
14.00 = atomic weight of nitrogen
1000 = the conversion of mgN/100 g to gN/100 g sample
6.25 = the protein-nitrogen conversion factor




# DETERMINATION OF CARBOHYDRATE CONTENT

**AIM** – To estimate the carbohydrate content of the sample by Phenol-Sulphuric Acid method

**Materials Required** –

- 0.1gm of Sample
- Phenol 5%
- Sulphuric Acid 96% reagent grade
- Glucose (standard solution)
- Boiling tube
- Centrifuge tube
- Sodium carbonate
- 2.5N HCL
- Pipette
- Spectrophotometer

**Method-**

- Weigh 100mg of sample into a boiling tube
- Hydrolyse by keeping it in boiling water bath for 3hrs with 5ml of 2.5N HCL and cool it to RT
- Neutralize with sodium carbonate until the effervescence stops
- Make up the volume to 100ml and centrifuge
- Pipette out 0.2, 0.4, 0.6, 0.8 and 1ml of the working standard in a series of test tube
- Pipette out 0.1 and 0.2ml of the sample solution in two separate test tube and make up the volume in each test tube till 1ml with DW
- Set a blank with 1ml of DW
- Add 1ml of phenol solution to each test tube
- Add 5ml of 96% $H_2SO_4$ in each test tube
- Shake the contents well after every 10 mins

**Calculations-** Use spectrophotometer to read the absorbance at 490nm and calculation for the total amount of carbohydrate present in the sample solution is done using the standard graph of glucose.

# DETERMINATION OF TOTAL FLAVONOID CONTENT

**AIM** – To estimate the total flavonoid content of the sample using Aluminium Chloride Calorimetric method.

Total Flavonoid content is determined by Aluminium Chloride calorimetric method and Quercetin is used as a standard.

**Materials Required –**

- Aluminium Chloride – 10%
- Potassium Acetate – 1M
- Methanol
- Quercetin
- UV-Spectrophotometer
- 2gm of Sample

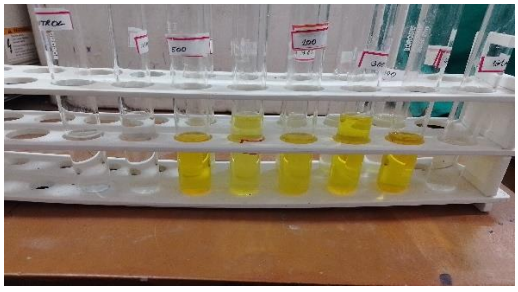
**Preparation of Standard Quercetin Solution** – 1mg quercetin was dissolved into 1ml DW so that the concentration of the solution is 1mg/ml or 1000µg/ml. This is called stock solution. Then serial dilution was done in order to prepare different solution ( 10µg/ml, 50µg/ml, 100µg/ml, 250µg/ml ).

**Preparation of Blank**- Blank consist of all the reagents except for the extract is substituted with 0.25ml of ethanol

**Preparation of the extract solution –**

- 1ml of sample extract of different concentration solution was taken in a test tube
- 3ml methanol was added into test tube
- 200µl of 10% $AlCl_3$
- 200µg of Potassium Acetate
- 5.6ml of DW
- Test tube was incubated at room temperature for 30 mins

**Calculation** - Use spectrophotometer to read the absorbance at 420nm and calculation for the total amount of Flavonoid present in the sample solution is done using the standard graph of Quercetin.



# ESTIMATION OF TOTAL PHENOLIC CONTENT

**AIM** – To determine the total phenolic content of the sample

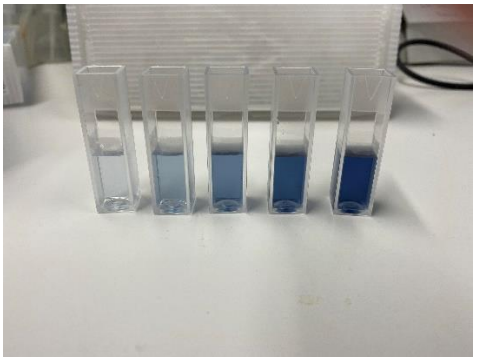
**Materials & Reagents Required-**

- Gallic Acid
- Folin Ciocalteu Reagent
- Sodium carbonate
- Methanol
- Volumetric flask
- Test Tubes
- 2gm of Sample
- UV-Vis Spectrophotometer

**Method-**

- The stock solution of the sample extracted in methanol
- Test tubes covered in aluminium foil as FC reagent is light sensitive. 2ml of the extracted sample were pipetted out
- 2ml of FC reagent was added followed by 2ml of methanol in each test tube
- The mixture was mixed well and after that 2ml of sodium carbonate was added. Blank is prepared using 2ml of methanol instead of the sample. The test tubes were kept in dark for 1hr
- The OD is measured at 765nm. A series of test tube was set up in which 0.5ml of gallic acid in concentration of 100,200,300,400 and 500µg/l was added along with 0.5ml FC reagent, 0.5ml methanol and 0.5ml of sodium carbonate and allowed to stand for 1hr in dark.

**Calculation**- Using spectrophotometer to read the absorbance at 765nm and calculation for the total amount of Phenolic content present in the sample solution is done using the standard graph of Gallic acid.



# DETERMINATION OF ANTIOXIDANT PROPERTIES – DPPH ASSAY

**AIM-** To determine the antioxidant property of the sample using 2,2-Diphenyl-1-picrylhydrazyl (DPPH Assay). It includes use of free radicals assessing the potential of a sample to serve as free radical scavenger.

**Materials & Reagents Required –**

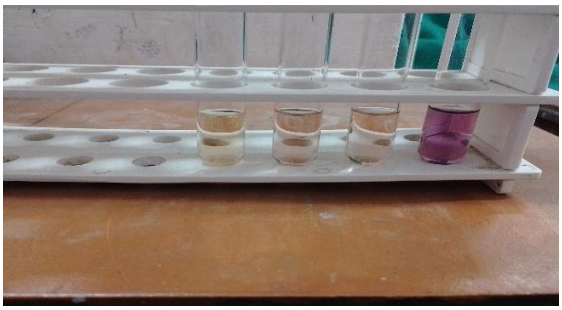
- 2,2-Diphenyl-1-picrylhydrazyl (DPPH)
- Volumetric Flask
- Methanol
- Filter paper
- Funnel
- 2gm of sample

**Method-** The plant extracts were prepared in methanol by adding 100 ml of methanol to 1 g of plant powder. The infusions were stirred on the magnetic stirrer at room temperature for 5 h. This was then centrifuged at 6000 rpm at 4° for 10 min and the supernatant was stored at -4° for further analysis

**Phytochemical determination:**

Powdered plant samples (5 g) were extracted with a mixture of methanol and water (150 ml) in the volume ratio 4:1 using Soxhlet for 12 h. The extract was cooled and filtered through Whatman filter paper. The filtrate (methanol and water) was reduced to approximately $1/10^{th}$ of its original volume and acidified with 2M $H_2SO_4$. This filtrate was extracted with 75 ml (3×25 ml) chloroform in a separating funnel. The chloroform layer was separated and evaporated to dryness on a water bath maintained at 45°. This contains phenolics and terpenoids. The aqueous layer obtained after the separation was adjusted to pH 10 with 2M NaOH. It was further extracted with 60 ml chloroform and methanol (3:1) followed by extraction with 40 ml chloroform in a separating funnel.

**Calculations** - Absorbance of the DPPH radical without antioxidant, i.e. blank was also measured. The capability to scavenge the DPPH radical was calculated using the following equation. DPPH Scavenged (%) = $((A_B - A_A)/A_B) \times 100$, where, $A_B$ is absorbance of blank at t= 0 min; $A_A$ is absorbance of the antioxidant at t= 30 min. A calibration curve was plotted with % DPPH scavenged versus concentration of standard antioxidant



# ANALYSIS OF PRODUCT COLOUR

Color is an important parameter, principally because of its influence on the visual attractiveness of a product. Here, the blends produced from the banana pulp and banana peel had similar averages for the a, b, C, and H parameters. For color measurements, a MiniScan XE Plus colorimeter was used in the powder function. The values of L, a, and b were determined. The coordinate C is the chroma and was determined in accordance with Eq. 1. The coordinate H is the hue angle and was determined in accordance with Eq. 2.

$$Chroma\ C* = \sqrt{(a*)^2 + (b*)^2} \qquad (1)$$

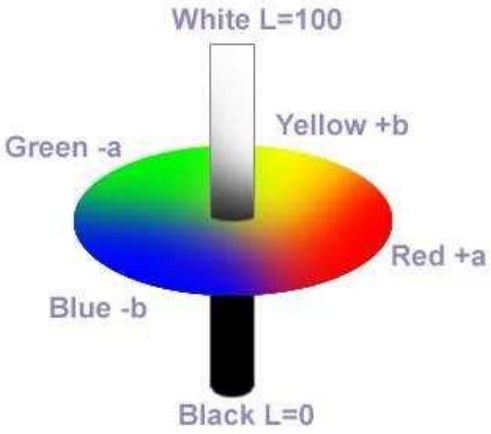
$$H* = tan^{-1}\frac{b^*}{a^*} \qquad (2)|$$

Color of the samples was determined by holding the sensing head in direct contact with their surface using a Minolta Chroma-Meter CR-200 colorimeter equipped with a xenon lamp in the L*, a*, and b* system, calibrated with a standard white background plate (L*¼94.4000; a*¼0.3134; b*¼0.3205). The L*, a*, and b* readings obtained directly from the instrument provided measures of lightness, redness, and yellowness, respectively. Qualitative color differences using lightness (L*) and chroma [Cab ¼(a2þb2)1/2] representations were calculated using Equations (1) and (2):

$$\Delta L^* = L_t^* - L_s^*, \qquad (1)|$$

$$\Delta C^* = C_t^* - C_s^* \qquad (2)$$

where the subscripts t refers to the sample and s to standard or control sample



# TEXTURE PROFILE ANALYSIS

**AIM** – To understand and analysis the texture quality of the sample

**Materials Required** –

- 2gm of sample
- Texture Profile Analyser machine (TPA)

Texture profile analyser as the name implies measures the texture of a sample. During TPA test the samples are compressed, penetrated twice to provide inside about how the sample behave when chewed. The TPA test mimics the mouth's biting action.

TPA comprises as a range of techniques that follow the principal of measuring force as a function of time and distance as the probe attached to the Texture analyser deforms the sample. The specific probe is moved at a definite speed in up and down direction and the resisting force is measured throughout the time period. TPA measures the hardness, Fracturability, Cohesiveness, Adhesiveness, Gumminess, Chewiness, Springiness and Shringiness.

A TPA generally follows a format:

1. **1st Penetration** – The probe descends on to the sample, once the contact is detected measurement begins and the probe descends at a defined speed for a set distance and time
2. **1st Withdrawal**- Once the target distance/time is reached the probe ascends away from the sample at a typically faster speed
3. **Wait** – The sample is allowed to recover before the process is repeated
4. **2nd Penetration & 2nd Withdrawal**- It is repeated again in the same manner.

**Method-**

- A specific probe was selected according to the food sample
- The food sample was kept on a plate
- The target distance and probe speed were pre-set
- The probe descended and penetrated the sample and the peak force encountered was measured
- The probe was withdrawn from the sample and the process was repeated twice.

**Calculation –** The result is obtained in a graphical form where we can get the values of resisting force as a function of distance and time. Area under the curve for the compression side is also measured.

# RESULTS AND DISCUSSION

## Calculation for Moisture Content

$$\textbf{Moisture Content \%} = \frac{W_s - (W_2 - W_1)}{W_S} \times 100$$

Ws = Weight of the Sample

$W_1$ = Weight of Petri dish

$W_2$ = Weight of petri dish + sample (after drying)

**For Sample –** 7.93 %

**For Control (Unfortified noodles) –** 5.55 %

## Calculation for Ash Content

$$\textbf{Ash content \%} = \frac{W_2 - W_1}{W_s} \times 100$$

$W_S$ = Weight of the sample

$W_1$ = Weight of the crucible

$W_2$ = Weight of the crucible + Ash

**Ash % for sample** – 3.06 %

**Ash % for Control (unfortified)** – 2.3 %

## Calculation for Fat Content

**% fat = (W2 – W1) x 100/S**

W1 = Weight of Empty Flask
W2 = Weight of Flask + extracted fat
S = Weight of Sample

**Fat % for Sample = 1.36 %**

**Fat % for Control (unfortified) = 0.97 %**

## Calculation for Crude Fibre

$$\textbf{Crude Fibre \%} = \frac{W_1 - W_2}{W_S} \times 100$$

$W_1$ = Weight of crucible with Fibre
$W_2$ = Weight of crucible with Ash
$W_S$ = Weight of Sample

**Crude Fibre % for Sample =** 35 %

**Crude Fibre % for control** = 20%

## Calculation for Protein Content

$$\textbf{\% Protein} = \frac{(b-a) \times 0.1 \times 14}{W} \times 100 \times \frac{6.25}{1000}$$

$W_S$ = Weight of the sample
a = volume (ml) of 0.1N H2SO4 used in blank titration
b = volume (ml) of 0.1N H2SO4 used in sample titration
14.00 = atomic weight of nitrogen
1000 = the conversion of mgN/100 g to gN/100 g sample
6.25 = the protein-nitrogen conversion factor for fish and its by-products

**Protein % of Sample** = 13.51 %

**Protein % of Control (unfortified)** = 14.04 %

## Determination of Colour Analysis

| | L | a | b |
|---|---|---|---|
| **Control** | 57.6 | -1.7 | 26.49 |
| **Sample** | 42.71 | -1.06 | 18.11 |

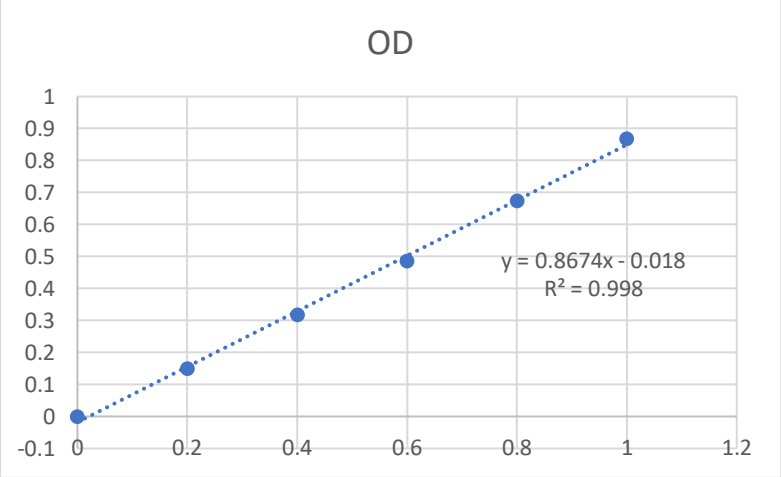
$$\textbf{E} = \sqrt{(L_1 - L_2) \pm (a_1 - a_2) \pm (b_1 - b_2)}$$

E = 12.13

# Calculation for Carbohydrate Content

For Standard Curve of Glucose:

| Concentration | OD |
|---|---|
| | |
| 0 | 0 |
| 0.2 | 0.15 |
| 0.4 | 0.318 |
| 0.6 | 0.486 |
| 0.8 | 0.673 |
| 1 | 0.867 |




From the equation: **Y= 0.86674x – 0.018**

| Concentration | Control | Sample |
|---|---|---|
| 0.1 | 0.537 | 0.112 |

Solving the equation with respect to the 0.1 and 0.2 concentration both for Sample and control where Y is known absorbance and X is un-known we get:

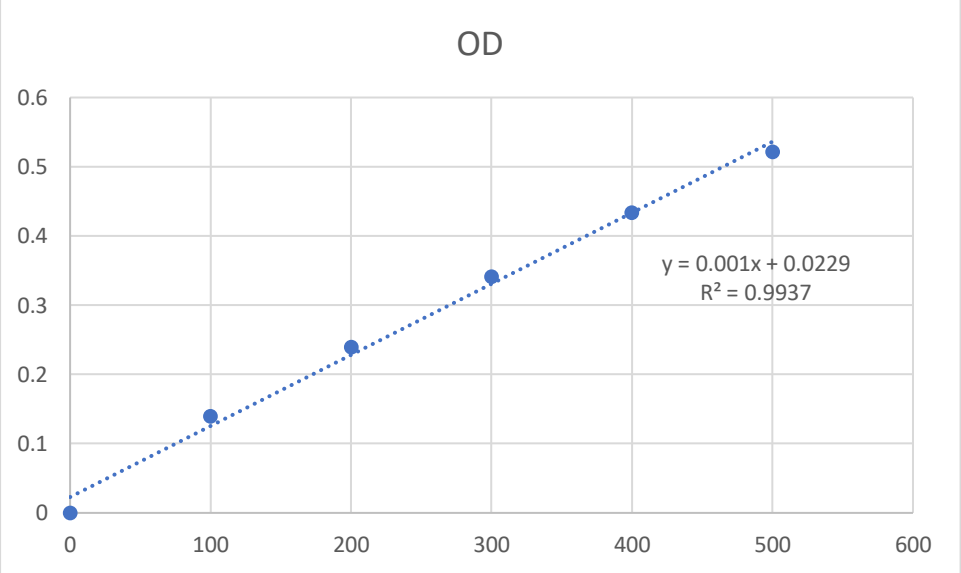
| Concentration | **Control** | Carbohydrate Content |
|---|---|---|
| 0.1 | 0.644 | 644 mg/gram |

| Concentration | **Sample** | Carbohydrate Content |
|---|---|---|
| 0.1 | 0.637 | 637 mg/gram |

# Calculation for Total Phenolic Content

For Standard Gallic Acid Curve

| Concentration | OD |
|---|---|
| | |
| 0 | 0 |
| 100 | 0.14 |
| 200 | 0.24 |
| 300 | 0.341 |
| 400 | 0.434 |
| 500 | 0.522 |




Using UV-Vis Spectrophotometer at 765nm we have recorded the absorbance for Sample & Control and the result is:

Sample = 0.128

Control = 0.08

Now solving the equation | Y = 0.001x + 0.0229 we get:

**For Control =** 57.1 or 28.55 mg/g

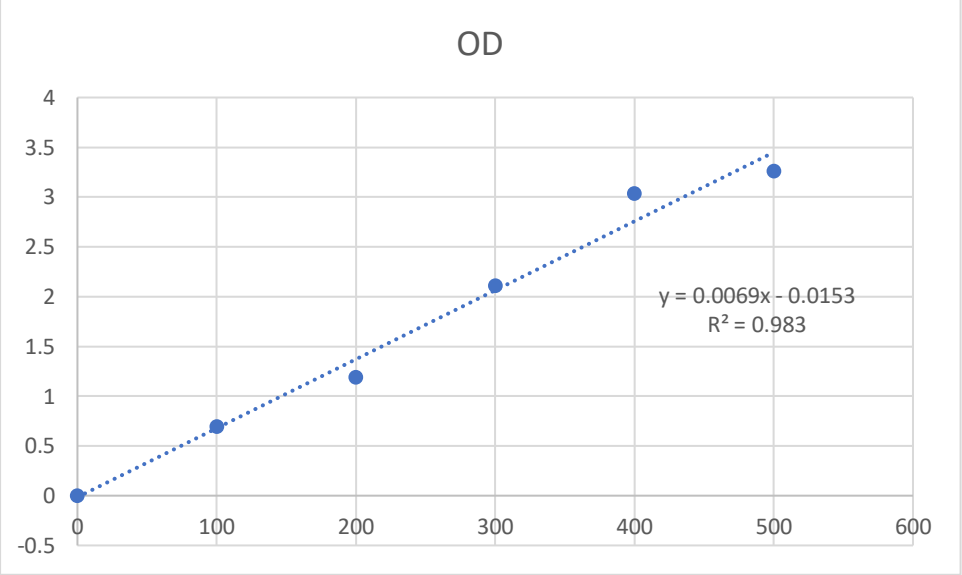
**For Sample** = 105.1 or 52.55 mg/g

By this we can say that for Control – 57.1mg of gallic acid equivalent is present in 2gm of control and 105.1mg of gallic acid equivalent is present in 2gm of sample.

# Calculation for Total Flavonoid Content

For Standard Quercetin graph

| Concentration | OD |
|---|---|
| | |
| 0 | 0 |
| 100 | 0.698 |
| 200 | 1.194 |
| 300 | 2.11 |
| 400 | 3.035 |
| 500 | 3.265 |




Using UV-Vis Spectrophotometer at 420nm we have recorded the absorbance for Sample & Control and the result is:

Sample = 0.065

Control = 0.014

Now solving the equation | Y = 0.0069x + 0.0153 we get:

**For Control** = 4.246 mg/g

**For Sample** = 11.637 mg/g

By this we can say that for Control – 4.246 mg of catechin equivalent is present in 1gm of control and 11.637 mg of catechin equivalent is present in 1gm of sample.

# Calculation of Antioxidant Potential – DPPH Assay

Concentration of DPPH taken – 0.5 millimolar

Amount of Sample taken = 2.02gm in 50ml of methanol

Amount of Control taken = 2.02gm in 50ml of ethanol

} To make Extract

DPPH Scavenged (%) = $((A_B - A_A)/A_B) \times 100$, where, $A_B$ is absorbance of blank at t= 0 min; $A_A$ is absorbance of the antioxidant at t= 30 min. A calibration curve was plotted with % DPPH scavenged versus concentration of standard antioxidant

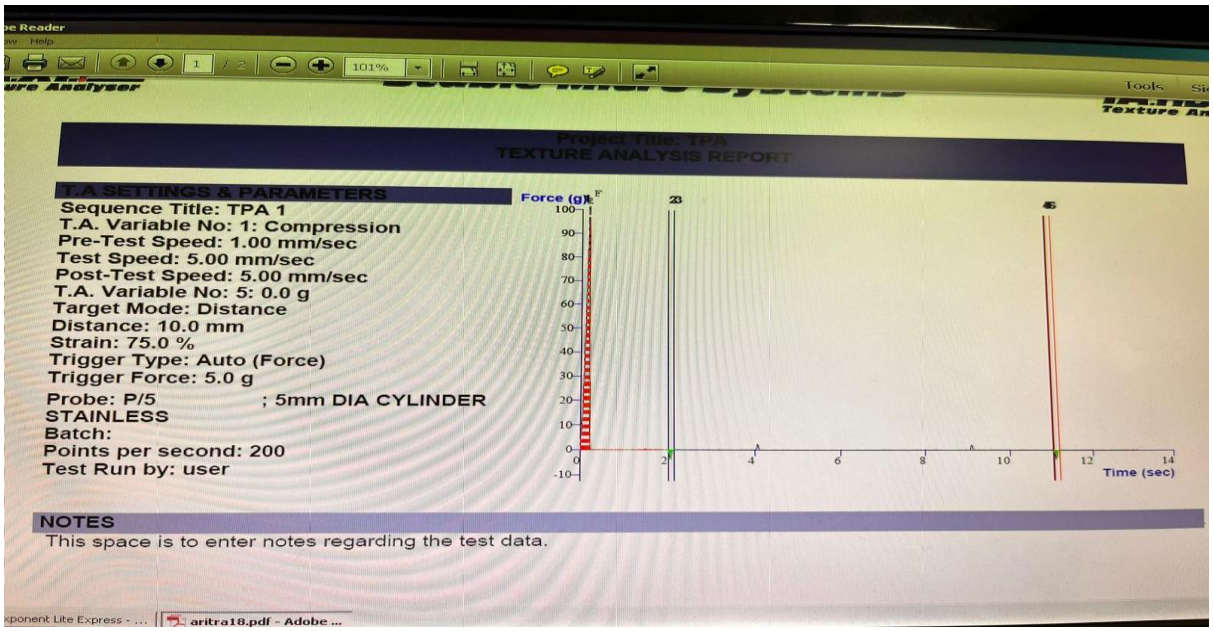
| | **OD** | **% obtained** |
|---|---|---|
| Blank | 1.757 | |
| Sample | 0.365 | 79.2 % |
| Control | 0.846 | 51.8 % |

Various Concentration of the sample and control extract was taken into consideration and the absorbance was recorded as follows:

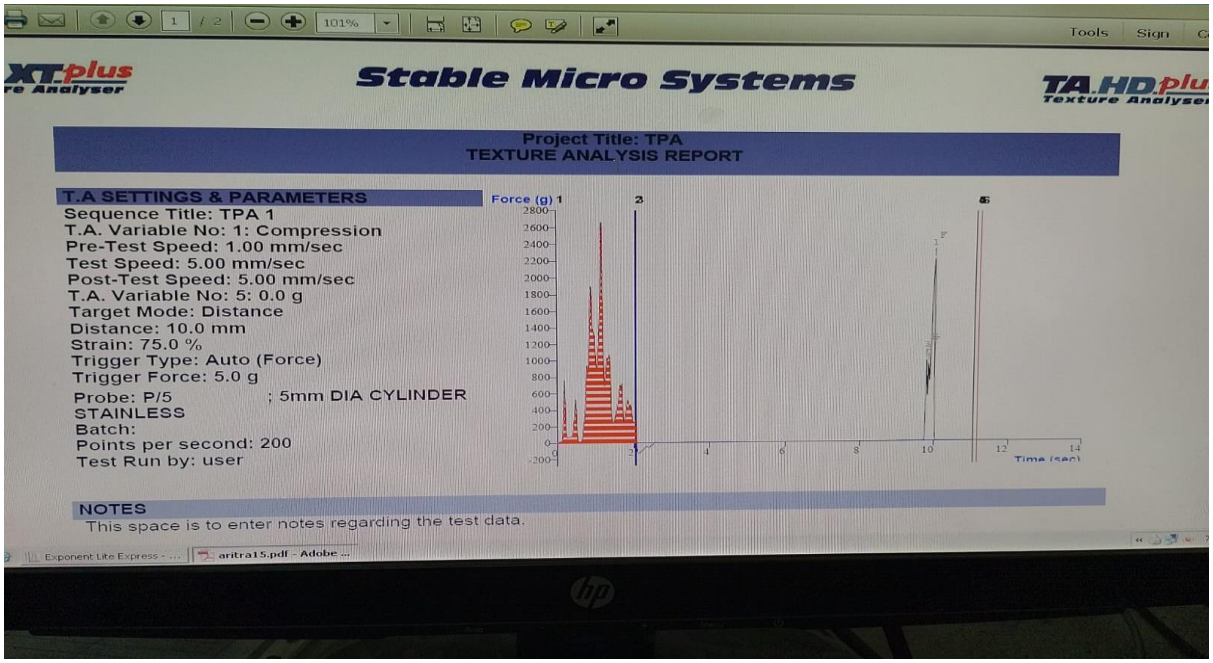
| **Amount of Extract** | **DPPH % of sample** | **DPPH % of control** |
|---|---|---|
| 1ml | 56.8 % | 20 % |
| 1.5ml | 58 % | 36 % |
| 2ml | 88 % | 86.1 % |

# TEXTURE PROFILE ANALYSIS

## For Control




## For Sample



# CONCLUSION

Cooked Banana Peel fortified noodles was subjected to sensory evaluation. For sensory assessment, noodles were served on coded plates. Panelists were asked to assess their degree of liking by paper ballot using a ten points hedonic rating scale, where $10^{th}$ best, and $1^{st}$ worst. Forty untrained judges were briefed on noodles protocol and then proceed to randomly evaluate the coded
spaghetti in terms of overall acceptability where the aroma, texture, and taste were included as specific criteria. Product characterization was carried out under subdued, reddish-orange, lighting in an USDA approved sensory evaluation room. The evaluation was mentioned earlier in this thesis under the term OVERALL ACCEPTABILITY, the scores were precisely mentioned heading to the conclusion the it can be an accepted product with respect to criteria mentioned as Cooking Yeild, Cooking Loss, WAC.
The Optimised Result which has been obtained from the RSM and has undergone several proximate analysis tests which clearly demonstrate that the fortified Green banana Peel noodles is a highly nutritious product with good amount of fat, carbohydrate, protein, ash content and most specifically the antioxidant content shows a spike in value when compared it with the normal unfortified wheat flour noodles. After all sensory analysis and proximate analysis we can conclude that Green banana peel flour fortified noodles is a complete food with richness of both micro and macro nutrients and has also passed the sensory evaluation under specific parameters.

This study demonstrates, but makes use of the considered to be an underutilised subproduct of low commercial value and significance in the food industry, has shown merit as a functional food ingredient in product processing and nutrition enhancement.
In addition, the product exhibited textural properties somewhat comparable to commercial wheat noodles, as well as resistance to retrogradation during prolonged refrigerated storage. The GBF noodles also serve as a gluten-free option for people with celiac disease.

Many food products could be developed and optimized to suit consumer sensory acceptance and preference base on the pasting properties of banana flours, despite being rich in nutritional values. Pisang Tanduk flour, observed with the highest peak viscosity among the banana flours, is suitable and stable to be used for many food products such as snacks and cookies. Pasta prepared from Pisang Nipah flour is recommended for production of green banana pasta which has brighter colour while Pisang Nangka flour is suggested for production of green banana pasta with firmer texture after cooked. Additionally, the ease to transform green banana into flour with low water activity, which facilitates in handling and transportation, enhances its potential as a good choice of raw material in food processing industry.

We can valorization the green banana peel waste by converting it into a fortified product and utilise the product which and ultimately contribute in reducing food waste and developing the food economy around it.

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