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Development of traditional food products with nutritional assessment for the vulnerable rural population of West Bengal

Thesis

Submitted by

NAJMUN NAHAR

Registration No. D-7/ISLM/61/16 date: 27.07.2016

For the Degree of Doctor of Philosophy (ISLM)

Department of Food Technology and Biochemical

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Dissertation

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Under the supervision of

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Abstract

Traditional foods play a vital role in human nutrition by being the primary source of carbohydrates, protein, fat, vitamins, and minerals. Besides, it provides bioactive compounds and good bacteria, which are highly critical to human well-being and the prevention of deadly diseases.

Though judging the nutritional quality, we can know how much nutrients a food contains, which increases our awareness about that food and increases the social value of the food. The product development and nutrient extraction processes play a crucial role in realizing the potential of different traditional food. In both cases, the formal process has been mainly used for their cheap set-up, easy scale-up, and control. Novel techniques can provide better performance as they often involve multiple energy transfer pathways. This review summarizes the principal mechanisms involved in different methods and their application.

The Second Chapter of this thesis evaluated the Black gram nuggets (*bori*), a popular traditional pulse-based food item in India, which are prepared from aerated paste (batter) of soaked black gram (*Phaseolus mungo*) and have high nutritional importance. This study collected samples from spinach bori, carrot bori, tomato bori, wax-gourd bori, and daikon bori. Carbohydrates, protein, fat, ash, moisture, antioxidants, and activity were analyzed. The incorporation of vegetables improved the antioxidant content and activity of *bori* samples. Improvement in total phenolic content to the range of 0.76-1.15 mg/g, entire flavonoid content to the field of 0.77-1.33 $\mu\text{g/g}$. FRAP assay activity to the range of 6.92-11.48 $\mu\text{mol/g}$, and DPPH assay activity to the range of 7.50-36.04 %, against control was observed. Total carbohydrate and fat content also improved to 0.84-2.39 % and 8.00-15.50 %, respectively. Protein and ash content decreased to 2.82-1.35%-2.82 % and 1.11-10.31 % against control. The moisture content of all samples increased during storage compared to the initial day. Moisture content helps to indicate their shelf life. Principal component analysis justifies the correlation of characterization parameters and *bori* varieties. A texture profile analyzer helps to analyze their textural properties.

In Part A of the Third Chapter, the effects of moisture content of batter, air integration in batter, and temperature of tray dryer were studied on hardness, whiteness index, water absorption capacity, and oil uptake ratio of black gram nugget (*bori*) and it was optimized using response surface methodology. The optimized conditions were: moisture content 67.01%, air incorporation 21.68% (v/v) of batter and 600C temperature required to attain maximum whiteness index of 81.21, water absorption capacity 41.86 ml/gm-min, minimum hardness value 44.59 N and oil uptake ratio 14% of nuggets. The carbohydrate, protein, fat, and ash contents of optimized black gram nuggets were 65.49%, 25.70%, 1.45%, and 1.87%. HPLC analysis showed the presence of different antioxidants in it. The color, texture, porosity, and diameter changes of the optimized black gram nuggets during cooking indicated that it was of good quality.

The Part B of the Third Chapter compares the mode of selected drying techniques (hot-air, freeze, microwave drying) on drying kinetics, followed by the development of suitable mathematical modeling for the process. Additionally, the antioxidant, color, and textural properties of dried products were evaluated for their acceptability and associated health benefits. Based on regression parameters, it was discovered that the page model fit better ($R^2 = 0.999$ to 0.991 and $SS_{\text{error}} = 0.000025$ to 0.0424) the experimental data compared with other models. The effective moisture diffusivity exhibited an inverse relation to drying time. Among tested drying, it was found that TB in microwave drying at 450 W had the highest amount of phenolic content (5.27 mg / g), flavonoid content (1.72 mg/ 100 g), ferric reducing antioxidant power assay (45.71 $\mu\text{mol/g}$), 61.42 $\mu\text{mol/g}$ of ABTS assay, and 67.81 $\mu\text{mol/g}$ of DPPH assay values were found. The freeze-drying products were better for physicochemical parameters than other drying process products. The presence of phytochemicals was responsible for the high bioactivity of microwave-dried nuggets.

In the Fourth Chapter, Part A, this study was conducted on lotus rhizomes to find the kinetics of drying and ultrasound-assisted extraction process of antioxidant, energy-economic, quality parameters, and phytochemicals under different drying processes. Milli et al. model was found to be the best-fitted drying model with a low SS_{error} (0.0145 – 0.0088), RMSE (0.02 to 0.005), and highest R^2 (0.999 to 0.992) value. The energy consumption cost (1518.33 Rs) is increased in tray dryers and low in microwave dryers (28.68 Rs). The vacuum-dried lotus rhizomes had a high content of total phenolics of

78.364 mg/g, flavonoids of 10.819 mg/g (dm) content, DPPH of 74.621 $\mu\text{mol/g}$, ABTS of 104.36 $\mu\text{mol/g}$, and FRAP of 108.312 $\mu\text{mol/g}$. Low hardness (12.642 N), resilience (0.468), and high whiteness (61.158) were observed in freeze-dried rhizomes. Microwave and vacuum drying showed a short drying process with better energy economy and higher antioxidant content, but quality parameters are best for a freeze-drying product.

In the Fourth Chapter, Part B, the spongy endosperm of germinated palmyra seed is very nutritious and delicious as a food item. Due to their macro and micronutrient enrichment with antioxidant compounds, it is used to satisfy hunger and promotes good health for vulnerable groups in many developing countries. Morphological analysis and bioactive compounds were also studied to find a suitable time-effective drying process and the effect of this drying method on the quality attributes. WPS Workbench evaluated the kinetics, mathematical modeling, and retention time of the ultrasound-assisted extraction process of different drying methods. Ink software. Color and texture are determined by Hunter Lab colorimeter and TA. XT texture analyzer, respectively. A morphological study was conducted on Field Emission Scanning Electron Microscope (FESEM).

A statistically significant difference was determined by Minitab 19.0 software. The water molecule present in SE-GPS is directly absorbed by electromagnetic energy in microwave drying resulting in quick dehydration in a comparatively short time (6 min). Two-term is the best model with the lowest value of s_{error} (0.091 – 0.00043), RMSE (0.114 -0.0079), and high R^2 (0.969 – 0.999). The free phenolic (6.854 mg/g), free flavonoid contents (1.358 mg/g), DPPH (56.071 $\mu\text{mol/g}$), FRAP (47.841 $\mu\text{mol/g}$), and ABTS (54.287 $\mu\text{mol/g}$) present in the highest amount in MD 450-W dried product. The minimum retention time (6 to 9 min) was observed in MD 450-W dried product in the UAE process. SEM helps to determine the morphological changes in different drying processes. The freeze-dried product showed an acceptable change in the quality parameters that had less hardness (13.362 N), high porosity (73.793%), high springiness (1.268), and high whiteness (88.522) value. MD at 450-W is the best drying technique in a short time with high moisture evaporating capacity, less retention time of UAE, high amount of antioxidant content, and antioxidant activity. FD is considered as best according to its physical quality parameter. High-temperature long-time exposure to drying can be harmful to bioactive compounds. The low cost-effective short-time microwave drying process was the best drying

process with lots of bioactive compounds of SE-GPS, which suggested the potential application in the food and medicinal industry. Retention time helps to determine the maximum free antioxidant content with minimum extraction time and prevent the loss of phytochemicals during the UAE process. Color, texture, and morphology studies helped to determine the physical properties.

In the Fifth Chapter, Ready supplementary food has been the best choice to arrest hunger and malnutrition in developing countries. To create low-cost, highly nutritious additional food with locally available ingredients, those fill-ups up the requirements of nutrients of Indians per day at different age groups according to recommended dietary allowance. To prevent malnutrition and keep children healthy, the ICDS center provides several foods: poushtic laddu, made with rice, wheat, groundnut, gram flour, and sugar. The women of the self-help group mainly make these nutritious laddu ingredients and provide them to the ICDS center. Currently, several ICDS centers offer poushtic powders made by CINI known as Nutrimix, which is advised to feed the children as laddu at home. This laddu powder lags far behind in nutrition and phytochemicals; this is the reason for submitting the report to improve the quality of this laddu in terms of nutrition. Three different poushtic powders were prepared, marked as P, PC, and PI, by healthy and nutritious food ingredients locally available in the market and environment. After experiments, it was found that P, PI, and PC are best for protein (28.315 g), iron (23.77 mg), and calcium (325.502 mg) content, respectively. A sufficient amount of macro and micronutrients is present in all poushtic powders. Phytochemicals like ascorbic acid, gallic acid, chlorogenic acid, valinic acid, routine, trans-cinnamic acid, ferulic acid, quercetin, apigenin, and kaempferol are found to be present. An antioxidant activity like FRAP (12.854 $\mu\text{mol/gm}$), ABTS (19.217 $\mu\text{mol/gm}$), and DPPH (19.167 $\mu\text{mol/gm}$) is high in the PC sample. Every poushtic powder is good in one way or another. SEM determines morphology and particle size with a correlation with hardness and fineness. Different storage containers define the shelf life of the products. In this study cost of the three products is analyzed for product marketing. Locally available ingredients help to prepare the low price with highly healthy and nutritious ready-to-supplementary food products that improve human health and nutritional status.

