Progress in Nutrition 2020; Vol. 22, N. 4: IN PRESS DOI: 10.23751/pn.v22i4.8742 © Mattioli 1885

Original article

Development and Characterization of Micronutrient Fortified Sesame Cake Flour Supplemented Doughnuts

Sabiha Abbas[1], *Mian Kamran Sharif*[1],*Masood Sadiq Butt*[1], *Muhammad Shahid*[2] *and Meijun Zhu*[3]

[1]National Institute of Food Science and Technology, University of Agriculture, Faisalabad
[2]Department of Biochemistry, University of Agriculture, Faisalabad
[3]School of Food Science, Washington State University, USA.

ABSTRACT

This study evaluated the quality of doughnuts prepared by using sesame cake flour fortified with micronutrient premix (comprising Fe, Zn, vitamin A, C and folic acid). Doughnuts developed with sesame cake flours (0, 10 and 20%) were analyzed for nutrient composition, mineral profile, physical properties, calorific value and storage stability. It was evident from results that supplementation with 20% sesame cake flour improved the protein (10.20% to 24.85%) and ash content. However, substantial decrease was noticed for carbohydrates. Similarly, mineral contents (P, Ca and Mg) also increased with increasing supplementation level of sesame cake flour. Likewise, increasing trend was observed for physical properties like hardness, cohesiveness and chewiness. Calories were also raised from 350.07±3.47 to 394.00±7.12Kcal/100g. Color analysis showed that L* values decreased as darker (brown) color was observed in doughnuts due to caramelization reaction between the amino acids and sugars with the addition of sesame cake flour. Storage analyses also showed significant differences between 100% wheat doughnuts and sesame cake flour supplemented samples regarding Peroxide value, Thiobarbituric Acid Number and Mold growth. It was concluded that 20% supplementation of wheat flour with sesame cake flour produced doughnuts with superior quality and better overall acceptability.

Key words: Sesame Cake Flour, Doughnuts, Supplementation, Quality, Physicochemical Attributes

Introduction

Malnutrition is a worldwide concern, commonly among the poor and vulnerable ones distributed in all age groups especially in developing countries (1). It is a physical discrepancy that arises due to improper consumption of food as a function of quality as well as quantity. According to WHO, it is a physical state resulting from complete or relative shortage of one or more essential nutrients. It occurs when there is a deficit in the availability of food or when food is accessible, but the body cannot absorb it (2).The protein energy malnutrition is escalating in individuals from under-developed and developing countries mainly due to poverty and food insecurity. Children are severely affected by the ailments like stunting, wasting

---

[1] Corresponding Author: sabihaabbas08@gmail.com

and under-weight due to consumption of monotonous diets and reliance on poor sources of proteins and other nutrients. Consequently, edema, wasting of body tissues, subcutaneous and muscular fat, poor health and inadequate mental and physical activities are significant among children (3).

Micronutrients deficiency is another major global health problem. More than 2 billion people in the world are facing deficiency of one or more micronutrients especially zinc, iodine, iron and vitamin A. The major causes of deficiency are poor access to micronutrient rich foods like vegetables and fruits. Moreover, fortified foods and animal products are expensive or unavailable in local markets(4). Addition of some vital micronutrients *i.e.* minerals and vitamins in food products in order to enhance its nutritional quality as well as provision of health benefits at very low risks is referred as food fortification (5). Food fortification has been recognized as an effective and long-standing method to improve the nutritional levels among the masses (6, 7). This strategy is considered as the most economical among the public health interventions. In this approach, main emphasis is on selection of suitable vehicle for the delivery of nutrients to the masses (8). In developing countries, food fortification has resulted in the effective control of mineral (zinc, iodine and iron) and vitamin (A, D, C, B1, B2, B3 and folic acid) deficiencies (9).

Poverty is greatly hampering the food accessibility in less developed countries. Furthermore, inadequate supply and higher cost of animal protein is the leading cause of certain health ailments in the populations. Scientists are striving hard to explore low cost plant protein sources for incorporation into formulations for better nutritional quality. Recently, much emphasis is being given to oilseeds including cotton, rapeseed, soya, sunflower and peanut for extraction and utilization of their protein isolates. Sesame seed belonging to the genus *Sesamum* of family *Pedaliaceae* is one of the important oilseeds. Nutritionally, it is considered as an important protein source because of higher amounts of some essential amino acids as compared to other oilseeds (10). Additionally, sesame cake flour obtained after oil extraction contains high amount of protein *i.e.* 35-40% which is considered best nutritive source for the maintenance of optimal health. Recently, researches have probed partially defatted sesame flour for its incorporation in food products to enhance the protein contents and curtail associated health disorders such as Marasmus, Kwashiorkor, edema and wasting of body tissues. (11). Sesame seeds are considered as wholesome food ingredient. Likewise, sesame meal obtained after extraction of oil has been utilized in numerous confectionery and bakery products including bread, bars, cookies, bread sticks, doughnuts, crackers, cereal mixes, cakes, buns and *tahini* or sesame butter (12).

Wheat (*Triticum aestivum*), the topmost staple grain of Pakistan is one of the major crop in the country with 1.7% share in GDP (13). White flour (generally termed as refined flour) obtained after wheat milling exhibits good nutritional profile. Wheat flour is the most suitable commodity for supplementation of various nutrients by the addition of oilseeds and other crops. The supplemented wheat flour can be further utilized for the production of different baked products like biscuits, cookies, leavened pan bread, cakes and doughnuts (14).

Doughnuts are sweet snacks made from fried dough which are greatly relished by children in many countries. These are usually consumed as such or taken with milk or coffee, at doughnut shops or fast food restaurants. Processed legumes and oilseeds have pronounced potential as snack food for school aged children (15). Sesame flour being rich in protein, vitamins, minerals and dietary fiber can be used for the production of novel and inexpensive value-added products. The present research project was designed to develop energy- and nutrient-dense doughnuts using sesame cake flour of indigenously grown cultivars along with the evaluation of shelf stability through storage study analysis.

Materials and methods

Procurement and Preparation of Raw Materials

Sesame seeds of Pakistani white cultivar (TH-6) were procured from Oilseed section, Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan.

Manual cleaning of sesame seeds was done to remove the physical impurities followed by partial oil extraction through Manual Oil Press (Carver Inc., Wabash, IN, USA). Micronutrients pre-mix comprising of Zn, Fe, vitamin A, C and folic acid (B9) was obtained from Fortitech Inc. Schenectady, NY, USA. Subsequently, sesame cake samples were ground to get sesame cake flour that was further utilized for product development. All laboratory reagents used were of analytical grade.

Flour blend formulations

Commercial wheat flour was blended with 0, 10 and 20% sesame cake flour as shown in Table 1.

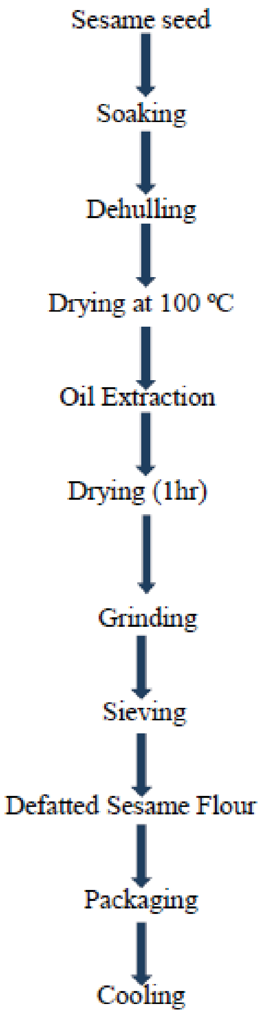

Figure 1. Flow diagram for production of defatted sesame flour

Table 1. Treatments used in study (g/100g)

Treatments	Sesame cake flour (%)
T_0	0
T_1	10
T_2	20

Preparation of Doughnuts

All ingredients were mixed and kneaded to form dough followed by sheeting and molding (round shaped doughnuts of specific size). Furthermore, frying was done at 175°C and finally all samples were packed in polyethylene zip bags for further analyses.

Analyses of Doughnuts

The prepared doughnuts were analyzed for proximate & minerals composition, water activity, texture, color and calorific value using their respective procedures. Storage study was also done to analyze various parameters *i.e.* Peroxide Value, Thiobarbituric Acid Number and Mold Growth.

Proximate Composition

Sesame cake flour supplemented doughnuts were analyzed for moisture, fat, fibre, protein, ash and nitrogen free extract using their respective methods as described by (18).

Mineral Contents

The prepared doughnuts were studied for Na, K using Flame Photometer-410 and Ca, Mg, P, Fe and Zn via Atomic Absorption Spectrophotometer after wet digestion by following methods of (19).

Water Activity

An electronic Hygropalm water activity meter (Hygropalm AW1, Rotronic AG, Bassersdorf, Bulach, Switzerland) was used to estimate water activity of the doughnuts (19).

Texture Analysis

The doughnut samples were evaluated for textural profile by using a texture analyzer (TA-XT Plus, Stable Micro Systems Ltd., Surrey, UK) equipped with Texture Expert version 1.22 Software. The instrument was having a load cell (5kg) and a cylinder-shaped probe (20mm). The firmness test was performed at 1.0mm/s and complete information of the sample without excessive densification was provided by 50% strain level. Texture characteristics such as hardness, cohesiveness, springiness and chewiness were determined by using double compression deformation curve of the samples as described by (20).

Color Measurement

Color of the doughnuts was determined using color meter (Chroma Meter CR-400, Konica Minolta, Sensing Inc. Japan) as described by (21) with some modification. The L*-value in color system showed luminance/brightness with 0-100 (darkness-brightness); a*-value depicts the green to red colors ranging from -100 to 0 and 0 to -100; b*-value measures blue (-100-0) to yellow (0-100).

Calorific Value

Calorific value of the doughnuts was evaluated by using oxygen bomb calorimeter (C2000 Basic, IKA-WERKE GmbH & CO., Germany) as reported by (22). In decomposition vial, sample (0.5g) was placed with the support of a cotton thread and ignition wire. Afterwards, decomposition vial was tightened with the screw cap and directed into the filler head. The measuring cell cover was closed by pushing the start button. The sample was burnt through electric spark within the vial. The produced heat was noted by C5040 CalWin software (IKA-Werke, Germany) in a graphical form indicating the temperature versus time which reflects the number of calories/gram in the test sample.

Storage Study

All prepared doughnuts were stored for 7 days at refrigerated temperature (4°C) and analyzed for peroxide value (19), thiobarbituric acid number (23) and mold growth (18) at the initiation, middle and end of the storage interval.

Peroxide Value

The peroxide value of samples was calculated in terms of iodine formed by the reaction of iodide ions and hydrogen peroxide by following AOAC Method No. Cd 8-53 (19). Purposely, 5g sample was taken in a flask (250mL) followed by addition of glacial acetic acid-chloroform (3:2 v/v) solution. The flask was spun for a while in order to completely dissolve the oil in the solvent mixture. 0.5mL of freshly prepared saturated solution of potassium iodide (KI) was added in the flask. The contents were titrated against standard solution (0.1N sodium thiosulphate *i.e.* Na2S2O3) with constant shaking to eliminate the yellow color. Then starch solution (0.5mL) was added as an indicator and titration was continued with vigorous shaking till the fading of blue color. The reading for blank was separately observed. Peroxide value was calculated by using the following formula:

$$\text{Peroxide value (mEq/Kg of fat)} = \frac{(B - A) \times N \times 1000}{\text{Weight of oil sample (g)}} \times 100$$

B = Volume of Na2S2O3 used for blank
A = Volume of Na2S2O3 used for sample
N = Normality of Na2S2O3

Thiobarbituric acid Number (TBA No.)

In distillation flask, sample (10g) was taken and heated to obtain distillate (5mL) in glass stopper test tube with 5mL TBA reagent (0.2882g/100 of 90% glacial acetic acid) and heated in water bath for 35 minutes along with a blank sample. After cooling the tubes were placed in water for 10 min and absorbance (D) was determined at 538nm using spectrophotometer. TBA No. was estimated by using the following relationship:

$$\text{TBA No. (mg malenaldehyde/Kg sample)} = 7.8 \times D$$

Mold Growth

Mold growth was monitored by following AACC Method No. 42-50 (18). Purposely, media (potato dextrose agar) was sterilized in autoclave. Sterile spoon was used to take the sample (1g) and shifted in sterile blender along with sterile (9mL) buffered phosphate diluent and mixed thoroughly at low speed for 1-2 min. 1mL of each dilution was shifted into labelled duplicate petri dishes. Subsequently, 15mL of media was poured in the plates immediately. It was mixed well and allowed to solidify. For series of samples, dilutions were mixed with the rotation of plates on the surface. Before inverting plates, these were incubated at room temperature. Colonies were counted (<50 colonies) as CFU/g on the plates and multiplying further with the dilution factor.

Statistical Analysis

The data obtained from all parameters were statistically analyzed using Statistical Package (SPSS) to determine the level of significance. Means were compared through Tukey's honestly significant difference test following the methods as described by (24).

Results and discussion

Proximate Composition

The results for proximate composition of sesame cake flour supplemented doughnuts have been presented in Figure 2. It was observed that protein content increased from 10.20±0.26 to 24.85±0.40% with gradually increasing supplementation level of sesame cake flour. Likewise, fat content of doughnuts also increased from 9.25±0.23 to 14.41±0.46%. This result corroborates earlier reports of increased protein content during formulation of sesame-based composite breads (11). An increase in the protein content from 13.3 to 14.8% was observed with sesame cake flour supplementation as compared to the control bread (9.2%) due to lower protein content of wheat flour. It was also related to previous research in which oilseeds (*Sesamum indicum*) were added in wheat flour and assessed for impact on nutritional composition of leavened pan bread. The fat content of the supplemented products was increased from 5.8 to 10.0% as compared to samples without supplementation (3.7%). The results of this study elucidated increase in fat content of the end products due to the presence of higher levels of inherent fat contents in sesame flour (11). Moisture content was increased from 7.53±0.19 to 8.38±0.12%. In an earlier study, it was reported that low moisture content enhances the keeping quality of flours (25). Crude fiber and ash content were also increased with significant differences. Similar increase in crude fiber and mineral contents were noted in composite bread samples with increase in the supplementation of sesame flour which has high content of lignin, hemicelluloses and cellulose and also due to increased presence of inherent content in sesame flour. Carbohydrate contents were decreased with increased supplementation. Similarly, supplementation of wheat flour with sesame flour showed reduction in NFE of the composite bread samples. The highest NFE was observed in the control sample (53.90%) whereas the lowest (32.46%) in sample containing sesame flour. This revealed that wheat flour was the main contributor of the NFE in the bread (26).

Mineral Profile

The mineral contents of sesame cake flour supplemented doughnuts are presented in Figure 3. Supplementation of wheat flour with sesame cake

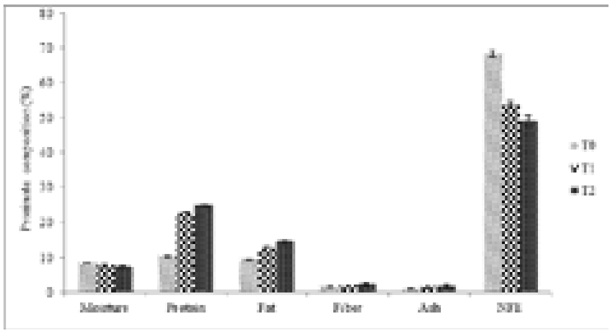

Figure 2. Effect of treatments on the proximate composition (%) of sesame cake flour supplemented doughnuts

T_0= Doughnuts without supplementation act as control
T_1= Doughnuts supplemented with 10g/100g of sesame flour
T_2= Doughnuts supplemented with 20g/100g of sesame flour

flour (T2 i.e. 20%) increased sodium (42.03±0.95 to 65.35±0.74 mg/100g), potassium (19.65±0.46 to 32.52±0.71 mg/100g), calcium (84.26±1.70 to 236.38±3.00 mg/100g), magnesium (95.06±2.31 to 176.21±3.10mg/100g), phosphorus (468.32±14.41 to 520.18±8.80mg/100g), iron (10.25±0.15 to 22.64±0.64 mg/100g) and zinc (10.15±0.23mg/100g to 20.92±0.24mg/100g). The high content of minerals in the sesame cake flour supplemented doughnuts was due to high ash content in the sesame flour. Phosphorus was highest among all the samples. Whereas, iron and zinc were improved significantly with the increased supplementation of sesame cake flour and fortification of micronutrients. Similar results were found in a previous study, where biscuits were supplemented with flaxseed flour, indicated the increased mineral composition with the increased supplementation of flour (27).

Texture Analysis

Results for textural characteristics of sesame cake flour supplemented doughnuts are reported in Table 2. Increased supplementation of sesame cake flour in the wheat flour increased the hardness (42.27±0.81 to 113.72±3.64N), cohesiveness (0.15±0.21 to 0.25±0.42) and chewiness (0.23±0.18 to 0.47±0.02) but decreased the springiness (0.77±0.41 to 0.71±0.26) of the doughnuts. The highest levels of hardness (113.72±3.64N), cohesiveness (0.25±0.42) and chewiness (0.47±0.02) were found in doughnuts having 20% sesame cake flour. While, highest value for springiness was noted in control sample. Hardness is one of the important attribute of doughnuts texture. It is the force required for first compression of the product. There is a strong correlation between hardness and bulk density. In a previous study, in sesame-based snacks as the level of supplementation increased, there was gradual increase in bulk density and ultimately hardness of product (28). Cohesiveness indicates that how well a product resists the second deformation relative to first deformation. Cohesiveness of the supplemented products is related with the hardness of snacks. Hardness and chewiness depend upon cohesiveness between different molecules of the product. In this regard, protein acts as a potent binder, so increased content of protein resulted in increased cohesiveness of the sesame supplemented products. Similarly, increase in cohesiveness was accredited to starch expansion and gelatinization as well as share of protein rich ingredients (29, 30). Springiness indicates that how well a food product springs back after its first deformation during the first compression (31). Springiness is inversely related to hardness and consequently it decreases due to low moisture and fat content in the product (32).

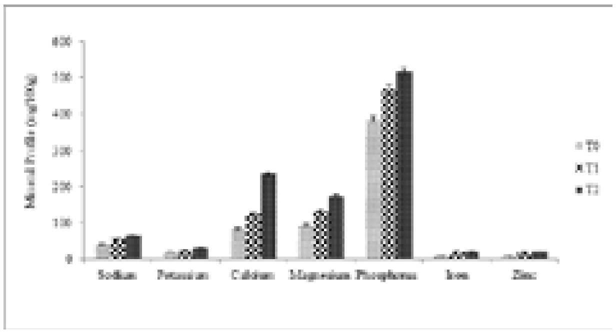

Figure 3. Effect of treatments on the mineral contents (mg/100g) of sesame cake flour supplemented doughnuts

Table 2. Effect of treatments on the textural characteristics of sesame cake flour supplemented doughnuts

Treatments	Hardness	Cohesiveness	Springiness	Chewiness
T_0	42.27±0.81c	0.15±0.21c	0.77±0.41a	0.23±0.18c
T_1	102.69±1.67b	0.22±0.34b	0.74±0.36ab	0.32±0.06b
T_2	113.72±3.64a	0.25±0.42a	0.71±0.26b	0.47±0.02a

Means having same letters in a row are statistically non-significant (P>0.05)
Means ± S.D
T_o = Doughnuts without supplementation act as control
T_1= Doughnuts supplemented with 10% of white sesame flour of TH-6
T_2 = Doughnuts supplemented with 20% of white sesame flour of TH-6

Color Analysis and Calorific Value

The results for color (L*, a*, b*) and calorific values are given in Figure 4. The color of the doughnuts revealed significant decrease in L* values while there was significant increase in a* (redness) and b* (yellowness) values with increased supplementation of sesame cake flour. The color became darker due to more chances of Maillard reaction as a result of more available amino acids and protein for reaction with sugars along with addition of micronutrient premix (33). In a previous study, more reddish color (a* value) of breads fortified with anthocyanin rich black rice was due to pigments and high baking temperatures (34). Similar changes in a* and b* values were reported by researchers due to the Maillard reaction and development of dark color in the product. High sugar contents initiate the Maillard reaction that resulted in brown color of the final product (35).

The results for calorific value of doughnuts indicated gradual increase with the increased supplementation of sesame cake flour. The highest value (394.00±7.12Kcal/100g) was noticed in doughnuts having 20% sesame cake flour. The increase in calorific values might be due to more fat content of these products. Similar findings have been reported in earlier studies in which oilseeds-based gluten free crackers and sesame-based products exhibited calorific values in the range of 320-430Kcal/100g with the increased supplementation of sesame flour (36). In another research, calorific value of sesame flour supplemented breads ranged from 320 to 390Kcal/100g, depending upon the levels of supplementation (37).

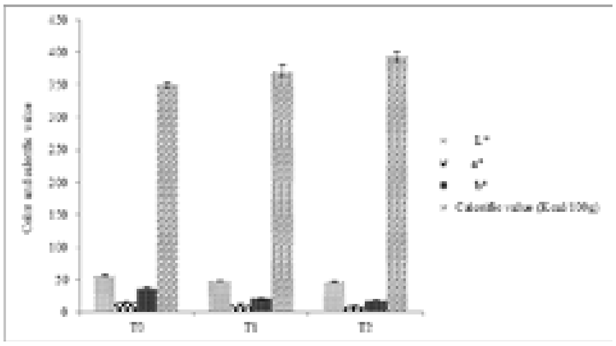

Figure 4. Effect of treatments on the color and calorific value of sesame cake flour supplemented doughnuts

Storage Study

Results for storage study parameters of sesame cake flour supplemented doughnuts are shown in Table 3. Mean values for water activity, peroxide value, thiobarbituric acid number and mold growth of doughnuts revealed significant differences among the treatments during the storage. It was obvious from the results that there was gradual decrease in water activity of doughnuts with increase in the supplementation level of sesame cake flour. Storage interval also has significant effect on the water activity as it steadily increased from 0.597±0.27 to 0.657±0.45 during storage. In a similar study, quality characteristics and shelf studies of deep-fried snack prepared from rice flour and legumes was observed. The results indicated increase in water activity during storage due to variation in humidity and temperature, hygroscopic nature of the raw materials and nature of packaging materials. This may cause negative effect on consumer acceptability and textural attributes of the product (38). In another research, relationship between water activity of crisp bread and its mechanical properties were analyzed which revealed that the water activity of sesame and wheat-based bread increased from 0.55 to 0.72 during storage (39). Food products with low water activity are considered useful especially for school nutrition programs in less developed nations having warm environmental conditions as well as meager infrastructure for the storage of commodities (21).

Peroxide value was decreased from 10.72±0.33 to 4.84±0.60meq/Kg with the increased supplementation of sesame cake flour. It is apparent from the results that doughnuts containing 20% sesame cake flour exhibited minimum peroxide value. There was gradual decrease in peroxide value with the increased supplementation of sesame cake flour. It was due to the presence of bioactive components *i.e.* sesamin, sesamol and sesamolin and phenolics in sesame cake flour. Previously, antioxidant activities of sesame extracts were analyzed by using 2, 2-diphenyl l-1-picrylhydrazyl (DPPH) methods. The white sesame varieties showed highest DPPH (up to 56.37%) as compared to standard commercial antioxidants *i.e.* BHA and TBHQ (40). Storage interval also has pronounced impact on peroxide value of the stored products. In fresh samples, it was 6.73±1.14meq/kg which gradually increased to 7.68±0.98 & 8.99±0.61 meq/Kg during 3 and 7 days storage, respectively. In a previous study, marjoram powder supplemented cakes were prepared and assessed for peroxide value during storage at room temperature. There was decrease in peroxide value of marjoram powder supplemented cakes from 12.47 to 3.40 meq/Kg in comparison with control sample. It was concluded that marjoram powder suppressed the oxidation reactions due to the presence of natural antioxidants (41).

Thiobarbituric acid number (TBA) was decreased with increasing levels of sesame cake flour supplementation. Storage also has significant effect on thiobarbituric acid number of the doughnuts. At the initiation of storage, TBA value was 0.476±0.20 mg/Kg which gradually increased to 0.535±0.28 mg/Kg and 0.571±0.34 mg/Kg on 3rd and 7th day of storage. Thiobarbituric acid number is considered as a standard marker for determining the lipid peroxidation changes during storage. In an earlier study, there was increase in the TBA value (0.270 to 0.517 mg/Kg) of cakes supplemented with marjoram powder during storage. It indicates that the natural antioxidants and some bioactive components incorporated into cakes caused prevention of lipid oxidation during storage (41).

The results of present study indicated that there was a decrease in mold growth in doughnuts with the subsequent increase in supplementation level of sesame cake flour. This was due to low water activity of these treatments which has inhibitory effect on growth of micro-organisms. Storage has significant effect on mold growth in doughnuts. At the start of study, it was (0.258×10^2±0.23 CFU/g) which gradually increased to 0.337×10^2±0.34 CFU/g and 0.503×10^2±0.46 CFU/g at the mid and end of study, respectively. In a similar study, cereals and nuts bars were developed using sesame flour, oat, skim milk powder and almonds. It was observed that mold growth increased (0.30 to 0.66×10^2 CFU/g) during storage intervals (42).

Table 3. Effect of treatments and storage on the stability analysis of sesame cake flour supplemented doughnuts

Treatments	**Storage (days)**			**Means**
	S0	**S3**	**S7**	
Water activity				
T0	0.691±0.37	0.712±0.43	0.720±0.52	0.707±0.38a
T1	0.601±0.26	0.642±0.32	0.671±0.47	0.638±0.22b
T2	0.501±0.13	0.551±0.22	0.582±0.36	0.544±0.16c
Means	0.597±0.27c	0.635±0.32b	0.657±0.45a	
Peroxide value (meq/kg)				
T0	11.70±0.83	10.82±0.71	10.63±0.38	10.72±0.33a
T1	6.39±0.53	7.63±0.89	9.47±0.50	7.83±0.56b
T2	3.09±0.06	4.58±0.65	6.86±0.53	4.84±0.60c
Means	6.73±1.14b	7.68±0.98b	8.99±0.61a	
Thiobarbituric acid number (mg/kg)				
T0	0.661±0.19	0.665±0.27	0.649±0.65	0.658±0.30a
T1	0.446±0.08	0.498±0.19	0.552±0.54	0.499±0.22b
T2	0.322±0.05	0.443±0.09	0.513±0.42	0.426±0.16c

(continued)

Means	0.476±0.20b	0.535±0.28a	0.571±0.34a	
Mold count ($\times 10^2$ CFU/g)				
T0	0.280±0.15	0.460±0.31	0.650±0.55	0.463±0.33a
T1	0.243±0.27	0.260±0.16	0.420±0.39	0.308±0.27b
T2	0.250±0.35	0.290±0.27	0.440±0.24	0.327±0.19c
Means	0.258±0.23c	0.337±0.34b	0.503±0.46a	

Means having same letters in a row or column are statistically non-significant ($P>0.05$)
Means ± S.D

Conclusions

The current exploration indicated that upto 20% addition of sesame cake flour in wheat flour were found to be superior for the preparation of doughnuts with no adverse effect on sensory attributes. Conclusively, the protein enriched doughnuts would provide appreciable quantities of proteins needed by the body to perform its functions. This increase in nutritional attributes of the doughnuts was due to gradual increase in the supplementation level of sesame cake flour in wheat flour along with the addition of micronutrients Hence, potential utilization of sesame cake flour as an imperative tool for supplementation of wheat flour can help to elevate the nutrition level of numerous food products. Moreover, it can also play pivotal role in alleviating the problem of protein energy malnutrition among the masses.

"No potential conflict of interest relevant to this article was reported by the authors"

References

1. WHO. Reducing Risks and Promoting Healthy Life: An overview. World Health Report 2002; Geneva, Switzerland.
2. Black RE, Victora CG, Walker SP, Bhutta ZA, Christian P, de Onis M, Ezzati M, Grantham-McGregoe S, Katz J, Martorell R, Uauy, R. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet 2013; 382: 427451.
3. Shakeel M, Abdullah M, Akhtar MN, Nasir M. Nutritional improvement and value addition of buffalo milk kurut with soya protein isolate. Pak J Zool Suppl 2009; 9: 389395.
4. WHO. Global Prevalence of Vitamin A Deficiency in Populations at Risk 1995–2005. World Health Organization Global Database on VAD. 2009; Geneva, Switzerland.
5. Allen L, de Benoist B, Dary O, Hurrell R. Guidelines on Food Fortification with Micronutrients. World Health Organization (WHO) and Food and Agricultural Organization (FAO), 2006; Geneva, Switzerland.
6. WHO. Iron Deficiency Anemia: Assessment, Prevention and Control: A Guide for Program Managers. 2001; Geneva, Switzerland.
7. Mannar MG, Sankar R. Micronutrient fortification of foods-rationale, application and impact. Indian J Pediatr 2004; 71: 997–1002.
8. Akhtar S, Anjum FM, Anjum MA. Micronutrient fortification of wheat flour: Recent development and strategies. Food Res Int 2011; 44: 652–659.
9. Lynch SR. The impact of iron fortification on nutritional anaemia. Best Pract Res Clin Haematol 2005; 18: 333–346.
10. Radha C, Kumar PR, Prakash, V. Preparation and characterization of a protein hydrolysis from an oilseed flour mixture. Food Chem 2007; 106: 1166–1174.
11. Kanu PJ. Biochemical analysis of black and white sesame seeds from China. Am J Biochem Mol Biol 2011; 1: 145–157.
12. Nzikou JM, Matos L, Bouanga-Kalou G, Ndangui C.B, Pambou-Tobi NPG, Kimbonguila A, Silou T, Linder M, Desobry S. Chemical composition on the seeds and oil of sesame (*Sesamum indicum*L.) grown in Congo-Brazzaville. Adv J Food Sci Technol 2009; 1: 6–11.
13. GOP. Economic Survey 2017-18. Government of Pakistan, Economic Advisor Wing, Finance Division, 2018; Islamabad, Pakistan.
14. Abril AP, Sandez OR, Baranzini ALR, Quintanar RLV, Garcia MGS. Relationships between chemical composition and quality related characteristics in bread making with wheat flour-fine bran blends. J Food Quality 2015; 38: 30–39.
15. Estevez AM, Escobar B, Ugarte V. Use of mesquite cotyledon (*Prosopischilensis*) in the manufacturing of cereal bars. Arch Latin Nutr 2000; 50: 148–151.

16. Oke, EK, Tijani AO, Abiola OT, Adeoye AK, Odumosu, BO. Effects of partial substitution of wheat flour with breadfruit on quality attributes of fried doughnut. J Agric Sci 2018; 13: 72–80.
17. Nsabimana P, Powers JR, Chew B, Mattinson S, Baik BK. Effects of deep-fat frying temperature on antioxidant properties of whole wheat doughnuts. Int J Food Sci Technol 2018; 53: 665–675.
18. AACC. Approved methods of American association of cereal chemists, American Association of cereal chemist, (10th ed.) 2000; Inc St Paul, MN, USA.
19. AOAC. Official methods of analysis. The Association of official analytical Chemists (20th ed.) 2016; Arlington, VA, USA.
20. Mazumder P, Roopa BS, Bhattacharya S. Textural attributes of a model snack food at different moisture contents. J Food Eng 2007; 79: 511–516.
21. Sharif MK, Rizvi SSH, Paraman I. Characterization of supercritical fluid extrusion processed rice soy crisps fortified with micronutrients and soy protein. Food Sci Technol 2014; 56: 414–420.
22. Krishna G, Ranjhan SK. Gross energy value of herbage, feces, urine, milk, meat and silage. In: Laboratory Manual for Nutrition Research. 1981. Vikas Publishing House (Pvt.) Ltd Delhi, India.
23. Kirk, S.R. and R. Sawyer. 1991. Person's Composition Analysis of Food. AWL Harlow, England.
24. Steel RGD, Torrie JH Dickey DA. Principles and Procedures of Statistics: A Biometrical Approach, (3rd ed.) 1997; McGraw Hill Book Co Inc NY, USA.
25. Echendu CA. Nutritional value of processed and raw food thickeners commonly used in Southeastern Nigeria. Afr J Sci 2004; 5: 1107–1121.
26. Mepba HD, Eboh L, Nwaojigwa SU. Chemical composition, functional and baking properties of wheat-plantain composite flours. Afr J Food Agri Nutr Develop 2007; 7: 1–22.
27. Zaib-un-Nisa MS. Thesis. Effect of Flaxseed Supplementation on Chemical Properties of Biscuits, University of Agriculture, Faisalabad, Pakistan. 2004.
28. Altan A, McCarthy KL, Maskan M. Evaluation of snack foods from barley tomato pomace blends by extrusion processing. J Food Engr 2008; 84: 231–242.
29. Ratanatriwong P, Barringer S. Particle size, cohesiveness and charging effects on electrostatic and non-electrostatic powder coating. J Electro 2007; 65: 704–708.
30. Sirrichokworrakit S, Intasen P, Angkawut C. Quality of donuts supplemented with Hom Nin rice flour. Int. J Nutr Food Engr 2016; 10: 1307–6892.
31. Bourne MC. 2002. Food Texture and Viscosity, Academic Press, San Diego, USA.
32. Shih FF, Daigle KW, Clawson EL. Development of low oil uptake donuts. J Food Engr Phy Proper 2001; 66: 141–144.
33. Budryn G, Zyzelewicz D, Nebesny E, Oracz J, Krysiak W. Influence of addition of green tea and green coffee extracts on the properties of fine yeast pastry fried products. J Food Res Int 2013; 50: 149–160.
34. Xiaonan S, Yan Z, Weibiao Z. Bread fortified with anthocyanin-rich extract from black rice as nutraceutical sources and its quality attributes and in-vitro digestibility. J Food Chem 2016; 196: 910–916.
35. Paraman I, Wagner ME Rizvi SSH. Micronutrient and protein fortified whole grain puffed rice made by supercritical fluid extrusion. J Agri Food Chem 2012. 60: 11188–11194.
36. Mohamed E, Souhail B, Olivier R, Christophe B, Hamadi A. Quality characteristics of sesame seeds and by-products. J Food Chem 2007; 103: 641–650.
37. Makinde FM, Akinoso R. Nutrient composition and effect of processing treatments on anti-nutritional factors of Nigerian sesame (*Sesamum indicum* L.) cultivars. Int Food Res J 2013; 20: 2293–2300.
38. Tiwari U, Gunasekaran MA, Jaganmohan R, Alagusundaram K, Tiwari BK. Quality characteristics and shelf studies of deep-fied snack prepared from rice broken and legumes by-product. Food Bioproc Technol 2011; 7: 1172–1178.
39. Jakubczyk E, Marzee A, Lewicki PP. Relationship properties between water activity of crisp bread and its mechanical properties and structure. Pol J Food Nutr Sci. 2008; 58: 45–51.
40. Srinivasan K. Role of spices beyond food flavoring: Nutraceauticals with multiple health effects. Food Rev Int 2005; 21: 167-188.
41. Hafez AA. Physicochemical and sensory properties of cakes supplemented with different concentration of marjoram. Aus J Appl Sci 2012; 6: 463–470.
42. Al-Hooti S, Sidhu JS, Al-Otaibi J, Al-Ameeri H, Qabazard H. Cereal and nuts bars fortified with almonds, sesame seeds, oat flakes and skim milk powder. J Plant Foods Hum Nutr 1997. 51: 125–135.