DOI 10.7251/JEPM181002023B
UDC 664.681:664.64.016.3

Journal of Engineering & Processing Management

ORIGINAL SCIENTIFIC PAPER

Nutritional and sensory quality of buns enriched with soy fiber (Okara)

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Keywords:
fiber enrichment, nutritional composition, digestible protein and starch, bioaccessible iron and calcium, sensory quality

Abstract
Dietary fiber obtained from by-products of food industries acts as a potential functional food ingredient and used in baking, beverages and meat products. Soybean, a rich source of plant protein is a suitable substitute to dairy milk. Processing of soy milk leaves behind large quantities of fiber, which could be incorporated in food formulation as a dietary supplement. With this background high fiber buns were formulated using soy fiber at different levels and analyzed for nutritional quality, physical characteristic and sensory acceptability. Nutritional characteristics of enriched buns were determined using standard methods and results (per 100 g) were: protein, 7.1-7.7 g; fat, 4.8-6.6 g; iron 2.2-3.0 mg and calcium, 74.0-81.0 mg. Phytic acid and tannin were in the range of 19.0-22.8 mg and 47.4-50.1 mg/100g respectively. Bioaccessible Fe ranged from 11.1-23.3 % and Ca from 50.2-95.5 % of total. *In vitro* digestible protein and starch ranged from 46.8-49.5 and 34.9-68.6 % of total respectively. Addition of fiber influenced the color of the buns as measured by Hunter Lab color meter. Incorporation of soy fiber lowered sensory scores of buns. In conclusion, soy fiber buns were nutritionally superior and can fulfill the consumer requirement of health food.

1. INTRODUCTION

Wheat is the most widely produced cereal in the world, most of which is for human consumption; thus, its contribution to energy intake is significant, particularly in America with 77,325 thousand metric tons (TMT) and Middle East, 60,730 TMT (USDA, 2018). The processing of whole-wheat flour is generally concentrated in few large mills. The resulting white flour is largely used for baked foods, pasta, and other products. Naturally, wheat possess several health benefits when consumed as whole wheat flour and products prepared from it. Examination of wheat kernel reveals that nutrients are mainly present in the aleurone layer (or bran) and germ (Heshe et al., 2016), where the former is a rich source of protein (~14%), carbohydrate (~27%), minerals (~5%), and fat (~6%) (Anuwarul et al., 2002). Hence, whole wheat flour consists of bran, germ and endosperm having all the nutrients, while the refined wheat flour obtained after conventional milling retains carbohydrate rich-endosperm layer. The resulting flour is devoid of essential nutrients and phytochemicals like dietary fiber, minerals, and vitamins (such as thiamine, riboflavin, niacin, pyridoxine, vitamin E as well as iron and zinc) which are effective in the prevention of several health conditions such as cardiovascular diseases, obesity, diabetes, constipation, etc (Ragaee et al., 2012). The process of milling wheat to wheat flour is what determines the nutrient profile of the wheat derived products, as most of the vitamins and minerals are concentrated significantly in the outer layers of the wheat grain. In a refined wheat flour with a milling extraction rate of 68%, about 32% of original grain material is removed, while the whole wheat flour retains all the portions of the grain due to 100% milling extraction rate. Hence, converting wheat into highly refined wheat not only excludes considerable amounts of

nutrients, but gives flour with poor nutrient profile in comparison with whole wheat flour (Heshe et al., 2016). According to Kumar et al., (2011), one of the reasons for the rise in the prevalence of the non-communicable disease among population is increased consumption of foods prepared from refined wheat flour.

Food processing industry has been growing rapidly in the recent times due to increasing demand. The solid wastes generated during these operations may be desirable or undesirable and are considered as industrial effluents. The waste generated is particularly rich in fiber and either used for feeding animals or reused in the development of functional foods due to its unique nutritional property (Ammar, 2014). Diets rich in fiber such as cereals, nuts, legumes, fruits and vegetables have a positive effect on health since their consumption has been related to decreased incidences of several diseases (Dhingra and Jood, 2002). Moreover, since consumer awareness and demand for high quality and healthy foods is increasing, introduction of functional foods, that is foods which contain ingredients that provide additional health benefits beyond basic nutritional requirement, is essential (Ndife and Abbo, 2009). Therefore, the trend to produce specialty breads made from whole grains flour and other functional ingredients like fiber from plant, fruit and vegetable origin is known as health bread or functional foods which might have a powerful influence on health and wellbeing (McKee and Latner, 2000; Dewettinck et al., 2008). Pomace from fruit and vegetable or other industry constitutes a major part of waste, however, at present efforts are being made to utilize most of it effectively. In this context, fortification and/or enrichment of conventional products with ingredients generated from industrial waste is a possible method to restore the healthful components lost during processing. Buns are traditional products prepared using refined wheat flour, hence they are low in fiber. Soybean is a nutritious legume grown widely and consumed in different forms. Production of soybean milk and tofu generates huge amounts of solid waste which is high in fiber. The objective of the present study was to use soybean okara (residue left over after removing the liquid portion from soaked and ground soybean) to enrich buns and study the nutritional, sensory and physical quality of prepared products.

2. MATERIALS AND METHODS

2.1. Study design

The study comprised enrichment of bun with soy fiber (okara) at 4, 6, and 8% substitution and analyzing the prepared products for baking quality, nutritional composition, available nutrients (starch, protein, iron and calcium) and sensory quality. Products prepared without soy fiber served as control.

2.2. Materials

Ingredients needed for preparation of buns, namely, refined wheat flour (*Triticum aestivum*), soybean (Glycine max), refined sunflower oil, salt, yeast and calcium propionate, were procured from local market. Soybean was processed to obtain the residue in the laboratory. All analytical experiments were carried out in duplicate/triplicate with analytical grade chemicals and double distilled water. The enzymes used for the study were pepsin (Batch No. 3-0060), pancreatic (Batch N0. 0-0864); bile salt (Batch No: G358107), diastase (Batch No. 0695/195/270511), papain (Batch No. B0112, New 93DP100-74), amyloglucosidase (powder) (A-7255) from Sigma-Aldrich, Germany and glucose oxidase peroxidase kit (Ref: B0112/Lot No: 5354) was procured from Autospan, Span diagnostics Ltd., Gujarat, India. The dialysis tubing was procured from Sigma-Aldrich Co. USA with a molecular mass cut off 8000 Kda.

2.3. Methods

2.3.1. Preparation of Okara

The soy fiber or 'okara' was prepared in the laboratory using soybeans, with initially washing the beans with distilled water followed by soaking it for 8 hours. The soaked beans were blended using a kitchen mixer with enough water for about 3-5 minutes or until it was finely ground to get soy milk. Soymilk was further strained to separate the fibrous mass known as 'okara', which was then dried in the oven at 70°C overnight. The fiber on drying was powdered and used for formulation of products at 4, 6 and 8% substitution of base flour.

2.3.2. Preparation of buns

For the basic product, proportion of ingredients used were the following: refined wheat flour - 73.5 g, sugar 14.7 g, oil - 7.4 g, skimmed milk powder - 1.8 g, salt - 0.9 g, yeast - 1.5 g, and calcium

propionate - 0.2 g. All ingredients were mixed together with water to form a dough, 70 g of dough was shaped into rounded ball, transferred on to the baking tray and kept for proofing for 1 hour at room temperature. Proofed buns were then baked at 200°C for 20 min. After the buns were cooled, they were subjected to the instrumental analysis for bun quality as well as chemical and sensory analysis.

2.3.3. Physical characteristics of buns

The quality of the enriched buns in terms of crumb/crust color was measured using Hunter lab color measuring system, (Color Analyzer, Model Lab scan, XE, Reston, VA, USA). Crumb firmness was measured using texture analyzer, LR-5K (Lloyd Instruments Ltd, Hampshire, UK) with 5 kg load cell as per the standard AACC (2000) method. The force required to compress 25% was recorded by using the following conditions: sample thickness, 25 mm; load cell, 5 kg; plunger diameter, 35 mm and plunger speed 100 mm/min. The values reported are the average of 3 readings. Volume was measured by the procedure described by Cauvain and Young (2006).

2.3.4. Nutritional composition

The nutritional composition of samples was determined according to standard procedures (AOAC, 2005). Moisture content of the sample was determined by repeated hot air oven drying and recording constant weight. The estimation of nitrogen was determined by Kjeldhal method and protein content obtained by multiplying the nitrogen value with 5.70 and total fat by solvent extraction by Soxhlet method (Raghuramulu et al., 2003). Total starch was analyzed by degradation of starch to glucose with amyloglucosidase followed by estimation of glucose (Batey and Ryde, 1982). Total dietary fiber was determined by separation of non-starch polysaccharide by enzymatic and gravimetric method measuring the dietary fiber equivalent to physiologically unavailable fiber (Asp et al., 1983). Total ash was estimated by incineration of the sample in a muffle furnace at 550-600◦C for 5-6 hours after which the mineral solution was used for estimation of iron by colorimetry using α-α-dipyridyl method and calcium as calcium oxalate precipitate and subsequent titration against potassium permanganate (Oser, 1965 and Raghuramulu et al., 2003). Vitamins like thiamine were determined based on the oxidation of thiamine to thiochrome, which fluoresces in UV light and riboflavin was analyzed based on the native fluorescence of riboflavin in neutral pH (Raghuramulu et al., 2003). Antinutrients such as total oxalate were determined by titrimetric method (Baker, 1952), tannin content was measured spectrophotometrically (Ranganna, 2007) and phytic acid was extracted and determined according to supernatant difference method (Thompson and Erdman, 1982).

2.3.5. Digestible/ available nutrients

In vitro digestible protein was estimated according to Akeson and Stahman (1964). A 2.0 g sample was digested with pepsin and pancreatin enzymes to mimic the gastric digestion, insoluble protein was separated using trichloroacetic acid and soluble protein was determined through Kjeldahl method. In vitro digestible starch was determined by modified procedure as follows- sample weighing about 100 mg was digested with α-amylase, pepsin, pancreatin and amyloglucosidase sequentially with appropriate pH adjustment and incubation as required. Finally, glucose was determined in a measured amount of digest and converted to starch by multiplying the value by 0.9 (Holm et al., 1985). In vitro bioaccessible calcium and iron were measured through determining the proportion of mineral diffused through a semi permeable membrane after digesting the samples with pepsin and pancreatin(Luten et al., 1996). The iron and calcium in dialysate were measured following the procedure described under section 2.3.4.

2.3.6. Sensory Evaluation

Buns enriched with soy (okara) fiber were subjected to sensory analysis and evaluated by semi-trained panelist (n=30) with the help of a score card. The products were coded and presented in an order, the control bun was placed first followed by samples with increasing level of enrichment, i.e., 4%, 6% and 8%. Various attributes of buns such as crust characteristics, and cell structure, color, texture and aroma was evaluated using qualitative descriptive analysis with a 15.0 cm scale described by*Cauvain and Young (2006). Water was served in between the samples for better evaluation of products.*

2.4. Statistical Analysis

The data were analyzed statistically to determine mean ± SD for all values; Analysis of variance (ANOVA) and Student 'T' test was used for the compositional analysis and sensory data. Post- test was also carried out to check for any significant differences between the samples.

3. RESULTS AND DISCUSSION

The results of the study are compiled in tables 1-4 and figures 1-2. The crumb color of the buns as measured by Hunter lab color measuring system using L, a, and b values is presented in Table 1. A significant difference was seen in the L* value for control and treated samples. The a* value indicates the intensity of color in the direction of blue to red. Control buns had a* value of 0.30 and a positive change was seen in the treated sample due to addition of okara indicating higher presence of red color at 1.2 with 8% okara addition, the difference being significant. The yellowness of the bun crumb is indicated by b* value, and showed an increase in value as the level of okara increased, and a significant difference between control and 4, 6 and 8% added okara bun was seen. Similarly, color difference as indicated by ΔE also increased with the increase in the level of okara in buns.

Table 1. Measurement of specific volume, texture and color of buns

Buns	Specific volume (g/ml)	Texture	Color			
		Maximum Load (N)	L* Crumb	a* Crumb	b* Crumb	ΔE
Control	2.85 ± 0.0^{a}	30.0 ± 1.35^{a}	80.43 ± 0.01^{a}	0.30 ± 0.02^{c}	18.24 ± 0.28^{b}	20.87 ± 0.28^{c}
4 % SF	2.50 ± 0.1^{b}	30.0 ± 2.20^{a}	75.50 ± 1.00^{b}	0.60 ± 0.10^{bc}	19.20 ± 0.50^{b}	25.30 ± 0.90^{b}
6 % SF	2.00 ± 0.0^{c}	30.3 ± 0.90^{a}	75.50 ± 0.90^{b}	0.80 ± 0.00^{b}	19.30 ± 0.20^{b}	25.30 ± 0.80^{b}
8 % SF	1.32 ± 0.0^{d}	30.3 ± 3.50^{a}	74.50 ± 0.50^{b}	1.20 ± 0.20^{a}	20.60 ± 0.60^{a}	26.60 ± 0.70^{a}

*Values are mean ± standard deviation. values with different superscripts indicate significant differences among samples in the same column according to **T**ukey's test ($p<0.05$).

3.1. Nutritional composition of products

The nutritional composition of the fiber enriched buns is presented in Table 2. Moisture content of buns did not show any significant differences between the control and fiber enriched buns. Total protein content of control bun was significantly higher, that is, 10.4 g when compared to the enriched buns, which ranged from 10.1 to 9.6 g/100g of dry weight (dwb). Total starch content of buns was found to be similar in control and treated samples with no significant difference. However, it was seen that, as the soy fiber content increased, total starch content of buns decreased. Fat content of control sample was high (10.7 g) and lowest was seen in 8% fiber enriched bun (6.5 g/100g dwb). Total dietary fiber fractions such as the insoluble and soluble fiber content of soy fiber enriched buns was significantly higher than control buns (4.7 g and 2.3 g /100g of dwb respectively), ranging from 6.9 - 11.3 g and 2.4 - 2.5 g/100 dwb respectively. A similar study reported on utilization of okara in bread making with 10% substitution showed acceptable sensory properties and higher fat, protein and crude fiber content of 3.10, 9.74 and 0.14% when compared to control white bread with 2.31, 8.37 and 0.10% respectively (Wickramarathna and Arampath, 2003).The ash content of the fiber-enriched bun was higher than the control bun. Enrichment with okara improved the mineral content of buns. Buns with 8% soy fiber exhibited highest total iron and calcium content of 4.1 mg and 109.1 mg/100g when compared to control with 2.70 and 27.5 mg/100g respectively (Table 2). Fermentation of dough with yeast improved the vitamin content; however, no significant difference was seen in the thiamine and riboflavin content of control and enriched buns. This observation agrees with other studies, wherein it was said that the thiamine content of rye bread depends on flour extraction rate. In wheat flour about 5% of thiamine is present in phosphorylated form which is more thermolabile than any other

form (Martinez-Villaluenga et al., 2009). During the dough fermentation thiamine is transformed into thiamine phosphate, which is more unstable during cooking as noted by Batifoulier et al., (2005). Several such research studies on thiamine losses ranging from 5 to 56% in white bread during the baking process have been reported (Martinez-Villaluenga et al., 2009). Phytic acid content of control and enriched buns was found to be low on account of fermentation of the dough which degrades phytic acid. The control sample had 23.3 mg/100g of phytic acid while it ranged from 25.1-30.8 mg/100g dwb in enriched buns. Tannin content of the control bun was significantly low (49.2 mg/100g) and fiber enriched buns showed high tannin content, ranging between 62.64 to 71.6 mg/100g dwb in 6 and 8% okara bun.

Table 2. Nutritional composition of buns (per 100g)

Constituents		Control	4% SF	6% SF	8% SF
Proximate composition					
Moisture (g)		23.3 ±0.3^{d}	24.3 ± 5.0 ^{c}	26.8 ± 0.7 ^{a}	26.0 ± 0.0 ^{b}
Protein (g)		8.0 ± 0.1^{a} (10.4)	7.7 ± 0.1^{b} (10.1)	7.4 ± 0.0^{b} (10.1)	7.1 ± 0.0^{c} (9.6)
Fat (g)		8.2 ± 0.2 ^{a} (10.7)	6.6 ± 0.3^{b} (8.7)	6.5 ± 0.1^{b} (8.8)	4.8 ± 0.0^{c} (6.5)
Total starch (g)		47.7 ± 0.5^{ab} (62.2)	49.9 ± 0.8^{a}(65.9)	45.7 ± 1.1^{ab} (62.5)	43.2 ± 3.1^{b}(58.4)
Dietary fiber (g)	**Insoluble**	3.6 ± 0.0^{d} (4.7)	5.2 ± 0.8^{c} (6.9)	6.4 ± 0.1^{b} (8.7)	8.4 ± 0.2^{a} (11.3)
	Soluble	1.7 ± 0.0^{b} (2.3)	1.8 ± 0.1^{ab} (2.4)	1.7 ± 0.1^{ab} (2.4)	1.9 ± 0.0^{a} (2.5)
Total Ash (g)		0.8 ±0.1^{b} (1.0)	1.3 ± 0.0^{a} (1.7)	1.0 ± 0.2^{ab} (1.4)	1.2 ± 0.1^{a} (1.6)
Minerals & Vitamins					
Iron (mg)		2.0 ± 0.3^{c} (2.7)	2.2 ± 0.2^{c} (3.0)	2.6± 0.6^{b} (3.6)	3.0 ± 0.1^{a} (4.1)
Calcium (mg)		21 ± 0.7^{d} (27.5)	74 ± 0.8^{c} (97.3)	75 ± 0.0^{b}(102.4)	81 ± 1.0^{a} (109.1)
Phosphorous (mg)		93.5 ± 0.5^{a} (122.0)	76.5 ± 0.4^{b} (101.0)	75.1 ± 6.6^{b} (102.7)	64.5 ± 2.0^{c} (87.1)
Thiamine (μg)		22.6 ± 0.0^{a}(29.4)	23.73 ± 1.3^{a} (31.3)	23.9 ± 2.7^{a} (32.7)	25.7 ± 2.6^{a} (34.7)
Riboflavin (μg)		27.8 ± 1.4^{a} (36.3)	29.74 ± 4.7^{a} (39.3)	30.2 ± 3.7^{a} (41.3)	31.0 ± 1.7^{a} (42.0)
Antinutrients					
Phytic acid (mg)		17.9 ± 2.5^{a} (23.3)	19.0 ± 0.1^{a}(25.1)	20.8 ± 1.5^{a} (28.4)	22.8 ± 3.1^{a} (30.8)
Tannin (mg)		37.7 ± 1.0^{b} (49.2)	47.4 ± 4.2^{ab} (62.64)	50.1 ± 2.5^{a} (68.52)	53.0 ± 5.7^{a} (71.6)

*Values are mean ± standard deviation. values with different superscripts indicate significant differences among samples in the same column according to **T**ukey's test ($p<0.05$).

3.2. Digestible and bioaccessible nutrients

In vitro digestible protein and starch and bioaccessible iron and calcium in buns were determined and the results are presented in Table 3 and Figure 1. Digestible protein content of the control bun was 5.1%, and in fiber enriched buns it was reduced from 5.0 to 4.5%. As the addition of soy fiber increased the protein digestibility decreased, though the differences were insignificant between treated and control samples. When considered as percent digestible protein, the values were high in 4 and 6% fiber enriched buns with 49.5% and 48.5% respectively. According to Dhingra and Jood (2002) bread supplemented with 5% soy flour and 5% defatted soy flour exhibited a much higher percent digestible protein values of 70.6 and 72.1%.

Table 3. Selected *in vitro* digestible and bioaccessible nutrients in buns

Products	In vitro digestible fraction (g/100g)		In vitrobioaccessible fraction (mg/100g)	
	Protein	Starch	Iron	Calcium
Control	3.9 ± 0.4 [a] (5.1)	32.8 ± 1.8[a] (42.7)	0.2 ±0.0 [c] (0.3)	10.6 ± 0.9[b] (13.8)
4% SF	3.8 ± 0.0[a] (5.0)	29.1 ± 1.7[a] (38.4)	0.6 ± 0.0[b] (0.7)	70.3 ± 0.9[a] (92.9)
6% SF	3.6 ± 0.1[a] (4.9)	16.0 ± 2.1[b] (21.8)	0.5 ±0.0[b] (0.7)	66.5 ± 0.9[a] (90.0)
8% SF	3.4 ± 0.0[a] (4.5)	16.1 ± 0.9[b] (21.7)	0.6 ± 0.0 [a] (0.8)	69.1 ± 1.3[a] (93.4)

Values are mean ± standard deviation. Figures in parenthesis represent values on a dry weight basis. Values with different superscripts indicate significant differences among samples in the same column according to Tukey's test ($p<0.05$).

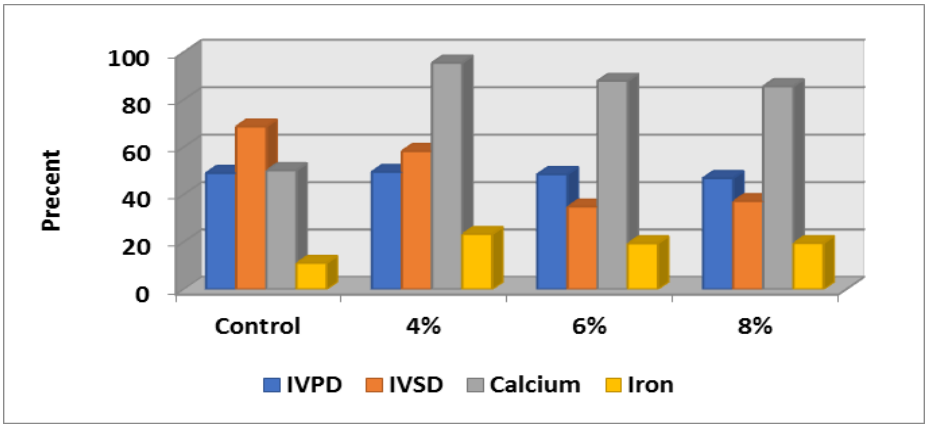

Figure 1. Percent digestible protein (IVPD) and starch (IVSD) and bioaccessible calcium and iron in buns

These results can be explained on the basis of added soybean flour which had high protein content of (38-40%). The buns formulated in the present work used soybean fiber (okara). The protein content of okara is reported to range from 24% - 28.4% depending on the variety of soybean used (Wickramarathna and Arampath, 2003). In another study effect of baking on bread protein efficiency and lysine availability was studied both in vivo (in rats) and in vitro and the results revealed, decreased protein and lysine digestibility due to exposure to high amount of heat (Palamidis and Markakis, 1980). Digestible starch content of buns showed a significant difference between control and treated buns with 6% and 8% SF addition. Digestible starch content of the control bun was high (42.7g) while it was low in 6% and 8% SF enriched buns (21.8 and 21.7 g/100g respectively). Studies have reported that several technological factors affect digestibility of starch such as the type of processing (eg. autoclaving, baking, fermentation, extrusion) and ingredients (eg. the presence and ratio of dietary fiber, sugar, fat and the type of starch). A study on the effect of wheat bran on in vitro starch digestibility of biscuit showed that as the protein and dietary fiber increased, digestible starch content decreased. Biscuit with 5, 15 and 30% coarse bran had protein and dietary fiber content of 7.3, 7.9 and 8.6%; and 6.5, 10.2 and 14.8% respectively; digestible starch content of the product was 44.8, 40.4 and 33.0% with a starch hydrolysis index (HI) of 32, 34 and 37. Similarly values for control biscuits with no added fiber were 6.8, 4.7, 47.5% and 32 respectively. However, addition of fine bran (15%) showed low HI of 29, while the digestible starch was 40.0%, which could be due to bran structure which impacted HI (Sozer et al., 2014). Another reason

for low starch digestibility could be the formation of resistant starch during heat treatment. During baking, swelling and gelatinization of starch granules occur and depending on the temperature and amount of water, an amorphous network is formed which on cooling retrogrades and becomes more crystalline. This reduces starch digestibility, as the starch is unavailable for enzyme digestion. Similarly, another study confirmed a 20% increase in dietary fiber content in white bread due to the formation of resistant starch when compared to other flours. Several factors influence the yield of resistant starch during heat treatment, such as amylose content, temperature, time, water content, and extent of starch gelatinization, pH, amylose/amylopectin ratio, number of heating - cooling cycles, freezing and drying (Calixto and Abia, 1991). Both bioaccessible calcium and iron were seen to increase with the addition of SF. Bioaccessible iron content of control buns was only 0.3 mg whereas, in fiber enriched buns it ranged from 0.7 to 0.8 mg/100g with 4% and 8% fiber addition. Bioaccessible calcium was also high in treated samples when compared to control, which had only 13.8 mg/100g. Bioaccessible calcium showed a significant difference between control and fiber enriched buns, with 8% fiber bun having the highest calcium content of 109.1 mg followed by 102.4 and 97.3 mg/100g dry weight in 6 and 4% buns respectively. Calculated as percent of total, both bioaccessible iron (11.1-23.3%) and calcium (50.2-95.5%) were much higher in enriched buns than control indicating nutritional superiority. Since mineral deficiencies, especially in iron, are prevalent worldwide, and a poor bioavailability of iron is a major causative factor, nutritionists look forward to food products with high total and bioavailable iron.

3.2.1. Sensory analysis of products

The organoleptic quality of buns is presented in Table 4.

Table 4. Mean scores for sensory attributes of buns

Treatments	Control bun	4% SF	6% SF	8% SF
External characteristics				
Uniformity	12.57 ± 2.66^{a}	11.57 ± 2.67^{ab}	10.48 ± 3.41^{ab}	11.14 ± 2.18^{b}
Crust Characteristic	12.82 ± 2.00^{a}	7.60 ± 4.15^{b}	8.81 ± 3.75^{b}	8.12 ± 4.01^{b}
Internal characteristics				
Cell Structure	11.53 ± 3.80^{a}	9.13 ± 3.79^{ab}	8.57 ± 3.43^{b}	7.82 ± 4.06^{b}
Colour	12.94 ± 2.23^{a}	9.75 ± 3.86^{b}	9.39 ± 3.46^{b}	7.55 ± 3.61^{b}
Texture	13.60 ± 0.92^{a}	9.12 ± 3.42^{b}	8.75 ± 3.84^{b}	7.14 ± 3.61^{b}
Flavour & Aroma	12.37 ± 2.87^{a}	8.51 ± 3.95^{b}	9.03 ± 3.34^{b}	7.23 ± 3.42^{b}

Values are mean ± standard deviation. Values with different superscripts indicate significant differences among samples in the same row according to Tukey's test ($p<0.05$).

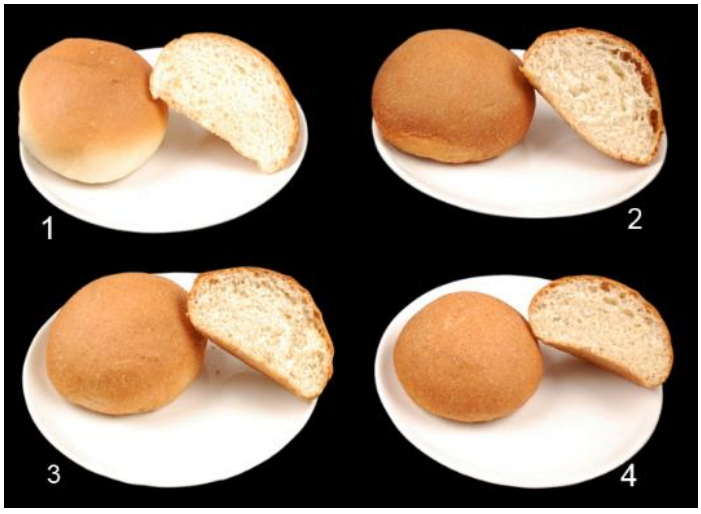

Figure 2. Photo showing control bun and buns enriched with Soy fiber (okara)
1: Control; 2: 4% Soy fiber bun; 3: 6% Soy fiber bun and 4: 8% Soy fiber buns

The scores for external characteristics (uniformity and crust characteristic) were 12.57 and 12.82 respectively and decreased significantly for enriched buns due to addition of soy fiber. The mean score for SF enriched bun decreased as the SF level increased. The scores for internal characteristics like crumb- cell structure, color, texture and aroma of the product were also found to be lower in enriched buns than in the control bun. Low mean score for enriched buns with respect to taste, flavor and aroma, may be probably due to the beany flavor of okara and the color change due to the creamish-yellow colour of okara as shown in Figure 2. Addition of extra fiber also influences the texture of the product, making it firm, hence causing low scores. However, since the consumer would prefer it as a fiber rich healthy product, an altered taste may still be acceptable.

4. CONCLUSION

The overall observation indicates that addition of soy fiber (okara) enhanced the level of dietary fiber, iron, calcium, thiamine and riboflavin in buns. There was also an increase in bioaccessible iron and calcium indicating that soy fiber incorporated buns are nutritionally superior. Consumption of two buns (of approximately 57-58g per bun) containing 6 or 8% soy fiber (okara) provides minimum of 9 to 12g of dietary fiber, which amounts to half of the recommended daily intake of fiber which can be obtained from fruits and vegetables and whole-grain foods (Nishida et al, 2004). If percent daily value (% DV) per 100g of dietary fiber in bun enriched with okara (6 and 8%) is calculated, it provides 36 or 49 % DV which is considered as a 'high' intake (FDA, 1995). Therefore, based on these findings, enrichment of bakery product like bun with soy fiber (okara) has good potential for both consumer appeal and imparting health benefits.

Acknowledgment

This research was supported by University Grant Commission, New Delhi, India.

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