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APPLICATION AND EFFECT OF ADDITION OF POPPED MAKHANA FLOUR ON THE PROPERTIES AND QUALITIES OF BUN

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ABSTRACT

Popped makhana (*Euryale ferox*) flour due to their increased water absorption capacity and changes in the starch structure, represent an opportunity to increase bun quality and yield in bakery production. Moreover, popping may modify the bun characteristics. The aim of this study was to investigate the application and effect of the substitution from 5% to 25% of the popped makhana flour into wheat flour on proximate, physical, textural and sensory properties of bun. The proximate composition of the bun prepared was almost same as control for all the treatments. Substitution of makhana flour increases the volume and specific volume upto 10:90 (makhana:wheat) ratio, however further substitution significantly reduces the bake loss and increases the baking yield. L* value of crust and crumb were reduced when the makhana flour increases in the bun while and hardness was found to be low in crumb. The other textural properties were also changes significantly. These results indicate that a high quality bun produced with using 15% popped makhana flour in dough and the bun upto 20:80 (makhana:wheat) ratio was acceptable by the sensory panelist.

Keywords: Bun, Bread, Makhana, Popped Makhana flour.

INTRODUCTION

Quality is one of the most important parameter for the bun or bread products and to obtain a higher quality of bun and bread from composite flour is gaining popularity now a days. The addition of popped or extruded flour may be used to enhance the water absorption properties of the dough of bun or bread. The buns is popular yeast leavened bakery product like bread and the raw materials and procedure is similar to bread except buns are rounded and moulded with bun moulders. The manufacture of buns requires flours having good viscoelastic characteristics, gas retention to obtain good dough with a good volume and a uniform crumb (Esteller *et al.,* 2005).

Euryale ferox is known as makhana in India and is an important aquatic crop (Jha, 1968; Jha *et al.,* 1991). In India it is mainly cultivated in the states of Bihar and some parts of eastern India (Mishra *et al.,* 2003). Makhana is stored in two forms i.e, seeds and poped makhana. Despite its nutritional and health importance, makhana has not gained much research attention due to less awareness among the researchers (Zhang, 2010; Zhang *et al.,* 2011 and Jha *et al.,* 1991). The nutritional values of popped makhana were also reported by several researchers (Boyd, 1968; Jha, 1968; Jha and Prasad, 1996; and Jha *et al.,* 1991) but different properties of makhana flour were not reported till date. Makhana is graded into 4 to 5 grades based on size and light weight. Lower grade like murra and thurri are being sold at very low prices. It constitute about 15-20% of the total popped makhana production. Lower grades of makhana can be converted into powder or flour form and sold for preparation of bakery or other products. In addition of this, only a few studies have reported the puffing or popped flour blended with other grains flour for the preparation of bakery products. The changes occur by popping on starch structure and physical properties modify the water holding capacity of product. Popped makhana flour may possibly serve as a useful alternative in nutritious food products and could improve the physicochemical, functional and sensory characteristics of products.

Therefore, the aim of this work was to examine the proximate, physical, colour, textural and sensory properties of bun prepared from makhana flour (5-25%).

MATERIALS AND METHODS

MATERIALS

Wheat flour was purchased from local market in Sangrur, Punjab (India). Popped makhana were purchased from Darbhanga, Bihar. The popped makhana was grounded into fine powder, and then mixed with wheat flour at different proportion (100:0 , 95:05 (C_1), 90:10 (C_2), 85:15 (C_3), 80:20 (C_4) and 75:25 (C_5)) of wheat flour and popped makhana flour respectively.

METHODS

FORMULATION OF BUN

Buns were prepared using sponge and dough method from wheat and makhana composite flour at different proportions as per AACC (2000) method no. 10-13A. Wheat bun without makhana flour was termed as control. The ingredients used were taken in grams per 100 g flour basis like; for sponge, ingredients per 70 g flour were 3 g yeast, 0.3 g yeast food and 46 g water respectively. These ingredients were mixed in howart mixer (Sujata, India) for (1 minute at speed 1 and 1 min at speed 2). Sponge was fermented for 3-4 hours at 29^0C. For dough ingredients are 30 g flour, 18 g HFCS (High Fructose Corn Syrup), 6 g shortening, 2 g salt, 100-200 ppm ascorbic acid, 0.12 g calcium propionate and appropriate amount of water. Dough ingredients were mixed for 30 s at speed 1. Sponge was then added and mixed for 30 sec at speed 1. Dough was mixed at speed 2 for optimum gluten development. Fully mixed dough was allowed to unhandle for 10 min at 29^0 C. Dough was divided into 56 g pieces and rounded. Dough pieces were flattened using the head rolls of the molder. Molded dough were placed into bun pans and placed in proofing cabinet (Indulge, India) at 43^0 C and 90% RH. Bun dough was baked at 224^0 C for 11 min. After cooling for 30 min, buns were weighed and double bagged in LDEP (Low density poly ethylene) packets and held for room temperature until further analysis.

PROXIMATE COMPOSITION

Moisture, protein, ash, fat and crude fiber of bun prepared with different proportion of makhana and wheat flour were quantified according to AOAC (2000). Carbohydrates were determined by difference method.

PHYSICAL PROPERTIES OF BUN

BUN VOLUME

Bun volume was measured by a standard rapeseed displacement method as prescribed by Sahin and Sumnu (2006).

SPECIFIC VOLUME

It was measured by AACC (2000) method no.10-05 after 30 min of baking for each sample.

$$Specific\ volume\ \left(cm^3/g\right) = \frac{Loaf\ volume\ of\ bun}{Weight\ of\ bun}$$

DENSITY

Bun density was calculated as the ratio of the loaf mass to the loaf volume (Shogren *et al.*, 2003) and expressed in g/cm^3.

BAKING LOSS

Bake loss is defined as the amount of water and organic material (sugars fermented and released as CO_2) lost during baking. This loss was calculated as per Laura *et al.*, (2010).

$$Bake\ loss\ (\%) = \frac{Weight\ of\ loaf\ before\ baking - Weight\ of\ loaf\ after\ baking\ and\ cooling}{Weight\ of\ loaf\ before\ baking} \times 100$$

YIELD

Bun yield was calculated as follows (Puhr *et al.*, 1992).

$$Yield\ (\%) = \frac{Weight\ of\ baked\ bun}{Weight\ of\ loaf\ before\ baking} \times 100$$

COLOR MEASURMENT

The crust and crumb color were determined by a Hunter lab Color Spectrophotometer (Gretag Macthbeth, I-5, USA). The colour parameters L* (Lightness), a* (redness) and b* (yellowness) were separately recorded. The total color difference (ΔE) was calculated by $\Delta E = [(L_5 - L^*)^2 + (a_5 - L^*)^2 + (b_5 - L^*)^2]^{\frac{1}{2}}$ using white tile color as the reference.

TEXTURAL PROPERTIES

TPA was performed one day after baking with a Texture Analyzer (TA-XT 2I, Stable Microsystems, Surrey, UK), equipped with a 25 kg load cell and a 35 mm aluminum cylindrical probe. Immediately before instrumental testing, buns were sliced (25 mm thick slices) with a bread cutting knife. From each bun replicate, the end slices were discarded in order to avoid crust influence and the two middle slices were selected. Disks of crumb (3 cm diameter) were cut and analyzed under the following conditions Pre-test speed, test speed and post-test speed were 2 mm/s, trigger force was 20 g, distance was 10 mm (40% compression) and wait time between first and second compression cycle was 5 sec (Huttner *et al.*, 2010). Hardness (g), springiness, cohesiveness, gumminess (g), chewiness (g) and resilience were calculated.

SENOSRY ANALYSIS

Sensory analysis was conducted by semi trained panel of 10 members from Department of Food Engineering and Technology, Sant Longowal Institute of Engineering and Technology, Longowal (Punjab). Buns were evaluated on the basis of acceptability of their crust, shape, internal texture, flavour, appearance, and overall acceptability by a 9 point Hedonic scale.

STASTICAL ANALYSIS

All the experiments were carried out in triplicate and results were represented as mean±SD. The significance of differences among the values was determined using one way analysis of variance (ANOVA) followed by Duncan's multiple-range test (Duncan, 1955). STATISTICA 7 (Stat Soft, Tusla, USA) statistical software packages ($p<0.05$) was used to determine which means are significantly different.

RESULTS AND DISCUSSION

PROXIMATE ANALYSIS OF FORMULATED BUN

The proximate composition of the prepared buns along with control bun were determined and presented in

Table 3.1. The data thus obtained was statistically analyzed. It was found that the moisture content of the control sample was 30.66% while the moisture content in prepared but with different levels i.e. 5% to 25% of makhana flour was found to be in the range of 32% to 34.20% respectively. This may be due to the higher water absorption capacity of makhana flour. Similar results were reported by Ozola *et al.*, (2012) when the extruded maize flour was added to produce the gluten free breads. It was found that the protein content of the prepared bun increase slightly with the increase in the proportion of makhana flour because of its higher protein (12.37%) as compare to wheat flour (11.84%). The fat and ash content of the prepared bun decreases slightly with the increase of proportion of makhana flour in the blend. The crude fiber content of bun containing makhana flour was almost same that of control bun. It was found that the carbohydrate content and energy value decreased as the ratio of makhana flour increase from 5% to 25% in the prepared bun. This may be due to the differences in the other proximate composition of different bun samples.

Table 3.1 Proximate analysis of formulated bun

Parameters	Wheat bun	$C_{1\ (95:5)}$	$C_{2\ (90:10)}$	$C_{3\ (85:15)}$	$C_{4\ (80:20)}$	$C_{5\ (75:25)}$
Moisture (%)	30.66^c±0.16	32^b±0.80	31.53^{bc}±0.61	32.40^b±0.52	33.83^a±0.73	34.20^a±0.40
Protein (%)	10.79^{ab}±0.36	10.54^b±0.08	10.79^{ab}±0.10	10.90^a±0.09	11.08^a±0.10	11.14^a±0.20
Fat (%)	4.46^a±0.66	4.17^a±0.32	4.23^a±0.25	3.93^a±0.11	4^a±0.20	3.96^a±0.20
Ash (%)	0.87^a±0.11	0.81^a±.06	0.83^a±0.06	0.80^a±0.06	0.82^a±0.00	0.79^a±0.03
Crude fiber (%)	0.84^a±0.03	0.87^a±0.01	0.83^a±0.03	0.83^a±0.03	0.86^a±0.05	0.86^a±0.05
Carbohydrate[1] (%)	52.36^a±1.00	51.59^a±0.53	51.65^a±0.80	51.26^a±0.21	49.40^b±0.75	49.04^b±0.54
Energy Value[2] (kJ/100 g)	1237.01^a±13.74	1211.52^b±15.58	1221.08^{ab}±2.67	1202.98^b±6.69	1178.36^c±11.17	1176.89^c±5.28

Mean ±S.D. with different superscripts in a row differ significantly ($p<0.05$) (n=3)
[1]Carbohydrate by difference method. [2]Energy value by theoretical method.

PHYSICAL PROPERTIES OF FORMULATED BUN

Physical characteristics of the bun including volume, specific volume, density, weight loss and baking yield are presented in Table 3.2. The volume of the control bun was reported as 206.33 cm^3. Volume of the bun varied from 181.66 cm^3 to 227 cm^3 with the addition of makhana flour in the range of 5% and 10%. It was observed that the volume of bun at 5% and 10% substitution level was found to be higher than that wheat bun. The higher volume of bun may be due to the amount of fermentable sugar consumed by yeast. The lesser volume may be due to lesser dough expansion (due to gas expansion and the final phases of gas production by yeasts during baking). The decrease in loaf volume upon the incorporation of low gluten flour is expected as indicated by previous investigators (Czuchajowska and Paszczynska, 1996). The similar trend of increase in volume of wheat bread was reported when extruded wheat flour was added at 5% of different time temperature combinations (Martinez *et al.*, 2013). Furthermore, the makhana flour increased the bread specific volume upto 10% and after that there was linear decrease in the specific volume of bun. It probably attributed to the fact that the makhana flour substituted dough showed lower elasticity and resistance which make the air easily escaped and then less air pressure to expansion in fermentation and baking process. Similar trend was also reported by Wang *et al.* (2013) when extruded hemp flour was added at different percentage in bread. Bun prepared from 25% substitution reported the maximum density and 5% substitution having the least value. There was increase in density when higher amount of substitution of makhana flour was added in bun. This may be due to the change in mass and volume of different bun sample.

The major loss in bun making process is weight loss of product. There was gradual decrease in the weight loss when the amount of makhana flour increased in the blend. This can be explained by changes in the starch granules during the popping; makhana flour has better water absorption capacity. Similar trend was also obtained by Ozola *et al.* (2012) when extruded maize flour was added at different level to produce the gluten free breads. Yield of product during baking is the ratio of weight of the product to the weight of dough loaf. There was linear increase in the baking yield when the amount of makhana flour increased in the blend. This may be due to higher amount of moisture content of makhana flour substituted bun than the control bun. The same findings were also confirmed by Nazni and Shemi George (2012).

COLOUR CHARACTERISTICS OF FORMULATED BUN

The colour of the bun crust and crumb were measured in the terms of L*, a*, b*, ΔE and whiteness index and presented in the Table 3.3 and 3.4. It was found that there was decrease in the L* and b* in both the cases which may be due to the lower value of makhana flour. The similar trend of decrease in L* of wheat bread crust was reported when extruded wheat flour was added at 5% level at different time temperature combinations (Martinez *et al.*, 2013). It was also found that there was decrease in a* of crust may be due to the lower value of makhana flour but in the case of crumb there was linear increase in the value. The ΔE and whiteness index of all the bun samples shows the differences may be due to the differences in the basic colour parameters for both crust and crumb.

Table 3.2 Physical properties of formulated bun

Parameters	Wheat bun	$C_{1\ (95:5)}$	$C_{2\ (90:10)}$	$C_{3\ (85:15)}$	$C_{4\ (80:20)}$	$C_{5\ (75:25)}$
Volume (cm^3)	206.33^{c}± 3.21	227^{a}± 3.60	214.33^{b}± 4.04	200.33^{c}± 5.03	185^{d} ±3.00	181.66^{d}± 3.51
Specific volume (cm^3/g)	3.65^{bc}± 0.05	3.84^{a}± 0.02	3.73^{ab}± 0.11	3.53^{c}± 0.12	3.26^{d}± 0.07	3.23^{d}± 0.06
Density (g/cm^3)	0.27^{cd}± 0.004	0.24^{e}± 0.003	0.26^{d}± 0.006	0.28^{c}± 0.01	0.31^{b}±0.007	0.32^{a}± 0.01
Bake loss (%)	14.71^{a}± 0.33	12.79^{b}± 0.11	11.98^{bc}± 0.44	11.25^{cd}± 0.91	10.66^{d}± 0.22	8.98^{e}± 0.94
Baking yield (%)	85.28^{e}± 0.33	87.20^{d}± 0.11	88.01^{cd}± 0.44	88.74^{bc}± 0.91	89.33^{b}± 0.22	91.01^{a}± 0.94

Mean ±S.D. with different superscripts in a row differ significantly ($p<0.05$) (n=3)

Table 3.3 Crust color analysis of formulated bun

Parameters	Wheat flour	$C_{1\ (95:5)}$	$C_{2\ (90:10)}$	$C_{3\ (85:15)}$	$C_{4\ (80:20)}$	$C_{5\ (75:25)}$
L*	61.57^{a}±0.71	60.49^{b}±0.19	57.19^{d}±0.08	59.00^{c}±0.76	58.95^{c}±0.09	56.93^{d}±0.56
a*	17.25^{a}±0.61	13.62^{2}±0.08	14.47^{b}±0.14	13.74^{c}±0.33	11.69^{d}±0.57	10.47^{e}±0.11
b*	29.13^{a}±0.19	24.69^{b}±0.10	22.80^{c}±0.02	24.22^{b}±0.03	22.15^{c}±0.97	19.13^{d}±0.08
ΔE		46.77^{c}±0.07	48.76^{a}±0.09	47.74^{b}±0.65	46.17^{c}±0.54	46.21^{c}±0.48
Whiteness index	48.78^{c}±0.85	51.46^{a}±0.08	49.38^{c}±0.09	50.43^{b}±0.66	51.90^{a}±0.50	51.72^{a}±0.49

Mean ±S.D. with different superscripts in a row differ significantly ($p<0.05$) (n=3)

Table 3.4 Crumb color analysis of formulated bun

Parameters	Wheat bun	$C_{1\ (95:5)}$	$C_{2\ (90:10)}$	$C_{3\ (85:15)}$	$C_{4\ (80:20)}$	$C_{5\ (75:25)}$
L*	76.85^{a}±0.14	72.38^{b}±0.31	68.79^{c}±0.66	67.24^{d}±0.73	62.66^{e}±0.23	60.20^{f}±0.98
a*	4.38^{c}±0.21	5.54^{b}±0.19	5.52^{b}±0.07	5.61^{b}±0.29	6.80^{a}±0.01	7.02^{a}±0.06
b*	17.11^{a}±0.19	12.72^{bc}±0.13	12.42^{c}±0.08	12.61^{bc}±0.62	13.10^{b}±0.12	12.95^{bc}±0.09
ΔE		28.85^{e}±0.37	31.86^{d}±0.60	33.35^{c}±0.78	37.93^{b}±0.26	40.18^{a}±0.89
Whiteness index	70.88^{a}±0.02	69.07^{b}±0.35	65.96^{c}±0.61	64.45^{d}±0.78	59.85^{e}±0.26	57.56^{f}±0.90

Mean ±S.D. with different superscripts in a row differ significantly ($p<0.05$) (n=3)

TEXTURAL ANALYSIS OF FORMULATED BUN

The textural properties of formulated bun are presented in the Table 3.5. It was concluded that the hardness of composite flour bun was lesser than the wheat bun. Composite flour bun was having lower gumminess and chewiness than the control bun and lowest value observed with 25% makhana flour addition. The highest cohesiveness and resilience values were observed in bun with 15% makhana flour addition, indicating the best resistance to deformation and instantaneous elasticity. Higher springiness values were observed in bun made with 15% makhana flour addition compared to control bun. The texture of the popped makhana flour formulated bun exhibit better properties than the control sample.

Table 3.5 Texture analysis of formulated bun

Parameters	Wheat bun	$C_{1\ (95:5)}$	$C_{2\ (90:10)}$	$C_{3\ (85:15)}$	$C_{4\ (80:20)}$	$C_{5\ (75:25)}$
Hardness (g)	2414.78^{a}±9.20	2189.82^{b}±4.31	1317.64^{e}±13.11	1682.21^{c}±6.93	1553.13^{d}±6.14	1105.16^{f}±6.81
Springiness	0.87^{d}±0.008	0.96^{b}±0.005	0.98^{a}±0.007	0.99^{a}±0.004	0.94^{c}±0.004	0.86^{d}±0.01
Cohesiveness	0.66^{c}±0.005	0.77^{b}±0.02	0.86^{a}±0.01	0.87^{a}±0.005	0.80^{b}±0.01	0.56^{d}±0.03
Gumminess (g)	1395.67^{a}±35.49	1117.81^{b}±27.44	863.73^{d}±40.38	929.26^{c}±32.06	873.56^{d}±12.32	602.27^{e}±4.48
Chewiness (g)	1226^{a}±24.09	1077.25^{b}±29.92	853.49^{d}±34.89	922.12^{c}±31.29	824.97^{d}±15.57	520.32^{e}±5.26
Resilience	0.35^{d}±0.02	0.49^{ab}±0.007	0.49^{ac}±0.004	0.51^{a}±0.002	0.48^{bc}±0.004	0.36^{d}±0.001

Mean ±S.D. with different superscripts in a row differ significantly ($p<0.05$) (n=3)

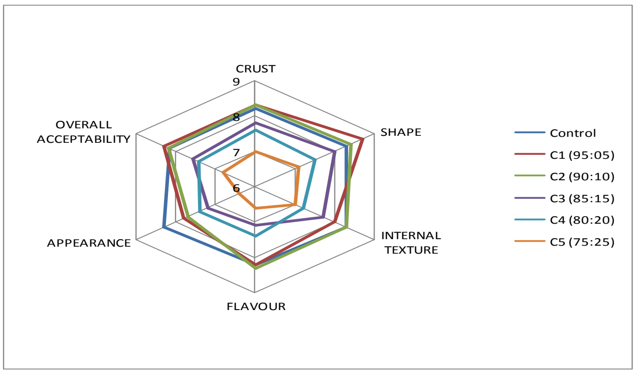

Figure 3.1 Sensory evaluation of formulated bun

Figure 3.2 Digital image of formulated bun

SENSORY EVALUATION OF FORMULATED BUN

Results of the sensory evaluation are depicted in Figure 3.1. The crust score of the wheat bun (control sample) was reported as 8.2 with respect to 9. The popped gorgon nut substituted bun at 5% and 10% got highest scores which were even higher than wheat bun. The 25% was got lowest score but was still acceptable. This may be due to the darkening of the crust and slightly change of the crust surface. The change in crust color may be attributed to maillard reaction between reducing sugars and proteins (Raidi and Klein, 1983). Regarding the shape, internal texture and flavor composite flour bun at 5% to 15% got slightly lower score than wheat bun but was acceptable. The 20% and 25% substituted buns got lowest score but were liked by the panelists. In the overall acceptability, the bun which was made by 10% substitution of wheat flour with gorgon nut flour got the highest score as compared to other samples.

CONCLUSION

Application of popped makhana in the bakery product has been identified and used. The popped and puffed makhana can be used to develop gluten free bun or bread with improved texture and quality. From this study it was concluded that popped makhana flour up to 15% were acceptable with wheat flour for better quality of bakery products however for the non-gluten bakery product proportion may be increased. It is advisable in the future to use other popped flour and established the limits of bun output with the increasing quantities of popped flour and to determine quality in other kinds of bakery products.

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