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Sensorial and Functional Properties of Nutri-Cereal Bran Enriched Muffins and Buns

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Authors' contributions

This work was carried out in collaboration among all authors. Author DBM wrote first draft of manuscript, planned, conducted all protocols during study and performed statistical analysis. Author TVH helped in designing the study, guided throughout and corrected the paper critically. Authors AK, MS and VSR were the committee members who helped in planning the study. All authors read and approved the final manuscript.

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ABSTRACT

Bran is waste generated during primary processing of cereal grains. These brans are rich source of dietary fiber, nutrients, phytonutrients especially phenols and flavonoids contributing to their antioxidant properties. Thus, bran is gaining lot of attention as functional ingredient in bakery industry due to their nutritional properties. Millets are tiny grains that are highly nutritious hence termed as nutri-cereals but their primary processing is tedious given its small size. This leads to loss of major portion of grain generating huge amount of bran and bran-rich fractions that are usually discarded or used as animal feed. Utilization of millet brans in value addition of bakery products still remains understudied. Thus, present study was designed to evaluate functional

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properties of minor millet bran (proso and barnyard) enriched flour (0 – 30%) and formulate bakery products viz. buns and muffins. It was evident from results that water absorption capacity of flour increased with addition of bran but water solubility index, oil absorption and foaming capacity decreased. The sensory scores of muffins and buns reduced with increased bran incorporation and control scored highest. Study concluded that muffins with 30% and buns with 20% proso and barnyard bran showed better acceptability.

Keywords: Proso bran; barnyard bran; bakery products; dehulling; fiber; sensory evaluation.

1. INTRODUCTION

Dietary fiber is defined by American Association of Cereal Chemist as “the edible parts of plants or analogues carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine” [1]. Thus, are associated with numerous health benefits like hypoglycemic, hypocholesterolemic, laxative effects and delay in gastric emptying [2]. Several studies associate consumption of whole grains in reducing the risk of many non-communicable diseases due to presence of fiber, thus reinstating the beneficial role of fiber in diet [3,4,5].

Despite this, fiber consumption had decreased since past few decades coupled with increased consumption of empty calorie, fast foods, processed foods especially bakery products like breads and muffins. These bakery products are mainly combination of refined flours, sugars and fats thus are only calorie dense and lack fiber. The liking of bakery products by all age groups and its increased consumption [6] along with other empty calorie fast foods have attracted many noncommunicable diseases like obesity, diabetes, hypercholesterolemia and also cancers [7,8]. Increase in incidences of these lifestyle disorders consumers are becoming concerned and turning towards healthy life style and opting nutrient rich foods substitutes [6,9]. A study also remarked that consumers are becoming aware about the benefits of fiber and thus seeking fiber rich products as healthy substitutes [10]. Considering this a challenge is presented in front of researchers and food industries to develop fiber rich bakery products.

Fiber is obtained from many sources like cereal grains, plants extracts, vegetables, fruits, legumes and also their processing byproducts [2]. Current researches communicate that cereal fiber especially bran is drawing abundant interests given its health benefit after consuming whole grains and antioxidant associated dietary fiber compounds [3,11]. Cereal brans are hard outer layers discarded as by-products during primary processing but are rich source of dietary fiber, minerals, vitamins, phytonutrients and antioxidants [11]. Rice, wheat, oat and barley bran are abundantly available. Thus, plenty of studies have been conducted on utilising rice, wheat, oat and barley bran in value addition of bakery products [12,13].

Millets are also gaining importance these days given their health benefits due to presence of plentiful antioxidants, dietary fiber, resistant starch, minerals and protein and thus are termed as nutri-cereals. Primary processing of millets like dehulling, decortication, dehusking etc. are necessary to improve its cooking quality and edibility [14] but the processing of these millets is difficult due to their tiny size, nutrient portions are lost during processing in the form of bran and bran rich fractions [15]. Despite the benefits associated with the millet bran it remains understudied, underutilized and limited work is conducted on its use for value addition of bakery products. Thus, the present work aimed at investigating the functional properties of proso and barnyard bran enriched flour and subsequent utilization of the same in the development and evaluation of buns and muffins.

2. MATERIALS AND METHODS

2.1 Preparation of Bran Samples

Proso millet, barnyard millet and all other material necessary to develop buns and muffins were purchased from a local vendor at Hyderabad. For collecting bran both the minor millets were cleaned to remove stones or any foreign materials and dehulled for 30 minutes in a mini dehuller. After dehulling the dehulled grains were separated from bran, and the collected bran included some part of husk, true bran and ground broken grain. The obtained bran was ground and mixed homogeneously followed by immediate stabilization at 900W for 2.5 minutes using a microwave oven [16]. Stabilized bran was stored in an airtight container at – 20°C until further use.

2.2 Preparation of Bran Enriched Flour and Assessing Its Physicochemical and Functional Properties

Refined wheat flour was replaced with each proso and barnyard bran at 10, 15, 20, 25 and 30%. Refined wheat flour without bran addition served as control. The enriched flour was assessed for its physicochemical and functional properties viz. water absorption, water solubility, oil absorption and foaming capacity.

2.3 Water Absorption Capacity (WAC) and Water Solubility Index (WSI)

For water absorption and solubility standard protocol was followed [17]. Accurately weighed (1g) flour mix was added to distilled water (30 ml) and mixed thoroughly. Further, the mixture was kept still in room temperature (30°C) and then centrifuged (3000 rpm for 30 minutes). The supernatant was decanted carefully in a previously weighed Petri plate (W1) and sample was weighed to analyzed the absorbed water. Further for water solubility index, the petri plate was dried at 100°C and after drying weight was recorded (W2). Water absorption capacity was expressed as g/100 g and water solubility was calculated and expressed as %.

$$\text{Water absorption capacity (g /100 g)} = \frac{\text{Water absorbed by sample}}{\text{Initial weight of sample}} \times 100$$

$$\text{Water solubility (\%)} = \frac{\text{W2-W1}}{\text{Initial weight of sample}} \times 100$$

2.4 Oil Absorption Capacity (OAC)

A 1 g sample was added to 10 ml refined oil (V1) and this was vortexed properly and then allowed to stand at room temperature for 30 minutes, followed by centrifugation (3000 rpm for 30 minutes), the supernatant was transferred carefully in graduated cylinder and measured (V2). The oil absorption capacity was determined by analyzing difference between initial and final volume [17].

$$\text{Oil absorption capacity (g /100 g)} = \frac{\text{V1-V2}}{\text{Initial weight of sample}} \times 100$$

2.5 Foaming Capacity (FC)

Foaming capacity was determined as per the method described by Chandra et al. [18] with slight modifications. Accurately 1 g of sample was measured and transferred in a graduated cylinder, to which 50 ml distilled water (V1) was added. This mixture was shaken to mix well and then homogenised for 5 minutes to foam. The volume of foam at 30 seconds was noted (V2), and foaming capacity was calculated using the following formula.

$$\text{Foaming capacity (\%)} = \frac{\text{V2-V1}}{\text{V1}} \times 100$$

Where, V1 = volume before whipping, V2 is volume after whipping.

2.6 Development of Buns and Muffins

Both proso and barnyard bran enriched flour at various incorporation levels were used to formulate buns and muffins. Refined wheat flour buns and muffins served as control.

Muffins were formulated using the procedure described by Heo et al. [6] with slight variation. Baking powder and salt were added to flour, sifted thrice and kept aside. Oil and sugar were creamed in one vessel. Egg was added to the creamed mixture and beaten till it became fluffy. To this sifted flour was added and mixed thoroughly. The prepared batter was poured in muffin tray and baked in the preheated oven at 180°C for 25 min.

Similarly, procedure described by Arora and Saini [19] with slight variation was used to develop buns. Flour was sifted and mixed with salt sugar and fat. In another container, accurately weighed yeast was added to a measured amount of lukewarm water and kept aside for 15 mins. When the yeast water became frothy, it was used to prepare the dough. This dough was kneaded for 10-15 mins and allowed to proof for 1 hour till the volume doubled. Once the proofing was done, equal round portion were made, placed on a greased tray, with bun rings around it and again proofed for 15 minutes. Followed by this they were baked for 25 min in the preheated oven at 180°C

2.7 Physical Characteristics of Buns and Muffins

Height was measured using calipers and weight was recorded on weighing scale for both buns and muffins before and after baking. Baking loss rate was calculated as protocol described by Heo et al. [6]. Average of 5 replications were considered.

2.8 Sensory Evaluation

Samples were coded randomly and placed inside the booth of sensory laboratory with glass of water. The semi-trained panelists were asked to rinse mouth and drink water in between sample testing. Using 9-point hedonic scale score card 21 semi-trained panel members were asked to evaluate buns and muffins to select the best accepted products among the different incorporation levels [20]. The score card had scores ranging from 1 (Dislike extremely) to 9 (Like extremely).

2.9 Statistical Analysis

The experiments were conducted in triplicates if otherwise stated and subjected to analysis of variance (ANOVA). The means were compared using Fisher's least significant difference (LSD) procedure and CD (critical difference) value. Statistical analysis was conducted using INDOSTAT software for windows.

3. RESULTS AND DISCUSSION

3.1 Physicochemical and Functional Properties of Bran Enriched Flour

Physicochemical and functional properties like water and oil absorption and foaming capacity have vital role in the food processing industry especially in formulating bakery products [21,22]. These properties affect the texture, mouth feel, flavor and appearance of developed products making it essential to understand the effect of bran upon addition in refined flour before product development.

3.2 Water Absorption Capacity (WAC) and Water Solubility Index (WSI)

WAC of proso millet bran enriched flour is presented in Table 1. It was observed that the water absorption capacity significantly increased ($p<0.05$) with addition of bran as compared to refined wheat flour used as control (RWF). The highest WAC was in P30 (248.42 g/100 g) and lowest was in control (209.20 g/100 g). No significant difference was observed in P10 (228.76 g/100 g), P15 (231.13 g/100 g) and P20 (240.52 g/100 g). Also, there was no significant difference between P25 and P30. In barnyard bran enriched flour significant increase in WAC compared to control (RWF) where B30 had highest WAC followed by B25, B20, B15 and B10 (Table 2). In both the brans enriched flours, water solubility decreased as compared to control. In proso bran enriched flour, significant decrease was observed in WSI as bran proportion increase, but in barnyard bran enriched flour although there was reduction in WSI it was not significant (Tables 1 and 2). The increased WAC and decreased WSI can be associated to the addition of bran that improved fiber content of flour. Bran being good source of polysaccharides that might result in enhanced water absorption ability [22]. These results are similar to study, where WAC increased with increased addition of cereal bran in flour [23,24]. Similarly decrease in WSI was also recorded by Pauline et al. [24] in composite flour prepared with cereal bran incorporation. The good water absorption capacity of bran enriched flours made it clear that bran enriched flours can be used in product formulations where water retention is desired, viscous products and also in bakery products [22].

3.3 Oil Absorption Capacity (OAC)

In both proso and barnyard bran enriched flours oil absorption capacity decreased compared to refined wheat flour but no significant difference was noted (Tables 1 and 2). In both bran enriched flours OAC decreased form 246.70 g/100 g (RWF) to 220.12 g/100 g (P30) and 233.55 g/100 g (B30). Presence of fat in flour can negatively impact the OAC [17], thus in the present study OAC might have decreased as the bran incorporated was not defatted. Defatted rice bran had slightly higher OAC compared to full fat bran [25].

3.4 Foaming Capacity (FC)

Inverse relation was observed in foaming capacity and addition of bran. Foaming capacity reduced as the bran incorporation bran increased (Tables 1 and 2). Significantly lowest values were observed in P30 (12.80%) and B30 (10.67%) compared to RWF (19.33%). Lower foaming capacity can be due to the low flexibility of proteins and presence of globular protein [26]. Thus, suggesting that bran proteins are less flexible and more globular in nature. The results in present study are in accordance with study conducted by Egbedike et al. [23].

Table 1. Physicochemical and functional properties of flour enriched with proso millet bran

Flour	WAC (g/100 g)	WSI (%)	OAC (g/100 g)	FC (%)
RWF	209.20^{a}	7.41^{c}	246.70^{NS}	19.33^{c}
P10	228.76^{b}	6.64^{bc}	230.39 ^{NS}	16.80^{b}
P15	231.13^{b}	6.39^{ab}	227.64 ^{NS}	14.00^{a}
P20	240.52^{bc}	6.29^{ab}	224.57 ^{NS}	14.80^{ab}
P25	246.51^{c}	5.87^{a}	222.11 ^{NS}	14.33^{ab}
P30	248.42^{c}	5.69^{a}	220.12 ^{NS}	12.80^{a}
SEm ±	4.405	0.250	7.093	0.811
$CD_{0.05}$	13.574	0.770	21.855	2.498

Note: Proso millet bran (P), Refined Wheat Flour (RWF), Water absorption capacity (WAC), Water solubility index (WSI), Oil absorption capacity (OAC), Foaming capacity (FC). Means represented within same column having different alphabet show statistically significant difference at 5 % (p<0.05). NS indicates no significant difference within the treatments (p>0.05)

Table 2. Physicochemical and functional properties of flour enriched with barnyard millet bran

Flour	WAC (g/100 g)	WSI (%)	OAC (g/100 g)	FC (%)
RWF	209.20^{a}	7.41^{NS}	246.70^{NS}	19.33^{d}
B10	219.86^{b}	7.38 ^{NS}	236.18 ^{NS}	18.67^{cd}
B15	226.25^{c}	7.39 ^{NS}	234.42 ^{NS}	16.67^{bc}
B20	231.52^{cd}	7.31 ^{NS}	233.88 ^{NS}	14.67^{b}
B25	235.79^{d}	7.14 ^{NS}	233.50 ^{NS}	12.00^{a}
B30	245.79^{e}	7.11 ^{NS}	233.55 ^{NS}	10.67^{a}
SEm ±	1.820	0.178	5.785	0.770
$CD_{0.05}$	5.607	0.550	17.824	2.372

Note: Barnyard millet bran (B), Refined Wheat Flour (RWF), Water absorption capacity (WAC), Water solubility index (WSI), Oil absorption capacity (OAC), Foaming capacity (FC). Means represented within same column having different alphabet show statistically significant difference at 5 % (p<0.05). NS indicates no significant difference within the treatments (p>0.05)

3.5 Physical Characteristics of Buns and Muffins

Six variations (0, 10, 15, 20, 25 and 30% bran incorporation) of buns and muffins were prepared from each proso and barnyard bran. Physical properties viz. height and weight before and after baking were recorded for both the products (Tables 3 – 6). Except the control, all the proso and barnyard bran enriched muffins and bun variations did not have any significant difference in weight or height measurements both pre and post baking. But when compared before and after baking weight showed reduction after baking and height showed increase. Decreased weight after baking is due to loss of moisture and CO_2 that takes place during baking making the products porous and spongy. The rise in height after baking is also caused due to the release of gas bubbles. While comparing between the variations weight (after baking) was slightly higher (though insignificant) in bran enriched buns and muffins when compared to their respective controls.

Similarly, height (after baking) in both bran enriched buns and muffins enriched decreased slightly when compared to their respective controls. This height difference was not significant in both control and bran enriched muffins (Tables 3 and 4). But amongst buns, significant reduction in height (after baking) was observed as the bran incorporation increased, compared to control buns prepared without adding bran (Tables 5 and 6). This reduction in height and increase in weight after bran addition could be due to the fiber content of bran that holds water during baking and reduces the escaping of gas bubbles. Similar decrease in height and increase in weight was reported for barnyard bran and kimchi fiber enriched muffins [6,27].

Baking rate loss (%) non-significantly decreased as the percent bran incorporation increased for both bran enriched buns and muffins. In proso bran muffins control muffins i.e. PM0 (10.80%) had highest baking loss while PM30 (8.61%) lowest (Table 3). Similarly, even in barnyard bran highest baking loss rate (%) in control muffin

(BM0) was 11.41% that decreased to 9.33% (BM30) in 30% barnyard bran muffin (Table 4). In both buns similar trend was observed, where proso and barnyard bran buns had reduced baking loss and increase bun weight compared to their controls (Tables 5 and 6). Baking rate loss ranged from 8.96% (PB0) – 7.30% (PB30) and 7.70% (BB0) – 6.79 % (BB30) in proso and barnyard bran buns respectively. The decrease in baking rate loss is associated with increased weight of muffins and buns due to increased WAC of the bran. These results imply that bran addition negatively affects gluten networks and reduces extensibility of both buns and muffins thus, slightly reducing their height [28]. Similar reports for reduction in baking rate loss are presented in fiber enriched muffins by Heo et al. [6].

Table 3. Weight and Height of proso bran muffins

Variations	Weight (g)		Height (cm)		Baking loss rate (%)
	Before baking	After baking	Before baking	After baking	
PM0	33.60	30.20	1.68	3.86	10.80
PM10	33.30	30.30	1.62	3.82	9.91
PM15	33.40	30.40	1.64	3.86	9.26
PM20	33.80	30.70	1.68	3.86	8.89
PM25	33.60	30.70	1.66	3.84	8.64
PM30	33.50	30.60	1.68	3.84	8.61
SEm ±	0.236	0.633	0.051	0.084	0.584
$CD_{0.05}$	0.690^{NS}	1.848^{NS}	0.150^{NS}	0.245^{NS}	1.704^{NS}

Note: PM: Proso bran muffin; 0,10,15,20,25,30: percent bran incorporation. Means represented within same column having different alphabet show statistically significant difference at 5 % (p<0.05). NS indicates no significant difference within the treatments (p>0.05)

Table 4. Weight and height of barnyard bran muffins

Variations	Weight (g)		Height (cm)		Baking loss rate (%)
	Before baking	After baking	Before baking	After baking	
BM0	33.30	29.50	1.60	3.32	11.41
BM10	33.40	30.20	1.59	3.28	9.56
BM15	33.40	30.20	1.62	3.28	9.58
BM20	33.12	30.00	1.62	3.28	9.42
BM25	33.10	30.00	1.60	3.26	9.35
BM30	33.20	30.10	1.62	3.24	9.33
SEm ±	0.168	0.229	0.048	0.101	0.822
$CD_{0.05}$	0.490^{NS}	0.669^{NS}	0.140^{NS}	0.294^{NS}	2.400^{NS}

Note: BM: barnyard bran muffin; 0,10,15,20,25,30: percent bran incorporation. Means represented within same column having different alphabet show statistically significant difference at 5 % (p<0.05). NS indicates no significant difference within the treatments (p>0.05)

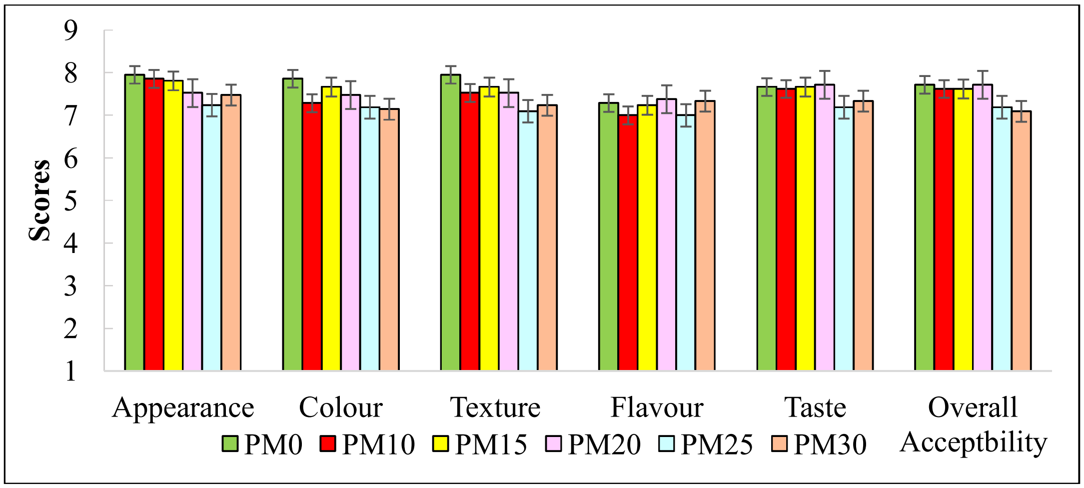
Table 5. Weight and height of proso bran buns

Variations	Weight (g)		Height (cm)		Baking loss rate (%)
	Before baking	After baking	Before baking	After baking	
PB0	87.70	82.50	2.82	4.58^{c}	8.96
PB10	87.90	83.50	2.78	4.42^{b}	8.30
PB15	87.50	83.50	2.74	4.38^{b}	8.10
PB20	87.70	83.50	2.78	4.06^{a}	7.87
PB25	87.50	83.40	2.76	4.02^{a}	7.42
PB30	87.40	83.80	2.78	3.94^{a}	7.30
SEm ±	0.359	0.316	0.059	0.048	0.382
$CD_{0.05}$	1.049^{NS}	0.923^{NS}	0.172^{NS}	0.140	1.115^{NS}

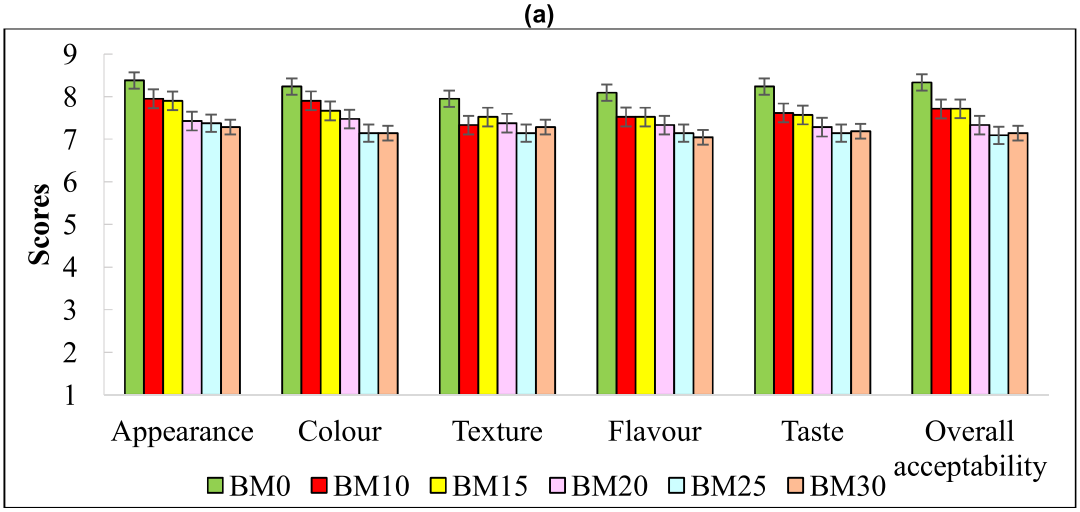
Note: PB: Proso bran bun; 0,10,15,20,25,30: percent bran incorporation. Means represented within same column having different alphabet show statistically significant difference at 5 % (p<0.05). NS indicates no significant difference within the treatments (p>0.05)

3.6 Sensory Evaluation

Results regarding sensory evaluation are depicted in Figs. 1 and 2. The products prepared in this study are presented in Fig 3. Sensory evaluation scores depicted that all proso bran enriched muffins were on par with control and significant difference was observed in the sensory parameters viz. appearance, texture, colour, flavour, taste and overall acceptability. The overall acceptability reduced form 7.71 in control muffin (PM0) to 7.10 in 30% proso bran enriched muffin. Though there was slight decrease in sensory scores all bran enriched muffins scored above 7 indicating that they were acceptable and the panel members liked it moderately (Fig. 1a). Whereas muffins prepared with replacement of barnyard bran resulted in significant decrease ($p<0.05$) for all sensory parameters. BM10 and BM15 showed statistical resemblance with control (BM0) for parameters like appearance, colour and flavour. In terms of texture, flavour and taste there was significant reduction in scores compared to control as bran percent increased with BM30 scoring lowest for all parameters. Although the scores decreased with increased replacement of bran, they were above 7 showing that the muffins formulated with bran were acceptable (Fig. 1b). These results revealed that bran enrichment up to 30% was acceptable in muffins. These levels are higher than that of previous reports where up to 15% barnyard millet bran was acceptable [27].



(a)



(b)

Fig. 1. Mean sensory scores for (a) proso millet bran and (b) barnyard millet bran enriched muffins

Note: PM: Proso bran muffin; BM: barnyard bran muffin; 0,10,15,20,25,30: percent bran incorporation

Considering the evaluation of buns, bran incorporation resulted in significant reduction of sensory scores. Proso bran incorporation demonstrated that only appearance of PB10, PB15 and PB20 were on par with control while, only PB10 showed similarity with control in colour, texture, flavour and taste attributes. It was observed that control bun scored 7.81 for overall acceptability which reduced to 6.71 (PB25) and 6.76 (PB30) in bran enriched buns. No significant decrease was noted in PB20, PB25 and PB30. Buns up to 20% proso bran scored above 7 and had no significant difference in overall acceptability indicating that buns with 20% proso bran were acceptable by the sensory panel. Bran enriched buns with 25% and 30% scored least scores below 6 for all parameters (Fig. 2a). Barnyard bran incorporation also exhibited similar trend where in control scored highest followed by BB10 >BB15 > BB20 > BB25 and BB30. Bran incorporation beyond 25 – 30% the sensory scores dropped below 7 (6.81: BB25 and 6.57: BB30) showing that they were not liked much by the panel. Overall acceptability showed no significant difference between BB0 and BB10. BB15 and BB20 also showed no significant difference in appearance, texture, flavour, taste and overall acceptability with both scoring above 7. Thus, it was noted that BB20 i.e. up to 20% bran incorporation was acceptable (Fig. 2b). Both proso and barnyard bran enriched buns were acceptable up to 20% and these levels are higher than previous studies which indicate cereal bran addition in bread from 10 – 15% was highly acceptable [12,28,29,30].

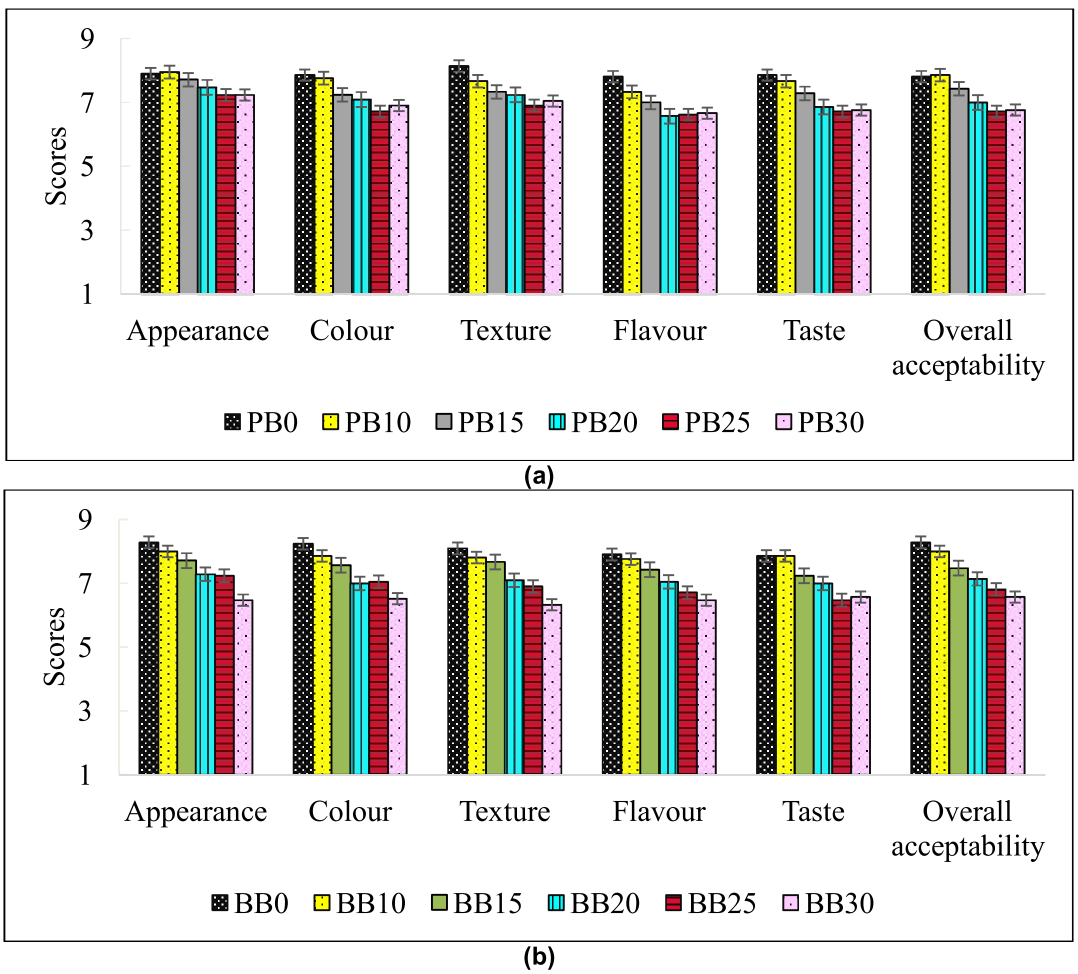


Fig. 2. Mean sensory scores for (a) proso millet bran and (b) barnyard millet bran enriched buns

Note: PB: Proso bran bun; BB: Barnyard bran bun; 0,10,15,20,25,30: percent bran incorporation

Table 6. Weight and Height of barnyard bran buns

Variations	Weight (g)		Height (cm)		Baking loss rate (%)
	Before baking	After baking	Before baking	After baking	
BB0	88.00	82.00	2.94	4.54^{e}	7.70
BB10	88.00	82.10	2.84	4.40^{de}	7.60
BB15	87.70	82.10	2.82	4.36^{cd}	7.52
BB20	87.70	82.20	2.82	4.20^{c}	7.29
BB25	88.20	82.20	2.84	3.86^{b}	6.83
BB30	88.40	82.40	2.84	3.66^{a}	6.79
SEm ±	1.029	0.723	0.070	0.055	0.320
$CD_{0.05}$	3.004^{NS}	2.110^{NS}	0.204^{NS}	0.162	0.935^{NS}

Note: BB: barnyard bran bun; 0,10,15,20,25,30: percent bran incorporation. Means represented within same column having different alphabet show statistically significant difference at5 % (p<0.05). NS indicates no significant difference within the treatments (p>0.05)

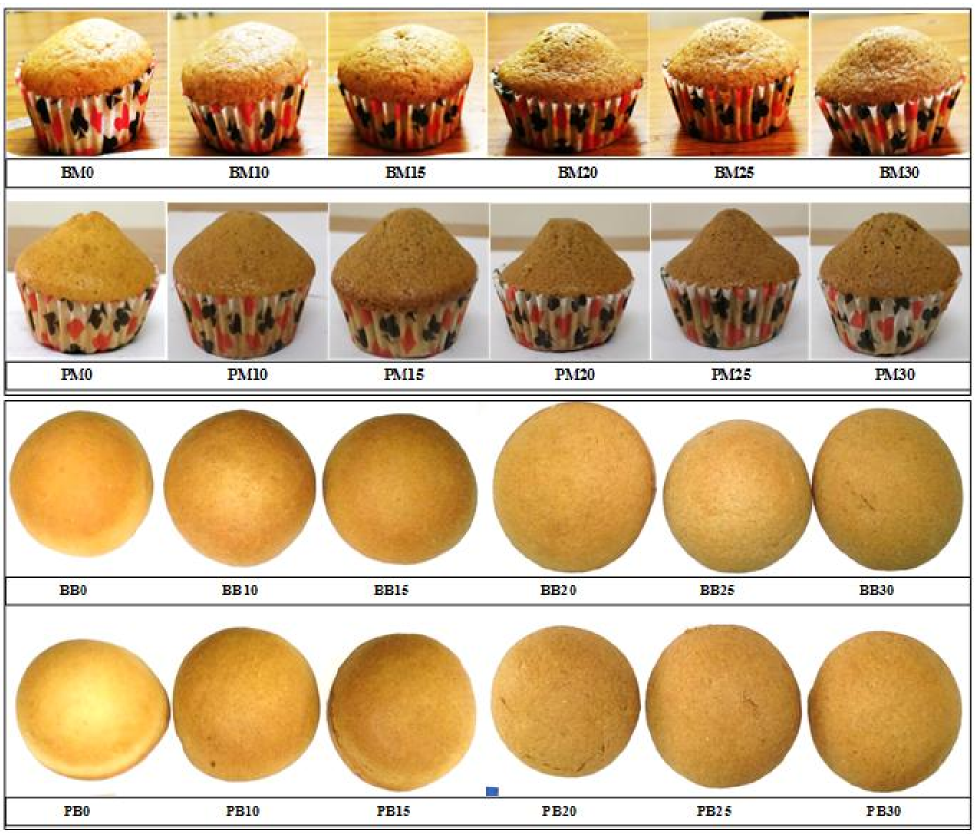


Fig. 3. Proso and barnyard millet bran enriched muffins and buns

Note: PM: Proso bran muffin; BM: Barnyard bran muffin; PB: Proso bran bun; BB: Barnyard bran bun; 0,10,15,20,25,30: percent bran incorporation

Overall results of sensory evaluation imply that scores reduced as the percent bran increased irrespective of the product (bun or muffins). The detrimental effects of bran were more in buns compared to muffins. These reductions in scores and acceptability can be due to rough or grainy texture imparted by bran particles. Also, the taste variations caused due to husky or sandy taste imparted by bran resulted in reduction of scores as the bran percentage increased. Similar results have been demonstrated by Lebesi and Tzia [9]. Scores for texture also reduced as bran imparted hardness to buns and muffins. As commented by semi trained panellists in sensory evaluation the softness of muffins and buns decreased and roughness, hardness in texture increased.

Previous study also indicated that addition of stabilized wheat bran up to 15% resulted in increased hard texture of cookies and addition of only 5 % bran was acceptable [31]. Another reason for reduction in sensory scores was due colour that became darker with bran incorporation in both bran (proso and barnyard) enriched muffins and buns. Similar results for bread loves becoming darker in colour with addition of 12% brown sorghum bran were seen in previous study [32]. Colour darkening was also reported in other products after addition of wheat bran [33,34].

4. CONCLUSION

Nutri-cereal bran being a good source of minerals, phytonutrients and fiber can be used as fortificant in bakery products to improve its nutritional profile. The results in present study indicated that bran addition increased the water absorption capacity but reduced water solubility, and foaming capacity. It was also concluded from present study that partial replacement with millet bran up to 30% in muffins and 20% in buns is possible without significantly damaging the sensory palatability. Thus, millet bran enriched buns and muffins can act as better substitutes to commercially available empty calorie bakery products.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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