Original Research Article

Nourishing mornings: Development and sensory profile assessment of Browntop (*Brachiaria ramosa L.*) millet-based breakfast cereal enriched with foxnut flour

ABSTRACT

Millets have surfaced as a unique ingredient which has a potent presence as a predominant component in breakfast cereals. They have emerged as a convenient choice for almost all categories of people be it children, housewives, working professionals or elderly group. The growing curiosity of health-conscious people towards the usage of millet in daily diet is due to their rich composition of protein, dietary fiber, vitamins and minerals. By incorporating millets into the cereal matrix food manufacturers can produce naturally gluten-free ingredient appropriate for people with gluten-sensitivity. This study focused on developing a browntop millet-based breakfast cereal enriched with oat and fox nut flour followed by its nutritional and organoleptic evaluation. The findings reveal 11.75% moisture, 63.75% carbohydrates, 10.62% fiber, 12.29% protein, 7.32% fat and rich mineral content. The energy calculated for all the breakfast cereal variants ranged from 328-344 kcal, which showed decrement from the standard cereal commonly available in the market. The sensory analysis conducted on 9-point hedonic scale reported Sample B (40:20:15) to be the most acceptable whereas Sample C (50:10:15) as the least preferred variant by observing overall acceptability scores. Moreover, the accessibility of nutrient-blended breakfast cereals could help combat malnutrition and enhance sustainability in the agricultural sector. They also have the potential to promote food security by ensuring long-term resource conservation and flourishing the market of plant-based foods.

Keywords: Accessibility, Cereal matrix, Gluten-free, Gluten-sensitivity, Malnutrition, Nutrient-blended, Plant-based foods, Sustainability.

1. INTRODUCTION

Breakfast cereals are nutritive and wholesome convenience foods that have acquired ubiquitous presence in the modern day households across the globe. They have experienced a remarkable evolution from corn flakes to extruded grain puffs to multi-grain cereals to chocolate filled millet puffs and granola. Although breakfast is considered to be the most essential meal of the day as it is consumed after a long duration, it needs to be dense in nutrients and minimal in sugar and additives content (Nayik et al., 2023). As per the current scenario, the application of extrusion process to the millet based cereals is in trend and has overcome the problems of gluten insensitivity, micronutrient deficiency and food insecurity at the grass root level. The growing consumer demand and globalization of food

market have devised new measures to utilise varied ingredients for the development of breakfast cereals including millets, nuts, dried berries, rice crisps, oat meal and cereal bran (Kapoor et al., 2020).

Millets are a sustainable source of nutrition that is densely packed with complex carbohydrates, dietary fibre, vitamins, minerals, antioxidants and phytonutrients. The replacement of processed ingredients with diverse variety of millets not only increases the nutritional quotient but also popularise itself as vegan and sustainable food choice for health-conscious consumers. One such millet is Browntop millet (BTM) that possesses the highest fibre content among the millet family, which is used in the development of this breakfast cereal (Srivastav et al., 2023).

Oats (*Avena sativa*) are exceptionally nutritive, environmental friendly cereal grains exhibiting anti-diabetic, anti-obesity, anti-oxidant and immuno-modulatory properties. They are composed of high quality protein, micronutrients, polyphenol compounds, anti-oxidants, starch granules and β-glucan. Several studies conducted by now have vehemently reported its suitability in enhancement of overall nutritional profile in whichever recipe it has been fortified (Rasane et al., 2013).

Foxnuts (*Euryale ferox*) are low-glycaemic index, protein rich, white puffed nuts that promote weight management and improve digestive health. This cash crop is rich in essential amino acid composition that has diverse culinary uses in day-to-day life at household and industrial levels. Their immunity boosting, cardio-protective and anti-ageing property is due to its low-calorie feature. Its addition to different recipes greatly enhances the nutritive value and eases digestion process (Liaquat et al., 2022).

2. MATERIAL AND METHODS

2.1 Procurement and processing of raw materials

The primary raw materials required for the study i.e. BTM and rolled oats, were purchased from the local market of Varanasi, Uttar Pradesh, India. They underwent pre-processing methods to reduce the anti-nutritive factors and enhance the quality of the final product. The rolled oats were dry roasted in a pan for 3-4 minutes and then kept at room temperature to cool down. Next, they were ground into a mixer on the pulse mode. For the BTM, rinse and soak it for 6-8 hours in water. Sun-dry the millet grains for 24-48 hours in a clean place and then ground it into a fine powder.The fox nut powder was procured by dry roasting them in a pan and grinding into a mixer to obtain its fine powder after bringing it to the room temperature.

2.2 Formulation of flour blends

Three variants were prepared and the control sample was purchased from the local market for comparing its organoleptic evaluation with the other fortified samples. All the ingredients required for the recipe preparation is mentioned in the Table 1 along with their quantities.

Table 1. Composition of major ingredients of breakfast cereal (per 100 g)

Ingredients	A	B	C
BTM flour (g)	30	40	50
Oat flour (g)	30	20	10
Fox nut flour (g)	15	15	15
Cocoa powder (g)	10	10	10
Brown sugar (g)	5	5	5
Peanut butter (g)	5	5	5
Milk (ml)	5	5	5

2.3 Preparation of breakfast cereals

The recipe for the fortified breakfast cereals was standardized and varied as per the proportions given in Figure 1 to develop three samples.

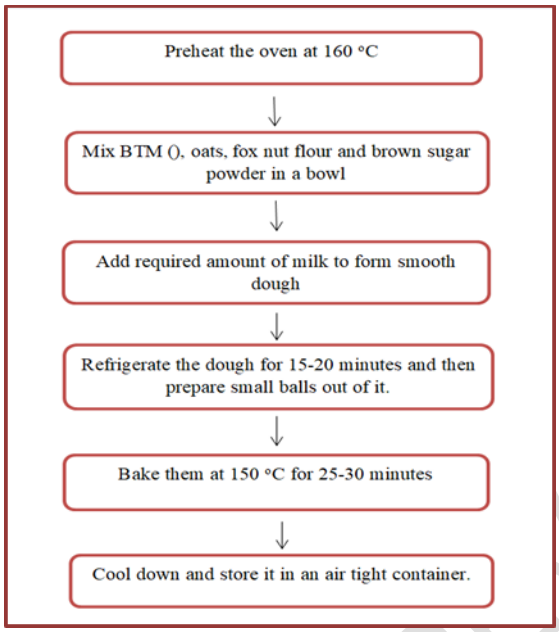

Figure 1. Preparation of breakfast cereal

2.4 Nutritional analysis

The proximate assessment of the millet-based breakfast cereal variants included moisture, fibre, protein, fat, carbohydrate to be conducted by AOAC standardised methods. The mineral composition analysis was determined for calcium and iron content for the prepared samples (AOAC 2005).

2.5 Sensory evaluation

The prepared millet-based breakfast cereals were subjected to sensory assessment by a panel of 25 semi-trained evaluators. The samples were coded as Standard, A, B, C and then presented to the panellists. They evaluated them on the 9-point hedonic scale by tasting and checking for other necessary parameters and the results were analysed (Chopra et al., 2018).

2.6 Statistical analysis

All the determinants were carried out in triplicates and results were expressed as mean ± standard deviation by applying ANOVA (Analysis of Variance) in the SPSS 21.0 version.

3. RESULTS AND DISCUSSION

3.1 Proximate analysis of the breakfast cereal variants

All the prepared breakfast cereal variants not only had better protein and fibre content but also low in fats quotient as depicted in Table 1. The energy and carbohydrate profile of the standard variant was better than the other three developed cereals and all the samples were higher in moisture content. Among the prepared samples, energy (343-329 kcal), protein (12.50-12.10 g) and fat values (7.4-7.0 g) decreased with the increase in millet and decrease

in oat flour. On the other hand, moisture, carbohydrate and fibre content have observed a surge in the samples on increasing the browntop millet and decreasing the oat flour content.

A combination of oat bran, wheat bran, carrot and soybean breakfast cereal have increasing protein, carbohydrate and crude fibre content on addition of bran and pomace (Delgado-Nieblas et al., 2021). The dietary fibre composition of the breakfast cereal rings was enhanced as the quantity of inulin proportion increased but the energy quotient got reduced [2]. Similarly, the protein and crude fibre levels improved on addition of pearl millet and date fruit flour. The increment in moisture content and decrement in fat composition of the prepared variants is against the results reported in a study (Okoye at al., 2023). The blending of pearl millet, mung bean and tigernut flour produced enhanced proximate values of the samples including moisture, ash, protein, fat, fibre and carbohydrate contents (Eweama et al., 2021).

Table 2 Nutrient profile of developed breakfast cereal variants

Samples	Moisture (g)	Carbohydrate (g)	Protein (g)	Fibre (g)	Fat (g)
Standard	9.4±10.24	72±2.04	7±1.11	2.7±2.64	14±1.30
A	11.58±0.12	63.45±0.14	12.42±0.12	10.59±0.05	7.49±0.11
B	11.75±0.24	63.75±0.21	12.29±0.14	10.62±0.02	7.32±0.23
C	11.92±0.12	64.05±0.23	12.18±0.24	10.65±0.04	7.15±0.21

All the values expressed are Mean±SD determined in triplicate combinations

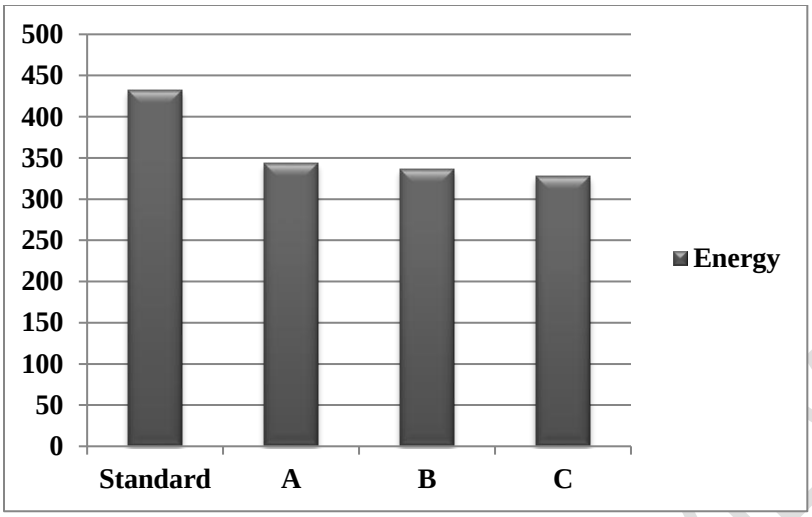

Figure 2. Energy composition of Breakfast cereal

2.2 Mineral analysis

It was revealed from the table 2 that the mineral composition of the prepared breakfast cereals is high in calcium and iron content. All the three samples have almost double the quantity of these minerals as compared to the control sample which was bought from the market. Sample A had the maximum content of calcium and iron that decreased with the decrease in oat flour proportion and increase in millet percentage. The control variant consisted of only 22 mg calcium and 1.3 mg iron but the millet-based breakfast cereal lied between the range of 53-58 g calcium and 4.2-4.4 mg iron respectively.

A study study reported that the highest amount of calcium and iron was present in the combination cereal of finger millet and beetroot powder (Fasua et al., 2022). The increasing addition of finger millet and carrot powder to the breakfast cereal enhanced the levels of iron and amino acids (Prakash et al., 2021). A study conducted by proved that on increasing the supplementation with finger millet, soyabean and peanut flour, the calcium content goes down but on the other hand zinc, potassium and sodium level gets increased (Idris et al., 2019). Similarly a study reported that on incremental addition of soybean and groundnut flour significantly decreased calcium and iron content in the variants (Ujong et al., 2023). On the contrary, a study explained the increment in iron content on implying roasting as a processing method (Arora et al., 2023).

Table 3. Mineral content of the developed breakfast cereal variants

	Minerals (per 100 g)	
Samples	**Calcium (mg)**	**Iron (mg)**
Standard	22 ±1.35	1.3±2.31

A	58.1±0.24	4.40±0.12
B	56.0±1.23	4.31±0.22
C	53.3±0.11	4.23±0.36

All the values expressed are Mean±SD determined in triplicate combinations.

2.3 Acceptability evaluation of the breakfast cereal variants

A semi-trained panel of 20 members were asked to taste the prepared breakfast cereal and provide their valuable feedback on the 9-point hedonic scale for further analysis. Table 4 depicts the average scores of acceptability on the basis of parameters namely appearance, aroma, taste, texture and overall acceptability. Sample B that was made out of BTM and oat flour in the ratio 40:20 respectively categorised itself to be the most organoleptic variety as it received best markings in terms of aroma, texture, taste and overall acceptability parameters. This calculated proportion of the ingredients proved to be pleasant in taste which had appropriate percentage of millet. Whilst, Sample C was the least accepted variety due to its high millet content that was not considered much palatable by the panellists on all the parameters. Although its texture was appealing to them, but the scores suggests poor taste, appearance and overall acceptability.

The incorporation of sprouted finger millet flour in the breakfast cereal augmented the taste, mouth feel and overall acceptability when compared to the control variant of maize cereal (Acheampong et al., 2024). Brennan in his study proved the usage of amaranth and buckwheat enhanced the organoleptic properties of extruded cereals (Brennan et al., 2012). On the contrary, a study reported that the inclusion of pearl millet and sorghum in the development of instant breakfast cereal resulted in unpalatable varieties but the colour was acceptable by majority (Akoth et al., 2012). The mean scores of a sensory assessment of porridge prepared from pearl millet, sesame and moringa leaf powder showed lower acceptability than the standard variants but had higher score for mouth feel (Adgidzi et al., 2021).

Table 4. Acceptability evaluation scores of the developed breakfast cereal variants

	Sensory parameters				
Samples	**Appearance**	**Aroma**	**Texture**	**Taste**	**Overall acceptability**
Standard	8.64±3.65	7.59±1.44	8.14±2.63	8.06±0.14	8.54±2.54
A	8.36±1.59	7.89±1.91	7.63±0.83	7.22±1.26	7.42±0.26

B	7.64±0.67	8.22±0.23	8.85±1.47	8.86±0.24	8.88±1.64
C	5.69±2.56	6.16±1.25	7.21±2.41	5.36±2.34	6.32±0.48

All the values expressed are Mean±SD determined in triplicate combinations.

Figure 3. Comparison of standard and most acceptable (Sample B) breakfast cereal variant

4. CONCLUSION

The study conducted revealed that the most preferred sample by the sensory panelists was composed of BTM and oat flour in 40:20 proportions. The incorporation of foxnut flour in adequate amounts to the breakfast cereal fairly improved the overall calcium, fiber and protein content. Moreover, this variant is low in fats and carbohydrate content that makes it suitable for gluten-sensitive and moderately diabetic patients also. The ready-to-eat breakfast cereals available in the market lack essential nutrients like protein, dietary fiber, minerals and vitamins and have higher quantities of fat, sugars, sodium and preservatives. To overcome this issue and reduce the instances of food insecurity, millets should be incorporated in numerous recipes to obtain the maximum possible therapeutic benefits.

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