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Physico chemical, textural and sensory evaluation of optimized millet based milk biscuits

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Abstract
The optimized biscuits were made with optimized flour blends consisting of 6% pearl millet, 3%, finger millet and 22% Skim milk powder at 160 °C for 15 min. pH, Water activity, TBA value, Hardness, Spread ratio and Sensory evaluation had been evaluated for optimised millet based milk biscuit(MMB). For comparison control biscuits (C-without skim milk powder and millets) and milk biscuits (MB-without millets) were prepared. The results indicate that the incorporation of millet significantly improved the textural attributes and overall acceptability of the biscuits, aligning with findings that millet enhances nutritional value. The reduced hardness and increased spread ratio suggest a favorable impact of millet on biscuit quality. The findings highlight the potential of millet as a beneficial ingredient in biscuit formulation, promoting both health and consumer preference.

Keywords: Milk biscuit, millet based milk biscuit, consumer preference

1. Introduction
Biscuits, a low cost, processed food, are widely consumed due to their numerous benefits: good price compared with conventional snack items, easy to consume at home or during travel, easily available in a wide variety of shapes, sizes, tastes, packs and suitable for all age groups. The term biscuit was derived from the Latin word biscoctus, meaning twice cooked. Biscuits are popular foodstuff, consumed by a large number of people today, due to their pleasant taste, prolonged shelf life and easy availability at fairly low cost (Masih *et al.*, 2017) [13].

In India, the prevalence of micronutrient deficiencies can be largely attributed to suboptimal dietary habits and insufficient dietary intake. The current dietary patterns across the majority of Indian states are deficient in 11 of the 25 essential nutrients. Iron is a vital micronutrient, regulated chiefly by dietary consumption, intestinal absorption and the recycling of iron (Shah *et al.*, 2021) [18]. In developing countries, the major contributor to iron deficiency anemia is the low bioavailability of iron within the dietary habits. Gastroenteritis or malabsorption syndromes may also lead to diminished iron absorption (Kapur *et al.*, 2002) [8]. Malnutrition is largely driven by poverty and insufficient dietary diversity, but promoting nutrient-dense crops can serve as a cost-effective and sustainable strategy to combat this problem. Millets have shown greater nutritional benefits compared to other major cereals (Longvah *et al.*, 2017) [11].
Pearl millet (*Pennisetum glaucum* (L.) R. Br.) ranks as the sixth most important cereal globally, following rice, wheat, maize, barley and sorghum. Pearl millet's high levels of slowly digestible starch (SDS) and resistant starch (RS) result in a low glycemic index (GI), making it a preferred choice in modern dietary trends and the food industry (Satyavathi *et al.*, 2020) [17]. Finger millet (*Eleusine coracana*) classified as a minor cereal offers several health benefits primarily due to its high polyphenol and dietary fibre content (Devi, 2014) [3]. Considering this facts, Millet based milk biscuit prepared in this study for effective utilization of skim milk powder.

2. Materials and Methods
The optimized biscuit produced with millet flour (6% PM, 3% FM) baked at a temperature of 160 °C for a duration of 15 minutes. The wheat biscuits were prepared by without adding skim milk powder and millets. The milk biscuits were prepared by without adding millets.

The other ingredients were kept constant. The formulation for different biscuits were shown in Table 1. An electrical blender was used to blend the mixture. To prepare the dough, butter was creamed for four minutes before adding powdered sugar. The dry ingredients were then incorporated, and the mixture was kneaded into dough. The dough was rolled out to an even thickness, shaped using moulds and baked in a preheated oven at various 160 °C temperature and 15 minutes. The pH value was measured using the pH Meter. The spread ratio (SR) of the biscuit was measured according to Arepally *et al*. (2023) [1]. Spread ratio was calculated by dividing diameter by thickness. The hardness of the biscuit was estimated using a texture analyser (TA-XTplus, Stable Micro Systems, Godalming, UK). A compression force was applied according to Malik *et al*. (2022) [12] by penetrating the cylinder probe of (6 mm diameter, P/6) with a 50 kg load cell. The test conditions were maintained as pre-test speed at 0.5 mm/s, test speed at 1.5 mm/s, the post-test speed at 10 mm/s, penetration distance at 3 mm and trigger type as 'auto'. Water activity was measured using a Pawkit water activity meter. Thiobarbituric acid value was determined using Kathalsar *et al*. (2020) [9] method.

Sensory attributes such as color, flavor, texture, crispiness and overall acceptability of the product samples were assessed using a 9-point hedonic scale. The evaluation was carried out by a panel consisting of 15 semi-trained members. To minimize bias, each panellist was given sufficient privacy during the assessment. The samples were properly coded before being presented to the panellists for evaluation.

Table 1: Formulation for different biscuits

Ingredients (%)	Control	Milk Biscuit	Millet based Milk Biscuits
Skimmed milk powder (%)	22	22	22
Wheat flour (%)	60	30	21
Pearl millet (%)	-	-	6
Finger millet (%)	-	-	3
Butter (%)	27.2	27.2	27.2
Sugar (%)	19.9	19.9	19.9
Baking powder (%)	0.8	0.8	0.8
Salt (%)	0.1	0.1	0.1

3. Results and Discussion

The mean values along with their standard deviation for physical properties, textural properties and sensory evaluation of the optimised millet based milk biscuit are given in Table 2.

Table 2: Physical properties, textural properties and sensory evaluation of the optimised millet based milk biscuit

Parameters	Control	Milk Biscuit	Millet based Milk Biscuits
pH	6±0.06^{a}	6.1±0.04^{b}	6.3±0.06^{c}
Hardness	45.16±0.17^{a}	22.41±0.55^{b}	13.91±0.33^{c}
TBA (MDA/kg)	0.02±0.03a	0.03±0.02b	0.03±0.00b
Spread ratio	4.03±0.07^{a}	4.99±0.05^{b}	5.47±0.09^{c}
Water activity	0.44±0.06^{a}	0.35±0.06^{b}	0.27±0.01^{c}
Color	6.8±0.08^{a}	7.2±0.16^{b}	8.28±0.07^{c}
Flavor	7.13±0.05^{a}	7.78±0.07^{b}	8.4±0.14^{c}
Texture	7.2±0.08^{a}	8.2±0.06^{b}	8.6±0.10^{c}
Crispiness	7.1±0.06^{a}	7.78±0.11^{b}	8.51±0.07^{c}
OAA	7.01±0.07^{a}	7.93±0.10^{b}	8.7±0.06^{c}

No of observations-18.

Row wise: Means with different superscripts (a, b, c) differ significantly (p<0.05)

The pH values for different type of biscuits ranging from 6 to 6.3 showed significant differences (p<0.05) among the various treatments, indicating that the biscuits composition significantly affected its pH levels. The optimised millet based milk biscuits were more alkaline. This rise in pH may be attributed to the buffering capacity of millet flour, which is known to contain certain minerals and proteins that can alter the hydrogen ion concentration in food matrices (Shobana *et al.*, 2007) [19].

The peak value of fracture force (maximum) was recorded as hardness at a point when the cookies were broken into two major pieces (Mudgil *et al.*, 2016) [14]. A significant reduction (p<0.05) in hardness was observed in millet-based milk biscuits (13.91±0.33 N) compared to control (45.16±0.17 N) and milk biscuits (22.41±0.55 N). The soft texture in the millet-based product can be linked to its higher fibre content and the altered gluten structure, which likely resulted in a more tender and crumbly texture (Gull *et al.*, 2015) [6]. Hardness decreased significantly from 45.16 for control to 13.91 for millet biscuits, indicating a softer texture, which is desirable in baked goods (Arepally *et al*., 2023) [1].

Significant changes in Thio Barbituric Acid (TBA) values between Control and Milk biscuit & Optimised milk biscuit were found (p<0.05). This shows addition of skim milk powder slightly increased the TBA values during baking. No significant changes between Milk biscuit and optimised milk biscuit were found. This showed addition of millets didn't create any impact over TBA values. There were no significant differences in TBA values among milk and millet-based biscuits, with values ranging from 0.02 to 0.03 mg MDA/kg. This suggests that the lipid oxidation level remained low and within acceptable limits across all formulations, indicating good oxidative stability

The spread factor of the control sample was considered as standard (100%). Spread ratio is a measure of cookie quality. For better biscuits, higher spread ratio is desirable. In comparison to the control sample, there was an increase in the spread factor of milk biscuit and optimised milk biscuit. The spread ratio was significantly higher in millet-based biscuits (5.47±0.09), followed by milk (4.99±0.05) and control (4.03±0.07). This increase may be attributed to the reduced gluten content in millet, which tends to produce a softer dough with greater spread during baking (Noorfarahzilah *et al.*, 2014) [15]. This also might be due to the combined effect of sugar and fibres in the dough. Similar findings were reported by Kulkarni *et al.* (2021) [10]. In cookies containing 20% Pearl Millet Flour, the high sugar and low fibre content resulted in increased diameter and reduced thickness of cookies during baking.

The water activity (aw) always important parameter influencing stability of biscuits during storage, in particular the resistance against microbes and rheological properties of the products. Water activity was significantly lower in millet-based milk biscuits (0.27±0.01) compared to the control (0.44±0.06). A lower water activity is beneficial for shelf life as it inhibits microbial growth and enhances product crispiness (Ronda *et al.*, 2005) [16].

The color values of different biscuits ranged from 6.8 to 8.28. There were significant changes (p<0.05) between Control, Milk biscuit and Optimised millet based milk biscuits. This suggesting addition of skim milk powder and millets in biscuits made better appealing than control a darker or more appealing appearance. This may be due to the natural pigments in millet flour and Maillard browning during baking. Millet contributes to darker color due to polyphenols and browning (Devi *et al.*, 2014) [3].

Flavor scores showed significant improvement in millet-based milk biscuits (8.4±0.14) compared to control (7.13±0.05). There were significant changes (p<0.05) between Control, Milk biscuit and Optimised millet based milk biscuits. The findings showed skim milk powder and millet flours improve the flavour than control. The nutty and earthy flavor of millets might have contributed positively to the taste profile, enhancing consumer acceptability (Chandra *et al.*, 2015) [2].

The Texture values of different biscuits ranged from 7.2 to 8.6. Values significantly increasing between different treatments. The values showed that addition of skim milk powder and millets improved the texture greatly. It can be co related with hardness values. The Crispiness values of different treatments ranged from 7.1 to 8.51. There were significant changes (p<0.05) between Control, Milk biscuit and Optimised millet based milk biscuits. Millet-based biscuits scored the highest for both texture (8.6) and crispiness (8.51), indicating improved mouth feel and bite. This aligns with the observed lower hardness and water activity, suggesting a more desirable and palatable product (Dharmaraj *et al.*, 2011) [4].

The Overall acceptability values have been significantly increasing (p<0.05). The values ranged from 7.01 to 8.7. Millet-based biscuits received the highest overall acceptability score (8.7±0.06), reflecting favorable consumer perception. The combination of improved color, flavor, texture, and crispiness likely contributed to this preference.

The incorporation of millet flour in milk biscuit formulation positively influenced both physicochemical, textural and sensory attributes. Millet-based milk biscuits demonstrated superior textural properties, enhanced flavor, lower water activity, and higher consumer acceptability compared to control and conventional milk biscuits. These findings support the potential of millet as a functional and appealing ingredient in value-added bakery products. Consumers show increased acceptance for millets in baked products due to taste and health perception (Singh *et al.*, 2015) [2].

4. Conclusion

The millet-based milk biscuits exhibited improved pH, reduced hardness, enhanced spread ratio, lower water activity and superior sensory attributes (color, flavor, texture, crispiness and overall acceptability) compared to control biscuits, indicating their potential as healthier snack alternatives. The sensory evaluation confirms that millet-based biscuits not only retain but enhance key attributes, making them a viable alternative to traditional wheat biscuits. This also can be a best alternatives for skim milk value addition. This supports the growing interest in millet as a health-promoting ingredient in snack production

Conflict of Interest
Not available

Financial Support
Not available

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