A Comparison Study on Nutritional, Textural and Sensory Evaluation of Biscuits Made from Millet

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Abstract: ***Millets are the superfood and future food of the world, they meet the UN sustainable goals. Millets are gluten-free, underutilized grains with high nutritional value. The prevalence of allergies and lifestyle diseases due to the consumption of single cereal leads to the search for alternative grains to produce bakery products. This study investigates the potential of different millets for biscuit production as a substitute for refined wheat flour. Chemical composition analysis of barnyard, finger millet, and pearl millet was conducted. Biscuits were prepared by blending millet flour and refined wheat flour in a 50:50 ratio, and evaluated for chemical composition, color, texture, and sensory quality. Millet biscuits showed significant variations in fat and ash content. Finger millet biscuits exhibited superior texture, while pearl millet biscuits displayed superior nutrition, color, and sensory attributes. Barnyard millet also demonstrated comparable quality. Overall, pearl millet biscuits were deemed the most suitable for biscuit production.***

Keywords: Finger millet, Pearl millet, Barnyard millet, Biscuit

1. Introduction

Bakery products constitute an important component in our diet because of their convenience, availability in different forms, unique sensory profile and availability at a lower price. There is a growing demand for bakery products both for home consumption and in the food service industry. Among the bakery products, biscuits, cookies and crackers are preferred by people of all age groups and economic segments as they are self-stable and nutrient dense. Furthermore, the bakery industry is continuously innovating in the creation of newer variants using different formulations, additives, novel ingredients, flavours; machinery and packaging. Diversification has resulted in a further upsurge in their consumption and market growth. Rapid economic expansion, the establishment of food chains and changing eating habits have all contributed to a large increase in popularity among the common people.

Most bakery products are prepared from wheat grains due to the peculiar visco-elastic properties given by gluten protein [1]. After the Green Revolution, the consumption of wheat and rice increased drastically. The consumption of wheat regularly causes allergenicity in people and many of them are prone to non-communicable diseases like obesity, diabetes, and other nutritional disorder problems. In the recent past, with the emergence of celiac diseases that cause inflammation of the intestinal wall, there is a need for alternatives that can replace wheat and gluten-containing grains in the diet [2].

Millets are grown and consumed extensively in semi-arid areas of Africa and Asia. The cultivation of millet reduced after the Green Revolution, but it is the staple diet of Africans and South Indians. As per FAO STAT [3], millets are the sixthhighest yielding grains. Total millet global production was 30.08 million tonnes in 2021; of which Asia produces nearly 48.5%, followed by Africa (47.5%), Europe (2.9%) & America (1%). India is the largest producer of millet with 13.21 MT in 2021 with a CAGR of 1.83%, followed by Niger and China. Millets are also called super grain, superfood, wonder grains, etc. They are considered nutri-cereals because of their high nutrition profile. Millets are classified into two groups based on their grain size: major millet and minor millet. Sorghum, pearl, and finger millet are major millets while foxtail, proso, kodo, barnyard, and little millet are minor millets [4]. Millets are rich in fibres, micronutrients such as iron, zinc, copper, vitamin B groups, polyphenols, and a wide variety of phytochemicals. The starch of millet crops is also slowly digestible and the presence of enzyme inhibitors lowers the starch digestion in the gut, which makes them an ideal dietary component for diabetes and obese individuals. Higher levels of antioxidants in millet assist in minimizing oxidative stress and thus lifestyle-associated diseases [5].

Owing to the consequences obtained by major cereals, an attempt has done to make a convenient bakery product. Considering the health benefits of millet and its functional role in biscuit making, millets have been used to make biscuits. The main objective of this study is to evaluate the nutritional, textural and sensory attributes of a biscuit.

2. Materials & Methods

2.1 Materials

Commercial Barnyard, finger millet, pearl millet flour and refined wheat flour were supplied by B.D Super store market (Karnal, Haryana) and the proximate was carried out according to the AACC method. Ground sugar, skim milk powder (SMP), whey protein concentrate (WPC), cake gel, salt, baking powder, ammonium bicarbonate, sodium bicarbonate & ammonium iron citrate were procured from the local market.

2.2 Biscuit dough preparation

Three types of biscuits were made from barnyard, finger millet and pearl millet flour. The biscuits were prepared by blending millet flour and refined wheat flour (50:50). Biscuits were prepared by the creaming method [6]with slight modifications. Fat & sugar were creamed (40% of flour each) to a cream consistency in Hobart planetary mixer. Salt (1%) & ammonium iron citrate (2 ppm) were dissolved in water and added at the final stage of creaming. The accurately calculated amount of dry ingredients like flour (100 %), SMP (4 %), baking powder (1%), ammonium bicarbonate (0.6%) and sodium bicarbonate (0.4%) were sieved to provide aeration and remove higher particles. These dry ingredients were added to the cream and mixing continued at a low speed until the dough attains a smooth homogeneous mass. The dough was rolled out into a thin sheet of 2–3 mm thickness and 4 mm diameter by means of a wooden rolling pin and the sheets were then cut into the desired shape using a biscuit cutter mould. The cut pieces were baked at 175°C for 13±3 minutes in the oven.

2.3 Proximate analysis

Moisture, fat, protein and ash were carried out according to AACC [7] method.

2.4 Hardness of biscuits

The sample biscuits were evaluated for hardness using Texture analyser TA-HD plus (Stable Microsystems, USA) fitted with a 50 kg load cell. The equipment was fitted with HDP/BS blade and the biscuit was kept on the heavy-duty platform. Blade cuts the biscuits and the maximum force required to cut the sample was recorded. The test conditions were pre-test speed- 2mm/s, test speed- 3mm/s, post-test speed- 10mm/s and distance- 10mm. The hardness of the biscuits was obtained by taking the absolute peak force from the cutting strength curve [8].

2.5 Colour analysis and water activity

A Tristimulus spectrophotometer Hunter Lab model Colour Flex® (MiniScan XE plus, Hunter Associates Laboratory Inc., Reston, Virginia, U.S.A.) and the software (version 4.10) were used to measure the colour of the biscuit and the results were expressed in terms of the CIE-LAB system. The measurement was done according to the method mentioned by Agrahar-Murugkar [9]. The water activity meter of Aqua lab (Model Series 3 TE) supplied by M/s Decagon Devices, WA, USA, was used for the determination of the water activity of biscuits. The instrument was calibrated with charcoal and then the sample readings were taken in triplicate.

2.6 Sensory evaluation

The sensory evaluation of biscuits was evaluated by an expert panel of judges on a 9-point hedonic scale wherein a score of 1 represented ‘dislike extremely’ and a score of 9 represented ‘like extremely’ [10]. The samples for evaluation were coded appropriately before serving the samples to the judges for sensory assessment. Evaluated Parameters are like taste, texture, colour, flavour, and overall acceptability.

2.7 Statistical analysis

The data obtained from the experiments were recorded as mean ± standard deviation and subjected to statistical analysis to arrive at valid and meaningful influences. Data was analysed using one way-ANOVA. The least significant differences were calculated by the Tukey (HSD) test and the significance at $p < 0.05$ was determined. These analyses were performed using SPSS for Windows Version 26.0

3. Results and Discussions

3.1 Proximate analysis

The analysis was carried out to see the effect of flour on the quality attributes of biscuits. The data on the chemical composition of various flours are given in Table 1. The moisture content of the flour varies from 9.33% to 11.13%. The highest fat and protein content were found in pearl millet ($p<0.05$). Sharoba[11] reported a similar proximate composition of pearl millet flour as obtained during the present investigation. The protein in the raw ingredient should be ideal for making biscuits, as the protein gives structure to the dough and easier machinable handling. Compared to refined wheat flour, all variant of millet flourwas found rich in ash content, this is due to the fact that it is difficult to remove the bran content from millets, hence they have high ash content. Similar findings were reported by Longvah[12]. The amount of ash in flour indicates the degree of purity of flour in terms of bran fragments. The higher the ash, the more the bran content and the bran content further affects the colour of the product. Saha [13] found 6.47% protein, 1.91% fat and 2.34% ash in finger millet flour. Anju and Sarita [14] reported a similar composition for barnyard millet.

Table 1: Proximate composition of flour

Parameters	Pearl millet	Barnyard	Finger millet	Refined wheat flour
Moisture (%)	9.56^a±0.01	11.13^c±0.19	10.43^b±0.34	9.33^a±0.20
Fat (%)	5.52^c±0.07	4.63^b±0.24	1.90^a±0.07	1.67^a±0.02
Ash (%)	1.73^b±0.03	1.92^b±0.06	2.15^c±0.11	0.65^a±0.03
Protein (%)	10.80^b±0.60	10.80^b±0.49	7.18^a±0.17	9.88^b±0.02

Data are presented as Means ± S.D (n=3). Means with different superscripts ^{abc} in a row are significantly different from each other at $p<0.05$.

3.2 Chemical composition of biscuits

Cookies are low-moisture baked foods and higher moisture in cookies may result in a moist and soft texture, thereby lowering consumer appeal [15]. The moisture percentage of the biscuit samples ranged from 0.20% to 0.68%, while the fat content ranged from 18.84% to 23.89%. The highest fat content of biscuits was found in pearl millet due to the high fat present in pearl millet flour compared to others ($p<0.05$). Adebiyi [16] reported similar results for the biscuits prepared from pearl millet flour. There is no statistical difference between the protein content of all the biscuits, but Florence [17] reported almost similar protein values for pearl millet cookies. Higher ash content was obtained for the finger millet biscuits. It is difficult to separate out seed coat from finger millet, the seed coat is rich in mineral content.

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Gopalan [18] reported that finger millet is rich in calcium (344 mg) and phosphorous (283 mg). Due to the higher content of minerals in finger millet, the biscuit had high ash content. Singh [19] had a similar protein~5.6%, fat~20% and ash 2.5% in a finger millet biscuit. Nutritionally, the millet biscuits were superior, but finger millet biscuits had a low-fat content compared to others. Anju and Sarita [10] observed the protein~6.11% and ash 1.31% for biscuits made from a blend of barnyard and refined wheat flour (45:55). The results for barnyard biscuits are aligned with the findings of Anju and Sarita [14].

Table 2: Chemical composition of biscuits

Parameters	Pearl millet	Barnyard	Finger millet
Moisture (%)	$0.23^{a}\pm0.01$	$0.68^{b}\pm0.07$	$0.20^{a}\pm0.02$
Fat (%)	$23.89^{c}\pm0.23$	$21.67^{b}\pm0.65$	$18.84^{a}\pm0.88$
Ash (%)	$0.55^{a}\pm0.02$	$1.00^{b}\pm0.70$	$1.31^{c}\pm0.09$
Protein (%)	5.86±0.31	5.82±0.24	5.09±0.57

Data are presented as Means ± S.D (n=3). Means with different superscripts ^{abc}in a row are significantly different from each other at $p<0.05$.

3.3 Colour and water activity

The biscuit's colour and water activity are key parameters as colour influences the consumer acceptability of a product. Similarly, water activity is critical as it determines the product's shelf life and texture. Table 2 shows the colour of the biscuit samples expressed in terms of tri-stimulus characteristics, L*, a*, and b* values. A significant difference between the three biscuits was found. The highest lightness value was obtained for pearl millet compared to others. Due to the inherent colour characteristics of finger millet and the dull cream colour of barnyard millet, the lightness was less ($p<0.05$). The seed coat of the finger millet usually turns dark on heat treatment [20]. The redness of the barnyard biscuit is high compared to other samples. A similar finding was reported by Goswami [21] in their evaluation the redness of muffins increased with the substitution of barnyard millet flour. Pearl millet biscuit had the highest yellowness values due to the original characteristics of pearl millet than the others ($p<0.05$). A trend of increasing intensity of brown colour in biscuits with the addition of finger millet flour was reported by Shimray[22]. Water activity indirectly indicates the texture of biscuits, as it is an important parameter during storage, therefore initial water activity plays a vital role. The water activity of the biscuits varied from 0.165 to 0.195 and the highest water activity was obtained for finger millet. High water activity in finger millet was due to more water holding capacity (665% @97°C) of fibres in finger millet biscuit [20].

Table 3: Colour and water activity of biscuits

Parameters	Pearl millet	Barnyard	Finger millet
L*	$44.34^{c}\pm0.16$	$33.62^{b}\pm0.16$	$32.56^{a}\pm0.56$
a*	$9.93^{a}\pm0.11$	$13.06^{c}\pm0.12$	$10.47^{b}\pm0.29$
b*	$25.33^{c}\pm0.29$	$21.93^{b}\pm0.20$	$19.15^{a}\pm0.90$
a_w	$0.165^{a}\pm0.011$	$0.175^{ab}\pm0.011$	$0.195^{b}\pm0.003$

Data are presented as Means ± S.D (n=5). Means with different superscripts ^{abc}in a row are significantly different from each other at $p<0.05$.

3.4 Hardness of biscuits

Cutting strength denotes the hardness of the biscuit. Hardness refers to the maximum force required to compress the biscuit. From the consumer's point of view, hardness is an important property that decides the quality and consumer perception of that product. There is no statistical difference among the biscuits ($p<0.05$). The highest hardness was obtained for finger millet than others, it may be due to the high fibre content and carbohydrate of finger millet compared to others. The carbohydrate helps in the recrystallization of sugar after baking, hence the pronounced hardness of the finger millet biscuit. From Table 2, we can see the low fat content in finger millet compared to other biscuits, as fat contributes to the tenderness of biscuits. Chugh [23] reported similar findings where the reduction in fat levels increased the hardness of a composite biscuit. Shimray [22] observed that the biscuits became brittle with the replacement of refined wheat flour and they concluded tannins and phytates from finger millet bound to gluten protein leading to a decrease in the cohesiveness of dough. The lowest hardness is recorded for barnyard millet.

Table 4: Hardness of biscuits

Parameter	Pearl millet	Barnyard	Finger millet
Hardness (kg)	6.44±1.58	5.55±0.44	6.54±0.73

Data are presented as Means ± S.D (n=10).

3.5 Sensory attributes

Sensory evaluation is an important attribute in new product development and to know consumer acceptability and their preferences based on their likes and dislikes. Table 4 gives the sensory profile of biscuits from millet-based composite flours. There was no statistical difference among the biscuit samples($p<0.05$). Taste-wise barnyard biscuit was good, in terms of colour and texture, pearl millet scored high, but there was no statistical difference ($p<0.05$). Both pearl millet and barnyard scored high in terms of flavour and over-acceptability. Salunke [24] optimised the barnyard biscuit by sensory evaluation, the highest score was obtained for the biscuit made from barnyard with refined wheat flour (70:30) composition. The purchasing decision of the product depends on the colour and taste [25]. Finger millet had a low score in colour due to dark crust and crumb colour, hence these biscuits were less acceptable and most of the panellists did not like the taste of this biscuit. Shimray[22] reported the sensory score was reduced with the substitution of refined wheat flour with finger millet flour (>40%). Saha [11] reported the composite biscuit (60:40) from finger millet flour had better surface characteristics, crispiness and mouth feel.

Table 5: Sensory evaluation of biscuits

Parameters	Pearl millet	Barnyard	Finger millet
Taste	7.60±0.89	8.40±0.54	7.40±1.14
colour	8.20±0.83	7.60±0.54	7.00±1.22
Texture	8.00±0.71	7.80±0.44	7.80±0.83
Flavour	8.00±0.70	8.00±0.00	7.40±1.14
Overall acceptability	7.80±0.44	7.80±0.45	7.40±1.14

Data are presented as Means ± S.D (n=5)

4. Conclusion

In conclusion, millets prove to be highly nutritious and comparable to major cereals in terms of their nutritional profile. Among the millets studied, pearl millet and barnyard millet exhibit richness in fat and protein content, while finger millet stands out for its mineral and fiber content. This makes finger millet an appealing choice for health-conscious consumers due to its lower fat content. Color analysis indicates that pearl millet displays the highest lightness value, while finger millet exhibits the highest hardness. Overall, both pearl millet and barnyard millet biscuits received high scores for acceptability. However, considering the overall quality attributes of the biscuits, pearl millet emerges as the most suitable choice for biscuit making. Overall, millet flour presents a viable alternative to refined wheat flour in biscuit production, offering nutritionally superior products with desirable quality attributes. In conclusion, millets prove to be highly nutritious and comparable to major cereals in terms of their nutritional profile. Among the millets studied, pearl millet and barnyard millet exhibit richness in fat and protein content, while finger millet stands out for its mineral and fiber content. This makes finger millet an appealing choice for health-conscious consumers due to its lower fat content. Color analysis indicates that pearl millet displays the highest lightness value, while finger millet exhibits the highest hardness. Overall, both pearl millet and barnyard millet biscuits received high scores for acceptability. However, considering the overall quality attributes of the biscuits, pearl millet emerges as the most suitable choice for biscuit making. Overall, millet flour presents a viable alternative to refined wheat flour in biscuit production, offering nutritionally superior products with desirable quality attributes.

Disclosure statement

The authors confirm that they have no conflicts of interest with respect to the work described in this manuscript.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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