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RESEARCH ARTICLE

Preparation of gluten-free version of *Gulab Jamun* using kodo and foxtail millet

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Abstract: *Gulab Jamun*, a popular Indian sweet, is traditionally made from *dhap* variety *khoa* and *maida.* However, regular consumption of *maida* can have negative health implications, especially for people with celiac disease. This study aimed to develop gluten-free *gulab jamun* using kodo and foxtail millets in two different forms, viz., paste and flour forms. *Gulab jamun* prepared using paste form of millet had lower phytic acid content and higher overall sensory acceptability. Optimized *gulab jamun* formulations with 30% kodo millet and 35% foxtail millet (paste form) showed better sensory scores than their flour form of millets, though it was still lower than the control. Across all sample of *gulab jamun*, the control samples showed the highest moisture (33.81±0.17%). *Gulab jamun* made from foxtail millet flour had the highest protein (8.62±0.12%), ash (2.27±0.14%) whereas highest carbohydrate (45.22±0.37%) present in *gulab jamun* made from paste form, while kodo millet flour based *gulab jamun* had the highest fat (12.86±0.08%) content. Phytic acid was highest in foxtail millet flour form (49.95±0.21mg/g) and lowest in control samples (0.11±0.00mg/g).

Keywords: *Gulab jamun*, Gluten-free, Foxtail millet, Kodo millet, Phytic acid

Introduction

Milk production in India is estimated as 239.30 million tonnes in year 2023-24 registered a growth of 5.62% over the last 10 years which was 146.3 million tonnes in 2014-15. Further, the production has increased by 3.78% during 2023-24 over the previous year 2022-23. About 50-55% milk produced is converted to traditional Indian dairy products (TIDPs), which is growing at an annual rate of 20% (DAHD**,** 2023**).** Examples of TIDPs include *khoa, ghee, paneer, kheer, curd, lassi,* etc. Among these, *khoa* is popular product prepared by heating milk at atmospheric pressure to evaporate moisture thereby giving it a concentrated semi-solid consistency. Good quality *khoa* is typically white with a slight brown color, has a mild cooked flavor, and a smooth characteristics and granular texture (Badola et al. 2022**).** *Khoa* is an intermediate dairy product used for *khoa*-based products preparation such as *burfi, gulab jamun, kalakand, milk cake, peda* and *pantua* **(**Aneja et al. 2002**;** Prasad et al. 2017; Vinod et al. 2023**).** *Gulab jamun* is a popular Indian sweet that has been enjoyed in homes and confectioneries for many years. Conventionally, refined wheat flour *(maida)* is mixed with the *dhap* variety of *khoa* to serve as a binding agent for *gulab jamun*. *Gulab jamun* has a soft, moderately spongy texture, a precisely spherical shape, and a consistent brown color. A fine granular texture, a slightly cooked aroma, and the absence of lumps or hard cores are desirable (Vasava et al. 2018).

Refined wheat flour (*maida*) is an essential ingredient for *gulag jamun* preparation. Through network formation, it tends to hold the ingredients together thus maintains the structural integrity of the *gulab jamun* balls (Rawat et al. 2023). However, gluten is an important constituent in *maida.* Gluten intake is a factor in celiac disease, an autoimmune condition where the immune system reacts to gluten, damaging the intestinal lining and affecting nutrient absorption. This condition can cause a “leaky gut” and other digestive issues. Studies show that for each additional gram of gluten consumed daily, the risk of celiac disease autoimmunity increases by 6.1%, and the risk of celiac disease itself rises by 7.2% (Andrew, 2019). Considering these aspects, application of alternative binding agents for *gulab jamun* appears necessary.

Millets, often referred to as “nutritious cereals,” include Sorghum (jowar), Finger Millet (ragi), Pearl Millet (bajra), Proso Millet, Buckwheat, Barnyard Millet, Kodo Millet, Foxtail Millet, and Amaranth. These grains are highly nutritious, rich in proteins, vitamins, and minerals, and are naturally gluten-free. Their low

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glycemic index makes them a healthy choice for individuals with diabetes or celiac disease. Millets, being naturally gluten-free and rich in essential nutrients, are ideal for large-scale use in producing various food products, including baby foods, dietary items and snacks, either in grain or flour form. Given their nutritional advantages and versatility, the present study was aimed at utilization of kodo millet and foxtail millet for preparation of gluten free *gulab jamun* with an aim to enhance the nutritional profile of the traditional sweet while promoting the broader use of these nutritious cereal grains in innovative food applications.

Material and methods

Materials

Dhap khoa (60-65% TS) obtained from fresh raw buffalo milk procured from Experimental Dairy of ICAR-National Dairy Research Institute, Karnal. Millets (kodo and foxtail), soyabean refined oil and canned sugar was purchased from local market at Karnal, Haryana. All the chemicals used for physico-chemical analysis were purchased from M/s HiMedia Laboratories Pvt. Limited, Mumbai.

Millets (kodo and foxtail) in two different states that is flour and paste form, were directly mixed with *khoa* and kneaded to make smooth dough. Millet pastes were prepared by boiling in water followed by soaking (27±2°C) for 12 hours in water using a grain-to-water ratio of 1:3. After that, the millets were ground into a paste for addition in *gulab jamun*.

A 50% sugar syrup was prepared by heated over a medium flame and stirred continuously to ensure the sugar dissolved completely. Once fully dissolved, the solution was brought to a gentle boil while being stirred occasionally to prevent crystallization and cooled for further activity.

Preparation of millets-based gluten free *gulab jamun*

The prepared *dhap* variety of *khoa* was cooled to room temperature, and both forms of millets were mixed with the *khoa* at different levels. Kodo (25%, 30%, and 35%,) and foxtail (30%, 35%, and 40%.) millets were added to *khoa* and kneaded to a smooth dough form. After that, the dough was shaped into small balls, each ball size 14-15 g. The balls were then fried in refine oil at 120-140°C for 10-15 minutes. Once fried, the balls were removed from the oil and soaked in a 50% concentrated sugar syrup for 2-3 hours. After soaking, they were transferred to a fresh 50% concentrated sugar syrup and stored at refrigeration temperature (Fig. 1.).

Proximate compositional analysis of millets based *gulab jamun*

Moisture content in *gulab jamun* was determined using the (FSSAI 01.072:2022) method. About 5g of sample was taken in a dried and pre-weighed aluminium dish. The contests were kept in an oven at 102 ± 2 °C for moisture evaporation till a constant weight (i.e., difference between the two successive weighing was not more than 1 mg) was achieved, cooled in a desiccator, and weighed. The moisture content was calculated by subtract. This was followed by cooling the dish in a desiccator and weighed. Moisture content in the sample was calculated using the following formulae:

$$\% \text{ Moisture} = \frac{\text{Loss of weight of sample}}{\text{Weight of sample}} \times 100$$

Fat content was determined using the Mojonnier method (FSSAI 01.073:2022). About 3g sample was taken and fat from the sample was extracted using a mixture of 25 mL diethyl ether and 25 mL petroleum ether, this was followed by evaporation of the solvent. The extracted fat content was weighed after multiple drying the content in an oven at 102±2 °C. The difference in weight of the dried flask before and after washing with petroleum ether represented the fat percentage in the sample.

Fat (% by weight) = wt. of fat extracted /wt. of sample × 100

$$\text{Fat content} = \frac{(W3-W1)}{W2} \times 100$$

Where, W1 = weight of empty Soxhlet flask

W2 = weight of sample taken for the test

W3 = weight of the Soxhlet flask with extracted fat

Protein content in the sample was determined using micro Kjeldahl method using the FSSAI 01.026:2022 method. About 5g sample was digested using a mixture of 20 mL concentrated sulfuric acid, 12 g potassium sulfate, and 1.0 mL copper sulfate. Digestion was performed at 180-230°C and gradually raised to 410-430°C and held for 1 hour. After digestion, the sample was cooled and 85 mL of water was added. Distillation was conducted by adding 55 mL of 40% (w/w) sodium hydroxide, and the distillate was collected in a boric acid solution. Subsequently, the boric acid solution was titrated with 0.1 N hydrochloric acid, and the volume of acid consumed was recorded. The crude protein content was determined by multiplying the nitrogen content (calculated from the titration data) by a factor of 6.38 and expressing the result as a percentage of the initial sample weight.

$$\% \text{ Nitrogen in sample} = \frac{\text{No.of ml of N /10 NaOH} \times 0.0014}{\text{Weight of sample}} \times 100$$

% Protein = % of Nitrogen in sample ×6.38

Ash content was determined according to FSSAI 01.077:2022 method. About 3g of sample was dried, incinerated on a hot plate, and then further burned in a muffle furnace at 550 ± 20°C until a grey ash was obtained. The crucible was cooled in a desiccator and weighed. This heating and weighing process was repeated until a constant weight was achieved.

$$\text{Total solid (\%)} = \frac{(W3-W1)}{(W2-W1)} \times 100$$

Where, W1= weight (g) of the empty crucible.

W2= weight (g) of the crucible with sample.

W3 = weight (g) of the crucible with ash.

Total carbohydrate content was calculated by subtracting the sum of moisture, fat, protein, and ash content from 100%.

Phytic acid test performed using a kit supplied by Megazyme International Limited, Ireland. About 1g of sample was weighed in a 75 mL beaker and extracted with 20 mL of 0.66 M hydrochloric acid for at least 3 hours at room temperature. The extract was centrifuged, and 0.5 mL of the supernatant was neutralized with

Milk

↓

Standardisation

↓

Khoa (Dhap) ←Addition of millets (kodo, foxtail)

↓

Kneading and smooth dough

↓

Ball formation (8-10 g)

↓

Frying in refine oil (120-140°C for 10-15 min)

↓

Soaking (sugar syrup 50%) for 2-3 hours

↓

Transfer to fresh sugar syrup (50%)

↓

Stored under refrigeration (7°C)

Fig. 1. Flow diagram of preparation of millets-based gluten free *Gulab jamun*

0.5 mL of 0.75 M sodium hydroxide. This neutralized extract was then used for the subsequent enzymatic dephosphorylation reaction. The absorbance was measured of both the "Free Phosphorus" and "Total Phosphorus" samples at 655 nm.

Phytic acid in the sample was determined using the following formula:

$$\text{Concentration of phytic acid} = \frac{\text{Phosphorus (g/100g)}}{0.282}$$

Sensory evaluation

Using composite scoring scale for given the judgement on prepared sample *(gulab jamun*) by panel of Nine semi-trained judges, consisting of faculty members and research scholars from the Dairy Technology Division, were selected for their expertise in discrimination and communication judged for overall acceptability and sensory quality of *gulab jamun* such as flavour, body and texture, appearance, color acceptability. All types of scores of triplicate samples noted and using statistically analyzed. The samples were number coded for identification after judgement.

Statistical analysis

All experimental data collected were recorded as mean ± standard error (SE) and underwent statistical analysis to derive precise and valid conclusions. A one-way analysis of variance (ANOVA) was performed on the data, followed by Tukey's post-hoc test to identify significant differences between mean values at a 5% significance level ($P< 0.05$).

Results and Discussion

Gulab jamun samples were prepared using kodo and foxtail millet in two different forms, *viz*., paste and flour form, and was compared with the control sample (prepared using refined wheat flour) for proximate composition and sensory attributes. The results so obtained are discussed in the following sections.

Proximate composition of millet added *gulab jamun*

Proximate composition of *gulab jamun* prepared using different forms of kodo millet is presented in Table 1. Moisture content in *gulab jamun* sample prepared using kodo millet flour was 31.78±0.30% and kodo millet paste was 32.25±0.21%, which was significantly ($p<0.05$) lower than the control *gulab jamun* sample prepared using refined wheat flour (33.81±0.17%). Fat content in all the samples were significantly not different ($p>0.05$) and ranged from 12.51±0.25 to 12.86±0.08%. Protein content in the product increased significantly ($p<0.05$) with the application of kodo millet flour (8.26±0.09%) as compared to control sample (8.09±0.07%). Similarly, ash content in the product also increased significantly ($p<0.05$) with the application of kodo millet. Ash content in the sample prepared using kodo millet flour was 1.98±0.05% and kodo millet paste was 1.88±0.08%, which was significantly higher ($p<0.05$) than the ash content in the control sample (1.64±0.06%). Also, carbohydrate content in the product was highest in kodo millet flour added sample (45.13±0.31%) as compared to the kodo millet paste added sample (44.68±0.59%) and control sample (43.64±0.21%). Phytic acid (an anti-nutritional factor) content was higher in the sample prepared using kodo millet flour (0.31±0.00 mg/g), followed by the sample prepared using kodo millet paste (0.21±0.00 mg/g) and the control sample (0.11±0.00 mg/g). Changes in the proximate composition of the product, *viz*., decrease in moisture content and increase in protein, ash and phytic acid content with the addition of millet could be attributed to the higher protein, ash and phytic acid content in the millet as compared to the kodo millet. Vijaykumar et al. (2013) subjected kodo millet to heat treatments such as boiling for 25 minutes at 95-100°C, steaming at 80-90°C and pressure cooking at 9.8×10^{4} Pa for 20 minutes. The authors reported that boiling resulted into the highest porosity and water absorption among the different treatments. Similar results are reported by Deshpande et al. (2015) while processing kodo millet for preparation of traditional Indian food products.

Moisture content in *gulab jamun* prepared using foxtail millet flour was 31.46±0.22% and 31.81±0.42% in the sample prepared using foxtail millet paste, both of which were significantly lower ($p<0.05$) than the moisture content of control *gulab jamun* sample (33.75±0.34%). Fat content in all the three samples ranged from 12.38±0.19% to 12.77±0.14%, which were significantly not different ($p>0.05$) from each other. Similarly, protein content in the three samples were significantly not different ($p>0.05$) from each other and ranged from 8.41±0.11% to 8.62±0.12% (Table 2). Ash content in the control *gulab jamun* sample was 1.57±0.08%, which was significantly lower ($p<0.05$) than the sample prepared using foxtail millet flour (2.27±0.14%) and foxtail millet paste (2.07±0.11%), which could be attributed to the higher amount of minerals in foxtail millet as compared to refined wheat flour. Similarly, carbohydrate content in control sample was (43.46±0.28%), which was significantly lower than the foxtail millet flour (44.88±0.21%) and foxtail millet paste (45.22±0.37%) added sample. Phytic acid content in foxtail millet added sample was 3-5 time higher (0.50±0.00 mg/g product in flour added sample and 0.32±0.00 mg/g product in paste added sample) as compared to control sample (0.11±0.00 mg/g product). This could be attributed to the refining process employed during the manufacture of refined wheat flour which results into lowering of phytic acid content in it. Further, foxtail millet paste added sample had significantly lower ($p<0.05$) phytic acid content as compared to foxtail millet flour added sample, which could be the boiling and soaking treatment might have resulted into decrease in the phytic acid content in the foxtail millet. Pawar and Machewad (2006) soaked foxtail millet grains in distilled water (1:5, w/v) for 12 h at ambient room temperature, followed by cooking in distilled water (1:3, w/v). The authors reported that phytate content in the grain decreased by 49.89% upon processing of the grains.

Sensory attributes of millet added *gulab jamun*

Gulab jamun prepared using different forms of kodo millet was presented to the sensory panellists and the results so obtained are presented in Table 3. Control *gulab jamun* had flavour score

Table 1: Proximate composition of *gulab jamun* using different forms of kodo millet[#]

Sample	Moisture (%) (w\w)	Fat (%) (w\w)	Protein (%) (w\w)	Ash (%) (w\w)	Carbohydrates (%) (by diff.)	Phytic Acid (mg/g)
Control	33.81±0.17^{a}	12.81±0.14^{a}	8.09±0.07^{b}	1.64±0.06^{b}	43.64±0.21^{b}	0.11±0.00^{c}
Paste	32.25±0.21^{b}	12.51±0.25^{a}	8.17±0.05^{ab}	1.88±0.08^{a}	44.68±0.59^{a}	0.31±0.00^{a}
Flour	31.78±0.30^{b}	12.86±0.08^{a}	8.26±0.09^{a}	1.98±0.05^{a}	45.13±0.31^{a}	0.21±0.00^{b}

*Values are mean ±SD (n=3)
a b c: values with different superscript in the same column denote significant difference ($P<0.05$)
#: kodo millet added at 30% level

Table 2: Proximate composition of *gulab jamun* using different forms of foxtail millet[#]

Sample	Moisture (%) (w\w)	Fat (%) (w\w)	Protein (%) (w\w)	Ash (%) (w\w)	Carbohydrates (%) (diff.)	Phytic Acid (mg/g)
Control	33.75±0.34^{a}	12.79±0.09^{a}	8.43±00.15^{a}	1.57±0.08^{b}	43.46±0.28^{b}	0.11±0.00^{c}
Paste	31.81±0.42^{b}	12.38±0.19^{b}	8.41±0.11^{a}	2.07±0.11^{a}	45.22±0.37^{a}	0.32±0.00^{b}
Flour	31.46±0.22^{b}	12.77±0.14^{a}	8.62±0.12^{a}	2.27±0.14^{a}	44.88±0.21^{a}	0.50±0.00^{a}

*Values are mean ±SD (n=3)
a b c: values with different superscript in the same column denote significant difference ($P<0.05$)
#: foxtail millet added at 35% level

of 33.83±0.17, body and texture score of 27.68±0.69, appearance score of 18.19±0.62, color score of 14.19±0.37 and overall acceptability score of 93.83±1.38. *Gulab jamun* prepared using paste form of kodo millet had flavour score of 29.22±1.01, body and texture of 25.19±0.62, appearance score of 17.27±0.59, color score of 13.25±0.30, and overall acceptability of 84.91±2.13, while the sample prepared using flour form of kodo millet had 25.52±1.33 flavour score, body and texture score of 24.44±0.53, appearance score of 17.22±0.59, color score of 13.24±0.28, and overall acceptability of 80.42±0.89. It was observed that control sample had significantly higher ($p<0.05$) sensory acceptability as compared to the sample prepared using kodo millet. This could be attributed to the constituents imparted by the millet, *viz*., fibre, phytochemicals and mineral, which altered the flavour and other sensory attributes of the product. Further, *gulab jamun* prepared using paste form of kodo millet had higher sensory acceptability as compared to the product using flour form of the millet. This could be attributed to the changes in structure and characteristics of the millet upon boiling in hot water and subsequent grounding.

Sensory attributes of *gulab jamun* prepared using different forms of foxtail millet is presented in Table 4. Control *gulab jamun* had flavour score of 32.91±0.63, body and texture score of 27.71±0.75, appearance score of 18.29±0.26, color score of 13.41±0.38 and overall acceptability score of 92.66±1.31. *Gulab jamun* prepared using paste form of foxtail millet had flavour score of 27.58±0.69, body and texture of 26.54±0.63, appearance score of 17.79±0.44, color score of 12.83±0.51, and overall acceptability of 84.75±0.57, while the product prepared using foxtail millet flour had flavour score of 25.00±0.65, body and texture score of 25.12±0.57, appearance score of 17.12±0.13, color score of 13.33±0.19, and overall acceptability of 80.46±0.81. Similar to kodo millet samples, control sample had higher sensory acceptability as compared to foxtail millet added *gulab jamun*, and paste form of foxtail millet

Table 3: Sensory scores of gulab jamun using different forms of kodo millet[#]

Parameters	Flavour	Body and texture	Appearance	Color	Overall acceptability
Control	33.83±0.17[a]	27.68±0.69[a]	18.19±0.62[a]	14.19±0.37[a]	93.83±1.38[a]
Paste	29.22±1.01[b]	25.19±0.62[b]	17.27±0.59[a]	13.25±0.30[b]	84.91±2.13[b]
Flour	25.52±1.33[c]	24.44±0.53[b]	17.22±0.42[a]	13.24±0.28[b]	80.42±0.89[c]

*Values are mean ±SD (n=3)
a b c: values with different superscript in the same column denote significant difference ($P<0.05$)
[#]: kodo millet added at 30% level

Table 4: Sensory scores of gulab jamun using different forms of foxtail millet[#]

Parameters	Flavour	Body and texture	Appearance	Color	Overall acceptability
Control	32.91±0.63[a]	27.71±0.75[a]	18.29±0.26[a]	13.41±0.38[a]	92.66±1.31[a]
Paste	27.58±0.69[b]	26.54±0.63[ab]	17.79±0.44[ab]	12.83±0.51[a]	84.75±0.57[b]
Flour	25.00±0.65[c]	25.12±0.57[b]	17.12±0.13[b]	13.33±0.19[a]	80.46±0.81[c]

*Values are mean ±SD (n=3)
a b c: values with different superscript in the same column denote significant difference ($P<0.05$)
[#]: foxtail millet added at 35% level

Table 5: Sensory scores of gulab jamun using different forms of millets#

Millets	Flavour	Body and texture	Appearance	Colour	Overall acceptability
Control	33.33±0.47[a]	27.29±0.62[a]	19.17±0.23[a]	14.17±0.23[a]	93.96±0.62[a]
Kodo (30%)	31.62±1.06[b]	26.98±0.66[b]	18.62±0.45[b]	12.70±0.19[b]	89.93±1.02[b]
Foxtail (35%)	29.46±0.85[c]	27.25±1.02[b]	18.00±0.66[b]	13.41±0.40[ab]	88.12±1.06[b]

*Values are mean ±SD (n=3)
a bc: values with different superscript in the same column denote significant difference ($P<0.05$)
#: kodo millet added at 30% level, foxtail millet added at 35% level

Table 6: Proximate scores of gulab jamun using different forms of millets#

Sample	Moisture (%) (w\w)	Fat (%) (w\w)	Protein (%) (w\w)	Ash (%) (w\w)	Carbohydrates (%) (by diff.)	Phytic Acid (mg/g)
Control	33.79±0.22[a]	12.84±0.18[a]	8.07±0.17[a]	1.62±0.03[a]	43.61±0.31[a]	0.11±0.00[a]
Kodo (30%)	32.54±0.15[b]	12.26±0.11[b]	8.40±0.07[b]	2.04±0.07[b]	45.98±0.02[b]	0.21±0.00[b]
Foxtail (35%)	31.38±0.15[c]	12.14±0.06[b]	8.65±0.11[b]	2.16±0.05[b]	45.67±0.29[c]	0.32±0.00[c]

*Values are mean ±SD (n=3)

a b c: values with different superscript in the same column denote significant difference (P<0.05)

#: kodo millet added at 30% level, foxtail millet added at 35% level

had higher sensory acceptability as compared to flour form of foxtail millet.

Selection of millet and its form for preparation of gluten free *gulab jamun*

In the next part of the research, millet added *gulab jamun* samples having highest sensory acceptability was selected for both the millet and compared with control sample. For both the studied millet, paste form of millet addition was found to be more preferable as compared to the flour form. This could be attributed to the changes taking place in the millet with soaking, boiling treatment and grounding treatment. Soaking would have resulted into increasing in the moisture content of the millet and boiling treatment would have resulted into heat induced changes in the millet, viz., decrease in anti-nutritional factors (Yousaf et al. 2021).

Among the two millets, it was observed that *gulab jamun* prepared using kodo millet paste (31.62±1.06) had higher flavour score as compared to foxtail millet (29.46±0.85), while the product prepared using refined wheat flour (control) had highest flavour score (33.33±0.47) among the three samples (Table 5). Body and texture score of all the samples ranged from 26.98±0.66 to 27.29±0.62, which was significantly not different (p<0.05) from each other. Appearance score of the sample prepared using foxtail millet was significantly lower (p<0.05) as compared to the other samples. Color score of the control sample (14.17±0.23) was highest and the sample prepared using kodo millet paste (12.70±0.19) was significantly lower (p<0.05). Overall acceptability score of control *gulab jamun* was 93.96±0.62, which was significantly higher (p<0.05) than the sample prepared using kodo millet paste (89.93±1.02) and foxtail millet paste (88.12±1.06).

The selected millet based *gulab jamun* sample was compared with the control sample prepared using refined wheat flour for proximate composition and the results are presented in Table 6. Among the three samples, control sample had highest moisture content (33.79±0.22%), while the moisture content in kodo millet (32.54±0.15%) and foxtail millet (31.38±0.15%) was significantly lower (p<0.05) than that of the control sample. Fat content in the samples ranged from 12.14±0.06% to 12.84±0.18% and was significantly not different (p>0.05) from each other. Protein content in the sample ranged from 8.07±0.17% to 8.65±0.11% and the sample prepared using foxtail millet had significantly higher (p<0.05) protein content as compared to other *gulab jamun* samples. Similar to ash content and carbohydrate content were significantly higher (p<0.05) in the samples prepared using millets. Phytic acid in the millet added samples were higher as compared to the control samples. Further, the samples prepared using foxtail millet had significantly higher (p<0.05) phytic acid content as compared to the sample prepared using kodo millet.

Conclusion

This study successfully developed a gluten-free version of *gulab jamun* by incorporating kodo and foxtail millet, particularly in paste form, as substitutes for refined wheat flour. The use of millets significantly enhanced the nutritional profile, increasing protein and ash content while reducing moisture compared to the traditional recipe. While sensory scores for the millet-based versions were slightly lower, the paste form showed better overall acceptability. Kodo millet paste emerged as the most promising option, offering a balanced combination of nutritional benefits and desirable sensory attributes. These findings support the incorporation of millets in traditional sweets, providing a healthier, gluten-free alternative that meets dietary needs without compromising taste.

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