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# Cooking Properties and Textural Dynamics of Proso Millet-Rice Flour Noodles: A Gluten-Free Approach

Anushka Singh, Sunil Kundu, Manisha Malik *, Aastha Dewan * and Aazad Reddu

*Department of Food Technology, Guru Jambheshwar University of Science and Technology, Hisar125001, India*
*(e-mail:malikmanisha252@gmail.com (M.M.); 23aastha10@gmail.com (A.D.))

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## ABSTRACT

The present study aimed to develop nutritionally enhanced, gluten free noodles suitable for gluten-related disorders and health-conscious consumers. Rice flour (RF) and proso millet flour (PMF) were used to prepare different noodles formulations namely, S1-100:0, S2-75:25, S3-50:50, S4-25:75, S5-0:100, respectively. Proximate composition, cooking, textural, and sensory properties of prepared gluten-free noodles were investigated. PMF incorporation in noodle formulation resulted in significant increment in ash content, crude fiber and crude protein values. S1 (0% PMF) had the lowest value of 1.9% crude protein and 0.69% crude fiber, whereas S5 (100% PMF) were observed with 12.60% crude protein and 12.05% crude fiber. Cooking time increased from 7.34 min (S1) to 11.02 min (S5) with rising concentration of PMF which might be attributed to its higher protein content. Cooking loss enhanced with increasing proportion of PMF in samples due to the higher content of fiber which resulted in porous structure and loose binding of soluble components. PMF-based noodles represented higher cooking yield due to their high fiber directing higher water uptake during cooking. Firmness of noodles enhanced with increasing percentage of PMF in noodles indicated by increase in hardness from 9.48 N (S1-0% PMF) to 14.07 N (S5-100% PMF). Sensory evaluation indicated the acceptance of all developed gluten free noodles; however, it was highest (7.76) for noodle prepared with 75% PMF and 25% RF. The study suggests that 75% PMF can be substituted in formulating gluten free noodles which are healthy and nutritionally wholesome for consumers.

**Keywords:** cooking quality, proso millet noodles, protein content, firmness, overall acceptability

## INTRODUCTION

Noodles have been an Asian cuisine cornerstone for millennia. Unfermented dough is stretched, extruded, or rolled to develop various shapes (Niu & Hou, 2020). Noodles account for almost 40% of wheat grown in Asia and consumed worldwide owing to its affordability, convenience and versatility in texture and flavor (Malik et al., 2024a). Noodles are believed to have originated in China around 5000 BC and spread across various Asian countries (Hou, 2020). According to WINA's (World Instant Noodles Association) May 2024 report, total 120210 million servings were consumed by world in 2023. Globally, China has a huge demand for instant noodles, followed by Indonesia, Vietnam, India, Japan, and the US (Statista 2022). Typically, noodles are manufactured by mixing wheat flour, water, salt and alkaline reagents (Malik et al., 2024b), thereby containing gluten which make them unsuitable for individuals with gluten intolerance or those following gluten-free diets (Koca et al., 2018). Gluten is a water-insoluble wheat protein complex mainly composed of gliadin and glutenin, responsible for viscoelastic nature of dough (Dewan et al., 2024).

Wheat-based meals and processed items are widely consumed owing to its affordability, availability, and viscoelastic qualities. However, this trend has led to the rise of gluten-related disorders such as celiac disease and non-celiac sensitivity (Singla et al., 2024). Celiac disease (CD) is a type of autoimmune condition that arises from genetic factors (HLA-DQ2 and HLA-DQ8), autoantibodies (anti-transglutaminase), and environmental factors (gluten ingestion), leading to intestinal (diarrhoea, abdominal discomfort, and constipation) and extraintestinal (weight loss, anaemia, osteoporosis, dermatitis herpetiformis, and neurological disorders) manifestations (Mazzola et al., 2024). CD prevalence is believed to be around 1% globally, however it appears to be rising, via inconsistent distribution and areas exceeding up to 3% (sero-prevalence) across Saudi Arabia (Ashtari et al., 2021). At present, a gluten-free diet (GFD) is the backbone of CD treatment and gluten related disorders (Aljada et al., 2021).

Consumer demand for gluten-free (GF) products has surged over the past decades (Christoph et al., 2018). To develop gluten-free product, rice flour is the most ideal substitute for wheat flour due to its hypoallergenic and neutral nature (Garcia et al., 2016; Wu et al., 2019). Despite, its low fibre and micronutrient content, along with limited dough forming capabilities responsible for poor textural characteristics (Matos and Rosell, 2015). Hydrocolloids such as guar gum have been recognised to enhance viscoelastic and water retention of rice-based doughs. Guar gum's ability to create hydrogen bonds with water molecules improves dough chewiness and elasticity, which results in smoother noodles and a better mouthfeel (Singh et al., 2021). However, many researchers have explored rice as base in formulating comfort food for celiac patients like gluten-free noodles utilising white rice (Sofi et al., 2020), and gluten-free based rice snacks (Chuechomsuk et al., 2024).

Millets are small, seeded cereal crops from the Gramineae family that are commonly farmed for both food and feed (Srujana et al., 2022). According to Dewan et al. (2022), pearl millet (Pennisetum glaucum), foxtail millet (Setaria italica), proso millet (Panicum miliaceum), and finger millet (Eleusine coracana) are the most extensively grown species globally. Proso millet is widely grown throughout the arid and semiarid regions of worldwide, including Asia and Europe. Proso millet is nutrient-dense and gluten-free, with high quantities of resistant starches and amylose content (Chang et al., 2023). Proso millet has been explored to develop many gluten-free products like bread (Vučko et al., 2022), cookies (Kumari et al., 2023), cupcakes (Raza et al., 2024) and other convenience food (Naga Sai Srujana, 2023). However, its combination with rice flour has not been investigated yet to formulate gluten-free noodles.

Thus, the present study aimed to develop gluten-free noodles employing varying proportions of rice flour and nutrient dense proso millet flour, stabilized with guar gum. Gluten free noodles were assessed in terms of proximate composition, cooking quality, textural characterises, and sensory properties with the goal of providing a nutritious and acceptable alternative for gluten-sensitive and health-conscious consumers.

## MATERIALS AND METHODS

### Materials for Dried Noodles

Procured Proso Millet Flour (Ravikamal Flour Mills Pvt Ltd. (Chinchawali Gohe, Maharashtra, India)procured from Amazon), Rice Flour (glutinous rice) (Satvyk procured from Amazon) and Guar Gum Powder (Feyn Foods Pvt Ltd.(Secunderabad, Telangana, India) procured from Amazon) was passed through a 375-mesh sieve. The flour was then stored in an airtight sealed bag, away from sunlight, until required for further study.

### Preparation of Noodles

RF and PMF were weighed in ratio as mentioned in Table 1 and blended with 1% guar gum in a Kitchen Machine Kenwood KM010 dough mixer at room temperature for 5–10 min at a constant speed. 40% water was added. To avoid moisture loss, the dough was rested in zip-lock pouches for around 30 min at room temperature (25 °C). Additionally, a rice-based dough was made using a control consisting of 40 mL of water, 100 g of rice flour and 1 g of guar gum. After resting, the dough was sheeted and laminated four times in a noodle-making machine. Sheeted dough was run through a noodle-making machine to achieve a thickness of 1.0 mm. Fresh noodles were oven dried at 75–80 °C for 25–35 min. Then prepared noodles were stored in airtight zip-lock pouches as per stated by Malik et al. (2024c).

**Table 1.** Ratio of Proso millet and rice flour for formulations of dried noodles (in g)

| Ingredients | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|
| Rice flour | 100 | 75 | 50 | 25 | 0 |
| Proso Millet Flour | 0 | 25 | 50 | 75 | 100 |

### Chemical Composition

Moisture content (%), crude protein content (%), crude fat content (%), crude fiber content (%) and ash content (%) were measured in triplicates using AOAC-approved procedures (AOAC, 2012). Total carbohydrate was estimated using the difference approach (Huber & BeMiller, 2024). All parameters were determined on dry-weight method. Nitrogen content was measured using the macro-Kjeldahl method, and factor 6.25 was used to convert nitrogen to crude protein.

### Cooking Quality

Following the AACC method 66-50 (AACC, 2005), 10 g noodle strands were added to 500 mL of boiling water in a beaker. Optimum cooking time was determined when the white centre of ungelatinized starch had just disappeared. To quantify cooking loss, a part of 10 mL of the water that remained after cooking, along with rinsings, was collected in pre-weighed petri-plates and dried in an oven at

105 °C for 4 h. After cooking, the noodles were cooled in running tap water for 1 min. The drained noodles were wiped to remove excess water from their surface, then weighed and stored in a covered petri plate at room temperature (25 °C) for 5 min before the texture analysis. 50 mL of aliquot was taken from the water left after cooking along with rinsing and was evaporated in oven at 105 °C in petri plate until constant weight to determine cooking loss. Results have been reported as % weight loss during cooking. The gain in noodle weight after cooking was recorded as cooked weight (Malik et al., 2024c).

**Sensory Evaluation**

Sensory assessment was performed using 9-point hedonic scale (Malik et al., 2024c). Noodles were cooked in boiling water to optimum cooking time with just disappearance of inner white core and served at room temperature to 45 semi-trained panellists. Panellistsanalysed sensory attributes such as appearance, aroma, taste, texture and overall acceptability of every noodle sample and water was provided for thorough rinsing between two samples's sensory evaluation.

**Texture Analysis**

The textural parameters of cooked gluten-free noodles were analysed using textural analyzer (TA-XT plus) as per Malik et al., 2024b. The evaluation of texture comprised two different types of tests: a texture profile analysis (TPA) test with a flat cylindrical probe P/75. The test was performed by measuring force on compression, using a 5 kg load cell and a trigger force of 0.05 N. For the perforation test, the perforation distance was 3 mm, the pretest speed was 2.0 mm/s, the test speed was 1.0 mm/s, and the post-test speed was also 1.0 mm/s. For the TPA test, the compression distance was 50% of the average strand thickness, and the pretest, test, and post-test speeds were all equal to 0.5 mm/s. Two compression cycles were performed with a 5 s interval between them. The properties evaluated through the TPA were hardness, adhesiveness, cohesiveness, springiness, gumminess, and chewiness. The tests were performed at room temperature ranging from 27 °C to 30 °C.

**Statistical Analysis**

All the raw data obtained was subjected for statistical analysis using excel and represented as mean ± standard deviation. The data was subjected for ANOVA using Duncan's multiple range test for statistical significance employing SPSS software version 16.0 (SPSS Inc., Chicago, IL, USA)

**RESULTS AND DISCUSSIONS**

**Proximate Composition of Proso Millet and Rice-Based Gluten-Free Noodles**

Rice flour comprised of 5.6% moisture content, 0.93% ash content, 1.85% crude protein content, 0.69% crude fibre content, 0.48% crude fat and 90.45% as carbohydrate content (Table 2). Proximate analysis of proso millet revealed 6.5% moisture content, 4.4% ash content, 12.52% crude protein content, 12.02% crude fibre content, 2.7% crude fat content and 61.86% carbohydrate content.Moisture content of gluten free noodles ranged from 8.8% (S1) to 7.1% (S5). Significant decline in the moisture content was notice on the increasing PMF concentration.When PMF concentration was least i.e., 25%, the moisture content of dried noodles was 8%, while with 100% PMF in the noodles, the moisture content was 7.1%. A previous study on rice flour and different millet flours revealed that the moisture content of rice flour (11.10%) is slightly more than proso millet flour (10.93%) (Kumari et al., 2023).
Ash content of the prepared noodles was increased from 0.96% for S1) to 4.43% (S5).
The possible reason for this rise might be the higher mineral content of proso millet flour. According to Dewan et al. (2022), the mineral content of proso millet ranges from 1.5% to 4.2%. However, the mineral content also decreases due to process of dehulling (Singh et al., 2024). The protein content was enhanced significantly from 7.9% (0% PMF) in S1 to 12.6% (100% PMF) in S5. This could be due to the rising concentration of proso millet flour which is rich in protein (Sun et al., 2014). The fiber content of noodles also increased at a greater extent from 0.69% (S1) to 3.64% (S2), 6.62% (S3), 9.71% (S4) and 12.05% (S5). This also due to that dehulled proso millet grain has highest fiber content 14.91% almost equal to kodo millet with 14.94% as crude fiber conten (Ch et al., 2020). The fat content of PMF contain gluten-free noodle is little higher (1% in S2; to 1.11% in S4) than that of 100% rice flour noodles (0.98% fat). Overall, the chemical composition of prepared noodles manifested that the proso millet enhanced the nutritional quality of gluten free noodles with significant rise in the content of protein, ash and fiber in S5.

**Table 2.** Chemical composition of gluten free noodles.

| Sample | Moisture (%) | Ash (%) | Crude protein (%) | Crude fiber (%) | Crude fat (%) | Carbohydrate (%) |
|---|---|---|---|---|---|---|
| S1 | 8.8 $^{c}$ ± 0.13 | 0.96 $^{a}$ ± 0.04 | 1.9 $^{a}$ ± 0.05 | 0.69 $^{a}$ ± 0.07 | 0.48 $^{a}$ ± 0.03 | 87.18 $^{e}$ ± 0.08 |
| S2 | 8 $^{b}$ ± 0.03 | 1.86 $^{b}$ ± 0.03 | 5.07 $^{b}$ ± 0.35 | 3.64 $^{b}$ ± 0.03 | 1.05 $^{b}$ ± 0.03 | 80.43 $^{d}$ ± 0.14 |
| S3 | 7.8 $^{b}$ ± 0.18 | 2.72 $^{c}$ ± 0.05 | 7.45 $^{c}$ ± 0.13 | 6.62 $^{c}$ ± 0.07 | 1.44 $^{c}$ ± 0.07 | 73.97 $^{c}$ ± 0.13 |
| S4 | 7.6 $^{ab}$ ± 0.23 | 3.59 $^{d}$ ± 0.06 | 10.02 $^{d}$ ± 0.17 | 9.71 $^{d}$ ± 0.20 | 2.17 $^{d}$ ± 0.05 | 66.31 $^{b}$ ± 0.04 |
| S5 | 7.1 $^{a}$ ± 0.56 | 4.43 $^{e}$ ± 0.04 | 12.60 $^{e}$ ± 0.31 | 12.05 $^{e}$ ± 0.19 | 2.71 $^{e}$ ± 0.05 | 61.21 $^{a}$ ± 0.21 |

Values are presented as mean ± standard deviation of triplicate readings. Superscript with different letter in the same column are significantly ($p < 0.05$) different. Ratio of RF and PMF as S1-100:0, S2-75:25, S3-50:50, S4-25:75, S5-0:100, respectively. Abbreviations: RF—Rice flour, PMF—Proso millet flour.

## Cooking Quality of Noodles

Cooking quality of gluten free noodles are presented in Fig. 1 and Table 3. Cooking time (CT), cooked weight (CW), cooking loss (CL) or gruel solid loss, and water uptake are all important factors that determines the cooking quality of noodles. Superior quality noodles require less time to cook and lose just a little soluble solid in the cooking water (Malik et al., 2024b). Cooking time of the developed gluten-free noodles samples varied from 7.34 to 11.02 min. The least cooking time 7.34 min was observed for noodles prepared with 100% RF only. However, on the other hand, with the rising proportion of proso millet in noodles, cooking time tend to surge owing to the more protein content of proso millet flour. It has been proven that the increasing concentration of protein content in the formulation of noodles increase it's cooking time (Dewan et al., 2025). Cooking loss of developed noodles varied from 5.2% to 6.4%. It was noticed that the cooking loss of rice-based noodles was least (5.2%). Nevertheless, on increasing the percentage of proso millet in noodles, the cooking loss augmented due to the enhancement in the protein content of the finished product. Increasing concentration in the noodle formulation holds the network firmly resulting in less cooking losses (Dewan et al., 2025). Among the many elements that influence water absorption (WA) are amylose, protein, degraded starch, and other flour ingredients (Xiao et al., 2023). Water uptake of developed gluten free noodles ranges from 22.21 g to 28.03 g and it is comparatively higher than millet-based noodles i.e., around 12% (as reported by Xiao et al., 2023). The higher water uptake in developed noodles may be due to the addition of guar gum as guar gum swells and creates a strong hydrogen bond when mixed with a polar solvent (Mahmood et al., 2017). The noodles' ability to retain water was enhanced by the strong hydrogen bond they developed (Dahal et al., 2020). Overall, proso millet and rice-based gluten-free noodles were easy to cook and yielded acceptable cooking quality for commercial production and consumption as noodles made from rice flour have a bouncy and silky feel and require less cooking time (Chen et al., 2024).


Fig. 1. Images of 5 cooked gluten free noodles samples where Sample 1 (S1) is made of 100% rice flour, sample 2 (S2) with 75% rice flour and 25% proso millet flour, sample 3 (S3) with 50% rice flour and 50% proso millet flour, sample 4 (S4) with 25% rice flour and 75% proso millet flour and sample 5 (S5) with 100% proso millet flour.

**Table 3.** Cooking parameters of RF and PMF based gluten free noodles.

| Samples | Cooking time (min) | Cooking loss (%) | Cooked weight (g) | Water uptake (g) |
|---|---|---|---|---|
| S1 | 7.34 $^{a}$ ±0.41 | 5.2 $^{a}$ ± 0.20 | 33.29 $^{a}$ ± 0.64 | 22.21 $^{a}$ ± 1.05 |
| S2 | 7.50 $^{a}$ ±0.35 | 5.7 $^{b}$ ± 0.20 | 34.85 $^{b}$ ± 0.52 | 24.82 $^{b}$ ± 0.56 |
| S3 | 8.40 $^{b}$ ± 0.33 | 5.8 $^{b}$ ± 0.24 | 36.48 $^{c}$ ± 0.36 | 26.44 $^{c}$ ± 0.62 |
| S4 | 9.29 $^{c}$ ± 0.69 | 6.1 $^{bc}$ ± 0.22 | 37.3 $^{cd}$ ± 0.65 | 27.09 $^{cd}$ ± 0.36 |
| S5 | 11.02 $^{d}$ ± 0.25 | 6.4 $^{d}$ ±0.23 | 38.09 $^{d}$ ± 0.42 | 28.03 $^{d}$ ± 0.60 |

Values are presented as mean ± standard deviation of triplicate readings. Superscript with different letter in the same column are significantly ($p < 0.05$) different. Ratio of RF and PMF as S1-100:0, S2-75:25, S3-50:50, S4-25:75, S5-0:100, respectively. Abbreviations: RF—Rice flour, PMF—Proso millet flour.

## Texture Analysis

Table 4 summarizes the texture profile of cooked gluten free noodles which includes their hardness, adhesiveness, cohesiveness, springiness, and chewiness. Textural analysis revealed that S5 were hardest sample 14.07 N, while S1 were the softest 9.48 N among all samples. Inclusion of proso millet flour to the sample enhanced the hardness of the noodles. The possible reason might be the increasing protein concentration in the noodles resulting in the firmer texture. Adhesiveness of the samples ranged from 0.34 N/s and 1.6 N/s. Maximum adhesiveness (1.6) was noticed with S1, while the lowest (0.34) with S5. It indicated that rice-based noodles are more adhesive, whereas with increasing percentage of proso millet reduced the adhesiveness of noodles. This might be due to that rice noodles had low amylose concentration exhibited stronger adhesiveness, resulting in stickier cooked noodles (Ahmed et al., 2016). Higher amylose content tends to produce firmer noodles resulting in lower breakage rate, lower cooking and better noodle quality. The interaction of starch and protein create more compact and stable network in rice-based noodles making rice as a suitable ingredient in developing gluten-free noodles (Huang et al., 2023). Proso millet addition improves the quality and protein content of noodles as referred by Han et al., 2011 that lower adhesiveness indicates high-quality noodles, resulting in a smooth and clean texture. El-Sohaimy et al. (2020) defined cohesiveness as a ratio of the area under the pressure peaks during second compression to the area impacted by pressure during first compression. It can also be quantified based on the degree of mechanical crushing (Ayuningtyas et al., 2024). Cohesiveness of the noodle samples ranged from 0.41 to 0.9 where S5 was highly cohesive and S1 was least cohesive. Enhanced cohesiveness might be responsible due to the rising strength and bonding of internal structure of noodles due to the rising concentration of protein content of proso millet. Addition of guar gum and xanthan gum were found to enhance the water holding capacity and textural properties of gluten free noodles formulated employing corn flour, millet flour and egg (Dahal et al., 2020). Proso millet starch granules were held in network by employing hydrocolloids like xanthan gum and guar gum in formulating gluten-free pasta (Romero et al., 2017). Chewiness of cooked gluten-free noodles increases from S1 (2.52 N) to S5 (10.51 N), indicating that increasing the percentage of proso millet flour in the noodles formulation resulted in enhanced chewiness. Increasing proportion of protein content in gluten-free noodles formulation results in firm, springier and chewier noodles which is the desirable quality.

**Table 4.** Textural properties of Rice flour and Proso millet flour-based gluten-free noodles.

| Samples | Hardness (N) | Springiness | Adhesiveness (N/s) | Cohesiveness | Chewiness (N) |
|---|---|---|---|---|---|
| S1 | 9.48 $^{a}$ ± 0.07 | 0.65 $^{a}$ ± 0.04 | 1.6 $^{d}$ ± 0.11 | 0.41 $^{a}$ ± 0.02 | 2.52 $^{a}$ ± 0.51 |
| S2 | 10.12 $^{b}$ ± 0.03 | 0.69 $^{ab}$ ± 0.10 | 1.2 $^{c}$ ± 0.06 | 0.55 $^{b}$ ± 0.05 | 3.87 $^{b}$ ± 0.75 |
| S3 | 11.94 $^{c}$ ± 0.03 | 0.72 $^{ab}$ ± 0.04 | 0.98 $^{b}$ ± 0.02 | 0.61 $^{bc}$ ± 0.06 | 5.24 $^{c}$ ± 0.52 |
| S4 | 13.14 $^{d}$ ± 0.06 | 0.78 $^{ab}$ ± 0.04 | 0.87 $^{b}$ ± 0.01 | 0.7 $^{c}$ ± 0.03 | 7.17 $^{d}$ ± 0.51 |
| S5 | 14.07 $^{e}$ ± 0.02 | 0.83 $^{b}$ ± 0.14 | 0.34 $^{a}$ ± 0.05 | 0.9 $^{d}$ ± 0.08 | 10.51 $^{e}$ ± 0.50 |

Values are presented as mean ± standard deviation of triplicate readings. Superscript with different letter in the same column are significantly ($p < 0.05$) different. Ratio of RF and PMF as S1-100:0, S2-75:25, S3-50:50, S4-25:75, S5-0:100, respectively. Abbreviations: RF—Rice flour, PMF—Proso millet flour.

## Sensory Analysis

Sensory evaluation reveals how customers actually perceive food indicating it to be the most essential way to assess the acceptance of developed noodles (Du et al., 2021; Malik et al., 2025). Evaluation markers include the principal taste, colour, and texture (i.e., elasticity, smoothness, hardness, and adhesiveness) (Li et al., 2017). Sensory evaluation is the most crucial test since it provides information about the final product's general acceptance (Meena et al., 2019). Sensory panellists assessed the product's acceptability in terms of appearance, aroma, taste, texture and overall acceptability.

Table 5 indicated the sensory scores of developed gluten free noodles. The gluten free noodles having 100% RF showed the highest overall acceptability of 8.13 as these noodles had best appearance and texture among all noodle samples. However, on incorporation of PMF to the gluten-free noodles, appearance and texture declined significantly in sample 2, 3, 4 and 5. On the contrary, overall acceptability of S4 was the highest i.e., 7.66 among PMF containing noodle samples. Hence, 75% PMF can be added to rice-based gluten free noodles as these noodles are having better acceptable sensory qualities in terms of appearance, aroma, taste and texture.

Acceptability of gluten-free products like cookies (Ajay and Pradyuman, 2018) is dependent on the right proportion of sugar, fat and functional ingredients like skim milk protein powder, copra meal and amaranth.Noodle sample prepare using 100% RF were completely disintegrated upon first bite indicating the least firmness and weak structural integrity due to the minimum interaction of starch and protein in the noodle matrix. On the other hand, noodles prepared employing 100% PMF were firm enough for first bite breakage and revealed higher springiness upon comparing with other noodle samples. The sensory experiences of the samples were in corroboration with the textural analysis.

**Table 5.** Sensory evaluation of gluten free noodles incorporated with Rice flour (RF) and Proso millet flour (PMF) using 9-point hedonic scale.

| Sample | Appearance | Aroma | Taste | Texture | Overall acceptability |
|---|---|---|---|---|---|
| S1 | 8.6 $^{c}$ ± 0.18 | 7.47 $^{a}$ ± 0.57 | 7.66 $^{a}$ ± 0.68 | 8.8 $^{c}$ ± 0.02 | 8.13 $^{b}$ ± 0.36 |
| S2 | 7.9 $^{bc}$ ± 0.27 | 7.23 $^{a}$ ± 0.46 | 7.24 $^{a}$ ± 0.49 | 7.9 $^{b}$ ± 0.27 | 7.56 $^{ab}$ ± 0.37 |
| S3 | 7.5 $^{b}$ ±0.14 | 7.66 $^{a}$ ± 0.29 | 6.93 $^{a}$ ± 0.11 | 7.2 $^{b}$ ± 0.26 | 7.37 $^{a}$ ± 0.20 |
| S4 | 7.6 $^{b}$ ±0.09 | 7.73 $^{a}$ ± 0.13 | 7.25 $^{a}$ ± 0.21 | 7.4 $^{b}$ ± 0.23 | 7.76 $^{ab}$ ± 0.41 |
| S5 | 6.33 $^{a}$ ± 0.86 | 7.66 $^{a}$ ± 0.23 | 7.66 $^{a}$ ± 0.24 | 6.1 $^{a}$ ± 0.73 | 7.29$^{a}$ ± 0.45 |

Values are presented as mean ± standard deviation of triplicate readings. Superscript with different letter in the same column are significantly ($p < 0.05$) different. Ratio of RF and PMF as S1-100:0, S2-75:25, S3-50:50, S4-25:75, S5-0:100, respectively. Abbreviations: RF—Rice flour, PMF—Proso millet flour.

## CONCLUSIONS

Proso millet and rice flour-based dried noodles offer a nutritious and versatile alternative to traditional wheat-based noodles. The nutritional profile of gluten free rice noodles was largely impacted by the inclusion of PMF. The chemical composition of noodles manifested that proso millet and rice-based gluten free noodles can be a good source of protein, fiber and mineral content on comparison with rice-based noodles. Although, cooking quality revealed the higher cooking loss, cooked weight and cooking time, with increasing the proportion of proso millet in noodles which might be due to its fiber content. Desirable textural parameters such as least adhesiveness (0.34 N/s), higher springiness (0.83), chewier (10.51 N) and firmer (14.07 N) cooked noodle strands were revealed with 100% proso millet noodles. However, overall acceptability showed the highest acceptance with noodle sample (S4) prepared using 75% PMF and 25% RF. Overall, the present investigation indicated the highest sensory acceptance of gluten-free noodles prepared with 75% PMF and 25% RF with 10.02% protein, 3.59% minerals and 9.71% fiber could be the best solution among the prepared samples. This blend of PMF and RF could offer a healthy, nutritious alternative to traditional wheat-based noodles and rice-based noodles.

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## CONFLICTS OF INTEREST

There is no conflict of interest among authors regarding the publication of this article.

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