

Research Paper

## Effect of substituting pearl millet flour with rice, wheat and soy flours on quality of noodle strands

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### ABSTRACT

Wheat noodles are very popular due to their unique, versatile culinary use, texture and consumer acceptability. But, a noticeable part of the population requires nutritious noodles, while avoiding gluten to the maximum possible extent due to the intolerance towards gluten digestion. Pearl millet is one of the grains suited to resolve this issue. Additionally, it is hypoglycaemic and thus useful for people prone to diabetes. However, the noodles rich in fibre and lacking gluten are unable to withstand cooking and thereby lead to a high level of losses in the absence of gluten. In view of this, the noodle strands were prepared using pre-treated pearl millet flour through extrusion process. The noodles yielded a significantly lower level of solid loss with a higher level of hydration capacity, cooking time and hardness on substituting pearl millet with defatted soy flour at 50%. This was obtained with respective values of 11.6%, 1.67, 213 seconds and 57.7 N respectively.

**Key words:** Cooking quality, Defatted soy flour, Extrusion processing, Millet pasta, Pearl millet Noodle, Textural quality

### INTRODUCTION

Noodle is a variant of pasta and commonly associated with spaghetti, macaroni and vermicelli etc. The variants of pasta are in consistent demand with immense potential in the Indian market. Indian Pasta Market Outlook Report (2023-2028) revealed its growth from US \$785 million in 2022 to its speculated value at US \$2, 062 million in 2028 (<https://www.imarcgroup.com/indian-pasta-market>). Noodles are universally preferred due to their convenience, versatility, ease of cooking, storage and supply to consumers. The consumption pattern can be understood by the fact that they are the second most consumed form of products in the world, prepared from wheat. The basis behind the preference for wheat is its gluten content, helping in achieving desirable traits of elasticity, plasticity and cohesiveness (Kumar and Prabhashankar 2015). The pasta variants have traditionally been prepared from wheat products following secondary processing. Wheat semolina (*Triticum aestivum*) is utilized as the basic raw material in the preparation of pasta (Gull *et al.* 2017, Jalgaonkar *et al.* 2018a). Durum wheat semolina (*Triticum durum*) is considered the most preferred ingredient exhibiting favourable cooking qualities with uniqueness in colour and flavour.

However, people are looking for alternative grains in the diet with nutritional and functional qualities. Gluten-containing cereals are likely to affect approximately 8.4% of the world population due to wheat allergy, sensitivity to gluten or celiac disease (Sharma *et al.* 2020). The afore mentioned facts have drawn the attention of researchers, industrialists and planners towards the substitution or replacement of wheat with relatively nutritious and functional ingredients for the preparation of noodles. These are prepared from wheat dough, shaped in the desired form and steaming of either in the dough form or noodles or both for gelatinization. The blend of ingredients is moistened and conditioned following the extrusion processing to obtain noodles. Extrusion is a cooking process involving rapid cooking at high temperature and is preferred for continuous operation with relatively higher uniformity. It performs mixing of ingredients followed by kneading, cooking and shaping into the desired form of the final product. The process is utilized to prepare the puffed products through hot extrusion (Prakash *et al.* 2021) and pasta products through cold extrusion (Jalgaonkar and Jha 2016, Prakash *et al.* 2024). Finally, the dried form of the same is cooled under ambient conditions prior to

subjecting it to packaging and storage. In view of enriching noodles with improved nutritional and functional qualities, millets have emerged out of stigma as 'poor man's cereal' to 'nutri cereal'. In the recent past, research has been attempted for preparing the millet-based pasta (Ranganna *et al.* 2014, Thilagavathi and Kanchana, 2017, Jalgaonkar *et al.* 2018a, Hymavathi *et al.* 2019, Bhuvaneshwari and Nazni 2020). Pearl millet is the major millet available in abundance throughout Asia and Africa. Considering the significance of pearl millet and the advantages of extrusion, Prakash *et al.* (2024), attempted to prepare the noodles using pre-treated flour of pearl millet through extrusion. This study has additionally exhibited the possibility for industrial production of millet-based noodles through extrusion processing. Cooking quality, especially solid loss, was quite higher than the acceptable level of 8% as recommended for wheat noodles by BIS: 1485 (2010). Previous reports also indicate the degradation in noodle quality on substitution or replacement of wheat, primarily measured through cooking and textural qualities, including solid loss, cooking time, hydration capacity and hardness. Hence, the influence of rice flour, wheat flour and soy flour on such quality parameters of noodles needs to be documented.

The purpose was to find the composition with improved noodle quality, while harnessing the maximum benefits of pearl millet. Rice flour was chosen to maintain a gluten-free composition while examining the cooking and textural qualities. It is also preferred due to low content of fat and sodium (Turabi *et al.* 2008). Wheat, a staple food, is rich in gluten and was included for its favorable cooking and sensory properties, at low substitution levels. Soy flour was introduced to improve cooking and textural qualities with enhanced nutritional and functional qualities of gluten-free noodles. Rahman *et al.* (2012), also highlighted soybean with its richness in protein, essential amino acids, vitamins, phosphorus and calcium..

Keeping the facts under consideration, this study was planned on substituting pearl millet flour (PMF) with rice, wheat and soy flours. It was aimed to investigate the relative improvement in noodle quality on substituting pearl millet with different ingredients at various levels. The purpose was to develop pearl millet-based pasta with improved cooking and textural qualities, while harnessing the highest possible goodness of pearl millet.

## MATERIALS AND METHODS

### *Procurement and preparation of raw materials*

Pearl millet grain (var. Pusa composite 1201) was obtained from the research farm of ICAR-IARI, New Delhi (India). The grains were cleaned and dried in the laboratory of Food Science and Post harvest Technology Division at IARI before keeping the same in a storage container for periodic use. It was subjected to milling through a hammer mill (Make: Sanco, India) to yield flour with a mean particle size of 425 microns. The flour ingredients were cooled, followed by the addition of guar gum (2%) and mixing thoroughly with quantified boiling water to attain 34.7% moisture content (Prakash *et al.* 2024). Guar gum was procured from the local suppliers and potable water was used after the reverse osmosis process. The flour sample was sieved and kept under refrigerated conditions for 24 hours to ensure the mixing was uniform (Lazou and Krokida 2010). It was allowed to attain room temperature before experiment. The substituting ingredients, viz. rice, wheat and soy flours, were purchased from the local market.

The experiment was planned, starting from the selection of a suitable ingredient among rice, wheat and soy flours for pearl millet flour. However, the substitution with soy flour led to broken noodles during extrusion. It was linked with its high oil content. To address this issue, defatted soy flour (DSF) was used for further investigation. It was based on the cooking and textural quality of noodle strands up to 50% level of substitution. The noodles were compared for 100% PMF (pearl millet flour) with the same from selected blends of rice, wheat and defatted soy flours in PMF for the least solid loss. Comparison of noodle quality was based on cooking and textural characteristics, followed by sensorial quality. Finally, the colour values were determined for noodles obtained from selected ingredient compositions.

### *Preparation of noodles*

The samples containing pearl millet flour were processed through the twin-screw extruder (Make: BTPL, Kolkata, India) at various levels of substitution with rice, wheat and defatted soy flours as described by Prakash *et al.* (2024). The extrusion processing variables were 74°C barrel temperature, 34.7% moisture content and 178 rpm screw speed. The experiment was conducted at various levels of substitution of pearl millet flour in

the range of 0-50%. In the experiment, the ratio of feeder speed and screw speed was 1:10 as suggested by Jalgaonkar *et al.* (2019). The extruded noodles were kept in a tray dryer (Make: MSW-216, Macro Scientific Works, New Delhi) at  $50\pm 2^\circ\text{C}$  to have their moisture level near 8-9% for safe storage. These noodles were then cooled at ambient conditions, followed by packaging and storage until quality analysis of noodle strands.

### Characterization of noodles

*Cooking quality (Solid loss, hydration capacity and cooking time analysis)*

The noodle strands were weighed (10g), placed in 100ml of boiling water kept in a pre-weighed beaker. It was continued until white cores disappeared as seen through compressing the strands between the glass plates (Yadav *et al.* 2014; Schmid *et al.* 2023). The weight of cooked noodles ( $W_c$ ) relative to the same for raw noodles ( $W_r$ ) was termed the hydration capacity (equation 2). Cooking loss was presented as solid material lost (%) in cooking water relative to the sample weight (equation 1). The gruel was kept in a tared beaker and placed overnight in a hot air oven at  $105^\circ\text{C}$  until achieving a constant weight and was weighed again after evaporation of cooking water. The time elapsed for the disappearance of white cores on placing noodle samples in the boiling water is termed as cooking time, as mentioned in equation 3 (Yadav *et al.* 2014).

$$\text{Solid loss (\%)} = \frac{\text{Gruel weight after evaporation}}{\text{Weight of raw noodles}} \times 100 \quad \dots (1)$$

$$\text{Hydration capacity} = \frac{\text{weight of cooked noodles}}{\text{Weight of raw noodles}} \quad \dots (2)$$

$$\text{Cooking time (Second)} = (\text{Time for disappearance of white cores}) - (\text{Cooking start time}) \quad \dots (3)$$

### Colour analysis

Colour of noodle strands was determined in terms of  $L^*$  (lightness),  $a^*$  (redness) and  $b^*$  (yellowness) values. The colour parameters were measured using Hunter Colour Lab (Make: LX 16244, Hunter Associates Laboratory, Virginia) following Rhee *et al.* (2004) and Veronica *et al.* (2006). It was standardized with white and black tiles before analyzing the samples. It yielded ' $L^*$ ', ' $a^*$ ' and ' $b^*$ ' values indicating lightness, redness and

yellowness, respectively. The ' $L^*$ ' value ranged from 0 (black) to 100 (white), whereas ' $a^*$ ' and ' $b^*$ ' values were meant for variations from green to red and blue to yellow, respectively. Colour values were reported as the average of three replications.

Texture analysis: The pre-test, test and post-test speeds were 3 mm/s, 1 mm/s and 10 mm/s, respectively, for a 50% distance in the compression mode in the texture analyzer (Make: TA+HDI<sup>R</sup>, Stable Micro Systems, UK) with a p/75 mm cylindrical probe. The average of three replications is reported as mean  $\pm$  standard deviation.

### Sensory analysis

The organoleptic test of noodle samples prepared from selected blends at 50% substitution and control was conducted using 9-point hedonic scale (Farzana and Mohajan 2015) in the Division of Food Science and Post harvest Technology at ICAR-IARI, New Delhi, with the help of a semi-trained panel of 30 members. Score card was based on a scale as per the intensity from 1 for like extremely and 9 for dislike extremely in terms of appearance, texture, taste and overall acceptability.

### Statistical analysis

Pearl millet flour was substituted with rice, wheat and defatted soy flours in the range of 0-50% and the effect of substitution was studied as a completely randomized design. Statistical analysis was conducted with the help of Web Agri Stat Package 2.0 available on the ICAR-CCARI-403402 website.

## RESULTS AND DISCUSSION

The noodle strands were prepared at various levels of substitution of pearl millet flour with rice, wheat and defatted soy flours. Characterization of noodles was primarily based on solid loss, hydration capacity, cooking time and hardness up to 50% level of substitution. The purpose was to select a suitable ingredient for substituting pearl millet flour.

### Selection of substituting ingredients for improvement in the quality of pearl millet noodles

Cooking quality, especially solid loss, is one of the most important parameters to be considered for the development of noodles. So, some of the ingredients were primarily investigated for cooking quality as a function of the levels of incorporation.

The solid loss of noodles was recorded as

**Table 1.** Noodle quality as a function of substitution levels of pearl millet flour with rice, wheat and defatted soy flours

Level of substitution	0%	10%	20%	30%	40%	50%	CD (at 5%)
<b>Solid loss (%)</b>							
RF	<sup>d</sup> 18.2 ±0.7	<sup>a</sup> 25.8 ±1.4	<sup>b</sup> 23.2 ±1.2	<sup>c</sup> 20.9 ±0.6	<sup>c</sup> 20.2 ±0.8	<sup>c</sup> 16.2 ±0.6	1.7
WF	<sup>cd</sup> 18.2 ±0.7	<sup>a</sup> 21.8 ±0.7	<sup>ab</sup> 21.0 ±2.0	<sup>bc</sup> 19.5 ±0.5	<sup>cd</sup> 18.0 ±1.0	<sup>d</sup> 16.9 ±1.4	2.1
DSF	<sup>c</sup> 18.2 ±0.7	<sup>a</sup> 35.1 ±2.0	<sup>b</sup> 27.0 ±1.6	<sup>c</sup> 18.7 ±1.3	<sup>c</sup> 17.6 ±1.6	<sup>d</sup> 11.6 ±0.4	2.5
<b>Hydration capacity</b>							
RF	<sup>a</sup> 1.85 ±0.05	<sup>a</sup> 1.79 ±0.03	<sup>a</sup> 1.76 ±0.02	<sup>a</sup> 1.76 ±0.04	<sup>a</sup> 1.75 ±0.06	<sup>a</sup> 1.75 ±0.02	--
WF	<sup>a</sup> 1.85 ±0.05	<sup>a</sup> 1.85 ±0.08	<sup>a</sup> 1.86 ±0.09	<sup>a</sup> 1.89 ±0.04	<sup>a</sup> 1.89 ±0.06	<sup>a</sup> 1.91 ±0.06	--
DSF	<sup>a</sup> 1.85 ±0.05	<sup>c</sup> 1.57 ±0.05	<sup>bc</sup> 1.63 ±0.03	<sup>b</sup> 1.64 ±0.03	<sup>bc</sup> 1.62 ±0.04	<sup>b</sup> 1.67 ±0.04	0.07
<b>Cooking time (second)</b>							
RF	<sup>a</sup> 422 ±08	<sup>b</sup> 317 ±06	<sup>c</sup> 284 ±06	<sup>d</sup> 263 ±09	<sup>de</sup> 254 ±07	<sup>e</sup> 245 ±16	16.2
WF	<sup>a</sup> 422 ±08	<sup>d</sup> 349 ±10	<sup>cd</sup> 358 ±10	<sup>c</sup> 372 ±08	<sup>b</sup> 392 ±12	<sup>b</sup> 400 ±10	17.5
DSF	<sup>a</sup> 422 ±08	<sup>b</sup> 320 ±07	<sup>c</sup> 266 ±06	<sup>c</sup> 255 ±05	<sup>d</sup> 231 ±06	<sup>e</sup> 213 ±08	11.9
<b>Hardness (N)</b>							
RF	<sup>a</sup> 36.5 ±3.1	<sup>b</sup> 25.0 ±1.5	<sup>c</sup> 17.3 ±1.0	<sup>cd</sup> 15.4 ±0.9	<sup>d</sup> 15.1 ±0.9	<sup>e</sup> 11.9 ±1.1	02.1
WF	<sup>a</sup> 36.5 ±3.1	<sup>b</sup> 28.4 ±2.1	<sup>b</sup> 26.5 ±1.9	<sup>c</sup> 21.7 ±1.4	<sup>c</sup> 20.0 ±1.6	<sup>d</sup> 16.8 ±1.6	02.7
DSF	<sup>d</sup> 36.5 ±3.1	<sup>a</sup> 49.1 ±3.1	<sup>bc</sup> 50.4 ±2.8	<sup>bc</sup> 51.9 ±2.3	<sup>ab</sup> 54.4 ±1.8	<sup>a</sup> 57.7 ±5.1	04.2

Data presented for comparing the values within rows alongwith the concerned CD values; RF: rice flour; WF: wheat flour; DSF: defatted soy flour

decreasing up to 16.2% and 16.9% respectively, on addition of rice and wheat flours at 50% level (Table 1). This decrease was associated with improvement in the binding properties of rice flour in boiling water and the gluten network with wheat flour. However, solid loss decreased upto 11.6% in the case of 50% substitution of PMF with DSF. It was associated with the strengthened starch-protein-gel network with defatted soy flour as protein protein-rich ingredient. Strengthening of the noodle structure was also reported as a result of protein denaturation at high temperature (Petitot *et al.* 2010). An increase in the solid loss was also reported on the addition of finger millet in refined wheat flour (Shukla and Srivastava, 2014). Jalgaonkar *et al.* (2016), revealed that the solid loss of pasta reduced below 8% with 50:50 blends of wheat semolina and PMF, while following the Indian standard (BIS, 1485-2010). Gull *et al.* (2015) described a weak network of gluten-protein as a result of low strength of noodle strands and increased solid loss on increasing the level of pearl millet flour. However, an increase in the solid loss at initial levels of substitution was associated

to structural discontinuity of the protein network (Ahmed *et al.* 2015).

Hydration capacity is the weight gain of noodle strands, while cooking, relative to the same for dry noodles. The high values of hydration capacity cause a sticky and soft texture, whereas lower values depict coarseness with a hard texture. The addition of rice flour yielded a hydration capacity of 1.75 at 50% as compared to 1.85 for the control. It was increased with a non-significant difference from 1.85 to 1.91 on the incorporation of wheat flour up to 50% in pearl millet flour. Similarly, DSF addition resulted in a decrease in hydration capacity from 1.85 to 1.67 at 50% level of substitution (Table 1). However, these values of hydration capacity were perceived as suitable in physical observation during cooking. The presented values were consistent with the findings reported by Ahmed *et al.* (2015). Chung *et al.* (2012) reported similar findings having a negative correlation of hydration capacity with the protein content, along with the altered gluten network.

Cooking time signified the ability of noodle strands to withstand the noodle structure while cooking in water and thereby required verifying the same. It varies with the gelatinization temperature of the respective starches in the noodle samples. It was decreasing gradually on the addition of rice and defatted soy flour, but increased with wheat flour beyond the 10% level. This steep decrease in cooking time at the initial level of substitution with wheat was associated to discontinuity of the gluten network (Qazi *et al.* 2014). The value decreased up to 245, 349 and 213 seconds during the experiment of substitution up to 50% with RF (rice flour), WF (wheat flour) and DSF (defatted soy flour), respectively (Table 1). Increase in the value at higher levels of WF or RF was consistent with the results reported by Ahmed *et al.* (2015). Substitution of PMF with DSF also caused a gradual increase in cooking time due to the strengthening of the starch-protein-gel network. Cooking time of all the samples was in an acceptable range, indicating the noodle strands have retained their structures after cooking.

Based on the cooking quality, 50% level of substitution qualified for subsequent investigation with the least solid loss, while having acceptable hydration capacity and cooking time. After cooking, hardness is one of the textural characteristics used for characterizing the strength of noodle strands after cooking. Thus, the cooked noodles prepared from selected blends were subjected to textural evaluation in terms of hardness through texture profile analysis. Hardness is related to the strength of gel structure under compression and is the peak force during the first compression cycle. It is depicted as the maximum force requirement for compressing the food between molar teeth (Szczeniak 2002).

Hardness was increasing with the incorporation levels of defatted soy flour (DSF), whereas decreasing with RF (rice flour) and WF (wheat flour). It was 36.5 N for control and varied as 49.1-57.7 N, 25.0-11.9 N and 28.4-16.8 N with variations of 10-50% of DSF, RF and WF, respectively (Table 1). Increase in the values with DSF was linked to the starch-protein-gel network as a result of the application of hydrothermal treatment with guar gum. Yamauchi *et al.* (2007), reported an association of noodle hardness with the protein content. Asenstorfer *et al.* (2010), also revealed a positive correlation of protein content of the flour with firmness of the cooked noodles. Dehghan-Shoar *et al.* (2010), explained noodle hardness as a result of an increase in cell wall thickness due to air bubbles, causing a decrease in porosity of the

extruded product. Thus, incorporation of DSF was favoured in reference to the hardness of cooked noodles. It exhibited comparatively firm strands of noodles on the incorporation of defatted soy flour, whereas flours of wheat and rice reduced the same. Foo *et al.* (2011), attributed this increase in hardness to the positive effect of a stronger protein network. Jalgaonkar and Jha (2016), revealed an increase in hardness from 7.48 to 20.81 N for cooked pasta with a decreasing level of pearl millet flour in semolina. The results were associated to a weak protein network with the addition of pearl millet flour. Jalgaonkar *et al.* (2018b), also reported similar results for pasta, while adding defatted soy flour in the 50:50 blend of pearl millet flour and wheat semolina.

#### ***Comparison of noodle quality from blends of rice, wheat and DSF in PMF for least solid loss with control***

The cooking and textural quality of noodle strands were compared for the best suited combination of RF, WF and DSF in PMF and 100% PMF as control (Table 2). Solid loss was significantly lower at 50% substitution of DSF in PMF among selected blends and the control. The hydration capacity was non-significantly different for noodle strands at a 50% substitution level of RF and DSF in PMF. There was no significant ( $p \geq 0.05$ ) difference for the hydration capacity of noodles using RF and DSF. The noodles from WF and control had statistically similar ( $p \geq 0.05$ ), but higher as compared to the RF and DSF noodles. However, the difference in the values was not creating much difference, as noted during physical observation. The cooked strands were found with improved strength, withstanding the structures after 213 seconds of cooking. The starch-protein-gel network formation strengthened the noodle strands to withstand the noodle structure at this level of substitution. In addition, it was supported as a result of protein denaturation at high temperature (Petitot *et al.* 2010). An increase in hardness with the formation of a stronger protein network was reported by Foo *et al.* (2011), in the case of DSF noodle. Jalgaonkar and Jha (2016), also reported weakening of the protein network upon addition of pearl millet flour. Similar results were revealed in a study, while substituting the mix of pearl millet flour and wheat semolina with DSF. Improvement in rice and corn starch-based pasta was also reported upon the addition of DSF in terms of firmness (Sereewat *et al.* 2015). Thus, the 50:50 combination of PMF-DSF has been identified as the

**Table 2.** Comparison of noodle quality from 100% PMF and selected blends of RF, WF and DSF in PMF

Parameters	PMF (100%)	RF (50%)	WF (50%)	DSF (50%)	CD (5%)
SL, %	<sup>a</sup> 18.2±0.7	<sup>b</sup> 16.2±0.6	<sup>ab</sup> 16.9±1.4	<sup>c</sup> 11.6±0.4	1.61
HC, g/g	<sup>a</sup> 1.85±0.05	<sup>b</sup> 1.75±0.02	<sup>a</sup> 1.91±0.06	<sup>b</sup> 1.67±0.04	0.09
CT, sec	<sup>a</sup> 422±8	<sup>c</sup> 245±16	<sup>b</sup> 400±10	<sup>d</sup> 213±08	19.8
Hardness, N	<sup>b</sup> 36.5±3.1	<sup>d</sup> 11.9±1.1	<sup>c</sup> 16.8±16	<sup>a</sup> 57.7±5.1	4.2

Control: 100% PMF; PMF: pearl millet flour; RF: rice flour; WF: wheat flour; DSF: defatted soy flour; SL: Solid loss; HC: Hydration capacity; CT: Cooking time

best-suited blend to produce noodle strands on the basis of cooking and textural quality investigation for noodles.

### Comparison of sensorial characteristics of noodle strands using best suited blends of rice, wheat and DSF in PMF with control

The selected blends of 50% RF, WF and DSF in PMF were compared with the control (100% PMF) for sensorial characteristics of noodle strands (Table 3). In terms of appearance, the control received the lowest score, followed by a statistically similar score for rice and wheat noodles, whereas DSF noodles received the statistically highest score.

Texture was scored highest for noodles for DSF noodle, followed by a statistically similar score for rice and wheat noodles. Noodles had the lowest score associated with control, with a statistically similar score for wheat noodles. The taste preference score was statistically different from each other, with the highest and lowest values for DSF and control noodle. Overall acceptability of rice and wheat noodles was statistically similar, with the lowest score for the control and the highest score for DSF noodle. The study revealed that the most acceptable noodle strand was obtained from the blend of 50% DSF in PMF. Sereewat *et al.* (2015), also reported sensory acceptability of DSF-added spaghetti comparable to the commercial spaghetti.

### Colour values of noodles from pearl millet flour as function of substitution level of flour

Noodle strands are supposed to have lightness ( $L^*$ ) and yellowness ( $b^*$ ) as desirable, whereas

redness ( $a^*$ ) an undesirable feature for sensorial acceptability. The lightness ( $L^*$ ), redness ( $a^*$ ) and yellowness ( $b^*$ ) values were  $46.3\pm 0.2$ ,  $2.8\pm 0.15$  and  $15.5\pm 0.29$ , respectively. Serrewat *et al.* (2015), reported  $L^*$ ,  $a^*$  and  $b^*$  values of pasta prepared from rice flour substituted with 15% DSF as 49.6, 5.61 and 24.3, as compared to 62.3, 0.10 and 15.3 for 100% rice flour pasta. The  $L^*$ ,  $a^*$  and  $b^*$  values were reported as 39, 9.7 and 11.3, respectively, for pasta prepared from yellow yam flour (Oke *et al.* 2023). Thus, the values in the present study were in line with the reported values. Schmid *et al.* (2023), reported a darker colour of millet pasta as compared to the corn and rice-based pasta.

Hence, the gluten-free nutritious noodle strands were obtained through extrusion processing using the best-suited blend at 50% substitution of PMF with DSF.

### CONCLUSION

The noodles prepared at 50% level of substitution of PMF with RF, WF and DSF were selected based on the cooking and textural quality of noodle strands. The quality parameters were compared with those for noodles prepared from 100% PMF as a control. Among the selected blends, the cooking quality, especially solid loss, was most favoured at 50% substitution of pearl millet flour (PMF) with defatted soy flour (DSF). The hydration capacity was also sufficiently high at 1.67 at this particular level, while withstanding noodle strands for a cooking time of 213 seconds. Noodle was obtained with lightness, redness and yellowness

**Table 3.** Sensorial characteristics for noodle strands prepared from 100% pearl millet flour and selected blends of rice, wheat and defatted soy flours in pearl millet flour

Treatment	PMF (100%)	RF (50%)	WF (50%)	DSF (50%)	CD (0.05)
Appearance	<sup>c</sup> 3.1±0.7	<sup>b</sup> 5.0±0.8	<sup>b</sup> 5.3±0.8	<sup>a</sup> 6.9±0.6	0.7
Texture	<sup>c</sup> 3.8±0.9	<sup>b</sup> 4.7±0.5	<sup>bc</sup> 4.4±0.5	<sup>a</sup> 6.7±0.8	0.6
Taste	<sup>d</sup> 2.7±0.8	<sup>c</sup> 5.0±0.8	<sup>b</sup> 5.7±0.7	<sup>a</sup> 6.6±0.5	0.7
Overall acceptability	<sup>c</sup> 2.9±0.7	<sup>b</sup> 4.0±0.8	<sup>b</sup> 3.9±0.7	<sup>a</sup> 6.3±0.7	0.7

Control: 100% PMF; PMF: pearl millet flour; RF: rice flour; WF: wheat flour; DSF: defatted soy flour

of 46.3, 2.8 and 15.5 upon incorporation of DSF in PMF. The colour values favoured, especially in terms of the L-value, for the substitution of PMF with DSF. This was also revealed to be the most acceptable composition when investigated for sensorial characteristics. Thus, the experiment on the effect of substituting PMF with RF, WF and DSF yielded the best-suited blend composition as 50% of defatted soy flour in pearl millet flour.

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