Physical, cooking and textural properties of composite flour noodles using indigenous food grain of North-East, India

Thingujam Bidyalakshmi[1*], Khwairakpam Bembem[1] and Sanjarambam Nirupama Chanu[2]

(1. ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana, Punjab-141004;
2., Krishi Vigyan Kendra, East-Garo Hills, Meghayala-794111)

Abstract: A study was conducted on development of composite flour noodles using indigenous food grains of North-East India and assessment of their quality. The composite flour noodles were prepared in a single screw cold extruder using wheat flour (WF), black aromatic rice flour (BRF), white sticky rice flour (WRF), and millet flour (MF) in different proportion. The physical properties, cooking characteristics, textural characteristics, and sensory qualities of the noodle were examined. The results showed that the noodles' bulk density varied between 0.4 and 0.5 g ml^{-1} and their moisture content ranged from 8.63 to 8.91 (% wb). The cooking loss, cooking yield and the water absorption capacity of the noodles ranged from 7.9%-13.4%, 271.5%-370.9% and 1.72-2.71 g g^{-1}, respectively. As the amounts of MF and BRF reduced, a decrease in the hardness and adhesiveness of the noodles was observed. Based on the sensory evaluation, composite flour noodle having maximum amount of BRF and MF was found to be the most liked sample. In contrast to their lack of significance at 95 percent confidence level for water absorption capacity, different proportions of WF, BRF, WRF, and MF have a substantial impact on colour change, bulk density, cooking loss, and cooking yield.

Keywords: black rice flour, cooking loss, millet flour, texture, water absorption capacity

Citation: Bidyalakshmi, T., K. Bembem, and S. N. Chanu. 2024. Physical, cooking and textural properties of composite flour noodles using indigenous food grain of North-East, India. Agricultural Engineering International: CIGR Journal, 26(1): 249-258.

1 Introduction

Consumption of cereals in different product forms has recently gained popularity on a global scale. Nowadays, people worldwide prefer to have food either in semi-processed or processed forms which is not an exception for India too. Due to changes in lifestyle and eating habits, people in both urban and rural regions no longer want to spend time on cooking. As a result, processed foods like noodles are becoming more and more popular.

On the other hand, the popularity of composite flours in the market is increasing because of the growing demand for meals with better nutrition (Chandra et al., 2015). A combination of carbohydrates and other protein-rich foods is referred to as "composite flour”. Composite flour is produced from several grains and pulses, including rice, millet, barley, maize, wheat, chickpeas, and corn. Due to the low cost of the ingredient, blended flours are affordable and provide a healthy source of nutrition in developing countries. The benefits of consumption of composite cereal foods are well known to the wide section of society. Apart from the nutritional benefits, composite flour gives possibilities to use underutilized cereals grown in small pockets of the

---

Received date: 2023-04-18 **Accepted date:** 2023-12-24

***Corresponding author: Thingujam Bidyalakshmi**, Scientist, ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana, Punjab, India; Tel: +01612313167. Email: bidyala@gmail.com.

country efficiently and effectively. This may supplement the total availability of staple foods of the country to some extent.

The use of composite flour has positive effects in the final product with reference to the functional, physicochemical, and health benefits of raw blended flour along with percentage blending. Composite flour created products with different qualities and features based on the types and amounts of wheat flour used, making it a great new method to utilise unusual foods, Noorfarahzilah et al. (2014).

The phenolic acids included in composite flour—ferulic acid, benzoic acid, sinapic acid, diferulic acid, and p-coumaric acid—are significant contributors to its ability to prevent cancer, diabetes, and cardiovascular disease. It is also reported that composite flour considerably lowers the levels of serum lipids, glycosylated albumin, lipoprotein cholesterol, and glycosylated proteins in the blood (Banu et al., 2021).

Wide varieties of cereal crops are grown in the North-Eastern part of India. Some of such crops are still underutilized as energy food. The underutilized cereal crops are viz., white and black aromatic rice, sticky rice, millet, etc. People do not like to consume these cereals if they are cooked individually. Black rice is a nutrient-dense whole grain with high fibre, anthocyanin, antioxidants, Vitamin B and E, iron, thiamine, magnesium, niacin, and phosphorus. It has been reported that sticky black rice has medicinal and nutritional advantages (Devi et al., 2021).

On the other hand, millets are nutritionally comparable to other cereal grains and may be useful in the treatment of diabetes, obesity, and hyperlipidemia (Feyera et al., 2021). They are excellent suppliers of carbohydrates, minerals, and phytochemicals with nutraceutical characteristics (Rathod and Sarojani, 2018). Millet also serves as a major food component in various traditional foods and beverages such as bread and porridges as reported by Tumwine et al. (2019). Due to associated difficulties in processing, the consumption of millet was limited. However, with due course of time, the importance and health benefits of millet has been explored. One of the best ways for broad consumption of millet is to mix them with wheat flour after processing (Vijayakumar and Mohankumar, 2009, Vijayakumar et al., 2010).

Unleavened dough is used to make noodles, which are dry, thin strips of food. Usually, it is served after being boiled in water. The English word "noodle" comes from the German word "nudel," which is possibly linked to the Latin word nodus (knot). Noodles are said to have its origins in the north of China as early as 5000 BC. Noodles are generally made from wheat flour. However, reports on preparation of noodles from mixture of more than two cereal flours are limited. Hence, the present study has been undertaken with the objective to develop composite flour noodle using underutilized cereals of the North-east India and their quality evaluation thereof.

2 Materials and methods

2.1 Raw materials

Two types of rice, *Chakhao Angouba* (white sticky rice) and *Chakhao Amuba* (black sticky fragrant rice), were purchased from the local market of Manipur. Also, millet and maida (wheat flour) were purchased from local market of Sikkim, India.

2.2 Preparation of flour

In general, cereal flour with an average particle size of 212 μ was utilised to make noodles. Rice and millet grains were cleaned and sun dried. About 75% of the bran was removed from black rice and millet through polishing using an abrasive type polisher (Indosaw, India). To achieve consistent size, rice and millet were pulverized in a hammer mill (ICT, India) and sieved at 212 μ mesh size. Wheat flour was also sieved using the same sieve size. The prepared cereal flour was stored in the refrigerator until it is used to make noodles.

2.3 Preparation of noodles

Different cereal flours were taken in varying amounts to make noodles utilising composite cereal flours. The four different flour blend combinations made to prepare noodles were: wheat flour (WF), black aromatic rice flour (BRF), white sticky rice flour (WRF), and millet flour (MF). Whereas *Thupa* (local market noodle) was taken as the control sample Table 1.

Different ratios of WRF, BRF, and MF were taken while maintaining a constant WF. The use of WF was intended to keep the binding capacity high. The flours were combined with 45 ml of water for every 100 g of sample to create the noodles in an extruder (La Monferrina, model-Dolly, Italy) and mixed the blend for around 15-20 minutes. After that, the noodles are extruded via a 1.5 mm die. (No.7). The steps (extrusion and drying) involved in making noodles are depicted in Figure 1.

Table 1 Composition of composite flours used for developed noodle products

Sample	Blend Ratio (WF:BRF:WRF:MF)
1	45:25:10:20
2	45:20:20:15
3	45:15:30:10
4	45:10:40:5
5	*Thupa* (Control)

Figure 1 Preparation of noodles

2.4 Drying of noodles

Drying up to a safe moisture level was necessary for freshly made noodles. The noodles were dried until the moisture content was less than 10% (w.b.) in a tray dryer (CIAE, India) at a temperature of 55 ℃–60 ℃.

Figure 2 Pakaged dried noodle

2.5 Physical properties of noodles

The physical properties of the developed noodles were evaluated in terms of moisture content, bulk density and colour.

2.5.1 Moisture content (%wb)

Standard procedures of hot air oven (AOAC, 1997) were used to determine the moisture of the final dried products by keeping 2-3 g sample at 102 ℃ for 24 hours, (Figure 2).

2.5.2 Bulk Density (g mL^{-1})

Bulk density of extrudates were measured by placing 10 g of noodles in a measuring cylinder, as discussed by Wani and Kumar (2016), the volume of each sample was recorded for determination of bulk density by following Equation 1.

$$Bulk\,density(g\,mL^{-1}) = \frac{mass\ of\ the\ noodle\ taken}{volume\ occupied\ by\ the\ noodle} \quad (1)$$

2.5.3 Colour

The colour of the noodles was assessed as per the methodologies described in colorimeter (colorflex 45º/0º, Hunter Lab, USA) after calibration with a standard plate tile (black and white). The Hunter laboratory color coordinate system *L** = lightness (0 = black, 100 = white), a*(-a* = greenness, +a* = redness) and b*(-b* = blueness, +b* = yellowness) values were recorded as the means of three replicates. The colour scale has a corresponding apparent colour difference scale. Equation 2 was used to compute the overall colour difference ΔE* between the developed samples and control sample (Faisal et al., 2017; Faisal et al., 2018).

$$\Delta E^* = \sqrt{\left((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2\right)} \quad (2)$$

Where, $\Delta L^* = L^* - L_o$, $\Delta a^* = a^* - a_o$, $\Delta b^* = b^* - b_o$, L^*, a^*, and b^* are Hunter values for noodle samples and L_o, a_o and b_o are Hunter values for control sample (*Thupa*).

2.6 Cooking quality assessment

According to the established procedures outlined by Inglett et al. (2005), the cooking yield, cooking loss, and water absorption capacity of the noodles were measured. In a beaker with 200 ml of boiling water, 10 grams of noodles were added. A plate was placed over the beaker, and it was cooked for 10 minutes with minimal stirring. The cooked noodles were weighed after draining for 5 min. to determine the cooking yield. The filtrate/drained water was placed into a measuring cylinder, and the volume was increased by adding distilled water to make it 200 ml. 10 ml of the solution was placed onto an aluminium dish and dried to a consistent weight at 105 ℃ after being poured into a burette. The amount of cooking loss was calculated by letting the cooking water evaporate at 105 ℃ in a hot air oven. It was calculated how much solid was lost when cooking. After draining the water, the weight of the cooked noodles was measured. Cooking loss was determined as follows:

$$Cooking\ loss\,(\%) = \frac{dry\ matter\ in\ drained\ water\ (200mL)}{weight\ of\ the\ noodles\ taken?\ solid\ content\ of\ the\ dry\ noodles} \times 100$$

Cooking yield was also calculated as:

$$Cooking\ yield\,(\%) = \frac{weight\ of\ cooked\ noodles}{weight\ of\ fresh\ dry\ noodles} \times 100$$

Water absorption capacity (WAC) (g g^{-1}): Water absorption capacity of the noodle was calculated as:

$$WAC = \frac{cooked\ weight\ -\ fresh\ dry\ noodle\ weight}{fresh\ dry\ weight}$$

2.7 Textural characteristics of developed noodles

Each sample was prepared in the ratio of 1:15 (noodle: distilled water) and boiling it for ten minutes, draining it, and then immediately rinsing it with cold water. It was then immediately allowed to stand for fifteen minutes before testing. TA. HD Plus Texture Analyzer was used with a cylinder probe to test the noodles' hardness and adhesiveness (Stable Micro Systems, U.K). A 30 kg load cell and a P/25 (25 mm dia) cylinder probe were equipped with the texture analyzer. 75% strain was required to compress the sample at 2 mm s^{-1} during the test. As a result of measuring the samples, force-time graphs were produced. The force (N) corresponding to the positive peak on force-time graphs represents the hardness. The area under the negative curve of force-time plots used as the basis for the calculation of adhesiveness (N-s).

2.8 Sensory evaluation

A panel of 30 semi-trained panelists, ranging in age from 20 to 63 years, assessed the sensory attributes of the cooked samples. The four developed samples and the control sample, which had been coded differently for sensory quality evaluation, were given to the panelist. The acceptability of product qualities was assessed using a 9-point hedonic scale (Faisal et al., 2018). The penalist were asked to assess the acceptability of the created items using the given sensory evaluation proforma.

2.9 Statistical analysis

All experimental results were expressed as mean and standard deviation. The results of general components were analyzed using ANOVA (Analysis of Variance) followed by Fisher's least significant differences at $p<0.05$. The results of textural properties were analyzed using Turkey's t-test at $p<0.05$.

3 Results and discussion

The results obtained in this research and possible discussions are presented below. The effect of different compositions was also analyzed. The physical properties, cooking quality and sensory characteristics of the prepared noodles are discussed below.

3.1 Physical properties

3.1.1. Moisture content and bulk density

Physical characteristics of the developed products, such as moisture content, bulk density, and colour, were assessed using the methods outlined in Section 2.5. Table 2 lists the bulk densities and moisture content of the developed product. The moisture content of the developed dry noodle sample was less than 10% (w.b.). The control sample's moisture content was observed to be 6.05% (w.b.). Bulk densities varied between 0.417±0.02 g mL^{-1} to 0.500±0.04 g mL^{-1}. These values of bulk density were comparable to the control sample's bulk density (0.435±0.05 g ml^{-1}). According to Omwamba and Mahungu (2014), bulk density is a measure of a product's porosity and varies according to the production parameters and the raw materials used. The bulk density strongly impacted by varying the flour proportions (p=0.0267, p>F).

Table 2 Physical properties of different noodles

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5 (ref)
Moisture (% w.b.)	8.91±0.34	8.85±0.66	8.96±1.17	8.63±0.35	6.05±0.35
Bulk density (g ml^{-1})	0.455±0.01	0.435±0.03	0.500±0.04	0.417±0.02	0.435±0.05

Table 3 Colour change of composite flour noodles

Parameter	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5(ref)
L^*	45.52	49.67	50.33	53.54	73.27
a^*	4.09	3.53	3.09	2.18	0.7
b^*	6.61	8.03	10.48	12.58	35.53
Colour difference (ΔE)	40.76±1.00	37.08±0.80	33.79±1.10	30.26±0.90	reference

3.1.2 Colour

According to the procedures outlined in Section 2.5, the colour of various composite flour noodles was measured. Table 3 lists the evolved noodles' L^*, a^*, b^*, and ΔE values. Table 3 shows that sample 4 had the greatest L^* and b^* values (L^*=53.54 and b^* = 12.58), while sample 1 had the lowest values (L^*=45.52 and b^* = 6.61) for lightness and yellowness. A declining trend in both values was seen when the samples' WRF content rose while their BRF and MF contents decreased. The increased lightness and yellowness of sample 3 and 4 might be attributable to their higher white rice flour content.

All the developed samples showed the opposite trend for the redness (a^*) value. The greater levels of millet flour and black rice flour in samples 1 and 2 may have contributed to the higher values of redness of the sample. Compared to the control, the prepared noodles were darker. The samples 1 and 2, as well as samples 3 and 4, had the highest ΔE values (40.76±1.0) when compared to the control sample. This might be attributed to lower WRF and greater MF and BRF for sample 1 and 2. The amount of WRF, BRF, and MF has a substantial impact on the colour of the noodles (p=0.0001, p>F).

3.2 Cooking analysis

Cooking properties of the developed composite flour noodles were measured in terms of cooking loss, cooking yield, and water absorption capacity. The measured values of cooking loss, cooking yield, and water absorption capacity are presented in Table 4.

Table 4 Cooking quality of composite flour noodles

Sl. No	Cooking loss (%)	Cooking yield (%)	Water absorption capacity (g g^{-1})
Sample1	7.9±0.10	370.9±10.00	2.71±0.50
Sample2	8.9±0.11	343.2±11.50	2.43±0.81
Sample3	13.4±0.23	342±15.00	2.42±0.32
Sample4	5.69±0.57	271.5±12.50	1.72±0.22
Sample5(ref)	3.19±0.20	282.8±17.00	1.83±0.30

3.2.1 Cooking loss

The cooking losses of various composite flour noodles ranged from 13.4%±0.23% to 5.69%±0.57% (Table 4). These results were higher than the market sample values (3.19%±0.20%). In the samples evaluated for the current investigation, there were variations in cooking loss, as shown in Figure 3. An overall rise in cooking loss was observed up to sample 3 as the WRF content of the noodles increased while the BRF and MF content decreased. The stickiness of the white rice, which created thicker gruel and a significant solid loss in the cooking water, may be the cause of this behavior. The variable flour proportion had a substantial impact on the cooking loss of the product, as indicated by the $p<0.05$ threshold.

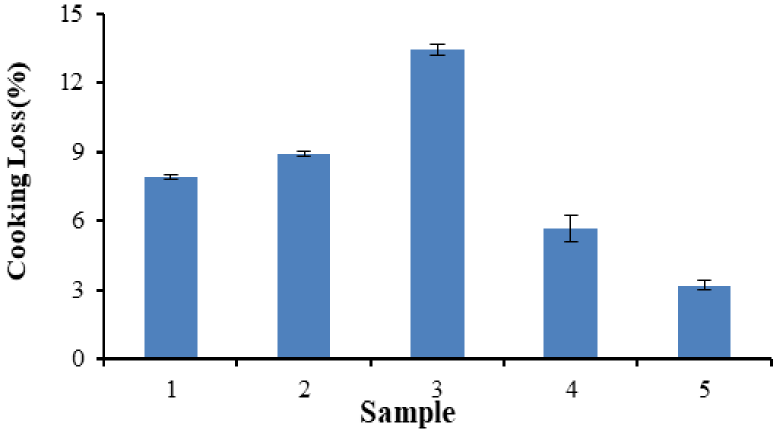

Figure 3 Cooking loss of different composite flour noodles

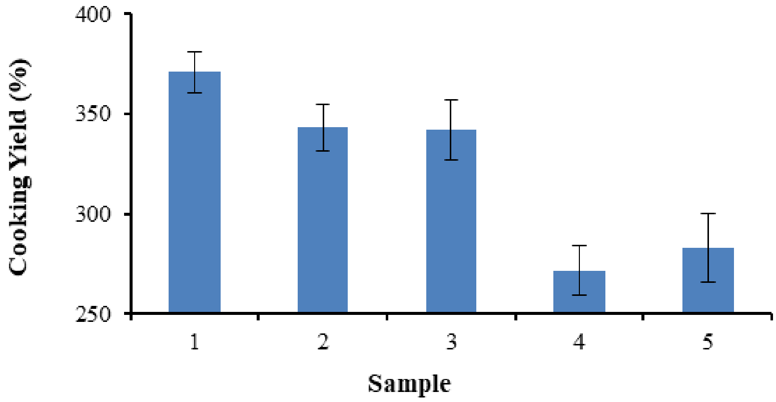

Figure 4 Cooking yield of different noodles

3.2.2 Cooking yield

The cooking yields of the samples ranged from 370.9%±10% to 271.5%±12.50%. while the cooking yield for the market sample was 282.5%±17% (Table 4). Cooking yield decreased when WRF increased and the BRF and MF decreased. The same justification as that provided for cooking loss may be used to explain this tendency. Similarly, a varied proportion of flour has a significant impact on cooking yield ($p<0.05$).

3.2.3 Water absorption capacity (WAC)

The water absorption capacity values of the developed samples are listed in Table 4. It has been observed that samples 1, 2, 3, 4, and 5 (reference sample) had WAC values of 2.71±0.50, 2.43±0.81, 2.42±0.32, 1.72±0.22 and 1.83±0.30 (g g^{-1}), respectively. For the composite flour noodles and market sample, the variance in WAC is shown in Figure 5. The composite flour noodles' WAC values declined when BRF and MF content decreased and WRF content increased. Vijayakumar and Mohankumar (2009) noted the same pattern of behaviour in composite flour made from millet flour. According to Kang et al. (2017), a product's ability to absorb water is influenced by the components' protein level and particle size. The ability of rice flour to absorb water is unaffected by its composition in different ratios (p=0.1895).

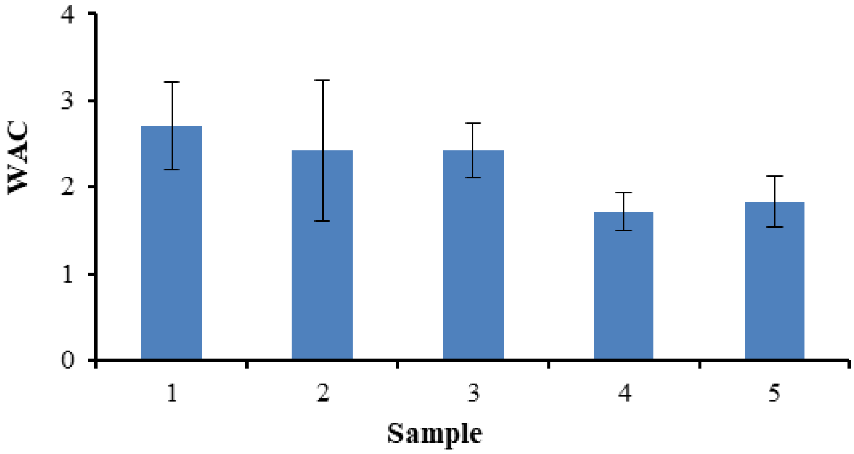

Figure 5 Water absorption capacity of developed noodles

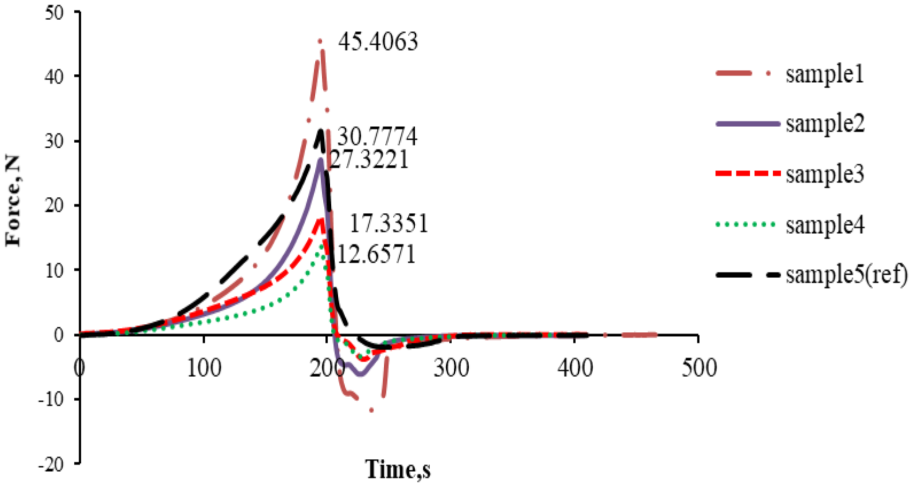

Figure 6 Force-time plot of noodle samples

3.3 Texture analysis of cooked noodles

One of the main standards for judging the quality of noodles is texture, which rates as one of the main variables determining the customer acceptability (Smewing, 2016). Measurements of the hardness and adhesiveness consider several characteristics of the interactions between starch molecules and the swelling of the starch granules in the noodle matrix. According to the procedure outlined in Section 2.7, the texture of the composite flour noodles was examined. Table 5 displays the hardness and adhesiveness values. The hardness ranges from 45.41±2.00 N to 12.66±3.60 N for all samples. The higher the value of maximum peak force required (N), the more force required to break the sample and higher the hardness of the sample (Sawant et al, 2013). The values of adhesiveness ranged from -2.42±0.005 (N-s) in sample 1 to -0.53±0.0014 (N-s) in the controlled sample. The increased viscosity of BRF relative to the other flours in the composition may be the reason why the adhesiveness was found to be higher in noodles with a larger proportion of BRF.

The impact of various composite flours on the textural characteristics of noodles is shown in Figure 6. The hardness (hardness = 30.80±1.80 N, adhesiveness = -0.53± 0.0014) falls when BRF and MF decrease in comparison to the control sample (N-s). Inglett et al. (2005) noted a similar pattern of behaviour for noodles made from both wheat flour and rice flour.

Table 5 Textural analysis of different noodles

Sample	Hardness (N)	Adhesiveness (N-s)
1	45.41±2.00	-2.42±0.005
2	27.32±2.50	-1.04±0.001
3	17.34±4.00	-0.76±0.002
4	12.66±3.60	-0.58±0.003
5	30.80±1.80	-0.53±0.0014

3.4 Sensory analysis

According to the procedure outlined in 2.8, the sensory evaluation of the composite flour noodles was conducted. The average values of sensory scores on hedonic scale for the various types of noodles' shown in Table 6. Sensory data revealed that sample 1 had the greatest ratings for colour (6.88±1.59), smell (6.75±2.05), taste (7.38±1.02), texture (6.63±2.39), and overall acceptance (7.38±0.96) out of the four created samples. Sample 1 is the most acceptable noodle sample, according to sensory scores.

Table 6 Sensory scores of different composite flour noodles

Sl. No	Colour	Smell	Taste	Texture	Overall acceptability
Sample1	6.88±1.59	6.75±2.05	7.38±1.02	6.63±2.39	7.38±0.96
Sample2	6.44±1.15	6.50±1.97	7.31±0.87	6.31±2.21	6.94±0.68
Sample3	6.00±1.14	6.31±1.92	6.44±0.89	5.19±2.04	6.06±1.00
Sample4	6.38±1.71	5.94±2.41	6.13±1.02	5.25±2.32	6.44±1.71
Sample5	8.00±0.89	5.44±2.71	6.75±1.29	6.75±1.73	6.63±1.71

4 Summary and conclusions

The noodle samples were made using four different mixtures of WF, BRF, WRF, and MF. Thupa, local market product, served as the control sample. While maintaining WF constant, different ratios of WRF, BRF, and MF were prepared. The dolly extruder with 1.5 mm diameter die was used to develop the noodles. The noodles were dried in a tray dryer at 55℃ to 60℃ until the moisture content dropped to less than 10% (w.b.). Physical, cooking, textural, and sensory qualities of the prepared noodles were examined.

The moisture content of the noodles ranged between 8.63%±0.35% to 8.91%±0.34% (w.b). For millet-fortified samples, the bulk density values ranged from 0.417±0.02 g ml^{-1} to 0.5±0.04 g ml^{-1}. With a rise in WRF content and a reduction in BRF and MF content in the samples, an increasing trend in *L** (lightness) and *b** (yellowness) values was observed. The opposite trend was observed for *a** (redness). As the BRF and MF increase, the colour gets darker. The highest Δ*E* values (40.76±1) were obtained for sample 1, followed by sample 2, sample 3, and sample 4, when compared to the control sample (sample 5). Cooking losses of various composite flour noodles ranged from 13.4%±0.23% and 3.19%±0.2%. With an increase in WRF content and a decrease in BRF and MF content in the noodles, there was an overall increase in cooking loss. The yield of the noodles after cooking ranged from 271.5%±12.50% to 370.9%±10.0%. As the BRF and MF declined and the WRF increased, the cooking yield decreased. The noodles' ability to absorb water ranged from 1.72±0.22 to 2.71±0.50 (g g^{-1}). In the composite flour noodles, WAC values declined as

BRF and MF content decreased and WRF content increased. As the BRF and MF drop, so do the noodles' hardness and stickiness. According to the sensory ratings, sample 1, which had the highest BRF and MF, was determined to be the most palatable sample. Different ratios of WF, BRF, WRF, and MF have a substantial impact on colour difference, bulk density, cooking loss, and cooking yield (p>F), but at the 95 percent confidence level, they have no significant impact on water absorption capacity.

Suggestions for future

Further research may be taken up to determine the optimized ratios of brown rice flour, white sticky rice flour, wheat flour, and millet flour for the development of high-quality noodles based on physical, textural, cooking, and sensory characteristics. The colour and flavour of the noodles made with millet and brown rice need to be improved via research.

Acknowledgement

The authors are grateful to Dr. A. I. Singh (L), Assistant Professor, Department of Processing and Food Engineering, College of Agricultural Engineering and Post-Harvest Technology, Central Agriculture University, Ranipool, Sikkim, India, for his sincere help and guidance during the work. This work is dedicated to him.

Reference

AOAC. 1997. *Official Methods of Analysis*. 16th ed. Washington, DC., USA: Association of Official Analytical Chemists.

Banu, M. T., J. Kaur, V. Bhadariya, J. Singh, and K. Sharma. 2021. Role of consumption of composite flour in management of lifestyle disorders. *Plant Archives*, 21(2): 201-214.

Chandra, S., S. Singh, and D. Kumari. 2015. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *Journal of Food Science and Technology*, 52: 3681-3688.

Devi, Y. P., T. B. Devi, K. Bembem, and Y. J. Devi. 2021. Processing and value addition of black scented rice. *Kerala Karshakan*, 8(9): 41-45.

Faisal, S., I. Mani, R. K. Gupta, D. Mridula, S. K. Jha, and B. Singh. 2018. Development of extruded snacks using maize, soy, apple pomace-a response surface methodology approach. *Journal of Agricultural Engineering*, 55(3): 21-31.

Faisal, S., I. Mani, R. K. Gupta, P. K. Sahoo, S. K. Jha, B. Singh, S. K. Sarkar, and T. K. Khura. 2017. Response surface analysis and process optimization of twin screw extrusion of apple pomace blended snacks. *Indian Journal of Agricultural Sciences*, 87(11): 1499-1506.

Feyera, M., F. Dasa, and K. Kebero. 2021. Formulation and quality evaluation of finger millet based composite food products. *International Journal of Nutrition and Food Sciences*, 10(3): 59-65.

Inglett, G. E., S. C. Peterson, C. J. Carriere, and S. Maneepun. 2005. Rheological, textural, and sensory properties of Asian noodles containing an oat cereal hydrocolloid. *Food Chemistry*, 90(1-2): 1-8.

Kang, J., J. Lee, M. Choi, Y. Jin, D. Chang, Y. H. Chang, M. Kim, Y. Jeong, and Y. Lee. 2017. Physicochemical and textural properties of noodles prepared from different potato varieties. *Preventive Nutrition and Food Science*, 22(3): 246-250.

Noorfarahzilah, M., J. S. Lee, M. S. Sharifudin, A. B. Mohd Fadzelly, and M. Hasmadi. 2014. Applications of composite flour in development of food products. *International Food Research Journal*, 21(6): 2061-2074.

Omwamba, M., and S. M. Mahungu. 2014. Development of a protein-rich ready-to-eat extruded snack from a composite blend of rice, sorghum and soybean flour. *Food and Nutrition Sciences*, 5(14): 1309-1317.

Rathod, J. M., and J. K. Sarojani. 2018. Evaluation of millet composite flour. *The Pharma Innovation Journal*, 7(7): 946-949.

Sawant, A. A., N. J. Thakor, S. B. Swami, A. D. Divate, and B. S. Vidyapeet. 2013. Physical and sensory characteristics of ready-to-eat food prepared from finger millet based composite mixer by extrusion. *CIGR Journal*, 15(1): 100-105.

Smewing, J. 2016. Navigating noodle texture: taking the rheological route. *Cereal Foods World*, 61(3): 92-95.

Tumwine, G., A. Atukwase, G. A. Tumuhimbise, F. Tucungwirwe, and A. Linnemann. 2019. Production of nutrient-enhanced millet-based composite flour using skimmed milk powder and vegetables. *Food Science and Nutrition*, 7(1): 22-34.

Vijayakumar, P. P., and J. B. Mohankumar. 2009. Formulation and characterization of *Millet* flour blend incorporated composite flour. *International Journal of Agricultural Sciences*, 1(2): 46-54.

Vijayakumar, T. P., J. B. Mohankumar, and T. Srinivasan. 2010. Quality evaluation of noodles from millet flour blend incorporated composite flour. *Journal of Scientific and Industrial Research*, 69: 48-54.

Wani, S. A., and P. Kumar. 2016. Development and parameter optimization of health promising extrudate based on fenugreek oat and pea. *Food Bioscience,* 14: 34-40.