International Journal of Research in Engineering, Science and Management
Volume 7, Issue 5, May 2024
https://www.ijresm.com | ISSN (Online): 2581-5792

Assessing the Influence of Partial Substitution of Wheat Flour by Brown Rice Flour, Kale and Pithecellobium Dulce Extract on Noodle Properties: A Study of Physical, Nutritional, Antioxidant, and Sensory Characteristics

Hemalatha Murali[1], M. Sukumar[2*]
[1]Research Scholar, Centre for Food Technology, Alagappa College of Technology, Anna University, Chennai, India
[2]Professor, Centre for Food Technology, Alagappa College of Technology, Anna University, Chennai, India

Abstract*: The inclusion of brown rice flour (BRF), kale powder, and Pithecellobium dulce extract (PDE) in noodle preparation presents an opportunity for creating a nutritionally rich product, enriched with higher dietary fiber and essential minerals such as Ca, Mg, and Fe. This approach not only enhances the nutritional profile but also offers potential health benefits for individuals, particularly those with diabetes and cardiovascular concerns. The objective of this study was to develop nutrient-rich noodles by supplementing them with BRF, with wheat flour being replaced by 30%, 40%, and 50% BRF, while also adding 5% kale powder and 2% PDE. Various attributes including physical (cooking time, water absorption, cooking loss), chemical (proximate composition, total phenolic content, DPPH), textural (hardness, springiness, cohesiveness, chewiness), and sensory (color, taste, flavor, appearance, texture, overall acceptability) were evaluated. Optimal cooking time was determined to be 10 minutes, with a cooking loss ranging from 12.6% to 15.6%. The diameter of the noodles increased proportionally with higher levels of BRF incorporation. In addition, compared to the control sample, the improved noodles showed higher levels of ash, crude fibre, mineral matter, phenolic content, and DPPH radical scavenging activity). The addition of BRF also resulted in increased hardness and chewiness of the noodles, qualities which were favored by sensory panelists. Sensory evaluations indicated that a maximum of 40% BRF integration was optimal to achieve desired overall acceptability.

***Keywords*: Noodles, Brown rice flour (BRF), Kale powder, Crude fiber, Textural analysis, Sensory evaluation.**

1. Introduction

Noodles enjoy widespread popularity in numerous developed and developing countries, including India, due to their quick cooking time and appealing taste [1]. While commercially available wheat flour noodles offer convenience and are rich in carbohydrates, they often lack essential nutrients such as dietary fibers, essential amino acids, proteins, minerals, and vitamins. Consequently, there is a pressing need to improve the nutritional content of noodles and promote their health benefits to consumers. Enhancing the nutritional profile of noodles can be achieved by fortifying them with various additives rich in dietary fiber, proteins, and other nutrients, as well as antioxidants [2]. Inadequate dietary fiber intake is a significant concern in contemporary society, leading to a range of health issues such as obesity, diabetes, cancers, and coronary heart diseases. Brown rice, being gluten-free, offers numerous nutritional and health advantages. It boasts a high content of dietary fiber, complex carbohydrates, minerals, and vitamins, and is considered non-allergenic. Incorporating brown rice flour into noodles enhances their texture with a pleasant chewiness and imparts a distinctive flavor. Conversely, wheat flour commonly used in noodle production is primarily rich in starch but lacks sufficient dietary fiber. Therefore, the inclusion of fiber-rich ingredients in food products enhances their nutritional value and positively impacts human health. kale contains a noticeable amount of highly bioavailable Ca (about 9% of daily need), as well as vitamins A, K and C [3]. It possesses anticancer, anti-inflammatory, and cholesterol-lowering properties. Its high fiber content and lack of fat contribute to its low-calorie count. Utilizing kale in noodle production could be significant from a functional perspective, considering its numerous health benefits. Manila tamarind pulp is rich in essential nutrients like vitamin C, calcium, iron, and dietary fiber. It promotes digestive health by aiding regular bowel movements and contains antioxidants that may reduce the risk of chronic diseases by neutralizing free radicals. Some research indicates potential benefits for blood sugar regulation and thus it is utilized in making noodles in this study.

2. Materials and Methods

A. Soxhlet Extraction of Manila Tamarind Pulp

10 g dry and finely ground is cannulated in a Soxhlet extractor. Approximately 250 ml of water is used as extraction

*Corresponding author: sukumarcbt@gmail.com

solvent. The extraction process will take 6 hours at 100 degrees Celsius. After extraction, the solvent was removed by evaporation using a rotary evaporator turned on at 40 °C. The resulting extract was freeze-dried to form a powder form. Finally, 2% Pithecellobium dulce powder obtained by this method was included in the noodle making process.

B. Preparation of Noodles

Noodles were prepared using laboratory quality Kent noodle and pasta machine following the standard set by Gatade and Sahoo with minor modifications [4]. After mixing the dry ingredients for 5 minutes, add water and oil. The resulting dough is extruded from a 12-port die with a diameter of 0.8 mm using cold extrusion. After extrusion, separate the noodles using the standard method and cook for 5 minutes. Then properly air dry it for 8 hours at 50 degrees Celsius. Store dried noodles in polyethylene bags for further analysis.

Table 1
Formulation used for preparation of control and brown rice flour fortified noodles

Ingredients	T1	T2	T3	T4
Durum Wheat Flour	100	70	60	50
Brown Rice Flour	0	30	40	50
Kale Powder	0	5	5	5
Manila Tamarind Extract	0	2	2	2
Salt	2	2	2	2
Water	40	40	40	40
Oil	13	13	13	13
Guar Gum	0.5	0.5	0.5	0.5

C. Cooking Analysis

1) Cooking time

Using the method described in A.A.C.C. (2010) 66-50, 10 g noodle sample was put in 100 ml of boiling water to determine the ideal cooking time. Check the cooking process by gently pressing the cooked noodles on the two slides every 30 seconds until the white centre disappears, indicating that the noodles are cooked through.

2) Cooking loss

The amount of solids lost in the cooking water was measured to determine cooking loss using the A.A.C.C. (2010) 66-50 method. The noodle is cooked to its ideal cooking duration to achieve a uniform weight and then the water used for cooking is separated and dried in an oven. Dry residue is expressed as a percentage of the initial noodle weight.

Cooking loss (%) = Dried residue in cooking water/Noodle weight before cooking * 100

3) Water absorption capacity

In a pre-weighed centrifuge tube, 3 grams of flour suspension and 25 mL of distilled water are mixed together, and the mixture is agitated for 30 minutes to evaluate the water absorption capacity.

After centrifugation at 936 x g for 15 minutes, remove the supernatant and reweigh the centrifuge tube containing the sample [5].

Water absorption capacity (g/g) = Weight of sediment/Initial sample weight

D. Antioxidant Activity

1) Total polyphenol content (mg GAE/g)

TPC was analyzed according to the protocol described by Menga [6]. First, 1 gram of the sample is ground and then extracted with a mixture of 8 ml of methanol, distilled water and HCl in a ratio of 80:19:1 (v/v/v) using an orbital shaker for 30 min. After that, the extract was centrifuged for 15 minutes at 4000 rpm. Then, 200 µL of the extract was mixed with 1.5 mL of Folin-Ciocalteu reagent (previously diluted tenfold) in a test tube. The mixture was let to stand for five minutes, and then 1.5 mL of a 6% sodium carbonate solution was added. It was then kept at room temperature (26 ± 1°C) for 90 minutes. After incubation, the absorbance of the mixture was measured at 725 nm. The results are expressed as gallic acid milligrams per gram of dry matter.

2) DPPH ASSAY

10g of the sample underwent ethanol extraction overnight in an incubator shaker at 120 rpm and 40°C. The extracted samples were filtered using Whatman filter paper and dried at room temperature. The residue is used to prepare a stock solution with a concentration of 5 mg/ml and stored at 4°C. For the reaction, 1 ml DPPH was mixed with different concentrations of ethanol extract and incubated. Let it be in the dark for 2 to 5 minutes then read absorbance at 517 nm. BHT (5 mg/ml) was used as a positive control. Use the following formula to calculate percent inhibition by comparing test and control results.

% inhibition = (A - B)/A * 100; where A is the absorbance of the DPPH solution, and B is the absorbance of the sample or sample DPPH.

E. Proximate Analysis

The approximate composition of the prepared noodles was determined according to the method specified by AACC (2000). Measure moisture content using a gravimetric test in an oven at 100-105°C for 4 hours (AACC, Method 44-15A). Fat content is determined by extraction with petroleum ether and evaporation to constant weight (AACC, Method 30-25). Noodles' nitrogen content was examined using the Kjeldahl method (AACCI, 1995) Method 46-11.02. The nitrogen-protein conversion factor for the meat and grain sample, 6.25, was multiplied by the percentage of crude protein, which was represented as the total nitrogen percentage. This equation was used to compute the measurement of crude protein. Protein crude (%) = Nitrogen (%) in samples multiplied by 6.25. The acid digestion procedure, as described in AACC method 32-07, was used to determine the fiber content. Lastly, to calculate the ash content, dry mix method was used, sticking to the AACC method 08-01.

F. Texture Profile Analysis

The texture analysis of the noodles began by cooking them in boiling water (100°C) until the ideal cooking time was reached, after which they were soaked in cold water (20°C) and drained. Next, texture profile analysis (TPA) was performed on the noodles using a texture testing device (TA-XTS, Stable Micro System, Godalming, UK). Place 5 cm long noodles

Table 2
Effect of incorporation of different levels of brown rice flour in wheat flour on cooking parameters of noodles

Samples	T1	T2	T3	T4
Optimal cooking time (min)	6.3 ± 0.13	8.2 ± 0.21	9.4 ± 0.36	10.7 ± 0.42
Cooking Loss (%)	12.6 ± 0.17	14.3 ± 0.21	14.9 ± 0.28	15.6 ± 0.13
Water absorption capacity	1.8 ± 0.22	2.3 ± 0.15	2.5 ± 0.16	2.8 ± 0.08

parallel to each other on a metal plate at a distance of 0.5 cm. The sample was then compressed twice to 50% of the original sample height using a P/50R probe (50 mm diameter cylindrical aluminium) using a force of 5.0 g at a measurement speed of 5 mm/s. Four parameters were measured during testing, including hardness, cohesiveness, chewiness, and springiness [7].

G. Sensory Analysis

Thirty testers conducted sensory evaluations on each sample of the noodles, focusing on attributes such as appearance, color, texture, odor, flavor, and overall acceptance. Each sample was given a score between 1 and 9, where 1 represented extreme dislike and 9 represented extremely favorable likeness. These assessments were done in comparison to control noodles made with wheat flour, and the outcomes were noted [8].

3. Results and Discussion

A. Cooking Analysis

1) Cooking Time

The cooking time is the length of time required for the gelatinization of the starch in the center of a noodle, expressed in minutes, which is the commercial description for the disappearance of the white center [9]. As brown rice flour part of the composition goes up. In particular, the optimum cooking time for T1 (100% durum wheat flour) was 6.3 ± 0.13 min, while it increased to 10.7± 0.42 min for T4 (50% wheat and 50% brown rice flour). Time increasing from TI to T4 indicates that as the brown rice flour increases, the cooking time increases. Due to the unique properties of brown rice flour such as high moisture absorption and slow gelatinization which requires longer cooking time to achieve the desired texture and doneness compared to traditional wheat flour noodles. Brown rice flour increases the cooking time progressively due to the inherent differences in their cooking characteristics.

2) Cooking Loss

From T1 featuring solely durum wheat flour to T4 comprising a 50% wheat and 50% brown rice flour blend, a consistent pattern emerges. T1 displayed the lowest cooking loss at 12.6± 0.17 %, while T4, with the highest brown rice flour content, showed the highest cooking loss at 15.6 ± 0.13%. The reason for this rise in cooking loss can be attributed to the distinct characteristics of brown rice flour, which include its higher ability for absorbing water and a slower rate of gelatinization as compared to wheat flour. When cooking, noodles with higher percentages of brown rice flour absorb more water, which changes the overall quality and characteristics of the cooked noodles.

Conversely, wheat flour's gluten proteins form a robust network that imparts elasticity and texture to noodles. Nonetheless, the absence of gluten in brown rice flour dilutes the gluten network, yielding noodles with diminished structure and chewiness.

3) Water absorption capacity

Water absorption capacity: The WAC of the noodle samples T1, T2, T3, and T4 is 1.8 ± 0.22, 2.3 ± 0.15, 2.5 ± 0.16, and 2.8 ± 0.08, respectively. Because brown rice flour has more fiber than wheat flour, WAC increases when it is added. Because of the fiber's capacity to both absorb and hold water, the dough's WAC rises. This result is in line with research by Monika Piwinska, who showed that adding fiber-rich oat flour to oat flour enhances its moisture retention [10]. Due to higher fiber content of kale powder, the samples gained the ability of higher water absorption than the control sample. Similar results were reported by Foshia [11] and Bouasla [12]. There is no doubt about the correlation between WAC and fiber content: absorption capacity rises with fiber content. Therefore, there is a direct correlation between the rise in fiber from brown rice flour and the increase in WAC.

B. Antioxidant Activity

1) Total phenolic content (mg GAE/g):

For formulations T1, T2, T3, and T4, the total phenolic content (TPC), expressed in milligrams of gallic acid per gram, is 0.7±0.03, 2.9±0.07, 3.3±0.02, and 3.7±0.04, in that order. The TPC is reported at 0.7 in the wheat-only control sample, T1. However, the TPC was significantly raised by adding kale powder, brown rice flour, and powdered manila tamarind extract to formulations T2, T3, and T4.

Table 3
TPC content of control noodles and brown rice flour fortified noodles

	T1	T2	T3	T4
TPC (mg GAE /g)	0.7±0.03	2.9±0.07	3.3±0.02	3.7±0.04

Phenolic substances known for their antioxidant qualities, such as coumaric acid, caffeic acid, and ferulic acid, are found in brown rice flour [13]. To further enhance the total antioxidant activity, brown rice flour also has a high amount of dietary fibre, which has been linked to antioxidant effects. Moreover, kale powder which is well-known for having a high polyphenol content contributes significantly to the elevated TPC seen in formulations T2, T3, and T4.

2) DPPH ASSAY

The IC50 values of the samples varied, according to the results of the DPPH assay. For example, the IC50 value of BHT (standard) was 295 ± 5.83 µg/ml, while the compounds T1, T2, T3, and T4 had IC50 values of 2550.32 ± 7.91, 1920.85 ± 11.3, 1832.62 ± 13.54, and 1765.91 ± 21.1 µg/ml, respectively. For both the fortified and control noodles, the IC50 values varied between 1765.91 and 2550.32 µg/ml. Notably, when compared to other formulations, the antioxidant activity of noodles enhanced with brown rice flour, kale powder, and manila tamarind extract demonstrated a notable improvement. The IC50 value of T4 was discovered to be 1765.91 µg /ml, which is significantly lower and indicates high antioxidant activity.

The fortified noodles have a higher capacity to generate antioxidants compared to the control noodles, as seen by their IC50 value of 2550.32 µg/ml,1. which was significantly higher. (T2, T3, T4).

Table 4
Effect of incorporation of different levels of brown rice flour in wheat flour on antioxidant properties of noodles

Samples	IC50 of DPPH, µg/ml
BHT (std)	295 ± 5.83
T1	2550 ± 7.91
T2	1920 ± 11.3
T3	1832 ± 13.54
T4	1765 ± 21.1

The substitution of brown rice flour for wheat flour in the noodles had an impact on all chemical attributes. The ash, fat and fibre contents increased whereas moisture and protein contents decreased. The protein content of noodles varies across different types, with percentages as follows: T1 at 11.35% ± 0.26, T2 at 10.2% ± 0.38, T3 at 9.78% ± 0.45, and T4 at 9.2% ± 0.24. Protein content was found to have decreased in T2, T3, and T4 from T1, with respective values ranging from 11.35% to 9%. As a gluten-free cereal with an 8.5% protein content, brown rice was shown to have a lower protein level than wheat four, which has a 10.9% protein content [14].

The ash content of T1, T2, T3, and T4 samples is measured at 0.67% ± 0.03, 0.92% ± 0.07, 1.17% ± 0.05, and 1.31% ± 0.12 respectively. The addition of kale and brown rice flour to the formulation causes the ash level to rise significantly. This rise can be explained by the fact that brown rice flour has a larger ash level (1.4%) than wheat flour (0.59%), which is probably because brown rice's bran layer has a higher mineral content. The amount of ash in kale leaves varies from 2.00% to 2.18% per 100 grams.

Notably, among the estimated mineral components, notable concentrations of magnesium, potassium, and calcium were discovered, according to Sikora [15]. The addition of kale and brown rice flour to the formulation causes a discernible rise in the amount of fiber. This rise in fiber content in brown rice may be attributed to its bran portion. Kale, being a rich source of dietary fiber, contributes to this increase. On average, kale contains about 2.6 grams of fiber per 100 grams serving. The observed increase in fiber

content is due to the inherent fibre-rich nature of both brown rice and kale, which enhance the overall fibre content of the samples.

There was an apparent increase in the fat content of noodles containing brown rice flour (14.4%), as fats are concentrated in the outer bran layer and the germ region of the whole grain/ brown rice. The moisture content decreased progressively from T1 to T4 in the samples. T1 consisted solely of 100% durum wheat flour, while T2, T3, and T4 incorporated varying proportions of brown rice flour alongside wheat. Additionally, T2, T3, and T4 contained kale powder. The reduced moisture level in the samples from T1 to T4 can be ascribed to the higher absorbency of brown rice flour in comparison to durum wheat flour, as well as the addition of kale powder, which can absorb additional moisture.

C. *Texture Analysis*

The hardness of noodles is linked to both the swelling capacity of the flour and the compactness of the noodle's internal structure, reflecting their resistance to compression [16]. In the noodle samples (T1 to T4), the hardness value generally rises as the percentage of brown rice flour does. The reason for this is that compared to wheat flour, brown rice flour has less gluten.

Gluten provides elasticity and structure to noodles, so reducing its proportion by adding brown rice flour results in noodles with a weaker structure and higher hardness. Therefore, increasing the ratio of brown rice flour in wheat noodles usually leads to an increase in their hardness value. The product's capacity to revert to its original position following the initial compression and before the second compression starts is gauged by its springiness value. As the ratio of brown rice flour increases in the noodle samples (T1 to T4), the springiness tends to decrease due to the lower gluten content in brown rice flour, resulting in reduced elasticity. Moreover, the weakened gluten network from brown rice flour compromises the structural integrity of the noodles, diminishing their ability to maintain shape. Brown rice flour possesses distinct starch compositions compared to wheat flour, potentially influencing noodle texture and structure. Changes in starch behaviour, such as gelatinization and retrogradation, induced by the inclusion of brown rice flour, can further impact noodle springiness by altering gel structure and starch interactions within the dough, ultimately leading to diminished springiness in the final noodles.

Cohesion often decreases when brown rice flour content rises in the noodle samples (T1 to T4). This is due to the fact that wheat flour has a larger amylopectin to amylose ratio than

Table 5
Effect of incorporation of different levels of brown rice flour in wheat flour on proximate parameters of noodles

Samples	Moisture	Protein	Fat	Carbohydrate	Ash	Fibre
T1	10.12 ± 0.32	11.35 ± 0.26	12.35 ± 0.25	65.04±0.486	0.67 ± 0.03	0.47 ± 0.06
T2	8.3 ± 0.15	10.2 ± 0.38	13.4 ± 0.34	65.88±0.547	0.92 ± 0.07	1.3 ± 0.11
T3	7.8 ± 0.23	9.78 ± 0.45	13.9 ± 0.13	65.75±0.527	1.17 ± 0.05	1.6 ± 0.06
T4	7.1 ± 0.31	9.23 ± 0.24	14.4 ± 0.29	66.06±0.517	1.31 ± 0.12	1.9± 0.12

Table 6
Effect of incorporation of different levels of brown rice flour in wheat flour on textural properties of noodles

Sample	Hardness (N)	Springiness (cm)	Cohesiveness	Chewiness
T1	13.45 ± 0.02	0.88 ± 0.04	0.73 ± 0.08	845 ± 63.95
T2	15.17 ± 0.09	0.81 ± 0.07	0.68 ± 0.02	1002 ± 72.7
T3	16.23 ± 0.15	0.75 ± 0.03	0.65 ± 0.09	1067 ± 56.43
T4	18.56 ± 0.21	0.70 ± 0.05	0.63 ± 0.07	1094 ± 87.26

brown rice flour, which promotes stronger gel formation and cohesion.

Conversely, brown rice flour's starch composition may lead to weaker gel formation and reduced cohesiveness. Moreover, brown rice flour's coarser texture and larger particle size can hinder the formation of a cohesive matrix in the noodle dough, further diminishing cohesiveness as its proportion increases.

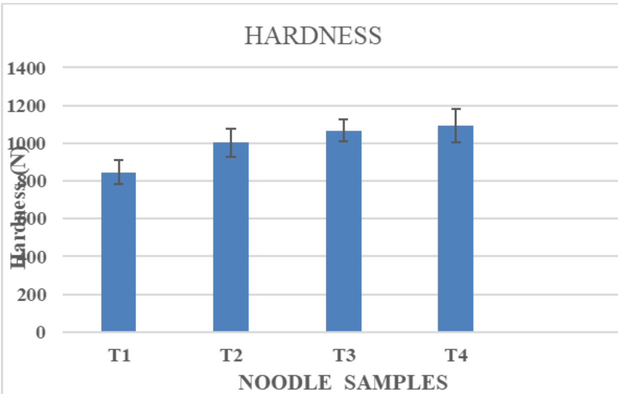

Fig. 1. Hardness value of control and fortified noodles

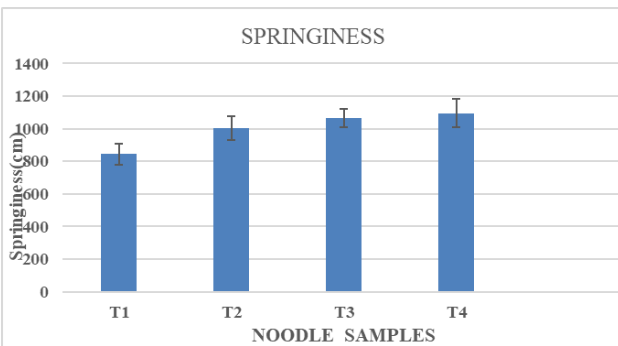

Fig. 2. Springiness value of control and fortified noodles

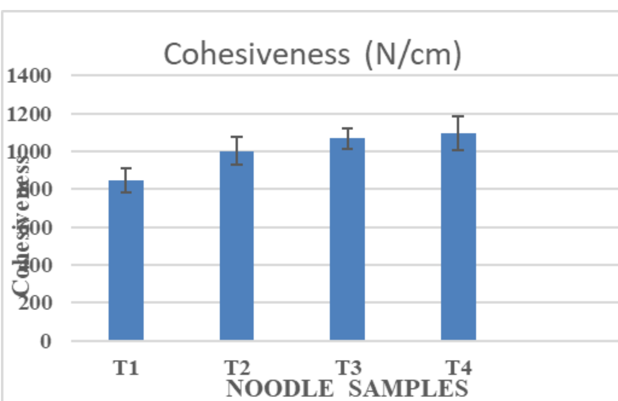

Fig. 3. Cohesiveness value of control and fortified noodles

As the proportion of brown rice flour increases in the noodle samples (T1 to T4), there is typically a rise in chewiness. Brown rice flour possesses a texture that differs slightly from wheat flour, often contributing to a firmer and more substantial mouthfeel in the noodles. This altered texture can heighten the perceived chewiness of the noodles, as they offer greater resistance to the teeth during consumption. Additionally, the unique starch properties of brown rice flour play a role in gel formation and water absorption within the noodle dough. When combined with wheat flour, the starches from brown rice flour create a gel network that has an enhanced capacity for water retention. Consequently, the resulting noodles retain moisture more effectively, yielding a chewier texture upon cooking.

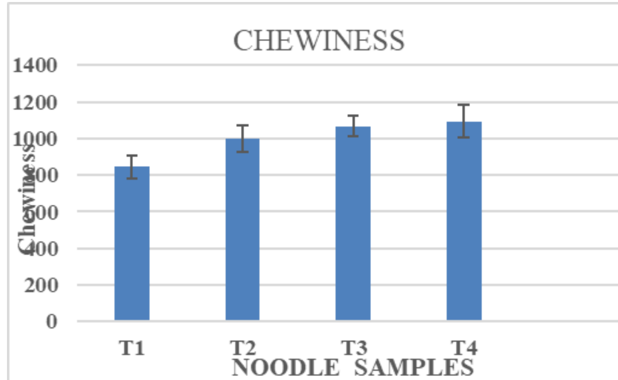

Fig. 4. Chewiness value of control and fortified noodles

D. *Sensory Analysis*

Table 7
Effect of incorporation of different levels of brown rice flour in wheat flour on sensory characteristics of cooked noodles

Samples	T1	T2	T3	T4
Color	8.5±0.15	8.1±0.26	7.9±0.18	7.5±0.14
Appearance	7.75±0.13	7.65±0.16	7.40±0.11	7.12±0.15
Hardness (Texture)	7.68±0.12	7.53±0.08	7.11±0.14	6.8±0.11
Taste	7.93±0.07	7.5±0.12	7.05±0.17	6.5±0.12
Overall Acceptability	7.96±0.12	7.69±0.17	7.36±0.13	6.98±0.12

There is increased interest in products colored with natural substances because color is a critical quality factor that directly influences consumer perception [17]. The green color seen in the noodles is a result of the kale powder, which had a favorable effect on panelists' assessments of color. The appearance of noodles enriched with more than 40% brown rice flour (BRF) varied noticeably because of increased surface roughness, which was probably caused by higher dietary fiber contents and because of increased surface roughness, noodles enriched with more than 40% brown rice flour (BRF) looked significantly different from one another. This is probably because of higher levels of dietary fiber and and the non-uniformities occurred at the noodles preparation time. Textural alterations (hardness increased) and taste ratings (slightly lowered), potentially as a result of the unique flavor profile of brown rice flour, were observed when 30% or more BRF was added. Noodles containing 30% BRF were generally more well-liked than other formulations. When the entire acceptability score was considered, 30% brown rice flour demonstrated higher acceptance when compared to the other noodles.

4. Conclusion

In summary, we studied about the cooking behavior, antioxidant potential, nutritional composition, texture, and sensory perception of noodle compositions that include different proportions of wheat flour and brown rice flour. Brown rice flour has its effect on cooking time, cooking loss, and WAC of the noodles. The distinctive qualities of brown rice flour, such as its slower gelatinization and increased water absorption, cause cooking time and cooking loss to increase proportionately. Noodles supplemented with kale powder, brown rice flour, and manila tamarind extract exhibit higher levels of antioxidant activity which is obvious from the greater total phenolic concentration and lower IC50 values in the DPPH assay. These ingredients are packed with phenolic compounds and dietary fiber, both known for their antioxidant properties. Substituting brown rice flour for wheat flour changes the nutritional composition of the noodles by increasing ash, fat, and fiber content while decreasing moisture and protein content. These changes are because of brown rice flour's inherent qualities and the addition of kale powder.

The texture of the noodles is affected by the inclusion of brown rice flour. It increased the hardness and chewiness and slightly decreased the springiness, and cohesiveness. This is because of difference in starch composition and gluten content between brown rice flour and wheat flour.

In sensory evaluation, noodles with brown rice flour were assessed for color, appearance, hardness, taste, and overall likability. While the green hue from kale powder positively influenced color perception, higher levels of brown rice flour brought about textural and taste differences.

References

[1] Aydin, E., & Gocmen, D. (2011). Cooking quality and sensorial properties of noodle supplemented with oat flour. *Food Science and Biotechnology*, *20*, 507-511.

[2] Chin, C. K., Huda, N., & Yang, T. A. (2012). Incorporation of surimi powder in wet yellow noodles and its effects on the physicochemical and sensory properties. *International Food Research Journal*, *19*(2).

[3] Heaney, R. P., Weaver, C. M., Hinders, S. M., Martin, B., & Packard, P. T. (1993). Absorbability of calcium from brassica vegetables: broccoli, bok choy, and kale. *Journal of Food Science*, *58*(6), 1378-1380.

[4] Gatade, A. A., & Sahoo, A. K. (2015). Effect of additives and steaming on quality of air-dried noodles. *Journal of food science and technology*, *52*, 8395-8402.

[5] Rani, S., Singh, R., Kamble, D. B., Upadhyay, A., & Kaur, B. P. (2019). Structural and quality evaluation of soy enriched functional noodles. *Food Bioscience*, *32*, 100465.

[6] Menga, V., Amato, M., Phillips, T. D., Angelino, D., Morreale, F., & Fares, C. (2017). Gluten-free pasta incorporating chia (Salvia hispanica L.) as thickening agent: An approach to naturally improve the nutritional profile and the in vitro carbohydrate digestibility. *Food chemistry*, *221*, 1954-1961

[7] Jirukkakul, N. J. F. R. (2021). Improvement of physical properties and phenolic compounds of egg noodles by banana pulp and peel flour fortification. *Food Research*, *5*(4), 14-20.

[8] Parvin, R., Farzana, T., Mohajan, S., Rahman, H., & Rahman, S. S. (2020). Quality improvement of noodles with mushroom fortified and its comparison with local branded noodles. *NFS journal*, *20*, 37-42.

[9] De Pilli, T., Derossi, A., & Severini, C. (2013). Cooking quality characterisation of ‘spaghetti’ based on soft wheat flour enriched with oat flour. *International journal of food science & technology*, *48*(11), 2348-2355.

[10] Piwińska, M., Wyrwisz, J., Kurek, M., & Wierzbicka, A. (2015). Hydration and physical properties of vacuum-dried durum wheat semolina pasta with high-fibre oat powder. *LWT-Food Science and Technology*, *63*(1), 647-653.

[11] Foshia, M., Peressini, D., Sensidoni, A., Brennan, M.A., Brennan, C.S. (2015). How combinations of dietary fibers can affect physicochemical characteristics of pasta. LWT - Food Science and Technology, 61, 41-46.

[12] Bouasla, A., Wojtowicz, A. (2019). Rice-buckwheat gluten free pasta: effect of processing parameters on quality characteristics and optimization of extrusion-cooking process. Foods, 8, 1-16.

[13] Ye, L., Zhou, S., Liu, L., Liu, L., Waters, D. L., Zhong, K., ... & Liu, X. (2016). Phenolic compounds and antioxidant capacity of brown rice in China. *International journal of food engineering*, *12*(6), 537-546.

[14] Dhillon, B., Sodhi, N. S., Aneja, E., Kumar, A., & Jaiswal, S. (2021). Physico-chemical and textural (sensorial and electromyographic) evaluation of cookies formulated using different ratios of brown rice flour and refined wheat flour. *Journal of Food Measurement and Characterization*, *15*, 219-227.

[15] Sikora, E., & Bodziarczyk, I. (2012). Composition and antioxidant activity of kale (Brassica oleracea L. var. acephala) raw and cooked. *Acta Scientiarum Polonorum Technologia Alimentaria*, *11*(3), 239-248.

[16] Wang, R., Li, M., Chen, S., Hui, Y., Tang, A., & Wei, Y. (2019). Effects of flour dynamic viscosity on the quality properties of buckwheat noodles. *Carbohydrate Polymers*, *207*, 815-823.

[17] Vimercati, W.C., Macedo, L.L., Araújo, C.S., Filho, A.M.M., Saraiva, S.H., Teixeira, L.J.Q. (2020). Effect of storage time and packaging on cooking quality and physicochemical properties of pasta with added nontraditional, ingredients. Journal of Food Processing and Preservation, 44, 1.