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Probing nutritional and functional properties of salted noodles supplemented with ripen Banana peel powder

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Abstract

Banana peel is appreciated for higher dietary fiber, phenolics, flavonoid contents, and minerals (particularly iron, calcium, and potassium), despite being a waste product. After drying, it can be processed into powder/flour to be combined with wheat flour (WF) for development of value-added products. In this study, we substituted WF with banana peel powder (BPP) at supplementation rates of 5, 10, and 15%, and evaluated their suitability to develop salted noodles. The results showed that the composite flour with 15% BPP had significantly higher protein, ash, and crude fiber content as compared to control. Higher antioxidant capacity was observed in composite flour noodles: total phenolics content (TPC), total flavonoid content (TFC), ferric reducing power (FRAP) and DPPH reducing power were increased up to 278, 260, 143 and 13 percent respectively in the noodles containing 15% BPP as compared to control (100% WF). On the other hand, values for viscosity decreased up to 22% with addition of BPP in WF. Furthermore, water absorption capacity and cooking losses were increased up to 15 and 13 percent respectively with 15% BPP incorporation in WF. Results for sensory evaluation demonstrated that noodles with 10% BPP scored highest for sensory profile.

Keywords: Banana peel, Noodles, Bioactive compounds, Pasting properties, Waste utilization

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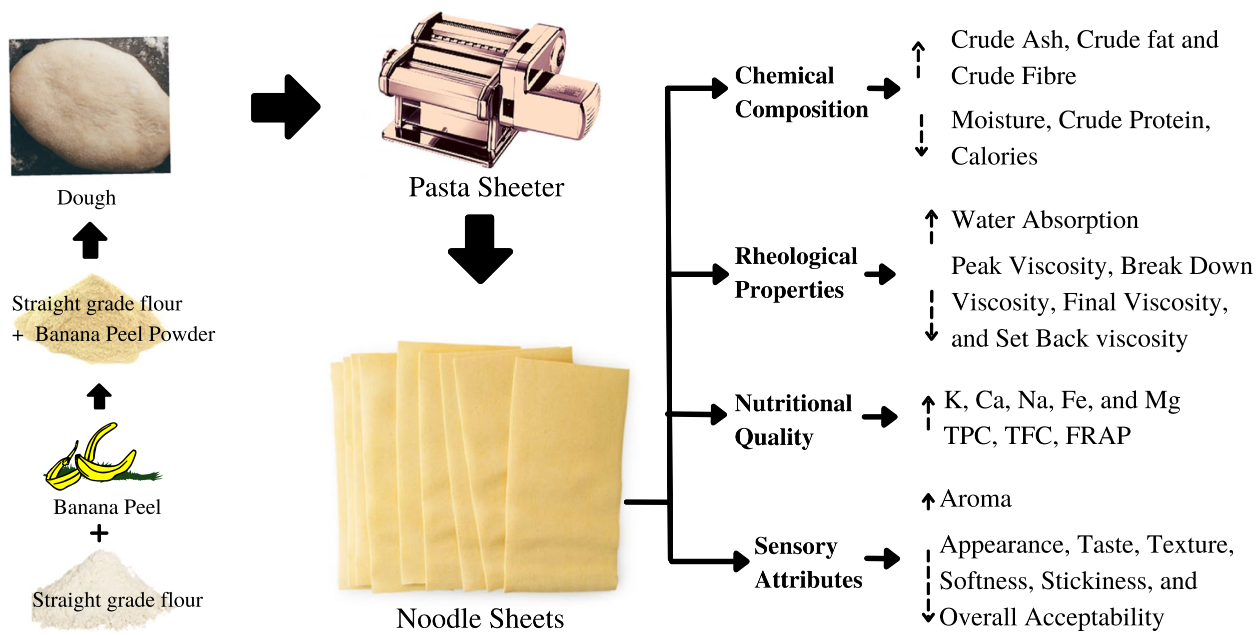
Graphical abstract



Introduction

Banana is one of the most widely consumed fruits all over the world. Ripened banana peel is an industrial and household by-product, which is about 40% of the fresh ripened banana fruit. It is not considerably brought in commercial use and discarded as a waste (Aurore et al. 2009; Happi Emaga et al. 2008). Annually about 0.11 million tons of banana is produced in Pakistan (FAO 2017) and peel is being wasted. Numerous fruits by-products have been analyzed for development of value-added products. Increasing threats of food insecurity and malnutrition have drawn attention towards utilization of waste/by-products in functional foods development (Ismail et al. 2014; Padam et al. 2014). Banana peel extract and peel powder are generally used for ethanol production, wine production, soap production, steel corrosion inhibitor, and domestic wastewater treatment (Eddy et al. 2008; Ilori et al. 2007). However, only a few studies on the use of BPP for development of functional foods (e.g., cakes, chicken sausage, unleavened flat bread etc.) have been reported in the literature (Kurhade et al. 2016; Zaini et al. 2020).

Noodles are rated second among the foodstuffs consumed in South Asia, followed by the rice products (Hatcher 2001). Noodles consumption patterns also increased significantly among the Western people over the last decade as it became a part of ethnic foods (Zhang & Ma 2016). Wheat flour that constitutes major part of the noodles recipe is considered an excellent source of carbohydrates but it lacks essential amino acids, fiber, and minerals. Therefore, noodles have been widely attempted for the fortification with different flours such as buckwheat flour, barley flour, coconut flour, sweet potato flour, rye flour and soy flour (Bilgiçli 2009; Gunathilake & Abeyrathne 2008). Composite flour noodles have significantly improved nutrition, however, compositing with buckwheat, sweet potato or coconut etc. might add to the cost (Izydorczyk et al. 2005).

Banana peel powder supplementation in noodles recipe is an innovative approach to increase their nutritional quality (Martins et al. 2019). Banana peel powder is nutritionally significant as it is enriched with micronutrients (K, P, Ca and Mg), polyunsaturated fatty acids, essential amino acids (leucine, phenylalanine threonine and valine), protein, pectin and numerous bioactive compounds (Kurhade et al. 2016; Martins et al. 2019). Moreover, BPP has higher water-holding, and swelling capacity owing to high soluble fiber content, required for the better quality noodles (Bilgiçli 2009).

Supplementing WF with BPP can be a sustainable approach for improving nutritional profile (antioxidants, secondary metabolites, minerals, dietary fiber, and essential amino acids) of noodles (Ortiz et al. 2017). The use of

BPP in salted noodles has not been reported in the literature to the best of our knowledge. Therefore, this study was designed to assess nutritional potential of locally grown banana cultivar peel, impact of BPP addition on functional properties of composite flour and sensory quality of BPP composite flour noodles.

Materials and Methods

Plant material and blend production

Commercially available fully ripened bananas (*Musa acuminata*) were procured from the Ayyub Agricultural Research Institute, Faisalabad, Pakistan, and wheat flour (*Triticum aestivum* L.) (WF) from local market of Faisalabad, Pakistan. Fruits were washed and peel was manually removed. The peel was dipped in citric acid solution (0.5%, w/v) for 25 min to inhibit enzymatic browning before drying. Then, the peel was tray dried at 35 °C for 48 h and disintegrated by a laboratory scale blender to clear through a 0.5 mm mesh. The WF particle size was < 350 μm. The blends were prepared with following composition: (T_0) 100 g of WF (control sample); (T_1) 95 g of WF + 5 g BPP; (T_2) 90 g of WF + 10 g BPP; and (T_3) 85 g of WF + 15 g BPP. The supplementation rate of BPP in WF was limited to 15% as higher replacement might lead to poor quality dough and strong aroma in finished products that might affect consumer acceptability (Kurhade et al. 2016; Martins et al. 2019).

Pasting properties and water absorption

Composite flour pasting properties were studied using Rapid Visco Analyzer (RVA Super 4, Newport Scientific, USA). Water absorption was analyzed through Farinograph (D-4100 SEW, Brabender, Germany) following AACC (2000) method No. 54–21.

Noodles preparation

The salted noodles recipe comprised of following i.) wheat flour/composite flour (100 g), distilled water (40 ml), salt (2 g), and Kansui reagent (1 g). The dry components were mechanically mixed for 2 min. Salt and Kansui reagents were dissolved in distilled water prior to the addition to the mixture. The mixer was run at speed-1 (60 rpm) for 8 min at room temperature (~ 40 °C). The dough was passed though the noodle machine (150 mm-Deluxe, Marcato, Italy) rollers set on gap width-1 (the maximum width can be offered by the equipment). The sheeting repeated two more times with longitudinal folding each time to ensure homogeneity. Subsequently, the dough sheet was passed progressively decreasing gap setting from 2 to 6 (without folding in-between the gap settings) until sheet thickness reached ~ 2 mm. The final sheets were cut into noodles strands (60 mm long and 2 mm wide). Finally, the product was steamed for 2 min and dried in a hot-air oven (UFB-400, Memmert, Germany) at 40 ± 1 °C up to 4 h (Fig. 1). The product was cooled at ~ 40 °C and stored in plastic zip bags until further analyses.

Proximate analysis

Moisture, fat, ash, crude protein, and crude fiber contents were quantified by the standard procedures (AACC 2000). Percent nitrogen were multiplied by 5.7 for the estimation of crude protein. The gluten contents were determined by the handwashing method of AACC (2000).

Bioactive compounds determination

Total phenolic contents were analyzed through UV–Vis spectrophotometer at 760 nm (U2020, IRMECO, Germany) by using Folin-Ciocalteu reagent, while gallic acid was used as standard (Y. Li et al. 2015). Total flavonoids were determined at 510 nm by the method of Li et al. (2015). For DPPH radical scavenging activity, 0.5 g sample was extracted in 5 ml methanol (80% v/v). The standard was prepared by dissolving 2 mg DPPH regent in 50 ml methanol. About 50 μl of DPPH regent was allowed to react with 2 ml DPPH regent for 10 min in dark place. Both standard and sample absorbance were measured at 517 nm (Can-Cauich et al. 2017). FRAP was performed using 2,4,6-Tris(2-pyridyl)-s-triazine reagent and absorption measured at 593 nm (Chen et al. 2015).

Mineral analysis

Samples of BPP, composite flour, and product were wet digested in the di-acid mixture (HNO_3: $HClO_4$ in the ration of 3:1) on hot plate at 95° C until transparent color appeared and volume (100 ml) was made up using distilled water, as described in AOAC (Latimer Jr. 2016). Digests were analyzed for minerals profiling through atomic absorption spectrophotometer (AA240, Varian, Australia). The digested samples were run followed by standards. The absorbance for all the standards and samples were recorded and results were computed by using calibration curves.

Cooking loss quantification

Five-gram noodles sample was placed in 300 ml of boiling water for 8 min, and cooking water was evaporated at 100 ± 1 °C in a hot air oven for 20 h. The ratio of initial weight and final weight after drying was used to calculate cooking losses.

Sensory evaluation

Students and faculty members from National Institute of Food Science and Technology, University of

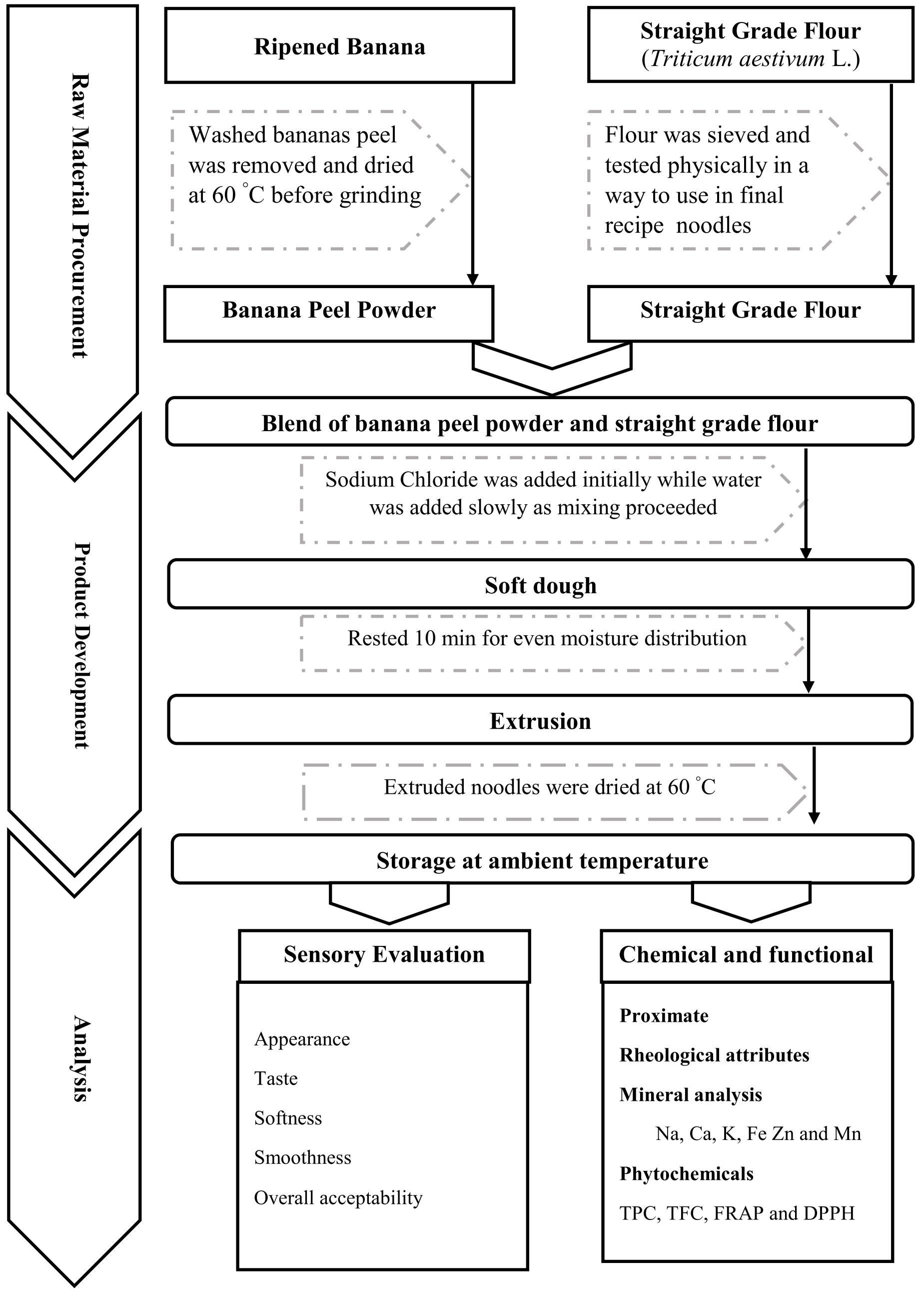


Fig. 1 Flow line of study showing important steps

Agriculture, Faisalabad, Pakistan who normally consume noodles more than once in a week voluntarily participated in sensory evaluation ($n=25$) of the products. Freshly cooked noodles prepared in boiling water were presented before judges to evaluate appearance, flavour, taste, texture, and overall acceptability in triplicates. The intensity of each attribute was rated on a nine-point hedonic scale (1 = dislike extremely and 9 = like extremely) (L.-Y. Li et al. 2013). Noodles were coded with a digital number and placed in the transparent plates along with spoons. Mineral water was provided to clean their mouths to avoid cross-mixing.

Statistical analyses

Data from each parameter are presented as means of triplicate samples ± standard deviation (otherwise mentioned). Treatment significance was determined using analysis of variance under completely randomized design, and means were ranked using the Honestly Significant Difference (HSD) Tukey test ($p \leq 0.05$) (Steel et al. 1997). Statistical analyses were performed on Statistix 8.2® (Analytical Software for Windows, Tallahassee, USA).

Results and discussion

Proximate composition of BPP supplemented noodles

Study outcomes revealed that BPP addition had no significant effect on moisture, protein, and fat percentage (Table 1). The slight increase in the moisture content of peel supplemented noodles (e.g., 7.99 and 10.37% in T_0 and T_3 respectively) may be associated with higher dietary fiber in BPP as compared to WF (Happi Emaga et al. 2007). Decreasing trend (non-significant) for protein content in BPP composite noodles, i.e., 12.97% (T_0) to 11.96% (T_3) demonstrates higher protein in WF than BPP (Table 1). The composite flour noodles with 15% BPP had ~ 5-folds higher crude fibre content while, ~ 5% lower caloric value than the noodles made of 100% WF. Lower caloric foods help in prevention and management of various metabolic syndrome (i.e., high blood pressure, high blood sugar levels, and higher body mass index) (Liaquat et al. 2022). A significantly higher inorganic residues (22.1%) were observed in the BPP as compared to WF (0.3%). The mineral content of composite noodles increased significantly and the noodles comprising 15% BPP had ~ 128% higher ash content as compared to control (100% WF). Our results were similar to the study reported by (Aurore et al. 2009) that BPP contains ~ 300-folds higher minerals content than WF. The fat content was significantly higher in BPP as compared to WF, and it increased ~ 20% in the composite flour noodles containing 15% BPP as compared to control. The results showed a similar trend as previously reported by Ndife et al. (2011). Higher level of fat in noodles is undesirable because of its susceptibility to rancidity in storage which impart unpleasant odor to products (Gotoh et al. 2007). In this context, higher rates of BPP does not seem suitable for value addition in sheeted noodles.

Banana peel powder improves noodles mineral content

Minerals are essential for human nutrition that support our skeleton and regulate metabolic processes (Gupta & Gupta 2014). Growing dependence on cereals based foods is mainly associated with minerals deficiencies, because they lack sufficient amount of minerals to meet human requirements (Ahsin et al. 2020). The minerals in banana peel powder were recorded as K (7124.4 mg/kg), Ca (332.6 mg/kg), Na (440.5 mg/kg), Fe (1216.3 mg/kg), and Mn (54.3 mg/kg) that are significantly higher than WF, while Zn (2.0 mg/kg) and P (647.3 mg/kg) were significantly lower (Table 2). Addition of 15% BPP improved Fe, Mn and Na concentration of composite flour noodles (T_3) by 452, 122, and 14% respectively, as compared to control (WF), whereas Zn and P were decreased by 15 and 6% respectively. It has been reported that addition of micro minerals rich fruit peels in WF is a sustainable method to increase mineral content (Ismail et al. 2014).

Phytochemicals and antioxidant activity of BPP supplemented noodles

Total phenolic content in BPP (581 mg GAE/100 g) was significantly higher than WF (30 mg GAE/100 g) (Table 3). The TPC in composite flour noodles (T_3) was increased up to 270% as compared to control. Significantly higher TPC in BPP has been reported in literature with a ranges of 5–47 mg GAE/g (Hernández-Carranza et al. 2016; Mosa & Khalil 2015). Interestingly, banana peel contains about 1.5 to 3-folds higher TPC than flesh (Sulaiman et al. 2011). Banana peel ranked second among tropical fruits (avocado, papaya, pineapple, watermelon, melon, and passion fruit) as a source of TPC in functional foods development (Morais et al. 2015). Therefore, higher

Table 1 Chemical analysis of the wheat flour (WF), ripened banana peel powder (BPP), and BPP composite noodles together with the control sample (% on DW basis)

Sample	Moisture	Crude Protein	Fat	Ash	Crude Fiber	NFE	Calories
WF	12.85 ± 1.73^a	12.29 ± 1.59^a	1.71 ± 0.23^b	0.47 ± 0.07^b	0.33 ± 0.02^b	85.19 ± 1.78^a	405.35 ± 1.36^a
BPP	6.36 ± 0.65^b	8.82 ± 0.64^b	4.52 ± 0.59^a	22.10 ± 3.01^a	11.20 ± 1.73^a	53.36 ± 2.50^b	289.40 ± 2.18^b
Noodles							
T_o	7.99 ± 1.24^a	12.97 ± 1.76^a	1.81 ± 0.24^a	2.07 ± 0.89^d	0.35 ± 0.03^d	84.37 ± 1.61^a	405.69 ± 1.58^a
T_1	8.65 ± 1.12^a	12.69 ± 1.96^a	1.96 ± 0.14^a	3.97 ± 0.56^c	0.92 ± 0.13^c	82.78 ± 1.92^{ab}	399.53 ± 1.10^b
T_2	9.70 ± 0.71^a	12.30 ± 1.65^a	2.07 ± 0.32^a	3.72 ± 0.33^b	1.50 ± 0.19^b	81.34 ± 1.40^{ab}	393.20 ± 3.90^c
T_3	10.37 ± 1.41^a	11.96 ± 1.85^a	2.19 ± 0.28^a	4.72 ± 0.62^a	2.08 ± 0.28^a	79.78 ± 1.56^b	386.68 ± 1.38^d

Values are means of triplicates ± SD with different superscript letters in the same column shows the significant ($p \leq 0.05$) difference among the variables based on HSD-Tukey Test

T_0 = 0% BPP + 100% WF; T_1 = 5% BPP 95% + WF; T_2 = 10% BPP + 90% WF; T_3 = 15% BPP + 85% WF

Table 2 Mineral analysis of the ripened banana peel powder (BPP), and BPP composite noodles together with the control sample (mg/kg on DW basis)

Sample	Potassium	Calcium	Sodium	Iron	Manganese	Zinc	Phosphorus
WF	1542.4 ± 5.5^{b}	24.1 ± 1.8^{b}	159.9 ± 15.6^{b}	39.4 ± 2.9^{b}	5.7 ± 0.9^{b}	8.1 ± 1.1^{a}	782.6 ± 106.4^{a}
BPP	7124.4 ± 3.7^{a}	332.6 ± 44.7^{a}	440.5 ± 59.2^{a}	1216.3 ± 188.1^{a}	54.3 ± 7.0^{a}	2.0 ± 0.1^{b}	647.3 ± 47.2^{b}
Noodles							
T_o	1503.6 ± 33.1^{d}	250.9 ± 32.5^{c}	4930.5 ± 596.5^{a}	41.2 ± 5.5^{d}	6.1 ± 0.4^{c}	8.6 ± 0.9^{a}	826.8 ± 107.1^{a}
T_1	1884.7 ± 59.2^{c}	414.0 ± 64.0^{bc}	5110.2 ± 670.9^{a}	103.3 ± 10.5^{c}	8.6 ± 1.2^{bc}	8.2 ± 1.1^{a}	820.0 ± 59.8^{a}
T_2	2212.9 ± 60.2^{b}	573.5 ± 74.3^{ab}	5296.0 ± 587.8^{a}	165.4 ± 21.4^{b}	11.1 ± 1.7^{ab}	7.7 ± 1.0^{a}	792.7 ± 106.5^{a}
T_3	2547.1 ± 42.9^{a}	736.8 ± 99.0^{a}	5657.1 ± 731.5^{a}	227.5 ± 29.5^{a}	13.6 ± 1.4^{a}	7.3 ± 0.9^{a}	775.5 ± 119.9^{a}

Values are means of triplicates ± SD with different superscript letters in the same column shows the significant ($p \leq 0.05$) difference among the variables based on HSD-Tukey Test

T_0 = 0% BPP + 100% WF; T_1 = 5% BPP 95% + WF; T_2 = 10% BPP + 90% WF; T_3 = 15% BPP + 85% WF

Table 3 Total phenolic contents (TPC), Total flavonoids contents (TFC), antioxidant activity (DPPH and FRAP) of ripened banana peel powder (BPP), and BPP composite noodles together with the control sample (on DW basis)

Sample	TPC (mg GAE/100 g)	TFC (mg CE/100 g)	FRAP (mM Fe^{2+}/100 g)	DPPH (%)
WF	30.41 ± 3.85^{b}	12.40 ± 1.55^{a}	1.34 ± 0.20^{b}	17.82 ± 2.72^{b}
BPP	581.44 ± 74.44^{a}	225.63 ± 34.33^{b}	14.42 ± 1.80^{a}	39.77 ± 5.04^{a}
Noodles				
T_o	32.0 ± 3.5^{c}	12.9 ± 2.0^{d}	1.4 ± 0.2^{c}	19.1 ± 2.4^{a}
T_1	61.2 ± 9.3^{bc}	24.5 ± 3.1^{c}	2.1 ± 0.3^{bc}	19.8 ± 3.0^{a}
T_2	90.3 ± 13.8^{b}	35.5 ± 4.5^{b}	2.8 ± 0.4^{ab}	20.6 ± 2.6^{a}
T_3	121.5 ± 15.2^{a}	46.4 ± 5.9^{a}	3.4 ± 0.5^{a}	21.6 ± 3.3^{a}

Values are means of triplicates ± SD with different superscript letters in the same column shows the significant ($p \leq 0.05$) difference among the variables based on HSD-Tukey Test

T_0 = 0% BPP + 100% WF; T_1 = 5% BPP 95% + WF; T_2 = 10% BPP + 90% WF; T_3 = 15% BPP + 85 WF

phenolics in BPP can provide significant amount of antioxidants, which are helpful in controlling cholesterol and blood sugar and prevent heart diseases and cancer (Sirajudin et al. 2014; Someya et al. 2002). Flavonoids have potential to inhibit cell damage and repair of damaged DNA (Panche et al. 2016), and BPP contains significantly higher amount of flavonoids (TFC = 225.63 mg CE/100 g) as compared to WF (12.40 mg CE/100 g) (Table 3). Addition of 15% BPP in WF increased TFC in noodles by 260%. The observed TFC in BPP was substantially lower than reported data for banana peel (467 to 756 CE/100 g), which may be associated with cultivar, fruit maturity, soil health and postharvest management (Huang et al. 2005; Someya et al. 2002).

In vitro antioxidant assay, DPPH radical scavenging activity of BPP (39.8% inhibition) was significantly higher than WF (17.82% inhibition) (Table 3). Addition of 15% (w/w) BPP in WF increased DPPH inhibition power by 13%. Our findings were had similar trends as reported by Ajila et al. (2010) who stated that addition of mango peel into macaroni formulation increased the DPPH radical-scavenging activity. FRAP assay is widely used to measure the antioxidant activity of food products. The results show that BPP is rich in antioxidant power (14.42 mM Fe^{2+}/100 g) and can be used to enhance the antioxidant potential of WF (1.34 mM Fe^{2+}/100 g) products. Therefore, BPP composite noodles had significantly increased antioxidant power (142% by addition of 15% BPP). The observed FRAP in this study was higher than the data on antioxidant activity of banana peel, which may associated with fruit maturity, growing condition, and postharvest management (Huang et al. 2005; Sulaiman et al. 2011).

Pasting properties and water absorption of BPP supplemented noodles

Flour water absorption capacity (WAC) principally determines its rheological attributes and the higher capacity is appreciated by food processors (Barbiroli et al. 2013). Water absorption capacity of composite flour was increased with the concentration of BPP in the recipe (57.03 and 59.83% and 61.51% in T_0 and T_3, respectively) (Table 4). The same results were observed by Eshak (2016) in BPP supplemented flat bread. This might be due to higher amount of fibre in banana, which is considered

Table 4 Rheological properties of the ripened banana peel powder (BPP) and composite flours (values are in centipoise)

Sample	Peak Viscosity (cP)	Break Down Viscosity (cP)	Final Viscosity (cP)	Set Back viscosity (cP)	Water absorption (mL)
T_o	2261 ± 41^a	681 ± 14^a	2718 ± 34^a	1149 ± 21^a	57.04 ± 0.36^d
T_1	2199 ± 82^b	654 ± 11^b	2638 ± 42^b	1063 ± 15^b	58.29 ± 0.28^c
T_2	2126 ± 68^c	621 ± 15^c	2567 ± 31^c	982 ± 17^c	59.84 ± 0.14^b
T_3	2061 ± 51^d	594 ± 09^d	2486 ± 29^d	901 ± 14^d	61.53 ± 0.21^a

Values are means of triplicates ± SD with different superscript letters in the same column shows the significant ($p \leq 0.05$) difference among the variables based on HSD-Tukey Test

T_0 = 0% BPP + 100% WF; T_1 = 5% BPP 95% + WF; T_2 = 10% BPP + 90% WF; T_3 = 15% BPP + 85

a good water binder, so water absorption capacity of composite flour was increased. Similarly, dough stability time also increased with percentage of BPP supplementation, least in T_0 (5.62 min) and highest in T_4 (6.89 min). Literature also suggests that fruits peel powder supplementation increases the flour water absorption capacity (Gunathilake & Abeyrathne 2008).

Pasting properties demonstrated the cooking behaviour at higher temperature and pressure. Decreasing trend in peak viscosity (2261 to 2061 cP), and final viscosity (2718 to 2486 cP) was observed by incorporation of BPP in WF (Table 4). Break down viscosity (BDV) represents the disintegration of cooked starch, whereas setback viscosity (SV) represents the syneresis of cooked starch upon cooling. Setback viscosity and BDV also decreased from 1149 to 901 cP and 681 to 594 cP respectively. Higher set BDV denotes the higher stability of pasta noodles during sheeting without incorporation of BPP. Product exposed to higher mechanical shear and temperature in holding phases leads to starch granules destruction and thus decrease the breakdown viscosity (Barbiroli et al. 2013). Lower protein content has been reported to make starch granules more prone to rupture, resulting in a decrease in BDV with pulp substitution (Barbiroli et al. 2013). Because gelatinisation and retrogradation occur concurrently, starch dilution reduces peak viscosity (Yadav et al. 2014). The final viscosity of starch granules reflects molecular and structural changes.

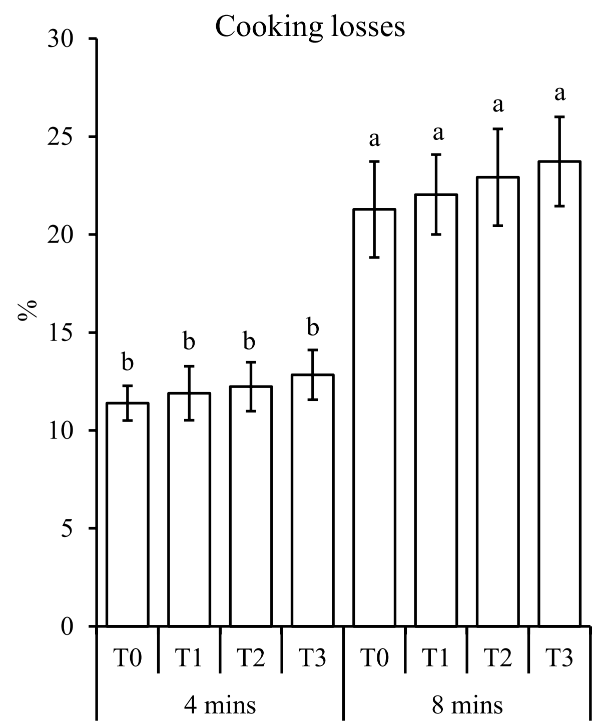


Fig. 2 Effect of banana peel incorporation in cooking losses of wheat flour noodles. Values are means ranked on HSD Tukey test ($p \leq 0.05$) $n = 3$, different letters on bars show the significant difference < 0.05. Error bar represents the standard deviation. T_0 = 0% BPP + 100% WF; T_1 = 5% BPP 95% + WF; T_2 = 10% BPP + 90% WF; T_3 = 15% BPP + 85% WF

Cooking losses for BPP supplemented noodles

Cooking losses are important to assess the ability of the product to retain water during cooking and directly contribute to the final product yield. In this experiment, cooking losses for composite flour noodles increased up to 13% as compared to WF noodles (T_0) (Fig. 2). Park and Baik (2009) reported that addition of 6% gluten content in soft wheat flour decreased cooking losses by 15%. Therefore, The increase in cooking losses may be explained by lower amount of amylose starches in BPP that resulted in higher leaching (Lucisano et al. 2012).

Sensory quality of BPP supplemented noodles

The sensory evaluation shows that noodles prepared with 15% BPP were quite comparable and acceptable (7.8) in comparison with control (8.7). Banana peel can be supplemented in noodles up to 10%, while high fibre proportion interferes with the flour matrix in a way to disintegrate the shape, texture, taste, and appearance score (Fig. 3). Higher fibre content leads to reduced score for texture (7.1), consequently reducing the overall acceptability (7.8) of composite noodles enriched with

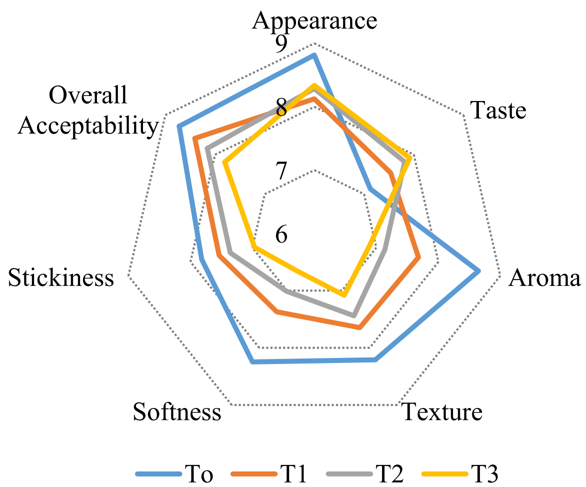


Fig. 3 Sensory characteristics of noodles samples with different levels (0, 5, 10 and 15%) of banana peel powder. Values are means score ($n = 25$). $T_0 = 0\%$ BPP + 100% WF; $T_1 = 5\%$ BPP 95% + WF; $T_2 = 10\%$ BPP + 90% WF; $T_3 = 15\%$ BPP + 85% WF

15% BPP. Results for sensory attributes showed that score for noodles containing 15% BPP was maximum for taste (7.9). From the score of sensory data, it was clear that highest score for stickiness was obtained by the control sample. Texture, softness and aroma, which represent the feel of the product, were scored highest by control sample. The control noodles scored best for aroma. The score for appearance for the control sample was slightly higher than composite flour samples. The overall acceptability scores differed a little between the four samples. Similar results were reported by Eshak, (Eshak 2016) for different types of flours. The BPP contains a higher amount of fructose, glucose, and proteins (Happi Emaga et al. 2007), which makes it susceptible to Maillard's reaction during the powder production while existing oxidase enzymes also contribute to the enzymatic browning (Thipayarat 2007). Therefore, the appearance of the banana peel supplemented noodles scored lower as compared to the control sample**.** Similarly, a lower taste score for BPP containing sample might be owing to the presence of tannins in peel which impart a bitter taste (Ehiowemwenguan & Inetianbor 2014). The softness of the noodles decreased with BPP supplementation as it contains higher dietary fiber content.

Conclusion

In this study, we evaluated nutritional and functional profile of banana peel, which is typically considered a waste. Banana peel powder was evaluated for its suitability for salted noodles preparation. The proximate analysis showed that BPP contained significantly higher amount of ash, crude fibre and crude fat than 100% wheat flour noodles, however, protein content was significantly lower. Minerals (K, Ca, Na, Fe, and Mn) concentration of BPP was significantly higher than WF. Higher amount of phytochemicals in BPP was demonstrated by higher phenolics, flavonoids, and antioxidants. In the development of noodles, addition of BPP significantly increased ash, crude fibre, fat, micro-minerals and antioxidant capacity of the supplemented noodles as compared to control. However, pasting properties and water absorption capacity were negatively influenced with BPP incorporation. Moreover, cooking losses of composite flour noodles also increased slightly as compared to control. Based on sensory data, control sample scored highest for appearance while 10% BPP had relatively better acceptability for taste. In conclusion, BPP has significant nutritional potential for the development of flour based value-added products like noodles and pasta.

Abbreviations

AACC: American Association for Cereal Chemists; AOAC: Association of Official Analytical Chemists; BDV: Breakdown Viscosity; BPP: Banana Peel Powder; CE: Catechin Equivalent; cP: Centipoise; DPPH: 2,2-Diphenyl-1-picrylhydrazyl; FAO: Food and Agriculture Organization; FRAP: Ferric Reducing Antioxidant Power; GAE: Gallic Acid Equivalent; HSD: Honestly Significant Difference; SD: Standard Deviation; SV: Setback Viscosity; TFC: Total Flavonoid Content; TPC: Total Phenolic Content; WF: Wheat Flour; WHO: World Health Organization.

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Authors' contributions

Abdul Basit: Methodology; Formal analysis; Sensory – Convince and Organize; Farah Ahmad: Conceptualization; Writing – Review & Editing; Imran Pasha: Conceptualization; Supervision; Methodology; Writing – Review & Editing; Resources; Muhammad Ahsin: Data Analysis; Writing – Original Draft; The authors read and approved the final manuscript draft be submitted.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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