



Potentiality of Banana and Pumpkin Fruits Residues as a Cheap Source of Valuable Nutrients

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Abstract

Banana peel and pumpkin seeds are under-utilized by-products or wastes of the household and food processing industry but these could be rich in valuable nutritive compounds. Having a scientific database on the chemical and proximate analysis of the plants cultivated in the particular region would be helpful to the food product manufacturer, educator, researcher, public health personnel, policymaker, and population under food stress. Literature indicates that the nutritional and chemical composition of these under-utilized materials has not been characterized previously. The present study was designed to examine the nutritional, antioxidants, vitamin C, total phenolic and flavonoid contents of peels and seeds flour of selected fruits. Nutritional analysis reveals that the peel flour of *Musa acuminata* is rich in crude fiber 14.13%, carbohydrate 60.38%, and seed flour of *Cucurbita maxima* is rich in protein 30.05%, fat 43.81%, dietary fiber 13.81%. BPF showed more antioxidant activity (86.8%), total phenolic and flavonoid content than PSF, which is rich in vitamin C content (9.23 mg/100gm). Industrial by-products can be processed into value-added products such as flour that is more easily stored for further uses. By-product flour can easily include in food formulations due to its excellent nutritional qualities. Optimization of its use is beneficial in terms of nutritional and economical points of view.

Key words: Banana, Flour, Peel, Pumpkin, Seed

Introduction

The peels and seeds are a household as well as industrial food waste or by-product discarded in huge quantities in the environment. Fruits and vegetables naturally contain high nutrients and bioactive compounds (Bigliardi and Galati, 2013). From the cultivation to the final consumption, all parts of fruits and vegetables are not properly utilized such as leaves, peels, and seeds. These agricultural wastes or by-products are often neglected by the general consumers and also further remarkable involvement in industrial applications was not found (Martins and Ferreira, 2017). But scientists claimed that these unutilized and wasted parts of fruits and vegetables peels and seeds are enriched in many nutrients and sometimes they contain more concentrated nutrients as compared to the pulp (Oguntoyinbo *et al.*, 2020).

Different types of tropical and sub-tropical fruits and vegetables are available in Bangladesh. The banana and pumpkin are widely grown in Bangladesh. Bangladesh is one of the Asian countries that cultivate an enormous number of bananas. According to the data of FAOSTAT 2019, Bangladesh produces 833309 tons of bananas per year and Bangladesh occupies position 24 among the top 30 banana-producing countries globally. Banana is one of the nutritious fruits but fresh bananas have a peel that contributes to 40% of their entire weight (Lee *et al.*, 2010). Moreover, a wide range of vitamins and minerals are present in pulps and peels (Pyar & Peh, 2018). It also has potent natural antioxidant and antimicrobial effects and also acts as prebiotics (Aboul-Enein *et al.*, 2016). In addition, pumpkin is grown all over the world. Russia, India, and the Chinese Federation are the top pumpkin

producers, accounting for 88.4 percent of global production (FAO, 2017). Even Bangladesh also plays an important contribution to the world and the production of pumpkin is about 312,226 Metric Tons in 2019. The position of Bangladesh is 16 among other countries in squash, gourds, and pumpkins production (FAO, 2017). During processing, the major consumption part of the pumpkin is pulp but the peels or seeds are discarded about 18-21% of the fruit (Genevois *et al.*, 2016). These residues can be used for infectious medicine, and have antioxidants and wound healing properties as well (Bahramsoltani *et al.*, 2017). So, a large number of peels and seeds are generated as waste materials or by-products.

With the diversification and development of the agricultural sector in Bangladesh, the number of food companies has increased and the increase of fruit and vegetable processing creates the trouble of waste production (Qiu *et al.*, 2010). These agro or processing-based wastes, if not treated further, generate odor, soil contamination, insect harborage, and can cause major environmental pollution (Shalini and Gupta, 2010). These waste materials are directly thrown into the environment without any kind of treatment. Previously, various attempts had been made to utilize agro-wastes primarily for animal feed and fuel generation. Scientists have recently been able to produce value-added items such as cosmetics and medications from these by-products, and the recovery appears to be commercially attractive (Ashoush and Gadallah, 2011). Recently, in response to the growing interest in natural and trustworthy sources of bioactive components and the demand for bioactive functional foods, food items enriched with seeds and peels are being formulated (Babiker *et al.*, 2013). Household, agricultural, and food

processing industrial wastes and by-products should be possible sources of functional and bioactive components that are valuable both for pharmaceuticals and the food industry due to their nutritive quality, easy availability, and low cost (Babbar *et al.*, 2011). The concept of using agro or processing waste or by-products, particularly the peels and seeds, which account for about 30% - 40% of the total weight in some fruits have gradually got popularity particularly when researchers revealed that peels and seeds possessed superior biological function than other sections of the fruit (Moon and Shibamoto, 2009). To reduce the problem, it is necessary to develop technology and ways which enable the appropriate application of by-products and wastes generated in food manufacturing industries as well as contributing to the country's long-term growth and development. However, the possible application of fruit seeds and peels in dietary supplementation depends significantly on their proximate and chemical composition. Therefore, it is crucial to examine the composition of these waste materials through technological and scientific research to make possibilities for rotating them into beneficial processing industry as well as use by growing consumers. So, when thinking about the importance of the nutrients and bioactive components and the high amounts of waste materials produced during the banana and pumpkin processing, the present study designed to observe the nutritional, antioxidants, vitamin C, total phenolic and flavonoid contents of peels and seeds flour of selected fruits. This study explores the potential importance and value of these wastes or by-products.

Materials and Methods

Samples

Musa acuminata and *Cucurbita maxima* which indigenous names are "Sagor kola" and "Mistikumra" respectively, were selected for this study.

Chemical and reagents

The necessary chemicals used in the present study include Sodium hydroxide, sulfuric acid, hydrochloric acid, copper sulfate, methyl-red, potassium sulfate, boric acid, petroleum ether, anthrone reagent, dextrose, methanol, ethanol, ascorbic acid, meta-phosphoric acid, sodium bicarbonate, glacial acetic acid, 2,6-dichlorophenol indophenols, ferrous sulfate (FeSO_4), sodium carbonate (Na_2CO_3), gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), meta-phosphoric acid, diisopropyl-fluorophosphate, sodium nitrite, aluminum chloride were analytical grade. Chemicals were collected from Moon scientific, Dhaka, Bangladesh, Sigma Aldrich, Schnelldorf, Germany, and Fisher Chem Alert (Fair Lawn, NJ, USA). Soxhlet apparatus, Kjeldahl apparatus, UV spectrophotometer, muffle furnace, centrifuge machine, grinder, electric water bath, oven, micropipettes, etc were used as major apparatus.

Banana peel collection and preparation

Approximately 100 pieces of banana (*Musa acuminata*) were procured from the local market of Santosh (Tangail-1902, Bangladesh), with yellow skin color with a green tip. According to the Von Loesecke scale, the degree of skin color was 5. In the Food analysis lab of the Department of FTNS (Food Technology and Nutritional Science), Mawlana Bhashani Science and Technology University (Tangail-1902, Bangladesh), bananas samples were washed with water. Then spray with a chlorine solution (50 mg /L) for 15 minutes for sanitization purposes. Then bananas were kept on smooth tissue paper at room temperature to dry. Banana peels were removed manually from the pulp if needed using either a sharpened knife or a scraper. The separated peel is cut into even pieces (about 5 cm²). The pieces were bleached for 5 minutes at 95°C in a jacketed pan (Groen MGF Co., Millwood, WV, USA) to inactivate enzymes and allowed to dry at 54°C using a tray drier equipped with forced air (up to reach constant weight). The dried peels were ground using a Wiley Mill, model WI (Brabender, Duisburg, Germany). The grounded mass was passing through a sieve mesh size US 100 (mean particle size 0.15 mm). The flour obtained from the mill is called 'banana peel flour'. The flour was stored at room temperature in air-tight polypropylene plastic container (Fisher Scientific, Göteborg, Sweden). This flour is used as feedstock for later analysis.

Pumpkin seed collection and preparation

Cucurbita maxima are known as "Mistikumra" in Bangladesh. Total fifty pumpkin samples were purchased from the grower experimental plot located at Charabari, Tangail Sadar-1902, Bangladesh. Pumpkins were cultivated in the field inhomogeneous conditions. The pumpkin fruits selected were fresh, mature, and ready for market. The selected pumpkins were transported to the above-mentioned Laboratory immediately after sampling and collection. The sample pumpkins were washed with tap water then rinsed with distilled water to remove any surface contamination or dirt. The seeds were collected from the fruits within 2 days of arrival in the laboratory. Firstly, dividing the fruit into two pieces the flesh and the seeds of the fruit were separated with a plastic spoon. The seeds are then checked for containing any flesh with its outer surface. The collected seeds were dried in a sun drier until they had a moisture level of around 10%. Although the seeds came from different fruits, the seeds were uniformly mixed. The seeds were then dried in the sun for four consecutive days and ground into a fine powder (Pulvex-200 mill, México D.F. México). The powder was dried for 3 hours at 60°C using an electric oven. The powder was sieved through US 100-mesh. The obtained flour is called 'Pumpkin seed flour'. The flour was stored at room temperature in an air-tight polypropylene plastic container for the next analysis.

Proximate composition analysis

The proximate composition analysis (moisture, ash, crude fiber, protein, and fat) was determined by using the conventional method (AOAC, 2000). Five-gram samples were dried in an electric oven for 3 hours at 105°C to determine moisture content. Ash content was determined after the combustion of a 5 gm sample in a muffle furnace at 600°C for 4-5 hours. The crude fiber was evaluated by sulphuric acid treatment and subsequently heating 5 gm at 600°C. The protein content was calculated by following Kjeldahl estimation, where nitrogen content was multiplied with a conversion factor (6.25). Fat content was analyzed using the Soxhlet apparatus with petroleum ether. Anthrone method was used to determine carbohydrate content (Hedge and Hofreiter, 1962). All the analyses were performed in triplicate.

Preparation of methanol extract sample

The powdered particles were extracted in methanol to determine polyphenols and antioxidant activity. Five-gram samples were suspended in 100 ml methanol, agitated for 3 hours, centrifuged at 3000 rpm, and filtered through Whatman filter paper.

Determination of antioxidant activity

The DPPH (2, 2-diphenyl-1-picrylhydrazyl) free radical scavenging method was used to determine the extract's antioxidant activities (Brand-Williams *et al.*, 1995). In methanol, oxidized DPPH produces a rich violet color. An antioxidant molecule transfers an electron to DPPH, resulting in its reduction, and a change in hue from darkviolet to yellow was found. The absorption is measured using a spectrophotometer at 515 nm which gives the percent inhibition of the sample. Using the following formula, the percent inhibition of DPPH by extracts was determined using the following equation -

$$\text{Inhibition of DPPH (\%)} = (A-B/A) \times 100$$

where, A = pure DPPH's absorbance; B = samples absorbance

Vitamin-C estimation

The amount of vitamin-C in each sample was estimated using the AOAC method (2000). In a conical flask, 10 mL of standard vitamin-C solution was titrated against the dye solution, then 4 to 6 gm of sample was homogenized well with 3% meta-phosphoric acid and filtered through a doubled layer of muslin cloth. Centrifugation of the filtrate was held for 10 minutes at 3,000 rpm and finally, the supernatant was titrated with a solution of 2, 6-dichlorophenol indophenols. Comparing the titration result of a standard vitamin-C solution, the amount of vitamin-C in the extract was calculated using the following formula -

$$\% \text{ of vitamin C content (mg/100gm)} = \frac{\text{mg of vitamin C obtained}}{\text{weight of sample(g)}} \times 100$$

Total phenolic compounds (TPC) estimation

The total phenolic content of samples (methanol extracts) was measured by using the Folin-Ciocalteu reagents (oxidizing agent) and Gallic acid as a reference. Spectroscopic analysis was used to quantify the total phenolic content described by Agbo *et al.* (2015). The following equation was used to calculate the overall content of phenolic compounds in extracts of gallic acid equivalents.

$$C = \frac{eV}{m}$$

where, C = total phenolic components in GAE, mg plant extract; e = the gallic acid concentration (according to calibration curve), mg/ml; V = extracts volume in ml; m = pure plant extracts weight in gm.

Total flavonoid content (TFC) estimation

The AlCl₃ colorimetric technique was used to determine the concentration of total flavonoid. The extract's flavonoid concentration was measured in milligram of quercetin equivalent/gram of dried extract using quercetin as a standard (Agbo *et al.*, 2015). The following equation was used to calculate the overall content of flavonoids in plant extracts of quercetin equivalents.

$$C = \frac{eV}{m}$$

where, C = total flavonoid components in QE, mg plant extract; e = the quercetin concentration (according to calibration curve), mg/ml; V = extracts volume in ml; m = pure plant extracts weight in gm.

Statistical analysis

For statistical analysis, IBM SPSS version 21.0 was applied. Each sample was subjected to a triplicate analysis. Means and standard deviations were used to express the experimental results.

Results and Discussions

Proximate compositional analysis of *M. acuminata* peel & *C. maxima* seed flour

The proximate composition analysis offers information about the fundamental chemical makeup of food processing or agricultural waste. The proximate compositions are carbohydrate, fat, protein, moisture, ash, and fiber. These elements are essential in determining the nutritional quality of the food.

Table 1 and Table 2 showed the proximate composition of banana peel flour (BPF) and pumpkin seed flour (PSF) respectively. The BPF possessed 6.02±0.77% moisture content. A value of 88.10±0.18% moisture content was obtained by Aboul-Enein *et al.* (2016) in the banana peel of another variety. But, a higher value of moisture content (90.84±3.52%) was observed by Abou-arab and Abu-salem (2017) in the banana peel. On the other hand, PSF possessed 5.7±0.74% of moisture content which is lower than 90.76±0.16% was observed in *Cucurbita moschata* Duchesne fruit peel by Bahramsoltani *et al.* (2017). In this study, we observed

high moisture content in BPF than PSF. Shelf life and freshness are determined by the moisture level of foods or their processed items and food items with high water content are more susceptible to microbial decomposition, degradation, and limited shelf life (Tressler *et al.*, 1980; Adepoju and Onasanya, 2008). The moisture content of a food is sometimes related to the dry matter content (Warner, 2081). Reduced moisture content lengthens the shelf life, adds value, and reduces the perishability of food (Emperatriz *et al.*, 2008).

Table 1. Proximate composition of banana peel (*M. acuminata*) flour

Parameter	Amount (%) *
Moisture	6.02±0.77
Ash	9.39±0.29
Crude fiber	14.13±0.17
Carbohydrate	60.38±0.63
Protein	7.02±0.12
Fat	5.33±0.38

*All values are means of triplicate determinations ± standard deviation (SD)

BPF showed 9.39±0.29% ash content. Bakar *et al.* (2018) reported a range of 9.36±0.02% to 12.50± 0.06% ash content among four species of banana. The ash content of PSF observed a value of 6.14±0.43% in our investigation. Mala and Kurian (2016) found a similar value of 6.04±0.43% ash content in pumpkin peel. In terms of ash content, BPF contained more than PSF. The amount of ash in a product can help determine its quality. The high ash values suggested that there was a considerable amount of mineral content (particularly the macro minerals) present in the sample. The present study showed that BPF had 14.13±0.17% fiber content. The fiber content of the BPF sample was fairly higher than those observed by Hassan *et al.* (2018) for *Musa Sapientum* peel (8.37±0.18%). The PSF showed 13.81±0.04% fiber content which is notably higher than fiber content (10.851%) in pumpkin seed previously observed by Kim *et al.* (2007). The removal of moisture content might be the cause of the rise in ash and fiber content, which tends to enhance the nutrients' concentration (Morris *et al.*, 2004). The high fiber content in flour implies that flour can be used as a source of dietary fiber supplements. Fiber content measures the lignin, hemicelluloses, and cellulose content of food. Polymers of phenolic acids construct lignin and heteropolymers of polysaccharides construct hemicellulose (Zakpaa *et al.*, 2010). Diets rich in fiber have been accounted to increased removal of potential mutagens, carcinogens, bile acids, xenobiotic and steroids by absorbing or binding to fiber components, and be quickly excreted, thus these wastes or by product will have health benefits for non-ruminants and also ruminants (Ayoola and Adeyeye, 2009). In our investigation, carbohydrate content of BPF was 60.38±0.63%. Bakar *et al.* (2018) showed the variation

of carbohydrate content among four different species and the range of total carbohydrate content was 64.6-72.8%. This result was close to the previous report (68.31±0.83%) evaluated by Aboul-Enein *et al.* (2016). However, the observed value of carbohydrate content was 12.58±0.05% in PSF. Damiani *et al.* (2016) observed 61.85±0.05% carbohydrate content in pumpkin peel. Such an amount of carbohydrate content implies the flours can be a good choice for diabetic patients' diets. In this study, we found that the protein content of BPF and PSF was 7.02±0.12% and 30.05±0.08% respectively. A similar value of 7.57±0.3% protein content was observed by Aboul-Enein *et al.* (2016) in the banana peel. But the protein content of PSF represented a higher value than protein content (29.81 %) was obtained from pumpkin seed by Kim *et al.* (2007). Protein is a necessary component of the human diet to survive. The basic function of protein in nutrition is to provide the required necessary amino acids in an adequate amount. Deficiency of protein causes muscle wasting, growth retardation, edema, accumulation of fluids in the body, and swelling of the belly (Mounts, 2000).

Table 2. Proximate composition of pumpkin seed (*C. maxima*) flour

Parameter	Amount (%) *
Moisture	5.7±0.74
Ash	6.14±0.43
Crude fiber	13.81±0.04
Carbohydrate	12.58±0.05
Protein	30.05±0.08
Fat	43.81±0.18

*All values are means of triplicate determinations ± standard deviation (SD)

The fat content of BPF was found to be 5.33±0.38% which conforms with the value (5.33±0.38%) reported by Hassan *et al.* (2018). On the other hand, the fat content of PSF was found to be 43.81±0.18%. PSF may be a good source of fat-soluble vitamins. Crude fat contents indicate the presence of free fatty acids in food. This attribute can be applied as the base in determining required processing temperatures and auto-oxidation that can direct rancidity. The low-fat content (5.33%) of BPF will contribute to enhancing the shelf life of flour by reducing the possibility of developing rancid flavor. It also indicates that the BPF may not supply a significant amount of fat-soluble vitamins. Lipid oxidation might be the cause of the reduction in lipid content in the dried samples. Chemical changes, such as oxidation, have been accounted to cause nutrient loss. Many stimuli, including heat, radiation, and light have been shown to enhance lipid oxidation (Savage *et al.*, 2002).

Analyses of total antioxidant activity, vitamin C, Total phenolic and flavonoid content

DPPH is normally used to evaluate antioxidant activity. The reduction capability of the DPPH radical is measured by the reduction in its absorbance at 515 nm, induced by antioxidants. The decrease in absorbance of DPPH radical is affected by antioxidants, because the reaction between antioxidant molecules and radicals, progresses, which results in the scavenging of the radical by hydrogen donation. Table 3 represented that

BPF and PSF showed 86.8±0.36% and 74.6±0.65% total antioxidant activity respectively. Sad *et al.* (2018) found a higher value of (93.26±0.12%) total antioxidant activity in BPF. Whereas the value of 57.79±2.09% total antioxidant activity was obtained by Sharma and Bhat (2021) in pumpkin peel flour.

Table 3. Total antioxidant activity, vitamin C, total phenol and flavonoid content of banana peel flour and pumpkin seed flour

Sample	Antioxidant Activity (%)	Vitamin C (mg/100g)	TPC (mg GAE/gm)	TFC (mg QE/gm)
Banana peel flour (BPF)	86.8±0.36	2.03±0.23	166.68±0.74	120.27±0.98
Pumpkin seed flour (PSF)	74.6±0.65	9.23±0.31	146.07±0.19	111.73±0.52

*All values are means of triplicate determinations ± standard deviation (SD)

The quantity of phenolic and flavonoid chemicals in plant materials is closely correlated with their antioxidant activity (Velioglu *et al.*, 1998). Phenolics are secondary metabolites found in plants that play a significant role in chelating redox-active metal ions, disabling lipid-free radical sequences, and preventing conversions of hydrogen peroxide into reactive oxyradicals. The most universal antioxidant compounds in foods and plants are the water-soluble phenolic compounds (Macheix and Fleuriet, 1990). Flavonoids are one of the other most important groups of antioxidants that are generally found in plants, fruits, leaves, and vegetables. This study showed that the total phenolic content of BPF was 166.68±0.74 mg GAE/gm which is higher than the total phenolic content present in PSF (146.07±0.19 mg GAE/gm). Sad *et al.* (2018) found 146.07±0.19 mg GAE/100gm total phenol content in banana peel flour. The total flavonoid content found in BPF was 120.27±0.98 mg QE/gm. The flavonoid content observed in PSF was 111.73±0.52 mg QE/gm. So results indicated that BPF showed high flavonoid contents than PSF. These outcomes prove that peels carry a potential number of flavonoid compounds. Table 3 also represents the vitamin C content of samples. Results suggested that PSF (9.23±0.31 mg/100g) contains more vitamin C content than BPF (2.03 ± 0.23 mg/100g). But these results do not agree with the results observed by Mosa and Khalil, (2015). They conclude that banana peel flour contains 10.82±2.0 mg/100g vitamin C, which is higher than the present value found in BPF.

Conclusions

Banana peel and pumpkin seeds are under-utilized by-products or wastes of the household and food processing industry but these could be rich in valuable nutritive compounds. Results imply the interest is increasing in the good use of these wastes as a cost-effective source of nutrients because these cheap by-products contain a high content of lipid, fiber, flavonoids, antioxidants, and vitamin C. By-products from food industries can be processed into value-added products such as flour that is more easily stored for further uses. By-products flour

can easily include in food formulations due to its excellent nutritional qualities. Optimizations of its use are beneficial in terms of nutritional and economical aspect.

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