Study of Nutritional, Phytochemicals and Functional Properties of Mango Kernel Powder

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Food ingredient with good nutritional and phytochemical properties is always in search. This research was conducted to study the effect of different treatments, namely soaking and blanching, on nutrient, phytochemical, and functional properties of mango kernel powder (MKP). Three treatments were carried out to produce MKP, which were soaking (48 h), heat treatment/blanching (45 °C for 2 min), and control. The seed was cut into four pieces and dried in cabinet drier for 7 h at 60 °C until it becomes brittle. The kernel was ground to pass through a 0.85 mm size sieve. Powder from three treatments was subjected to nutrient analysis, phytochemical analysis, and functional properties evaluation. Crude fat increased significantly (p<0.05) in soaked mango kernel powder, while the treatment decreased total ash, iron, calcium, and phosphorous significantly (p<0.05). Oil absorption capacity (OAC), water absorption capacity (WAC), and wettability of MKP decreased significantly (p<0.05) after treatment, while bulk density increased significantly (p<0.05). The wettability of soaked MKP decreased significantly (p<0.05), while it significantly increased for heated MKP (p<0.05). The heat treatment produced a significant reduction (p<0.05) in ascorbic acid (18.24%), polyphenol content (4.7%), tannin (76.44%), and flavonoid (7.38%) compared to untreated flour while soaking result in a significant reduction (p<0.05) in ascorbic acid (13.1%), polyphenol (3.47%), tannin (63.73%), and flavonoid (21.76%). The antioxidant activity was found to be significantly less (68.33%) in heat-treated MKP compared (p<0.05) to the soaked MKP (79%) and untreated MKP (84.33%). A positive correlation was found between the polyphenol and antioxidant activity. It can be concluded that MKP without treatment can be explored for composite flour as phytochemicals and functional property were found to be better than treated flour.

Keywords: Angle of Repose, Antioxidant Activity, Mango Kernel, Polyphenol, Tannin

Introduction

Mango (Mangifera indica) is the king of the fruit and is popular worldwide due to its exotic flavor and delicious taste. Around 20 % of mango are processed for products such as puree, nectar, leather, canned slice and chutney, juices, fruit bars, and pies. During the processing of ripe mango, its peel, and seed are generated as a waste, which is approximately 40-50 % of the total fruit weight (Ashoush and Gadallah, 2011). The mango seed represents about 20 % of the total weight of fruit, while the kernel is 45-85 % of the seed (Arogba, 1997; Solis-Fuentes and Duran-de-Bazua, 2011). Mango seed accounts for around 9.42 million tons from 47.1 million tons mango (Altendorf, 2017).

As reviewed by Schieber et al. (2001), mango seed kernel is rich in minerals like potassium, calcium, copper, and zinc along with phytosterols. Mango kernel powder (MKP) is a rich source of ascorbic acid, carotenoid, polyphenol, and also exhibits good anti-oxidant property. Antioxidant compound from mango kernel was extracted and added in buffalo ghee to study the stability of ghee (Puravanekara et al., 2000). Mango seed kernel also possesses anti-microbial activity, which shows its potentiality as a natural antibiotic and antifungal (Mutua et al., 2017). The minced beef with 3% MKP shows the lowest microbial count after storage periods of 48 h in refrigerated condition (Gadallah and Fattah, 2011).

Despite high nutritional and health benefits, mango kernel is a major byproduct of the mango processing industry and commercial exploration is negligible (Torres-Leon et al., 2016 and Jahurul et al., 2015). Research has been carried out to partially substitute wheat flour by MKP for the formulation of cookies, biscuits, and bread (Ashoush and Gadallah, 2011; Bandypadhyay et al., 2014; Menon et al., 2014). This agro-waste has high tannin content as reported by Arogba (1999), which may affect the organoleptic quality (aromatic taste) of bakery products or other composite flour products (Eleazu et al., 2014). Many researchers have reviewed the nutritional, phytochemicals, and functional properties of MKP. Abdalla et al. (2007) found that mango seed kernel of Egyptian varieties is rich in all eight essential amino acids. Sogi et al. (2013) found that drying methods affect the polyphenol, anti-oxidant activity, and functional properties of MKP. Torres-Leon et al. (2016) reviewed that mango kernel oil does not contain trans-fatty acid, and carry the great potentiality for the food industry.

Many kinds of research are focused to recognize the cheap source of flours to substitute wheat flour, either partially or completely (Noorfarahzilah et al., 2014). For the utilization of flour in composite flour, the functional property of powder should be assessed to explore the potentiality. Functional properties are related to the interrelationship between composition (mainly protein and carbohydrate), structure, molecular confirmation, and physiochemical
properties of food (Chandra et al., 2015). Many authors have researched the formulation of bread and biscuit by incorporating mango kernel powder (Arogba, 1999; Legesse and Emame, 2012; Menon et al., 2014). However, research is lacking on the processing effect on the functional properties and phytochemical constituents of mango kernel powder.

The concept of healthy ingredient has raised the interest in the use of flour with an ample amount of phytochemicals (Wang and Bohn, 2012). So, this research attempt to highlight the effect of different treatments on nutritional quality, functional properties, and phytochemicals components of mango kernel powder and there might be a possibility of commercializing mango kernel powder.

Materials and methods

Materials

Ripe mango fruits of Alfonso (Magnifera indica) variety were bought from the local vegetable market (Kuleshwor) of Kathmandu. The chemicals used for the analysis were of analytical grade, which was, 2,2-diphenyl-1-picrylhydrazyl (DPPH), Phenol reagent, gallic acid, and methanol, purchased from Sigma-Aldrich Company (Germany), Finar Limited (India), LOBA Chemie (India) and Fisher Scientific (India) respectively. Sodium tungstate and phosphomolybdic acid for Folin-Denis reagent were purchased from Fisher Scientific, India. Sodium tungstate and phosphomolybdic acid for Folin-Denis reagent, Sodium hydroxide, concentrated Sulphuric acid, tannic acid, and potassium permanganate were purchased from Fisher Scientific, India.

Preparation of mango kernel powder

Mango seed was manually removed and soaked in water for 30 min. The kernel from mango seed was manually removed by using a stainless knife. The mango kernel was subjected to three treatments, blanched in warm water (2 min for 45°C, water: seed=2:1), soaking (48 h, water: seed=2:1) (Yatnatti, et al., 2014) and other was control. All the seeds were dried in cabinet drier at 60°C for 7 h. The dried seed was ground to pass through a 0.85 mm mesh size (HT/standard sieves).

Proximate and mineral analysis

The moisture content was determined by the hot-air oven method by drying the sample in a hot air oven at 105°C to constant weight as described by AOAC method number 930.15 (AOAC, 2005).

The protein content of mango kernel powder (MKP) were calculated from the nitrogen content measured by the Kjeldahl method as described by AOAC method number 920.152 (AOAC, 2005).

The fat content of the MKP was determined by solvent extraction by continuous extraction in a Soxhlet apparatus for 3 hours using petroleum ether as a solvent as mentioned in AOAC method number 991.36 (AOAC, 2005).

The crude fiber of MKP was determined as described by AOAC method number 934.01 and a total ash content of the MKP was determined as per AOAC method number 945.46 (AOAC, 2005).

Total carbohydrate content (Ranganna, 2002) was calculated by the difference method as in equation (i):

\[ \text{Carbohydrate (% dry basis)} = 100 - (\text{crude protein} + \text{total ash} + \text{crude fiber} + \text{crude fat}) \]

The calcium, iron, and phosphorous content of MKP were also determined by as per the method described by Ranganna (2002).

Extract preparation, phytochemical quantification and antioxidant activity determination

The MKP extract was prepared according to the method described by Sigdel et al. (2018) with some modification. Briefly, 1 gram of powder was kept under continuous shaking for 20 minutes with absolute methanol (30 ml) and then filtered. A similar process was repeated twice and the final volume was made up of 100 ml with methanol.

For the estimation of polyphenol content, the method described by Mahdavi et al., 2011 was followed with some modifications, where the prepared extract was treated with Folin- Ciocalteau solution and absorbance was measured at 760 nm in UV-Vis spectrophotometer (GENESYS™ 10S Vis Spectrophotometer, Thermo Scientific™, Germany). Phenols react with phosphomolybdic acid in Folin-Ciocalteau reagent in alkaline medium and produce the blue colored complex (molybdenum blue). Gallic acid (as a standard phenolic acid) solution was used to prepare a standard curve as a reference. The result was expressed in mg gallic acid equivalent (GAE)/100 g.

For the determination of flavonoid content, the method described by Walvekar and Kaimal (2014) was followed using the aluminum chloride assay and measuring the absorbance at 510 nm in UV-Vis spectrophotometer. The principle of the aluminum chloride colorimetric method is that aluminum chloride forms acid-stable complexes with the C-4 keto group and either the C-3 or C-5 hydroxyl group of flavones and flavonols. Gallic acid solution is used for the preparation of a standard curve as a reference. The result was expressed in mg gallic acid equivalent (GAE)/100 g.

For tannin content determination, Folin-Denis reagent was used for color development and absorbance was measured at 755 nm in UV-Vis spectrophotometer. The tannic acid solution was used to prepare a standard curve (Elgailani and Ishak, 2014). The result was expressed in mg tannic acid equivalent (TAE)/100 g.

The ascorbic acid content of mango kernel flour was determined by 2,6-dichloro-indophenol visual titration method as described by Ranganna (2002).

The antioxidant activity of ground powder was determined by the DPPH radical scavenging method as described by Walvekar and Kaimal (2014) with some modifications. The principle of DPPH method is based on the reduction of DPPH in the presence of a hydrogen donor.
donating antioxidant due to the formation of diphenyl picryl hydrazine. Briefly, 3 mL extract was mixed with 3 mL of 0.004% DPPH (2,2-diphenyl-1-picrylhydrazyl) solution and incubated in dark for 30 min. The absorbance was taken at 517 nm using a UV-Vis spectrophotometer. Absolute methanol was used as a blank. The scavenging activity of the extract against the stable DPPH was calculated using the following equation (ii):

\[
\text{Scavenging activity (\%) = } \frac{(A - B)}{A} \times 100 \quad \text{(ii)}
\]

where A is the absorbance of DPPH and B is the absorbance of DPPH and the extract combination. The calculated value was given by 10000 ppm (1 g powder in 100 ml methanol) of mango seed extract.

**Functional properties**

The bulk density was determined according to the method described by Kanpairo et al. (2012). About 5 g of flour was put into a 25 mL graduated cylinder and tapped to a constant volume. The bulk density (g/cm³) was calculated using the formula as in equation (iii):

\[
\text{Bulk density} = \frac{\text{Weight of flour (g)}}{\text{flour volume (cm³)}} \quad \text{...............(iii)}
\]

The method described by Onuegbu et al. (2014), was adopted to determine the oil absorption capacity (OAC). Refined soybean oil (density 0.92 g/ml) and the MKP was mixed in the ratio of 10:1 (volume/weight) and centrifuged at 2000 rpm for 20 minutes. The difference in weight divided by the weight of the sample was measured as oil absorbed and calculated in percentage.

The method of Nwosu et al. (2014) was adopted for the determination of water absorption capacity (WAC). A similar process was carried out as OAC, where water was used instead of oil.

The gelation capacity of flour was determined as described by Chandra et al. (2015) with some modifications. The suspension (3-8%) was prepared with 5 ml distilled water in a test tube, heated for 1 h, cooled rapidly in the refrigerator and kept for 2 h at 4°C. The test tube was inverted to see if content will fall or slip off. The least gelation concentration is that concentration where the sample from the inverted test tube does not fall or slip.

**Solubility** was determined by using Nwosu (2011) method with slight modifications. The MKP (0.5 g) was mixed with 10 mL water and heated for 30 min in a water bath at 60°C. The mixture was centrifuged at 3000 rpm for 10 min, the supernatant was recovered (weight measured). The supernatant was dried in the oven. The solubility percentage was calculated by using the formula as shown in equation (iv):

\[
\text{Solubility} = \frac{\text{weight of supernatant after drying}}{\text{weight of MKP} \times 100} \quad \text{...............(iv)}
\]

**Wettability** was determined by the method described by Nwosu (2011) with some modifications. 1 g of the sample was poured from a test tube in a beaker containing 400 mL water and time was noted to completely wet the sample.

The method described by Shittu and Lawa (2007) was used to determine the angle of repose with slight modifications. Glass funnel was kept 2 cm from the base and powder was dropped from the funnel, the diameter of the base was measured. The angle of repose (φ) was measured by the following relations as shown in equation (v):

\[
\text{Angle of Repose } \phi (°) = \tan^{-1}\frac{h}{D} \quad \text{..........(v)}
\]

where, Φ = angle of repose (°); h = height of the pile (mm); D = diameter of the pile (mm).

**Research design and statistical analysis**

The research methodology used was a completely randomized design (CRD), with three treatments and triplicate analyses for each parameter. All the mean data obtained in this research work were compared by Analysis of Variance (ANOVA) with the help of SPSS (Statistical Package for the Social Sciences) (Version 16). Duncan’s Post Hoc Test was used to determine significant differences (p < 0.05) between means. Results were expressed as the mean value ± standard deviation of triplicate samples.

Table 1

| Sample | Blanched mango kernel powder | Soaked mango kernel powder | Untreated mango kernel powder |
|--------|------------------------------|---------------------------|------------------------------|
| Moisture (%) | 2.87 ±0.3^a | 3.60 ±0.2^b | 2.97 ±0.15^a |
| Crude protein (%) | 6.50 ±0.3^a | 6.47 ±0.15^a | 6.13 ±0.12^a |
| Crude fat (%) | 9.63 ±0.15^a | 10.17 ±0.21^b | 9.53 ±0.11^a |
| Total ash (%) | 1.83 ±0.06^a | 2.17 ±0.11^b | 2.53 ±0.11^c |
| Crude fiber (%) | 3.47 ±0.12^a | 3.53 ±0.15^a | 3.77 ±0.25^b |
| Available carbohydrate (%) | 78.57 ±0.29^a | 77.67 ±0.15^b | 78.03 ±0.15^c |
| Iron (mg/100 g) | 5.44 ±0.15^a | 1.60 ±0.20^b | 6.27 ±0.11^c |
| Calcium (mg/100 g) | 115.00 ±5.00^a | 96.67 ±6.11^b | 199.33 ±9.01^c |
| Phosphorous (mg/100 g) | 68.33 ±1.52^a | 70.00 ±2.00^b | 85.00 ±5.00^c |

All data are the mean ± standard deviation of its triplicates. Different letters in the same row indicate significant differences (p<0.05). All parameters are on a dry basis except moisture.

**Results and Discussion**

**Chemical analysis of mango kernel powder**

The chemical analysis of mango kernel flour is shown in Table 1. The values were significantly different at p<0.05. The crude protein (%), crude fat (%), total ash (%), and
available carbohydrate (%) range from 6.13-6.5, 9.53-10.17, 1.83-2.53, and 77.67-78.57 respectively.

Crude fat was increased significantly (p<0.05) in soaked mango kernel powder, while the treatment decreased total ash, iron, calcium, and phosphorous significantly (p<0.05). Okpala & Gibson (2013) reported carbohydrate, crude fat, crude protein, total ash contents of mango kernel powder as 74.41%, 11.0%, 6.0%, 2.02% respectively. Abdalla et al. (2007) reported fat content 12.3% in the mango kernel powder dried at 50°C. Jahural et al. (2017) analyzed seven varieties of mango in Malaysia and found fat in the range of 7.6-13.7% in MKP (freeze-dried) extracted by using supercritical carbon dioxide. Eleghede et al. (1995) and Ashoush and Gadallah (2011) reported protein content 6 and 7.76% respectively in MKP, which were similar to the result obtained. The analysis showed that treatment produces a significant reduction (p<0.05) in total ash content, while fat content was only increased (p<0.05) by soaking. An increase in fat content in soaked kernel might be due to swelling of the kernel during soaking, as increase surface area induce efficient extraction of fat (Shashego, 2019).

**Table 2**
The functional properties of mango kernel flour

| Sample | Blanched mango kernel powder | Soaked mango kernel powder | Untreated mango kernel powder |
|--------|-----------------------------|-----------------------------|-------------------------------|
| Bulk density (g/ml) | 0.51±0.01a | 0.57±0.01b | 0.45±0.02c |
| Oil Absorption Capacity (%) | 72.60±1.51a | 60.00±2.00b | 80.00±2.00c |
| Water Absorption Capacity (%) | 131.67±6.5a | 142.7±2.50b | 173.33±5.77c |
| Wettability (s/g) | 37.33±3.00a | 17.33±1.20b | 35.33±0.24c |
| Gelation (%) | 9.00±0.00a | 9.00±0.00a | 9.00±0.00a |
| Angle of repose (°) | 63.00±1.00a | 70.33±0.58b | 67.00±1.00c |
| Solubility (%) | 14.66±0.57a | 15.67±0.57a | 16.00±1.00a |

All data are the mean ± standard deviation of its triplicates. Different letters in the same row indicate significant differences (p<0.05).

There was a significant reduction (p<0.05) in iron, calcium, and phosphorous of MKP produced by the treatment. Blanching and soaking may result in leaching loss of soluble components as reviewed by Moktan and Ojha (2016). According to Yatnatti et al. (2014), the iron content and calcium content in MKP (soaked and then blanched) is 12mg/100g and 170mg/100g respectively, while Eleghede et al. (1995) reported phosphorous content 140mg/100g in MKP. The calcium content in this study was found to be similar to the past result while iron and phosphorous were found to be less.

**Functional properties of mango kernel powder**
The functional properties of mango kernel powder obtained from different treatments are shown in table 2. The values were significantly different at p<0.05.

Oil absorption capacity (OAC), water absorption capacity (WAC), and wettability of MKP decreased significantly (p<0.05) after treatment, while bulk density increased significantly (p<0.05). The wettability of soaked MKP decreased significantly (p<0.05), while it significantly increased for heated MKP (p<0.05). Legesse & Emire (2012) reported bulk density of mango kernel flour grown in Ethiopia was 0.61 g/mL and the value obtained in this study was slightly lower which might be due to the varietal difference. Bulk density is useful to study the potentiality of flour in complementary food (low bulk density) because we can feed more products with high nutritional density. Mepba et al., 2007; Chandra et al., 2015. WAC of the powder is dependent mainly on the amount and nature of the hydrophilic constituents and to some extent on the pH and nature of the protein (Owuarnanam et al., 2013). The ability of the protein to bind water is indicative of its water absorption capacity. Treatment (soaking and blanching) the kernels before the flour preparation led to a significant reduction (p<0.05) of WAC and OAC. Moreover, it shows that the MKP sample with the lowest wettability dissolves the fastest in water (Ubbing and Akobondu, 2009).

Chandra (2013) revealed that the flour having higher starch content gelatinizes at low temperatures. There was no significant difference in the gelation capacity of flour with the treated and control MKPs. The angle of repose is important in the proper design of hoppers to maintain a continuous flow of the flour. The angle of repose of powder samples in this study was found to be higher than as reviewed by Geldart et al. (2006). The angle of repose up to 35° indicates free flowability and 35° to 45° indicates some cohesiveness.

**Analysis of Bioactive Compounds of MKP**
The result of bioactive compounds of mango kernel flour is shown in table 3. The values of ascorbic acid, polyphenol, tannin, and flavonoid of MKP produced by soaking and blanching were significantly less (p<0.05) compared to control, but antioxidant activity was only significantly reduced (p<0.05) by heat treatment. The heat treatment produced a significant reduction (p<0.05) in ascorbic acid (18.24%), polyphenol content (4.7%), tannin (76.44%), and flavonoid (7.38%) compared to untreated flour while soaking result in a significant reduction (p<0.05) in ascorbic acid (13.1%), polyphenol (3.47%), tannin (63.73%), and flavonoid (21.76%).

The value of ascorbic acid (112-137.33 mg/100 g) content obtained was more than reported by Sogi et al. (2013), who found ascorbic acid in the range of 61.22-74.48 mg/100 g in mango kernel. The drying methods also affect the ascorbic content of mango kernel (Sogi et al., 2013). Blanching and soaking significantly reduced the ascorbic acid content of MKP.
The polyphenol content of the samples ranged from 1630±0.67 to 1645±5.71 mg GAE/100g, and the flavonoid content of MKP ranged from 683 to 816 mg GAE/100g. Sogi et al. (2013) reported the polyphenol content of mango kernel powder in the range of 11.23-20.03 g/100 g, while Abdel-Razik et al. (2012) reported 2.19 g/100 g. In contrast, Abdalla et al. (2007) reported polyphenol 112 mg/100 g in mango kernel. Abdel-Razik et al. (2012) found polyphenols and flavonoids 17.4 and 3.33 g/100 g seed of mango kernel. Dorta et al. (2012) and Dorta et al. (2014) reported flavonoid 1.3 g/100 g and 0.95 g/100 g respectively in mango kernel. The values reported were quite different from the result obtained, which might be due to the difference in the extraction method employed, variety, and the procedure of estimation. Polyphenols and flavonoids were reduced significantly (p<0.05) by blanching and soaking. This might be due to leaching loss.

According to the result, tannin content in mango kernel powder ranged from 179 mg TAE/100g to 893 mg TAE/100g. Gunte et al. (2018) reported tannin content 210 mg/100 g in soaked and blanched mango kernel powder. The value was similar to the result obtained. Tannin content was high in the case of untreated kernel flour. It showed that there is a reduction in tannin content due to heat treatment and soaking.

Table 3
Bioactive compounds in MKP.

| Sample               | Blanched mango kernel powder | Soaked mango kernel powder | Untreated mango kernel powder |
|----------------------|-----------------------------|----------------------------|-------------------------------|
| Ascorbic acid (mg/100 g) | 112.00 ±6.00               | 119.33 ±4.16             | 137.33 ±7.50                 |
| Polyphenol (mg GAE/100 g)   | 1553.33 ±30.00           | 1573.33 ±15.00          | 1630.00 ±10.00              |
| Tannin (mg TAE/100 g)                     | 235.00 ±15.00            | 316.67 ±20.80          | 873.33 ±15.30               |
| Flavonoid (mg GAE/100 g)               | 773.33 ±32.14a           | 650.00 ±20.80          | 835.00 ±25.00b             |
| Antioxidant activity (%) (10000 ppm)  | 68.33 ±2.88           | 79.00 ±6.55b          | 84.33 ±4.04b               |

All data are the mean ± standard deviation of its triplicates. Different letters in the same row indicate significant differences (p<0.05).

The tannin levels reported by Legesse and Emire (2012), after soaking at 30°C, 40°C and 50°C were 1.23, 1.50 and 1.43 respectively. The obtained value of the antioxidant activity of mango kernel powder in the range of 11.23-20.03 g/100 g, while Ribeiro et al. (2008) reported 67.7% by 5000 ppm of extract. The higher antioxidant activity for the MK extract may be due to the higher level of phenol present in the extract as the antioxidant activity has been found to be positively correlated with total phenol content as shown in Figure 1.

Antioxidant activity of a phenolic compound is due to free radical scavenging activity and metal chelation (Apak et al., 2007). A similar positive correlation was established by Puravankara et al. (2000).

Conclusions
The treatment (soaking and heating) not only produced a significant reduction in mineral content (iron, calcium, and phosphorous) of mango kernel powder (MKP) but also reduced phytochemicals (ascorbic acid, polyphenol, flavonoid, tannin). Decrease in water absorption capacity and oil absorption capacity after soaking and blanching prevails that untreated MKP has more potentiality for complimentary food preparation. Further research can be carried out to see its implication on complimentary food.

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