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Pumpkin (*Cucurbita pepo* L.) Pulp Flour as a Source of Dietary Fiber: Chemical, Physicochemical and Technological Properties

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ABSTRACT

In this study, the characteristic properties of pumpkin pulp flour (PPF) obtained from the waste of the pumpkin seed production were determined. The pulp parts of the de-seeded and peeled pumpkins were used for this purpose. Proximate composition, total dietary fiber (TDF), insoluble dietary fiber (IDF), soluble dietary fiber (SDF), mineral content, amino acid content, β-carotene content, pH, color, glass transition temperature (T_g), water holding capacity (WHC), oil holding capacity (OHC), swelling capacity (SC), emulsion stability (ES) and emulsion activity (EA) values of PPF were determined. PPF had a low lipid content (0.72±0.06%) and a high ash content (8.34±0.19%). The pH, T_g, TDF, IDF, SDF, WHC, OHC and SC values are 5.61±0.01, 19.19±1.86°C, 26.13±0.17%, 19.82±0%, 6.31%±0.35, 12.91±0.40 g/g, 3.74±0.10 g/g, 12.48±0.57 mL/g, respectively. PPF were a rich source of glutamic acid, glycine, and aspartic acid, and contains high levels of potassium among major elements, and iron among minor elements.

Keywords: Pumpkin pulp flour, Dietary fiber, Glass transition temperature, Amino acid, Water-oil holding capacity

Diyet Lifi Kaynağı Olarak Kabak (*Cucurbita pepo* L.) Posası Unu: Kimyasal, Fizikokimyasal ve Teknolojik Özellikler

ÖZ

Araştırmada, çekirdekleri için kullanılan kabağın atıklarından elde edilen kabak posası ununun (PPF) karakteristik özellikleri belirlenmiştir. Çekirdekleri çıkarılmış kabukları soyulmuş olan kabakların posa kısımları bu amaç için kullanılmıştır. Kabak posası ununun kompozisyonu, toplam diyet lifi (TDF), çözünmez diyet lifi (IDF), çözünebilir diyet lifi (SDF), mineral madde içeriği, amino asit içeriği, β-karoten içeriği, pH, renk, camsı geçiş sıcaklığı (T_g), su tutma kapasitesi (WHC), yağ tutma kapasitesi (OHC), şişme kapasitesi (SC), emülsiyon stabilitesi (ES) ve emülsiyon aktivite (EA) değerleri tespit edilmiştir. PPF'nin düşük lipid (%0.72±0.06), yüksek kül (%8.34±0.19) içeriğine sahip olduğu belirlenmiştir. pH, T_g, TDF, IDF, SDF, WHC, OHC ve SC değerleri sırasıyla 5.61±0.01, 19.19±1.86°C, %26.13±0.17, %19.82±0.18, %6.31±0.35, 12.91±0.40 g/g, 3.74±0.10 g/g, 12.48±0.57 mL/g olarak belirlenmiştir. Kabak posası ununun glutamik asit, glisin ve aspartik asit bakımından zengin bir kaynak olduğu ve majör elementlerden potasyum, minör elementlerden ise demiri yüksek seviyede içerdiği tespit edilmiştir.

Anahtar Kelimeler: Kabak posası unu, Diyet lifi, Camsı geçiş sıcaklığı, Amino asit, Su-yağ tutma kapasitesi

INTRODUCTION

Agricultural by-products attract attention in terms of dietary fiber, sugars, organic acids, pigments, aroma compounds and bioactive components that have antimicrobial-antioxidant- effects, and studies to evaluate these gain importance day by day. Especially as a result of the processing of fruits and vegetables, a large amount of waste consisting of shell, seed and pulp and corresponding to 30-90% of the total weight of the fruit and vegetable depending on the processed fruit and vegetable could be obtained [1]. Considering the functional, technological and nutritional properties of these products, it is important to evaluate them due to economic and environmental issues. One way of keeping agricultural by-products in a stable form and incorporating them into various food formulations as needed is to dry them into powder. Thus, a product rich in functional components such as dietary fiber could be obtained.

There is no single accepted definition for dietary fiber. According to the Codex Alimentarius Commission, dietary fiber is defined as carbohydrate polymers with three or more monomers that cannot be digested or absorbed in the human small intestine [2]. Dietary fibers are very important components for health. Maphosa and Jideani [3] stated that these components have therapeutic effects by preventing heart complications, obesity, diabetes, hemorrhoids and some types of cancer. Soluble dietary fibers have the ability to reduce serum cholesterol levels, reduce glycemic response, and improve glucose tolerance, and insoluble dietary fibers have low density and porous, have the ability to improve normal laxation, increase fecal bulk, and decrease intestinal transit [3]. In addition to these benefits in terms of health, they also improve technological properties such as water-oil binding, increasing viscosity and ion exchange capacity in the used products [4]. Therefore, there is a need to find new dietary fiber sources that could be used in the food industry.

Pumpkins belong to the family Cucurbitaceae and the genus Cucurbita [5]. Cucurbitaceae family has five major genera: *Cucurbiticae Citrullus*, *Cucurbiticae Cucumis*, *Cucurbiticae Lagenaria*, *Cucurbiticae Sechium* and *Cucurbiticae Cucurbita*. There are five species of *Cucurbiticae Cucurbita*, which are economically important, *C. turbaniformis, C. maxima*, *C. moschata*, *C. ficifolia* and *C. pepo* [6]. In Türkiye, the most common pumpkin species grown is *C. pepo* [7]. This species is mostly grown in Nevşehir. 21 526 tons of the 60 970 tons of pumpkin produced as seed pumpkin in Türkiye were grown in Nevşehir [8]. After the seeds are separated from the pumpkin, the remaining shelled flesh part is discarded without being evaluated. This part constitutes approximately 92-95% of the seed pumpkin. Considering the stated situation, it is possible to state that tons of waste will be produced. These wastes are usually left to rot in the harvested areas and cannot be used sufficiently. This situation is both damage the country's economy and causes environmental pollution, and thus researches on the use of waste is of great importance both environmentally and economically. The aim of this research, the planned considering the stated situations, is to determine the various physicochemical and technological properties of PPF obtained from pumpkin (*Cucurbita pep*o L.) pulp and to reveal whether it can be used as a potential dietary fiber source.

MATERIALS and METHODS

Materials

Fresh whole pumpkins (*Cucurbita pep*o L.) were obtained from a local vegetable farm after harvest, Nevşehir, Türkiye. After they were washed, peeled and seeded, their pulp parts were cut into 0.5-cm^3-thick cubes. The samples were frozen at -80ºC, and then freeze drying was carried out in the freeze drier (Operon FDU-8612, South Korea). Dried samples were crushed into a fine powder and powdered samples were sieved through a 100mm sieve. Powdered samples were vacuum packaged (KV-600, Novivac, Türkiye) and stored at 18ºC until usage.

Composition of Pumpkin Pulp Flour

Analysis of moisture, ash, protein, and lipid contents in PPF were determined by AOAC official methods 925.10, 920.153, 928.08, and 991.36, respectively [9]. The conversion factor of nitrogen to crude protein was 6.25.

The contents of TDF and IDF were determined by the enzymatic-gravimetric method 991.43 [9]. SDF was calculated by subtracting of the IDF from TDF. Analyzes were performed in triplicate.

Starch content (w/w) was determined using a commercially available starch quantification kit (R-Biopharm AG, Darmstadt, Germany).

Extraction and saponification of carotenoids were performed according to Koning and Roomans [10]. The resulting residue was dissolved in a methanol/ tetrahydrofuran mixture (75:25, v / v) using an ultrasonic shaker. Aliquot portions (20 µL) were injected into the Zorbax ODS column (5µm particle size, 4.6 mm id) of the reversed-phase LC system (LC20, Shimadzu, Tokyo, Japan) equipped with a UV detector. The elution mixture was methanol and tetrahydrofuran 95:5 (v/v) with a flow rate of 0.8 ml/min.

Separation and analysis of amino acids were carried out in a high-performance liquid chromatography (Series 1100, Agilent, California, USA) equipped with a fluorescence detector. The chromatographic column was a 5 µm, 4.6 x 150 mm, cartridge, Hypersil BDS-C18 (Agilent, California, USA). The mobile phase used was a mixture of 40 mM Na_2HPO_4, pH 7.8 (A) and methanol (B) with a linear gradient starting in a 50:50 (v/v) and ending, after 10 min, in a 10: 90 (v/v) mixture of A and B.

Analysis of minerals was carried out by a Scott Spray chamber (Norwalk, CT, USA) ICP-MS (PerkinElmer

ELAN DRC-e model) after the microwave digestion process.

Physicochemical Properties of Pumpkin Pulp Flour

For analysis, 0.5 g of PPF in triplicated were homogenized with 50 mL of distilled water for 30 seconds with Ultra-Turrax (MTOPS SR 30, Republic of Korea), and pH values were measured by using a pH meter (Titroline 5000, SI Analytics, Germany) calibrated in buffer solutions at pH: 4 and pH: 7.

Color values of PPF were measured using a Minolta colorimeter CR-400 (Konica Minolta Corp. Japan), with an 8 mm aperture, a 10° observer angle and a D65 illuminant. L*(lightness), a* (redness) and b* (yellowness) were analyzed according to the system of the International Commission of Illumination (CIE LAB System).

X-ray analysis of PPF was taken using an X-ray diffractometer (Rigaku, Miniflex 600, Tokyo, Japan) with Cu Kα radiation, 1.54–1.56 °A. The radiation intensities of the PPF samples were measured in the range of 3°–100° of 2θ diffraction angle, with a scan step size of 0.02° with a scanning speed of 5°/min. The determination was conducted at room temperature. The degree of crystallinity (%) was calculated as shown in equation (1) according to Stevenson et al. [11].

$$\text{Crystallinity (\%)} = \left(\frac{A_c}{A_c + A_a}\right) x100 \quad (1)$$

where A_c is the crystalline area on the X-ray diffractogram and A_a is the amorphous area on the X-ray diffractogram.

The T_g of PPF was determined using a DSC (DSC 6000, Perkin Elmer, USA). The DSC was calibrated with indium and water for temperature and heat flow calibration (melting point: 156.6°C, ΔH= 28.47 J/g for indium, melting point: 0°C, ΔH= 333.20 J/g for water). To detect the T_g of PPF samples approximately 10 mg were weighed into the hermetic DSC pans (product number 03190029, Perkin Elmer, USA). The samples were cooled from 20°C to -60°C at a 5°C/min cooling rate, held at this temperature for 30 min, and then heated from -60°C to 200°C at 5ºC/min heating rate in a nitrogen atmosphere (flow rate 30 mL/min). An empty pan was used as a reference. The DSC measurements were done in triplicate. The onset, midpoint and end point values of the glass transition region were determined, and the midpoint value reported as the T_g.

Pasting properties of PPF were determined by using a Rapid Visco Analyser (RVA 4500, Perten, Sweden). The flour sample (3.0 g, dry basis) was weighted into the RVA vessels and dispersed in 25.5 g of distilled water. The suspension was stirred in RVA at 960 rpm for 10 seconds and stabilized for 1 minute at 50°C, and then heated to 95°C in 4 minutes and held for 2.5 minutes at 95°C. Finally, the suspension was cooled from 95°C to 50°C in 4 minutes and held for 2 minutes at 50°C. RVA analysis was carried out in triplicate under constant stirring at 160 rpm. The RVA parameters (pasting temperature, peak, trough, breakdown, final, and setback viscosity) were obtained from the RVA viscogram.

Techno-Functional Properties

The WHC and OHC of PPF were measured as described by Lopez-Marcos et al. [12]. The WHC and OHC were expressed as the weight of water and oil held by 1 g PPF sample.

The SC of PPF was determined by the method of Gomez-Ordonez et al. [13], and expressed as mL/g of corresponding PPF sample.

The EA and ES of the PPF were determined by the method of Chau and Huang [14]. The EA as a percentage was calculated from the ratio of the depth of the emulsified layer to the depth of the total volume of content inside the centrifuge tube. The ES was calculated in the same way as EA and also expressed as percentage of the unheated control.

WAI and WSI of PPF were determined by the method of Anderson et al. [15]. WAI and WSI were calculated according to equations 2 and 3.

$$\text{WAI} = \frac{\text{pellet weight (g)}}{\text{dry weight of original sample (g)}} \quad (2)$$

$$\text{WSI} = \frac{\text{weight after drying (g)}}{\text{dry weight of original sample (g)}} \quad (3)$$

Data Analysis

All the analyses were performed in triplicate. Results were presented as mean ± standard deviation (SD).

RESULTS and DISCUSSION

Composition of Pumpkin Pulp Flour

The compositions of PPF are shown in Table 1. The results showed that PPF have low contents of fat. Such low lipid content could provide and opportunity in its potential application as ingredient in foods. The PPF had a high ash content. The use of a product with such a high ash content may pose a problem for potential applications in foods due to the possibility of increasing oxidation due to the many metal ions it contains. As a result of a study conducted by Ahmed et al. [16] using pumpkin (*Cucurbita moschata*), ash, lipid and protein contents were determined as 5.6%, 1.04%, and 9.1%, respectively. In another study performed on the peeled and unpeeled pumpkins (*Cucurbita moschata*), these values were determined as 7.39%, 0.70%, 4.91% and 7.32%, 1.08%, 5.43%, respectively. Nakhon et al. [17] determined the ash, lipid and protein contents in pumpkin (*Cucurbita moschata*) flour as 5.91%, 6.74%, and 10.88%, respectively. The differences in results may be attributed to the used cultivar and the geographical location.

Table 1. Composition of pumpkin pulp flour

Composition	Value
Moisture (%)	13.58±0.21
Protein (%)	7.89±0.18
Fat (%)	0.72±0.06
Ash (%)	8.34±0.19
SDF (%)	6.31±0.35
IDF (%)	19.82±0.18
TDF (%)	26.13±0.17
Starch (%)	1.52±0.03
β-carotene (µg/100g)	903.50±14.50

±: Standard deviation of three replicate. SDF: Soluble dietary fiber, IDF: Insoluble dietary fiber, TDF: Total dietary fiber

TDF, SDF and IDF contents of PPF are shown in Table 1. As a result of the research conducted by Kalala et al. [18], the TDF, IDF and SDF contents were determined as 27.7, 19.4, 8.3 in *Cucurbita pepo*, and 23.8, 13.9, 9.9 in *Cucurbita maxima duchene* spp, respectively. The values obtained as a result of this research are similar to the values obtained from *Cucurbita pepo*. As a result of studies conducted with fruit and vegetable by-products, it has been revealed that these products are rich sources of dietary fiber. TDF contents of the olive, papaya, blueberry and pineapple byproducts powders were found to be 53.68, 32.23, 47.51 and 45.23g/100 g dry matter, respectively [1]. The amount of TDF obtained from fruit-derived by-products such as pear, grapefruit, mango and peach was determined as 36.1, 44.2, 28.05 and 35.8g/100g dry matter. The TDF content in PPF is close to that in mango. Depending on the values obtained, the ratio of IDF to SDF was 3.14. Dietary fiber has an important place in the human diet. The recommended dietary fiber intake for adults is 25 to 30g/day based on epidemiological and clinical data and the IDF/SDF ratio should be 3:1 [19]. However, the average dietary fiber intake is about half the recommended value in many countries [20]. For example, it is around 15g/day in the USA, 16g /day in Spain. IDF and SDF have different properties and therefore have different physiological effects. IDF is responsible for intestinal regulation, increasing fecal bulk, and water absorption. Water absorption is one of the most important properties, as it provides laxative effects and improves peristalsis. SDF, on the other hand, has prebiotic potential and plays an active role in the reduction of cholesterol levels and decreasing the amount of glucose absorbed in the small intestine [3].

β-carotene content of PPF is shown in Table 1. Obtained results indicated that PPF is a good source of carotene which is the precursor of vitamin A. The β-carotene content of yellow pumpkin is reported to be 1180 µg/100 g [27]. Carotenoids could be inhibited lipid peroxidation by reacting with any radical species presumably to be encountered in the biological system and reducing the cellular release of lactate dehydrogenase [21].

Amino acid contents of PPF are shown in Figure 1. Among the essential amino acids, mostly arginine, lysine and leucine amino acids were detected. From the non-essential amino acid group, the most asparagine, glycine and glutamine amino acids were determined. As a result of a research conducted on pumpkin by-products, the highest amino acid contents were determined in the peels of *C. maxima* species and in the seeds of *C. pepo* species [22]. Fernandez-Segovia et al. [23] stated that the asparagine and glutamine contents in seaweeds were high, and these amino acids were associated with the umami flavour. Therefore, the presence of these amino acids in PPF would be play an important role in the used as flavour enhancer.

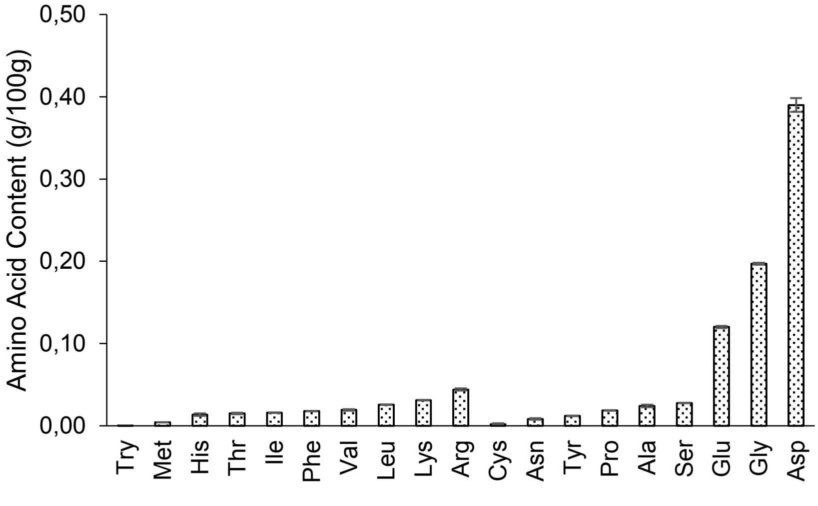

Figure 1. Amino acid content of pumpkin pulp flour

The mineral contents of PPF are shown in Figure 2a and Figure 2b. Among the main mineral substances that are essential for human beings, potassium was found to be at the highest level, followed by calcium, sulfur, phosphorus and magnesium, respectively (Figure 2a). Main and trace elements have many functional roles such as electrolyte, enzyme components, building materials in bones and teeth. Sodium, plays a role in maintaining of the osmotic pressure of the extracellular fluid. Potassium plays a functional role in the regulation of osmotic pressure within the cell, in the activation of various respiratory and glycolytic enzymes. Magnesium is present in the structure of enzymes that are particularly involved in the conversion of energy-rich phosphate compounds and plays a role in the activation of these enzymes. It also plays an important role as the stabilizer of nucleic acids, intracellular and plasma membranes. Calcium is an essential ingredient as it is involved in the structure of the muscular system and controls essential processes such as muscle contraction. Loughrill et al. [24] reported that the calcium/phosphorus ratio (Ca:P) is important for bone growth and development in infancy, and this ratio should be between 1:1 and 2:1. As a result of this research carried out on PPF, this ratio was found 2:1.

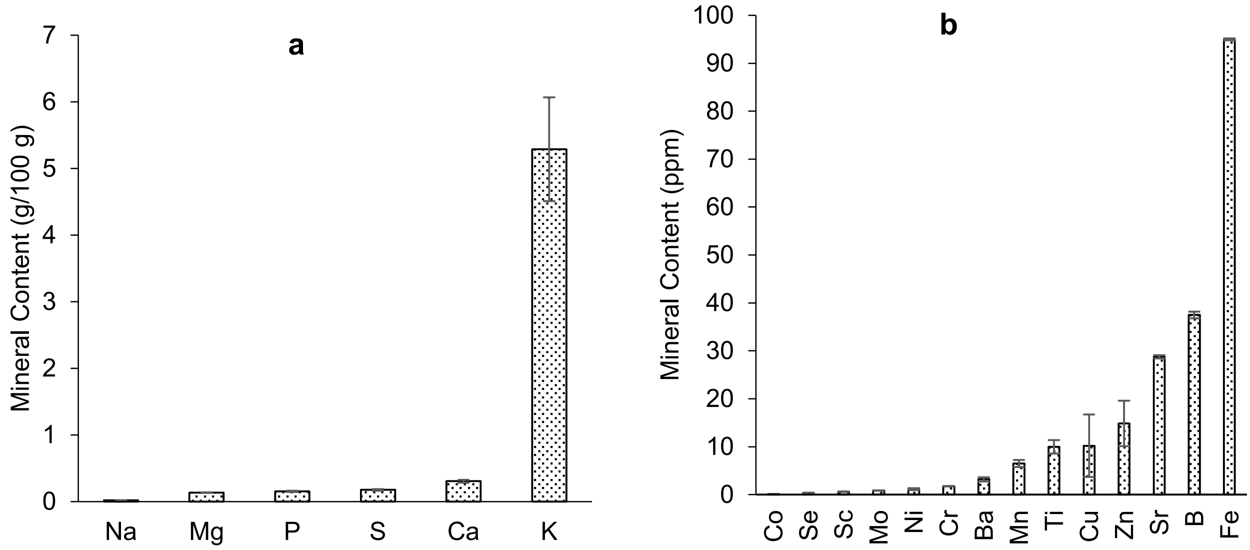

Figure 2. The mineral contents of pumpkin pulp flour. a: Main minerals, b: Trace elements.

Among the trace elements, the highest level of iron was detected in PPF, followed by B, Sr, Zn, Cu, Ti, and Mn, respectively (Figure 2b). Since high iron content causes lipid oxidation, it is not a desirable element in food processing. Copper element plays a role in the functionality of many oxido-reductase enzymes. However, since it causes many problems during the processing and storage of foods, copper is not desired to be present in the high levels such as iron. As a result of a study carried out by our research group, an increase in the thiobarbituric acid reactive substances values of bologna type sausages produced using PPF was determined, and it was concluded that the minerals contained in PPF played an active role in this increase [25]. Another important element determined in PPF is zinc. Zinc is an essential micronutrient element for human health, and present in many enzymes (glutamate dehydrogenase, lactate dehydrogenase, alcohol dehydrogenase, malate dehydrogenase, carboxypeptidase, dipeptidase, alkaline phosphatese, lecithinase and enolase) and acts as a cofactor. Wessels and Brown [26] reported that approximately 17.3% of the world's population was faced with the risk of Zn deficiency. Another important result of this study is that PPF contains selenium even if it is not very high. Similar to Zn, selenium is an important micronutrient element. Kubachka et al. [27] emphasized that Se is not only vital for the development and functions of organs but also has antioxidant properties.

Physicochemical Properties

pH value of PPF is shown in Table 2. The pH of dietary fiber is one of the most important characteristics of fiber. Because the pH value indicates which dietary fiber can be added to product without changing the technological properties of the product. For example, dietary fibers with acidic pH can be used in acidic products such as yogurt, and dietary fibers with basic or near neutral pH values can be used in emulsified meat products. As a result of a research carried out by our research group, it was determined that there was a slight decrease in both dough pH and final product pH [25].

Color is one of the most important quality criteria that affect the attractiveness of consumers in foods. Color values of PPF are shown in Table 2. As can be seen in Table 2, a high L value was determined for PPF. The L* value close to 100 indicates that the lightness of the sample is high. Obtained negative a* value represents the greenness, while the +b* value represents yellowness. This situation may be attributed to the carotene content of PPF. A similar situation was found in the result of a study carried out on peeled and unpeeled pumpkin flour [28].

Table 2. Physicochemical properties of pumpkin pulp flour

Physicochemical properties	Value
pH	5.61±0.01
L*	85.23±0.39
a*	-1.43±0.07
b*	21.57±0.43
T_g (°C)	19.19±1.86
Pasting temperature (°C)	84.00±0.01
Peak viscosity (RVU)	210.00±0.05
Trough viscosity (RVU)	109.20±1.13
Breakdown viscosity (RVU)	103.30±2.40
Final viscosity (RVU)	324.48±0.74
Setback viscosity (RVU)	217.78±3.15

±: Standard deviation of three replicate

The X-ray pattern of the PPF is shown in Figure 3. The PPF exhibited a peak at diffraction angle 2θ=21.96°. The resulting diffractogram showed the presence of a substantially amorphous structure (97.10%), and the degree of crystallization was 2.9%. This result is consistent with the low starch content (1.5%, dry basis) determined in PPF. Nakhon et al. [17] reported that the pumpkin (*Cucurbita moschata* L.) flour had a low crystallinity degree (8.63%) due to non-starch components (ash, fiber, protein and fat) in its structure and low starch concentration (25%, dry basis). Similarly, in the present study, the very low starch content (1.5%, dry basis) of PPF samples can be cited as the reason why the crystallinity was too small to calculate.

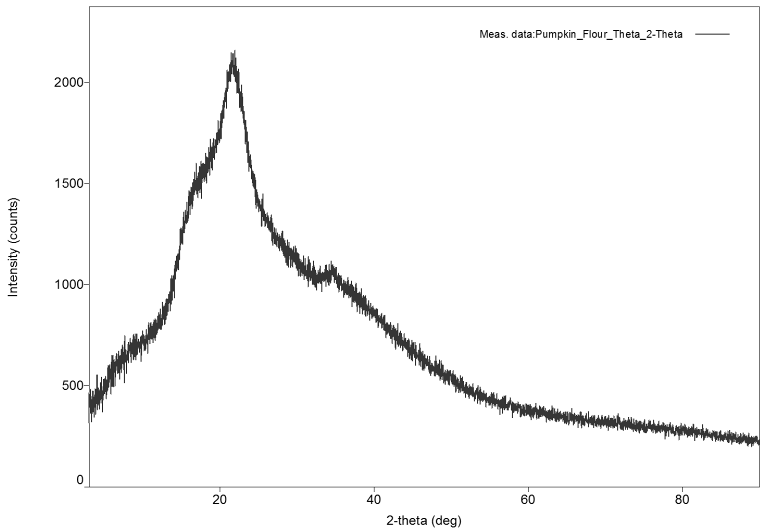

Figure 3. X-ray pattern of pumpkin pulp flour

T_g is a reference temperature that provides information about the storage temperature. It is stated that any food remains stable if stored at a temperature lower than the T_g [29]. The T_g occurs over a wide range of temperatures. Therefore, the onset, midpoint and endset temperatures of the glassy change are given, and the midpoint is generally expressed as the T_g. As can be seen in Table 2, the T_g was determined as 19.19°C. This situation shows that PPF should be stored at a temperature lower than this temperature. As a result of a study conducted on pumpkin powders (*Cucurbita moschata*) obtained by grinding in different sizes after freeze-drying, it was found that the T_g increased as the particle size decreased [16]. The researchers reported that the mid-point values for T_g ranged from 6.80°C to 12.97°C. As a result of DSC analysis performed between 20°C and 120°C in dispersions prepared by adding water to PPF, no endothermic change was detected. This might be attributed to the low level of starch and lipid content.

Pasting parameters determined by RVA of PPF are shown in Table 2. The pasting temperature, peak, trough, breakdown, final, and setback viscosity values of the PPF were higher than those of the values obtained from the flour of *Cucurbita moschata* and starch isolated from C*ucurbita maxima* [11, 17]. This situation may be related to the high protein, fiber, and fat contents and low starch concentration in PPF. Nakhon et al. [17] stated that the protein and lipid fractions in pumpkin flour interacted with amylose and it caused an increase in pasting temperature and a decrease in the viscosity values of pumpkin flour.

Techno-Functional Properties

WHC of PPF is shown in Table 3. WHC is defined as the quantity of water retained by the hydrated fiber following the subjected to an external force such as centrifugation or pressure. WHC of dietary fibers is correlated to the chemical structure, porosity, particle size, pH, the ratio of IDF/SDF, and source of vegetable. The WHC of the dietary fiber obtained from yellow passion albedo was 13 g water/g sample, papaya powder 8.93 g water/g sample, and pineapple powder 6.06 g water/g sample [1, 30]. The value obtained from the PPF is close to the value obtained from passion albedo. Such a high WHC value suggests that PPF may have potential applications in products that require viscosity development, hydration, and preservation of freshness, such as cooked food products. Cui et al. [31] stated that dietary fibers with high WHC could be prolonged mastication, and thus affecting satiation and increasing fecal volume.

Table 3. Technological properties of pumpkin pulp flour

Technological properties	Value
WHC (g/g)	12.91±0.40
OHC (g/g)	3.74±0.10
SC (mL/g)	12.48±0.57
EA (%)	70.00±0.16
ES (%)	85.71±0.19
WAI (%)	9.34±0.58
WSI (%)	0.09±0.02

±: Standard deviation of three replicate. WHC: Water holding capacity, OHC: Oil holding capacity, SC: Swelling capacity, WAI: Water adsorption index, WSI: Water solubility index.

OHC of PPF is shown in Table 3. The OHC for passion fruit albedo and passion fruit seeds and pulp mix (2.03 and 1.43 g oil/g sample), for pomegranate bagasse (5.9 g oil/g sample), for mango (1.6 g/g sample), passion fruit (0.9 g oil/g sample), guava (0.7 g oil/g sample), for insoluble dietary fibers obtained from citrus and grapefruit peels (3.6 to 8.2 g oil/g sample) were obtained [30, 32-33]. OHC is a technological property associated with the chemical structure of dietary fiber. This property varies depending on the surface properties of the fiber, total charge density, shape, size, porosity, hydrophobicity of the fiber particles [30, 34-35]. OHC is important to product yield during the cooking process, to flavor retention, to stabilize food emulsions and to decrease fat digestion and absorption in the gastrointestinal tract, to influencing in the body weight control and to the regulation of blood lipid profiles [12, 36].

SC of PPF is shown in Table 3. The SC showed a situation similar to the WHC. Thus, these properties imply that PPF could be used as an agent to improve the texture and juiciness in the food industry such as meat and fish products.

The values of ES and EA of the PPF are shown in Table 3. These results showed that PPF has a good ES and EA. High ES and EA values are preferred for emulsion formation and extending shelf life in the food industry. The ES of oat, bamboo, potato, pea, apple, and wheat dietary fibers were 51.9, 51.0, 29.9, 48.2, 35.0, 56.8, and their EA were 53.0, 56.4, 30.6, 49.0, 37.0 and 57.9, respectively [35]. ES of lemon, grapefruit, pomegranate, lemon albedo and tiger nut dietary fibers were 93.18, 89.88, 90.52, 95.80, 96.15, and EA were 53.67, 54.67, 53.0, 80.0, 78.0, respectively [12].

WAI and WSI of PPF are given in Table 3. WAI is a function of the internal voids in the sample powder [37]. The more these voids, the more water would be absorbed by the sample. WSI provides information on the amount of soluble solids that pass from the material to an aqueous medium.

CONCLUSION

The ratio of IDF to SDF of the PPF was 3.14, and it may be considered as a balanced dietary fiber source. The powder showed good techno-functional properties, and therefore it could be used as a food additive in the food industry. The results revealed the high potential for recovery of waste derived from seed pumpkin to obtain a functional product. The richness of PPF in amino acids such as glutamine and asparagine, which enhance umami flavor, has revealed its potential use as a flavor enhancer in food. Additionally, its high water and oil retention capacities, along with increased emulsion stability and activity, indicate its suitability for use in emulsified products.

Conflict of Interests

There is not any conflict of interests.

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