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Nutritional and functional properties of protein isolates extracted from defatted peanut flour

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Abstract

Food waste management plays a vital role in source minimization and by-product recovery in the food industries. In the present research, defatted peanut flour (DPF) of indigenous varieties *i.e.* Golden and BARI-2011 was used for the extraction of proteins through isoelectric precipitation. The results showed that the protein content ranged from 26.17±0.56% to 27.42±0.61% in GOLDEN and BARI 2011 respectively. The protein isolate recovery was 27.573±0.49% and 29.057±0.30% while protein yield was found to be 79.047±1.95% and 86.840±3.52% respectively for both peanut varieties. Results regarding the functional properties i.e. bulk density, oil & water absorption capacity, foaming & emulsion properties revealed that the values increased by the addition of protein isolates. In the nutshell, protein isolates obtained from defatted peanut flour hold the potential to enrich various baked products. Such protein enriched products can be further utilized to control the menace of protein energy malnutrition in developing economies likes Pakistan.

Introduction

Food waste management has become a major task in food processing facilities as environmental regulations worldwide become more stringent. Surplus quantity of waste materials in the form of shells, peels, seeds, stones, cakes, and oilseed meals are obtained during the processing of fruits, vegetables, nuts, legumes and oilseeds. The most effective approach for food waste management is source minimization and by-product recovery (Schieber *et al.*, 2001). The role of proteins in human nutrition is substantial. According to Modern Nutrition Recommendations, human beings should rely mostly on vegetable and legume proteins to meet the protein requirement in their diet (Oreopoulou and Tzia, 2007). In addition to their nutritional value, proteins provide great potential as functional food ingredients enhancing the useful properties when incorporated into food commodities. In order to utilize a by-product as a protein source, it should contain high protein content and protein value (quality) based on well-balanced essential amino acids (Shalini and Gupta, 2010).

Peanuts *(Arachis hypogaea)* rank as fifth largest source of vegetable oil throughout the world that indicates that a large proportion of peanut produced is used for oil extraction. Peanut residue left from oil extraction is referred to as oil cake/meal (Kain *et al.*, 2009). Generally, this material is available in the form of flakes or grits and may be further processed to partially defatted peanut flour (DPF) (Triveni *et al.*, 2001). DPF is inexpensive protein rich source that offers the same health and dietary benefits of peanut with less fat. It generally contains 47-55% high quality protein with high essential amino acid content which lends itself being used in many food applications (Kain *et al.*, 2009; Rehrah *et al.*, 2009; Ma *et al*., 2010).

The peanut production in Pakistan has reached a level of 100 thousand tonnes due to extraction of peanut oil that is used for the preparation of various food products (Iqbal *et al.*, 2013). The defatted peanut flour left after extraction is matter of great concern and usually sold as animal feed. However, the recent scenario suggests the implementation of concepts of value addition in the food chains (Manzini and Accorsi, 2013). Thus, the present research project was designed to extract the proteins from defatted peanut flour. The extracted proteins were further evaluated for various nutritional and functional properties. It also highlights the protein content, recovery and yield of the extracted protein

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isolates. The results of present research intervention are important to warrant utilization of peanut protein isolates for the preparation of various baked products to ensure the proper quality protein availability to the masses suffering from the menace of protein energy malnutrition.

Materials and Methods

Two varieties of peanut (GOLDEN & BARI 2011) were procured from Barani Agriculture Research Institute Chakwal. Chemicals were purchased from Sigma Aldrich, Tokyo, Japan and other consumables were obtained from local market.

Chemical analysis of peanut flour

Peanut flour was analyzed for moisture (Method No. 44-15A), crude protein (Method No. 46-30), crude fat (Method No. 30-25), ash (Method No. 08-01), crude fiber (Method 32-10) and nitrogen free extract (NFE) according to recommended methods described in AACC (AACC, 2000).

Preparation of protein isolates

Protein isolates from the defatted peanut flour samples were prepared by the method as described by Makri *et al.* (2005). The defatted flour was dispersed in distilled water (1/10); pH was adjusted to 9.5 with the aid of 1 N NaOH and shaked for 40 min at room temperature using a mechanical shaker. Following centrifugation at 4000 rpm for 20 min supernatant was collected. The residue was collected and dispersed in distilled water (1/5) and stirred. Following centrifugation at 4000 rpm for 20 min, the respective supernatant was collected and combined with the supernatant collected from the first centrifugation and the pH was adjusted to 4.5, the precipitated protein was recovered by centrifugation at 4000 rpm for 20 min, neutralized and freeze dried.

Protein isolates assay

Protein content

The nitrogen percentage was measured by Kjeltech system and the protein was calculated by multiplying percent nitrogen with conversion factor 6.25.

Isolate recovery

Recovery of peanut protein isolates was estimated as weight of protein isolates attained after isoelectric precipitation per 100 g weight of defatted peanut (Wang *et al*., 1999).

Protein yield

Protein yield was calculated by the following formula using isolate recovery, protein content of isolate and peanut (Gurpeet, & Sogi, 2007).

$$\text{Yield} = \text{Isolate recovery} \times \frac{\text{Isolate protein (\%)}}{\text{Legume protein (\%)}} \times 100$$

Functional properties of peanut protein isolates

Functional properties such as bulk density, water and oil absorption capacities, emulsion activity and stability and foaming capacity and stability of the respective peanut protein isolates were determined according to their respective procedures as described by Gurpeet and Sogi (2007).

Statistical analysis

The data obtained for each parameter was subjected to statistical analysis in order to determine the level of significance as described by Steel *et al.* (1997).

Results

Chemical characteristics

Results for the proximate composition (Table 1) of two peanut varieties (GOLDEN and BARI 2011) showed moisture content of 5.28±0.32 in GOLDEN and 5.41±0.23 in BARI 2011. Protein contents of two peanut varieties were determined as 26.17±0.56 and 27.42±0.61 in GOLDEN and BARI 2011, respectively. Results showed that GOLDEN contains 43.87±0.21 fat, while BARI 2011 contains 44.57±0.74 fat. Mean values showed that fiber contents were 2.56±0.01 in GOLDEN while 2.57±0.01 in BARI 2011.

Mean values (2.06±0.18) for ash content of GOLDEN were higher as compared to BARI 2011 (1.84±0.18). Nitrogen free extract is generally determined by subtracting sum of all above parameters from 100. The mean values for nitrogen free extract (NFE) were 20.04± 0.63 and 18.17±1.25 for GOLDEN and BARI 2011 respectively.

Table 1. Proximate composition (%) of peanut varieties

Proximate composition (%)	GOLDEN	BARI 2011
Moisture	5.28±0.32	5.41±0.23
Crude protein	26.17±0.56	27.42±0.61
Crude fat	43.87±0.21	44.57±0.74
Crude fiber	2.56±0.01	2.57±0.01
Ash	2.06±0.18	1.84±0.18
NFE	20.04± 0.63	18.17±1.25

Table 2. Protein isolates recovery and yield

Varieties	Protein Content	Protein Isolate Recovery	Protein Yield
GOLDEN	74.840±1.38[b]	27.573±0.49[b]	79.047±1.95[b]
BARI 2011	81.620±1.41[a]	29.057±0.30[a]	86.840±3.52[a]

Protein isolates recovery, crude protein and protein yield

The mean values for protein isolate recovery, crude protein and protein yield are given in Table 2). The value for protein isolates recovery noticed in BARI 2011 was 29.05±0.30 followed by (27.57±0.49) in GOLDEN. Similarly, crude protein revealed in isolates of BARI 2011 was 81.62±1.41 and in GOLDEN variety it was found to be 74.84±1.38. Likewise, higher protein yield (86.84±3.52) was recorded in BARI 2011 while it was 79.04±1.95 for GOLDEN.

Functional properties

Results for the bulk density of proteins isolated from two peanut varieties (GOLDEN and BARI 2011) are shown in Table 3. The mean value for this characteristic found in protein isolates from BARI 2011 was 0.54±0.01g/cm^3 whilst for GOLDEN it was 0.51±0.01g/cm^3. Results for water absorption capacity are depicted in Table 3. Higher water absorption capacity (WAC) was observed in protein isolates from BARI 2011 (206.92±6.92%) followed by protein isolates from GOLDEN (205.22±8.35%). The results for oil absorption capacity are shown in Table 3. The higher oil absorption capacity 101.60±2.43% was observed in BARI 2011 followed by 100.67±2.45% in GOLDEN. The mean values regarding emulsion capacity (EC) of protein isolates are depicted in Table 3. These results revealed a value of 72.00±4.00% for BARI 2011 and 64.00±8.00% for GOLDEN. The results for emulsion stability (ES) indicate a value of 46.08±5.90% for BARI 2011 and 52.15±7.31% for GOLDEN as illustrated in Table 3. The results for foaming capacity (FC) indicated a value of 93.47±3.15% for BARI 2011 and 88.30±2.79% for GOLDEN as portrayed in Table 3. The results for foaming stability (FS) are indicated in Table 3. The value for foaming stability of protein isolates from BARI 2011 was found to be 52.44±3.87% whilst the value for GOLDEN was 54.75±3.80%.

Discussion

Chemical characteristics

The moisture contents not only have economic importance but are also important with regard to the keeping qualities of peanut products. The results of the present investigation are comparable to the findings reported by Atasie *et al.* (2009). They interpret that peanut contains about 5-7% moisture on average basis. The protein content contributes towards the nutritional quality of different food products. The protein content could be related to the studies of Tang *et al.* (2006) which stated that quantity of protein depends on the growing conditions, genotype, environment and their interactions. Grosso *et al.* (2000) reported similar results of protein content. The results for protein content also fall within the limits to the findings of Aurelia *et al.* (2009) who found the protein content ranging from 29.5% to 30.1%. The fat content is comparable to the findings of Atasie *et al.* (2006) who reported the fat content ranging from 46-52%. The results for fiber content are in conformity with previous findings of El-tayeb *et al.* (2011) who reported similar results with respect to chemical characteristics.

Table 3. Functional properties of protein isolates

Functional Properties	Golden	BARI 2011
Bulk Density (g/cm^3)	0.51±0.01[a]	0.54±0.01[b]
Water Absorption (%)	205.22±7.35[a]	206.92±6.92[b]
Oil Absorption (%)	100.67±2.45[a]	101.60±2.43[b]
Foaming Capacity (%)	88.31±2.79[a]	93.47±3.15[b]
Foaming Stability (%)	52.45±3.80[a]	54.75±3.86[b]
Emulsion Capacity (%)	64.00±6.14[a]	72.00±4.39[b]
Emulsion Stability (%)	46.08±4.19[a]	52.15±5.90[b]

The ash content generally represents the concentration of mineral content present in a product. The results of ash content fall within the limits according to the findings of Sai-Ut *et al*. (2009), they found that the ash content ranged from 2.2 to 3.8%. The results are also in agreement with the findings of Grosso *et al.* (2000) who reported the ash content for peanut ranging from 2.3 to 2.6%. The results for NFE are in harmony with the findings of Muhammad *et al.* (2010).

Protein isolates recovery, crude protein and protein yield

The results regarding recovery of peanut protein isolates are in agreement with the findings of Khan *et al.* (2011) showing 26.84±0.22 to 28.32±0.29% recovery of protein isolates. The results for crude protein are in concord with the findings of Suliman *et al*. (2006). They observed 80% crude protein in protein isolates. The present results of protein isolates yield are in accordance with the findings of other researchers as they observed 77% protein yield.

Functional properties

The reason for lesser bulk density in protein isolates from GOLDEN peanut variety might be the differences in particle size that ultimately results in lower bulk density while in BARI 2011 protein isolates refinement of particle size made the proper settling of isolate easy and therefore improved the bulk density. These results are in harmony with the results observed by Suliman *et al.* (2006). They reported that the bulk density of protein isolates ranged from 0.61g/cm^3 to 1.14 g/cm^3. Furthermore, these results are in agreement with Butt and Batool (2010), they found value for this trait as 0.53g/cm^3.

The water absorption capacity represents the ability to bind water molecules under deficient water conditions. The literature supports the WAC values observed in the present study. Overall, the WAC of peanut protein isolates varies from 203 to 222% (Aguilera *et al*., 2009; El-tayeb *et al*., 2011; Li, *et al*., 2010). Oil absorption capacity is an essential parameter since oil increase the mouth feel of food and act as flavor retainer in certain food products. The present results of oil absorption capacity (OAC) are in conformity with Aguilera *et al.* (2009), they observed oil absorption capacity of protein isolates as 109%.

The values for emulsion capacity (EC) of peanut protein isolates are in agreement with those of Suliman *et al*. (2006), estimated emulsion capacity as 75.3%. The current results are also similar to the findings of Aguilera *et al.* (2009), found emulsion capacity for protein isolates 62.9%. These findings for peanut protein isolates are also in harmony with Sai-Ut *et al.* (2009), reported emulsion capacity 68.80%. Emulsion properties of protein isolates may differ with conformational stability, molar mass, hydrophobicity and physicochemical factors such as pH, temperature and ionic strength. The above mentioned results for emulsion stability (ES) of protein isolates are in conformity with Suliman *et al.* (2006), observed values for this attribute 41.4%. The existing results are in concord with El-tayeb *et al.* (2011), discovered foaming capacity of 88.32±0.02%. The present findings are also similar to Aguilera *et al.* (2009), who depicted the value for this trait as 95%. The current findings for foaming stability (FS) of peanut protein isolates are in harmony with Singh *et al.* (2008) illustrated 62.34% foaming stability in legume protein isolates.

Conclusions

It is concluded from the overall results that defatted peanut flour (DPF) is a vital source of protein and the protein isolates thus obtained have high recovery and protein yield. Owing to their excellent functional properties, peanut protein isolates can be further utilized for the supplementation of various food products. Bakery products can be supplemented with these protein isolates in order to enhance the nutritional value of the commodity.

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