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Chemical Composition and Functional Properties of Prickly Pear (*Opuntia ficus indica*) Seeds Flour and Protein Concentrate

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Abstract: Proximate composition and functional properties of prickly pear seed flour (PPS); protein concentrate and the effect of pH on these properties were investigated. The protein content, crude fat and crude fiberof PPS flour and protein concentrate averaged 13.62 and 62.41, 10.43 and 3.57 and 9.23 and 5.31%, respectively. The minimum protein solubility was observed at pH 4.5, as 16. and 15% while maximum protein solubility was observed at pH 11 which as 85 and 92%, repectively. Measurement of emulsion and foaming properties of PPS flour and protein concentrate showed that they are greatly affected by pH levels. The minimum values of both emulsion and foam properties were obtained at pH 4.5 which was the isoelectric point of the protein. The maximum values were obtained at pH 10. PPS flour and its protein concentrate had high water and oil absorption (4.71 and 3.16g water/g flour; 2.43 and 3.26 g oil/g flour, respectively) and protein concentrate tended to have higher values than those of PPS flour.

Key words: Prickly pear · Chemical composition · Amino acids · Protein · Concentrate · Functional properties

INTRODUCTION

About 1500 species of cactus belong to the genus Opuntia are distributed mainly in Africa, Mediterranean countries, southwestern United States, northern Mexico and other areas [1]. The main studies on the Opuntia fruits were concerned withthe chemical analysis of pulp, skin and seeds [2] and use in jam production [3]. Also the composition of prickly pear seed during the maturation period was studied [4]. Plant protein is used in foods as functional ingredient to improve stability and texture as well as nutritional quality of the product [5]. Solubility of protein under varying conditions is one of its important functional properties, because this greatly influences other properties such as emulsification, foaming and gelation; thus the protein may possess satisfactory properties, e. g. nutritional value, acceptable flavour, odour and texture [6]. Functional properties of food protein are important in food processing and product formulation. Some of these properties are water/oil binding, emulsification and foam formation. These properties are affected by the intrinsic factors of protein such as molecular structure and size and many environmental factors including the method of protein separation/production, pH, ionic strength and the presence of other components in the food system. The importance of these properties varies with the type of food products in which the protein concentrate is used. For example, proteins with high oil and water binding are desirable for use in meats, sausage, breads and cakes, while proteins with high emulsifying and foaming capacity are good for salad dressing, sausage, bologna, soups, confectionery, frozen dessert and cakes [7]. It is well known that there shortage in protein sources, so this study was undertaken to assess chemical composition, amino acids profile and functional properties of prickly pear seed flour and its protein concentrate. Also, the effect of pH on their functional properties was investigated, in order to these seeds in food formulations as unconventional protein source.

MATERIALS AND METHODS

Materials: Prickly pear fruits (Opuntia ficus indica) in the ripe stage were obtained from the local market.

Methods

Preparation of Prickly Pear Seeds Flour: At the laboratory, Fresh mature prickly pear fruits of *Opuntia ficus-indica* were washed carefully and peeled with knife

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and the pulp was mixed for a few minutes in a mixer. The seeds were recovered from the resulting pulp juice by straining and washed using distilled water for several times. After drying at room temperature (35°C), they were cracked in an analytical grinder for a few minutes and their pericarps were recovered after sieving on 20 mesh sieve.

Preparation of protein concentrate: protein concentrate was prepared according to [8].

Proximate Composition: Moisture, protein, fat, ash and fiber of prickly pear seeds flour and protein concentrate were determined according to [9]. Carbohydrate was determined by difference. Amino acids composition was determined according to [10].

Functional Properties: Solubility profile, Emulsion capacity (EC), foaming capacity (FC) and stability (FS) were determined according to [11]. The water and oil absorption capacity was determined as described by [12] and was expressed as the percentage of increase in the sample weight.

Statistical Analysis: Triplicate samples were statistical analyzed [13].

RESULTS

Proximate Composition: Table 1 shows the proximate composition of the prickly pear seed flour and protein concentrate. It was clear that PPS flour has higher contents of moisture, fat, ash, fiber and carbohydrate as compared to the protein concentrate. While, PPS protein concentrate has high protein content.

Amino Acids Composition: The amino acids composition of PPS flour and its protein concentrate are presented in Table 2. Glutamic acid was the most predominant amino acid followed by aspartic acid, leucine, lycine and arginine. The values of amino acids showed that cyctine and methionine were in the lowest levels in PPS flour and protein concentrate. On the other side, essential amino acids represented 28.68 and 30.46%, while nonessential amino acids represented 43.81 and 45.88% and E/N was 0.65 and 0.66 for PPS flour and protein concentrate, respectively.

Nitrogen Solubility: The nitrogen solubility as a function of pH is shown in Fig. 1. The data show three regions of nitrogen solubility, at acidic pH, near to the isoelectric point and at alkaline pH. The minimum nitrogen solubility was observed at pH 4.5 which was 16 % for PPS flour compared to 15% for protein concentrate, indicating the isoelectric point of the protein; in the acid media (pH1). 73% of the protein was soluble compared to 79% for protein concentrate. At pH 8, 51 and 56% of protein was soluble, while 85 and 92% was soluble at pH 11.

Emulsion Capacity: The effect of pH on emulsion capacity of PPS flour and protein concentrate are shown in Fig. 2. It was found that PPS flour and protein concentrate had a minimum emulsion capacity (13 and 21 ml g^{-1}) at pH 4.5, On the other hand, maximum emulsion capacity of PPS flour and protein concentrate were 88 and 105 ml g^{-1} at pH 10.

Foam Capacity and Stability: The foam capacity (FC) of PPS flour and protein concentrate is shown in Fig. 3. The lowest FC (30 and 27%) was obtained at pH 4.5 (isoelectric point of protein); at this point the molecules are in more compact from than other pH values. FC significantly increased, especially at pH 8 and 10 reaching 84 and 96; 97 and 103% for both PPS flour and protein concentrate.

The effect of pH and time on the foam stability of the PPS flour and protein concentrate is shown in Fig. 4 and 5. Regardless of the mixture pH, foam stability gradually decreased with time. At pHs 4.5 and 6 the foam stability gradually decreased and reached to 11 and 12% when the foam stood for 90 min, while at acidic (pH 2) and alkaline (pH 8 and 10) the foam stability was increased.

Water and Oil Absorption Capacity: According to Fig. 6 the WAC of protein concentrate tended to be higher (4.71 ml water/g sample) than those of PPS flour (3.16 ml water/g sample).The same trend was observed with OAC.

DISCUSSION

Several studies had been reported that prickly pear seeds are considered untraditional source of protein. Therefore, we have a large amount of pearkly pear fruits

Table 1: Proximate composition of prickly pear seed flour and protein concentrate(Mean ±SE)

Sample	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate
PPS flour	9.03±0.38^{a}	13.62±0.58^{b}	10.43±0.63^{a}	6.47±0.45^{a}	9.23±0.39^{a}	51.11±1.25^{a}
PPS protein concentrate	7.16±0.32^{b}	62.41±1.43^{a}	3.57±0.27^{b}	5.31±0.40^{a}	5.29±0.41^{b}	15.79±0.57^{b}

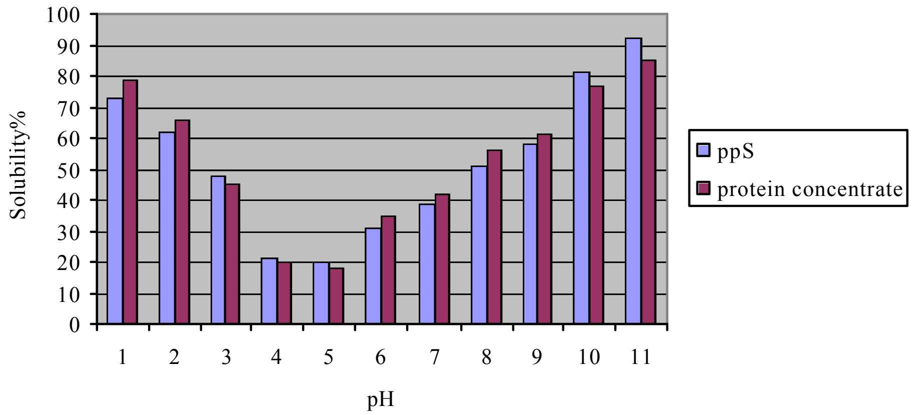

Fig. 1: Effect of pH on protein solubility of prickly pear seed flour and protein concentrate

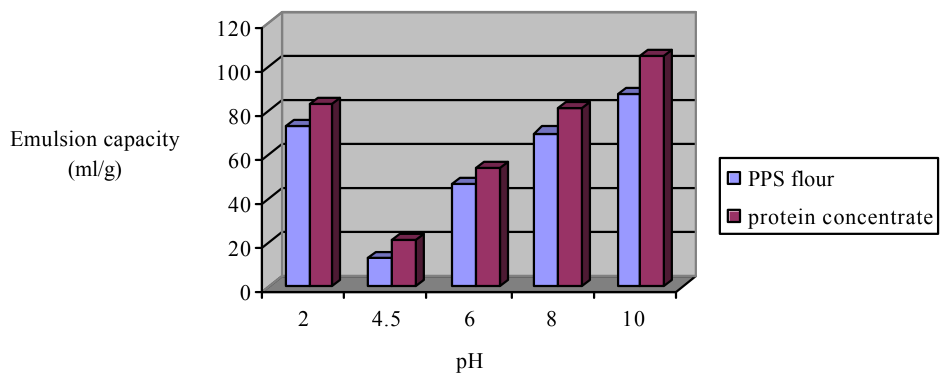

Fig. 2: Effect of pH on emulsion capacity of prickly pear seed flour and protein concentrate

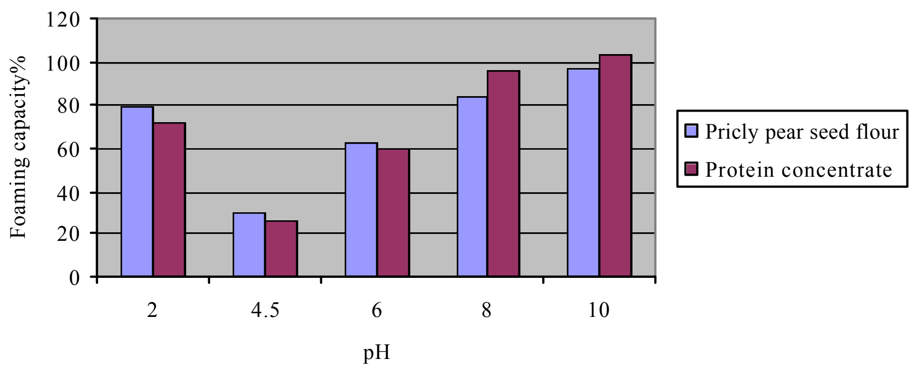

Fig. 3: Effect of pH on the foam capacity of prickly pear seed flour and protein concentrate

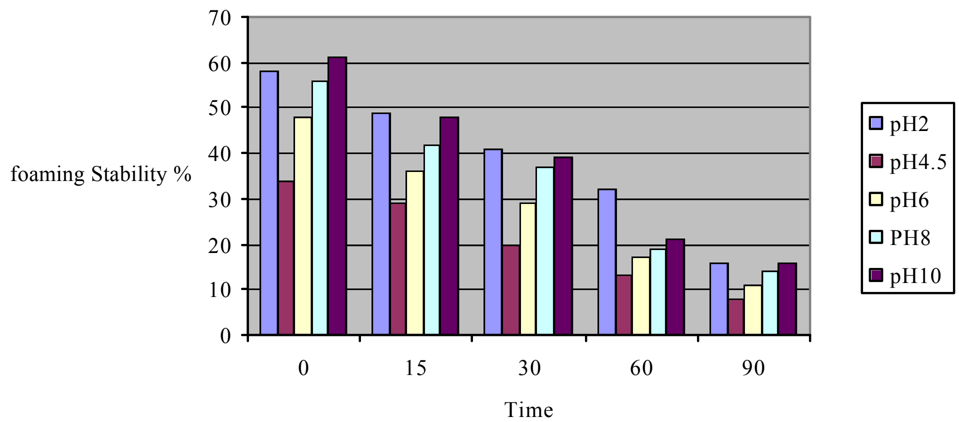

Fig. 4: Effect of pH on the foam stability of prickly pear seed flour

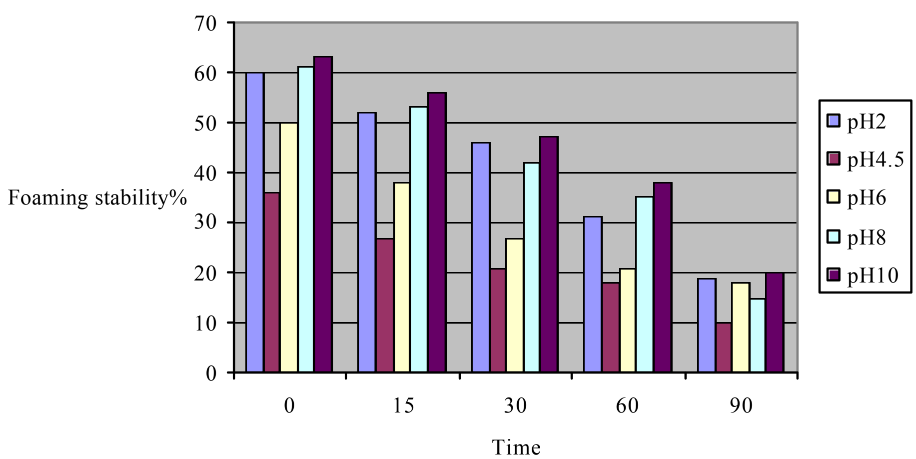

Fig. 5: Effect of pH on the foam stability of prickly pear seed flour protein concentrate

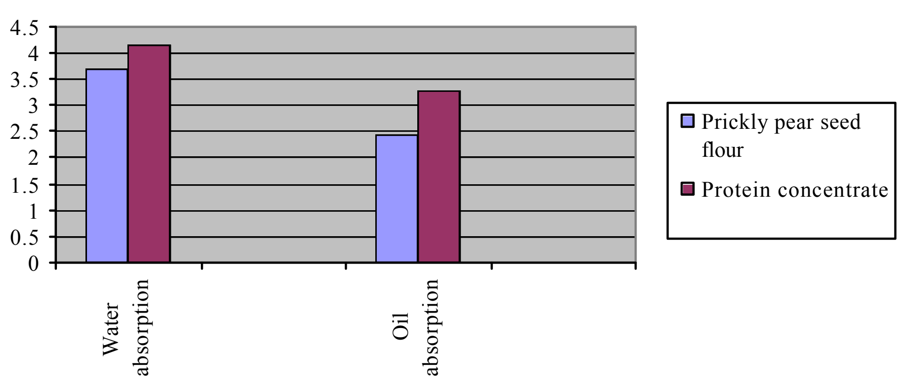

Fig. 6: Water and oil absorption capacity of prickly pear seed flour and protein concentrate

Table 2: Amino acids composition of prickly pear seed flour and protein concentrate

Amino acids	Prickly pear seed flour	Prickly pear seed Flour protein concentrate	FAO/WHO reference protein
Leucine	7.21	7.82	4.8
Isoleucine	4.50	4.76	4.2
Methionine	0.51	0.47	2.2
Phenylalanine	3.81	3.96	2.8
Lysine	4.93	4.98	4.2
Therionine	1.11	1.46	4.0
Tyrosine	2.24	2.38	4.1
Valine	4.37	4.63	4.2
Aspartic	7.56	7.79	
Glutamic	15.73	15.58	
Serine	6.14	6.77	
Glycine	3.67	3.89	
Alanine	3.45	3.71	
Histidine	2.26	2.87	
Arginine	4.81	5.09	
Cystine	0.27	0.18	
Total essential amino acids (E)		28.68	-30.46
Total non essential amino acids (N)		43.81	45.88
E/ N ratio		0.65	0.66

and we wish to implementation in food technology. The current work indicated that the fat and carbohydrate of PPS flour are largely removed during protein concentrate preparation. These results are in accordance with that reported by [14]. Also, all the essential amino acid except methionine, therionine and tyrosine occurred at higher level in the PPS flour and protein concentrate than those of the FAO/ WHO reference protein [15]. Amino acids content for both PPS flour and protein concentrate are in agreement with those recorded by [16]. Protein solubility is the most important functional property because it influences other functional properties. Similar observations were reported by several workers for legumes e.g. [8] for fenugreek and [17] for African locust bean.At pH 4 and 5 there was a sharp decrease in protein solubility for both PPS and protein concentrate, but it showed good solubility in acid and alkaline pH regions which is an important characteristic in food formulations [18]. Beside, at highly acidic and alkaline pHs the protein acquires net positive and negative charges, respectively, which favors the repulsion of the molecules and thereby increase the solubility of the protein [19]. The formation and stability of emulsion is very important in food systems such as salad dressing. Protein is composed of charged amino acids, non charged polar amino acids and non polar amino acids. Emulsion capacity had low level of PPS flour and protein concentrate at pH 4.5, at this pH value the protein tend to precipitate, leading to reduction in emulsion formation. However results revealed that the emulsion capacity was pH dependent and the alkaline pH improved the emulsion capacity more thane did the acidic pH. Similar results were reported by [20]. On the other hand, foam capacity of PPS flour and protein concentrate has a more compact structure, especially at acidic and neutral pH values. At the alkaline pH 8 and 10 foam capacity of the PPS products were increased, probably as a result of an increase in the negative charge density of the proteins. Increased charge density would enhance unfolding of the protein molecules into more flexible structures which form foams better than the more compact molecules that exist at pH 2,4.5 and 6 [21]. The charge effect is particularly noticeable in foam formed by PPS protein concentrate, which had low volumes at pH 2 and 6, while it was completely unstable at pH 4.5. However, at pH 8 and 10 foam capacity was increased for the protein concentrate. The increase in foam stability of PPS flour and protein concentrate under highly acidic and alkaline condition might be attributed to the increase in flexibility of the protein molecules, which diffuse more rapidly to the air water interface to encapsulate air particles, leading to enhance foaming [22]. Also, results indicated that, increase in the foam stability values of protein concentrate at acidic and alkaline condition compared with PPS flour. The high values associatedwith protein concentrate sample may be due to their high protein content and increase solubilization of these protein. The same trend was observed by [23]. Water absorption capacity (WAC) represented the ability of a substance to associate with water under a limited water condition [24] both protein and carbohydrates improved WAC in particularly protein concentrate, this may be due to smaller lipid content in its content compared with flour [25]. Oil absorption capacity (OAC) is another important functional property, since it plays an important role in enhancing the mouth feel and retaining the flavour [26]. The OAC of the protein concentrate was greater than those of the PPS flour.This could result from higher protein content of the protein concentrate leading to a greater extent of hydrophobic interaction between protein and fat.

In conclusion, pearkly pear grows successfully under Egyptian condition, so it can be completely utilize to obtain unconventional protein source. Based on our results, PPS flour and protein concentrate have good functional properties and can be included in food formulation system.

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