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Chemical Characterization of Peach Kernel Oil and Protein: Functional Properties, *in vitro* Digestibility and Amino Acids Profile of the Flour

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ABSTRACT

Kernels of peach fruits contain 54·5% and 27·5% oil and protein, respectively, but ash and total carbohydrates were quite low. Total lipids contained 98% triglycerides; sterols and polar lipids constituted 0·41% and 1·1% respectively. Fatty acid composition revealed the presence of oleic (63·8%) and linoleic (15·4%); there was 20·7% of saturated fatty acids. The defatted flour showed good fat absorption and emulsification properties but water absorption and foaming properties were slightly low. The solubility of protein was high at both acidic and alkaline pH with a minimum solubility at pH 4·3. Albumins were the major protein fractions (60%) followed by non-protein nitrogen (17%); globulins and glutelins constituted 9·5% and 8·2%, respectively, and prolamines only 6·0%. The protein was highly digested by pepsin–pancreatin followed by pancreatin and pepsin and the lowest digestibility was by trypsin. The protein is rich in lysine, leucine, isoleucine, valine, threonine, basic and acidic amino acids but poor in methionine. PAGE showed five bands with different relative mobilities and they contained both high and low molecular weight protein fractions.

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INTRODUCTION

Stone fruits, such as apricot and peach, are grown in many areas of Egypt. The fruits are used either fresh or after processing and there is no definite use for the remaining by-products. The previous two papers of Abd El-Aal *et al.* (1986*a*,*b*) were focused on the chemical and nutritional evaluation and possible uses of apricot kernel oil and protein. Therefore, this study was conducted to continue our work on the second major stone fruit used in Egypt. Chemical characterization of both oil and protein fractions of peach kernel flour was the main objective of this work. However, the functional properties, amino acid composition, *in vitro* digestibility and polyacrylamide gel electrophoresis pattern of the defatted flour were also determined.

Removal of amygdalin, the most toxic and bitter substance in both peach and apricot kernels, is under progress in our laboratory; promising data have already been obtained and will be published shortly.

MATERIALS AND METHODS

Materials

Peach fruits

The peach fruits (*Prunus persica*) were obtained from the local market of Alexandria city during the summer season of 1986. The pits were removed from the tissues by hand, washed with tap water and sun-dried at ~ 30°C for about 2 weeks. The dried pits were cracked by hand and the collected kernels used for physical and chemical analysis.

Standard lipids

Cottonseed lipid extract (60 days after flowering), containing all known lipid fractions, was used as a reference (Abd El-Aal, 1981).

Analytical methods

Moisture, total proteins, lipids, ash, hydrocyanic acid and crude fibre were determined by AOAC methods (AOAC, 1980). The method of Dubois *et al.* (1956) was used to estimate total sugars in the ethanol extract using glucose as standard. Total carbohydrates were calculated by difference.

Physicochemical characteristics of peach kernel oil

The oil was extracted from the ground peach kernels by hexane as already described by Abd El-Aal *et al.* (1986*a*). The extracted oil, after removing

hexane, was immediately analysed for iodine, saponification value, acid and peroxide number, unsaponifiable matter, specific gravity, refractive index, titre and colour by the standard methods recommended by the AOCS (1973). The hydrocyanic acid content of the extracted oil was determined by the method of Blinn & Boyd (1964).

Fractionation of total lipids

This was carried out according to the method of Mangold & Malins (1960) as described in detail for apricot kernel oil by Abd El-Aal *et al.* (1986*a*).

Fatty acids analysis

The methyl esters of crude oil were prepared according to Chalvardjian (1964), using 1% of H_2SO_4 in absolute methanol. The rest of the determination was as reported elsewhere (Abd El-Aal *et al.* 1986*a*).

Functional properties of peach kernels defatted flour

The defatted flour of peach kernels was used to study the protein fraction properties. Water and oil absorption capacities were determined according to the methods of Sosulski (1962) and Sosulski *et al.* (1976), respectively. Emulsification capacity was measured by the method of Yasumatsu *et al.* (1972). Refined corn oil was used for oil absorption and emulsifying capacity studies. Foaming properties (foam capacity and stability) were measured by the method of Huffman *et al.* (1975).

Nitrogen-pH solubility profile

The method described for apricot kernel flour (Abd El-Aal *et al.*, 1986*b*) was followed. The nitrogen solubility index was also determined in different solvents, i.e. distilled water, 5% NaCl and 0·02M NaOH solutions.

Fractionation of total protein on the basis of solubility

The Osborne classification of protein was done according to Abd El-Aal *et al.* (1986*b*) using distilled water, 1M NaCl, 70% ethanol and 0·2M NaOH solutions for albumins, glubulins, prolamines and glutelins, respectively. Non-protein nitrogen was determined in a separate sample by the method of Bhatty (1973) and subtracted from the albumin value. The remaining residue, after the successive extractions, was quantitatively transferred into a Kjeldahl flask and digested with conc. H_2SO_4 to determine the residual protein.

Protein *in-vitro* digestibility

The digestibility index by a pepsin–pancreatin system was determined according to the procedure of Akeson & Stahmann (1964). Digestibility by the other different proteolytic enzymes in a single system such as pepsin, trypsin and pancreatin was also performed as described for apricot kernels protein by Abd El-Aal *et al.* (1986*b*).

Tannins and phytic acid content

The tannin content of peach kernel flour was determined by the method of the AOAC (1980). The method of Wheeler & Ferrel (1971) was followed to estimate the flour phytic acid content.

Amino acids analysis

The amino acids other than cystine and tryptophan were determined in the acid hydrolysate according to Moore *et al.* (1958), using a Beckman Amino Acid Analyzer (Model 121 M) as described by Youssef *et al.* (1986). The results are reported as milligrams of amino acid per gram of nitrogen.

Polyacrylamide gel electrophoresis (PAGE)

This was performed by the method of Davis (1964) in 0·01M sodium phosphate buffer of pH 7·8 and 7·5% gel. Amido Black was used to stain the protein bands and 7·5% acetic acid used to remove the unbound dye.

RESULTS AND DISCUSSION

The proximate chemical composition of full fat peach kernels along with some physical properties are given in Table 1. Fats represent the major component in the kernels (i.e. twice the protein content). The other components were in the following decreasing order: total carbohydrates, total soluble sugars, total ash and crude fibre. Cruess (1958) reported that most stone fruit kernels contain oil and protein as major components, which agrees with our results. Hydrocyanic acid, a product of amygdalin hydrolysis by the enzyme emulsin, was 0·19% (Table 1). This is higher than that found in Egyptian apricot kernels (0·15%) (Abd El-Aal *et al.* 1986*a*). This level is toxic if peach kernels are used as a protein source for human food (Rieders, 1965). Thus, detoxification of kernels is necessary before utilization in food products.

TABLE 1
Proximate Chemical Composition of Whole Peach Kernel

Constituents	*Percentage*
Crude protein (N × 6·25)	27·5
Crude lipid	54·5
Total soluble sugars (as glucose)	4·79
Total ash	3·35
Crude fibre	2·97
Total carbohydrates (excluding glucose)	6·74
Hydrocyanic acid	0·19
Physical properties:	
Weight of 100 pits	425
Kernel %	12·6

The weight of 100 peach pits is quite high but the kernels represent only 12% of the pit. This value is quite low compared to 31·2% for apricot kernel reported by Abd El-Aal *et al.* (1986*a*). Cruess (1958) reported that peach kernels represent about 7% of the pit. The higher value reported by us could be due to either varietal variations or climatic conditions. The pit wall of peach is quite thick and strong and responsible for the low yield of kernels.

The peach kernel oil was very light yellow in colour, had an acceptable odour and was completely free from the toxic hydrocyanic acid (Table 2). The peach kernel oil had slightly higher values for specific gravity, refractive index, saponification number and unsaponifiable matter compared with apricot kernel oil. The iodine number was fairly low (84·2) compared with apricot kernel oil (104); thus, peach kernel oil could be classified as a non-drying oil. The acid and peroxide values are good indices for the stability of

TABLE 2
Some Physico-chemical Characteristics of Peach Kernel Oil (Hexane extract)

Property	*Value*
Refractive index (25/25°C)	1·469 5
Specific gravity (25/25°C)	0·915 8
Titre (°C)	7·4
Iodine number (Hunus)	84·2
Acid number	0·10
Peroxide value (meq/kg)	0·22
Saponification value	192
Unsaponifiable matter (%)	0·88
Hydrocyanic acid	0·0
Colour	0·4*R*, 4·2*Y*

TABLE 3
Chemical Composition of Peach Kernel Total Lipids

Constituent	*Percentage*
Hydrocarbon + sterol ester	0·18
Triglycerides	98·1
1,3 Diglycerides	Tr
1, 2 and 2, 3 Diglycerides	0·21
Free fatty acids	Tr
Sterols	0·41
Polar lipids	1·10

the oil and its susceptibility to rancidity during storage. These two parameters were very low (Table 2). This clearly indicates that peach kernels may have low levels of oxidative and lypolytic activities or may have high contents of natural antioxidants.

Fractionation and composition of peach kernel lipids

The relative percentages of the major lipid classes are presented in Table 3. The neutral lipid content was 98·1% of the total lipids. However, polar lipids accounted for only 1·1%. These values were very close to those of apricot kernel lipids (97% and 3%, respectively) reported by Abd El-Aal *et al.* (1986*a*). Cruess (1958) reported that most stone fruits are almost identical in their lipid compositions, which agrees with our findings.

The neutral lipid fraction revealed the presence of hydrocarbons, triglycerides, sterols and diglycerides (1, 3 and 2, 3 and 1, 2 diglycerides). While triglycerides represented 98·1% and constituted the major fraction of the neutral lipids, diglycerides and hydrocarbon + sterol esters were very minor and represented only 0·21% and 0·18%, respectively. Sterols were at twice the concentration of diglycerides.

Fatty acid composition

Table 4 illustrates the fatty acid content of peach kernel lipids. The unsaturated fatty acid content was 79·4% and consisted mainly of oleic and linoleic acids. The linolenic acid was at trace level. However, the saturated fatty acid content was 20·7%, almost four times higher than that found in apricot kernel lipids (4·83%) by Abd El-Aal *et al.* (1986*a*). Palmitic acid was the major saturated fatty acid, followed by stearic. Myristic acid content was only 0·88% (Table 4). Some unsaturated vegetable oils have an ability to reduce serum cholesterol level and this may focus interest on the use of peach kernel oil in human foods because it is quite highly unsaturated.

TABLE 4
Fatty Acid Composition of Peach Kernel Oil (Hexane extract)

Fatty acid	*Percentage*
Myristic	0·88
Palmitic	13·4
Stearic	6·41
Palmitoleic	0·16
Oleic	63·8
Linoleic	15·4
Linolenic	Tr
Total saturated fatty acids	20·7
Total unsaturated fatty acids	79·4

Functional properties

The functional properties of defatted peach kernel flour are given in Table 5. The flour absorbs and retains more oil than water; the oil absorption capacity was twice the water absorption capacity. This may give an advantage to peach flour in some bakery products such as cake or biscuits which require flour with good oil absorption capacity. It is interesting to note that apricot kernel flour showed an opposite trend, regarding fat and water absorption capacities, to that of peach kernel flour (Abd El-Aal *et al.* 1986*b*). Therefore, blending of both flours will give a product with improved ability to absorb and retain more water and oil, which would be an advantage in many food products. Emulsification capacity of the flour was

TABLE 5
Functional Properties of Defatted Peach Flour[a]

Functional properties	*ml/g flour*	*g/g flour*
Water absorption	—	1·38
Fat absorption	2·9	2·61
Emulsification capacity	60·8	54·7
Foam capacity (% increase)	23·0	
Foam stability ml at:		
0·0 min	15·0	
15 min	12·8	
30 min	12·0	
45 min	11·8	
60 min	11·5	

[a] Average of three determinations.

also high which may be of interest in products such as sausage, and other meat analogues. The foaming properties of the peach kernel flour were fairly good and would suit soft drinks and beverages; at the same time use of the flour increases the protein content and improves the nutritional quality of such drinks. However, the foaming properties were lower than those of apricot kernel flour (Abd El-Aal *et al.*, 1986*b*).

The protein solubility at different pH values is illustrated in Fig. 1. The

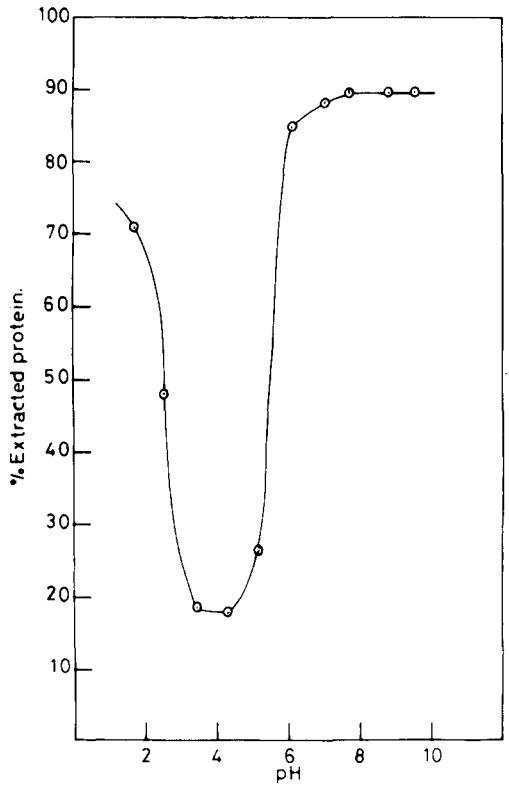

Fig. 1. Protein solubility index of peach flour at different pHs.

solubility of the protein at extreme pHs was very high (71% and 90% at pH 1·7 and 9·5, respectively). However, at the minimum solubility region (between pH 3·4 to 4·3) about 18% of the protein was soluble. It is noteworthy that the increase in solubility between pH 6·1 to 9·5 was only 5%, which may be due to weak binding of the peach protein with other fractions, i.e. lipids and carbohydrates. This actually helps during preparation of protein isolates; at pH 7·0 about 88% of the protein will be extracted without any danger of denaturation. Also, the protein of peach

kernel flour will possess good functional properties because it is highly soluble and will not affect the properties of any product in the neutral pH range. The solubilities in distilled water, 5% sodium chloride and 0·02M sodium hydroxide were 47·3%, 53·4% and 55·1%, respectively.

The protein fractions of peach kernel flour, based on the Osborne classification, are given in Table 6. Albumins represent the major protein component in the kernel. The other fractions were minor. Globulins and glutelins were 9·6% and 8·23%, respectively. These figures are similar to

TABLE 6
Nitrogen Content of the Protein Fractions of Peach Kernel Flour[a]

Protein fraction	*Soluble nitrogen (%)*	*Nitrogen solubility index (%)*
Albumins	5·39	60·0
Globulins	0·86	9·57
Prolamines	0·53	5·89
Glutelins	0·74	8·23
Non-protein nitrogen	1·47	16·4
Residual protein	0·0	0·0
Total nitrogen	8·99	100

[a] Average of three determinations.

those of apricot kernel protein reported by Abd El-Aal *et al.* (1986*b*). However, there are two noteworthy points from the data; the first is the high level of the non-protein nitrogen fraction (16·4% compared with 1·17% reported for apricot kernel flour). The second is the complete solubility of the total nitrogen by the solvents used, which may indicate that the protein of peach kernels is loosely bound with other components of the kernel such as carbohydrates and lipids. This may be an advantage during preparation of the protein isolates, thus increasing the yield.

The *in vitro* digestibilities of peach kernel flour by different enzyme systems are shown in Table 7. The digestibility of casein, as a standard protein, was also done for comparison. The digestibility of peach kernel flour could be arranged in the following decreasing order: pepsin–pancreatin, pancreatin, pepsin and trypsin. The observed low digestibility by trypsin could be due to the presence of anti-trypsin components in the flour. The same order of digestibility was reported for apricot kernel flour by Abd El-Aal *et al.* (1986*b*). Tannin and phytic acid content of the flour were determined and found to be 150 mg and 14·9 mg per 100 g of flour. These two

TABLE 7
In vitro Digestibility of Peach Kernel Flour[a]

Enzyme system	*Digested protein (%)*	
	Casein	*Peach flour*
Pepsin	88·2 ± 2·3	49·1
Trypsin	72·8 ± 2·5	32·7
Pancreatin	95·9 ± 1·8	58·2
Pepsin–pancreatin	99·1 ± 0·3	74·0

[a] Average of two determinations.

TABLE 8
Amino Acid Composition of Peach Kernel Flour Compared with Soybean Meal

Amino acid	*mg amino acid/g nitrogen in the flour*	
	Peach	*Soybean*[b]
Aspartic acid	233	731
Threonine[a]	265	241
Serine	25	320
Glutamic acid	556	1 169
Proline	205	343
Glycine	250	261
Alanine	549	266
Valine[a]	310	300
Methionine[a]	19	79
Isoleucine[a]	236	284
Leucine[a]	485	486
Tyrosine	126	196
Phenylalanine[a]	230	309
Lysine[a]	452	399
Histidine	229	158
Arginine	691	452
Ammonia	112	—

[a] Essential amino acids.
[b] Amino acid values from Braddock & Kesterson (1972).

components may also be responsible for the observed low digestibility of peach kernel protein.

Table 8 gives the amino acid composition of peach kernel flour. The essential amino acids, threonine, valine, leucine, isoleucine and lysine, were found in comparable amounts to soybean. However, some of these amino acids were higher (i.e. threonine, valine and lysine). Therefore, peach kernel flour could be used as a good source of these essential amino acids in food products. It is also rich in both acidic and basic amino acids, but very poor in methionine, the sulphur-containing amino acid, and cannot be used as a single source of it. In general, peach kernel flour is a good source of most amino acids important in human and animal nutrition and, by blending with other vegetable protein materials, will produce well balanced diets.

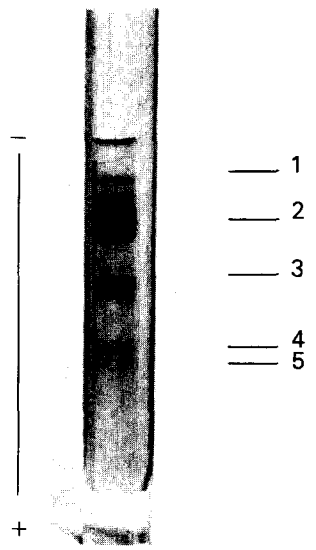

Fig. 2. Polyacrylamide gel electrophoresis of peach kernel protein in 0·01M sodium phosphate buffer of pH 7·8. Relative mobility of protein: band 1, 0·09; band 2, 0·21; band 3, 0·38; band 4, 0·56 and band 5, 0·60.

The polyacrylamide gel electrophoresis in sodium phosphate buffer is shown in Fig. 2. There are five protein bands with relative mobilities of 0·09, 0·21, 0·38, 0·56 and 0·60, respectively. Only one band, with a relative mobility of 0·21, represents the major protein fraction in the kernel. However, the other four bands were minor in their concentrations. The PAGE pattern reveals that peach kernel protein contains both low and high molecular weight protein fractions. To the best of our knowledge the electrophoresis pattern of peach kernel protein has not been reported previously.

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