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Unconventional protein sources: apricot seed kernels

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In the early 1960 wide-spread interest was aroused in the international community about the development of low-cost nutritious food from unconventional sources. Partly the excitement was caused by increased recognition of the importance of malnutrition, but uncertainty about continuing supply from existing nutritious sources played an important role.

Protein malnutrition is without doubt the main nutrional problem facing low-income countries. The family of food that has received the most attention as fortifiers or ingredients of the formulated foods are the oilseeds. The principal difficulties in exploiting them for human consumption are color, toxic factors, digestibility and palatability.

Single cell protein, fish protein concentrate, leaf protein concentrate and wheat protein concentrate are used primarily in animal feed. Whether these protein sources can be incorporated into diets or as a base in formulated foods merits considerable exploitation.

In the present study, some by-products of food processings were evaluated as unconventional sources of food proteins. One of these by-products are apricot seed (Prunus armeniace) kernels.

Materials and methods

Selection and preparation of samples:

1. *Hamawy apricot kernels (Sweet):* Dried apricot fruits (var. Hamawy) were obtained from El-Kharga oases. Kernels were removed manually and ground for analysis.
2. *Amar apricot kernels (bitter):* The seed was obtained as by-products form kaha (food processing factory). Kernels were manually removed, and divided into two parts. The first part was ground for analysis. The second one was treated in different ways to reach the best method for removing bitterness. The best method found was by boiling the kernels for 30 minutes in 0.1 % sodium bicarbonate solution, soaking for 24 hours in running tap water and then drying at 100 °C. The dried kernels were ground for analysis.

Chemical analysis

Moisture, crude protein, ether extract, ash, and phosphorus were determined according to the methods recommended by the Association of Official Agricultural Chemists (1965). Soluble proteins were extracted at 20 °C, and nitrogen was determined in both the extract and residue. Fiber was determined according to Pearson (1962). The method used for iron determination was that of Elvehjem (1930).

Calcium was determined according to Kramer (1921). Carbohydrate content was calculated by difference. The dried defatted samples were subjected to acid hydrolysis for 24 hours. The amino acids in the hydrolysates were separated by the two-dimensional paper chromatographic technique of Block et al. (1958). The solvents used were butanol, acetic acid, and water (4 : 1 : 5) in the first run and 0.3 % ammonia in 80 % phenol in the second run.

Quantitative determination was made whenever possible for some of the separated amino acids using the method of Giri et al. (1952). Tryptophan was not determined, as it is destroyed by acid hydrolysis.

Biological evaluation of the seed's protein

The following basal diet (Campbell, 1961) was used:

Corn starch	80 g
Cotton seed oil	10 g
Cellulose	5 g
Salt mixture	4 g
Vitamin mixture	1 g

The salt mixture used was that of Hubbel et al. (1937), and the vitamin mixture was that of Campbell (1961). The dried defatted samples were added at the expense of starch to produce 10 % protein level. Casein was used in the standard diet.

Determination of the protein efficiency ratio (P.E.R.): The method used was that of Campbell (1961). Weanling albino rats of a single strain, 20–23 days old, were used. The rats were devided into groups of 6 animals for each diet. The groups were equalized as nearly as possible with respect to sex and weight. Diets and water were supplied ad libitum. The experiment was extended to four weeks, at the end of which calculations of the protein efficiency ratios (P.E.R.) were made for each rat.

$$\text{Where P.E.R.} = \frac{\text{g gain in body weight}}{\text{g protein intake}}$$

P.E.R. for experimental diets were recalculated as percentage of that for casein.

Determination of the net protein ratio (N.P.R.): A control group of rats of nearly equal weight and age as in P.E.R. experiment was fed a protein-free (basal) diet for 10 days to determine the loss in weight corresponding to the maintenance requirements of the rats. An approximate estimate of N.P.R. was done for the four-week period from the loss in weight of group means over 10-day period.

$$\text{N.P.R.} = \frac{\text{weight gain of test protein group} + \text{weight loss of the protein-free diet group}}{\text{protein intake}}$$

Blood analysis

At the end of the experimental period, rats were killed by chloroform, and blood samples were taken by cardiopuncture. The total serum protein was determined by Kjeldahl method according to the A.O.A.C. (1965). Serum samples of 0.2 ml were subjected to electrophoretic separation of proteins. The apparatus used was that of Elphor and the separation was carried out at pH 8.9 for 18 hours using Durrum method (1950). The dye used was bromophenol blue. Elution of the stained bands was carried out using 0.5 % solution, and the albumin/globulin ratio was determined colorimetrically. The free non-essential/essential amino acid ratio was determined using the method of Abdou and Awadalla (1973).

Results and discussion

Table 1 shows the percentage of flesh, seed, shell, and kernel in the apricots used. The percentage of kernel in seed was found to be 34.4 and 31.4 for Hamawy and Amar varieties, respectively.

Table 2 shows the percentage of moisture in the different samples, and the percentage of crude protein, ether extract, fiber, ash, and carbohydrate in the same samples on dry-weight basis.

It is clear from table 2 that treated apricot kernels contained a higher percentage of moisture compared with the untreated ones. These results are in agreement with those found by Dang et al. (1964), using the two Indian varieties, Morpanka with sweet kernels and Chavau with bitter kernels. They gave values that are in the same range as those reported here. It is clear from this table, too, that apricot kernels are a good source of protein and fat. Data regarding the solubility of protein of the apricot kernels are shown in table 3. It is clear that the amount of protein extracted by cold water in the different samples of apricot kernels is approximately the same.

Treatment of Amar apricot kernels to remove bitterness decreased the amount of protein extracted by boiling water, which may be due to protein denaturation during treatment.

Table 4 shows the amounts of phosphorus, calcium and iron in the different samples. The amounts of phosphorus and calcium in Amar kernels are higher than the corresponding values in Hamawy kernels. The treatment process caused a considerable loss in phosphorus.

Apricot kernels are reasonably good sources of iron. The three investigated apricot kernels were found to contain the amino acids: cystine, aspartic acid, serine, glutamic acid, glycine, threonine, lysine, histidine, arginine, alanine, methionine, valine, phenyl-alanine, isoleucine and

Table 1. The percentage composition of flesh, seed, shell and kernel in apricots.

	Hamawy	Amar
Flesh	90.7	88.5
Seed (shell + kernel)	9.3	11.5
Shell	6.1	7.9
Kernel	3.2	3.6

Table 2. The percentage of macronutrients in apricot seed kernels calculated on dry-weight basis.

Sample	Crude protein	Ether extract	Fiber	Ash	Carbo-hydrate	Moisture
Hamawy	23.74	50.91	15.08	2.46	7.81	5.15
Amar (treated)	25.46	42.21	18.02	1.74	12.76	29.11
Amar (bitter)	25.70	46.53	17.27	2.19	8.31	18.93

Table 3. Solubility of protein apricot kernels (g soluble protein/100 g, dry material).

Sample	Cold-water-extracted protein	Boiling-water-extracted protein	Residual protein content	Total protein	
				calculated	estimated
Hamawy apricot kernels	2.29	6.19	15.03	23.51	23.74
Amar apricot kernels	2.38	7.88	15.04	25.30	25.70
Treated apricot kernels	2.41	2.54	20.17	25.12	25.46

Table 4. Phosphorus, calcium and iron content of the different samples of apricot kernels (mg/100 g dry material).

Sample	Phosphorus	Calcium	Iron
Apricot kernels			
Hamawy	88.9	138.08	14.84
Amar (bitter)	144.9	183.36	14.99
Amar (treated)	93.3	175.45	13.65

leucine. Tryptophan was not determined as it is destroyed by the acid hydrolysis. Tryosine was found in the untreated kernels and disappeared in the treated one.

On the other hand, proline was found only in the treated kernels.

Table 4 shows the quantitative determination of some amino acids in the investigated apricot kernels.

Lysine was low in all tested samples.

Hollabo (1972) reported that sulfur-containing amino acids were completely missing from treated apricot kernel cake, which was not the case here. This difference might be due to the different methods employed for removing bitterness.

He concluded that apricot kernel cake protein was higher in valine and isoleucine and lower in lysine than the F.A.O. reference protein.

Biological results

Table 6 shows the P.E.R. values of the different samples together with casein (control diet) 10 % level of protein intake. The protein level in diets containing apricot kernels was 10 %.

This level was recommended by Mitchell et al. (1962) for evaluating proteins for maintenance and growth.

Values for the protein efficiency ratio show the protein of treated apricot kernels, in which bitterness was removed to be of lower value than that of Hamawy kernels. Diet containing the Amar apricot kernels (bitter) just maintained the body weight of rats, growth was zero, and hence the P.E.R. was zero. The food intake was markedly lowered in this case.

On the protein-free diet, the average daily loss in body weight over 10 days period was 1.01 g/rat with standard deviation equal to + 0.07. The net protein ratio for Hamawy kernels was found to be approximately similar to that of Amar kernels, while the treated kernels show a higher N.P.R. than the previous ones. These results are different from those obtained by the P.E.R. method. The N.P.R. is more valid than the P.E.R. for evaluating poor quality proteins, which do not promote growth as it makes allowance for the maintenance requirements.

The nutritive values of proteins for maintenance have been shown to be different from those for growth depending upon qualitative differences in amino acid requirements, or quite likely upon the relative rats of biosynthesis in the metabolism of maintenance as compared with the metabolism of growth. Osborne et al., 1911, found casein to be superior to edestin for growth, but for maintenance the reverse was true. Mitchel et al. 1950

Table 5. The concentration of some amino acids in the investigated apricot kernels.

Protein source	Hamawy apricot kernels		Amar apricot kernels		Treated apricot kernels	
Amino acid	mg/100 g dry seed	mg/g N	mg/100 g dry seed	mg/g N	mg/100 g N dry seed	mg/g N
Aspartic acid	920	241	831	202	785	193
Glutamic acid	1250	328	1125	274	813	199
Serine	642	168	758	184	722	177
Alanine	641	168	872	212	832	204
Lysine	438	115	554	135	521	128
Argenine + histidine	1271	334	1345	327	1358	334
Leucine + isoleucine	2048	538	2325	566	2278	560

Table 6. The P.E.R. and N.P.R. values for casein, different kernels.

Protein source	Level of protein intake	Average food intake (g/rat)	Average gain in body weight (g/rat)	P.E.R. + S.D.	P.E.R. as % of casein value	N.P.R. + S.D.	N.P.R. as % of casein value
Casein	10 %	250.67	70.50	2.81 + 0.153	100	3.95 + 0.168	100
Hamawy kernels	10 %	266.83	43.67	1.64 + 0.074	58.36	2.70 + 0.089	68.35
Amar kernels (bitter)	10 %	105.50	No growth	No growth	–	2.81 + 0.463	71.14
Treated kernels	10 %	152	18.17	1.195 + 0.114	42.53	3.09 + 0.266	78.22

found beef muscle to be superior to wheat gluten for growth, while for maintenance they were nearly equal. For maintenance of the tissues it is known that proteins incomplete in one or more of the essential amino acids may nevertheless by used for the partial replacement of nitrogen.

Table 7 shows the average total proteins, albumin/globulin ratio and the free non-essential/essential amino acids in serum of rats fed the different kinds of diets. The results are in agreement with those obtained for the P.E.R. values, which are based on the effect of protein in stimulating growth.

Formation of albumins of plasma appears to be limited in the liver. It has been known that the synthesis of plasma proteins is dependent on the presence of the essential amino acids, and augmented when supplemented by a generous supply of the non-essential amino acids. A high level of amino acids favors the synthesis of plasma albumin fraction. When the amino acid level is low, there is a preferential synthesis of plasma globulin. About 80 % of plasma globulin is synthesized by the liver, while the rest may be synthesized by extrahepatic tissues.

It was noticed that subjects on an inadequate protein diet maintain a normal concentration of plasma globulin, while the albumin fraction falls. This is because of a propensity of the liver to produce globulin rather than albumin as the blood amino acid level falls.

In states of protein deprivation, certain tissues are able to contribute significant quantities of their protein for the preservation of certain vital functions. These include the plasma proteins (however, other tissue proteins are usually sacrificed to provide plasma proteins), proteins of the liver, gastrointestinal tract and kidney. As might be expected, dietary proteins effective in the repletion of the protein of one depleted tissue often are ineffective in the nutrition of another.

In the present study, the results revealed that the effect of experimental diets on growth of rats, measured as the protein efficiency ratio, was

Table 7. The average total proteins, albumin/globulin ratio and the free non-essential/essential amino acids in serum of rats fed the different types of diets.

Protein	Total protein G % + S.D.	Albumin globulin + S.D.	Non-essential/ essential amino acids + S.D.
Casein 10 %	7.25 ± 0.155	1.58 ± 0.032	2.2 ± 0.062
Hamawy apricot kernels 10 %	5.23 ± 0.100	1.07 ± 0.022	3.24 ± 0.104
Amar apricot kernels 10 %	4.41 ± 0.407	0.80 ± 0.018	4.03 ± 0.138
Treated apricot kernels 10%	4.78 ± 0.034	0.93 ± 0.045	3.43 ± 0.062
Protein-free diet	3.18 ± 0.193	0.77 ± 0.051	4.41 ± 0.119

parallel to the effect obtained on the blood criteria and different from that obtained regarding the effect on both weight maintenance, and growth as measured by the net protein ratio.

Summary

Hamawy apricot seed kernels (sweet), Amar apricot seed kernels (bitter) and treated Amar apricot kernels (bitterness removed) were evaluated biochemically.

All kernels were found to be high in fat (42.2–50.91 %), protein (23.74–25.70 %) and fiber (15.08–18.02 %). Phosphorus, calcium, and iron were determined in all experimental samples.

The three different apricot seed kernels were used for extensive study including the qualitative determination of the amino acid constituents by acid hydrolysis, quantitative determination of some amino acids, and biological evaluation of the kernel proteins in order to use them as new protein sources.

Weanling albino rats failed to grow on diets containing the Amar apricot seed kernels due to low food consumption because of its bitterness. There was no loss in weight in that case. The Protein Efficiency Ratio data and blood analysis results showed the Hamawy apricot seed kernels to be higher in biological value than treated apricot seed kernels.

The Net Protein Ratio data which accounts for both weight, maintenance and growth showed the treated apricot seed kernels to be higher in biological value than both Hamawy and Amar kernels. The Net Protein Ratio for the last two kernels were nearly equal.

Key words: apricot seed kernels, amino acid composition, PER-data

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