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STUDIES ON APRICOT SEEDS (*Prunus armeniaca*) TO USE AS A NONCONVENTIONAL SOURCE FOR EDIBLE OIL AND PROTEIN

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ABSTRACT

Refining of crude oil and detoxification of meal of apricot seeds, which were removed as a waste during apricot processing, are the main aims of this article. The results indicated that: a) Whole apricot kernel was rich in oil (48.95%), protein (28.2%), carbohydrates (16.70%), crude fiber (2.85%) and ash (2.15%), b) Crude oil of apricot kernel had a light yellow colour, 192.1 saponification value, 103 iodine number, low in unsaponifiable matter (0.88%), free fatty acids (2.22%) and free from peroxides. It consisted mainly of oleic (69.82%), linoleic (23.3%) and palmitic (5.4%) acids which is quit similar to sunflower oil. It was fractionated into 5 main classes and 4 main triglycerides on TLC plates. The antioxidant potency of 1% of this oil was nearly similar to that of 0.02% butylated hydroxy toluene (BHT) when both were added to refined sunflower oil and kept at 90^{o}C for 60 hrs, c) The refining loss of apricot kernel oil was 10.03% after degumming and 4.18% after neutralization. Refining process reduced 95.5% of free fatty acids and 71.8% of the colour of apricot kernel oil. The panelists accepted very well the organoleptic characteristics of chisster cheese dressing prepared from the refined apricot kernel oil, d) Agitating of apricot kernel meal for 6 hrs with 5 of its weight hot water (60^{o}C) for detoxification, reduced its content of HCN (91.8%), tannins (65%), phytic acid (42.8%) and improved *in-vitro* protein digestibility from 66.8 to 85.1%. The detoxified meal was rich in protein (54.76%), carbohydrates and minerals, especially P (651.2 mg/100 g), Ca (208 mg/100 g), K (1321.1 mg/100 g) and Mg (162.1 mg/100 g), and e) The protein of the detoxified apricot kernel meal was free from trypsin inhibitor, rich in most essential amino acids, except the sulfur-containing one, lysine and threonine. It had a good functional properties, water absorption, fat absorption, emulsification and foaming capacities. These properties encourage the utilization of this meal as a supplementary protein source and as a food extender in meat products.

INTRODUCTION

Due to the shortage of edible oil and protein over the world particularly in developing countries (Nout *et al*., 1995), it has become necessary to not only develop new cultivars high in both components but also search for new and nonconventional sources. Currently, large quantities of fruit seeds are discarded yearly at processing plants. Some of these seeds such as apricot, tomato, citrus, mango, … etc. are rich in oil, protein, carbohydrates and fibers (Kamel and Kakuda, 1992).

According to Sarhan (1970), about 15-16% of an apricot fruit is seed or pit. It consists of 31-38% kernel and 62-69% woody coat. Apricot kernels contain high levels of edible oil (43.4-52.3%) and dietary protein (25.4-26.1%) (Femenia *et al*., 1995). Apricot kernel oil has a light golden colour, rich in oleic, linoleic and palmitic acids (Abd El-Aal *et al*., 1986 b). The major

constraint against the utilization of apricot kernel protein for human or animal nutrition is the toxic cyanogenic glycoside amygdalin and the minor value of prunasin (Femenia *et al*., 1995). These components and their hydrolysed products may give rise to both acute intoxication and to chronic human central nervous system syndromes (Poulton, 1990). Jamieson (1943) stated that amygdalin is lethal to human at a dose of 1.71 g. Physical and microbiological practices have been suggested to detoxify apricot seeds (Rahma *et al*., 1994; Nout *et al*., 1995 and Tuncel *et al*., 1995).

The main aim of this work was to study the physical, chemical and nutritional characteristics of the apricot kernel oil and its meal after detoxification by a new suggested technique. The utilization of raw apricot kernel oil as a natural antioxidant and after purification for use in making cheese dressing was undertaken.

MATERIALS AND METHODS

A. Materials: Figures (1) and (2) illustrate the preparation and appearance of the different materials of apricot seed kernel.

1. Whole apricot seed kernel (WAK): About 100 kg of apricot seed (*Prunus armeniaca*) wastes from Edfina Company for Food Preservation, Alexandria, Egypt, were directly transported after processing inside jute sacks to pilot plant of Food Science and Technology Dept., Faculty of Agric., Alexandria University, Egypt. Seeds were subjected to spray washing under pressure to remove the adhered fruit pulp residues with seeds, then sorted, left for 72 hrs at room temperature (25$\pm$2^{o}C) for drying and manually dehulled. The obtained kernels were crushed and ground to small grits using Apex, Wiley England mill, then packaged in polyethylene bags and stored at 4^{o}C until utilization.

2. Crude and refined apricot seed kernel oil (AKO): The crude oil of apricot kernel grits was extracted with petroleum ether (40-60^{o}C) for 16 hrs using large unit (1 L) of Soxhlet apparatus (AOAC, 1990). After desolventization using rotary evaporator, the resulted crude oil was packed in a dark glass bottle and stored at 4^{o}C until utilization and analysis.

Crude oil was refined according to the method described by Lillard (1982) using 85% phosphoric acid for degumming, excess amount of 15% sodium hydroxide solution for neutralization, distilled hot water for washing, centrifugation at 2000 rpm for 30 min to remove soap-stock, drying under vacuum at 90^{o}C for 30 min, activated bleaching earth, Toncill Accff and Buchi 168, and vacuum distillation controllers for bleaching. The bleached oil was packed in brown glass bottles and stored at 4^{o}C until analysis. Refined apricot kernel oil at 13.3% level was used in addition to 12% water, 15% vinegar (6%), 8.9% egg yolk, 0.6% salt, 0.6% sugar, 2.2% Arabic gum, 32% chisster cheese, 0.4% white pepper and 16% skimmed milk to prepare chisster cheese dressing according to Binsted *et al*.(1962) method.

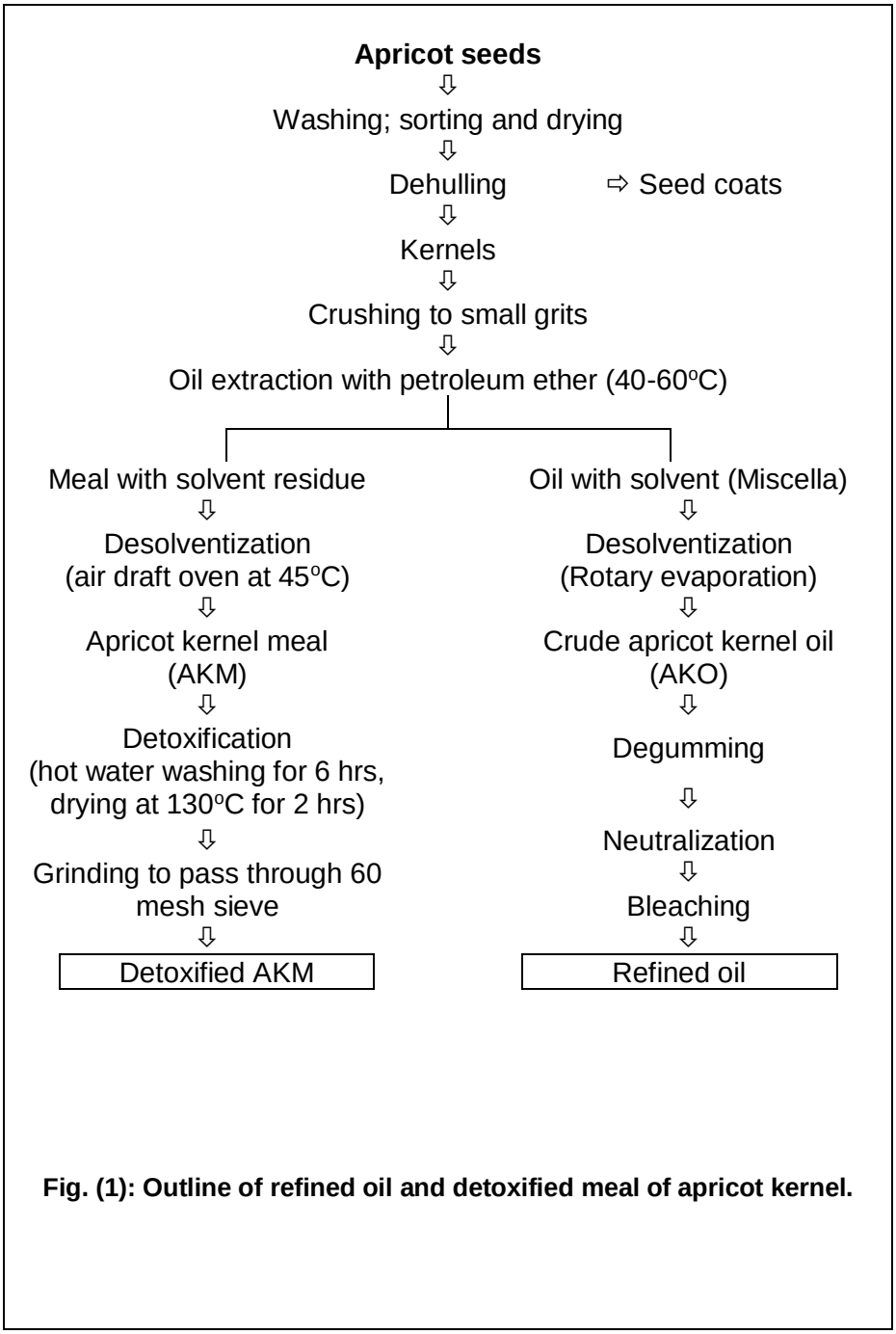

Fig. (1): Outline of refined oil and detoxified meal of apricot kernel.

Fig.(2): Appearance and colour of apricot kernel, meal, oil and chisster salad dressing.

3. Apricot seed kernel meal "AKM": The obtained defatted kernel grits were first desolventized using hot air draft at 45°C, then detoxified by mixing with hot water (60°C) (1:5 w/w) and agitated for 6 hours. During agitation, hot water was changed each 30 min. The resulted detoxified meal was dried at 130°C for 2 hrs, ground, packed in glass jar and stored at 4°C until analysis.

4. Other materials: Refined sunflower oil, vinegar, eggs, salt, sugar, chisster cheese, white pepper and skimmed milk were purchased from local market, Alexandria, Egypt. Butylated hydroxy toluene "BHT" was obtained from Sigma Chemical Company. Chemicals of analytical grade were used for analysis purposes.

B. Analytical methods:

1. Whole apricot kernel (WAK): Moisture, crude protein (N x 6.25), crude ether extract, crude fiber and total ash of WAK were determined according to AOAC (1990).

2. Apricot kernel oil "AKO": Specific gravity at 25°C, refractive index at 25°C, iodine value, saponification value, peroxide value (meq O_2/kg oil), free fatty acids (as % oleic acid) and unsaponifiable matter of crude AKO were determined according to AOCS (1983). The colour of AKO was estimated by measuring the absorption at 460, 550, 620 and 670 nm using Specol spectrophotometer and the suggested Eckey (1954) equation was used to calculate the colour values as follows:

Colour value = 24 A (460 nm) + 69.07 A (550 nm)
+ 41.02 A (620 nm) + 56 A (670 nm)

Refining loss after degumming, neutralization and bleaching was calculated as described by Eckey (1954) using the following equation:

$$\text{Total loss in oil (\%)} = \frac{\text{Weight of dried refined oil}}{\text{Weight of dried crude oil}} \text{x}100$$

Crude AKO was fractionated into its classes according to TLC method of Mangold and Malins (1960). Also, triglycerides were fractionated by TLC technique according to the method of Barrett *et al*.(1962).

Fatty acid composition of crude AKO was determined as described by Radwan (1978) using Shimadzu gas liquid chromatography (GC_4-CMPFE).

The antioxidant potency of crude AKO was determined by adding 1 g of this oil to a duplicate portions of 100 g refined sunflower oil. Samples were withdrown during the incubation period at 90°C up to 96 hours to determined peroxide value as reported in AOAC (1990). Control samples of refined sunflower free and containing BHT at 0.02% level were also incubated at 90°C and their PV was monitoring as mentioned above.

3. Apricot kernel meal "AKM": Phytic acid as described by Wheeler and Ferrel (1971); tannins (as tannic acid) as mentioned by Swain and Hill (1959); trypsin inhibitor as stated by Kakade *et al*.(1969); hydrocyanic acid (HCN) using alkaline titration method (AOAC, 1980) and *in-vitro* protein digestibility as reported by Saunder *et al*.(1973) as well as proximate composition, minerals contents of AKM (K,Na,Ca, Zn, Fe, Cu and Mn) using Perkin Elmer atomic absorption spectrophotometer Model 2380 and phosphorus "P" by colorimetric method at 630 nm (AOAC, 1990) were determined.

Amino acids composition of AKM protein were analyzed according to Duranti and Cerletti (1974) using a Beckman Model 119 CL analyzer. Also, functional properties including water and oil absorption; emulsifying capacity and stability were determined according to Sosulski (1962).

C. Organoleptic properties: Chisster salad dressing made from refined AKO was organoleptically evaluated using a set of 10 panelists from Food Science and Technology Department, Faculty of Agriculture, Alexandria

University. Each panelist was asked to evaluate the colour, texture and flavour of the sample using the five points scale according to Waltking (1982).

RESULTS AND DISCUSSION

A. Proximate composition of WAK: As shown from Table (1), apricot kernel is considered a good source of oil (48.95%) and protein (28.2%). It has also a considerable level of crude fiber (2.85%) and ash (2.15%). Similar results were stated by Kamel and Kakuda (1992) and Femenia *et al*.(1995). Results of Kappor *et al*.(1986) indicated that the apricot kernel composed of 6.09-10.82% moisture; 20.17-21.5% protein; 49.43-55.24% oil; 2.12-3.14% ash; 0.52-1.57% crude fiber and 16.64-17.41% carbohydrates.

Table (1): Proximate composition of whole apricot kernel.

Components	%
Moisture content	9.43
Crude protein*	28.20
Crude oil*	48.95
Crude fiber*	2.85
Ash*	2.15
Carbohydrates**	16.70

*** On dry weight basis** **** By difference***

B. Apricot seed kernel oil "AKO:

1. Identity characteristics: According to Fig.(2) and data in Table (2), the crude AKO had light yellow colour, low in both free fatty acids (2.22%) and unsaponifiable matters (0.88%), also free from peroxides, with 192.1 saponification value and 103.0 iodine value. These characteristics agree with those reported by Hallabo *et al*. (1975), Abd El-Aal *et al*.(1986 b) and Femenia *et al*.(1995) and also within the range of the other vegetable oils.

2. Fatty acid composition: Data in Table (2) revealed that the predominate fatty acid of crude AKO was oleic acid (69.82%) followed by linoleic acid (23.3%) and palmitic acid (5.4%), respectively. The ratio between unsaturated to saturated fatty acids was 14.72 : 1. This ratio may focus attention on the possible ability of using AKO to reduce the serum level of cholesterol. Linolenic acid was found in traces (0.23%). These findings agree well with those obtained by Kamel and Kakuda (1992) and Femenia *et al*.(1995). Rafique *et al*.(1986) found traces of myristic and palmitoleic acids in AKO. Generally, this composition of fatty acids of AKO is very close to that of sunflower oil. The later oil had 3-5% palmitic, 22-50% oleic and 40-67% linoleic acids according to sunflower variety (Bernardini, 1985).

Table (2): Identity characteristics and fatty acid composition of crude apricot kernel oil.

Characteristics	Value
1. Physicochemical characteristics:	
Colour	18.85
Specific gravity at 25°C	0.919
Refractive index at 25°C	1.4662
Saponification value	192.1
Iodine value	103.0
Free fatty acids (as % oleic acid)	2.22
Peroxide value (meq O_2/kg oil)	Traces
Unsaponifiable matter (%)	0.88
2. Fatty acid composition (%):	
Palmitic (16:0)	5.40
Stearic (18:0)	0.94
Oleic (18:1)	69.82
Linoleic (18:2)	23.30
Linolenic (18:3)	0.23
Others	0.31

3. Oil and triglycerides classes: Crude AKO was fractionated on TLC into 5 main classes (Fig. 3 a), polar lipids, sterols, 1,3-diglycerides, free fatty acids and triglycerides from base to front line, in addition to traces of 1,2-2,3-diglycerides and hydrocarbons. Triglycerides represented the major class. Results of Abd El-Aal *et al*.(1986 b) indicated that AKO consisted mainly of triglycerides.

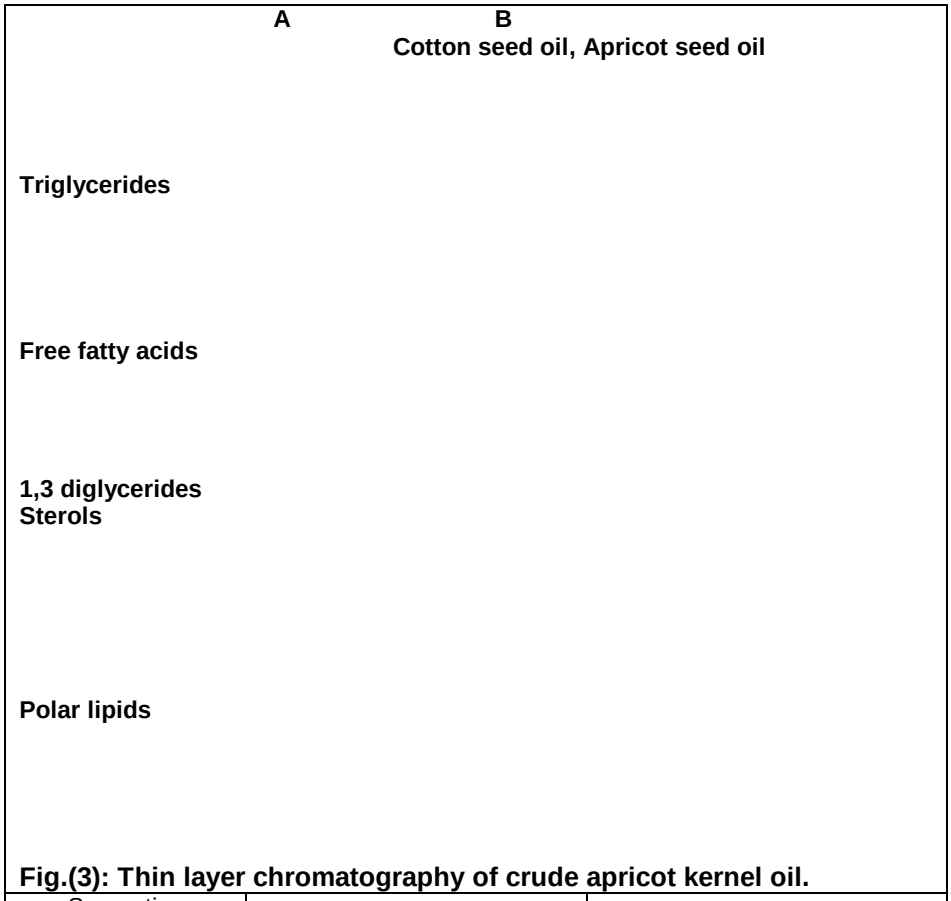

Fig.(3): Thin layer chromatography of crude apricot kernel oil.

Separation conditions	(A) Classes	(B) Triglycerides
Coating material	Silica gel G Merk type 60	Silica gel G Merk type 60 impregnated with 20% $AgNO_3$
Developing Solvent	Pet. ether : Diethyl ether : Acetic acid (70:30:2, v/v/v)	Toluene : Diethyl ether (96:4, v/v)
Visualization	Iodine vapour	Charring with 50% aqueous sulfuric acid

As illustrated in Fig. (3 b), triglycerides of AKO were fractionated on silver nitrate impregnated TLC into 11 fractions differing in their intensities. According to Park *et al*.(1984), the major triglycerides of AKO were $3xC_{18:1}$ (39.5%); $2xC_{18:1}$, $C_{18:2}$ (24.5%); $C_{18:1}$, $2xC_{18:2}$ (14.2%) and $3xC_{18:2}$ (2.2%). Also, Farines *et al*.(1986) showed that the major triglycerides of AKO were triolein; linoleodiolein and oleodilinolein.

4. Antioxidant potency: Results of antioxidant potency of 1% addition of crude AKO comparing with BHT to refined sunflower oil in term of peroxide value (PV) were reported in Table (3). No much differences were noticed in peroxide values of sunflower oils containing either BHT or 1% crude AKO

after 60 hrs of incubation at 90°C. This is an indication that at long storage period the inhibition effect of crude AKO was equal to BHT. Also, this may be due to the high content of natural antioxidants (840 mg tocopherol /kg) in this oil (Farines *et al*., 1984)..

Table (3): Antioxidant potency of crude apricot kernel oil.

Incubation period (hrs) at 90°C	Peroxide value (meq O_2/kg oil)		
	A	B	C
0	2.10	1.80	2.00
12	9.88	7.92	8.97
24	11.64	8.62	11.73
36	17.64	17.11	15.04
48	22.07	19.91	18.81
60	26.07	21.37	20.31
72	27.45	23.37	24.26
84	29.07	28.23	31.40
96	41.03	31.08	34.79

A: Sunflower oil (control).
B: Sunflower oil + 0.02% BHT.
C: Sunflower oil + 1% apricot kernel oil.

5. Refining: Table (4) summarized the changes in oil properties during refining. The total refining loss was 15.72%. The major loss occurred during degumming process (10.03%) followed by neutralization process (4.18%). Also, these steps reduced 95.5% of free fatty acids, 71.8% of colour (Fig. 2) and caused slight rise in peroxide value due to the removal of natural antioxidants during refining.

The refined AKO was used for preparing chisster cheese dressing. The panelists accepted this product very well. It had a light creamy colour, semisolid texture and attractive chisster flavour (Fig. 2). According to Hallabo *et al*.(1975), AKO has been used in both USA and Germany in cosmetics, medical purposes and macaroon paste.

C. Detoxified apricot seed kernel meal "DAKM": One of the problems in using apricot kernel as a food and feed is the occurrence of cyanogentic glycosides amygdalin, which upon hydrolysis yields hydrocyanic acid. Therefore, detoxification of meal is essential before its utilization in food and feed purposes (El-Adawy *et al*., 1994). The technique suggested and applied in this study for this aim depending on: (I) Saving the optimum conditions, temperature and agitation required for activation of hydrolysis enzyme, emulsin, found naturally in the AKM and is responsible for converting cyanogenetic glycosides amygdalin into HCN, glucose and benzaldehyde in aqueous media. (II) Continuing regeneration of aqueous medium, each 30 min, to remove the formed HCN and other hydrolyzed end-products which not only keep but also rise the activity of the hydrolyzed enzyme, emulsin.

Table (4): Refining loss and quality parameters of refined apricot kernel oil.

Parameter	Value
1. Refining loss (%) after:	
Degumming	10.03
Neutralization	4.18
Bleaching	1.50
Total loss	15.72
2. Quality parameters:	
Free fatty acids (as% oleic acid)	0.10
Peroxide value (meq O_2/kg oil)	1.70
Colour	5.31

1. Nutritional value:

One) Antinutritional factors: However, the data in Table (5) showed that undetoxified AKM was almost free from trypsin inhibitor, having low level of phytic acid (0.14%), tannins (0.2%), considerable *in-vitro* protein digestibility (66.8%) and containing hydrocyanic acid (0.32%), the same value (0.325%) was reported by Femenia *et al*.(1995). Detoxification led to reduce tannins (65%), phytic acid (42.8%) and HCN (91.8%) as well as to improve *in-vitro* protein digestibility from 66.8 to 85.1%. This will increase the availability of this product to be used in food purposes as a supplementary protein source in traditional low protein foods.

Table (5): Influence of detoxification on some antinutritional factors of AKM.

Constituent	Value	
	Before detoxification	**After detoxification**
Trypsin inhibitor (TIU)	Nil	Nil
Tannins (as % tannic acid)	0.20	0.07
Phytic acid (%)	0.14	0.08
Hydrocyanic acid (%)	0.32	0.026
In-vitro protein digestibility (%)	66.80	85.10

Two) Amino acid composition: According to Table (6), AKM protein contained moderate levels of essential amino acids except sulfur-containing amino acids, threonine and lysine. Glutamic acid is the most abundant non-essential amino acid, along with arginine and aspartic acid in AKM. These results were in agreement with those stated by Khairy *et al*.(1975) and Kamel and Kakuda (1992).

Blending AKM with other vegetable proteins rich in its limiting amino acids is necessary for using such product for food purposes (Femenia *et al*., 1995).

Table (6): Amino acid composition of detoxified apricot kernel meal.

Amino acid	Apricot kernel meal	FAO Provisional pattern*
	g / 100 g protein	
Essential amino acids:		
Leucine	5.60	4.80
Iso-leucine	1.30	4.20
Lysine	2.18	4.20
Phenylalanine	4.50	2.80
Methionine	0.99	2.20
Threonine	1.91	2.80
Valine	2.95	4.20
Non-essential amino acids:		
Glutamic acid	26.32	
Aspartic acid	16.30	
Argenine	10.13	
Histidine	2.25	
Serine	4.30	
Proline	5.17	
Glycine	5.11	
Alanine	5.01	
Tyrosine	3.49	

*** Gupta (1983).**

2. Proximate and minerals composition: As shown from Table (7), all components were increased after extraction the oil from WAK. The protein became the main component followed by carbohydrates and fiber. Because oil was extracted from apricot kernel grits, the meal was considered relatively high in this parameter. AKM contained considerable levels of macroelements such as K (1321.1 mg/100 g), P (651.2 mg/100 g) and Ca (208.2 mg/100 g) as well as Mg (162.1 mg/100 g). Other elements were found in small concentrations. Because DAKM contained less value of phytic acid, it can be expected the high bioavailability of their minerals. Generally, these results were in line with those reported by Khairy *et al*.(1975), Normakhmatov and Khudaishukurov (1975) and Rahma *et al*.(1993).

3. Functional properties: Data in Table (7) revealed that DAKM had highest water and fat absorption as well as foaming and emulsification capacities and low foam stability. These may be due to its high content of protein and carbohydrates, also its low levels of tannins and phytic acid. According to Moharram *et al*.(1982), the fat and water absorption depends on the polar and non-polar groups of the protein molecules and the effeciency of these groups to bind both water and fat. Emulsification capacity of oil seed meal depends on the protein solubility. Generally, these results were in agreement with those reported by Abd El-Aal *et al*.(1986 a) and encourage the utilization of this meal as food extender in meat formulation and as a supplementary protein source.

Table (7): Proximate composition, minerals content and functional properties of detoxified apricot kernel meal.

Property	Value
I. Proximate composition (%):	
Moisture	10.90
Crude protein*	54.76
Crude oil*	4.17
Crude fiber*	5.11
Ash*	3.52
Carbohydrates**	30.64
II. Minerals (mg/100 g)*	
K	1321.10
Na	9.61
Ca	208.20
P	651.20
Zn	7.01
Fe	12.80
Cu	1.30
Mg	162.10
Mn	7.20
III. Functional properties:	
Water absorption (ml/100 g)	482
Fat absorption (ml/100 g)	419
Emulsification capacity (ml oil/g)	25
Foaming capacity (%)	79
Foaming stability (ml) after:	
10 min	65
20 min	30
30 min	21

*** On dry weight basis** **** Calculated by difference***

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دراسات على بذور المشمش كمصدر غير تقليدى للزيوت والبروتينات الغذائية

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هدف هذا البحث إلى تكرير الزيت الخام وإزالة سمية جرش بذور المشمش والتى تنتج كمخلف أثناء تصنيع منتجات المشمش. وأوضحت النتائج التالى (أ) غنى نوى المشمش فى الزيت (48.95%) والبروتين (28.2%) والكربوهيدرات (16.70%) والألياف الخام (2.85%) والرماد (2.15%)، (ب) كان لزيت نوى المشمش الخام لون أصفر فاتح، 192.1 رقم تصبن، 103 رقم يودى ونسبة منخفضة من المواد غير القابلة للتصبن (0.88%) والأحماض الدهنية الحرة (2.22%) وخالى من البيروكسيدات. وتكون من (69.82%) حمض أوليك، (23.3%) حمض لينوليك، (5.4%) حمض بالمتيك مثل زيت عباد الشمس، وتم فصله إلى 5 أقسام أساسية وإلى أربعة مكونات رئيسية من الجليسريدات الثلاثية باستخدام كروماتوجرافيا الطبقة الرقيقة وتشابه الفعل المضاد للأكسدة بتركيز 1% من هذا الزيت الخام مع 0.02% من BHT خلال 60 ساعة عند تخزين زيت عباد الشمس المكرر على درجة 90ºم، (جـ) كان فاقد التكرير لزيت نوى المشمش 10.03% بعد إزالة الصموغ، 4.18% بعد المعادلة. وأدت عملية التكرير إلى خفض الأحماض الدهنية الحرة بنسبة 95.5% واللون بنسبة 71.8%. وكانت درجة تقبل المتذوقين لتتبيلات سلطة الجبنة الشيدر المصنعة من زيت نوى المشمش المكرر عالية جداً، (د) التخلص من سمية نوى المشمش بالخلط مع 5 أضعاف وزنه ماء دافئ (60ºم) لمدة 6 ساعات مع التقليب المستمر وأزال (91.8%) من حامض الهيدروسيانيك، (65.0%) من التانين، (42.8%) من حامض الفيتيك وحسن من الهضمية المعملية للبروتين من 66.8 إلى 85.1%. وتميز جرش نوى المشمش المزال السمية بغناه فى البروتين (54.76%) والأحماض الأمينية الضرورية عدا الأحماض الأمينية الكبريتية والليسين والثريونين ومرتفعة فى الكربوهيدرات والمعادن خاصة الفوسفور (651.2 ملجم/100 جم) والكالسيوم (208 ملجم/100 جم) والبوتاسيوم (1321.1 ملجم/100 جم) والماغنسيوم (162.1 ملجم/100 جم)، (هـ) تميز البروتين بخلوه من مثبط انزيم التربسين وجودة خواصه الوظيفية من امتصاص الماء والدهن وسعة الاستحلاب وتكوين الرغوة مما يشجع الاستفادة به لرفع نسبة البروتين فى الأغذية الفقيرة فيه وفى انتاج منتجات اللحوم.