Food Chemistry **19** (1986) 287–298

Apricot Kernel Oil: Characterization, Chemical Composition and Utilization in Some Baked Products

M. H. Abd El-Aal & M. K. M. Khalil

Food Science and Technology Department, Faculty of Agriculture, Alexandria University, Alexandria, Egypt

&

E. H. Rahma*

Food Science and Technology Department, Faculty of Agriculture, University of Menoufeia, Shebin El-Kom, Egypt

(Received: 2 July, 1985)

ABSTRACT

Apricot kernel oil was extracted, characterized and evaluated for use in preparing biscuits and cake. The hexane-extracted oil fraction has a light yellow colour and is free from toxic material (hydrocyanic acid). The major fatty acids were oleic, linoleic and palmitic. Chloroform–methanol extracts consisted mainly of neutral lipids in which triglycerides were predominant components. The triglycerides consisted of six types of glycerides. Glycolipids and phospholipids were the minor fractions of the total lipids and their major constituents were acylsterylglycosides (62·3%) and phosphatidyl choline (72·2%), respectively.

Evaluation of the crude apricol kernel oil added to different types of biscuits and cake revealed that it has excellent properties and is comparable with corn oil at the same level. It did not affect the flavour, colour and texture of these products.

* To whom correspondence should be addressed.

Food Chemistry 0308-8146/86/$03·50

INTRODUCTION

Production of vegetable fats and oils is inadequate in several parts of the world, particularly developing countries. This shortage offers a great challenge to food scientists and technologists and might be solved either by seeking new plant sources or plant breeding to increase the oil content of traditional oil crops.

In Egypt, about 3931 acres are cultivated with apricot orchards producing 15 724 tons of apricot fruits. The pit constitutes 15–16 % of the whole fruit (Sarhan, 1970; Hallabo *et al.*, 1975). However, the kernel represents from 31 % to 38 % of the pit (Dhar & Chavhan, 1963; Sarhan, 1970; Hallabo *et al.*, 1975; Filsoof *et al.*, 1976). Apricot pits are a by-product of apricot processing which remain in large quantities and contain high percentages of oil (50 %) (Abd El-Aal *et al.*, 1986). Cruess (1958) has reported that the oil of apricot kernel was used in Germany and the United States of America in preparing fixed oil and macaroon paste.

The work reported in this paper was carried out to study the physical properties of apricot kernels and the physico-chemical properties, chemical and fatty acid compositions of the oil. The oil was used in the manufacturing of some bakery products (replacing some of the total fat used in the recipe) and its effect on the acceptability of the products was evaluated organoleptically.

MATERIALS AND METHODS

Materials

Apricot fruits

The apricot fruits (Amar variety, bitter type) were obtained from the local market of Alexandria City during the summer of 1984. 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 packed in tightly sealed polyethylene bags and stored at room temperature for about 5·5 months before use. The dried pits were cracked by hand and the kernel kept for measuring the physical properties.

Corn oil

The corn oil was obtained from the Alexandria Company for Oil and

Soap. It had the following characteristics: refractive index (25 °C), 1·4736; acid value, 0·22; iodine value, 125 and peroxide value, 2·1 (meq/kg).

Standard lipids

A lipid extract from cottonseed (20 days after flowering) was used as a reference containing all known fractions of the neutral-, glyco- and phospholipids (Abd El-Aal, 1981).

Analytical methods

The oil of ground apricot kernel was extracted with hexane in a soxhlet apparatus. 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 lipid classes

The total lipids of ground apricot kernels were extracted with chloroform–methanol (2:1 v/v) and purified according to the procedure of Folch *et al.* (1957). An aliquot of the total lipid in chloroform ($\sim$300 mg) was applied onto a 1 × 25 cm column filled with silicic acid (Bio-Sil HA $\sim$350 mesh). Neutral lipids were eluted with eight column volumes of chloroform. Acetone (forty column volumes) was used for eluting glycolipids. Phospholipids were then eluted with ten column volumes of 1N ammonium hydroxide in methanol (Rouser *et al.*, 1969; Robertson *et al.*, 1978). The eluted fractions were collected in preweighed flasks; solvents were removed at 40 °C in a rotary evaporator. Each eluted column fraction was determined as a weight percentage of the total lipid loaded onto the column. Three determinations were conducted and the averages were calculated.

Neutral lipid fractionation

This was carried out on a thin layer of silica gel H plate with a hexane–diethylether–acetic acid (80:20:1, by volume) solvent system, as described by Mangold & Malins (1960). The spots were visualized by charring them as a universal method of detection (Privett *et al.*, 1973) and identified by comparing with the R_f values reported in the literature (Wilson & Rinne, 1974), then further confirmed by co-chromatography with the neutral lipids standard.

Fractionation of glycolipids and phospholipids
This was done on a thin layer of silica gel H plate impregnated with 2% ammonium sulphate using acetone–benzene–water (91:30:8 by volume) and chloroform–methanol–acetic acid–water (85:10:10:2 by volume), respectively, according to the methods of Khan & Williams (1977) and Radwan (1978). The individual lipid components were identified by comparing with the R_f values reported in the literature (Christie, 1973; Khan & Williams, 1977; Radwan, 1978) and by specific spray reagents (Dittmer & Lester, 1964; Siakotos & Rouser 1965; Vaskovskii & Kostetskii, 1968), then further confirmed by co-chromatography with glyco- and phospholipid standards. For quantitative analysis of neutral, glyco- and phospholipids, the chromatograms were sprayed with 50% sulphuric acid solution and scanned using the charring densitometry technique (Blank *et al.*, 1964). The area under each peak of lipid component was measured by triangulation and the percentage of each fraction was calculated in regard to the total area.

Triglyceride analysis
For this analysis the triglyceride fraction of the total lipids was first isolated on a 20 × 20 cm plate coated with 0·5 mm silica gel H. The plate was developed with the solvent system petroleum ether–diethyl ether–acetic acid (90:10:1 by volume). The triglyceride band was visualized by iodine vapour and identified by comparing its R_f value with standard triolein. This band, carrying the triglycerides components, was scraped off the plate and recovered from the absorbent silica gel by repeated extraction with 10% methanol in diethylether (Roehm & Privett, 1970). The triglyceride components were further fractionated according to degree of unsaturation on a thin layer of silica gel H impregnated with 20% silver nitrate and developed with a solvent system of chloroform–methanol (99:1 by volume) according to Roehm and Privett (1970). The quantitative content of each separated triglyceride type on the plate was measured using the charring densitometry method (Blank *et al.*, 1964) and the area under each peak was measured by the triangulation method.

Fatty acid analysis
The methyl esters of crude oil were prepared according to Chalvardjian (1964), using 1% of H_2SO_4 in absolute methyl alcohol. A Perkin-Elmer gas chromatograph (model F 22) with a flame ionization detector was

used in the presence of nitrogen as a carrier gas. A glass column (2 m × 2·5 mm) packed with 10 % Silar 5 % on Gas Chrom Q 80/100 mesh at a temperature of 200 °C was used. Standard fatty acid methylesters were used for identification. The area under each peak was measured and the percentage expressed in regard to the total area.

Utilisation of apricot kernel oil in some bakery products

Sweet and salted biscuits, as well as cake, were prepared with hexane-extracted apricot kernel oil without further treatment. Corn oil was used for comparison. The following recipes were used for preparing these products.

Sweet biscuits
59·9 % soft wheat flour (72 % extraction), 20 % sucrose, 16 % fat (consisting of an equal mixture of palm oil and apricot oil or corn oil), 3 % whole dried egg, 1 % baking powder and 0·05 % vanillin.

Salted biscuits
75 % soft wheat flour (72 % extraction), 20 % apricot oil or corn oil, 3 % salt, 10 spices and 1 % baking powder.

Cake
59·95 % soft flour (72 % extraction), 20 % sucrose, 10 % fat (equal mixture of palm oil and apricot oil or corn oil), 6 % whole dried eggs and 4 % baking powder. The products were evaluated organoleptically for colour, texture and flavour by the paired comparison preference test according to Larmond (1967).

RESULTS AND DISCUSSION

Table 1 lists some physical properties of apricot kernel (percentage of kernel, weight of 100 kernels, length, width and thickness of apricot kernel) and also moisture content and percentage of the extracted oil either in hexane or in a chloroform–methanol mixture. The kernel represents 31·2 % of the total pit. This value is the highest of all the all-stone fruits, as reported by Filsoof *et al.* (1976). In addition, Hallabo *et al.* (1975) have reported a value very close to ours for apricots grown in Egypt.

TABLE 1
Some Physical Properties and Oil Content of Apricot Kernel

Property	*Value*
Kernel percentage (of whole pit)	31·20
Weight of 100 kernels (g)	42·80
Kernel length (mm)[a]	14·00
Kernel width (mm)[a]	10·20
Kernel thickness (mm)[a]	3·30
Moisture (%)	2·80
Crude oil (%)[b]	
Hexane extract	50·90
Chloroform–methanol extract	51·30

[a] Averages of 100 kernel measurements.
[b] On a dry weight basis.

There was not much difference between the oil extracted by hexane or by the chloroform–methanol mixture. It was 50·9% and 51·3% in the two solvent systems, respectively.

The hexane-extracted oil had a light yellow colour, acceptable odour and was completely free from hydrocyanic acid which has a toxic effect (Table 2). The values of refractive index, specific gravity and saponification number were: 1·4638, 0·9136 and 189·7, respectively in

TABLE 2
Physico-chemical Properties of Apricot Kernel Oil (Hexane Extract)[a]

Property	*Value*
Refractive index (25/25°C)	1·4638
Specific gravity (25/25°C)	0·9136
Titre (°C)	2·70
Iodine number	103·8
Acid number	0·12
Peroxide number (meq/kg)	0·04
Saponification number	189·7
Unsaponifiable matter (%)	0·86
Hydrocyanic acid (%)	Nil
Colour	35 Y. 5 R.

[a] Averages of three determinations.

good agreement with the previous reported data of Hallabo *et al.* (1975) and Filsoof *et al.* (1976). The iodine number was 103·8; thus, apricot kernel could be classified as a semi-dry oil. The acid and peroxide values are good indices for the stability of the oil and its susceptibility to rancidity during storage. These values were very low (Table 2) in spite of storing the pits for about 6 months at room temperature before oil extraction. This indicates that the 6 months old kernels possess low levels of oxidative and lypolytic activities.

Hexane is the solvent of choice by oilseed processors, but it only partially extracts phospholipids. Since chloroform–methanol is more polar than hexane, it tends to extract more non-triglyceride compounds, i.e. phosphatides and non-saponifiables (Christie, 1973). Therefore, the chloroform–methanol mixture was used for the study of true chemical composition of oil, rather than hexane.

Fatty acid composition

Table 3 illustrates the fatty acid contents of apricot kernel lipids. The unsaturated fatty acid content was 95·2% and consisted mainly of oleic and linoleic acids. The linolenic acid content was very low (0·12%). The saturated fatty acid content was only 4·83% with palmitic as a major fatty acid. The ability of some unsaturated vegetable oils to reduce serum cholesterol level may focus attention on apricot kernel oil because it is a highly unsaturated oil.

TABLE 3
Fatty Acid Composition of Apricot Kernel Oil (Chloroform–Methanol Extract)

Fatty acids	*Percentage*
Myristic	Trace
Palmitic	4·37
Palmitoleic	0·12
Stearic	0·46
Oleic	66·29
Linoleic	28·64
Linolenic	0·12
Total saturated fatty acids	4·83
Total unsaturated fatty acids	95·17

TABLE 4
Fractionation of Apricot Kernel Lipids (Chloroform–Methanol Extract) Through Silicic Acid Column

Lipid fraction	*Percentage*[a]
Neutral lipids	97·5 ± 0·5
Glycolipids	0·9 ± 0·1
Phospholipids	1·5 ± 0·2
Column recovery	99·9 ± 0·7

[a] Mean ± SE of three determinations.

TABLE 5
Densitometric Analysis of the Major Lipid Fractions of Apricot Kernel Total Lipids (Chloroform–Methanol Extract)

Lipid class	*Percent weight of the fraction*	*Percent of the total lipids*
Neutral lipids		
Hydrocarbons	0·50	0·49
Triglycerides	97·7	95·26
Free fatty acids	Trace	Trace
1,3-diglycerides	0·70	0·68
1,2- and 2,3-diglycerides	0·20	0·19
Sterols	0·90	0·88
Glycolipids		
Acylsterylglycosides	62·3	0·56
Monogalactosyldiglycerides	18·7	0·18
Sulphoquinovosyldiglycerides	4·50	0·04
Digalactosyldiglycerides	12·5	0·12
Unknown	2·00	0·02
Phospholipids		
Phosphatidylethanolamine	7·40	0·11
Phosphatidylcholine	72·2	1·08
Phosphatidylinositol	10·5	0·16
Lysophosphatidylcholine	3·30	0·05
Phosphatidylserine	6·60	0·10

Fractionation and composition of lipid class

The relative percentages of the major lipid classes are presented in Table 4. The neutral lipid content was more than 97% of the total lipids. However, glycolipids and phospholipids accounted for less than 3%. El-Sebaiy *et al.* (1984) reported that apricot kernel lipids had 1·34% phospholipids which is fairly close to the 1·5% reported in this study (Table 4).

Data in Table 5 and Fig. 1A summarize the quantitative and qualitative results of each individual lipid class. The neutral lipid fraction revealed the presence of the hydrocarbons, triglycerides, sterols and diglycerides

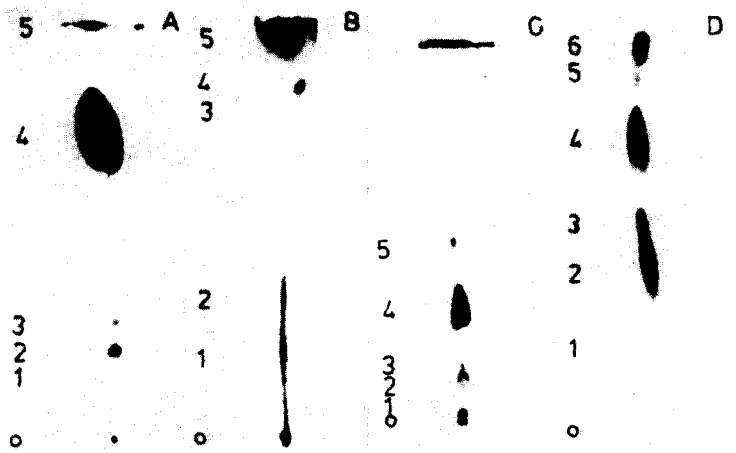

Fig. 1. Thin-layer chromatograms of major lipid fractions and triglycerides of apricot kernel lipids (chloroform–methanol extract). Detection: charring with 50% aqueous sulphuric acid.

A: Neutral lipids, silica gel H plate in hexane: diethylether: acetic acid (90:10:1 by volume). O = origin; 1 = 1,2-(2,3)-diglycerides; 2 = sterols; 3 = 1,3-diglycerides, 4 = triglycerides and 5 = hydrocarbons.

B: Glycolipids, ammonium sulphate impregnated silica gel H plate in acetone:benzene:water (91:30:6, by volume). O = origin; 1 = sulphoquinovosyl-diglycerides; 2 = digalactosyldiglycerides; 3 = unidentified lipid; 4 = monogalactosyldi-glycerides and 5 = acylsterylglycosides.

C: Phospholipids, ammonium sulphate impregnated silica gel H plate in chloroform:methanol:acetic acid:water (85:10:10:2, by volume). O = origin; 1 = phosphatidylserine; 2 = lysophosphatidyl choline; 3 = phosphatidylinositol; 4 = phosphatidylcholine and 5 = phosphatidylethanolamine.

D: Triglycerides, silver nitrate (20%) impregnated silica gel H plate in chloroform:methanol (99:1).

(1,3 and 2,3 and 1,2 diglycerides). While triglyceride represented 95% and was the major fraction of neutral lipids, diglycerides and sterols were of equal amounts (0·88%); also traces of hydrocarbons were noticed.

The glycolipid fraction showed five glycolipid components (Fig. 1B). These fractions were in the following decreasing order: acylsterylglycosides (62·3%), monogalactosyldiglycerides (18·7%), digalactosyldiglycerides (12·5%), sulphoquinovosyldiglycerides (4·5%) and an unknown component (2%).

Fractionation of phospholipids on thin-layer proved the presence of five components (Fig. 1C). These components were in the following decreasing order: phosphatidyl choline (72·2%), phosphatidyl inositol (10·5%), phosphatidyl ethanolamine (7·4%), phosphatidylserine (6·6%) and lysophosphatidyl choline (3·3%). El-Sebaiy *et al.* (1980) have reported a similar composition to ours for apricot phospholipids.

Triglyceride composition

Fractionation of triglycerides by silicic acid–silver nitrate thin-layer chromatography is illustrated in Fig. 1D and Table 6. As shown, triglycerides were fractionated into six bands (1–6) on the plate. The major subfractions were 2 and 4, the moderate subfractions were 3 and 6 and the minor subfraction, 5. Also, a trace amount of a subfraction (1) was detected.

Evaluation of apricot kernel oil in some bakery products

Sweet and salted biscuits, as well as a variety of cake, were prepared with added apricot kernel oil (hexane extract). Corn oil was used for

TABLE 6

Triglyceride Subfraction Contents of Apricot Kernel Lipids (Chloroform–Methanol Extract)

Subfraction number[a]	*Percentage*
1	Trace
2	28·1
3	17·0
4	33·5
5	2·30
6	19·1

[a] Number refers to Fig. 1D.

comparison. Taste panel testing indicated that there were no significance differences ($p = 0{\cdot}05$) in colour, flavour and texture between the biscuits and cake prepared with apricot kernel oil and corn oil. However, the judges showed a preference for that prepared with apricot kernel oil. Based on these results, apricot kernel oil has a potential in food products as a substitute for other traditional fats. It did not impart any off-flavour or change the colour or texture of the tested products.

REFERENCES

Abd El-Aal, M. H. (1981). *Changes in lipids and proteins composition in developing cottonseeds*, PhD Thesis, Faculty of Agriculture, Alexandria University, Alexandria, Egypt.

Abd El-Aal, M. H., Hamza, M. M. & Rahma, E. H. 1986. *In vitro*-digestibility, physicochemical and functional properties of apricot kernel proteins. *Food Chem.*, **19**, 197.

AOCS (1973). *Official and tentative methods of the American Oil Chemists Society*, Vol. 1 (3rd edn), AOCS, Champaign, IL.

Blank, M. L., Schmidt, J. A. & Privett, O. S. (1964). Quantitative analysis of lipid by thin-layer chromatography. *J. Am. Oil Chem. Soc.*, **41**, 371.

Blinn, R. C. & Boyd, J. E. (1964). Colorimetric determination of residues of the dithiolane insecticides in cottonseed and cotton foliage. *J. Am. Oil Ass. Chem.*, **47**, 1106.

Chalvardjian, A. M. (1964). Fatty acids of brown and yellow fat in rats. *Biochem. J.*, **90**, 518.

Christie, W. W. (1973). In: *Lipid analysis*. Pergamon Press, Oxford.

Cruess, W. V. (1958). In: *Commercial fruit and vegetable products*. McGraw-Hill, New York.

Dhar, K. L. & R. S. N. Chavhan (1963). Oil from seed kernels of *Prunus armemiaca*. *Agric. Univ. J. Res.*, **12**, 9.

Dittmer, J. C. & Lester, R. L. (1964). A simple specific spray for the detection of phospholipids on thin-layer chromatograms. *J. Lipids Res.*, **5**, 126.

El-Sebaiy, L. A., El-Mahdy, A. R., Moustafa, E. K. & Mohamed, M. S. (1980). Phospholipids of Egyptian vegetable oils. 2. Peanut, sesame, linseed, chufa, wheat germ and apricot kernel. *Alex. J. Agric. Res.*, **28**, 113.

Filsoof, M., Mehran, M. & Farrohi, F. (1976). Determination and comparison of oil characteristics in Iranian almond, apricot and peach nuts. *Fette, Seifen. Abstr.*, **78**, 150.

Folch, J., Less, M. & Sloane Stanley, G. H. (1957). A simple method for isolation and purification of total lipids from animal tissues. *J. Biol. Chem.*, **226**, 497.

Hallabo, S. A. S., El-Wakeil, F. A. & Morsi, M. K. S. (1975). Chemical and physical properties of apricot kernel, apricot kernel oil and almond kernel oil. *Egypt. J. Food Sci.*, **3**, 1.

Khan, M. U. & Williams, J. P. (1977). Improved thin-layer chromatographic methods for the separation of major phospholipids and glycolipids from plant lipid extracts and phosphatidyglycerol and bis (monoacylglycerol) phosphate from animal lipid extract. *J. Chromatography*, **140**, 179.

Larmond, E. (1967). *Methods for sensory evaluation of food.* Pub. No. 1284, Department of Agriculture, Canada.

Mangold, H. K. & Malins, D. C. (1960). Fractionation of fats, oils and waxes on thin-layers of silicic acid. *J. Amer. Oil. Chem. Soc.*, **37**, 383.

Privett, O. S., Dougherty, K. A., Erdahl, W. L., & Stolyhwo, A. (1973). Studies on the lipid composition of developing soybeans. *J. Amer. Oil Chem. Soc.*, **50**, 516.

Radwan, S. S. (1978). Coupling of two-dimensional thin-layer chromatography with gas chromatography for the quantitative analysis of lipid classes and their constituent fatty acids. *J. Chromatographic Science*, **16**, 538.

Robertson, A., Chapman, G. W., Jr and Wilson, R. L., Jr. (1978). Relation of days after flowering to chemical composition and physiological maturity of sunflower seed. *The Sunflower Newsletter*, **2**, 14.

Roehm, J. N. & Privett, O. S. (1970). Changes in the structure of soybean triglycerides during maturation. *Lipids*, **5**, 353.

Rouser, G., Kritchevsky, G., Simon, G. & Nelson, G. J. (1969). Quantitative analysis of brain and spinach leaf lipids employing silicic acid column chromatography and acetone for elution of glycolipids. *Lipids*, **2**, 37.

Sarhan, M. A. I. (1970). *Studies on the production of apricot juice.* MSc Thesis, Faculty of Agric., Cairo University, Cairo.

Siakotos, A. N. & Rouser, G. (1965). Analytical separation of non-lipid water-soluble substances and gangliosides from other lipids by dextran gel column chromatography. *J. Amer. Oil Chem. Soc.*, **42**, 913.

Vaskovskii, V. E. & Kostetskii, E. Ya. (1968). Modified spray for the detection of phospholipids on thin-layer chromatograms. *J. Lipid Res.*, **9**, 396.

Wilson, R. F. & Rinne, R. W. (1974). Phospholipids in the developing soybean seed. *Plant Physiol.*, **54**, 744.