

## Chemical Properties and Lipid Profile of Egyptian Pecan

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### Abstract:

Pecan is a promising crop that can replace walnuts and it can be consumed for its potential health benefit. In this study two cultivars of pecan (*Carya illinoensis*) grown in Egypt; Desirable and Moneymaker cultivars, were investigated for their kernel colours' chemical composition (moisture, sugars, starch, crude lipids, crude proteins, crude fibers and ash. Lipid oxidation of pecan was evaluated by measuring: peroxide, p-anisidine, total oxidation values and thiobarbituric acid value was also determined. Moreover, determination of fatty acid profile and minerals content were carried out.

The major chemical composition in pecan cultivars was crude lipids (74.84% - 75.94%). Moneymaker had higher total carbohydrates and sugars and lower protein than those of Desirable cultivar, while no significant differences were observed in crude fiber and total ash among the two pecan cultivars. Potassium, phosphorus, magnesium, iron, copper, zinc and calcium are the major minerals in both of pecan cultivars. Fatty acids profile of both pecan cultivars oil is characterized by its high content of unsaturated fatty acids; oleic,

linoleic and  $\alpha$ -linolenic acids. The ratio between unsaturated fatty acids to saturated fatty acids was 11.20:1 and 09.96:1 for Desirable and Moneymaker cultivars, respectively. Pecan kernels contained omega-3 fatty acids ( $\omega$ 3) family:  $\alpha$ -linolenic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in both cultivars.

Peroxide, p-anisidine, total oxidation values (totox value), acidity, free fatty acids, and thiobarbituric acid value (TBA) of Desirable cultivar were statistically significant lower than those of Moneymaker cultivar.

**Keywords:** Pecan (*Carya illinoensis*), acidity value, free fatty acids value, peroxide value, p-anisidine value, omega-3 fatty acids, thiobarbituric acid value.

### Introduction :

Pecan (*Carya illinoensis*), which belongs to the family *Juglandaceae*, is one of the oldest tree nuts in the world. In Egypt, pecan was grown in the last years of 20<sup>th</sup> century in scattered areas. Pecan is a promising crop that can replace walnut. According to Kays, (1979) and Senter and Forbus, (1979) the colour of pecan kernels is affected by moisture content, storage temperature, atmospheric gas composition and

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exposure to light. Also, deterioration of pecan kernel is often accompanied by darkening of their colour, which influences processors and consumers to associate light coloured kernels with pecan quality. Silva *et al.* (1990) and Silva *et al.* (1995) reported that the moisture content of pecan decreased as the harvest date was delayed, and moisture content may be a possible index of maturity. Singanusong *et al.*, (2003) stated that there were high significant variations between the different pecan cultivars, with respect to their moisture content, which ranged between 3.0 to 4.7%. Total lipids of different varieties of nuts ranged from 50.60 to 76.20%, and also, it was found that maturity and harvest date affected the total lipid content (Singanusong *et al.*, 2003 and USDA, 2005). Crude protein in pecan, almond, and walnut ranged from 9.17 to 16.66%. The variations in crude protein may be due to differences in cultivars, cultural practices, season and geographic locations (Singanusong *et al.*, 2003 and USDA, 2008). USDA (2008) reported that total dietary fiber of pecan, almond and walnut was 9.60, 12.20 and 6.70 g/100g dry matter, while, total carbohydrates contents were 13.86, 21.67 and 13.17 g/100g dry matter, respectively. Furthermore, Singanusong *et al.* (2003) stated that sucrose was the only sugar found in pecan kernels at maturity in detectable quantities, which ranged from 3.10 to 4.68 g/100g dry

matter. The same authors reported that starch content was 0.46, 0.74, and 0.06 g/100g dry matter in pecan, almond and walnut, respectively (Fourie and Basson, 1990 and USDA, 2008). Senter (1976) detected sixteen minerals in 10 pecan cultivars, using atomic absorption and emission spectroscopy, and he showed that there were significant differences among cultivars in the quantities of copper, iron, chromium, manganese, boron, zinc, barium, phosphorus, potassium and calcium.

Venkatachalam and Sathe (2006) and Villarreal-Lozoya *et al.* (2007) indicated that oleic acid (C18:1) was the main constituent of monounsaturated lipids, and linoleic acid (C18:2) was the major polyunsaturated fatty acid in pecan oil. Furthermore, it was reported that the total amount of unsaturated fatty acids content in pecan was higher than that of saturated one (Sabate, 2003 and Haddad *et al.*, 2006). Moreover, Sioen *et al.* (2006) reported that nuts content of linoleic acid,  $\alpha$ -linolenic acid, eicosapentaenoic acid (EPA), total omega-6 and total omega-3 were 6.60, 3.50, 0.60, 6.60 and 3.10%, respectively. Also, it was found that refractive index (25°C), iodine value and saponification value in some pecan cultivars ranged from 1.47 to 1.47, 100.35 to 108.20 and 189.29 to 191.49, respectively. Kaijser *et al.* (2000) reported that peroxide value of nuts ranged from 0.56 to 3.61 meq O<sub>2</sub> /kg oil. Oxidation is

catalyzed by a number of factors such as; oxygen, light, heat, heavy metals, pigments, alkaline conditions, and unsaturation degree of fats (Dziezak, 1986). Pyriadi and Mason (1968) found that there were differences between pecan cultivars in peroxide value and thiobarbituric acid value (TBA).

This work was conducted to study the difference between Desirable and Moneymaker Egyptian pecan cultivars regarding kernels colour, chemical composition (moisture content, dry matter, sugars, sucrose, starch, crude lipids, crude proteins, crude fibers, ash and minerals), fatty acids profile and physicochemical properties of pecan oil.

## **Material and methods**

### *2.1. Materials*

Two cultivars of pecan fruits namely: Desirable and Money-maker were brought from Agriculture Ministry of Egypt. The fruits were shelled and the kernels were packed in polyethylene bags and stored at (-16 - -18°C) until analyzed.

### *2.2. Colour of pecan kernels*

Colour of pecan kernels was measured by Lovibond system using Schofield Tintometer Type IA made by Tintometer LTD Salisbury Inst No. 2242 - England (Mackinnery and Little, 1962).

### *2.3. Chemical analysis*

Moisture content, dry matter, total sugars, reducing and non reducing sugars, sucrose, starch, crude lipids, crude proteins, crude fibers and ash were

determined according to the AOAC (2003).

### *2.4. Oil extraction*

*Oil was extracted by chloroform: methanol mixture (2:1, v / v) according to the method described by folch et al., (1957).*

The minerals were determined according to the method described in AOAC (2003). Calcium, iron, magnesium, zinc, boron, barium and copper were determined using Buck scientific 210-VGP Atomic Absorption Spectrophotometer. Phosphorus was determined calorimetrically, using SLM. Mingo 3000 Arrg. spectrophotometer. Potassium and sodium were estimated by flame photometer.

Fatty acid methyl esters (FAME) of oils were performed according to the procedure of Radwan (1978). A sample of oil (50 mg) was transferred into screw cap vial Benzene (2ml) and 1% H<sub>2</sub>SO<sub>4</sub> (10 ml) in absolute methanol were added. The vial was covered under stream of nitrogen gas before heating in an oven at 90°C for 90 min. Distilled water (10 ml) was then added to the cooled vial. The methyl esters in each vial were extracted with 5 ml of petroleum for three times. Analysis of fatty acid methyl esters were carried out using a gas chromatography (HP 6890 Hewlett Packard Co., Wilmington, DE, USA) AHP-5 (5% diphenyl 95% dimethyl poly siloxane) capillary column (30m×0.32mm×0.25µm) and flame ionization detector were used. Injector and detector tem-

perature were 220°C and 250°C, respectively. N<sub>2</sub> was employed as the carrier gas at a flow rate of 0.8 ml/min., the fatty acid composition was determined by area percentage and confirmation of fatty acid was performed by comparison of methyl ester with retention time.

### 2.5. Physicochemical properties of pecan oil

Refractive index, iodine value, saponification value and p-anisidine value (AV) were determined as described in AOCS (1990). The peroxide value (PV) of pecan oil was determined according to the AACC (1995). Total oxidation value (totox value) was calculated from the following equation:

Totox value = 2 × Peroxide value (PV) + P-Anisidine value (AV) according to IUPAC (1979). Acidity and free fatty acids values of pecan oil were determined according to the AACC (1995). Thiobarbituric acid value (TBA) of pecan oil was determined according to Pokorny and Dieffenbacher (1989). Accurately 100 mg of the oil sample was weighted into a 25 ml volumetric flask, dissolved in a small volume of 1-butanol and made up to volume with 1-butanol. Five ml of sample solution were transferred to a dry test tube and 5 ml of TBA reagent solution (2 mg/ml 1-butanol) were added. The tube was closed, mixed well and placed into a thermostated bath at 95°C. After 120 minutes, the sample tube was cooled under running tap water to

ambient temperature. The absorbance of the reaction solution was measured in a 1 cm cuvette at 530 nm against distilled water.

### 2.6. Statistical analysis

Statistical analysis was done by FACTOR and L.S.D. procedures available within the MSTAT-C software package (Ver. 1.2, 1991). Analysis of variance of different experiments was performed according to Steel and Torrie (1980).

## Results and discussion

### 3.1. Colour of pecan kernels

The data of Table (1) show the colour of pecan kernels as measured by Lovibond tintometer. It was observed that Desirable tends to be slightly more yellow in colour than that of Moneymaker, while the opposite was observed for the red colour. Colour is optimum when the moisture content of pecan is 3.5–4.0% (Senter and Forbus, 1979 and Hao *et al.*, 1989).

### 3.2. Chemical composition of raw pecan

The results of Table (2) show that Desirable cultivar had significantly lower content of moisture (4.17%) than that of Moneymaker cultivar (4.80%). Heaton *et al.* (1975), Silva *et al.* (1990), Silva *et al.* (1995) and Singanusong *et al.* (2003) reported that moisture content of several pecan cultivars ranged from 3.00 to 4.70%. Dry matter content in pecan cultivars Desirable and Moneymaker were 95.83 and 95.20% respectively. Desirable cultivar was significantly higher than Moneymaker

Table 1. Pecan kernels colour (measured by Lovibond tintometer)

Cultivars	Colour M±SD*		
	Blue	Yellow	Red
Desirable	2.90 <sup>***</sup> ±0.21	3.80 <sup>a</sup> ±0.20	3.00 <sup>a</sup> ±0.23
Moneymaker	2.90 <sup>a</sup> ±0.20	3.60 <sup>a</sup> ±0.22	3.60 <sup>a</sup> ±0.22
L.S.D	0.364	1.260	1.050

\*M±SD = Mean ± Standard Deviation.

\*\*Means in the same column sharing the same letters are not significantly different, using the revised L.S.D test at 0.05 level.

Table 2. Chemical composition of pecan kernel cultivars (on dry weight basis)

Component (%)	Cultivars		L.S.D
	Desirable M±SD*	Moneymaker M±SD	
Moisture content	4.17 <sup>b**</sup> ±0.67	4.80 <sup>a</sup> ±0.64	0.24
Dry matter	95.83 <sup>a</sup> ±0.67	95.20 <sup>b</sup> ±0.64	0.24
Crude lipids	75.94 <sup>a</sup> ±5.03	74.84 <sup>b</sup> ±5.13	0.34
Crude protein	9.15 <sup>a</sup> ±4.43	8.08 <sup>b</sup> ±4.54	0.27
Crude fiber	3.93 <sup>a</sup> ±0.17	3.71 <sup>a</sup> ±0.24	0.34
Ash	1.61 <sup>a</sup> ±0.37	1.50 <sup>a</sup> ±0.24	0.26
Total carbohydrates <sup>1</sup>	9.13 <sup>b</sup> ±1.10	10.78 <sup>a</sup> ±1.28	0.16
Total sugars	4.12 <sup>a</sup> ±1.03	4.65 <sup>a</sup> ±1.45	0.63
Reducing sugars	N.D <sup>***</sup>	N.D	-
Non-reducing sugars	4.12 <sup>a</sup> ±1.03	4.65 <sup>a</sup> ±1.45	0.63
Sucrose	3.91 <sup>a</sup> ±0.98	4.42 <sup>a</sup> ±1.37	0.60
Starch	0.463 <sup>a</sup> ±0.13	0.580 <sup>a</sup> ±0.13	0.56

\*M±SD = Mean ± Standard Deviation.

\*\*Means between columns sharing the same letters are not significantly different, using the revised L.S.D test at 0.05 level.

\*\*\*N.D = Not Detected

1- Calculated by difference.

cultivar in dry matter content.

The results in Table (2) clearly show that the major chemical component in pecan is crude lipid, Desirable pecan cultivar had significantly higher crude lipid content (75.94%) than that of Moneymaker cultivar (74.84%), these findings are relatively in accordance with that of Kays (1987) and Singanusong *et al.* (2003) who reported also that oil is the major constituent of pecan, with oil level ranged from 58.06 to 79.96%. Moreover, the same authors stated that the chemical composition of pecan plays an important role in maintaining quality, which means that, pecan with the highest crude lipid ratio is the best in flavour and quality.

It can be noted that, there was an inversely proportional relationship between moisture content and crude lipids content in both cultivars of pecan. These results are in good agreement with previous findings of Beuchat (1978) who noticed that there was an inversely proportional relationship between values obtained for percentages of moisture and lipid in nuts.

Protein is considered to be the third constituent in pecan. The results given in Table (2) show that Desirable pecan cultivar had significantly higher crude protein content (9.15%) than that of Moneymaker cultivar (8.08%), these results are compatible with the data reported by Singanusong *et al.* (2003) who found that pecan kernels are a good source of

protein which ranged from 8.07 to 17.34%. They attributed these variations to the differences in cultivars, cultural practices, season and geographic locations.

Crude fibers content were 3.93 and 3.71% in Desirable and Moneymaker, cultivars respectively, with no significant differences between them (Table; 2). USDA (2008) reported that the dietary fibers content of pecan kernels ranged from 1.60 to 9.60 % while, the total dietary fiber of almond and walnut was 12.20 and 6.70 %, respectively.

No significant difference was observed also, in ash content between both of Desirable and Moneymaker pecan cultivars ash contents were 1.61 and 1.50% for Desirable and Moneymaker pecan cultivars, respectively. USDA (2008) reported that ash content in pecan, almond and walnut were 1.49, 2.99 and 1.78%, respectively.

Total carbohydrates of pecan cultivars are given in Table (2), Moneymaker had significantly higher total carbohydrates content (10.78%) than that of Desirable cultivar (9.13%). These findings are relatively in agreement with USDA (2008) who reported that total carbohydrates contents were 13.86 and 13.17% in pecan and walnut, respectively. Total sugars content was 4.12 and 4.65% (Table; 2) in Desirable and Moneymaker, pecan cultivars respectively. Reducing sugars were not detected in pecan cultivars; meanwhile, Money-maker cultivar was significantly

higher in non reducing sugars than Desirable. These data are in accordance with Fourie and Basson (1990) and Borges *et al.* (2008).

The results of Table (2) illustrate that sucrose contents were 3.91 and 4.42% in Desirable and Moneymaker pecan cultivars, respectively. Singanusong *et al.* (2003) reported that sucrose content in pecan ranged from 3.10 to 4.68 g/100g dry matter, they also stated that sucrose content was the only sugar found in pecan kernels at maturity, and increased as kernels developed. And they suggested that the increase in total lipids may be due to conversion of carbohydrates other than sucrose to total lipids.

However, conversion of sucrose to lipid is a function of the available sucrose and to a degree, it is used for respiration and fatty acid metabolism. Therefore, these factors can interact to affect the sucrose content at any given time. USDA (2008) reported that lactose and maltose were not detected in pecan and walnut, but glucose and fructose were 0.04 and 0.04 % in pecan, 0.08 and 0.09 % in walnut. Starch contents were 0.463 and 0.580% in Desirable and Moneymaker pecan cultivars, respectively, with no significant differences between both pecan cultivars. The result agreed with the previous finding of USDA (2008) who reported that starch contents were 0.46 g/100g in pecan, on the contrary, starch contents of walnut were 0.06 g/100g.

Minerals contents of Desirable and Moneymaker pecan cultivars are presented in Table (3). Potassium, phosphorus, magnesium and calcium were the major minerals in both cultivars, while Sodium was found in a small amount. It could be concluded that pecan is considered to be an excellent source of bioelements as a result of its high content of the essential elements; iron, copper and zinc. On the other hand, magnesium, potassium and calcium were significantly higher in Desirable than those found in Moneymaker cultivar. The mineral contents of nuts, particularly magnesium and copper may play an important role in the mechanism of the protection against coronary heart disease (Morgan and Clayshulte, 2000). Wakeling *et al.* (2001) reported that minerals content of pecan kernels depends on cultivars, location, climate and agricultural practices.

### **3.3. Fatty acids composition**

The fatty acid contents of both pecan kernel cultivars are given in Table (4). Pecan oil generally contained higher percentage of unsaturated fatty acids than saturated ones. There were no significant differences between Desirable and Moneymaker pecan cultivars in respect of their content of fatty acids. Clearly, the fatty acids profile of pecan oil is characterized by its high content of oleic acid (89.071 and 87.625%), linoleic acid (1.07 and 1.220%), and  $\alpha$ -linolenic acid (1.01 and 0.98%) for Desirable and Moneymaker pecan cul

Table 3. Minerals content of pecan kernel cultivars (mg/100g dry weight basis)

Minerals	Cultivars		L.S.D
	Desirable M $\pm$ SD*	Moneymaker M $\pm$ SD	
K	660.00 <sup>a**</sup> $\pm$ 0.75	540.00 <sup>b</sup> $\pm$ 0.74	1.98
Mg	170.00 <sup>a</sup> $\pm$ 0.20	160.00 <sup>b</sup> $\pm$ 0.32	1.20
P	610.00 <sup>a</sup> $\pm$ 0.65	500.00 <sup>b</sup> $\pm$ 0.65	0.03
Ca	21.00 <sup>a</sup> $\pm$ 0.50	10.50 <sup>b</sup> $\pm$ 0.40	1.50
Zn	10.50 <sup>a</sup> $\pm$ 0.33	8.16 <sup>b</sup> $\pm$ 0.22	0.99
Na	0.45 <sup>b</sup> $\pm$ 0.20	0.63 <sup>a</sup> $\pm$ 0.20	0.02
Fe	1.93 <sup>a</sup> $\pm$ 0.44	2.11 <sup>a</sup> $\pm$ 0.45	0.54
Cu	0.82 <sup>a</sup> $\pm$ 0.88	0.87 <sup>a</sup> $\pm$ 0.87	0.07
B	0.81 <sup>a</sup> $\pm$ 0.21	0.74 <sup>a</sup> $\pm$ 0.23	0.67
Ba	0.55 <sup>a</sup> $\pm$ 0.42	0.63 <sup>a</sup> $\pm$ 0.41	0.09

\*M $\pm$ SD = Mean  $\pm$  Standard Deviation.

\*\*Means between columns sharing the same letters are not significantly different, using the revised L.S.D test at 0.05 level.

Table 4. Fatty acids composition of raw pecan cultivars oil

Fatty acids composition (%)		Cultivars		L.S.D
		Desirable	Moneymaker	
<b>Saturated Fatty Acids</b>				
Caproic	C6:0	00.05 <sup>a</sup>	00.08 <sup>a</sup>	0.102
Caprylic	C8:0	00.02 <sup>a</sup>	00.04 <sup>a</sup>	0.101
Myristic	C14:0	00.04 <sup>a</sup>	00.05 <sup>a</sup>	0.101
Palmitic	C16:0	05.00 <sup>a</sup>	05.94 <sup>a</sup>	2.442
Stearic	C18:0	02.94 <sup>a</sup>	02.78 <sup>a</sup>	0.415
Arachidic	C20:0	00.11 <sup>a</sup>	00.15 <sup>a</sup>	0.100
<b>Monounsaturated Fatty Acids</b>				
Palmitoleic	C16:1 ω7	00.10 <sup>a</sup>	00.09 <sup>a</sup>	0.100
Oleic	C18:1 ω9	89.07 <sup>a</sup>	87.62 <sup>a</sup>	4.079
Erucic	C22:1 ω9	00.04 <sup>a</sup>	00.04 <sup>a</sup>	0.110
<b>Polyunsaturated Fatty Acids</b>				
Linoleic	C18:2 ω6	01.07 <sup>a</sup>	01.22 <sup>a</sup>	0.266
α-Linolenic	C18:3 ω3	01.01 <sup>a</sup>	00.98 <sup>a</sup>	0.101
Arachidonic	C20:4 ω6	00.24 <sup>a</sup>	00.22 <sup>a</sup>	0.101
EPA <sup>1</sup>	C20:5 ω3	00.06 <sup>a</sup>	00.05 <sup>a</sup>	0.100
DHA <sup>2</sup>	C22:6 ω3	00.10 <sup>a</sup>	00.11 <sup>a</sup>	0.101
SFA <sup>3</sup>		08.19 <sup>a</sup>	09.06 <sup>a</sup>	1.654
UFA <sup>4</sup>		91.72 <sup>a</sup>	90.36 <sup>a</sup>	2.063
MUFA <sup>5</sup>		89.21 <sup>a</sup>	87.76 <sup>a</sup>	2.665
PUFA <sup>6</sup>		02.50 <sup>a</sup>	02.59 <sup>a</sup>	0.257
U:S ratio <sup>7</sup>		11.20:1 <sup>a</sup>	09.96:1 <sup>a</sup>	2.241
ω6:ω3 ratio		01.12:1 <sup>a</sup>	01.25:1 <sup>a</sup>	0.236

\*Means between columns sharing the same letters are not significantly different, using the revised L.S.D test at 0.05 level.

1- EPA= Eicosapentaenoic acid      2- DHA= Docosahexaenoic acid

3- SFA= Saturated fatty acids      4- UFA = MUFA + PUFA

5- MUFA= Monounsaturated fatty acids

6- PUFA= Polyunsaturated fatty acids

7- U: S ratio = Unsaturated/Saturated ratio

tivars, respectively. These results are in accordance with those of Villarreal-Lozoya *et al.* (2007) who confirmed that oleic acid, linoleic acid and  $\alpha$ -linolenic acid were the major components among unsaturated fatty acids, while palmitic and stearic acids were the major constituents among saturated fatty acids in the different pecan cultivars.

Total saturated fatty acids (SFA) were (08.19 and 09.06%), while total unsaturated fatty acids (UFA) were (91.72 and 90.36%), the ratio between them was (11.20:1 and 9.96:1) unsaturated: saturated fatty acids, and the ratio between omega-6 ( $\omega$ 6) to omega-3 ( $\omega$ 3) was 1.12:1 and 1.25:1, for Desirable and Moneymaker, pecan cultivars respectively. Toro-Vazquez *et al.* (1999) stated that pecan kernel oils had a high amount of monounsaturated fatty acids, depending on growing conditions, maturity and variety. Furthermore, pecan kernels contained omega-3 ( $\omega$ 3) family:  $\alpha$ -Linolenic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in both cultivars being 1.01, 0.06 and 0.10%, respectively, in Desirable pecan cultivar; 0.98, 0.05 and 0.11%, respectively, in Moneymaker pecan cultivar. Sioen *et al.* (2006) and Astorg *et al.* (2004) reported that linoleic acid,  $\alpha$ -linolenic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) contents in walnut were 0.05, 0.11, 0.05 and 0.05%, respectively. Linoleic and  $\alpha$ -linolenic

acids are essential for normal cellular function, and act as precursors for the synthesis of longer chained poly-unsaturated fatty acids (PUFAs) such as; arachidonic (AA), eicosapentaenoic (EPA) and docosahexaenoic acids (DHA), which have been shown to partake in numerous cellular functions affecting membrane fluidity, membrane enzyme activities and eicosanoid synthesis (Youdim *et al.*, 2000). Also, Morgan and Clayshulte (2000) compared dietary intakes of two group's people who consumed and did not consumed pecan. They found that dietary fat, monounsaturated fat, polyunsaturated fat, insoluble fiber, magnesium, and energy were significantly higher in the pecan diet group than in free pecan diet (control group). Body weight of people was unchanged in both groups.

#### **3.4. Physicochemical properties of raw pecan oil**

The physicochemical properties of the oil extracted from two pecan kernel cultivars are presented in Table (5). Values of refractive index of pecan oil are within the range for most common vegetable oils, they were 1.47 and 1.47 for Desirable and Moneymaker pecan cultivars, respectively, with no significant differences between them. Iodine value is an indicator for the degree of saturation for the fatty acids, which means that iodine value decreases as the saturation rate increases. In our results it

was found that iodine value of Desirable pecan cultivar had significantly lower value (104.10) than that of Moneymaker (110.61). William *et al.*, (1977) reported that iodine value of American pecan oils ranged from 95 to 122.

High saponification value indicates the presence of short chain fatty acids, which constitute the glyceridic part of the oil. Accordingly, the resulting oil has a low molecular weight. Data of Table (5) show that saponification values of pecan oil were 190.17 and 191.82 in Desirable and Moneymaker pecan cultivars, respectively. There were no significant differences between them. The peroxide value is an important indicator for oil oxidation. It can be used as a measurement of the extent to which rancidity reactions have occurred during storage. Data in Table (5) show that Desirable pecan cultivar had obvious lower peroxide value content (3.36 meq O<sub>2</sub> /kg oil) than that of Moneymaker pecan cultivar (3.84 meq O<sub>2</sub> /kg oil). Furthermore, overall peroxide value formation is generally low in whole pecan nuts as the kernel is protected by a thick pericarp. The same conclusion was found by Kaijser *et al.* (2000).

P-Anisidine value test is used to assess the secondary oxidation of oil or fat, which is mainly imputable to aldehydes and ketones. The data in Table (5) show that Desirable cultivar had significantly lower p-anisidine value

(0.87) than that of Moneymaker cultivar (1.01). These results are with the recommended values for oil acceptability as mentioned by Miraliakbari and Shahidi (2008).

The total oxidation value (to-tox value) is used as a measure of the precursor of non-volatile carbonyls present in processed oil, plus any further oxidation compounds developed during storage. The data in Table (5) show that Desirable had a slightly lower totox value (7.59) than that of Moneymaker cultivar (8.69). The data in Table (5) of acidity value is used to quantify the amount of acidity present in the oils. Acidity values were low in the two pecan cultivars. It was (0.19 mg NaoH /g sample) for Desirable cultivar being slightly lower than that of Moneymaker cultivar (0.21 mg NaoH /g sample). Free fatty acids value was slightly lower in Desirable cultivar (1.33%) than that of Moneymaker cultivar (1.49%). Forbus *et al.* (1980) found that free fatty acids of pecan kernel oil ranged from 0.05 to 0.38%. Thiobarbituric acid value (TBA value) is another oil oxidation indicator. The data in Table (5) show that Desirable pecan cultivar was slightly lower (0.81) in TBA value than that of Moneymaker pecan cultivar (0.83). Mexis *et al.* (2009) found that fresh walnut had a very low content of TBA value, changes in TBA value are affected by storage time, packaging material and light.

Table 5. Physicochemical properties of pecan kernel cultivars oil

Properties	Cultivars		L.S.D
	Desirable M±SD*	Moneymaker M±SD	
Refractive Index <sup>1</sup>	1.47 <sup>a**</sup> ±0.0004	1.47 <sup>a</sup> ±0.0001	0.003
Iodine value	104.10 <sup>b</sup> ±0.75	110.61 <sup>a</sup> ±0.55	1.22
Saponification value	190.17 <sup>a</sup> ±1.27	191.82 <sup>a</sup> ±1.36	1.78
Peroxide value <sup>2</sup> (PV)	3.36 <sup>b</sup> ±0.03	3.84 <sup>a</sup> ±0.08	0.47
P-Anisidine value <sup>3</sup> (AV)	0.87 <sup>b</sup> ±0.18	1.01 <sup>a</sup> ±0.12	0.12
Totox value <sup>4</sup>	7.59 <sup>b</sup> ±0.15	8.69 <sup>a</sup> ±0.13	0.88
Acidity value <sup>5</sup>	0.19 <sup>a</sup> ±0.02	0.21 <sup>a</sup> ±0.04	0.22
Free Fatty acids <sup>6</sup>	1.33 <sup>a</sup> ±0.03	1.49 <sup>a</sup> ±0.05	0.26
TBA value <sup>7</sup>	0.81 <sup>a</sup> ±0.46	0.83 <sup>a</sup> ±0.32	0.36

\*M±SD = Mean ± Standard Deviation.

\*\*Means between columns sharing the same letters are not significantly different, using the revised L.S.D test at 0.05 level.

1- 25°C

2- meq O<sub>2</sub> /kg oil

3- P-Anisidine value =  $\frac{25 \times \text{Sample} - \text{Blank}}{\text{Mass}}$

4- Total oxidation value (Totox value) = 2PV+ AV

5- mg NaOH /g sample

6- as % oleic acid

7-TBA value =  $\frac{25 \times \text{Sample} - \text{Blank}}{\text{Mass}}$

## Conclusions

The study declared that pecan and its oil are a very rich source of polyunsaturated fatty acids and omega-3 fatty acid and highly resistant to oxidation. In addition, it could be observed that there was a significant difference between the two Egyptian cultivars, where Desirable cultivar seems to have a higher quality attributes than Money-maker one. Also, pecan is considered to be an excellent source of bioelements.

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## الخواص الكيماوية وخواص الدهون للبيكان المصري

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البيكان من المحاصيل الهامة والذي يمكن أن يحل محل عين الجمل، وله فوائد صحية هامة. أجريت هذه الدراسة على صنفين من البيكان المصري (*Carya illinoensis*) وهما *Desirable* , *Moneymaker* . وقد تم دراسة خواصها المختلفة ولون الحبة والتركيب الكيماوي (الرطوبة - السكريات الكلية - النشا - الدهون - البروتين الخام - الألياف الخام - الرماد). وأيضا تم تقييم مدى قابلية الدهون للأكسدة، وذلك بقياس رقم البيروكسيد- البارانسيدن - قيم التأكسد الكلية - قيمة *thiobarbituric acid* . كما تم أيضا تقييم المحتوى من كل من الأحماض الدهنية والمعادن.

وجد من الدراسة أن الدهون تمثل (74.84% - 75.94%)، يحتوي صنف *Moneymaker* على نسب أعلى من كل من الكربوهيدرات والسكريات الكلية ونسب أقل من البروتين مقارنة بصنف *Desirable* ، بينما لم يلاحظ أي فروق معنوية بين صنفي البيكان موضع الدراسة في المحتوى من الألياف الخام والرماد. وقد وجد أيضا أن أكثر المعادن تواجدا في كل من صنفي البيكان (*Desirable* ، *Moneymaker*) البوتاسيوم - الفوسفور - الماغنسيوم - الحديد - النحاس - الزنك - الكالسيوم. تميز كلا من صنفي البيكان بموضوع الدراسة بحتوائهما على نسب عالية من الأحماض الدهنية غير المشبعة كحمض الأوليك و حمض اللينوليك وحمض الألفا لينولينك. وقد كانت النسبة بين الأحماض الدهنية غير المشبعة الى الأحماض الدهنية المشبعة هي 1:11.20، 1:9.96 في كل من صنفي البيكان (*Desirable* , *Moneymaker*) على الترتيب. ووجد أيضا أن البيكان يحتوي على عائلة الأحماض الدهنية أميجا 3 وهم: حمض الألفا لينولينك و *eicosapentaenoic acid* (EPA) و *docosahexaenoic acid* (DHA) في كل من الصنفين.

وقد وجد من الدراسة ان رقم البيروكسيد- البار أنسيدن- قيم التأكسد الكلية - رقم الحموضة- وقيمة الـ *Thiobarbituric acid* في صنف الـ *Desirable* كانت منخفضة معنويا بالمقارنة بصنف *Moneymaker*