# Chemical studies on grown jojoba oils under Egyptian conditions

**Abobatta, W.F.R. [1]; El Ghadban, E.A.E.[2] and Mahmud, G.F.[3]**
[1] Citrus Research Department**,** Horticultural Research Institute, ARC
[2] Medicinal and Aromatic Plants Department, Horticultural Research Institute (H.R.I); National Gene Bank (N.G.B.).
[3] Functional Foods Department, National Institute of Nutrition Canada, Ottawa.

## ABSTRACT

This study conducted under authority of medicinal and aromatic plants Department, Horticulture Research Institute (HRI), Agricultural Research Center (ARC), Egypt, during the seasons of 2012, 2013 and 2014. The seeds randomly collected after growth (10 kg of each site) in the different Egyptian sites six are north (Sheikh Zuid, North Sinai Governorate (B1); Sarabium, Ismailia Governorate (B2) and Wadi Natrun, Behara Governorate (B3)) and south (Valley Asiouty, Assiut Governorate (B4); Siwa Oasis, Matrouh Governorate (B5) and Arab Beny Ghalb Region, Assiyut Governorate (B6)) of Egypt. This paper conducted to study the effect of environment different on the food ingredients and chemical of the seed oils, as well as determine the importance and extent of adaptation to different environments and identify the best addition to the effect of climatic factors and conditions of the soil in which the plants cultivated under Egyptian conditions. From the obtained data, the higher Peroxide values (2.64, 2.49 and 2.78 milli equivalent/Kg) recorded with seeds from Valley Asiouty Assiyut Governorate (B4), while the lowest values) (0.59, 0.54 and 0.64 milli equivalent/Kg) founded in Sheikh Zuid, North Sinai Governorate (B1). Jojoba oil from Arab Beny Ghalb Region, Assiyut Governorate (B6) had the best oil characters comparison with other sites. In general, the site (B6) and site (B5) showed the best results of oil components, followed by Sheikh Zoweyd North Sinai (B1) and Sarabium Ismailia Governorate (B2), followed by Wadi Natrun (B3) and Asiouty Valley- Assiut Governorate (B4).

**Keywords:** Jojoba oil, Jojoba hulls, Phenolic compounds, Extraction oil.

## 1) INTRODUCTION

Jojoba, *Simmondsia chinensis* (Link) C. K. Schneid; is a native shrub of Mexico and USA cultivated in several arid and semi-arid zones. Jojoba plants grown now in many arid and semi-arid countries all over the world such as Egypt, Saudi Arabia, Sudan and North Africa. Seeds have an important commercial value due to the quantity and quality of their waxes. Jojoba shrubs are dioecious (**Gentry, 1958**). The small flowers have no odor or petals and do not attract pollinating insects. The

flowers pollinated by wind in late March. The green fruit dries in the desert heat, its outer skin shriveling and pulling back to expose a wrinkled brown soft-skinned seed (referred to as a nut or bean) the size of a small olive. These nuts, which resemble coffee beans, contain a vegetable oil that is clear and odorless but less oily to the touch than traditional edible oils. **(Bagby, 1988** and **Dasso, 1999)**.

Agriculture is one of the main corners of the Egyptian economy. Egypt has several competitive advantages when utilizing the suitable climate to produce raw material for industrial purposes despite to very scarce of water in the new reclaiming lands. Jojoba is considered one of the most practical and scientific solutions for land reclaiming in Egypt. Despite of the nature of environment and weather Egypt's are certainly most encouraging to plant Jojoba (**Yermanos, 1979** and **Borlaug, 1985)**.

Jojoba oil is a fixed oil of seeds. Seeds contain about 50% of the light Yellow, odorless oil referred to as jojoba oil and consists of a long series of esters instead of a mixture of triglycerides, which gives jojoba oil unique characteristics (**Al-Hamamre, 2013)**. The oil is widely used in the cosmetics industry for its properties of skin. The woody evergreen shrub reach 15 ft. (4.5 m) in height. Jojoba has flat gray-green leathery leaves and a deep root system that make it well adapted to heat and drought stresses. It has a life span of 100-200 years, depending on environmental conditions. Jojoba grows best in areas with 10-18 in (25-45 cm) of annual rainfall where temperatures seldom fall below 25°F (- 4°C) for more than a few hours at night. It can grow on many types of soils, including porous rocks, in slightly acid to alkaline soils, and on mountain slopes or in valleys **Bagby, (1988)** and **Borlaug, (1985).**

The chemical structure of jojoba oil is different. The oil is actually a polyunsaturated liquid wax that is similar to sperm whale oil, though without the fishy odor. It is made of fatty acids as well as esters composed entirely of straight chain alcohols. Both the acid and alcohol portions of jojoba oil have 20 or 22 carbon atoms, and each has one unsaturated bond. Waxes of this type are difficult to synthesize. As a wax, jojoba oil is especially useful for applications that require moisture control, protection and emolliency. Jojoba oil is liquid at room temperature because of its unsaturated fatty acids. It does not oxidize or become rancid and does not break down under high temperatures and pressures. Jojoba oil could heated to 370°F (188°C) for 96 hours without exhibiting degradation in general composition and carbon chain length. The stability shown by jojoba oil makes it especially useful for cosmetic applications. When the United States banned the use of sperm whale oil (spermaceti wax) **Ricks, (1990), Wisniak, (1994)** and **Akowuah *et al.*, (2005)**.

## 2) MATERIALS AND METHODS

This investigation was be carried out at medicinal and aromatic plants Department - Horticulture Research Institute - Agricultural Research Center - Dokki, during the seasons of 2012 and 2013 and 2014.

**Source the Jojoba seeds:**

Seed samples toke from six places in Egypt, three places represent Delta region and others represent Upper of Egypt region during 2012, 2013 and 2014 respectively. This investigation was to study the effect of different environments on the food ingredients and chemicals of jojoba. As well as determining its importance and the extent of their adaptation to different environments and identifying the best addition to the effect of climatic factors and soil conditions that planted by the plants under Egyptian conditions. These places were as follows:

1. Sheikh Zuaid Station, North Sinai Governorate - Center for Desert Research ($B_1$)
2. Forest Sarabium, area (Sarabum), (Ismailia Governorate), Ministry of Agriculture ($B_2$)
3. Khaled Abed jojoba farm - Wadi Natrun – (Behara Governorate) ($B_3$)
4. Valley Asiouty – (Assiyut Governorate) ($B_4$)
5. Private Farm at Siwa Oasis Region- Matrouh Governerate, ($B_5$)
6. Private Farm at Arab Beny Ghalb Region – (Assiyut Governorate), ($B_6$)

**Jojoba Samples:**

Hulls obtained after the ripening Jojoba seeds was crushed in Food Technology Institute lab - Agricultural Research Center and appreciated the protein, oil, fiber, humidity and Ash. The sampling was about 10 kg seeds of each site during seasons 2012.2013 and 2014.

**Chemical Characterization of Jojoba seeds**

Jojoba seeds were been analyzed for various quality attributes including proximate analysis, mineral composition, polyphenols and alkaloids. The procedures followed below:

**1. Proximate analysis**

**i. Moisture content**

Moisture contents of Jojoba seeds were estimated by drying the samples in an Air Forced Draft Oven (Model: DO-1-30/02, PCSIR) at 105 ± 5°C until constant weight (**A.A.C.C, 2000**; Method No. 44-15A).

**ii. Crude protein**

Crude protein content was determined by using Kjeltech Apparatus (Model: D-40599, Behr Labor Technik, Gmbh-Germany) as described in **A.A.C.C. (2000)** Method No. 46-30.

**iii. Crude fat**

Crude fat content was determined using hexane as a solvent in Soxtec System (Model: H-2 1045 Extraction Unit, Hoganas, Sweden) according to the procedure give in **A.A.C.C. (2000)** Method No. 30-25.

**iv. Crude fiber**

Crude fiber was estimated in fat free samples by treating with 1.25% $H_2SO_4$, left over material was subjected to further treatment with 1.25% NaOH solutions. Crude fiber of the samples was determined through Labconco Fibertech (Labconco Corporation Kansas, USA) as per procedure in **A.A.C.C. (2000)** Method No. 32-10.

**v. Nitrogen free extract (NFE)**

NFE calculated according to the following formula:

NFE percentage = 100 – (moisture contents % + crude protein % + crude fat % + crude fiber % + ash %) according to **A.O.A.C. (1990)**.

**2. Iodine value:**

Iodine Value is the number of grams of Iodine that combines with 100g of oil or fat. Iodine Value of an oil or fat indicates the amount of unsaturated acids present in it. In practice, the given oil dissolved in carbon tetrachloride and then treated with iodine monochloride solution; the unused Iodine was been determined by titration against standard sodium thiosulphate (hypo) solution. An Iodine solution is violet in color and any chemical group in the substance that reacts with iodine will make the color disappear at a precise concentration. The amount of Iodine solution thus required to keep the solution violet is a measure of the amount of Iodine sensitive groups **(A.O.A.C., 1998** and **A.O.A.C., 2003)**.

**3. Peroxide value:**

One of the most widely used tests for oxidative rancidity; peroxide value is a measure of the concentration of peroxides and hydro peroxides formed in the initial stages of lipid oxidation. Milli-equivalent of peroxide per kilogram of fat measured by titration with Iodide ion (**Singleton *et al.*, 1999**).

**4. Acid value:**

During storage, fats may become rancid because of peroxide formation at the double bonds by atmospheric oxygen and hydrolysis by microorganisms with the liberation of free acid. The amount of free acid present therefore gives an indication of the age and quality of the fat. The acid value is the number of milligrams of KOH that is required to neutralize the free fatty acid present in 1g of fat. A known amount of sample dissolved in an organic solvent is titrated with a solution of potassium hydroxide with known concentration and with phenolphthalein as a color indicator according to **Horwitz, (1980)**.

**5. Saponification value:**

The Saponification Value is the number of milligrams of KOH required to neutralize the fatty acids resulting from complete hydrolysis of 1 g of fat. The Saponification Value gives an indication of the nature of the fatty acids in the fat since the longer the carbon chain the less acid liberated per gram of fat hydrolyzed **(Hirai *et al.* 1988)**.

**6. Unsaponifiable matter:**

Many fats and oil contain substances that are not tri-glycerides. Saponifying the fat by heating with strong caustic soda or potash solution until all the tri-glycerides been decomposed into glycerin and soap does the determination of non-fat materials often other than water. These were soluble in water and washed away. The remains, the non-triglyceride, is part of the fat and be weighed. It is known an unsaponifiable matter.

**7. Polyphenols**

Total polyphenols were determined using Folin-Ciocalteu method and values were been expressed as gallic acid equivalent **(Singleton *et al.*, 1999; Akowuah *et al.*, 2005).** 20gm of seeds slurred in 200 mL of methanol. One mL of methanolic extract (10 g/L) mixed with 5mL of Folin-Ciocalteu reagent (10 %) and 4 mL of

sodium carbonate solution (75 g/L) and after 30 min absorbance (765 nm) was been noted on UV/VIS light spectrophotometer (CECIL CE 7200). Calibration/standard curve for gallic acid was been drawn with concentrations of 0.05, 0.10, 0.15, 0.20, 0.25 and 0.30 mg/mL methanol mixed with the same reagents. Total polyphenols content was been calculated by the following formula:

$C = c \times V/m$

C = total content of phenolic compounds in mg/g plant extract, in GAE

C = the concentration of gallic acid calculated from the calibration curve in mg/ml

V = the volume of extract in ml

m = the weight of plant methanolic extract in g

**8. Alkaloids**

Total alkaloids were determined by following the Method No. 20.20 as described in **A.A.C.C. (2000).**

**9. Extraction of fixed oil**

The oil from the Jojoba seeds was been extracted through solvent extraction technique as described in **A.O.C.S. (1998)**. The hexane was used a solvent was recovered by Rotary Evaporator (Eyela, Japan). The extracted oil was stored in dark place at room temperature. Jojoba oil fixed oil was been analyzed for physical & chemical characteristics and fatty acid profile using their respective methodologies as presented below Acid value Acid value is defined as the milligrams of KOH required for neutralization of free fatty acids present in one gram of oil. Neutral alcohol was been added to Jojoba fixed oil sample and titrated against KOH solution (**A.O.C.S., 1998**; Method No. Cd 3d-63).

**10. Antioxidant potential of fixed oil**

**10.1. Antioxidant activity**

Antioxidant activity based on coupled oxidation of β-carotene and linoleic acid evaluated using the method described by **Taga *et al.* (1984).** Oxidation of β-carotene emulsion was been monitored spectrophotometrically by measuring absorbance at 470 nm after 0, 10, 20, 30 and 40min. The degradation rate of the extracts calculated according to first order kinetics using following equation **(Al-Saikhan *et al.*, 1995).**

$\ln (a/b) \times 1/t$ = sample degradation rate

ln = the natural log

a = the initial absorbance (470 nm) at time zero

b = the absorbance (470 nm) after 40 min

t = the time (min).

The antioxidant activity (AA) was expressed as % inhibition relative to the control.

**11 - Statistical analysis:**

Obtained data of this study were tabulated and statistically analyzed using randomized complete block design according to **Snedecor and Cochran, 1967.**

## 3) RESULTS AND DISCUSSION

**Table 1** shows the Chemical Composition of jojoba seed hulls. During three seasons in six sites, the values ranged from 3.24 - 3.32 % of protein, 1.69 - 1.79 % of oil seed hulls, 3.28 -3.34 % of moisture, 67.54 - 67.57 % of nitrogen free

extract, 0.13 - 0.19 % of Simmondsin, 2.09 -2.15 % of ash, and 17.12 - 17.18 % of fiber seed hulls **(Nelson, 2001)**.

During three seasons, **Table 2** presents the Chemical Composition of jojoba seed. The protein values ranged from 27.26 - 36.77 %, while the values of nitrogen free extract ranged 6.13 - 12.58 %, and 1.36 - 1.62 % of ash **(Wisniak, 1987)**.

In **Table 3**, mean of Oil content ranged from 44.50 to 46.50 %, which is quite high as compared to other vegetable oils. This parameter indicates that substantial quantity of good quality oil could obtain from jojoba seeds for preparation of cosmetic base. On the other hand, mean moisture content gave low values from 0.039 to 0.061 %, as shown **Table 3**. This indicates that jojoba seeds retain very little moisture under normal agro-climatic conditions. It gives an indication to good quality of oil with superior shelf life can be obtained from it. Superior shelf life of cosmetic base oil is essential to store the cosmetics over a longer period **(Taga *et al.* 1984)**.

Perusal of data presented in **Table 4**. The mean of iodine value (g/100g) varied from 80.50 to 81.50 g/100g. The mass of iodine in gram absorbed by 100 g the oil/fat in the natural state is known as Iodine number/Iodine value. It is an index of the degree of unsaturation of the fat. Iodine value represents true unsaturation of fats only when double bonds are unconjugated and addition is not interfered by other groups. The higher the Iodine value, the more unsaturated fatty acid bonds are present in a fat/oil. This could also be said in another way also that application of Iodine value is in the determination of saturation of fatty acids as double bonds in fatty acids also react with Iodine compounds. It is a measure, which indicates the potential of a fat to be oxidized. This method measures the reaction of Iodine with double bonds of unsaturated fatty acids. Greater the numbers of double bonds more are the sites for oxidation. The moderate Iodine value of jojoba oil extracted from seed samples collected from six locations of study during three years of experimentation reveals that alcohols and acids have one double bond in each of them. Mean Peroxide value varies between 0.59 to 2.64 milli equivalent/Kg. Peroxide value is a measure of the concentration of peroxide and hydro peroxides formed in the initial stages of lipid oxidation. Milli equivalents of Peroxide per Kg. of fat are measured by titration with Iodide ion. High Peroxide values are a definite indication of rancid fat.

As shown in **Table 4**, the Peroxide values of jojoba oil are low which means minimum oxidation has occurred. This shows that low aldehydes are resulted because they may have volatilized. So low Peroxide values provide a clear guideline relating jojoba oils good shelf life. Since, Jojoba oil does not oxidize or become rancid, it added to other oils to extend their shelf life **(Singleton *et al.*, 1999)**.

**Table (1): Chemical Composition of jojoba seed hulls.**

| Location | Seasons | Composition (%) Protein | Oil | Moisture | Nitrogen free extract | Simmo ndsin | Ash | Crude fiber |
|---|---|---|---|---|---|---|---|---|
| $B_1$ | 2012 | 3.32 | 1.77 | 7.87 | 67.58 | 0.17 | 2.13 | 17.16 |
| | 2013 | 3.28 | 1.73 | 7.83 | 67.54 | 0.13 | 2.09 | 17.12 |
| | 2014 | 3.29 | 1.74 | 7.84 | 67.55 | 0.14 | 2.1 | 17.13 |
| $B_2$ | 2012 | 3.30 | 1.75 | 7.85 | 67.56 | 0.15 | 2.11 | 17.14 |
| | 2013 | 3.26 | 1.71 | 7.81 | 67.52 | 0.11 | 2.07 | 17.10 |
| | 2014 | 3.27 | 1.72 | 7.82 | 67.53 | 0.12 | 2.08 | 17.11 |
| $B_3$ | 2012 | 3.28 | 1.73 | 7.83 | 67.54 | 0.13 | 2.09 | 17.12 |
| | 2013 | 3.24 | 1.69 | 7.79 | 67.50 | 0.09 | 2.05 | 17.08 |
| | 2014 | 3.25 | 1.70 | 7.80 | 67.51 | 0.10 | 2.06 | 17.09 |
| $B_4$ | 2012 | 3.29 | 1.74 | 7.84 | 67.55 | 0.14 | 2.10 | 17.13 |
| | 2013 | 3.25 | 1.71 | 7.81 | 67.52 | 0.11 | 2.07 | 17.10 |
| | 2014 | 3.26 | 1.71 | 7.81 | 67.52 | 0.11 | 2.07 | 17.10 |
| $B_5$ | 2012 | 3.33 | 1.78 | 7.88 | 67.59 | 0.18 | 2.14 | 17.17 |
| | 2013 | 3.29 | 1.74 | 7.84 | 67.55 | 0.14 | 2.10 | 17.13 |
| | 2014 | 3.30 | 1.75 | 7.85 | 67.56 | 0.15 | 2.11 | 17.14 |
| $B_6$ | 2012 | 3.34 | 1.79 | 7.89 | 67.60 | 0.19 | 2.15 | 17.18 |
| | 2013 | 3.30 | 1.75 | 7.85 | 67.56 | 0.15 | 2.11 | 17.14 |
| | 2014 | 3.31 | 1.76 | 7.86 | 67.57 | 0.16 | 2.12 | 17.15 |

**Table (2): Chemical Composition of jojoba seed**

| Location | Composition (%) Protein | | | Nitrogen free extract | | | Ash | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 |
| $B_1$ | 29.75 | 29.58 | 29.66 | 10.17 | 10.00 | 10.08 | 1.54 | 1.37 | 1.45 |
| $B_2$ | 28.18 | 28.01 | 28.09 | 8.68 | 8.51 | 8.59 | 1.62 | 1.45 | 1.53 |
| $B_3$ | 28.43 | 27.26 | 27.34 | 6.30 | 6.13 | 6.21 | 1.59 | 1.42 | 1.50 |
| $B_4$ | 27.67 | 28.50 | 28.58 | 14.28 | 14.11 | 14.19 | 1.69 | 1.52 | 1.60 |
| $B_5$ | 31.39 | 31.22 | 31.30 | 11.87 | 11.70 | 11.78 | 1.60 | 1.43 | 1.51 |
| $B_6$ | 36.77 | 36.60 | 36.68 | 12.67 | 12.50 | 12.58 | 1.53 | 1.36 | 1.44 |

**Table (3): The concentration of moisture and oil (percent) of jojoba seed samples during the three seasons.**

| Location | OIL CONTENT (%) | | | | MOISTURE CONTENT (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | MEAN | 2012 | 2013 | 2014 | MEAN |
| $B_1$ | 45.500 | 46.00 | 45.00 | 45.50 | 0.050 | 0.050 | 0.05 | 0.050 |
| $B_2$ | 45.500 | 45.00 | 46.00 | 45.50 | 0.061 | 0.042 | 0.08 | 0.061 |
| $B_3$ | 45.500 | 47.00 | 44.00 | 45.50 | 0.039 | 0.047 | 0.03 | 0.039 |
| $B_4$ | 44.500 | 44.00 | 45.00 | 44.50 | 0.046 | 0.042 | 0.05 | 0.046 |
| $B_5$ | 45.000 | 43.00 | 47.00 | 45.00 | 0.042 | 0.043 | 0.04 | 0.042 |
| $B_6$ | 46.500 | 46.00 | 47.00 | 46.50 | 0.046 | 0.042 | 0.05 | 0.046 |

**Table (4): Iodine Value (g/100g) and Peroxide Value (meq/Kg) of Jojoba oil samples during the three seasons.**

| Location | PEROXIDE VALUE (meq/Kg) | | | | IODINE VALUE (g/100g) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | MEAN | 2012 | 2013 | 2014 | MEAN |
| $B_1$ | 0.59 | 0.54 | 0.64 | 0.59 | 80.50 | 81.00 | 80.00 | 80.50 |
| $B_2$ | 1.05 | 1.11 | 0.99 | 1.05 | 81.50 | 82.00 | 81.00 | 81.50 |
| $B_3$ | 0.92 | 0.81 | 1.02 | 0.92 | 81.00 | 80.00 | 82.00 | 81.00 |
| $B_4$ | 2.64 | 2.49 | 2.78 | 2.64 | 80.50 | 81.00 | 80.00 | 80.50 |
| $B_5$ | 0.67 | 0.53 | 0.81 | 0.67 | 81.00 | 80.00 | 82.00 | 81.00 |
| $B_6$ | 1.48 | 1.59 | 1.36 | 1.48 | 81.00 | 82.00 | 80.00 | 81.00 |

Mean of Saponification (mg/g KOH) value varied from 86.50 to 89 mg/g KOH and mean unsaponifiable matter varied from 48.23 to 48.96 %, during three years in all the locations (**Table 5**). The Saponification number is the number of milligrams of Potassium hydroxide required to convert one gram of the fat completely into soap and glycerin. It gives information concerning the character of the fatty acids of the fat and in particular concerning the solubility of their soaps in water **(Spencer and List, 1988)**.

**Table (5): Saponification value (mg/g KOH) and Unsaponifiable matter (%) of Jojoba oil samples during the three seasons.**

| Location | Unsaponifiable matter (% ) | | | | Saponification value (mg/g KOH) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | MEAN | 2012 | 2013 | 2014 | MEAN |
| $B_1$ | 48.60 | 48.75 | 48.44 | 48.60 | 87.00 | 88.00 | 86.00 | 87.00 |
| $B_2$ | 48.46 | 48.15 | 48.77 | 48.46 | 87.50 | 87.00 | 88.00 | 87.50 |
| $B_3$ | 48.23 | 48.17 | 48.28 | 48.23 | 88.00 | 90.00 | 86.00 | 88.00 |
| $B_4$ | 48.40 | 48.38 | 48.42 | 48.40 | 86.50 | 86.00 | 87.00 | 86.50 |
| $B_5$ | 48.96 | 48.75 | 49.16 | 48.96 | 89.00 | 88.00 | 90.00 | 89.00 |
| $B_6$ | 48.51 | 48.45 | 48.56 | 48.51 | 88.00 | 87.00 | 89.00 | 88.00 |

The higher the Saponification number of a fat free from moisture and Unsaponifiable matter, the more soluble the soap that be made from it. It used from making specialty soaps, shampoos, hair conditioners, moisturizers, shaving creams etc **(Singleton *et al.* 1984)**.

The Acid value of jojoba oil is less than one and the value does not change with time (**Table 6**), so it has a long shelf life, which is an important parameter as far as cosmetic value of oil is concerned.

**Table (6): Acid value (mg/g KOH) of Jojoba oil samples during the season (2013) after 0, 6, 12 and 18 months of oil extraction.**

| Location | 0 Month | 6 month | 12 month | 18 month | MEAN |
|---|---|---|---|---|---|
| **$B_1$** | 0.54 | 0.55 | 0.55 | 0.55 | 0.55 |
| **$B_2$** | 0.66 | 0.66 | 0.66 | 0.67 | 0.66 |
| **$B_3$** | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| **$B_4$** | 0.62 | 0.62 | 0.62 | 0.63 | 0.62 |
| **$B_5$** | 0.76 | 0.77 | 0.77 | 0.78 | 0.77 |
| **$B_6$** | 0.85 | 0.85 | 0.86 | 0.86 | 0.86 |
| **SED ±** | 0.015 | 0.014 | 0.013 | 0.013 | - |
| **CD 5%** | 0.033 | 0.030 | 0.028 | 0.030 | - |
| **CV %** | 2.637 | 2.415 | 2.270 | 2.372 | - |

In **Table (7)** shows the fatty acid contents of Egyptian Jojoba oil. The results indicated that the oil contains carbon atoms from C 16 to C 24 (saturated and unsaturated). Furthermore, the main fatty acids constituents of Jojoba wax are octadec-9-enoic acid (18:1) (oleic acid) and eicos-11-enoic acid (20:1) (gondoic acid). This is in agreement with reported data. Among these results, it noticed that the fatty acid 9, 12, 15-octadecatrienoic acid (18:3) (α-linolenic acid) was in higher percent within the Egyptian oil than those of Jojoba oil from around the world. In contrast, the fatty acids hexadecanoic acid (16:0) (palmitic acid), octadec-9-enoic acid (18:1) (oleic acid), octadec-11-enoic acid (18:1) (vaccenic acid) and eicos-11-enoic acid (20:1) (gondoic acid) were in lower percent within the Egyptian oil than those of Jojoba oil from around the world **(Katoh *et al.* 1988)**. This became clear after comparing Egyptian Jojoba oil results with that from the literature data regarding Jojoba oil fatty acids constituents. The best result was in the site (B6) for all composition of the fatty acid.

**Table (7): Fatty Acid Composition (%) of Jojoba oil samples during the season 2013 after the oil extraction.**

| Fatty Acid Composition (%) | Location | | | | | |
|---|---|---|---|---|---|---|
| | $B_1$ | $B_2$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ |
| **C16:0 Palmitic acid** | 2.73 | 2.69 | 2.70 | 2.66 | 2.68 | 2.68 |
| **C16:1 Palmitoleic acid** | 0.97 | 0.98 | 0.99 | 0.99 | 0.99 | 1.00 |
| **C18:0 Stearic acid** | 3.50 | 3.50 | 3.49 | 3.49 | 3.50 | 3.50 |
| **C18:1 Oleic acid** | 5.97 | 5.98 | 5.99 | 5.98 | 5.99 | 6.00 |
| **C20:0 Arachidic acid** | 2.26 | 2.27 | 2.26 | 2.27 | 2.25 | 2.23 |
| **C20:1 Gadoleic acid** | 67.97 | 67.98 | 67.98 | 67.98 | 67.99 | 68.0 |
| **C22:0 Behenic acid** | 0.87 | 0.88 | 0.86 | 0.88 | 0.85 | 0.85 |
| **C22:1 Erucic acid** | 10.98 | 10.98 | 10.97 | 10.98 | 10.99 | 11.0 |
| **C24:1 Nervonic acid** | 2.50 | 2.49 | 2.49 | 2.51 | 2.50 | 2.50 |
| **Others Fatty acid** | 2.25 | 2.25 | 2.27 | 2.26 | 2.26 | 2.24 |

The results in **Table (8)** show the percent of liquid wax esters (commonly called jojoba oil) in its seeds. This oil is rare in that it is an extremely long (C36-C46) straight-chain wax ester and not a triglyceride, making jojoba and its derivative jojoba esters, more similar to sebum and whale oil than to traditional vegetable oils. Jojoba oil is easily refined to be odorless, colorless and oxidative stable, and often used in cosmetics as a moisturizer and as carrier oil for specialty fragrances. It has also potential use as both for cars and trucks, as well as a biodegradable lubricant **(Miwa, 1980)**.

**Table (8): Composition of wax esters (%) of Jojoba oil samples during the season 2013.**

| Wax Esters Composition (%) | Location | | | | | |
|---|---|---|---|---|---|---|
| | $B_1$ | $B_2$ | $B_3$ | $B_4$ | $B_5$ | $B_6$ |
| **C36** | 1.98 | 1.96 | 1.94 | 1.95 | 1.99 | 2 |
| **C38** | 9.98 | 9.96 | 9.94 | 9.95 | 9.99 | 10 |
| **C40** | 53.98 | 40.95 | 26.55 | 45.95 | 53.65 | 56 |
| **C42** | 54.98 | 46.96 | 44.00 | 49.95 | 50.99 | 55 |
| **C44** | 11.98 | 9.33 | 8.01 | 10.02 | 12.99 | 13 |
| **C46** | 2.98 | 2.96 | 2.94 | 2.95 | 2.99 | 3 |

## 4) CONCLUSION

In Egypt, the suitable climate, soils, water available are the most important factors for the success of the cultivation of jojoba, as well as all the Egyptian territory is very suitable for its cultivation. The chemical and physical properties of jojoba oil cultivated under Egyptian conditions represent the best types of oil produced globally

because of the availability of important chemical material at a rate greater than the Jojoba cultivated elsewhere.

The aesthetic and technical qualities of jojoba oil make it a wide spread basic cosmetic ingredient. Chemical structure of jojoba oil is different from other vegetable oils. During storage, fats may become rancid because of peroxide formation at the double bonds by atmospheric oxygen and hydrolysis by microorganisms with the liberation of free acids. Low peroxide values provide a clear guideline relating jojoba oils good shelf life.

Since Jojoba oil does not oxidize or become rancid, it could add to other oils to extend their shelf life. Saponification substances are those that be converted into soap. The higher the Saponification number of a fat free from moisture and Unsaponification matter, the more soluble the soap that be made from it. That is why it used from making specialty soaps, shampoos, hair conditioners, moisturizers, shaving creams etc. The Acid value of Jojoba oil is less than one and the value does not change with time.

Therefore, it has a long shelf life, which is an important parameter as far as cosmetic value of oil is concerned. The low Acid Value, moderate Iodine Value and Saponification Number, Less Unsaponification matter and Peroxide Value make jojoba oil especially useful for cosmetic applications. It is a natural emollient, making skin softer, cleaner and all round healthier. Since jojoba is completely miscible with sebum, it forms a very thin, non- greasy, lipoid layer of jojoba and sebum when it could applied to the skin**.**

## RECOMMENDATIONS

The cultivation of jojoba is the most important crops in the future, especially in the desert of the Upper Egypt and the Sinai because of its suitable climate and water with the greater economic value and chemical contents. It is preferably more academic research especially in Egypt and the Arab states to enhance more and more the benefit of this plant in the future.

## REFERENCES

**A.A.C.C. (2000):** Approved Methods of American Association of Cereal Chemists. The 10th Ed. St. Paul. Minnesota, USA.

**Akowuah, G.A; Ismail, Z; Norhayati, I. and Sadikun A. (2005):** The effects of different extraction solvents of varying polarities of polyphenols of *Orthosiphon stamineus* and evaluation of the free radical-scavenging activity. Food Chemistry. 93: 311 – 317.

**Al-Hamamre, Z. (2013):** "Jojoba is a Possible Alternative Green Fuel for Jordan". Energy Sources, Part B: Economics, Planning, and Policy. Vol. 8 (3): 217 – 226.

**Al-Saikhan, M. S; Howard, L. R. and Miller, J. C. (1995):** Antioxidant activity and total phenolies in different genotypes of potato (*Solanum tuberosum* L.) J. Food Sci., 60 (2): 341-343.

**A.O.A.C. (1990):** Official Method of Analysis 15th Edition, Association of Official Analytical Chemists Washington, D. U.S.A**.**

**A.O.A.C. (2003):** Official Methods of Analysis of the Association of Official's Analytical Chemists. The 17th Ed., Arlington, Virginia.

**A.O.A.C. (1998):** Official Methods of Analysis of the Association of Official's Analytical Chemists. The 16th Ed., Maryland.

**A.O.C.S. (1998).** Official Methods and Recommended Practice of the American Oil Chemists' Society. 5th Ed; Methods. AOCS Press, Champaign, USA..

**Bagby, M.O. (1988):** Comparison of Properties and Function of Jojoba Oil and Its Substitutes, Proceedings from the Seventh International Conference on Jojoba and Its Uses, American Oil Chemists' Society, Champaign, IL.

**Borlaug, N. E. (1985):** Jojoba. New Crop for Arid Lands, New Raw Material for Industry, National Academy Press.

**Dasso, D. (1999):** Chemical characterization of jojoba seeds (*Simmondsia chinensis*). Actas de la Jornada Técnica sobre Jojoba en La Rioja y Catamarca, CRILAR, Anillaco, (7): 63.

**Gentry, Howard Scott (1958).** "The natural history of Jojoba (*Simmondsia chinensis*) and its cultural aspects". Economic Botany. 12 (3): 261–295.

**Hirai, Y.N.; Tonooka, T. and Ito K. (1988):** Application of the Compounds Related to Jojoba in cosmetics. Proceedings from the 7th International Conference on Jojoba and Its uses, American Oil Chemist Society, Champaign, IL, 305.

**Horwitz, W. (1980)** Official Methods of Analysis of the Association of Official Analytical Chemists.13th Ed. AOAC Washington D.C; USA.

**Katoh, M; M. Taguchi and T. Kunimoto, (1988):** Current Status of Jojoba Oil Utilization in Cosmetics in Japan, in Proceedings Seventh international Conference on Jojoba and Its Uses, edited by A.R. Baldwin, American Oil Chemists' Society, Champaign, IL, , pp. 318 - 342.

**Miwa, T.K. and Hagemann J.W. (1976):** Physical and Chemical Properties of Jojoba Liquid and Solid Waxes. Proceedings 2nd International Conf. Jojoba and its Uses. Ensenada, Baja California, Mexico.

**Miwa, T.K. (1980):** Fundamental and applied research communications, Notes. Reviews, Jojoba Plantation Products, Inc., Los Angeles, California, USA. Jojoba vol. (1): 318.

**Nelson, M. (2001):** Nitrogen fertilization effects on jojoba seed production, Industrial Crops and Products. 13: 145 - 154.

**Ricks, D.J. (1990):** Jojoba Oil in Cosmetics, 8th International Conf. Jojoba and Its uses, Asuncion, Paraguay.

**Singleton, V. L.; Orthofer, R. and Lamuela-Ravento, R. M. (1999):** Analysis of total phenols and other oxidation substrates and antioxidants by means of folinciocalteu reagent. Methods in Enzymology, 299: 152 - 178.

**Snedecor, G. W. and Cochran, W. G. 1967.** Statistical Methods.Iowa state Univ.Press, Iowa, USA.

**Spencer, G.F. and List, G.R. (1988):** Specifications, Physical Properties and Methods of Analysis for Jojoba Oil. Proceedings from the 7th International Conf. Jojoba and its uses. Americ. Chemists Soc; Champaign. IL, USA.

**Taga M.S; Miller, E. E. and Pratt D.E. (1984):** Chia seeds as a source of natural lipids antioxidants. J. Am. Oil Chem. Soc., (61): 928 - 931.

**Wisniak, J. (1987):** The Chemistry and Technology of Jojoba Oil. American Oil Chemist´s Society. Chmpaign, USA**,** IL. (43): 213 - 272.

**Wisniak, J. (1994):** Potential uses of Jojoba oil and meal a review. Ind. Crops Prod. 3: 43 – 68.

**Yermanos, D. M. (1979):** Jojoba – a crop whose time has come, California Agriculture …

# دراسات كيميائية على زيوت الجوجوبا المنزرعة تحت الظروف المصرية

**وليد فؤاد رزق أبو بطة[١]، الموافي عبده الموافي الغضبان[٢]، جميل فكري محمود[٣]**
[١] قسم بحوث الموالح، معهد بحوث البساتين، مركز البحوث الزراعية.
[٢] قسم بحوث النباتات الطبية والعطرية، معهد بحوث البساتين والبنك القومي للجينات، مركز البحوث الزراعية.
[٣] قسم الأغذية الوظيفية، المعهد الوطني للتغذية الكندية، أوتاوا.

أجريت هذه الدراسة من خلال قسم النباتات الطبية والعطرية - معهد بحوث البساتين - مركز البحوث الزراعية - مصر، خلال مواسم ٢٠١٢، ٢٠١٣، ٢٠١٤. وقد جمعت البذور المكتملة النمو بصورة عشوائية من اشجار الجوجوبا (١٠ كجم من كل موقع) والمنزرعة في ستة مناطق مختلفة وهي الشيخ زويد بمحافظة شمال سيناء (B1)، سرابيوم بمحافظة الإسماعيلية (B2)، وادي النطرون بمحافظة البحيرة (B3) في شمال مصر، ومنطقة وادي الأسيوطي بمحافظة أسيوط (B4)، واحة سيوة بمحافظة مطروح (B5)، منطقة عرب بنى غالب بمحافظة أسيوط (B6) في جنوب مصر. بهدف دراسة تأثير البيئات المختلفة على المكونات الغذائية والمواد الكيميائية لزيت الجوجوبا، وتحديد أهمية ومدى التكيف مع البيئات المختلفة وكذلك دراسة تأثير العوامل المناخية والتربة على الاشجار المنزرعة تحت الظروف المصرية. واعطي الزيت المستخلص من بذور الجوجوبا المنزرعة في الوادي الأسيوطي (B4) اعلى قيم لمحتوي الزيت من البيروكسيدات (٢,٦٤، ٢,٤٩ و٢,٧٨) بينما كانت اقل القيم (٠,٥٩، ٠,٥٤ و٠,٦٤) من الزيت الناتج من منطقة الشيخ زويد في شمال سيناء (B1) وأثبتت الدراسة ان مواصفات الزيت الناتج من بذور الأشجار النامية في منطقة عرب بنى غالب بمحافظ أسيوط (B6) أعطت أفضل النتائج مقارنة بباقي المواقع تحت هذه الدراسة.

واوضحت الدراسة ان النتائج المتحصل عليها من بذور الاشجار بمنطقة عرب بنى غالب بمحافظة أسيوط (B6)، ومنطقة واحة سيوة بمحافظة مطروح (B5) أعطت أفضل النتائج لمكونات الزيت وتليها منطقة الشيخ زويد بشمال سيناء (B1) وسرابيوم بمحافظة الإسماعيلية (B2) ويليها وادي النطرون بمحافظة البحيرة (B3) ومنطقة الوادي الأسيوطي بمحافظة أسيوط (B4).