

PHYSICAL AND CHEMICAL CHARACTERISTICS OF JATROPHA CURCAS L. SEED OIL.

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ABSTRACT

The present work was aimed to study the gross chemical composition of *Jatropha curcas* L. seeds physical and chemical characteristics of *Jatropha curcas* L. seed oil cultivated in Egypt during harvest season 2005 (first and second harvest). The results can be summarized as follows:

- *Jatropha curcas* L. seeds contained 9.18, 8.81% moisture, 21.51 and 29.93% crude oil, 16.41 and 17.92% crude protein, 29.44 and 23.63% crude fiber, 3.24 and 3.06% ash and 20.22 and 16.65% total carbohydrates in first and second harvest, respectively.
- Physical and chemical properties of *Jatropha curcas* L. seed oil indicated that refractive index, acid, peroxide, iodine values, k230 and 270 nm. and unsaponifiable matter, were (1.4719 and 1.4723 at 25°C), (5.6 and 4.12 mg/g oil), (0.36 and 0.27 mequiv./kg oil), (109.11 and 111.93 I₂/100g oil), (2.89 and 2.12 nm.), (0.56 and 0.35 mm.), and (1.08 and 1.34%) in first and second harvest, respectively.
- Fatty acids composition of *Jatropha curcas* L. seed oil was determined and the results indicated that the predominant unsaturated fatty acids in first and second harvest of *Jatropha curcas* L. seed oil was oleic acid (47.29 and 45.07%) followed by linoleic acid (30.68 and 33.07%), and also the major saturated fatty acid was palmitic acid (13.45 and 13.83% then stearic acid (7.29 and 6.78%), respectively.
- Analysis of the unsaponifiable matter of *Jatropha curcas* L. seed oil by GLC technique revealed that it contained 40.40 and 32.05% total hydrocarbons and 59.60 and 64.63% total sterols in first and second harvest, respectively. However, the squalene compound was the highest amount of total hydrocarbons (17.75 and 14.88%) while β -sitosterol was the major components of total sterols (46.78 and 43.57% in first and second harvest, respectively).

Keywords: *Jatropha curcas* L. seed oil, chemical composition of seeds and physical and chemical properties of oil.

INTRODUCTION

Jatropha curcas is a plant of Latin-American origin which is now widespread throughout arid and semiarid tropical regions of the world. A member of the Euphorbiaceae family, it is a drought-resistant perennial, living up to 50 years and growing marginal soils. The genus *Jatropha* contains approximately 170 known species. The genus name *Jatropha* derives from the Greek *Jator* (doctor), *trophe* (food), which implies medicinal uses. The seeds are toxic, they contain about 35% of a nonedible oil, which has the same medical properties of castor oil (Reinhard, 1998 and Reinhard and Rothkreuz, 2004).

Jatropha is a fast growing plant and can achieve a height of three meters within three years under a variety of growing conditions. Seeds production from plants propagation is easy and results in rapid; the bush can be expected to start bearing fruit within one year of planting (Jones and Miller 1992).

Species of the Genus *Jatropha* are known to be very toxic. *Jatropha curcas*, also known as 'physic nut, purging nut, big purging nut. American purging nut, pinoncillo, Habb-EI-Meluk, block vomit nut depending on the region is a member of the Euphobiaceae family (Schmook *et al.* 1997).

The toxicity of the seeds is mainly due to the following seed components: a toxic protein (curcin) and diterpene esters. (Heller Joachim 1996).

The seeds of *J. curcas* are a good source of oil although the seed cake (meal) is rich in protein, it is toxic to rats, mice and ruminants, therefore, can not be used as an animal feed. Several cases of *J. curcas* not poisoning in humans after accidental consumption of the seeds have been recorded. Symptoms such as giddiness, vomitina and diarrhea have been reported (Makkar and Becker, 1997).

The edible (non-toxic) varieties of *J. curcas* are restricted not only the Veracruz state in Mexico but are present in Quintana Roo state too. The seeds collected from Quintana Roo state seem to be of better quality as levels of protein, lipid and ash are higher and antinutritional and toxic factor lower in most samples. (Makkar *et al.*, 2002).

A non-toxic variety exists in Mexico which is used for human consumption after roasting. It does not contain phorbol esters. This non-toxic variety of *Jatropha* could be a potential source of oil for human consumption, and the seed cake can be a good protein source for humans as well as for livestock. (Reinhard and Rothkreuz 2004).

Crude protein, lipid and ash contents of kernels of the non-toxic provenance of *J. curcas* from Veracruz state range from 27 to 30%, 55-62%, and 3.7-5.2%, respectively (Makkar *et al.*, 2002).

The chemical composition of *Jatropha curcas* seeds cultivated in Egypt was: moisture (6.20%), protein (18.0%), fat (38.0%), carbohydrates (17.0%), fiber (15.5%) and ash (5.3%) (Reyadh, 2000).

Crude fat content (based on the seed) of *Jatropha curcas* seed of different samples from different locations, Fogo, Santiago and Sao Tome were 34.09, 32.9 and 23.67%, respectively (Heller, Joachim, 1996).

Numerous sources are available on the fatty acid composition of physic nut oil originating from different countries. The average saturated fatty acids content of the seed samples is low (15.38% and 6.24% palmitic and stearic acids, respectively). The average content of the unsaturated fatty acids (oleic and linoleic acids) is considerably higher (40.23 and 36.32%, respectively). depending on the origin both oleic and linoleic acids content is higher. The seed oil belongs to the oleic or linoleic acid group, to which the majority of vegetable oils (Rehm and Espig, 1991).

Accordingly, this work was carried out to study the gross chemical composition of *Jatropha curcas* L. seeds and physical and chemical properties of its oil.

MATERIALS AND METHODS

Materials:

***Jatropha curcas* L. seeds:** were obtained from Inshas Experimental Station, Water Management and Irrigation System Research Institute, National Water

Research Center, Ministry of Water Resources and Irrigation, Sharkiya Governorate, Egypt. The seeds were harvested twice the first one collected in June 2005 and the second was in Sept. 2005.

Methods:

1. Extraction of oil from *Jatropha curcas* L. seed:

Jatropha curcas L. seeds were crushed twice using grinder model (MF10 microfine grinderdrive), soaked in pure n-hexane for 24 hours. The miscella were collected and filtered. This process was repeated three times using fresh solvent each time. The solvent was evaporated under vacuum at 40-45°C in rotary-evaporator, the oil was dried over anhydrous sodium sulfate, filtered, stored in dark brown bottles without any further purification and then kept at 5°C until analysis (A. O.C.S. 1981).

2. Gross chemical composition of *Jatropha curcas* L. seed:

- Moisture, total lipids, crude protein, fiber and ash contents were determined according to the methods of the A.O.A.C (2000). Total carbohydrates: were estimated by deference.

3. Physical and chemical properties of *Jatropha* oil:

- Refractive index: of the oil was determined at 25°C according to A.O.A.C (2000) by using refractometer (NYRL-3 Poland).
- Acid, peroxide, iodine values, and unsaponifiable matters: were determined according to the methods of the A.O.A.C. (1995).
- Absorbency in ultraviolet at 230 and 270 nm.: ultraviolet and visible spectra were conducted using a Pye Unicam double beam recording spectrophotometer model SP 1600, as described by Kates (1972). The samples were dissolved in freshly distilled cyclohexane and the absorption were taken at 230 and 270 nm.

4. Fatty acid composition:

The fatty acids methyl esters were prepared using trans-esterification with cold methanolic solution of potassium hydroxide. The fatty acid methyl esters was identified by GC-Capillary column according to the methods of IOOC (2001).

5. Analysis of unsaponifiable matter by GLC:

The unsaponifiable matter was separated from the *Jatropha* seed oil at room temperature according to the method of A.O.A.C (2000). Identification of hydrocarbons and sterols contents of the unsaponifiable matter was carried out by comparison of their retention times and conjunction with authentic reference compounds. Quantitation was based on peak area integration.

RESULTS AND DISCUSSION

Gross chemical composition of *Jatropha curcas* L. seed :

Gross chemical composition of the first and second harvest of *Jatropha* seeds was carried out and the results are given in data presented in

Table (1), it could be observed that *Jatropha* seed contains 21.51 and 29.93% crude oil, 16.41 and 17.92% crude protein, 9.18 and 8.81% moisture content, 29.44 and 23.63% crude fiber, 3.24 and 3.06% ash and 20.22 and 16.65 % total carbohydrate in first and second harvest, respectively. These results are in the range found by Reyadh (2000).

Table (1): Chemical composition of *Jatropha curcas* L. seeds

Constituents (%)	Harvest	
	First	Second
Moisture content	9.18	8.81
Crude oil	21.51	29.93
Crude protein	16.41	17.92
Crude fiber	29.44	23.63
Ash	3.24	3.06
Total carbohydrates	20.22	16.65

Physical and chemical properties of *Jatropha curcas* L. seed oil:

The physical and chemical properties of *Jatropha* seed oil were estimated. The obtained results are shown in Table (2). Regarding to data in the same table, it could be noticed that the refractive index of the investigated oils beings 1.4719 and 1.9723 for first and second harvest of *Jatropha* seed oil, respectively. These low values of refractive index were in accordance with other vegetable oils. Acid value of *Jatropha* seed oils were 5.6 and 4.12 mg/gm oil for first and second harvest, respectively, these values were similar other edible vegetable oil. Peroxide values were 0.36 and 0.27 mequv. / kgm oil for first and second harvest of *Jatropha* seed oil, respectively. These low peroxide values indicated that crud oil contained a considerable amount of natural antioxidants which results in self protection during oxidation stages, these data of peroxide values were parell with data from K270 (0.56 and 0.35 nm.) for the same previous samples, respectively. Iodine value were 109.11 and 111.93 of *Jatropha* seed oil for first and second harvest, respectively, this may be due to the high amount of unsaturated fatty acids in *Jatropha* seed oil, especially oleic and linoleic acids. These results are in agreement with those reported by Reyadh (2000).

Table(2)Physical and chemical properties of *Jatropha Curcas* L. seed oil:

Physical and chemical properties	Harvest	
	First	Second
Refractive index at 25°C	1.4719	1.4723
Acid value (mg/gm oil)	5.60	4.12
Peroxide value (mequ/kg oil)	0.36	0.27
Iodine value (I ₂ /100g oil)	109.11	111.93
Diene at 230 (nm.)	2.89	2.12
Triene at 270 (nm.)	0.56	0.35
Unsaponifiable matter (%)	1.08	1.34

Fatty acid composition of *Jatropha curcas* L. seed oil:

Separation and determination of fatty acid methyl esters were carried out by GC-Capillary column chromatography to identify their types and

amount. The obtained results are shown in Table (4). The predominant unsaturated fatty acids related to first and second harvest of *Jatropha* seed oils are oleic acid (47.29% and 45.07%) followed by linoleic acid (30.68% and 33.07%), respectively. Also the major saturated fatty acids of the oil are palmitic acid (13.45% and 13.83%), followed by stearic acid (7.24% and 6.78%), respectively. The percentages of total saturated fatty acids of *Jatropha* seed oil were 20.97% and 20.86% and total unsaturated fatty acids were 79.03 and 79.14% in first and second harvest, respectively. From above mentioned data it could be concluded that *Jatropha curcas* L. seed oil contained a high amount of essential fatty acid linoleic acid (18:2 (ω6) which increased the nutritional properties of investigated oil. These results are in agreement with those obtained by Rehm and Espig (1991) and Reyadh (2000).

Table (3): Fatty acid composition of *Jatropha curcas* L. seed oil.

Fatty acids composition (%)	Harvest	
	First	Second
Palmitic acid (C _{16:0})	13.45	13.83
Palmitoleic acid (C _{16:1})	0.78	0.76
Stearic acid (C _{18:0})	7.24	6.78
Oleic acid (C _{18:1})	47.29	45.07
Linoleic acid (C _{18:2})	30.68	33.07
Linolenic acid (C _{18:3})	0.28	0.24
Arachidic acid (C _{20:0})	0.28	0.25
Total saturated fatty acids	20.97	20.86
Total unsaturated fatty acids	79.03	79.14

The components of unsaponifiable matter of *Jatropha curcas* L. seed oil:

The unsaponifiable matters of *Jatropha* seed oil were identified using GLC. The results are illustrated in Table (4). The unsaponifiable matter of *Jatropha* seed oil contains 40.4% and 32.05% total hydrocarbon and 59.60% and 64.63% total sterols in first and second harvest, respectively. The major compounds hydrocarbons in first harvest are squaline (17.75%), C₁₄ (8.46%), C₂₂ (6.91%) and C₂₀ (2.76%). Also the predominant hydrocarbons in second harvest are squaline (14.88%) followed by C₃₀ (7.38%), C₂₂ (4.49%), C₁₆ (3.74%) and C₂₀ (1.56%). On the other hand, the sterols components of *Jatropha* seed oil in first harvest consists mainly of three compounds, stigmasterol (5.41%), campsterol (7.06%) and β-sitosterol (46.78%) in first harvest, but the sterols components of *Jatropha* seed oil in second harvest contains of four compounds; stigmasterol (5.47%), campsterol (6.69%), β-sitosterol (43.57%) and Δ-7-Avenosterol (8.9%).

It is clear from the data presented in this study, that there is a little change in chemical composition of *Jatropha curcas* L. seeds and physical and chemical characteristics of oil during first and second harvest. This may be due to difference in climatic conditions during harvest June 2005 and harvest Sept. 2005 in Egypt, which play great role on the physical and chemical characteristic of *Jatropha* seed oil.

Table (4) Unsapariifiable matters of *Jatropha curcas* L. seed oil:

Unsupomifiuble matter (%)	Harvest	
	First	Second
C ₁₄	8.46	-
C ₁₆	4.52	3.74
C ₁₈	-	-
C ₂₀	2.76	1.56
C ₂₂	6.91	4.49
C ₂₄	-	-
C ₂₆	-	-
C ₂₈	-	-
C ₃₀	-	7.38
C ₃₂	-	-
Squaline	17.75	14.88
Unknown	-	3.32
Stigmasterols	5.41	5.47
Camasterols	7.06	6.69
β -sitosterols	46.78	43.57
Δ -7-Avenoslerol	0.65	8.9
Total hydrocarbons	40.40	32.05
Total sterols	59.60	64.63

In conclusion, the seeds of *Jatropha* are a good source of oil and the seed meal is rich in protein and carbohydrates contents and the natural antioxidants (squaline and β -sitostestrols) of its oil are a very high. Further studies should be carried out on the toxicity of *Jatropha curcas* L. seed (diterpene esters in oil and curcun in protein).

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الخواص الطبيعية والكيميائية لزيت بذور الجاتروفا

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يشتمل هذا البحث دراسة التركيب الكيميائي لبذور الجاتروفا والخواص الطبيعية والكيميائية لزيت بذور الجاتروفا المنزعة بمصر وذلك من خلال فترتي حصاد أولى وثانية عام ٢٠٠٥ ونتائج الدراسة يمكن توضيحها كالآتي:

- أظهرت دراسة التركيب الكيميائي لبذور الجاتروفا أنها تحتوى على ٩,١٨ ، ٨,٨١% رطوبة و ٢١,٥ و ٢٩,٩٣% زيت خام و ١٦,٤١ و ١٧,٩٢% بروتين خام ٢٩,٤٤ و ٢٣,٦٣% ألياف خام و ٣,٢٤ و ٣,٠٦% رماد و ٢٠,٢٢ و ١٦,٦٥% كربوهيدرات فى الحصاد الأول والثانى على التوالى.
- كما تم تقدير الثوابت الطبيعية والكيميائية لزيت بذور الجاتروفا وأشارت النتائج على أن معامل الانكسار ورقم الحامض ورقم البيروكسيد والرقم اليودى K230 and 270 ونسبة المواد الغير قابلة للتصين كانت (١,٤٧١٩ و ١,٤٧٢٣ على ٢٥°م) و (٥,٦ و ٤,١٢ جم/مجم زيت) و (٠,٣٦ و ٠,٢٧ ملغمكافى /كجم زيت) و (١٠٩,١١ و ١١١,٩٣ جم بود/١٠٠جم زيت) و (٢,٨٩ و ٢,١٢ نانوميتر) و (٠,٥٦ و ٠,٣٥ نانوميتر) و (١,٠٨ و ١,٣٤%) فى الحصاد الأول والثانى على التوالى.
- كما تم تقدير تركيب الأحماض الدهنية لزيت بذور الجاتروفا وأوضحت النتائج أن المكون الرئيسى للأحماض الدهنية الغير مشبعة لزيت بذور الجاتروفا فى فترة الحصاد الأولى والثانية كان حامض الأوليك (٤٧,٢٩ و ٤٥,٠٧%) يليه حامض اللينوليك (٣٠,٦٨ و ٣٣,٠٧%) وأيضا المكون الرئيسى للأحماض الدهنية المشبعة كان حامض البالميتك (١٣,٤٥ و ١٣,٨٣%) ثم حامض الاستيرك (٧,٢٤ و ٦,٦٨%) على التوالى.
- كما أظهر تحليل المواد الغير قابلة للتصين لزيت بذور الجاتروفا بواسطة جهاز الـ GLC أنها تحتوى على (٤٠,٤١ و ٣٢,٠٥%) هيدروكربونات كلية و (٥٩,٦٠ و ٦٤,٦٣%) استيروولات كلية فى الحصاد الأول والثانى على التوالى وعلى أية حال يمثل مركب الاسكوالين أعلى كميات الهيدروكربونات الكلية (١٧,٧٥ و ١٤,٨٨%) بينما البيتاسيتوستيروول هو المكون الرئيسى من الاستيروولات الكلية (٦,٧٨ و ٤,٣٠٧%) فى الحصاد الأول والثانى على التوالى.

