ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Physico-chemical properties of oil produced from *Moringa oleifera*, *Jatropha curcas* and *Carthamus tinctorius L* seeds

Arafat M. Goja

Department of Food Science & Technology, Faculty of Agriculture & Natural Resources, University of Bakht Alruda, Ed-Dueim, Sudan.

Manuscript Info

Manuscript History:

Received: 17 May 2013
Final Accepted: 25 May 2013
Published Online: June 2013

Key words:
Moringa oleifera,
Jatropha curcas,
Safflower,
Physicochemical properties.

Abstract

The aim of the present study was to investigate the physicochemical properties of *Moringa oleifera*, *Jatropha curcas and* Safflower (*Carthamus tinctorius L.*) seed oil obtained from the farm of the Faculty of Agriculture, University of Bakht Alruda and Forestry garden in Ed Dueim city, Sudan. The hexane-extracted oil yield of Moringa, Jatropha and Safflower was 34.5, 63 and 42% respectively. Results of physical and chemical parameters of the extracted oils were as follows: Peroxide number, 14.5, 16.5 and 83; Saponification value, 134.40, 206.93 and 141.78 mg/g; Iodine value, 14.5, 24.5 and 16.7 g/100g; Free fatty acids (FFA), 0.376, 0.765 and 0.210%; Viscosity, 40.7, 53,2 and 97.5 (mPas), respectively. The result's analysis of fatty acid profile of *Moringa oleifera* seed oil showed Oleic acid (42.43%) and α-Linolenic (32.82%) are the most predominant fatty acids, followed by Palmitic (9.04%), Elaidic (5.66%), Behenic (2.98%), Stearic (2.27%), Palmitoleic (2.07%) and Arachidic (1.61%). The Minor content of Nervonic, Myristic, Myristoleic, Linoleic and g-linolenic were present and the values don't exceed 0.50% of the total fatty acids. From the results obtained, it can be concluded that the hexane solvent is more effective in the extraction of oil from Jatropha seeds than Safflower and Moringa. However, Moringa seed oil can be used as edible oil in human nutrition due to their high content of unsaturated fatty acids (61.53%).

Introduction

Nowadays, seed oils produced from plants have been received a great amount of attention as natural oils as well as nutritional, industrial, biofuel and pharmaceutical importance. *Moringa oleifera* seed oil is commercially known as "Ben oil" or "Behen oil." The oil content is ranging from 25-41% (Lalas and Tsaknis, 2002) and characterized by high amounts of oleic acid up to 75 % (Anwar *et al.,* 2006), which make it suitable for edible purposes and due to good oxidative stability, its use in food industry as allowing for longer storage and high-temperature frying processing (Palafox *et al.,* 2012). This oil has also been used in perfume and skin lotion (Mahmood et al. 2010), illumination and lubrication (Anwar *et al.,* 2006), cosmetic purposes (García-Fayos *et al.,* 2010), Medicinal uses (Anwar *et al.,* 2007) antifungal activities (Chuang *et al.,* 2007) and lately for a potential nominee for biodiesel fuel production (Rashid *et al.* 2008; Palafox *et al.,* 2012).

Jatropha is a genus belongs to *Euphorbiaceae* family. It is the origin of Central America and Mexico (Asoiro *et al.,* 2011) and has been distributed in many tropical and subtropical countries, including Africa, India and North America (Adebayo *et al.,* 2011). The *Jatropha curcas* seeds yield 27 -40 % oil (Achten *et al.,* 2007), and it considered as the best source of biofuel production among the various plants based fuel resources (Tint and Mya, 2009), and it has been reported that by 2016 will be provided about 37 billion gallons of the world biofuel demand (Adebayo *et al.,* 2011). This means it could be reduced the oil imports and saving the hard foreign currency besides providing the much-needed energy security (Asoiro *et al.,* 2011). The extracted oil of Jatropha seeds can

be used in soap, dyes, insecticide, pesticide, illuminant, and alternative-fuel production (Ejilah *et al.,* 2010).

Safflower (*Carthamus tinctorius L.*) is commonly known as khortom in Sudan, kusum in India and Pakistan (Emongor, 2010) and honghua (red flower) in China (Chavan, 1961). It is oil seed crops, contain about 80% oleic and linoleic acid, iodine value (148) and saponification value (190) (Rafiquzzaman *et al.,* 2006b), cultivated mostly for its high-quality oil, cut flowers, vegetables and medicinal plant. Safflower oils were used as a source of oil in the paint industry and edible oil for cooking, margarine production, and salad oil (Emongor, 2010). Therefore, it needed to be developed the oils produced from Safflower to be as a commercial product for edible oil, medicinal uses and pharmaceuticals, source of α- tocopherol, paint, varnishes and soap manufacturing industries.

As interest increases in the composition of seed oils, many studies have reported in *Moringa oleifera* (Tsaknis *et al.,* 1999; Lalas and Tsaknis, 2002; Anwar and Bhanger, 2003; Abdulkarim *et al.,* 2005; Anwar *et al.,* 2005, Anwar and Rashid, 2007), *Jatropha curcas* (Nzikou *et al.,* 2009a; Ejelonu *et al.,* 2010; Ejilah *et al.,* 2010; Belewu *et al.,* 2010; Montes *et al.,* 2011; Inekwe *et al.,* 2012) and *Carthamus tinctorius L* (Ingale and Shrivastava, 2011; Golkar *et al.,* 2011; Vosoughkia *et al.,* 2011). These studies revealed a wide difference in the physico-chemical properties of seed oils depending on the species, cultivars and environmental conditions. Oils are the very important natural source for many applications in the industrial life due to their low of processing cost and environmentally accepted and safe. Therefore, it is important to know the physicochemical properties of some plant oils in order to meet the increasing demand of a specific requirement of the global industries. However, until now, a specific characterization of the oil produced from the seeds of some plants has not been fully reported. The objective of this study to investigate the physical and chemical characteristics of seed oils obtained from *Moringa oleifera*, *Jatropha curcas* and *Carthamus tinctorius L.*, which are cultivated in White Nile State, Sudan as the newest promising of natural oil crops.

Material and Methods

Collection of Samples

The seeds used in this study were obtained from two sources, Safflower (*Carthamus tinctorius L.*) and *Jatropha curcas* seeds collected from the farm of the faculty of Agriculture and Natural Resources, University of Bakht Alruda and *Moringa oleifera* seeds from the Forestry garden of the Ed Deium city, Sudan.

Oil extraction:

The seeds were prepared for extraction by grinding using a laboratory mortar and pestle after removal of the seed coat (AOCS, 2001)). The oil was extracted by sohxlet extractor using normal hexane and oil properties were analyzed. About 10g of each grounded seed were fed into a Soxhelt extractor fitted with a 500 mL round-bottom flask and a condenser. The extraction was executed in a water bath for 6 h with 250 mL of n-hexane. After the extraction completed, the oil was then recovered by evaporating off the solvent using rotary evaporator Model (EYELA, Rotary Vacuum Evaporator N.N. Series equipped with an Aspirator and a Digital Water Bath SB-651, Japan) and trace solvent was removed by placed the in an air-oven at 60ºC for 1 h and then cooled and stored under refrigeration until used for further analysis.

Determination of Physico-chemical properties:

Peroxide number, iodine value, saponification value and free fatty acid contents were determined according to standard analytical methods recommended by AOAC (2006).

Viscosity determination:

A rheometer as described by Nzikou *et al.,* (2007) was used to measure the different oil viscosities. The extracted oil, Viscometer and water were conditioned at a temperature of 20^{O}C in water bath. The viscosity values were expressed in mPas, based on the speed and the geometry of the sample.

Colour and odour measurements:

The colour and odour of oils were measured based on the visual observation and smell volatilized, respectively according to sensory evaluation of volunteer's trainees.

Proximate Analysis:

Proximate analysis of *Moringa oleifera* seeds was carried out as described by the Association of Official Analytical Chemists (AOAC, 2006).

Determination of Fatty Acid (FA) Profile of *Moringa oleifera* seed oil:

The fatty acid composition was determined using the Gas Chromatography Spectrophotometer (GC-2014, Shimadzu, Japan) and standard fatty acids after the oils were converted to fatty acid methyl esters by using Sodium hydroxide/Methanol method which they were already dissolved in hexane (Christie,1982). The identification of the peaks was obtained by comparing their retention time with standards fatty acids analyzed under the same

conditions. The relative percentage of fatty acid was calculated based on the peak area of a fatty acid species in the total peak area of all the fatty acids in the oil sample.

Results and Discussion:

The present study was carried out to investigate the physical and chemical properties of *Moringa oleifera, Jatropha curcas* and *Carthamus tinctorius L* oils (Table 1) and only *Moringa oleifera* oil was analysed for proximate composition (Table 2) and fatty acid profile (Table 3).

Table 1: Physicochemical characteristics of *Moringa oleifera, Jatropha curcas* and *Carthamus tinctorius L* seed oils.

Characteristics	*Moringa oleifera*	*Jatropha curcas*	*Carthamus tinctorius L.*
% of oil (Solvent extraction)	34.50	63.00	42.00
Peroxide number	14.50	16.50	83.00
Saponification value (mg/g)	134.4	206.90	141.78
Iodine value (g/100g)	14.30	24.50	16.70
FFA (%)	00.37	00.76	00.21
Viscosity (mPas)	40.70	53.20	97.50
Colour	Pale yellow	Golden	Yellow
Odour	Accepted	Unaccepted	Unaccepted

Oil content:

Data presented in Table 1, shown that the average content of oil was 34.5% for Moringa oleifera, 63% for *Jatropha curcas* and 42 % for *Carthamus tinctorius L*. The highest yield (63%) of Jatropha oil was come in agreement with 60-80% of Belewu *et al.* (2010) reports but higher than 39.7; 45.1 and 50.0 % reported by Adebayo *et al.* (2011); Ejelonu *et al.* (2010) and Nzikou *et al.* (2009a), respectively. However, in the reports of Adebayo *et al.* (2011); Ejelonu *et al.* (2010) and Nzikou *et al.* (2009a), petroleum ether was used as against the n-hexane used in this study. This could be due to the use of n-hexane has been more effective than petroleum ether in the extraction of oils from Jatropha seeds (Adebayo *et al.*, 2011). In the case of *Moringa oleifera* (34.5%) and *Carthamus tinctorius L.* (42%), the oil yield percent comes in agreement with the many authors finding, Anwar *et al.*, (2006) (30 – 38.37%), Anwar and Rashid (2007) (34.80%) obtained from *Moringa oleifera* seeds and Cosge *et al.* (2007) (20 – 45%), Ingale and Shrivastava (2011) (25.6 – 56.2%) obtained from *Carthamus tinctorius L* seeds.

Physico-chemical Properties:

The result showed that all the *Moringa oleifera, Jatropha curcas* and *Carthamus tinctorius L* seed oils had high saponification values, peroxide and viscosity and low iodine values and FFA contents, respectively. However, the colour and odour of oil for *Moringa oleifera* is Pale yellow and accepted respectively, while for those *Carthamus tinctorius L* and *Jatropha curcas* are yellow and golden with both unaccepted in the odour (Table 1). The peroxide number of *Carthamus tinctorius L* oil was higher (83 meq/kg) than the *Jatropha curcas* (16.5 meq/kg) and *Moringa oleifera* (14.5 meq/kg) oils. The values were indicated to the oxidative stabilities of the seed oil; the higher value, the greater development of oxidation and this cause deterioration of lipids. However, all the values obtained are greater than the limits of the values that are used for edible oils in food processing (< 10 meq/kg). Hence, mostly these oils are not used in food-processing Olaniyan and Oje, (2007), especially *Jatropha curcas* oil due to the presence of phorbol esters, which is reported to be orally toxic to humans (Ahmed and Salimon, 2009). Saponification value of *Moringa oleifera* (143.4mg/g) and *Carthamus tinctorius L.* (141.78mg/g) oils were lower than the value (206.93mg/g) of *Jatropha curcas*. The values of saponification are indicative of the average molecular weight of fatty acid content as a glyceride in the oil (Ngoddy, 1992; Inekwe *et al.*, 2012). Saponification value of *Jatropha curcas*, was in close agreement with values (205 – 210 mg\g) of Inekwe, *et al.* (2012) and slightly higher from Oladele and Oshodi, (2008); Akbar *et al.* (2009) and Ejilah *et al.* (2010), they reported saponification values of *Jatropha curcas* oil was 193.55, 198.5 and 198 mg/g, respectively. However, the values of *Moringa olei*fera and *Carthamus tinctorius L* were lower from the finding (181.4 mg/g) of Anwar and Rashid (2007) and (189 – 190 mg/g) of Rafiquzzaman *et al.* (2006a), respectively. Generally, the high number of saponification value is the indicator of the oil's suitability in the soap manufacturing (Akbar *et al.*,

2009). Iodine value is a reflection of the unsaturated degree of fats and oil and therefore, the high iodine values, indicator of the high number of unsaturated double bonds. The present results show the iodine value (24.5 g/100g) of *Jatropha curcas* oil was higher than the *Carthamus tinctorius L.* (16.7g/100g) and *Moringa oleifera* (14.3g/100g) and comes into agreement with the value (20.30 – 29.24 g/100g) obtained by Belewu *et al.* (2010). The higher values up to 60g/100g were reported by several authors in *Moringa oleifera* (Lalas Tsaknis 2002; Anwar *et al.*, 2006; Anwar and Rashid, 2007).

Proximate analysis of *Moringa oleifera* Seeds:
Table 2 showed the seeds of *Moringa oleifera* like other portentous seed, are a good source of proteins, fats and crude fibre.

Table 2: Results of proximate analysis of *Moringa oleifera* seeds

Constituents	Percentage value (%)
Moisture	03.10
Oil	34.50
Crude Protein	34.00
Crude fibre	04.90
Ash	03.50
Total Carbohydrates	17.50

In this study, the crude protein is about 34.0% and is in agreement with that result (34.37%) from Burkina Faso reported by Compaoré et al. (2011). Similar results obtained by Compaoré et al. (2011) and Anwar et al. (2006). It is higher, comparing to safflower seeds (*Carthamus tinctorius L*) (14 – 15 %) (Gecgel *et al.*, 2007) and *Jatropha curcas* (19.29 – 27.57%) (Montes *et al.*, 2011). The oil content (34.5%) in the present study comes within the range (25 – 35.7%) reported by Tsaknis *et al.* (1999). Similar findings (30.36 – 38.37%) were obtained by Anwar *et al.* (2006) using Soxhlet extraction methods with hexane solvent carried out on *Moringa oleifera* samples collected from drought and irrigated regions of Pakistan. Crude fibre of *Moringa oleifera* seed is about (4.9%) similar to Compaoré *et al.* (2011) findings (4.7%). It is slightly higher from that reported from Congo Brazzaville by Nzikou et al. (2009b) (3.2%) and lower from the range (6.6 to 9%) reported by Anwar *et al.* (2006). The low moisture content (3.1%) of *Moringa oleifera* seeds is a reflection of their ability to the storage, and it would prevent them to be attacked by microorganism. The Ash content (3.5 %) obtained in this study was near to that achieved (4.98%) by Compaoré *et al.* (2011) and comes within the range (2 – 7%) reported by Gecgel *et al.* (2007). Carbohydrates of *Moringa oleifera* seed are about 17.5%, which was agreed to a range (16.5 – 17.8 %) reported by Abdulkarim *et al.* (2005) and slightly higher than the value 9.17% and 13.6% obtained by Compaoré et al (2011) and Nzikou *et al.* (2009b), respectively. Generally, *Moringa oleifera* seeds as good concentration of proteins, ashes, fats, fibre and carbohydrates; it would be a good fodder for animal's feeding.

Fatty acid profile of *Moringa oleifera* seed oil:
The fatty acid profile of *Moringa oleifera* seed oil is the best indicator of its uses for nutritional, industrial and pharmaceutical purposes. The results of the analysis for fatty acids in the study showed that, Oleic acid (42.43%) and α-Linolenic (32.82%) was the most predominant fatty acids of *Moringa oleifera* oil, followed by Palmitic (9.04%), Elaidic (5.66%), Behenic (2.98%), Stearic (2.27%), Palmitoleic (2.07%) and Arachidic (1.61%). The lesser content of Nervonic, Myristic, Myristoleic, Linoleic and g-linolenic were present and the values of them did not exceed 0.50% of the total fatty acids (Table 3).

Table 3: Relative percent composition of fatty acid in *Moringa oleifera* seed oil

Fatty acid compounds	Concentration %
Myristoleic (C14:1c9)	00.29
Myristic (C14:0)	00.30
Palmitoleic (C16:1c9)	02.07
Palmitic (C16:0)	09.04
g-linolenic (C18:3c6,9,12)	00.06
Linoleic (C18:2 c9,12)	00.10
α-Linolenic (C18:3c9,12,15)	32.82
Oleic acid (C18:1c9)	42.43
Elaidic acid (C18:1c9)	05.66
Stearic acid (C18:0)	02.27
Arachidic (C20:0)	01.61
Behenic (C22:0)	02.89
Nervonic (C24:1)	00.45
Total saturated fatty acid	38.46
Total unsaturated fatty acid	61.53
Total	99.99

From the results, the major saturated fatty acids, including Myristic (C14:0), Palmitic (C16:0), Stearic (C18:0), Arachidic (C20:0) and Behenic (C22:0) were represented (38.46%) of the total fatty acids, while the main unsaturated fatty acids, Oleic (C18:1), Myristoleic (C14:1), Linoleic (C18:2), α-Linolenic (C18:3), g-linolenic (C18:3), Palmitoleic (C16:1), Elaidic (C18:1) and Nervonic (C24:1) are present in the ratio of 61.53%. Fatty acid's profiles

obtained in the study comes in partial agreement with results obtained by Compaoré *et al.* (2011) and Anwar *et al.* (2006) and differ from the results that have been reported by Abdulkarim *et al.* (2005). These differences between the findings could be due to the differences of environmental conditions, including climate cultivation, soil composition, maturity level and the harvesting time (Compaoré *et al.,* 2011). As observed in this study, the unsaturated fatty acids (61.53%) more than saturated fatty acids (38.46%), which were very important for human and animal health Moyo *et al.* (2011), especially the existence of polyunsaturated fatty acids (C18:2 and C18:3). On the other hand, the high content of monounsaturated fatty acid such as Oleic acid (42.43%), preferred for nutrition purposes like its stability in cooking and frying (Anwar *et al.,* 2006; Compaoré *et al.,* 2011).

Conclusion:

From the result obtained in the study, it can be concluded that the extraction of oil by Sohxlet apparatus using normal hexane is more effective in oil extraction from *Jatropha curcas* seeds than the safflower (*Carthamus tinctorius L.*) and *Moringa oleifera*. The characterization of *Moringa oleifera* seed oil indicates this oil contain high unsaturated fatty acids, which could make it possibly utilized in nutritional and industrial purposes. However, the seed itself can be used in animal feeding as the source of proteins, fats, fibre and carbohydrates.

References

Abdulkarim, S.M., Long, K., Lai, O.M., Muhamm, S.K.S. and Ghazali, H.M. (2005): Some physico-chemical properties of Moringa *oleifera* seed oil extracted using solvent and aqueous enzymatic methods. Food Chem., 93: 253-263.

Achten, W.M.J., Mathijs, E., Verchot, L., Sjngh, V.P., Aerts, R. and Muys, B. (2007): Jatropha bio-diesel fueling sustainability. Biofuel, Bioproducts, and Biorefining 1(4): 283-291.

Adebayo, G.B., Ameen, O.M. and Abass, L.T. (2011): Physico-chemical properties of biodiesel produced from *Jatropha curcas* oil and fossil diesel. J. Microbiol. Biotech. Res., 1(1): 12-16.

Adebayo, G.B., Ameen, O.M. and Abass, L.T. (2011): Physico-chemical properties of biodiesel produced from *Jatropha curcas* oil and fossil diesel. J. Microbiol. Biotech. Res., (1):12-16.

Ahmed, W.A. and Salimon, J. (2009): Phorbol ester as toxic constituents of tropical *Jatropha curcas* seed oil. European Journal of Scientific Research, 31(3):429-436.

Akbar, E., Zahira, Y., Siti, K.K., Manal, I. and Jumat, S. (2009): Characteristics and composition of Jatropha *curcas* oil seed from Malaysia and its potential as Biodiesel feedstock.Euro J. Sci.Res.

Anwar, F. and Rashid, U. (2007): Physico-chemical characteristics of *Moringa oleifera* seeds and seed oil from wild provenance of Pakistan. Pak. J. Bot., 39(5): 1443-1453.

Anwar, F., Ashraf, M., Bhanger, M.I. (2005): Interprovenance variation in the composition of *Moringa oleifera* oil seeds from Pakistan. J. Am. Oil Chem. Soc., 82(1): 45-51.

Anwar, F., Bhanger, M.I. (2003): Analytical characterization of *Moringa oleifera* seed oil grown in temperate regions of Pakistan. J. Agric. Food Chem., 51: 6558-6563.

Anwar, F., Latif, S., Ashraf, M. and Gilani, A. H. (2007): *Moringa oleifera*: A Food Plant with Multiple Medicinal Uses. Phytother. Res. 21: 17–25.

Anwar, F., Zafar, S.N. and Rashid, U. (2006): Characterization of *Moringa oleifera* seed oil from drought and irrigated regions of Punjab, Pakistan. GRASAS Y ACEITES, 57 (2): 160-168.

AOAC. (2006): Official Method of Analysis of AOAC International 18th edition. American Oil Chemists' Society Press: Champaign, IL.

AOCS. (2001): "AOCS Official Method Aa 4-38 Reapproved 1997 Revised 2001: Oil". In: Official Methods and Recommended Practices of the AOCS (5th ed.). American Oil Chemists Society Press: Champaign, IL.

Asoiro, F. U., Eng, M. and Akubuo, C.O. (2011): Effect of Temperature on Oil Extraction of *Jatropha curcas* L. Kernel. The Pacific Journal of Science and Technology,12(2): 456-463.

Belewu, M.A., Adekola, F.A., Adebayo, G.B., Ameen, O.M., Mohameed, N.O., Olaniyan, A.M., Adekola, O.F., and Musa, A.K. (2010): Physico-chemical characteristics of oil and biodiesel from Nigerian and Indian *Jatropha curcas* seeds. Int. J. Biol. Chem. Sci. 4(2): 524-529.

Chavan, V.M. (1961): Niger and Safflower. Indian Central Oilseeds Committee Publication, Hyderabad, India, 57-150.

Christie, W.W. (1982): Lipid analysis, isolation, separation, identification and structural analysis of lipids, 2nd Edn. Pergamon, Oxford, 1982, 51–61.

Chuang, P.H., Lee, C.W., Chou, J.Y., Murugan, M. Shieh, B.J. and Chen, H.-M. (2007): "Antifungal Activity of Crude Extracts and Essential Oil of Moringa oleifera Lam.," Bioresource Technology, 98 (1): 232-236.

Compaoré, W.R., Nikièma, P.A ., Bassolé, H.I.N ., Savadogo, A., Mouecoucou, J., Hounhouigan, D.J. and Traoré, S.A . (2011): Chemical Composition and Antioxidative Properties of Seeds of *Moringa oleifera* and Pulps of *Parkia biglobosab* and *Adansonia digitata* Commonly used in Food Fortification in Burkina Faso. Curr. Res. J. Biol. Sci., 3 (1): 64-72.

Cosge, B., Gurbuz, B. and Kiralan, M. (2007): Oil content and fatty acid composition of some (*Carthamus tinctorius L.*) varieties sown in spring and winter. Int J Nat Eng Sci., 1: 11-15.

Ejelonu, B.C., Oderinde, R.A. and Balogun, S.A. (2010): Chemical and Biological Properties of *Jatropha curcas* and *Mucuna Solan* Seed and Seed Oil. Libyan Agric. Res. Cen. J. Intl., 1 (4): 263-268.

Ejilah, I.R., Asere, A.A., Adisa, A. B. and Ejila, A. (2010): The effect of diesel fuel-*Jatropha curcas* oil methyl ester blend on the performance of a variable speed compression ignition engine. AJAE, 1(3):80-85.

Emonger, V. (2010): Safflower (*Carthamus tinctorius L.*) the Underutilized and Neglected Crop: A Review. Asian J. Plant Sci., 1-8.

García-Fayos, B., Arnal, J.M., Verdú, G., Saurí, A. (2010): Study of *Moringa oleifera* Oil extraction and its influence in primary coagulation activity for drinking water treatment. International conference on food innovation. Universidad Politécnica de Valencia. Valencia (Spain), 25-29 October 2010.

Gecgel, U., Demirci, M. and Esendal, E. (2007): Seed yield, oil content and fatty acid composition of safflower (*Carthamus tinctorius L.*) varieties sown in spring and winter. Int. J. Nat. Eng. Sci., 1: 11–15.

Golkar, P., Arzani,A., and Rezaei, A.M. (2011): Genetic Variation in Safflower (*Carthamus tinctorious L.*) for Seed Quality-Related Traits and Inter-Simple Sequence Repeat (ISSR) Markers. Int. J. Mol. Sci., 12: 2664-2677.

Inekwe, U.V., Odey, M.O., Gauje, B., Dakare , A.M., Ugwumma, C.D. and Adegbe, E.S. (2012): Fatty acid composition and physicochemical properties of *Jatropha curcas* oils from Edo and Kaduna states of Nigeria and India. Annals of Biological Research, 3 (10):4860-4864.

Ingale, S. and Shrivastava, S.K. (2011): Chemical, nutritional and anti-nutritional study of new varieties of oil seeds from Sunflower, Safflower and Groundnut. Inter. J. of Biotechnology Applications. 3(4): 118-129.

Lalas, S. and Tsaknis, J. (2002): Characterization of *Moringa oleifera* Seed Oil Variety ''Periyakulam 1''. Journal of Food composition and analysis, 15: 65–77.

Mahmood, K.T., Mugal, T.A. and Ul Haq. T. (2010): *Moringa oleifera*: a natural gift-A review. J. Pharm. Sci. & Res., 2 (11): 775-781.

Montes, J.M., Aliciardi, M.R., Chávez, J.V., Guzmán, C., and Calandri, E. (2011): Characterization of *Jatropha curcas L* seed and its oil, from Argentina and Paraguay. J. Argent. Chem. Soc., 98: 1-9.

Moyo, B., Masika, P.J., Hugo, A. and Muchenje, V. (2011): Nutritional characterization of Moringa (*Moringa oleifera* Lam.) leaves. Afr. J. Biotechnol., 10 (60): 12925-12933.

Ngoddy, P.O. (1992): Integrated Food Science and Technology for the Tropics. 2nd ed. Macmillian Press ltd. London.

Nzikou, J.M., Matos, L., Mobemba, F., Ndangui, C.B., Pambou -Tobi, N.P.G., Kimbonguila, A., Silou, T., Linder, M. and Desobry, S. (2009a): Characteristics and Composition of *Jatropha curcas* Oils, Variety Congo-Brazzaville. Res. J.Appl. Sci. Eng. Technol., 1(3): 154-159.

Nzikou, J.M., Matos, L., Moussounga, J.E., Ndangui, C.B., Kimbonguila, A., Silou, T. Linder, M. and Desobry, S. (2009b): Characterization of *Moringa oleifera* seed oil variety Congo Brazzaville. J. Food Technol., 7(3):59-65.

Nzikou, J.M., Mvoula-Tsieri, M., Matos, L., Matouba, E., Ngakegni, A.C., Linderand, M. and Desobry, S. (2007): *Solanum nigrum L.* seeds as an

alternative source of edible lipids and nutriment in Congo Brazzaville. J. Appl. Sci., 7: 1107-1115.

Oladele, E.P. and Oshodi, A.A. (2008): Effect of fermentation on some chemical and nutritive properties of Berlandier Nuttle Spurge (*Jatropha cathartica*) and Physic Nut (*Jatropha curcas*) seeds. Pakistan Journal of Nutrition 7(2): 292-296.

Olaniyan, A.M. and Oje, K. (2007): Quality characteristics of Shea butter recovered form Shea kernel through dry extraction process. J. Food Sci. Technol., 44 (4): 404-407.

Palafox, J.O., Navarrete, A., Sacramento-Rivero, J.C., Rubio-Atoche, C., Escoffie, P.A., Rocha-Uribe, J.A. (2012): Extraction and Characterization of Oil from *Moringa oleifera* Using Supercritical CO_2 and Traditional Solvents. American J. of Analytical Chem., 3: 946-949.

Rafiquzzaman, M., Hossain, M.A. and Hasan, A.M. (2006b): Studies on the Characterization and Glyceride Composition of Safflower (*Carthamus tinctorius*) Seed Oil. Bangladesh J. Sci. Ind. Res. 41(3-4): 235-238.

Rafiquzzaman, M., Rahman, M.S., Hossain, M.A. and Hasan, A. J.M.M. (2006a): Studies on the preparation of oleo-resinous wood varnishes by utilizing safflower (*Carthamus tinctorius*) seed oil. Bangladesh J. Sci. Ind. Res. 41(1-2): 77-82.

Rashid, U., Anwar, F., Moser, B.R. and Knothe, G. (2008): *Moringa oleiferaoil*: A possible source of biodiesel. Bioresource Technology, 99: 8175–8179.

Tint, T.K. and Mya, M. (2009): Production of biodiesel from Jatropha oil (*Jatropha curcas*) in Pilot Plant. World Academy of science, Engineering and technology, 477-480.

Tsaknis, J., Lalas, S., Gergis, V., Dourtoglou, V., Spilitois, V. (1999): Characterization of *Moringa oleifera* variety Mbololo seed oil of Kenya. J. Agric. Food Chem., 47: 4495–4499.

Vosoughkia, M., Ghareaghag, L.H., Ghavami, M., Gharachorloo. M., and Delkhosh, B. (2011): Evaluation of Oil Content and Fatty Acid Composition in Seeds of Different Genotypes of Safflower (*Carthamus tinctorius L.*). Inte. J. of Agric. Sci. and Res., 2 (1): 2-11.

****