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Quality assessment profile of *Jatropha curcas* (L) seed oil from Nigeria

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Abstract

This study investigated the nutritional and chemical properties of *Jatropha curcas* (L) seed oil from Abia State, Nigeria using standard analytical methods. Proximate composition results show it is rich in protein (29.4%), carbohydrate (16.89%) and fat (46.89%). Low concentrations of phytonutrients were also detected; alkaloids (1.5 g/100 g), flavonoids (0.81 g/100 g). The seed is also rich in essential and non-essential amino acids in varying concentrations. The mineral content is low ranging between 0.09 ± 0.01 Mg/Kg for Pb as lowest to 163.38 ± 4.00 Mg/Kg for Mg as the highest amongst other minerals. Physicochemical analysis result shows percentage yield (62.20), specific gravity (0.92), acid value (9.48), iodine value (95.00), and saponification number (195.00), while peroxide value and percentage free fatty acid were less than 5. The *Jatropha curcas* (L) oil is also rich in unsaturated fatty acids especially oleic acid (52.27%) and linoleic acid (27.87%). The dominant saturated fatty acids were palmitic acid (14.24%) and stearic acid (5.15%).These results suggest that *Jatropha curcas* (L) seed oil may not be suitable for human consumption except it is subjected to detoxification and purification before use, but may be suitable for industrial purposes such as production of soaps, paints and lubricants.

Introduction

In recent years, there has been tremendous increase in the biochemical investigation of vast number of oil seeds in the world (Nzikou *et al*., 2009). The quest to save resources spent on buying oil for domestic and industrial purposes have created a novel search for using underutilized seeds as sources of oil to complement the already existing traditional sources of oil (Akubugwo and Ugbogu, 2007). Several investigators have therefore developed interest in under-utilized oil seeds as an alternative source of food and energy (Nzikou *et al*., 2009; Emil *et al*., 2009). In Nigeria, there exists a wide variety of oil crops ranging from the largely known and highly-utilized to under-utilized seed oils (Odunfa and Oyeyiola, 1985; Oseni and Akindahunsi, 2011). There exists in Nigeria presently, using under-utilized oils that have not been investigated for their potential uses. One of such under-utilized seed is the *J. curcas* seed and its oil.

J. curcas (L) belongs to the family of Euphorbiaceae. It is a deciduous shrub that grows up to a height of 3-5 meters and with a productive life span of 50 years. It is a multipurpose shrub that grows throughout the arid, semi-arid tropical and subtropical regions of the world (Fairless, 2007). *J. curcas* (L) has gained a world reputation as a plant that can be grown in wasteland and infertile land, which does not require much water, fertilizer and management, and has high oil yield (Chitra *et al.*, 2005). The present study is to investigate the nutritional and chemical composition of *J. curcas* (L), hence determine its suitability as a source of oil for domestic and industrial purposes.

Materials and Methods

Healthy seeds of *J. curcas* (L) were collected from Amaku Nvosi in Isiala Ngwa South Local Government Area, Abia State, Nigeria. The seeds were identified at the Department of Plant Science and Biotechnology, Abia State University, Uturu Nigeria. Samples of the identified seeds were deposited at the herbarium of the department. The seeds were dehulled, cleaned, sun-dried, milled into a paste using thermal Willey Mill (Model ED - 5, USA).The seed oil was extracted using 50 g of prepared paste in normal hexane (60-80^{o}C) with a Soxhlet apparatus. A rotary evaporator was used to remove the solvent and recover the concentrated oil.

Proximate Analysis

The crude protein content was determined by the micro-Kjeldahl method, and nitrogen determined

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spectrophotometrically as described by Delanghe *et al.* (1989), and the protein content obtained by multiplying the quantity of nitrogen by the coefficient 6.25. Crude fat was determined by constant extraction in soxhlet apparatus (YSI-422 Yorco, USA) for 8 hours using n-hexane as solvent. Ash content was measured by a muffle furnace at 5500C as described by James (1995). The carbohydrate content was determined using the method described by Udoh and Ogunwole (1986), while alkaloids were measured using the method as described by Harbourne (1973). The moisture content was obtained through drying in an oven (SM-9053, England) at 100-105^{o}C to a constant weight (AOAC, 1990), the saponins and flavonoids were measured using methods described by Pearson (1976).

All the values for minerals were obtained using Atomic Absorption Spectroscopy (AAS) (UNICAM-939, England) and fatty acid profile obtained through Gas Chromatography (HP-6890, USA) with relevant standards. The amino acid composition of the defatted kernel was determined using an amino acid analyser as described by Bassler and Buchholz (1993) and the content of different amino acids recovered was presented in g/16 g^{-1} of nitrogen. The specific gravity of the oil was evaluated with specific gravity bottle as described by Pearson (1976). Iodine value determined by Wiji's method, while saponification values, acid values, and peroxide values were determined according to AOAC (1990). All the analyses were done in triplicate and reagents used were of analytical grade.

Results

Table 1 shows the results of proximate composition of the *Jatropha curcas* seed. The results obtained showed the following values; moisture (5%), crude fat (46.24%), crude fibre (2.57%), crude protein (29.40%), ash content (4.90%) and carbohydrate (16.89%). The seeds are rich in crude fat (46.24%) and crude protein (29.40%). Table 2 shows the result for phytochemical analysis of *Jatropha curcas* seeds. The seeds have low concentrations of flavonoids (0.81 g/100 g^{-1}) and alkaloids (1.5 g/100 g^{-1}), saponin (2.10%), tannins (8.50 g/100 g^{-1}), and phytate (8.76 g/100 g^{-1}) and high concentration of lectin (62.0%) and trypsin inhibitor (26.0 mg/g).

Table 3 shows the mineral composition of *Jatropha* seed (Mgkg^{-1} F.W). It contains Aluminum (16.40), Calcium (84.50), Iron (105), Potassium (1.86), magnesium (163), sodium (52.80), Phosphorus (4.90), lead (0.88), Zinc (65.10) and Cadnium (0.29). Results in Table 4 show the essential amino acid composition of defatted seed of *J. curcas* in mg/g; cysteine (1.74), methionine (1.50), valine (4.30), isoleucine (3.32), leucine (6), tyrosine (2.80), phenylalanine (4.03), histidine (2.90), lysine (3.50) and threonine (3.20). The non-essential amino acid composition of defatted seed of *J. curcas* include: aspartic acid (11.60), proline (4.10), serine (4.72), glutamic acid (15.80), glycine (4.54), alanine (4.20) and arginine (11.40).

The data obtained for the physicochemical properties of *J. curcas* seed oil are shown in Table 5. The oil extracted from *J. curcas* using normal hexane was liquid at room temperature; yellow in colour with an agreeable odour. The percentage oil content was (62.20), specific gravity (0.92), acid value (9.48), %FFA (4.77), peroxide value (3.20), iodine value (95.00) and saponification number (195.10). Table

Table 1. Proximate composition of *Jatropha curcas* seeds

Parameters	% composition
Miosture	5.00± 0.19
Crude fat	46.24± 0.20
Crude fibre	2.57± 0.02
Crude protein	29.4± 3.00
Ash content	4.90± 0.40
Carbohyrdate	16.89± 2.00

Values are mean ± S.D of triplicate determinations

Table 2. Phytochemical composition of *Jatropha curcas* seeds

Phytochemicals	values from the seed
Alkaloids	1.50± 0.01
Flavonids	0.81± 0.03
Tannins	8.50± 0.10
Trypsin inhibitor mg/g	26.00± 1.30
Lectin mg/ml^{-1}	62.00± 4.00
Phytate g/100 g	8.76± 0.20
Saponin %	2.10± 0.15

Values are mean ± S.D of triplicate determinations

Table 3. Mineral composition of *Jatropha curcas* seeds MgKg^{-1} F.W

Mineral composition	Composition (MgKg^{-1} F.W)
Aluminium	16.44± 0.33
Calcium	84.56± 1.20
Iron	105.45± 1.50
Potassium	1.86± 0.02
Magnesium	163.38± 4.00
Sodium	52.85± 1.00
Phosphorus	4.90± 0.35
Lead	0.09± 0.01
Zinc	65.15± 2.10
Cadnium	0.03± 0.002

Values are mean ± S.D of triplicate determinations

Table 4. Amino acid composition of the defatted seed of *Jatropha curcas*

Amino acid	g/100 g protein
Cystine	1.74
Methinione	1.50
Valine	4.30
Isoleucine	3.52
Leucine	6.00
Tyrosine	2.80
Phenylalanine	4.03
Histidine	2.90
Lysine	3.50
Threonine	3.20
Aspartic acid	11.60
Proline	4.10
Serine	4.72
Glutamic acid	15.80
Glycine	4.54
Alanine	4.20
Arginine	11.40

Values are mean ± S.D of triplicate determinations

6 shows the percentage fatty acid compositions of *J. curcas* seed oil. The results obtained indicate that *J. curcas* oil contains mostly oleic acid (52.72%), linoleic acid (27.87%). Others include lauric acid (0.019%), palmitic acid (14.24%), palmitoleic acid (0.16%), stearic acid (5.15%), and linolenic acid (0.29%).

Discussion

A low moisture content of 5% was observed for *J. curcas* seeds (Table 1). This value is lower than 10% moisture content limit recommended for storage stability of flour (Oladele and Oshodi, 2008). High crude fat value of 46.24% was also observed for *J. curcas* seeds. This oil content is higher than the value reported for *Bauhinia recticulata*, which belongs to the pea family (Amoo, 2003), but similar to the value reported for *T. occidentalis* and *Jatropha cathartica* seeds (Fagbemi and Oshodi, 1991). Fat and oils are the most abundant lipids found in nature. They are a heterogeneous group of organic compounds, which are important constituents of plants and animal tissue.

Crude fibre value of (2.57%) for *J. Curcas* seeds in this investigation (Table 1) is lower than that reported for raw African locust bean (11.7%) and raw melon seeds (15.8%) (Oladele and Oshodi, 2008) but higher than (0.2%) reported for soybean (Suarez *et al*., 1999). Crude fiber in diet consists mostly of plant polysaccharides that cannot be digested by human dietary enzymes such as cellulose, hemicellulase and some materials that encrust the cell wall (Oladele and Oshodi, 2008; Oduse and Cullen, 2012). Fibre content is a significant component of the diet. It increases stool bulk and decreases the time that waste materials spend in the gastrointestinal tract. It is commonly used as an index of value in poultry and feeding stocks feeds (Eze and Ibe, 2005; Amaechi, 2009). Protein content of the seeds of *J. curcas* (29.4%) is higher than 17.63% for *S. nigrum* reported by Akubugwo *et al.* (2007) and for *T. occidentalis* reported by Ekop (2007). This shows that the seeds can serve as an alternative source of plant seed protein.

Carbohydrate content of 16.89% observed in this study is higher than 6.45% reported for Jatropha cathertica and 6% for soybean (Oladele and Oshodi, 2008). Carbohydrate is essential for the maintenance of plant and animal life and also provides raw materials for many industries (Oduse *et al*., 2012). Low concentration of flavonoids (0.81 g/100 g^{-1}) and alkaloids (1.5 g/100 g^{-1}) and tannin concentration of (8.5 g/100 g^{-1}) were observed in *J. curcas* (Table 2). These values are low and may be considered as of no nutritional significance. Plant seeds contain different phytochemicals with biological activity that can be of valuable therapeutic use (Oduse *et al*., 2012). For example, phytochemical such as saponins, flavanoids, taninin and alkaloids have anti-inflammatory effects (Orhan *et al.*, 2007; Kumar *et al*., 2009). Tannins and flavonoids have been shown to have biological activities that are of benefit in the prevention and treatment of many aliments (Obasi *et al*., 2011; Oduse *et al*., 2012). Tannins also depress growth by decreasing proteins quantity and digestibility. They may cause liver damage and also inhibits absorption of minerals such as iron which leads to anaemia (Obasi *et al*., 2011).

Trypsin inhibitor activity of *J. curcas* was 26 mg/g. This is higher than the trypsin inhibitor activity of 3.9 mg/g in soybean reported by Gubitz *et al.* (1999). It is known that consumption of unheated soybean produces adverse effects in monogastrics. It is has been reported that trypsin inhibitor in *Jatropha* seed is high and may cause adverse physiological effects in monogastrics (Hajos *et al.*, 1995; Gubitz *et al*., 1999; Oseni and Akindahunsi, 2011).

Lectin activity of *J. curcas* was 62 mg/ml. The toxicity of *Jatropha* seeds is generally attributed to the presence of lectin in these seeds (Cano-Asseleih *et al*., 1989). Lectins are sugar binding proteins that are highly specific for their sugar moieties and causes severe allergic reaction and death. Lectins of *Jatropha* may not be responsible for acute toxicity of Jatropha but may enhance toxic effects in combination with other toxins such as curcin and phorbol esters (Rakshit *et al*., 2008). Stirpe *et al.* (1976) have reported that curcin is involved protein synthesis inhibition in an *in vivo* study, while Adolf *et al*. (1984) have shown the presence of complex mixtures of esters of tetracyclic diterpene, phorbols having tumor promoting activities.

The phytate content of *J. curcas* seed was 8.76%. This value is extremely high compared with 1.5% for soybean reported by Gubitz *et al.* (1999). This result indicates that consumption of *Jatropha* seeds can decrease the bioavailability of minerals especially Ca and Zn (Azza and Ferial, 2010). Phytates have also been implicated in protein digestibility as it decreases this by forming complexes and also by interacting with enzymes such as trypsin and pepsin (Reddy and Pierson, 1994). Phytate as a very stable and potent chelating food component is considered to be an anti-nutrient by virtue of its ability to chelate divalent minerals and prevent their absorption (Oboh *et al.*, 2003). Saponins concentration in *J. curcas* was lower than other anti-nutritional factors under study. Saponins, which are natural triterpene plant

Table 5. Physicochemical properties of *Jatropha curcus* seed oil

Physicochemical properties	Values for the oil
State at 27^{0}C	Liquid
Colour	Light yellow
Odour	Agreeable
Specific gravity	0.92± 0.17
Acid value MeqKg^{-1}	9.48± 0.22
FFA	4.77± 0.13
Peroxide value	3.20± 0.50
Iodine value	95.00± 1.00
Saponification number	195.10± 3.00

Values are mean ± S.D of triplicate determinations

Table 6. Percentage fatty acid composition of *Jatropha curcas* seed oil

Fatty acids	% Composition
Lauric acid	0.019
Palmitic acid	14.24
Palmitoleic acid	0.16
Stearic acid	5.15
Oleic acid	52.27
Linoleic acid	27.87
Linolenic acid	0.29

Values are mean ± S.D of triplicate determinations

glycosides found in many plants species, have been of great interest recently because of their physiological activities (Makkar *et al.*, 1997; Azza and Ferial, 2010).

The level of calcium, iron and magnesium, zinc and sodium are high while those of aluminum, potassium phosphorus, lead and cadmium are much lower (Table 3). The seed could therefore be referred to as a good source of calcium, iron, magnesium, sodium and zinc. Although zinc is a heavy metal, it has been found to be of low toxicity to man except on prolonged consumption of large doses, which could result in some health complication such as fatigue, dizziness and neutropenia (Hess and Schmid, 2002). Zinc on the other hand is an essential component of a large number (>300) of enzymes participating in the synthesis and degradation of carbohydrates, lipids, and metabolism of other micro-nutrients. Zinc stabilizes the molecular structure of cellular components and membrane structures and helps to maintain cell and organ integrity (Emebu and Anyika, 2011). Calcium is a major factor sustaining strong bones and plays a part in muscle contraction and relaxations, blood clotting, synaptic transmissions and absorption of vitamin B12 (Emebu and Anyika, 2011). The relatively high content of calcium (52.8 mg/g) in *J. curcas* suggests that it may be of therapeutic value in hypocalcaemic state like osteoporosis. Iron level of *J. curcas* (105.46 ± 1.50 MgKg^{-1} F.W) was higher than the FAO/WHO (1988) recommended dietary allowance for males (1.3 mg/day) and female (2.94 mg/day). Iron has been reported as an essential trace metal that plays numerous biochemical roles in the body, including oxygen-binding haemoglobin and acts as an important catalytic center in many enzymes for example, the cytochrome. Iron is an important trace element in the human body (Oduse *et al.*, 2012; Idowu *et al.*, 2012). It plays crucial roles in haemopoiesis, control of infection and cell mediated immunity. Sodium is an extracellular cation involved in the regulation of plasma volume, acid-base balance, and nerve and muscle contraction. High dietary sodium has been associated with hypertension. Magnesium plays a significant role in carbohydrate metabolism, nucleic acids and binding agents of cell walls (Russel, 1973). The presence of these minerals contributes to its medicinal value (Oloyede, 2008). This suggests that *J. curcas* can be good source of minerals.

The amino acid of *J. curcas* in this study compared favorably to the values reported for different provenance of *J. curcas* (Makkar *et al.*, 1997). The levels of essential amino acids except lysine were higher than that of the FAO/WHO reference pattern (Zarkadas *et al.*, 1995). The levels of essential amino acids except isoluecine, in the Jatropha seeds were higher or similar when compared to the castor bean seed (Makkar *et al.*, 1997; Martinez-Herrera *et al.*, 2006). Compared with casein, the levels of essential amino acids except, sulphur containing amino acids were lower in Jatropha, while methionine and cystine in Jatropha was higher than that in casein (Sarwar and Peace, 1994). The same trend was observed when non-essential amino acids of *J. curcas* seeds were compared with soybean (Martinez-Herrera *et al.*, 2006).

The studied physicochemical properties of oil extract from *J. curcas* are shown in Table 5. The oil extracted using n-hexane was liquid at room temperature, light yellow in colour with agreeable odour. The percentage oil yield of *J. carcas* was 62.20 ± 0.40%. The oil yield of *J. curcas* was found to be higher than some other vegetable oil such as linseed (33.3%), soybean (18.33%), palm oil (44%), groundnut (43%) and coconut (32.00%) (Akubugwo and Ugbogu, 2007; Emil *et al.*, 2010).The high oil content of *Jatropha* seeds has received considerable attention from investigators who want it developed as biodiesel feedstock and also as a material in the oleochemical industries. It can be considered as a good source of vegetable oil (Chinyere *et al.*, 2009; Emil *et al.*, 2010). It has a specific gravity of (0.92 ± 0.17) which is similar to (0.940) reported for the oil by (Minzangi *et al.*, 2011). Most popular plant oils have specific gravity ranging from 0.91 – 0.94 and specific gravity of 0.92 is considered a pretty good number for any cooking oil (Minzangi *et al.*, 2011).

The results indicate that *J. curcas* oil has high acid value (9.48 ± 0.22) and cannot be considered as fit for use as edible oil (Oladele and Oshodi, 2008). Acid value and percentage free fatty acid are used as indicator of the edibility of oil. These two parameters determine the use of oil for either edible or industrial utility. Acid value of the oil suitable for edible purpose should not exceed 4 mg KOH/g (Oladele and Oshodi, 2008).The low percentage FFA content of *J. curcas* (4.77%) seed oil indicates that the oil can be stored for a long time without spoilage via oxidative rancidity. This result is similar to the value for *Cola rostrata* (5.0 ± 0.20) reported by (Dosunmu and Ochu, 1995) and (3.74 ± 0.9) for *Abelmoschus esculentus* reported by Kimbonguila *et al.* (2009). Peroxide value obtained for the studied oil is (3.20 ± 0.50) and indicates freshness of the seed oil. Peroxide value is used as an indicator of deterioration of oils. Fresh oils have values less than 10 $M.Eq.Kg^{-1}$. Values between 20 and 40 result to rancid taste (Chinyere *et al.*, 2009). The iodine value is a measure of the unsaturated levels in fats and oils. A high iodine value (95.00 ± 1.00) in *J. curcas* oil is an indication of the presence of high unsaturated fatty acids such as oleic and linolelic acid (Emil *et al*., 2010). The iodine value of *J. curcas* oil is within the value of 120 as specified in (EN14214) which is an indication of its potential use as biodisesel feedstock (Knothe and Steidley, 2005). The saponification values of Jatropha curcas seed oil was (195.10 ± 3.00). A high saponification value observed indicates that *J. curcas* oil possesses normal triglycerides and may be useful in the production of liquid soap and shampoo (Emil *et al*., 2010).

The major saturated fatty acids in *J. curcas* seed oil are palmitic acid (14.24%) and stearic acid (5.15%), while the main unsaturated fatty acids are oleic acid (52.27%) and linoleic acid (27.87%). The results obtained in this study are in agreement with those of (Augustus *et al*., 2002; Akintayo, 2004). The prevalence of the unsaturated fatty acids and high values of the iodine index indicate that the *J. curcas* oil is of the unsaturated type (Nzikou *et al*., 2009). This high level of polyunsaturated fatty acid in the seed oil can be harnessed in the management of cardiovascular diseases (Nzikou *et al*., 2009; Chinyere *et al*., 2009). Oil containing high amount of polyunsaturated fatty acids tend to exhibit poor oxidation stability, and may not be useful at low temperatures due to a high pour points, but can find an application in the surface coating industries (Augustus *et al*., 2002; Emil *et al*., 2010; Nakay and Patel, 2010).

Conclusion

The results of this investigation suggest that *J. curcas* seeds and seed oils have great potentials for human nutritional purposes, but due to the presence of some toxic substances this cannot be achieved at the moment. So, detoxification is recommended. *J. curcas* oil can be used as a source of oil for the production of soaps, paints and lubricants. Further studies are on how *J. curcas* seed and seed oil can be more useful in human nutrition in form of dietary supplements and possibly for livestock feed production.

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