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Physico-Chemical Properties, Functional Properties, and Chemical Compositions Of *Ziziphus Mauritiana* (Jujube) Seed Oil

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Abstract

This study investigated the physico-chemical properties, functional properties, and chemical compositions of *Ziziphus mauritiana* (Jujube) seed oil using standard analytical methods. The results indicated that Jujube seed oil exhibited swelling capacity of 6.10±0.23 %, water absorption capacity of 20.22±0.45, oil absorption capacity of 18.53±0.43%, bulk density of 0.583±0.01%, gelatinization temperature of 72.34±1.67%, foaming stability of 56.36±0.12%, foaming capacity of 8.29±0.02%, emulsion ability of 30.21±0.13 and emulsion stability of 27.62±0.89. the oil also shows specific gravity of 0.913±0.08 Kg/L, acid value of 2.27±0.17 mgKOH/g, saponification value of 192.40±9.98 mgKOH/g, peroxide value of 2.22±0.12 mmol/Kg, free fatty acid of 1.14±0.09 % and iodine value of 66.74±4.29 g/100g. a total of 19 chemical compound were identified from Z. mauritiana seed oil using GC-MS. The most abundant compound N-[3-[N-Aziridyl] propylidene] hexyl amine with retention time (RT) and peak area (PA) of 5.523 s and 38.32 respectively, followed by Benzeneethanamine, 4-methoxy-2-Butyne-1,4-diol with RT and PA of 9.833% and 7.29 respectively while terebic acid, n-Capric acid and oxalic acid were among the least abundant compounds identified. In conclusion, the seed oil of *Ziziphus mauritiana* (Jujube) exhibited a desirable characteristic for nutritional and industrial application.

Keywords: Physio-chemical; Functional properties; Chemical compositions; *Ziziphus mauritiana*; Seed oil

Introduction

The United Nations projected that by 2050, the world population will reach 9.6 billion [1]. In order to meet up the increase demand due to population growth, oil crops production has to increase by 133 million tones to reach 282 million tonnes [2]. The major oil crops; soybean, sunflower, rape and oil palm, rape, and sunflower account for 83% of the global production [3], with temperate region; Europe and America accounting for about 60% of the global oil seed production while tropical regions such as Africa, Malaysia, and Indonesia account for less than 5% of the global oil seed production [4]. Majority of production from these tropical regions are cotton, coconut, oil palm, groundnut oil [2]. However, a pectoral of traditional oil seeds in tropical Africa remain underexploited and underutilized owing to the inadequate knowledge of the functional and nutritional properties as well as the economic values of the

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seed oil. One of such traditional oil seed is the Jujube seed (*Ziziphus mauritiana*) a member of Rhamnaceae family.

Ziziphus mauritiana Lam (*Z. mauritiana*) is a tropical fruit tree with oil producing seed, it is commonly known as Jujube or magarya (Northern part of Nigeria) and grows in arid and semiarid part of the tropics [5]. *Ziziphus mauritiana* leaves, fruit and seed commonly used by Nigerian traditional herbalist for treatment of various ailment including; sexual deficiency, diabetes, obesity, fever, cough, convulsion, epilepsy, diarrhea, ulcers, digestive and urinary discomfort, sleep disorders, burning sensations skin rashes and ulcers [6]. Various parts of *Ziziphus mauritiana* have also received scientific validation of its immunomodulatory [7], free radical antagonist [8], anticancer [9], anti-diarrhoeal [10] hypoglycemic [11], antiulcer [12], antimicrobial [13], antimycobacterial and antiplasmodial [14] activities.

However, despite the medicinal properties of *Ziziphus mauritiana*, its seed is less explored, underutilized and are often discarded as a waste. However, recent studies have indicated that the less underutilized seed could serve as a rich source of nutrient thus contribute to solving the problems of malnutrition. Our previous study shows that *Ziziphus mauritiana* (Jujube) seed as a protein source in the diet promote growth performance and stabilized hematology, lipid profile and serum chemistry profile of Rattus norvergicus [13]. To our knowledge, there are limited scientific reports on the physicochemical, functional and chemical composition of the oil produced from the seeds of *Ziziphus mauritiana*. This study was therefore carried out to determine the physicochemical, functional and chemical composition oil extracted from *Ziziphus mauritiana* seeds.

Materials and Methods

Sample collections

Matured fruits of *Ziziphus mauritiana* fruits were picked directly from the trees in March 2017 from Barnawa area of Kaduna, Kaduna State. The sample was identified and authenticated at the herbarium unit of Department of Biological Sciences Ahmadu Bello University where existing voucher number of the specimen (No. 7072) was given.

Sample preparation

The fruits were macerated in water to remove the pulp and the seeds were rinsed in clean water. Thereafter the seeds were spread out, sun dried. The dried seeds were grounded and sieved through a mesh to obtain a fine powder which was stored in airtight container.

Analysis of physicochemical properties

Ziziphus mauritiana seed oil was analysed for physicochemical properties using standard procedures [15]. Specific gravity was evaluated using Specific Gravity Hydrometers (Fisher Scientific, Pittsburgh, PA). The saponification values were determined according to the American Oil Chemists Society method [15]. The peroxide value, acid value and iodine value were calculated following the AOCS standard method (Cd 8b-90), (Cd, 3d-63) and (Cd, 1c-85) respectively. Free fatty acid composition was analysed using Gas Chromatograph (QP5050, Shimadzu, Japan) following the AOCS (Ce 2-66) standard.

Analysis of functional properties

The standard analytical procedures for food analysis as described below were used.

Bulk density: Firstly, a dried and empty 10 cm^3 measuring cylinder was weighed. The sample was filled gently into the weighed 10 cm^3 measuring cylinder and then gently tapped at the bottom on a laboratory bench several times until there was no further diminution of the sample level after filling to the 10 cm^3 mark. After this, the filled measuring cylinder was weighed and recorded [15]:

The bulk density (g/cm^3) = Weight of sample (g)/Volume of sample (cm^3)

Water/oil absorption capacity: From the ground sample, 1.00g was weighed into a conical graduated centrifuge tube and 10 cm^3 of water or oil was added to the weighed sample. A warring whirl mixer was used to mix the sample for 30 s. The sample was allowed to stand at room temperature for 30 min and then centrifuged at 5000 rpm for 30 min. After then the mixed sample was transferred from the graduated centrifuge tube into a 10 cm^3 measuring cylinder to know the volume of the free water or oil. The absorption capacity was expressed as grams of oil or water absorbed per gram of sample. Calculation; water/oil absorption capacity of the sample was calculated as:

(Total oil/water absorbed - free oil/water) × Density of oil/water [15].

Foam capacity and stability: From the powdered sample, 2.00 g were weighed, blended with 100 cm^3 of distilled water using warring blender (Binatone BLG- 555) and the suspension was whipped at 1600 rpm for 5 min. The mixture was then poured into a 100 cm^3 measuring cylinder and its volume was recorded after 30s. Foam capacity was expressed as percent increase in volume using the formula of AOAC [15].

$$Foam\ capacity = \frac{Volume\ after\ whipping\ -\ volume\ before\ whipping}{Volume\ before\ whipping} \times 100$$

The foam stability of the sample was recorded at 15, 30, 60 and 120 s after whipping to determine the foam stability (FS).

$$Foam\ stability = \frac{Foam\ volume\ after\ time}{Initial\ foam\ volume} \times 100$$

Gelatinization temperature: In triplicates, 5% sample was suspended in test tubes, heated in a boiling water bath with continuous stirring and 30 s after gelatinization was visually noticed, the temperature of the samples was taken as the gelatinization temperature [16].

Emulsification capacity (EC): From the sample, 2.00 g of sample were blended with 25 cm^3 of distilled water at room temperature for 30 s in a warring blender at 1600 rpm. After complete dispersion, 25 cm^3 of vegetable oil was gradually added and the blending continued for another 30s. Then the mixture was transferred into a centrifuge tube and centrifuged at 1600 rpm for 5 min. The volume of oil separated from the sample was read directly from the tube after centrifuging. Calculation: The emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample:

X Emulsion capacity = X/Y × 100

Where X = height of emulsified layer and Y = height of the whole solution in the centrifuge tube [15].

Gas Chromatography mass spectrometry (GC/MS) analysis

The GC/MS analysis of *Ziziphus mauritiana* seed oil was perform using GC-MS clarus 500 per kin Elmer system comprising an AOC-20i auto sampler. "The instrument is equipped with a VF 5 ms fused silica capillary column of 30 m length, 0.25 mm diameter and 0.25 µm film thickness." The temperatures employed were; column oven temperature 80°C, injection Temp 250 °C at a pressure of 108.0 kPa, with total flow and column flow of 6.20 ml/min and 1.58 ml/min, respectively. The linear velocity was 46.3 cm/s and a purge flow of 3.0 ml/min. The GC program ion source and interface temperature were 200.00 °C and 250.00 °C, respectively, with solvent cut time of 2.50 min. The MS program starting time was 3.00 min which ended at 30.00 min with event time of 0.50 s, scan speed of 1666 µl/s, scan range 40-800 u, and an injection volume of 1 µl of the propolis extract (split ratio 10:1). The total running time of GC-MS was 30 min. The relative percentage of the extract was expressed as percentage with peak area normalization as previously reported by Lawal et al. (2015).

Identification of the Components: Interpretation on the mass spectrum was conducted using the database of National Institute Standard and Technology (NIST) having more than 62,000 patterns. The fragmentation pattern spectra of the unknown components were compared with those of known components stored in the NIST library. The relative percentage amount of each bio-component was calculated by comparing its average peak area to the total area.

Results

Physicochemical Properties of *Z. mauritiana* seed

The physicochemical properties of *Z. mauritiana* seed are presented in Table 1; *Z. mauritiana* seed showed specific gravity of 0.913±0.08 Kg/L, acid value of 2.27±0.17 mgKOH/g, saponification value of 192.40±9.98 mgKOH/g, peroxide value of 2.22±0.12 mmol/Kg, free fatty acid of 1.14±0.09 % and iodine value of 66.74±4.29 g/100g.

Functional Properties of *Z. mauritiana* seed

The functional Properties of *Z. mauritiana* seed are presented in Table 2; the *Z. mauritiana* seed showed swelling capacity of 6.10±0.23 %, water absorption capacity of 20.22±0.45, oil absorption capacity of 18.53±0.43%, bulk density of 0.583±0.01%, gelatinization temperature of 72.34±1.67%, foaming stability of 56.36±0.12%, foaming capacity of 8.29±0.02%, emulsion ability of 30.21±0.13 and emulsion stability of 27.62±0.89.

Gas chromatography and mass spectroscopy (GC-MS)

The compound names, retention time and peak area of chemical compositions of *Z. mauritiana* seed oil using GC-MS are shown in Table 3: *Z. mauritiana* seed oil contains N-[3-[N-Aziridyl] propylidene] hexyl amine, Benzeneethanamine, 4-methoxy-2-Butyne-1,4-diol, Terebic acid, Pentanoic acid, 4-methyl-, methyl-ester, Hexadecanoic acid, methyl ester, 10-Undecynoic acid, 3-Dodecanol, Cyclopropane, Pentanoic acid, 2,6-Octadiene, Butane, 1,3,4-Thiadiazole, 2-amino-5-(heptylthio), 9-Oxononanoic acid, D-Galactose, Isoxazolidine, 5-ethyl-2,4-dimethyl, 2-Phenyl-1,2-propanediol, n-Capric acid, 1,3-Bis-t-butylperoxy-phthalan and oxalic acid.

Table 1: Physicochemical Properties of *Z. mauritiana* seed.

Parameter	*Z.mauritiana*
Specific gravity (Kg/L)	0.913±0.08
Acid value (mgKOH/g)	2.27±0.17
Saponification value (mgKOH/g)	192.40±9.98
Peroxide value (mmol/Kg)	2.22±0.12
Free fatty acid (%)	1.14±0.09
Iodine value(g/100g)	66.74±4.29

Data are Mean ± SEM of triplicate determination.

Table 2: Functional Properties of *Z. mauritiana seed*.

Functional properties	Value
SC (%)	6.10±0.23
WAC (%)	20.22±0.45

OAC (%)	18.53±0.43
BD (g/cm^3)	0.583±0.01
GT (0C)	72.34±1.67
FS (%)	56.36±0.12
FC (%)	8.29±0.02
EA (%)	30.21±0.13
ES (%)	27.62±0.89

Key: Data are Mean ± SEM of triplicate determination. SC: Swelling capacity, WAC: Water absorption capacity, OAC: Oil absorption capacity, BD: Bulk density, GT: Gelatinization temperature, FS: Foaming stability, FC: Foaming capacity, EA: Emulsion ability, ES: Emulsion stability.

Table 3: Chemical compositions of Z. mauritiana seed oil using Gas chromatography and mass spectroscopy (GC-MS).

S.No	Compounds	Retention time (s)	Peak Area
1	N-[3-[N-Aziridyl] propylidene] hexyl amine	5.523	38.32
2	Benzeneethanamine, 4-methoxy-2-Butyne-1,4-diol	9.833	7.29
3	Terebic acid	30.77	0.72
4	Pentanoic acid, 4-methyl-, methyl-ester	41.189	0.45
5	Hexadecanoic acid, methyl ester	49.084	13.83
6	10-Undecynoic acid	54.716	1.93
7	3-Dodecanol	54.964	3.48
8	Cyclopropane	55.906	1.69
9	Pentanoic acid	60.024	3.18
10	2,6-Octadiene	61.335	1.61
11	Butane	84.14	0.81
12	1,3,4-Thiadiazole, 2-amino-5-(heptylthio)	85.769	0.5
13	D-Galactose	86.578	1.54
14	9-Oxononanoic acid	89.431	0.6
15	Isoxazolidine, 5-ethyl-2,4-dimethyl	90.399	0.74
16	2-Phenyl-1,2-propanediol	92.619	0.59
17	n-Capric acid	93.503	0.39
18	1,3-Bis-t-butylperoxy-phthalan	95.174	1.59
19	Oxalic acid	98.493	0.49

Discussion

Food functional properties are very important for the appropriateness of the diet, behavior of nutrients during food processing, storage and preparation because they affect the general quality of foods as well as their acceptability [17]. Bulk density which is a function of particle size was 0.583±0.01 which is an indication that the particle size was high. This value is similar to the bulk density of 0.67±0.02 reported for date palm fruit [16]. Increase in bulk density is desirable because it offers greater packaging advantage, as a greater quantity may be packed within a constant volume [18]. The water absorption capacity of 20.22±0.45 recorded in this study is also similar to the 2.50±0.05 reported for date palm fruit [16]. This water absorption capacity of *Z. mauritiana* seed is an indication of its heaviness and suitability as a drug binder and disintegrate in pharmaceuticals industrials [19]. The present study also indicated that had very higher gelatinization temperature of 72.34±1.67% °C which affects the time required for the cooking of food substances.

The fat absorption capacity (FAC) which is critical in determining the flavour retention in food materials was found to be 18.53±0.43%. Emulsion stability (ES) was found to be 27.62±0.89% and is higher than 13.19±1.0% reported for Jack beans [20]. Emulsion stability is important for stabilization of additives in production of foods like soup and cakes. The higher value of foaming capacity (FC) and foaming stability (FS) of *Z. mauritiana* seed suggests its use as a whipping or aerating agent in food system [20].

A high saponification value (192.40±9.98 mgKOH/g) recorded in this study is similar to the saponification value of 197.80 recorded for *Z. oenoplia* seed oil [21], this high value could be attributed to high content of medium chain fatty acids (i.e., C16 and C18) in the seed oil. Furthermore, this high saponification value is a desirable property for production and manufacturing of shoe polish, alkyd

resin, shampoo and liquid soaps [21]. The value recorded in this study is also similar to saponification values of soybean (189–195) and groundnut (187–196) as reported by Gunstone [22]. The acidity is an important parameter in determining the quality of the seed oil. The low levels of free fatty acids (1.14±0.09 %) and acid value (2.27±0.17 mgKOH/g) of *Z. mauritiana* seed oil reported in this study is an indication of low hydrolysis of triglyceride and thus would enhance the shelf life and storage stability of the oil. The value recorded in this study is lower than the free fatty acids and the acid value of 0.39% and 0.64 mg of KOH/g respectively reported for L. *kerstingii* seed oil [2].

The iodine value of Z. *mauritiana* seed oil (66.74±4.29 g/100g) is similar to 60.72 g of /100 g reported for L. *kerstingii* seed oil [2], 65.90 g of /100 g reported for that of Moringa oleifera Lam. oil but lower than iodine values of cotton, olive oil, groundnut, and sunflower oils, which ranged from 86 to 145 g of /100 g of oil [23]. The relatively low iodine value implies low nutritional value, thus implying that Z. *mauritiana* seed oil is more nutritional than the cotton, olive oil, groundnut, and sunflower oils. Furthermore, the iodine value reported in this study suggests that the Z. *mauritiana* seed oil is relatively stable upon thermal degradation when used for frying or upon storage with respect to oxidation. The peroxide value of 2.22±0.12 mmol/Kg recorded in this study is below the 10 meq. O_2/kg of oil allowed for crude oils by Codex Alimentarius Committee [24,25].

Conclusion

The research work indicated that Z. *mauritiana* seed oil exhibited a desirable characteristic for nutritional and industrial application. The seed oil has great potential for the use of Z. *mauritiana* seed oil for both domestic and industrial uses instead of depending solely on palm oil and peanut oil that are scarce and costly.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

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