Extraction and Characterization of Oil from DATE PALM (*Phoenixdactylifera L.*) Seed

Abstracts

This work focuses on the extraction of oil from Date palm seed. Using n-hexane in Soxlet extraction apparatus, standard procedures were followed to determine the oil feed stock yield. Proximate compositions and physicochemical characteristics were carried out. Also, Fourier Transform Infrared Spectrophotometry (FTIR) and Gas Chromatography Mass Spectrophotometry (GC-MS) were used to determine the covalent bond /functional groups and the fatty acid composition of the oil respectively. The result shows that the appearance of Date palm seed oil is reddish brown in colour. Result from the FTIR analysis also shows that 16 peaks were noticed from Date palm seed oil, indicating the presence various functional groups such as OH, C-H, C=C, C=O, C≡ C and $C-N$. The dominating types and number of functional groups are found on the single bond stretch and on the fingerprint region skeletal vibration. Similarly, the GC-MS result also reveals that there are 5 dominating fatty acid compounds present in date palm seed oil in relation to their abundant relative weight composition. In date seed oil, oleic acid is found to be the only unsaturated fatty acid with the highest weight composition of 49.4%. The inferences that can be drawn from the results in this work in the area of application suggest that, date palm seed oil will be suitable for soap production and cleansing agents. Furthermore, research on the life shelf and storage of the oil should be looked into, as it relates to the peroxidation of oil.

Key Words: Proximate, Physico Chemical, Extraction, Date Palm Seed Oil, Functional Group, Fatty Acid Composition.

1. INTRODUCTION

Date palm (*Phoenix dactylifera L.*) plant is a member of the palm family -*Arecaceae*. It is one of the oldest cultivated perennial crop/plants on earth, and is being used as food for over 6000 years. Mainly, it is found in Saudi Arabia, Middle Eastern countries and Egypt [5]. The important quality criteria for consumers are the appearance including color, size and shape, physical condition and absence of defects, mouth feel or texture, flavor, and nutritional value. Report has shown that 30-40% of this fruit is mostly consumed in its fresh form, while up to 60 – 70% of it is consumed in its dried form at Rutab (semi-ripe) and Tamar (fully ripe) stages with little or no processing [8]. The consumption of dates, however, reaches its peak in the Muslim's holy month of fasting -"*Ramadan*," when dates are commonly taken to break the fast. The major component of dates are carbohydrates (mainly the sugars; sucrose, glucose, and fructose), which may constitute about 70%. Its natural constituents like phytochemicals, sterols, carotenes and flavonoids have been screened for various medicinal activities to reduce the side effects of artificial drugs that bring harm to human body systems [1]. The date seed have been used traditionally as animal feed or roasted to turn it into caffeine-free coffee substitute, which have been commercialized by the Arabs, but mostly discarded in Nigeria. The Date palm trees are grown extensively and commercially in the arid region of northern Nigeria from latitude 10°N in

the Sudan savannah and the Sahel regions [6]. Research has also shown that this seed has some oil content present in it.

It is well known that vegetable oils are usually obtained from various sources. These include common seeds vegetable oils such as Soybean seed oil, Cottonseed oil, Peanuts oil and Sunflower oil. They also include other oils such as Palm oil, Palm kernel oil, Coconut oil, Castor oil etc. The utilization of oil for various applications is largely determined by the yield, composition, physical and chemical properties of the oil. In Nigeria however, the foremost sources of edible oils are Peanut (*Arachis hypogoea*) and Palm oil (*Eloesis guineensis*). These oils are used mainly for cooking, baking, frying, for the production of soap, margarine, paints and cosmetics [7]. However, increase in demand has led to increase in the importation of cooking oils. In order to bridge this demand gap, there is need to source for local oil-bearing-seeds which are in most cases discarded as waste and can be used in production of oils both for consumption and industrial applications. This work will further buttress the opportunity of making wealth from waste.

The aim of this research work was achieved through the following objectives;

i. extraction and determination of oil yield from Date palm seeds.
ii. Determination of the proximate compositions of Date palm seeds.
iii. Determination of the physicochemical properties of oil from Date palm seeds.
iv. Determination of the functional groups present in the extracted oil using Fourier Transform Infrared Spectroscopy (FT-IR).
v. Determination of the fatty acids composition in the extracted oil using Gas Chromatography Mass Spectrophotometry (GC-MS).

2.0 MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Date palm seed Phoenix dactylifera L was purchased from Marmara in Wukari town of Wukari LGA, Taraba state. The Sample were screened and cleaned thoroughly to remove the bad ones and to ensure that it is free from dirt. *The* seeds were manually crushed and then washed in order to remove the peels and dry under the sun for four days before grounding to fine particle size

(250-149 μm), using mortar and pestle. The grounded sample was put in a plastic bottle and stored in a refrigerator for further analysis.

2.2 Procedures and Method of Analysis

The procedure and method used in carrying out the proximate, physicochemical, Fourier transform infrared spectroscopy (FTIR) and Gas Chromatography Mass Spectrometry (GC-MS) analysis of this study is adopted from the first part of this work by [21] on african locust bean seed oil and from [4].

3.0 RESULTS

3.1 Results of Proximate Analysis of Date Palm Seeds

The proximate analyses of date palm seeds is presented in Table 1.

Table 1. Results of Proximate Analysis of Date Palm Seed

Proximate parameters	**Mean Composition Amount (%)**
Moisture	3.34±0.02
Ash	1.20±0.04
Crude fibre	6.15±0.02
Crude fat	1.74±0.01
Crude protein	5.69±0.03
Carbohydrates	81.88±0.12

3.2 Results of Oil Yield and Physicochemical Parameters date palm Seed Oil

The percentage oil yield and physicochemical analyses in this study is presented in Table 2.

Table 2. Results of Oil Yield and Physicochemical Parameters of date palm Seed Oil

Physicochemical Parameters	**Mean Composition Amount (%)**
Yield (%)	2.63±0.03

Colour	Reddish Brown
Acid value (mg/g)	1.77±0.03
Iodine value (g/100g)	58.82±0.12
Peroxide value (meqO_2/kg)	1.91±0.01
Saponification value (mg KOH/g)	213.32±0.13
Specific gravity	1.2323±0.02
Free fatty acid (%)	0.89±0.01

3.3 Result of FTIR Analysis on date palm Seed Oil

The FTIR analysis on date palm seed oil is presented in Fig. 1.

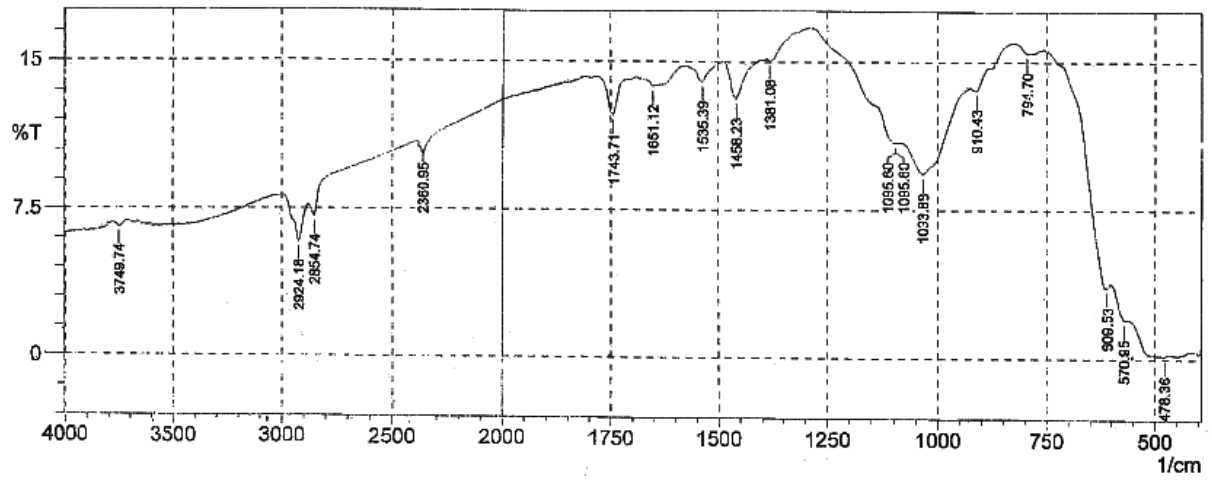

Figure 1: Result of FTIR analysis on Date palm seed Oil.

3.4 Results for GC-MS Analysis on Date Palm Seed Oil

The fatty acids compositions of Date palm seed oil that were detected in this study are presented on Table 3 below. The result reveals the fatty acids present and their corresponding weight compositions and retention time.

Table 3: Result for GC-MS Analysis on Date palm seed oil

Retention Time	IUPAC Name	Common Name	Saturation	Weight Composition(%)
5.479	Decanoic acid	Capric acid	C10:0	11.19
6.546	Dodecanoic acid	Lauric acid	C12:0	24.37
7.009	Cis-9-octadecenoic acid	Oleic acid	C18:1	49.40
14.229	Eicosanoic acid	Arachidonic acid	C20:0	7.69
18.070	Docosanoic acid	Behemic acid	C22:0	5.58

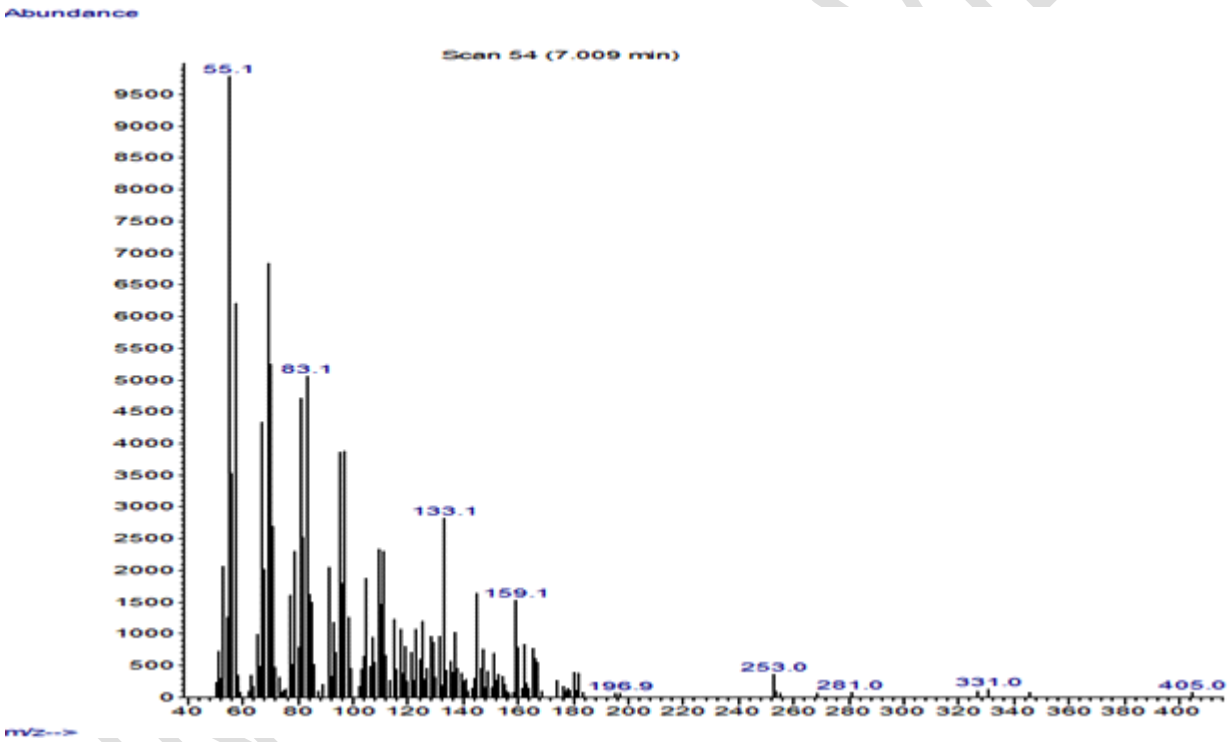

Figure 2: Oleic acid from Date palm seed oil (GCMS Analysis)

Discussion of Results

The paramount nutrients to consider when selecting foods for human consumption and as well as animal feeds are crude fibre, crude protein, moisture content, crude fat, ash content and energy. Therefore, Table 1 presents the results of proximate composition carried out on date palm seed.

The result indicates that date palm seed has a moisture content of 3.34%. This relative high moisture content might be as a result of difference in seed variety or in geographical growth conditions such as temperature, rainfall and humidity of the seeds [14]. This is also an indication that date palm seed has a relative low percentage of water which may make it less vulnerable to microbial attack compared to others like African locust bean (5.12%) as reported by [21], and also less than cashew seed, moringa seed bitter kola seed and melon seed as reported by [26]. Furthermore, the ash content which is also referred to as mineral content needed by the body was found to be 1.20% for Date palm seed. This value is within the recommended standard limit proposed by [10], which is within the range of 1-5%. However, in another literature by [11], it is also recommended that ash content in seeds should fall within the range of 1.5-2.5% in order to be suitable for feeds in animals. This low value for Date palm seed in this work is similar with values obtained for *Phoenix dactylifera L*. by [19] and [27]. Crude fibre which plays a significant role in the maintenance of internal distention in intestinal tract was found to be 6.15% for Date palm. This value is less than that of African locust bean seed (9.22%) as observed by [21] and date pits by [9]. However, it is greater when compared to the report by [27] for *Phoenix dactylifera L.* It is instructive to note that adequate consumption of dietary fibres from a variety of foods will help to guide against the risk of cardiovascular diseases and colon cancer.

Similarly, Fats are important in diet because they promote fat soluble vitamin absorption and are high energy nutrient. The crude fat value is 1.74% for Date palm seeds. The lower crude fat value of Date palm seed depicts low amount of energy giving food. This value is similar to the research survey of some Date palm fruit carried out in some major markets in Minna by [27]. However, this value fell short of the requirement for it to be classified as an oil-rich legume when compared to soybean [11] and other seeds such as *Citrullus Vulgaris Schrad* by [20] which

is grown in Nigeria. Moreover, the effort to reduce the amount of calories consumed and derived from fat in some countries such as the United States emphasizes the significance of understanding the lipid components of food [13].

Crude protein is known to enhance growth. In this study, the crude protein values for Date palm seeds is 5.69%. This value is low when compared with a similar study on Date palm seed by [19], *Pakia biglobosa* [21] and some legume such as *Phaseolus coccineus L.* [12]. Though, it can still serve as an alternative source of protein in a country like Nigeria where the staple food is more of the carbohydrate class. Furthermore, the carbohydrates content in date palm seed is 81.88%. this value is also higher compared to that found in african locust bean seed (52.94%) as reported by [21], the carbohydrate content of the six different varieties of date palm fruit from Sudan analyzed by [18] and those for Cranberry bean [12]. According to this study, date palm seed can actually offer a relative high amount of energy needed by the body and for feed formulations. This is why it is often recommended and used for breaking fast by Muslims during Ramadam, since both the edible part of the date palm fruit and its seed are good source of energy.

It is of paramount importance to note that the yield and physicochemical properties of any oil feed stock and oil extract its self is cardinal when considering it for use for both consumption and commercial purpose. Therefore, the results of oil yield and physicochemical analysis carried out on Date palm seeds oils is represented in Table 2. The result shows that the mean oil yield from date palm seed feedstock is 2.63%. This oil yield is lower compared to the oil yield from African locust bean seed (11.41%) as observed by [21] and a similar study of [28]. The variation in oil yield may be due to specie, climatic conditions, particle size and method of extraction [14]. This shows that date palm seed may not be a good oil feed stock for commercial purpose in

relation to its yield. Furthermore, physical observation from this study shows that date palm seed oil is reddish brown in colour, with specific gravity of 1.2323 which is greater than that of water. According to [25] and [28], date palm seed oil may require bleaching for further use.

Acid value which is an index of free fatty acid content and also an indicator for edibility of oil and suitability for industrial used was found to be lower in *Phoenix dactylifera L* (1.77mg/g) in relation to African locust bean seed oil (8.96 mg/g) as opine by [21]. The low value in *Phoenix dactylifera L*. indicates negligible amount of free fatty acid present in the oil but is closely comparable with Castor seed oil and Melon seed oils [28]. The low value of this oil in this study suggests that the oil is suitable for edible purpose as asserted [22]. The iodine value of any oil is known to predict and reflect the drying property of an oil. In this study, the iodine value is 58.82 g/100g, but is less compared to *Parkia biglobosa (*82.40 g/100g) as reported by[21]. This value shows that date palm seed oil does not fall under the category of a drying oil since iodine values is less than 100 [24]. According to [29], this iodine value also signifies the presence of C=C double bond in the *Phoenix dactylifera L* seed oil, which can be useful in the production of hydraulic brake fluid, candle lubricant , oil paint, vanish and cosmetics as reported by [2] and [23]. Also, the low iodine value (58.82 g/100g) observed in date palm seeds oil is also an indication that the oil contain low level of polysaturated fatty acid. The storage procedure to be used should ensure the protection of the oil from oxidative deterioration. This value compared favorably with values obtained by [15] for Peanut oil, [23] for Shea-nut oil.

The Saponification value for date palm seed oil is 213.32 mgKOH/g, which is higher than African locust seed oil by [21] but less than melon seed and and bitter kola seed by [26]. This value suggest that the oils from date palm seed, bitter kola seed and melon seed contain low molecular weight fatty acids and high molecular weight fatty acids in african locust bean seed

since according [10] AOAC 1990, saponification values greater or equal to 180mg KOH/g has low molecular weight fatty acid and vice versa. This is evident that the oil from this study will be suitable for soap production [17] and [3]. The last but not the least physicochemical properties of the date palm seed oil is the peroxide value, known to be the measure of oxidative rancidity of oil. in this study, the value is 1.91 meqO_2/kg. This low value is an indication that the oil may not be easily vulnerable to deterioration or peroxidation process, but will be able to remain fresh over a considerable period of time, having a better natural shelf life in comparism to melon seed oil, moringa seed oil and sesame seed having high peroxide value as reported by [24], and [26].

The essence of FTIR analysis is to know the types and number of functional groups present in the extracted Date palm oil. This will provide information on the area of application or use of the oil obtained from Date palm. The result on figure 1 reveals the functional groups present in Date palm which has a maximum transmittance of 16.5%. Out of the total 16 peaks on the result, 3 were recorded on the single bond stretch spectrum, 1 on the triple bond spectrum, 3 peaks were observed at the double bond stretch vibration while 9 peaks were recorded on the finger print region skeletal vibration where C-O, C-N and C-C groups are found.

There is an indication of the presence of hydroxyl (OH) functional group at a peak of 3749.74. The peaks in the 2924.18 - 2854.74 cm^{-1} region signify the presence of C-H functional group for alkanes on the band stretch. The peak at 1743.71 cm^{-1} is attributed to the C=O stretching vibration of carboxylic esters. The peak at 1651.12 cm^{-1} coincide with the C=C vibration of alkenes. The peak at 1536.39 cm^{-1} represents N-O asymmetric stretch of nitro compounds. The peak at 1458.23 cm^{-1} is assigned to C-C stretch aromatic compound. The peaks in the 1095.6-1033.88 cm^{-1} region are represented to the stretching vibration of C-N aliphatic amines. The peak at 910.43 cm^{-1} is ascribed to the C-H double bond unsaturated alkene hydrocarbon, and the peaks

from 794.7 - 570.95 cm^{-1} are attributed to the C-X stretch of alkyl halides. This result is similar those found in [16] and [21] for waste cooking palm oil and african locust bean seed oil respectively.

The Gas Chromatography Mass Spectrometry (GC-MS) result as shown on Table 3 for Date palm seed oil shows that there are 5 fatty acids compounds that are present in relative abundance quantity. Namely: capric acid, lauric acid, oleic acid, arachidonic acid and behemic acid. However, oleic acid is the only unsaturated fatty acid present in the date palm seed oil, having the highest percentage composition of 49.4%, eluting the gas chromatography column at 7.009 mins as shown on table 3 and figure 2 of this work.

Conclusion

The extraction and characterization of oil from date palm seed feed stock was successfully carried out to ascertain its potential properties and area of application. Date palm seed in this study has a relatively low mean oil yield compared to African locust bean seed, melon seed and sesame seed. The result from proximate analysis is quite reasonable having appreciable high carbohydrate content favourable as a good energy source for the body and for feed formulation. The physicochemical properties of this reddish brown oil will be useful for soap production base on its saponification value. Its iodine value and peroxide value shows that date palm seed oil is not a drying oil and as such is not susceptible to deterioration or peroxidation; of which when further refined can also be used for production of hydraulic brake fluid, oil paint, vanish and cosmetics. The FTIR and gas chromatograph result confirm the edibility of this oil due to the presence of carboxylic acid/ester functional groups as well as the unsaturation of the dominating oleic acid.

COMPETING INTERESTS

No competing or conflicting interests amongst the authors.

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Date palm seed

Ground powdered date palm seed

Date palm seed oil

Image: Date palm seed, Ground powdered date palm seed and Date palm seed oil