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ORIGINAL RESEARCH

Comparative Nutritional Analysis of *Phoenix dactylifera* and *Phoenix reclinata* Seeds

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Abstract:
This study examined the nutritional content of seeds of two date palm species; *Phoenix dactylifera* and *Phoenix reclinata*, using standard analytical procedures. Results obtained from proximate method shows a significant increase (P<0.05) in crude protein, carbohydrate and ash content of *P. dactylifera* seeds compared to that of *P. reclinata*. However, moisture content, crude fat and fibre was significantly higher (P<0.05) in seeds of *P. reclinata* than *P. dactylifera.* The mineral element analysis revealed a significant increase (P<0.05) in Na, K, Fe and Zn content in seeds of *P. reclinata* compared to *P. dactylifera*. However, a significant increase in Ca, Mg was observed in *P. dactylifera* as compared to *P. reclinata*. Hence, the study observed differences in the nutritional content of the seeds of the two date palm species, but concludes that both seeds demonstrate great nutritional potentials for humans. Thus, it recommends that further research should focus on seeds and other under-utilized portions of a large group of fruits for industrial exploitation.

Keywords: Seeds, Nutritional analysis, Phoenix species

All co-authors agreed to have their names listed as authors.

1. INTRODUCTION

Date palm (*Phoenix spp*) is one of the oldest and economically viable fruit crops in the world. It is known for its high nutritional content utilized as food, fodders, medicine, energy and some other industrial products [1][2][3][4]. *Phoenix spp* are diploid, perennial, dioecious, and monocotyledonous plants with unique biological and developmental characteristics that necessitate special propagation, culture, and management techniques mostly adapted to arid environments [5].

The fruit of date palm is often called date while the whole date palm plant has been referred to as "*tree of life*" in the holy Bible, perhaps because of its nutritional value, productivity and longevity [6]. Dates are mostly cultivated in the Northern part of Nigeria but are commonly consumed by the general population as major food most especially during the Lenten and the fasting seasons of Ramadan probably due to its high caloric value. They are hence a main income source for local populations in Nigeria.

The world production of dates is around 6.5 million tons in 2000 and 6.4 million tons in 2007 with the highest production in 2004, 7.03 million tons [7][8]. Approximately 80% of the total world production of date palm in 2009 is from the Arab world [7], with Saudi Arabia ranked among the chief producers of date among others that harbours about 450 cultivars [9].

Dates could be dehydrated, grinded and mixed with grains to form a nutritious stock feed. In northern Nigeria, some livestock (e.g. camels, horses and dogs) are often fed with dried dates perhaps because of its high calorie value. In addition, dates and peppers are important ingredients in the preparation of the native beer that is less intoxicating and energetic when consumed. Fresh dates can be processed into juice, vinegar, wine, beer, sugar, syrup, honey, chutney, pickle, paste, dip, and food flavouring [10] [11].

Consumers of dates often discard the seeds. However, these seeds have high nutritional content similar to the date, which is of considerable nutritional importance to humans. Previous study conducted reported that date seed oil have unique fatty acid and tocols composition, high absorbance of UV light and other desirable physicochemical characteristics that indicate potentials in the cosmetic industries [12].

According to a report, date seed oils could be easily conserved due to their high oxidative stability [13]. It is characterized by the presence of fatty acids which include oleic, linoleic, palmitic, myristic and lauric, with oleic acid being the most abundant in date seed oil [13][14]. The function of oleic fatty acid is very important in nervous cell construction related to vessel level and blood coagulation and has a fundamental role in cardiovascular diseases prevention [12].

In general, date palm possesses immense genetic diversity within species, hence, the nutritional value of date products relatively varies from one species to another [15]. This may probably explain why researchers find so much interest in date palm. Myriads of cultivars exist between date palms depending on the geographic distribution. *Phoenix dactylifera* is a common variety of date palm cultivated for its edible sweet, delicious fruits from the tropical oasis, brimming with much-needed vitamins (e.g. riboflavin, biotin, thiamine, ascorbic and folic acid) and minerals (e.g. calcium, iron, copper, etc.) [3][16][17].

Dates exhibits various useful properties to mankind in the form of antioxidant, antifungal, antiviral, anti-hyperlidimic activity and hepato-protective activity [3][18]. It has also been reported that it may enhance the neuro-protective property of the brain and thus, protecting the brain from the actions of reacting oxygen species (ROS) by utilizing its antioxidant property [18]. Vayalil (2012) suggested the use of dates in ayurvedic medicine particularly in the treatment of digestive and urinary disorders, ulcer and tooth ache [17]. Previous study also suggests that consumption of dates by women in the final four weeks of pregnancy has positive effects regarding labour [19].

In view of the nutritional content and health benefits of consuming dates as reported by several studies [17][18][19] and the dearth of information on nutritional composition of seeds of date palm, this present study attempts to provide a comparative nutritional analyses of the seeds of *Phoenix dactylifera* and *Phoenix reclinata* in Nigeria.

2. MATERIAL AND METHODS

Sampling and Sample preparation

Eight hundred (800) seeds of *phoenix reclinata* and *Phoenix dactylifera* were utilized for the analyses. Fresh sample of *Phoenix reclinata* were purchased from a popular market in Oba-Ile town in Osun state of Nigeria while that of *Phoenix dactylifera* were purchased from Liko in Sokoto state. The flesh of the fruits was separated from the seed manually and washed thoroughly by rinsing in order to eliminate traces of impurities and was dried in the oven at 50°C. These seeds were then grinded into powder. The powder of each seed sample was sieved and stored in air-tight sample containers and kept in the refrigerator until required for appropriate analysis.

Moisture content determination

The moisture content of date seeds of *Phoenix dactylifera* and *Phoenix reclinata* was determined using method described by the Association of Official Analytical Chemists [20]. 2.0g of sample size 2mm maximum dimension was accurately weighed in a weighed petri- dish that had been dried previously in an oven that previously been set to operate at 103±2°C for three hours. The dish was weighed after cooling in

desiccators. The procedure of drying, cooling and weighing was repeated until constant weight was achieved. The loss in weight is equivalent to the moisture content of the sample. The moisture content was then calculated as below:

$$\text{Moisture \%} = \frac{W_1 - W_2 \times 100}{W_3}$$

Where, W_1 = weight of dish + sample before drying = Wet weight, W_2 = weight of dish + dried sample = Dry weight, W_3= Wet weight of samples.

Ash content determination

Ash content of fruit samples was determined according to the method of AOAC (2005) [20]. Sample (2.0g) was weighed into a pre-weighed porcelain crucible and charred over a small flame and transferred into a muffle furnace at 550°C for six hours. The crucible was cooled in a desiccator and weighed immediately. The procedure of heating, cooling and weighing was repeated to achieve a constant weight. The residue in the crucible is the ash contained in the sample and hence, the total ash was calculated as follow:

$$\text{Ash content \%} = \frac{\text{Weight of ash} \times 100}{\text{Weight of sample}}$$

Crude fat determination

Crude fat was obtained method of AOAC (2005) [20]; briefly, 5g of sample was massed into a polypropylene centrifuge bottle. Sodium acetate, aliquots of methanol, chloroform and water were added into the bottle and shaken for 30 minutes. The content of the bottle was centrifugated at 2500 rpm for 10 min, then it was set in 25°C water bath for 15 minutes. The samples were evaporated to dryness under nitrogen blanket, heated in a drying oven for 30 minutes, and cooled in a desiccator for at least 30 minutes. Crude fat content was then determined using:

$$\text{Fat \%} = \frac{(W_2 - W_1) \times V_C \times 100}{(V_A \times S_W)}$$

Where, W_2 was the weight of glass tube and dried extract (g), W_1 was the weight of empty dried glass tube (g), V_C was the total volume of chloroform (ml), V_A was the volume of extract dried (ml), and S_W was the weight of the sample in grams.

Crude fibre determination

Fibre content was determined according to the method of AOAC (2005) [20]. Briefly, 5g of each sample of *Phoenix dactylifera* and *Phoenix reclinata* was weighed into a litre conical flask. Then, 200 ml of boiling 1.25 % (v/v) sulphuric acid was added and boiled for 30 minutes over a burner. It was allowed to cool and filtered under suction on a piece of coarse texture linen. The residue was transferred back to the conical flask, and then 200ml 1.25% sodium hydroxide (NaOH) solution was added, then refluxed for 30 minutes. It was cooled and filtered through a piece of coarse textured linen. The sample was oven-dried at 100ºC for 1 hour, cooled in a desiccator, filtered through a piece of coarse textured linen and weighed (W_1). Sample was packed into a crucible in a furnace at 55ºC for 3-4 hours; it was cooled in a desiccator and weighed again (W_2). Fibre was calculated thus:

$$\text{\% Fibre} = \frac{W_1 - W_2 \times 100}{\text{Weight of the sample}}$$

Determination of crude protein

Crude protein content of fruit was determined according to the method of AOAC (2000) [21].

Briefly, it involved three stages−Digestion, Distillation and Titration.

Digestion

Each sample (2.0g) was weighed and put into a Kjedahl flask (digestion flask); 20ml of concentrated sulphuric acid, Kjedahl catalyst (crystalline copper sulphate) and potassium sulphate were added. The digestion flask was placed on the digestion block heater and the mixture was digested for 2 hours. The digestion continued until a clear colourless solution was obtained. After digestion, the mixture in the flask was cooled and the volume was transferred into a 100 ml volumetric flask and made up to mark with distilled water [21].

Distillation

Boric acid 4% w/v (500 cm^3) was measured into a 500 ml Erlenmeyer flask and 3 to 5 drops of methyl red indicator was added. The flask was placed under condenser of a distillation unit in such a way that the end of the condenser tube extends beneath the surface of the boric acid in the flask and to the digested solution, 100 cm^3 of 50% sodium hydroxide solution was carefully added. A few pieces of granulated zinc were subsequently added to the mixture. The flask was tightly attached to distillation unit while low heat was applied to mix the content of the flask gently. The distillation continued until the total content in the Erlenmeyer flask was about 250 ml. The boric acid solution was used here to trap aqueous ammonia distillate and hence avoid its evaporation [21].

$$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3\,(aq) + Na_2SO_4 + H_2SO_4$$

$$H_3BO_3\,(aq) + 2NH_3\,(aq) \rightarrow (NH_4)_2BO_3\,(aq)$$

Titration

The solution obtained was titrated against 0.01M HCl contained in a 50 ml burette. Titration continued until a blue colour disappeared. A blank titration was carried out.

$(NH_4)_2BO_3$ (aq) + 2HCl → $2NH_4Cl$ + H_3BO_3 (aq)

Protein content was determined by multiplying the average titre value by protein factor usually 6.25 [22].

$$\% \text{ nitrogen in sample} = \frac{\text{Net weight of acid X conc. of acid X14}}{\text{Weight of acid (mg)}}$$

% crude protein = % nitrogen in sample x 6.25

Thus, the conversion factor for nitrogen to protein equals 6.25 [22]

Determination of nitrogen free extract

The percentage of moisture content, ash content, crude fat, crude fibre and crude protein was added up and the sum was subtracted from 100. The difference is the nitrogen free extract.

% nitrogen free extract = 100 – % (Moisture contents + Ash content + Crude fibre + Crude protein + Crude fat)

Determination of carbohydrate content

The percentage of crude fibre and nitrogen free extract represent the total carbohydrate in the sample. It was calculated thus;

% Carbohydrate = % crude fibre + % nitrogen free extract

Mineral Analysis

The method of A.O.A.C (1990) was employed for the determination of mineral content [23]. Briefly, 1g of the pulverized samples was placed in a crucible and ignited in a muffle furnace at 550°C for 6 hours. The resulting ash was dissolved in 10ml of 10% HNO_3 and heated slowly for 20 minutes. After heating, the dissolved ash was filtered and the filtrate was used for the determination of mineral content. Atomic absorption spectrophotometer (AAS) was used to determine Ca, Cu, Cd, Mn, Ni, Mg, Zn and Fe, while flame photometer was used for the determination of Na and K in the filtrate. The readings were taken from the equipment in mg/g and the results were converted to mg/kg, which is the actual concentration of the element in the sample using the equation described below [24]:

$$\frac{\text{Concentration of Element x Volume of Digest}}{\text{Weight of Sample}}$$
calibrated reading

Statistical Analysis

Analysis of variance (ANOVA) followed by Turkey's test were used for comparison of the data using SPSS 22. Differences between means were considered statistically significant ($P < 0.05$). Each value for nutritional parameters is expressed as Mean ± SEM for the seeds of *P.dactylifera* and *P.reclinata.*

3. RESULTS AND DISCUSSION

Table 1 presents the result of proximate analysis of date seeds and shows comparative variability between *P.dactylifera* and *P.reclinata*. The results obtained from this proximate method shows a significant increase ($P<0.05$) in crude protein, carbohydrate and ash content of *P. dactylifera* seeds was observed as compared with that of *P. reclinata*. However, moisture content, crude fat and fibre was significantly higher ($P<0.05$) in seeds of *P. reclinata* than *P.dactylifera*. The results of mineral analysis (Table 2) revealed a significant increase ($P<0.05$)in Na, K, Fe and Zn content in seeds of *P. reclinata* compared to *P. dactylifera*. However, a significant increase in Ca, Mg was observed in *P. dactylifera* as compared to *P. reclinata.*

Nutritional composition of *Phoenix dactylifera* and *Phoenix reclinata* Seeds by Proximate Analysis

Seeds are important structures in fruit crops and are mostly composed of proteins, carbohydrates and lipids, which is either in wax, fat or oil form. About 11-18% of the date weight comes from the seed [12] [13] [25]. Although, the moisture content of seeds for both species obtained was relatively high and thus typical of healthy fruits at maturity [26]. The seeds of *P. reclinata* had the highest percentage of moisture content (12.50 %) compared to the seeds of *P.dactylifera* (10.51%). Moisture content values obtained in this study was similar to those cited by El-Shurafa*et al* [27], but higher than values reported by Habib and Ibrahim [28]. The relatively high moisture content provides for greater activity of water-soluble enzymes and co-enzymes needed for metabolic activities of these date palm species.

Ash content could translate into the quantity of minerals present in foods [29]. Minerals are important for bone and teeth formation, blood clotting, muscle contraction, transmission of impulses in nerves and maintenance of osmotic balances [30]. The seeds of *P. dactylifera* contained the highest percentage of ash content (1.50 %) while the seeds of *P. reclinata* contained the lowest percentage (1.17 %). Ash content values obtained in this study were similar to those cited by El-Shurafa et al [27] but higher than values reported by Habib and Ibrahim [28]. Although, the ash content observed in *P. dactylifera* conforms within the range of values reported in several studies [2] [13] [31]

The crude fat content in *P. reclinata* (15.50 %) is higher than that of *P. dactylifera* (8.67%). Moreover, the crude fat value obtained for *Phoenix dactylifera* only falls

within body's energy requirement values reported by the Food and Agriculture Organization [32] while that *P.reclinata* falls within the range of values reported for dried date pits [33].

Proteins are essential components of diets needed for survival of animals and humans (e.g. transport oxygen in the vertebrate blood). Hence, their basic function in nutrition is to supply adequate amounts of required amino acids in nutrition [34]. In this study, seeds of *P.dactylifera* had the highest percentage of crude protein (13.50 %), while the seeds of *P.reclinata* had the lowest percentage (13.23 %). Plant foods that provide more than 12% of their calorific value from protein are good source of protein [35]. The values for crude protein in seeds of *P. reclinata* and *P. dactylifera* were considerably higher than values reported in several date palm studies [2][13][28] [31]. Hence, this result claims that *P. dactylifera* sampled in this study is a better source of protein than *P. reclinata*. Dietary fibre is essentially a health-promoting nutrient. The seeds of *P. reclinata* had the higher amount of crude fibre (16.52 %) while the seeds of *P. dactylifera* contained less (5.13 %). On the average, seeds of both species had a relatively high fibre content that corroborates findings of earlier studies [28] [36]. Hence, these values meet human energy requirements, and thus show a great potential for exploitation, particularly in making fiber-enriched supplements.

Carbohydrate is one of the vital sources of energy for the body metabolism drive. The carbohydrate content of seeds recorded in this study represented about 63 % of their dry weight in which seeds of *P. dactylifera* had the highest percentage of carbohydrate content (65.99 %) and that of *P. reclinata* contained the lowest percentage (60.44 %). Moreover, the carbohydrate content obtained for *P. dactylifera* in this study was not in agreement with values obtained in other studies [2][13[31].

In general, the difference in nutrient content among the species may be due to different date varieties, different origin, different harvesting time, and the use of fertilizers [37].

Table 1: Nutritional composition of *Phoenix reclinata* seeds and *Phoenix dactylifera* seeds by proximate analysis

Parameters (%)	*Phoenix reclinata*	*Phoenix dactylifera*
Moisture content	12.50 ± 0.41	10.51 ± 0.00
Ash	1.17 ± 0.24	1.50 ± 0.41
Crude fat	15.50 ± 1.47	8.67 ± 1.03
Crude fibre	16.52 ± 1.46	5.13 ± 0.27
Crude protein	10.39 ± 0.45	13.23 ± 0.32
Carbohydrate	60.44 ± 1.65	65.99 ± 0.89

Values are means ± standard deviations of triplicate determinations

Mineral composition of *Phoenix dactylifera* and *Phoenix reclinata* Seeds by Elements

Analysis

In this present study, ten (10) elements were considered for element analysis and these elements include calcium (Ca), Sodium (Na), potassium (K), magnesium (Mg), iron (Fe), zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd) and manganese (Mn). Sodium and potassium are important intracellular and extracellular cations respectively. Sodium is involved in the regulation of plasma volume, acid-base balance, nerve and muscle contraction [38]. The mean calcium content in seeds ranged from 1785.48 mg/kg in *P.dactylifera* to 1547.38 mg/kg in *P.reclinata*. However, the calcium content gotten in our study was higher than that reported by Nehdi et al. [12] in *P. Canariensis* seed. The mean sodium content in seeds ranged from 2117.55 mg/kg being higher in *P.reclinata* to 1950.89 mg/kg in *P.dactylifera.* Moreover, the sodium content *for P.reclinata* falls within the nutrient standard range and hence, an indication that it is a good source of sodium compared to *P.dactylifera.* The sodium content gotten in our study was higher than that reported by Nehdi et al. [12] in *P. Canariensis* seed.

Potassium is an essential nutrient used to maintain fluid and electrolyte balance in the body. The mean potassium content in seeds sampled ranged from 1847.49 mg/kg in *Phoenix reclinata* to 1348.96 mg/kg in *P.dactylifera.* Moreover, the potassium content *for P.reclinata* falls within the nutrient standard range and hence, an indication that it is a good source of potassium compared to *P.dactylifera.* The potassium content gotten in our study was higher than that reported by *P. Canariensis* seed [12], roasted date pits [33] and deglet nour seed [13].

Magnesium is one of the vital minerals that the body of humans and animals needs for normal body functions (e.g. It plays a vital role in the active transport of calcium and potassium ions across cell membranes, a process that is important to nerve impulse conduction, muscle contraction, and normal heart rhythm) [39]. In this study, the mean magnesium content in seeds ranged from 3840.28 mg/kg in *P. dactylifera* to 3538.66 mg/kg in *P. reclinata*. Hence, seeds of *P. dactylifera* had higher magnesium content compared to that of *P.reclinata.* The magnesium content gotten in our study was higher than that reported by Habib and Ibrahim [28] in seeds of other date varieties. Hence, this is an indication that both seeds of *P.dactylifera* and *P.reclinata* are rich sources of magnesium.

Iron is an important trace element in the human body, it plays crucial roles in haemopoiesis, control of infection and cell mediated immunity [40]. The mean iron content in seeds ranged from 1119.98 mg/kg being higher in *Phoenix reclinata to* 1029.66 mg/kg in *Phoenix dactylifera*. However, the iron content obtained in our

study was higher than that reported by Habib and Ibrahim [28] in seeds of other date varieties. Hence, this is an indication that both seeds of *P. dactylifera* and *P. reclinata* are rich sources of iron. Iron deficiency is the most prevalent nutritional deficiency and iron deficiency anaemia, estimated to affect over one billion people worldwide [41]. The consequences of iron deficiency include reduced work capacity, impairments in behaviour and intellectual performance and decrease resistance to infection [42].

Zinc is an essential micronutrient for human growth and immune functions [43]. The mean zinc content in seeds ranged from 491.28 mg/kg being higher in *Phoenix reclinata* compared to 379.55 mg/kg as observed in *Phoenix dactylifera*. More so, values fall within the standard nutrient range that shows that these seeds are rich sources of zinc. According to a report, an estimated 20% of the world population is at risk of inadequate Zinc intake [44]. Studies on Nigerians showed that zinc deficiency affects 20% of children less than five years; 28.1% of mothers and 43.9% of pregnant women [42]. The zinc content gotten in our study was higher than that reported by Ali-Mohamed and Khamis [45] on Bahraini dates seed and by Habib and Ibrahim on seeds of other date varieties [28]. Hence, this is an indication that both seeds of *P.dactylifera* and *P.reclinata* are rich sources of zinc.

Copper is an essential micronutrient that functions as biocatalysts, required for body pigmentation in addition to iron, maintain a healthy central nervous system, prevents anaemia and interrelated with the function of Zn and Fe in the body [46]. The mean copper content in seeds ranged from 123.45 mg/kg being higher in *Phoenix reclinata* to 122.54 mg/kg as observed in *Phoenix dactylifera.* Hence, these values fall within the standard nutrient range. Humans and livestock require little quantities of copper. The copper content gotten in this study are in considerable amounts, though higher than values reported by earlier study [45] on Bahraini dates seed on seeds of other date varieties [28]. Nickel, Cadmium and Manganese were not detected in our study. Nickel which may be toxic to plants and animals have been found to occur in low amount in date seed compared to coffee and barley, which indicate the safety level of the date seed to be used as a food or animal feed ingredient [45]. A study examined the total mineral content found in date seed and compared it with mineral content in barley and the study reported that date seeds are good source of minerals, and could be used to substitute the usage of barley in food products for the same purpose [45].

Table 2: Mineral Composition (mg/kg) of *Phoenix reclinata* and *Phoenix dactylifera*

Mineral elements (mg/kg)	*Phoenix reclinata*	*Phoenix dactylifera*
Calcium (Ca)	1547.38 ± 0.64	1785.48± 0.20
Sodium (Na)	2117.55 ± 0.11	1950.89± 0.00
Potassium (K)	1847.49 ± 0.23	1348.96± 0.04
Magnesium (Mg)	3538.66 ± 0.55	3840.28± 0.78
Iron (Fe)	1119.98 ± 0.42	1029.66± 0.52
Zinc (Zn)	491.28 ± 0.28	379.55± 0.01
Copper (Cu)	123.45 ± 0.31	122.54± 0.00
Nickel (Ni)	ND	ND
Cadmium (Cd)	ND	ND
Manganese (Mn)	ND	ND

Values are means ± *standard deviations of triplicate determinations; ND = Not Determined*

4. CONCLUSION

P. dactylifera seeds are richer in crude protein, carbohydrate and ash content than *P. reclinata* while *P. reclinata* is richer in moisture content, crude fat and fibre. This study adjudged that seeds of *P. reclinata* contains higher amount of Na, K, Fe and Zn content than *P. dactylifera*. Seeds of *P. dactylifera* are richer in Ca and Mg compared with that of *P.reclinata*. Both seeds clearly demonstrate a great nutritional potential for exploitation. The nutrient variability among these species may be due to genetic diversity that exists between cultivars of dates. Thus, this research could contribute substantially to the advancement or development of edible and non-edible products in food and pharmaceutical industries as food production experts can make better food supplements, fodder or medicine. Future research should however focus on providing more information about seeds and other under-utilised portions of other fruit crops.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Olapeju Adenekan designed the study wrote the first draft of the manuscript. Koleayo Omoyajowo, Olutunde Babalola, John Ogidan, Sunday Amiolemen, Kayode Olaniyan, Julie Akande and Ifeoluwa Idowu wrote the protocol, managed the literature searches and performed the statistical analysis. All authors read and approved the final manuscript.

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