Nutrients, Antinutrients and Sensory Evaluation of Jam Produced from Date Palm Fruit (phoenix Dactylifera)

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ABSTRACT

Background: *Providing information about the nutritional composition of underutilized edible fruits and their products can increase the willingness to consume this kind of food as potential remedy to malnutrition.*

Objective: *This study was aimed to determine the nutrient and antinutrient compositions and sensory attributes of jams produced from date fruit.*

Methods: *The matured fresh and dried date fruits were processed into jams by boiling with lemon. Nutrients and antinutrient contents of the date fruits and produced jams were evaluated using standard methods of analysis and results compared with commercial jams as control.*

Results: *The result showed that dried date fruit contains moisture (13.10 ± 0.10 g/100g), protein (4.38 ± 0.01 g/100g), crude lipid(1.00 ± 0.10 g/100g), crude fiber (0.40 ± 0.10 g/100g), ash (1.50 ± 0.01 g/100g)and rich in carbohydrate(79.62 ± 0.01 mg/100g). Its vitamin contents were vitamin C(8.28 ± 0.00 mg/100g), A (1.69 ± 0.71 mg/100g), and B3 (1.03 ± 0.00 mg/100g). Mineral composition was Fe (2.68 ± 0.00 mg/100g), P (73.10 ± 0.01 mg/100g) and Ca(63.31 ± 0.00 mg/100g). Dried date jam showed appreciable amount ($P<0.05$)of crude lipid (0.60 ± 0.10 g/100g), carbohydrate (32.79± 0.01 g/100g), ash (0.25 ± 0.10 g/100g), crude fibre (0.20 ± 0.01 g/100g)and micronutrient (vitamin C, Fe and Ca) contents compared with the raw fruit and the strawberry jam used as control. The result obtained for the anti nutritional factors showed a reduction ($P<0.05$) in tannin (0.90-0.09mg/100g) and oxalate (3.19 - 3.05±0.02mg/100) compared with dried fruit. However, the commercial jams (apricot and strawberry) were rated highest (albeit, $P>0.05$) in all sensory parameters and acceptability investigated.*

Conclusion: *Date fruit and their jams can serve to supplement the nutrients provided by other staples due to their nutritional quality and therefore should be promoted.*

Keywords: *Dates, Jam, Sensory, nutrients, antinutrients*

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INTRODUCTION

The fast growing global population, banditry and changing climate are shifting weather to more extreme events thereby aggravating global food productivity and increasing hunger (1,2). As a result, healthy food materials in local markets are becoming relatively expensive and unaffordable to most rural populations (3,4) which could further increase the rate of protein-energy malnutrition (PEM) and micronutrient deficiencies especially among children and women of child bearing age from developing countries(5,6). In Nigeria for instance, about 10 million children are found to be stunted as a result of acute malnutrition (7), while anaemia resulting from iron deficiency was reported to be responsible for 19% of the maternal mortality in the country (5,7).

Inadequate supply of proper amount of nutrients to maintain healthy body function has been reported to be the major contributory factor of malnutrition in the country (8). Millions of dollars are allocated annually for the provision of nutrient and vitamin supplements to tackle malnutrition crises in the country (9), also different strategies and interventions are underway to prevent or reduce nutritional deficiencies in Nigeria, yet, malnutrition continues to be one of the main causes of high mortality rates among children (4, 8), as these strategies might have fallen short of the pace required to ameliorate malnutrition crisis in the country.

While the government and other donor agencies emphasise on the provision of social amenities, and advancing agriculture towards reducing hunger and malnutrition, the contribution of edible wild fruits to rural nutrition and livelihoods cannot be overemphasised. In Africa, particularly in the Sahel regions where droughts and other weather-related calamities reduce traditional staple crop yields, wild fruits are gaining increasing importance(10) due to the awareness of the significant contribution it makes to the diets of a good percentage of the African population. Many rural households depend on wild fruit as a coping strategy during critical hunger periods in the agricultural cycle, which usually last for three to four months annually (11). Due to their appreciable nutritional values and health benefits (12), wide-fruits can therefore serve to supplement the nutrients provided of cereals, legumes and root crops. Moreover, the fruits are low in fats and cholesterol and provide essential micronutrients such as calcium, iron, potassium and vitamin C (13, 14) and are pleasant to taste. However, these fruits are seasonal in nature and fast disappearing with limited shelf-life, this may have dire consequences on the rural populace who eat them fresh. It is therefore important to improve existing methods and adapt new methods for the greater utilization of perishable wild fruits to enhance food security.

Jam is one novel method of preserving seasonal fruit for use in non-season or to make it available for the consumers to enjoy throughout the year and during off season (14). It is a fruit preserve with stable shelf-life made from whole fruit or fruit pulp and are used in eating foods like bread, biscuits, pies etc. they are made from two main ingredients, fruit and sugar. Date is the wild-fruit obtained from date palm (*Phoenix dactylifera L*)with the family of *Areacaceaea* (*Palmae)*, which can be considered as an idea food that provides a wide range of essential nutrients such as minerals (Fe, K, Ca and Mg), dietary fiber, vitamin C, amino acids(11, 12) and antioxidants (such as flavonoids) with many potential health benefits. Animal and human studies showed the antihyperglycemic effects of Dates (15,16). Due to its high content of phenolic compounds, dates fruits showed specific inhibitor of alpha-glycosidase and was found to reduce plasma sugar after fifty minutes of ingestion (16). Beside direct consumption of the whole dates, the fruits are traditionally used to prepare a wide range of different products such as date juice concentrates (jam, syrup and liquid sugar), fermented date products (wine, bioethanol, vinegar, organic acids) and date pastes for different uses (e.g. bakery and confectionary) (17).

The use of any seed as a source of nutritious food arises from the knowledge of the chemical compositions of the source and its products (18). Although little or no research is done on fresh date fruit in wet season, as it is also harvested and consumed during this season (wet season) in Nigeria, being a tropical country. There is therefore need to evaluate the chemical composition of jam prepared from fresh and dry date fruit regardless of its harvesting season. However, very few researchers have worked on this area of date palm studies and there is paucity of information in the literature on the possibility of developing novel jam product from both fresh and dried date. To fill this knowledge gap, this study assessed the chemical composition and sensory evaluation of jam produced from both fresh and dried date palm fruit.

MATERIALS AND METHODS

Sample Collection

The matured fresh and dried date fruits were purchased from Mubi main market, Adamawa state, Nigeria. The samples were transported immediately to Umudike, Abia State where sample preparation, processing, and analysis were carried out.

Sample Preparation

Samples (fresh and dried date fruits) on arrival to Umudike, Abia State Nigeria, were sorted and cleaned to remove dirt and damaged fruits. A weight of 200g of each sample (fresh and dried date fruits) was washed and the fruits were cut open and the seeds removed. The fresh fruit was milled to puree while the dried fruit was milled to fine flour (BN-2001-62WC-Germany). The fine flour of the dried date fruit and lemon (which served as a preservative) was added to water at boiling point and stirred thoroughly to form a gel-like substance while the freshly milled puree of the fresh date fruit was cooked at about 100°C for 40 minutes and lemon added and stirred until the jam was formed. The fresh date fruit jam and dried date fruit jam were stored in a jar respectivelyfurther preserved in a refrigerator pending analysis.

Proximate Analysis

The standard analytical procedures for food analysisdescribed in AOAC (19) were adopted for the determination of the moisture content, crude protein, crude fiber, percentage lipids, carbohydrate, ash, and calorific value of all the samples (DRDJ – Dried date fruit jam, FRDJ- Fresh date fruit jam, DRDF- Dried date fruits) including the controls (APRJ – Apricot jam and STRJ – Strawberry jam)

Moisture Determination

Moisture was determined using the gravimetric method (19, 20). The samples (5g each) were put into the crucibles and dried in an oven at 105°C overnight. The dried sample was cooled in a desiccator for 30 min and weighed to a constant weight. The percentage loss in weight was expressed as percentage moisture content on a dry weight basis. This was repeated three times to obtain triplicate values.

Crude Protein Determination

Crude protein was determined by the Kjedahl method (19, 20). The samples (5g each) were weighed in triplicate into a filter paper and put into a Kjedahl flask, 8 to 10 cm^3 of concentrated H_2SO_4 were added and then digested in a fume cupboard until the solution became colorless. Distillation was carried out with about 10 cm^3 of 40% NaOH solution. The condenser tip was dipped into a conical flask containing 5 cm^3 of 4% boric acid in a mixed indicator till the boric acid solution turned green. Titration was done in the receiver flask with 0.01 M HCl until the solution turned red.

Determination of Total Ash

This was carried out using the furnace incinerator gravimetric method (19). Five grams of each sample were put in a muffin furnace set at 550°C for 3 hours. The gray ash samples were carefully removed from the furnace and cooled in a desiccator. The sample was re-weighed by difference and obtained in percentage.

$$\%Ash = \frac{(W_2 - W_1)}{Weight of sample} \times \left(\frac{100}{1}\right)$$

Where,

W_1 = Weight of crucible and

W_2 = Weight of empty crucible.

Determination of Crude Lipid

This was obtained by the continuous solvent extraction method using a soxhlet apparatus (20). From the pulverized sample, 5.00 g was used for determining the crude lipid by extracting the lipid from it for 5 h with (60 to 80°C) petroleum ether in a soxhlet extractor. Double samples were extracted to obtain double values that were later averaged.

Determination of Crude Fiber

This was determined by the method described by James (20). Five grams of the defatted samples (during crude lipid analysis) was used twice to estimate crude fiber by 20% H_2SO_4 and 20% NaOHsolutionsin acid and alkaline digestion method.

Determination of Carbohydrate

The carbohydrate content was calculated by difference as the nitrogen free extractive (NFE). A method separately described by (21)and (20). The NFE was by:

%NFE = 100% (a + b + c + d + e)

Where, a = Protein, b = Fat, c = Fiber, d = Ash and e = Moisture

Determination of Energy/caloric Value

Energy value = (carbohydrate value x 4) + (crude protein value x 4) + (fat value x 9) kcal.

Determination of Micronutrients

Atomic absorption spectrophotometric (AAS) method was employed for mineral analysis following the methods described in Igwe*et al.,*(22) (**Table 1**). **Procedure:** A portion, 2g of each sample was incinerated in a muffle furnace at 600°C for 3 h. The ash obtained was cooled, dissolved in 5ml of 6N HCl and allowed to stand for 30 min (Acid digestion). It was later filtered and its volume made up to 50ml with deionized water. The resulting extract was used for the determination of minerals by the use of an atomic absorption spectrophotometer. The spectrophotometric method described by Onwuka,(23) was employed in the determination of vitamins A, B1, B2, B3 and C.

Determination of Phytochemical Content

Determination of Alkaloids

The quantitative determination of alkaloids was carried out by the alkaline precipitation through gravimetric method described by Okwu, (24). **Briefly:**Five grams (5g) of the sample was weighed and 200ml of 20% acetic acid in ethanol was added and covered to stand for 4 hours. This was then filtered and concentrated. Concentrated ammonium hydroxide was added drop wise to the extract until the precipitation was complete. The precipitation was dried and weighed after it was allowed to settle and filtered. Alkaloid content was calculated in percentage.

$$\% \text{ Alkaloid} = \frac{weight of residue}{weight of sample} \times \frac{100}{1}$$

Determination of Saponin

Twenty grams (20g) of the sample was added to 20 cm^3 of ethanol and was boiled for 4 h. After cooling it was filtered and 50 cm^3 of petroleum ether was added to the filtrate and the ether layer evaporated to dryness. 5 cm^3 of acetone/ethanol mixture was added to the residue. 0.4 cm3 of each was taken into 3 different test tubes. 6 cm^3 of ferrous sulphate reagent was added into them followed by 2 cm^3 of concentrated H_2SO_4. It was thoroughly mixed and after 10 min the absorbance was taken at 490 nm. Standard saponin was used to establish the calibration curve (25).

Determination of Tannin

Half grams (0.5g) of the sample was extracted with distilled water, shaken for 30 minutes and filtered. A standard tannin acid solution was prepared, 2ml of the standard solution and equal volume of distilled water dispersed into a separate 50ml volumetric flask to serve as standard and reagent blank respectively. 1ml of Folin-Dennis reagent was added followed by addition of 2.5ml of saturated Na_2CO_3 solution and diluted. Shake the mixture, incubate at room temperature for 90 minutes. Take the absorbance at 760nm with spectrophotometer.

$$\% \text{ tannin} = \frac{Au}{Ab} \times C \times \frac{100}{W} \times \frac{Vf}{Va}$$

Where,

Au = absorbance of the test sample, Ab = absorbance of blank, C = concentration of the standard tannin solution, Vf = total volume of extract, Va = volume of extract analyzed and W = weight of the sample used.

Determination of Flavonoids

Ten grams (10g) of the sample was weighed and repeatedly extracted with 100 cm3 of 80% methanol at room temperature. The mixture was then filtered through filter paper into a 250 cm3 beaker and the filtrate was transferred into a water bath and allowed to evaporate to dryness and weighed. The % flavonoid was calculated using the formula:

$$\% \text{ Flavonoid} = \frac{weight of residue}{weight of sample} \times \frac{100}{1}$$

Determination of Oxalate

A modification of the titrimetric method of Iwe, (25) was used in the determination of oxalate. In this method, 75 cm^3 of 1.5m H_2SO_4 was added to 2 g of the ground samples and the solution was carefully stirred intermittently with a magnetic stirrer for 60 minutes and filtered using Whatman

No 1 filter paper after which 25 cm^3 of the filtrate was collected and titrated against hot (90°C) 0.1m $KMnO_4$ solution until a faint pink colour that persisted for 30s appeared. This was repeated twice more and the concentration of oxalate in each sample was obtained from the calculation;

$$\frac{T\times(Vme)\times(DF)X10^3}{(ME)\times MF}\left\{\frac{mg}{wog}\right\}$$

Where,
T = titre of $KMnO_4$ (ml), Vme = Volume - Mass equivalent, Df = Dilution factor VT/A, VT = total volume of titrate, A = Aliquot used, ME = molar equivalent of $KMnO_4$and MF = mass of flour used.

Sensory Analysis Method

The sensory attributes of the jam were determined by using a simple hedonic test described by Iwe(26) and Munoz and King (27), with twenty semi-trained member panel that was neither sick nor allergic to the raw material, comprising of staff and students of the Human Nutrition Department, College of Applied Food Science and Tourism, Michael Okpara University of Agriculture Umudike, Abia State. A nine 9-point hedonic scale was used where 1 and 9 represented dislike extremely and like extremely respectively. The attributes that were evaluated include color, aroma, taste, texture (mouth feel), spreadability, and general acceptability using two different jams strawberry jam (STRJ) and apricot jam (APRJ) available in the commercial market as control.

RESULTS

Table 1 shows the proximate composition of dried date fruit (DRDF), fresh date fruit jam (FRDJ), dried date fruit jam (DRDJ), strawberry jam (STRJ) and apricot jam (APRJ).The results showed a mean values ± standard deviation($p<0.05$) in the moisture content, crude protein, ash, carbohydrate, crude fiber and energy levels of the samples. The moisture content levels of fresh date fruit jam (52.00 ± 1.00), dry date fruit jam (64.00 ± 1.02) and strawberry jam (30.67 ± 0.02) were high and varied while the dried date fruit (13.10 ± 0.10) and apricot jam (21.36 ± 0.01) were considered as half soft.

Table 1: Proximate composition of Date and Date jams (%)

Samples	Moisture	Crude protein	Ash	Fat	Crude fiber	Carbohydrate	Energy value
DRDF	13.10^{f} ± 0.10	4.38^{d} ± 0.01	1.50^{b} ± 0.01	1.00^{a} ± 0.10	0.40^{a} ± 0.10	79.62^{a} ± 0.01	346^{a} ± 1.00
FRDJ	52.00^{c} ± 1.00	2.84^{e} ± 0.01	0.25^{c} ± 0.10	0.55^{c} ± 0.10	0.03^{c} ± 0.01	44.35^{d} ± 0.01	193^{d} ± 0.10
DRDJ	64.00^{b} ± 1.02	2.41^{f} ± 0.01	0.25^{c} ± 0.10	0.60^{c} ± 0.10	0.20^{b} ± 0.01	32.79^{e} ± 0.01	146^{e} ± 0.10
STRJ	30.67^{d} ± 0.02	4.68^{c} ± 0.01	0.10^{c} ± 0.10	0.29^{d} ± 0.01	0.01^{d} ± 0.001	64.25^{c} ± 0.01	279^{c} ± 1.00
APRJ	21.36^{e} ± 0.01	6.80^{a} ± 0.01	0.02^{e} ± 0.00	0.36^{d} ± 0.01	0.01^{d}± 0.001	71.50^{b} ± 0.10	316^{b} ± 0.20

Means with different superscript and within same column are significantly different ($p<0.05$). Values are means ± standard deviation of two replicates.APRJ – Apricot jam, STRJ – Strawberry jam, DRDJ – Dried date fruit jam, FRDJ- Fresh date fruit jam, FRDF- Fresh date fruit, DRDF- Dried date fruit.

Table 2: Mineral composition of samples

Sample	Phosphorus (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Sodium (mg/100g)	Magnesium (mg/100g)	Iron (mg/100g)
APRJ	$26.07^{e} \pm 0.00$	$1.60^{a} \pm 0.01$	$10.48^{f} \pm 0.00$	$12.01^{f} \pm 0.01$	$10.41^{e} \pm 0.01$	$0.42^{e} \pm 0.00$
STRJ	$24.00^{f} \pm 0.00$	$1.52^{b} \pm 0.00$	$15.07^{e} \pm 0.00$	$14.16^{e} \pm 0.00$	$12.44^{c} \pm 0.00$	$0.41^{e} \pm 0.01$
DRDF	$73.10^{a} \pm 0.01$	$1.30^{f} \pm 0.00$	$63.31^{a} \pm 0.00$	$90.02^{a} \pm 0.01$	$21.01^{a} \pm 0.01$	$2.68^{a} \pm 0.00$
FRDJ	$36.64^{d} \pm 0.00$	$1.42^{d} \pm 0.00$	$42.88^{d} \pm 0.00$	$60.42^{d} \pm 0.01$	$14.42^{b} \pm 0.00$	$1.07^{d} \pm 0.00$
DRDJ	$40.12^{c} \pm 0.01$	$1.49^{c} \pm 0.00$	$49.91^{c} \pm 0.00$	$72.79^{c} \pm 0.01$	$11.15^{d} \pm 0.01$	$1.28^{c} \pm 0.00$

Means with different superscript and within same column are significantly different ($p<0.05$).¨Values are means ± standard deviation of two replicates.APRJ – Apricot jam, STRJ – Strawberry jam, DRDJ – Dried date fruit jam, FRDJ- Fresh date fruit jam, FRDF- Fresh date fruit, DRDF- Dried date fruit.

Table 3: Vitamin composition of the samples

Samples	A (mg/100g)	B1 (mg/100g)	B2 (mg/100g)	B3 (mg/100g)	C (mg/100g)
APRJ	$1.71^{d} \pm 1.41$	$0.027^{e} \pm 0.00$	$0.04^{d} \pm 0.00$	$0.61^{e} \pm 0.00$	$7.03^{b} \pm 7.05$
STRJ	$1.52^{f} \pm 0.71$	$0.02^{f} \pm 0.00$	$0.02^{e} \pm 0.00$	$0.38^{f} \pm 0.02$	$58.83^{a} \pm 0.02$
DRDF	$1.69^{e} \pm 0.71$	$0.03^{d} \pm 0.00$	$0.04^{d} \pm 0.00$	$1.03^{d} \pm 0.00$	$8.28^{b} \pm 0.00$
FRDJ	$2.00^{a} \pm 1.41$	$0.12^{a} \pm 0.00$	$0.09^{a} \pm 0.00$	$1.30^{a} \pm 0.00$	$11.05^{b} \pm 0.01$
DRDJ	$1.75^{c} \pm 2.83$	$0.04^{c} \pm 0.00$	$0.05^{c} \pm 0.00$	$1.11^{c} \pm 0.00$	$8.05^{b} \pm 0.01$

Means with different superscript and in same column are significantly different ($p<0.05$).¨Values are means ± standard deviation of two replicates.APRJ – Apricot jam, STRJ – Strawberry jam, DRDJ – Dried date fruit jam, FRDJ- Fresh date fruit jam, FRDF- Fresh date fruit, DRDF- Dried date fruit. 1.75c 2.83

Table 4: Antinutritional contents of the samples

Samples	Flavonoid (mg/100g)	Alkaloid (mg/100g)	Oxalate (mg/100g)	Saponin (mg/100g)	Tannin (mg/100g)
APRJ	$1.04^{e} \pm 0.00$	$0.08^{d} \pm 0.00$	$2.05^{e} \pm 0.01$	$0.10^{f} \pm 0.00$	$0.47^{f} \pm 0.00$
STRJ	$1.82^{c} \pm 0.00$	$0.12^{b} \pm 0.00$	$1.87^{f} \pm 0.00$	$0.40^{a} \pm 0.00$	$0.65^{e} \pm 0.01$
DRDF	$1.18^{d} \pm 0.01$	$0.12^{b} \pm 0.01$	$3.19^{d} \pm 0.01$	$0.15^{e} \pm 0.01$	$0.91^{b} \pm 0.00$
FRDJ	$2.09^{b} \pm 0.01$	$0.07^{e} \pm 0.00$	$3.05^{a} \pm 0.01$	$0.32^{b} \pm 0.00$	$0.68^{d} \pm 0.00$
DRDJ	$1.04^{c} \pm 0.00$	$0.10^{c} \pm 0.00$	$3.15^{c} \pm 0.02$	$0.21^{d} \pm 0.00$	$0.09^{a} \pm 0.01$

Means with different superscript and within same column are significantly different ($p<0.05$).¨Values are means ± standard deviation of two replicates.APRJ – Apricot jam, STRJ – Strawberry jam, DRDJ – Dried date fruit jam, FRDJ- Fresh date fruit jam, FRDF- Fresh date fruit, DRDF- Dried date fruit.

Table 5: Sensory quality preference of jam sampled by Panellists

SAMPLES	APPEARANCE	TEXTURE	FLAVOUR	TASTE
FRDJ	$5.4^{b} \pm 0.32$	$5.5^{b} \pm 0.20$	$5.7^{a} \pm 0.23$	$5.8^{a} \pm 0.48$
DRDJ	$4.4^{b} \pm 0.30$	$5.6^{ab} \pm 0.70$	$5.6^{a} \pm 0.24$	$5.7^{a} \pm 0.48$
STRJ	$6.6^{a} \pm 0.32$	$6.0^{a} \pm 0.70$	$6.0^{a} \pm 0.24$	$6.0^{a} \pm 0.48$
APRJ	$6.1^{a} \pm 0.40$	$5.4^{ab} \pm 0.70$	$5.6^{a} \pm 0.24$	$6.2^{a} \pm 0.48$

Means with different superscript and within same column are significantly different ($p<0.05$).
¨Values are means ± standard deviation of two replicates.APRJ – Apricot jam, STRJ – Strawberry jam, DRDJ – Dried date fruit jam, FRDJ- Fresh date fruit jam.

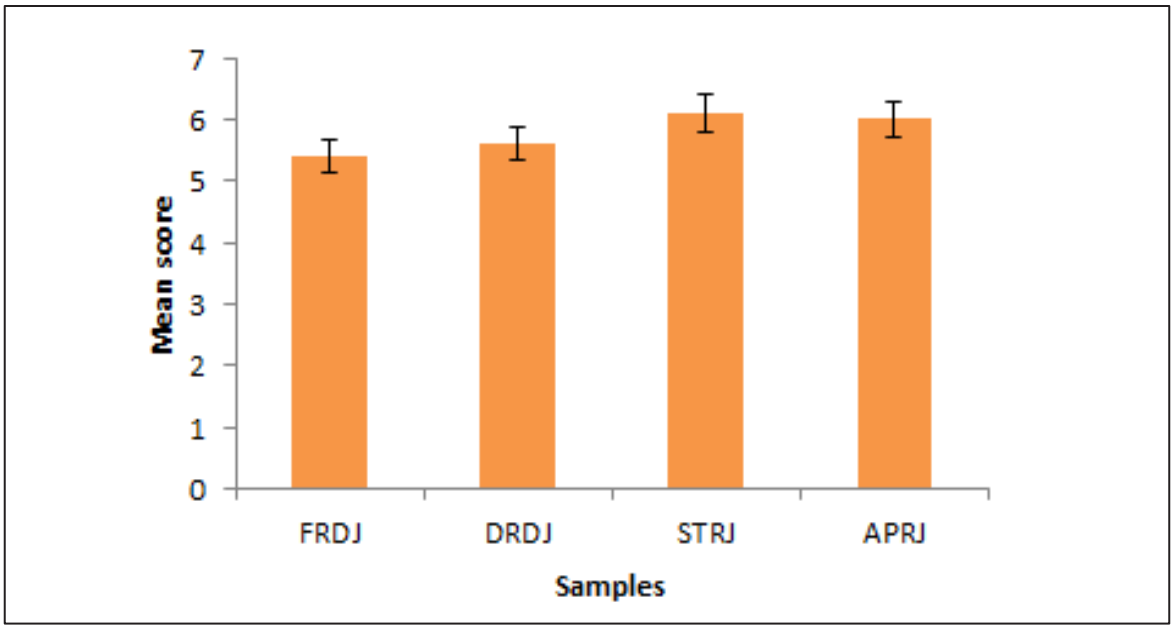

Figure 1: General acceptability of Fresh and Dried Date fruit jams
APRJ=Apricot jam, STRJ=strawberry jam, DRDJ=Dried date fruit jam, FRDJ=fresh date fruit jam

Table 2 summarizes the mineral composition of the samples. The fresh and dried date fruit jams contained appreciable amount of minerals although lower than the unprocessed date fruit. Dried date fruit was the highest for phosphorus content (73.10 ± 0.01), calcium (63.31 ± 0.00), sodium (90.02 ± 0.01), magnesium (21.01 ± 0.01) and iron content (2.68± 0.00).

Table 3 summarizes the vitamin content of the samples. The vitamin content of the six (6) samples were significantly different ($p<0.05$) from one another, the fresh date fruit jam (FRDJ) had the highest amount of vitamin A, B1, B2, B3 while strawberry ranked the highest in vitamin C

Table 4 shows the anti-nutritional properties of the samples of which there was a significant difference ($p<0.05$) among the flavonoid content of the samples. The flavonoid content ranged from 1.04 ± 0.00 in dried date fruit and apricot jam to 2.14 ± 0.01 in fresh date fruit jam. In addition, the alkaloid content of the samples significantly ($p<0.05$) ranged from 0.07 ± 0.00 in

fresh date jam to 0.13 ± 0.00 in fresh date fruit.

DISCUSSION

This study evaluated the nutritional compositions of date fruits and date fruit jams .The moisture content of any sample is seen as an index of water activity which is used as a measure of susceptibility to microbial contamination. There was a significant increase ($P<0.05$) in moisture content of the date fruit jams compared with the raw dried fruit. This could be due to the extra water added during the processing (boiling) stage. This higher moisture content in the jam could facilitate spoilage easily than low moisture content observed in the dried fruit. However, the reduction of pH due to addition of lemon juice could prevent the proliferation of spoilage bacteria and thus increase the shelf-life of the jams despite high moisture content observed. Xie *et al*.,(28) considered dates fruit as soft, if they present a water content more than 30%, dry if this rate is less than 10% and half-soft if the rate is between 10% and 30%. That unlike dry fruits, wet fruits like date cannot be stored for a very long time because of the high amount of moisture contained in it which promotes microbial growth therefore reducing the shelf-life of food products in comparison with dried products which has lower water content (28).

The dried dates and date jam contain 79.5% and 32.79 % carbohydrate respectively which is considered the main component of dates that plays an important role in the flavour and desirability of the dates. From a previously reported study carried out by Ogungbenle, (29), the total sugar content of 12 different varieties of dates varied from 44-77g/100g which is considerably in agreement with our report. However, our value is slightly lower than 80.67g/100g obtained by Gamal *et al*., (30). This difference could be due to the type and stage of maturity of the date used. Alkaabi *et al*., (31) reported that the carbohydrate content of dates depends on the type of date and the degree of ripeness.

The carbohydrate content of date and jam observed in our report may not necessarily portend risk to its consumers because Dates have low glycemic index (GI) ranging from 35-55 (31) which classifies them as low to medium GI food items, so they are good for diabetes as they are less likely to cause a spike in blood sugar levels. The low GI of dates can be attributed to their high fructose and dietary fiber content (31). In a study conducted by Mirghani, (15), dates fruits were found to reduce fasting plasma glucose and postprandial plasma glucose among patients with diabetes. This suggests that dates and its jam product can be consumed moderately without the risk of inducing undesirable post prandial excursions in blood glucose despite their high sugar composition. Advantageously, high carbohydrate content of date can provide readily accessible energy for physical performance and regulate nerve tissue transmission.

The protein content was higher in the raw date fruits (4.38±0.01) than the date jams (2.84 ± 0.01, 2.41 ± 0.01) but lower when compared with the standard strawberry jam used as control (6.80 ± 0.01) having the highest amount of protein. The amount of protein observed in the study agrees with recommended daily allowance of protein for adults as it serves as an enzymatic catalyst and helps to mediate cell responses, control growth and cell differentiation (32). The level of ash content is a reflection of the total available minerals in any food sample which also serves as an index for nutritive value of food in regards to the mineral contents. The ash content of dried dates obtained in our work was however similar with 2.6 g/100g reported by Rehman et al., (33). The result of the ash content in the sample is a suggestion of an appreciable deposit of mineral elements in the samples compared to the recommended values by FAO/WHO (34)

The average crude fat content in jams (1.00±0.10g/100g) showed an increased compared to the raw dried dates which are universally stored forms of energy in living organisms and also contributes significantly to the energy value of foods. This also should not be a concern to consumers as the fat content is low to meet the recommended daily amount (10-25%/day) at 100g (35).The crude fibre content for dried date fruit were lower than that obtained by Gamal et al.,(30) and Rehman et al., (33).The

dietary fiber content varies depending on the type and degree of ripeness of dates(34) which could account for the differences observed. However, the percentage of dietary fiber was similar to that previously reported by other researchers(35,36). This means that the consumption of 100g of dried dates can provide more than 50% of the recommended daily amount of fiber (37). Fibre content of foods helps in digestion process and prevention of cancer (38, 39).Crude fiber decreases the absorption of cholesterol from the gut in addition to delaying the digestion and conversion of starch to simple sugars, an important factor in the management of diabetes (40).

Minerals play many vital roles, working synergistically with vitamins, enzymes, hormones and other nutrient cofactors to regulate literally thousands of the body's biological functions (41). In this study, the dried date jams recorded the higher levels of mineral content (especially, Fe and Ca) compared with the jam. This variation in mineral content of the samples were attributed to the fact that every food preparation process reduces the amount of nutrients in food, particularly processes that expose foods to high levels of heat, light and/or oxygen (33, 42). However, the difference was not significant ($P>0.05$) compared with the raw dried fruit. Vitamins are essential micro-nutrients for organisms' multiple biochemical reactions (41). The study showed a significant difference ($p<0.05$) between the vitamin A, B1, B2 and B3 content of the samples indicating the nutrient density of date fruits regardless of its processing methods. The vitamin C content of the raw date fruit jam had the highest levels of vitamin C, emphasizing the importance of consuming fresh fruits and its product. This is in contrast to Ahmed et al. (16) which recorded a relatively low concentration of vitamin C that was however higher than apricot in line with this study. The dried date fruit and dried date jam generally had lower vitamin content which could be attributed to the effect of sundrying on the date fruit (33).

The nutritional importance of a given food depends on the nutrients and anti-nutritional constituents of the food (43).The study showed a significant difference between the flavonoids levels of the dried fruit jam (DRFJ) (1.04 ± 0.00) and the strawberry jam control jam (STRJ) (1.82 ± 0.00). The flavonoid levels of the date fruit jam recorded was distinctively lower than what was recorded in Dixo et al., (44). This was expected as flavonoids have been known to be responsible for the highlighted colour and aroma of fruits in contrast to the dull colouration and insignificant aroma of date fruit (45).

The level of oxalate in the fresh and dried date fruit jams (3.35 ± 0.01, 3.15 ± 0.02) was considerably lower than 7.57±0.04 observed by Ekop, (46). This low levels has enhanced its edibility as oxalate have been accounted for to have negative impact on accessibility of mineral which will prompt assimilation of fundamental minerals in body particularly calcium by framing insoluble salts (46). The study recorded low levels of saponin which is within the WHO permissible limit (48.50 mg/100 g) as recommended by WHO (47) and tannins suggesting the safety of consumption of this fruit jam regardless of its moisture content. However, the tannin levels were considerably higher in the fresh fruit jam (0.68 ± 0.00) than the dried fruit jam (0.09 ± 0.01).The anti-nutritional composition of the samples was low. This indicates that the fruit jams is safe for consumption and can be used effectively since the anti-nutritional composition is low and there would be no interference with the nutrient like protein and minerals in the body..

The sensory quality of the jam samples showed no significant relationship in the appearance of the fresh date fruit jam (FRDJ) and the dried fruit jam (DRDJ). The strawberry jam (STRJ) had the best colour while the dried date jam had the least preferred colour. This was however attributed to the effects of treatments added to the strawberry during its production. The general acceptability of the date fruit jams in this study was relatively high when compared with the commercial jams. This is in contrast to Mohammed et al., (48) who reported a general acceptability of 3.75 on a 9-point hedonic scale. The general acceptability of the samples in this study did not show a clear-cut preference of any of the jams as their preference ranged from 5.4 in fresh date fruit jam to 6.1 in

strawberry jam. This is in line with the observation of Ahmed et al., (49) that consumers are inclined to choose a product that has the closest organoleptic similarity to the reference sample that the consumers are familiar with.

CONCLUSION

The result showed that date fruits and its jam can serve as an excellent source of vitamins and minerals as date jam contains appreciable amounts of nutrients similar with the unprocessed date fruit. The results also indicated a reduction in the anti-nutritional factors in the jams compared with the raw fruits, highlighting the need for the use of date palm as an inexpensive source of digestible nutrients including crude fibre. The general acceptability and sensory qualities of the date jam studied was comparable to that of the commercially produced jams and should therefore be improved upon and encouraged as a positive alternative to conventional fruits in jam.

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