EVALUATION OF NUTRITIONAL COMPOSITION AND CHEMOMETRIC CHARACTERIZATION OF SOME VARIETIES OF DATE FRUITS.

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Abstract

Malnutrition is a major health problem to the world population especially in Africa, despite government's effort to promote food production. This problem occurs when people do not consume right amounts of essential nutrients, based on lack of information. It is the intention of this research to determine the proximate, food functional properties, mineral contents and characterize the fruit of Phoenix dactylifera L. (Dabino) using Chemometrics method with a view to compared the values and investigate the differences in these varieties. Different varieties of date fruits that are commercially available in Minna, Niger State were randomly collected. All the fresh date fruits were clean with distilled water, dried in laboratory and ground into powder. The results obtained showed that, moisture contents of the studied fruits ranged from (4.00 to 4.29%). Fat, ash, and fiber contents of the date fruits varieties ranged from 0.40 to 1.50%, 3.12 to 3.37% and 1.50 to 2.85% respectively. The Ajwa variety had the highest protein (2.91%) content and the Fari variety the lowest (1.53%). All the four varieties have high carbohydrate content (89.30%, 88.01%, 87.38% and 86.69%) for Dagalla, Fari, Dan-mali and Ajwa respectively. The results also indicated considerable amount of mineral elements such as K, Na, Ca, Mg, Fe, Mn and Cu. With the aid of principal component analysis, the Fari and Ajwa varieties were characterized by high protein, fiber contents, ash contents and emulsion capacity. The dendrogram for hierarchical cluster analysis for proximate composition, mineral contents and food functional properties show that one major cluster is identified which shows that all studied date fruits have some similarities. The sub-clusters which are observed indicates that Ajwa and Fari variety have close similarity in their nutritional contents and could therefore are used as substitute of each other when consumption choice has to be made.

Keywords: Characterization, Chemometric, Date Fruits Heirarchical Cluster Analysis, Principal Component Analysis

Introduction

Malnutrition causes increase in child mortality rate, diabetes, high blood pressure and cancer. Diets deficiency causes reduction in mental and physical development, child performance in school and loss of productivity in the workplace (Branca and Ferari, 2002). Balanced diets help to reduce or even eliminate nutrition related diseases in humans. Some trace elements such as copper, iron, manganese and zinc are very essential for life and are needed in human and animal diets in order to maintain good health (WHO and FAO, 2002). They are required for tissue repair, growth, metabolisms and for slowing down some of the abnormal processes. However, both deficiency and excesses of these essential trace elements give serious problems in the human and animal body. Some fruits are able to accumulate some trace elements in high concentrations. Studies have shown that there is a significant concentration of trace elements in date fruits (Hamza *et al.*, 2014).

Date (*Phoenix dactylifera L.)* fruit is very popular and widely consumed in Nigeria especially among the Muslim community. The crop is cultivated in northern part of the country. They are commercially available due to high market demand, and are mostly cultivated in all the

Northern African and Asian countries. Dates fruits contribute to the economy and social life within these regions (Abdulqadir *et al*., 2011). There are three different cultivars of date fruit, i.e., fresh, semi- dry and dry. There are three common colours of the fruits, which are the red, yellow and amber. However, other colours exist. The semi-dry date fruit consist of *Ajwa, lubiya* and *Dan-Mali,* and the dry cultivar includes *Fari* and *Daganlla*. The good nutritional values of dates are also based on their dietary fiber content, which makes them suitable for preparation of fiber based foods and dietary supplements. Dates contains high amount of dietary fiber, as 100g of dates provide 32% of the recommended daily intake of dietary fiber. They also contain higher crude protein than many fruits such as apples, oranges, bananas, grapes e.tc. which reduces as the fruit mature (Uba *et a*l., 2015), Suleiman *et al.,* (2012) postulated that Date fruits have high carbohydrate content. Agboola and Adejuma (2013) reported that date contain 65% of carbohydrate and Sultana *et al*., (2015) showed the highest carbohydrate content in *gounda* (51%) and *Trunji* (50%). Most of the carbohydrates in dates are in the form of fructose and glucose, which are easily absorbed by the human body (AL-Farsi and Lee,2008). The date fruit contain a good percentage of dietary fibre and serves as good source of mineral elements such as iron, potassium, selenium, and calcium (Sultana *et al*., 2015).

These variations determine their overall quality, not only the nutritive qualities (chemical, energy, protein, fibre and mineral contents) but also the sensory qualities (appearance, color, smell, texture, and flavor). The functional properties of the food materials are very substantive for the suitability of the diet, behavior of nutrients in food during processing, storage and preparation because they affect the general quality of foods as well as their acceptability (Omueti *et al*., 2009).

Chemometry is the use of mathematics and statistical methods to improve the understanding of chemical information and to correlate quality parameter or physical properties to analytical instrument data. It is applied to solve descriptive and predictive problems in chemistry. Due to the nature of the factors that might contribute to customer preference, multivariate chemometrics tools, especially pattern recognition techniques, appear to be useful tools to characterize these date fruit into natural clusters based on the selected parameters. These parameters involved various chemical, physical, and instrumental analysis. Consequently, exploration on the relationships among these parameters was carried out. In this study, the characterization of the date fruits is based on unsupervised pattern recognition technique such as principal component analysis (PCA), and hierarchical cluster analysis (HCA). Despite the important of chemometrics in data analysis, Nigeria date palm industry (production, processing and marketing) lack adequate information of the nutritional composition of date fruit using Chemometry techniques (Agboola & Adejumo, 2013). It is the intention of this research to evaluate and characterize the proximate composition, mineral contents and functional properties of 4 date (*Phoenix dactylifera L*.) fruits commonly found in Minna, Niger State, Nigeria using Chemometry method with a view of comparing the values and investigating the differences in these varieties.

Materials and Methods

Sample Collection

Twelve samples of date fruits (*Phoenix dectylifera L.)* varieties (*Fari, Dagalla, Dan-mali and Ajwa*) were purchased from three markets namely: Kure market, Bosso market and Kasuan Gwari in Minna, Niger State, Nigeria.

Digestion Procedure

Two grams of each homogenized dry sample blends were accurately measured into a 50cm^3 beaker. 10cm^3 of nitric acid was added to soak for 5hours and the beakers were covered with aluminum foil. After 5 hours, the beakers were placed on the hotplate in a fume cupboard. 2.5cm^3 of nitric acid and 1cm^3 of hydrogen peroxide were added on a low heat. After 10minutes of heating, the heat was increased to medium and 5cm^{3}of nitric acid and 2cm^3 of hydrogen peroxide were added on application of medium heat. After 15minutes of heating, 15cm^3 of water, 2.5cm3 of nitric acid and 1cm^3 of hydrogen peroxide were added on medium heat and heat for 15minutes. The heat was then increased to high and 15cm^3 of water, 5cm^3 of nitric acid and 1cm^3 of hydrogen peroxide were added and allowed to heat for 10minute. The digests were filtered with white filtered papers and made up to mark with distilled water in a 100cm^3 volumetric flask, transferred into sample bottles and labeled (Salau and Hassan, 2014).

Analysis of Proximate Composition

The proximate parameters; Moisture Content, Ash Content, protein content, Lipid Content were determined according to AOAC (2006) methods While the carbohydrate content was by the method reported by James (1995).

Energy Value

The energy value was calculated in kilocalories per 100 g (kcal/100 g) by multiplying the crude fat, protein and carbohydrate values by of 37, 17 and 17 respectively (Nweke *et al.,* 2011).

Determination of Functional Properties

Determination of Bulk Density (BD): Bulk density (BD) was carried out in accordance with the method reported by Cortes *et al* (2005). Bulk density (g/cm^3) is expressed as mass of the sample (g)/volume of the sample (cm^3).

Determination of Water Absorption (WAC): Water absorption (WAC) procedure was in accordance with Cortes *et al* (2005) and it was calculated as the product of the amount of water absorbed and density of water.

Determination of Oil Absorption Capacity (OAC): Oil absorption capacity (OAC) was carried out as described in Cortes *et al* (2005). This was expressed as the product of amount of oil absorbed and density of vegetable oil. The density of the oil was 0.87g/cm^3.

Determination of Foaming Capacity (FC): The method described in (Okafor *et al*., 2003; Okoye *et al.*, 1999) was used. The foaming capacity (% volume increase) is 100 (V_1–V_2)/V_1.
$\frac{100\ V\quad V}{V}$

Where
V_1= volume before whipping.
V_2 = Volume after whipping

Determination of Foam Stability (FS): The method described by Okafor *et al* (2003) was also adopted as follows

Foam Stability = $\frac{100V}{V}$

Where
V_2= Foam volume after time (t)
V_1 = Initial foam volume

Determination of Fat Emulsion Capacity (FEC)
The procedure described in Ogawa *et al* (2003) was used. It was expressed as the amount of oil emulsified and held per gram of sample. Emulsion Capacity was calculated using the following equations.
FEC= 100a/b
Where a = height of the emulsified layer
b= height of the whole solution in the centrifuge tube.

Determination of Gelation Capacity (GC): Gelation Capacity (GC) was determined by applying the method of Olaofe *et al* (2006) and the modification by Akintayo *et al* (2004). The gelation capacity was obtained as the least gelation concentration which was the concentration ($5cm^3$) when the samples in the inverted test tubes did not fall or creep out.

Results and Discussion

Table 1: Mineral contents of date fruits in mg/100g

Parameters	A	B	C	D
Cu	2.63±0.25	2.20±0.70	5.70±1.25	2.27±0.65
Mn	0.90±0.20	0.80±0.10	0.60±0.10	1.60±0.20
Fe	21.40±0.61	18.73±0.65	17.37±0.87	20.43±1.46
K	620±10.00	686.67±5.77	596.67±5.77	716.67±5.77
Ca	34.16±0.34	14.55±0.40	12.17±0.18	32.97±0.63
Na	171.80±0.42	161.07±0.02	182.40±0.22	378.40±0.04
Mg	82.19±0.35	68.16±0.46	51.80±0.15	85.97±0.06

Key: The values are means of triplet determinations ± standard deviations (SD), A: *Fari*, B: *Dan- mali*, C: *Dagalla*, and D: *Ajwa*

Table 1 shows the results of mineral contents of the date fruits. In the present study, the mineral contents of the date fruit showed that potassium was the most abundant element present. It ranged from 716.67mg/100g in *Ajwa*; 686.67mg/100g in *Dan-mali*; 620mg/100g in *Fari* to 596.67mg/100g in Dagalla. These values were higher When compared with the values *Fari*, *Dan-Mali* and *Dagalla* (360mg/100g, 310mg/100g and (265mg/100g) reported by Uba *et al (*2015). The iron content in *fari* (21.40mg/100g) was highest, followed by *Ajwa* (20.43mg/100g), *Dan-mali* (18.73mg/100g) and *Dagalla* (17.37mg/100g) with the lowest. This indicates that the date fruits could supply adequate iron intake when weight reduction is needed. The recommended daily requirement for iron (adult males) is 10mg, hence, a daily intake of 100g portion of date fruit could supply more iron than is required (IOM, 2000). The manganese content was highest in *Ajwa (1.60mg/100g),* followed by *Fari* (0.90mg/100g), *Dan-Mali* (0.80mg/100g) and Dagalla with the lowest. These values were higher when compared to values (Dagalla (0.08mg/100g, Fari (0.07mg/100g and Dam-mali (0.05mg/100g) reported Uba *et al (*2015). The Dietary Reference Intake (DRI) values of manganese for female and male are 1.8 and 2.3 mg/day respectively Uba *et al (*2015). Daily consumption of dates could easily complement the Dietary Reference Intake (DRI) values for manganese. Similarly, the higher copper value was recorded in *Dagalla* (17.70mg/100g), followed by *Fari* (2.63mg/100g), *Ajwa* (2.27mg/100g) and *Dan-mali* (2.20mg/100g) in decreasing order. These values were higher when compared to the values (*Ajwa* (0.37mg/100g), *Saffawy* (0.77mg/100g), *Khodry* (0.49mg/100g) reported by Ismail *et al*., 2015.

The result of this work showed that calcium was highest in *Fari* (34.16mg/100g), followed by 32.97mg/100g in *Ajwa;* 14.55mg/100g in *Dan-mali* and 12.17mg/100g in *Dagalla*. These values were higher when compared to values (*Ajwa* (0.339mg/100g), *Saffawy*

(0.467mg/100g), and *Khodry* (0.564mg/100g) reported by Ismail *et al*., 2015, which suggest that these fruits could supply adequate daily human calcium requirement. The current daily requirement of calcium for children (4-8 years) is (210mg) (IOM, 1997). Based on this, 200g portion of the fruits could supply adequate calcium need of this age group (Uba *et al,* 2015).

The levels of sodium in the date fruits were: *Ajwa* (378.40mg/100 g), *Dagalla* (182.40 mg/100 g), *Fari* (171.80 mg/100 g), and *Dan-mali* (161.70mg/100 g) respectively. These values were lower when compared to values reported by Ubal *et al* (2016 in *Dagalla* (618mg/100g), *Dan-mali* (614mg/100g) and fari (610mg/100g). Daily consumption of dates could easily complement the Dietary Reference Intake (DRI) values for sodium. Similarly, magnesium content of the date fruits were: *Ajwa* (85.97mg/100g), *Fari* (82.19mg/100g), *Dan-mali* (68.16mg/100g) and *Dagalla* (51.80mg/100g) respectively.

Table 2: Proximate compositions (%) of date fruits

Parameter (%)	A	B	C	D
Moisture	4.00±0.04	4.29±0.03	2.70±0.06	4.00±0.09
Ash	3.26±0.11	3.37±0.06	3.13±0.20	3.159±0.26
Fiber	2.15±0.10	2.60±0.06	1.50±0.06	2.85±0.64
Protein	1.84±0.02	1.53±0.06	1.82±0.02	2.91±0.12
Fat	0.45±0.03	0.50±0.29	1.50±0.03	0.40±0.03
Carbohydrate	88.01±1.35	87.38±0.92	89.30±1.66	86.69±1.73
Energy Value(kj/100g)	1544.1±0.1	1571.9±0.2	1562.61±0.1	1538.00±0.2

Key: The values are means of triplet determinations ± standard deviations (SD), A: *Fari,* B: *Dan mali*, C: *Dagalla,* and D: *Ajwa*

Table 2 shows the result of the proximate composition (%) and energy values (KJ/100g) of four date palm (*Phoenix dactylifera* L.) fruits. The moisture content of the four samples ranged from 4.29 to 2.70 percent. Dan-Mali had the highest (4.29%) followed by *Fari* (4.00%) and *Dagalla* had the lowest (1.33%). The values for moisture content observed in present study were in close agreement to the values (*Dan-mali* (4.60%) followed by *Fari* (2.17%) and *Dagalla* (1.33%) with the lowest) reported by Uba *et al.* (2015). These values were lower compared to that in *Aseel* (7.2±0.34%), *Daki* (5.0±0.25%) and were higher when compared to *Halavi* (0.84%) (Jamil *et al.,* 2010). The high moisture content facilitates spoilage of dates and low values of moisture are significant values for good storage quality.
The percentage protein contents in *Ajwa* (2.91%) were higher followed by *Fari* (1.84%), *Dagalla (1.82) and Dan mali* was found to contain the least (1.53%). These values were in agreement to ranged (2.77% to 1.88%) reported by Vinta and Darsha-punia (2016). Ismail *et al*. (2006) reported similar protein values of 2.3-2.7% and 2.1-3%, respectively for date fruit varieties. The crude protein was low when compared to protein rich foods in cowpea seed (24.7%) and lentil (26.1%). This low protein content indicates that date fruit cannot serve as a source of protein supplement to human.

The amount of fat found in *Dagalla* was highest (1.50%) followed by *Dan-Mali* (0.50%), *Fari* (0.45%) and *Ajwa* was found to contain the least content (0.40%) which was in close agreement to the range (0.50% to 0.17%) reported by Vinta and Darsh-punia (2016) and Sahari *et al*. (2007). The low fat content indicates that date fruits may not be a source of oil. The ash content in *Dan-Mali* (3.37%) was higher followed by *Fari* (3.26%), *Ajwa* (3.15%) and *Dagalla* was found to contain the least composition (3.13%). These values were higher when compared to ash values in Coconut (2.87±0.1%), *Halavi* (2.07±0.04%) (Jamil *et al.,* 2010). Higher ash content in dates indicates that the total inorganic mineral is high.

*Ajwa (*2.85%) was found to contain the highest value for the crude fibre followed by *Dan-mali* (2.60%), *Fari* (2.15%) and *Dagalla* (1.50%). Crude fiber is essential in diet because it influence digestion and absorption processes in the small intestine (Cherbut et al., 1995). The total carbohydrate content of the date fruits showed that Dagalla (89.30%) was the highest, followed by *Fari* (88.01%), *Dan-Mali* (87.35%) and Ajwa (86.69%) was found to contain the least. However, *Dan mali* (1571.90kJ/100g) was found to have the highest value of energy, followed by Dagall*a* (1562.61kJ/100g), fari (1544.10kJ/100g) and *Ajwa* (1538.00kJ/100g) was found to contain the lowest energy value. Carbohydrates are the most important constituents of dates, making them a rich source of energy for the human system.

Table 3: Food functional properties of date fruits

PARAMETER (%)	A	B	C	D
Bulky Density(g/cm^3)	1.33±0.02	0.69±0.02	1.41±0.02	0.87±0.10
Water Absorption Capacity (g/g)	3.05±0.02	2.70±0.20	1.89±0.01	2.50±0.02
Emulsification Capacity (%)	45.08±0.10	44.38±0.02	43.45±0.02	45.72±0.20
Foam Capacity (%)	5.08±0.10	6.03±0.02	6.01±0.02	5.12±0.03
Foam Stability (%)	35.16±0.02	36.01±0.02	34.0±0.02	35.10±0.02
Oil absorption Capacity (g/g)	1.24±0.02	1.43±0.02	1.50±0.02	1.23±0.03
Gelation Capacity (%)	15.99±0.02	15.78±0.01	16.72±0.20	16.58±0.02

Key: The values are means of triplet determinations ± standard deviations (SD), A: *Fari*, B: *Dan- mali*, C: *Dagalla,* and D: *Ajwa*

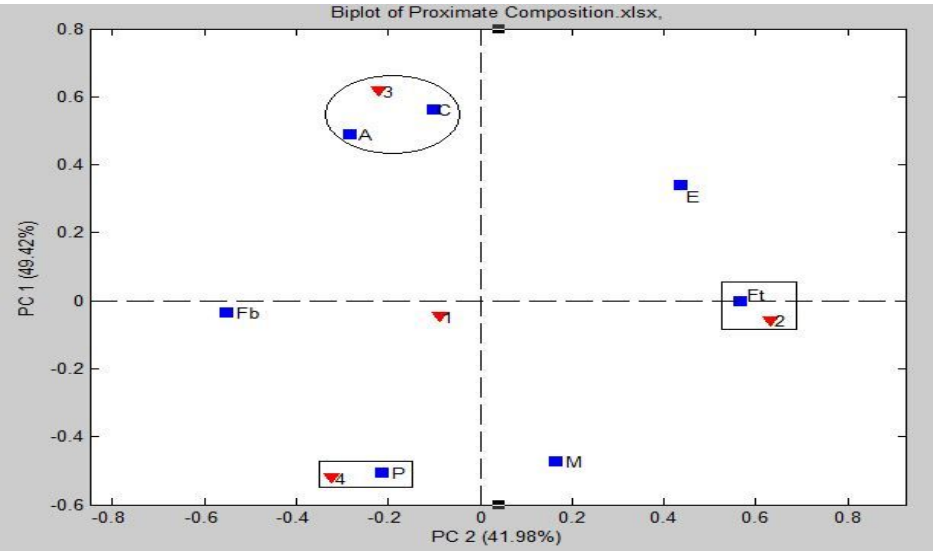
Table 3 shows the results of functional properties of the date fruits. The oil absorption capacity of the studied date fruits ranges from 1.23g/g in *Fari* to 1.50% in *Dagalla*. These results are in close agreement with the value reported by Shaba *et al.,* 2015. The results show that date fruits may be suitable for retaining the taste of food products due to high oil absorption capacity. Similarly, the water absorption capacity recorded for the studied date fruits shows that *Fari* had the highest (3.05g/g), followed by *Dan-mali* (2.70g/g), *Ajwa* (2.50g/g) and *Dagalla* (1.89g/g) with the lowest. The value obtained is higher than values reported for wheat flour (0.75g/g) (Akubor *et al*., 2013), breadfruit flour (1.55g/g) (Adepeju *et al*., 2011) and jackfruit seed flour (2.03g/g) (Chowdhury *et al*., 2012). The result shows that date fruit has the ability to associate with water under condition such as dough and pastes. It also indicates heaviness, suggesting its suitability as a drug binder and disintegrates in pharmaceutical industries (Zaku et al., 2009).)

The emulsification capacity ranges between 43.05 to 45.72%. These values were higher than wheat flour (11%) and akee seed flour (25.65%) (Akintayo *et al*., 2002). Differences in the emulsified ability of date fruits depends on the concentration, type and suitability of proteins (Eiklelifa, 2005). The similarity in the contents of fiber and proteins in studied date fruits indicates its suitability usage in the production of sausages. Similarly, the results for gelation capacity indicates that it ranges from 15.99 to 16.72%. The high gelling percentage in date fruits shows that the fruits are suitable to be used as gelling agent. The fruits with high gelation percentage are reported to be poor thickening agents (Noorfarahzilah *et al.,* 2017).

The bulk density of the date fruits shows that Dagalla had the highest with a value of 1.41%, followed by *Fari* (1.33%), *Ajwa* (0.87%) and *Dan-mali* had the lowest. The results show that *Dagalla* and *Fa*ri varieties may offer better packaging advantage than *Dan-mali* and *Ajwa* varieties. The studied date fruits also contained foaming capacity ranging from 5.08 to 6.03%

and foaming stability from 34.00 to 36.01%. The values which is in agreement with the values (Forming capacity, 5.15% and foam stability, 35.05%) reported by Shaba *et al.,* 2015

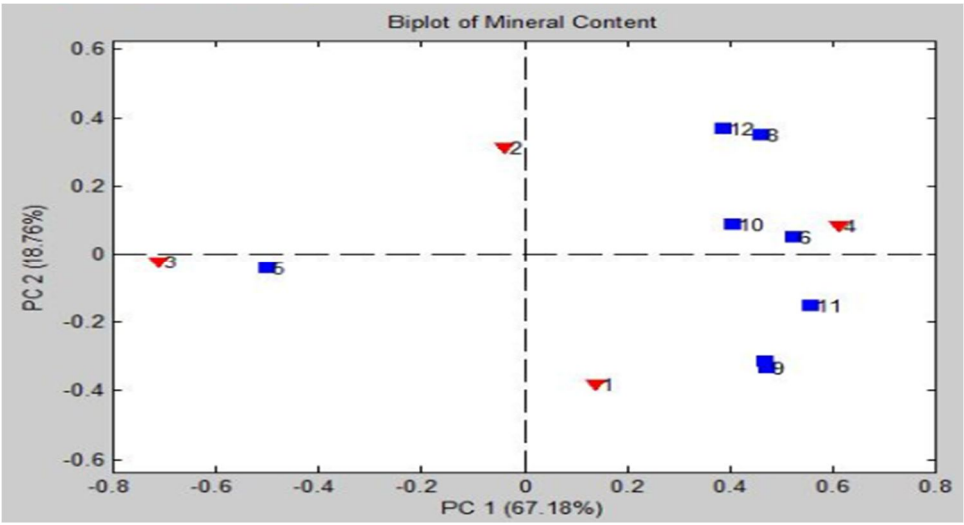
Principal component analysis (PCA)



Key: 1:Fari, 2:Dan-mali, 3: Daganlla, 4: Ajwa m: Moisture, A:Ash, Fb: Fibre, P: Protein, Ft: Fat, C: Carbohydrate, E: Energy

Figure 1: PCA biplot for the Proximate Composition

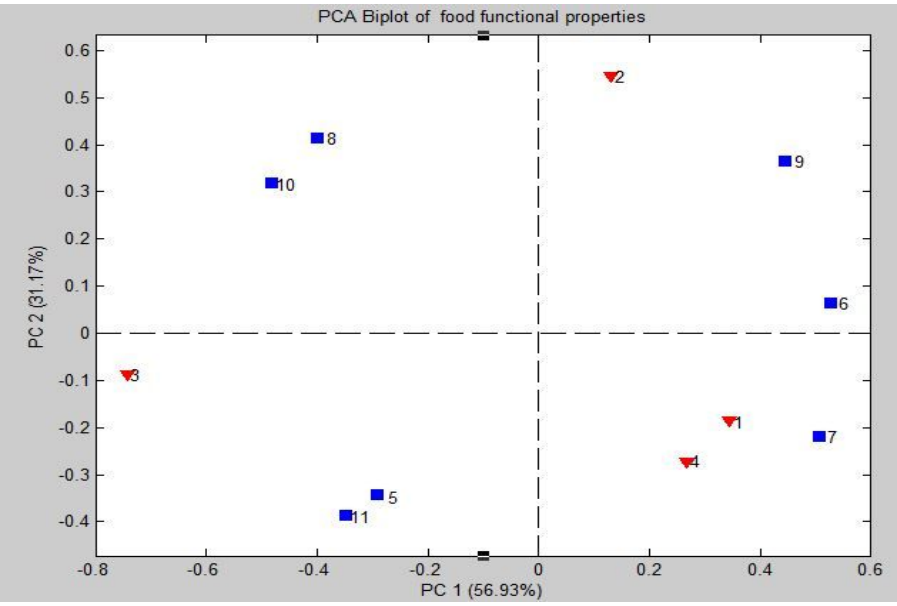
The results of PCA showed in the Figure 1 above indicates that PC1 account for 49.42% of the total variation and PC2 had 41.96% of the total variability which exhibits three non-linearly separable clusters similar to CA. It can be seen that sample 4 (*Ajwa*) is characterized by high protein and fiber contents and low fat content. Sample 2 (*Dan-mali*) is characterized by high fat and energy contents and relatively low in moisture contents. Similarly, sample 3 (*Dagalla)* is characterized by high carbohydrate and Ash content and had low amount of fiber content.



Key: 1: Fari, 2:Dan-mali, 3: Daganlla, 4: Ajwa 5Cu, 6 :Mn, 7:Fe, 8: Zn, 9: Ca, : 10: Na, 11: Mg

Figure 2: PCA biplot for Mineral Contents

The results of PCA showed in the Figure 2 above indicates that PC1 account for 67.18% of the total variation and PC2 had 18.76% of the total variability. It can be seen that sample 4 (Ajwa) is characterized by high amount of mineral contents like (Ca, Na, K, Mg and Cu). Sample 2 (Dan-mali) is characterized by low Cu and relatively high amount of K. Similarly, sample 1 (Fari) is characterized by high Ca and Mg contents.

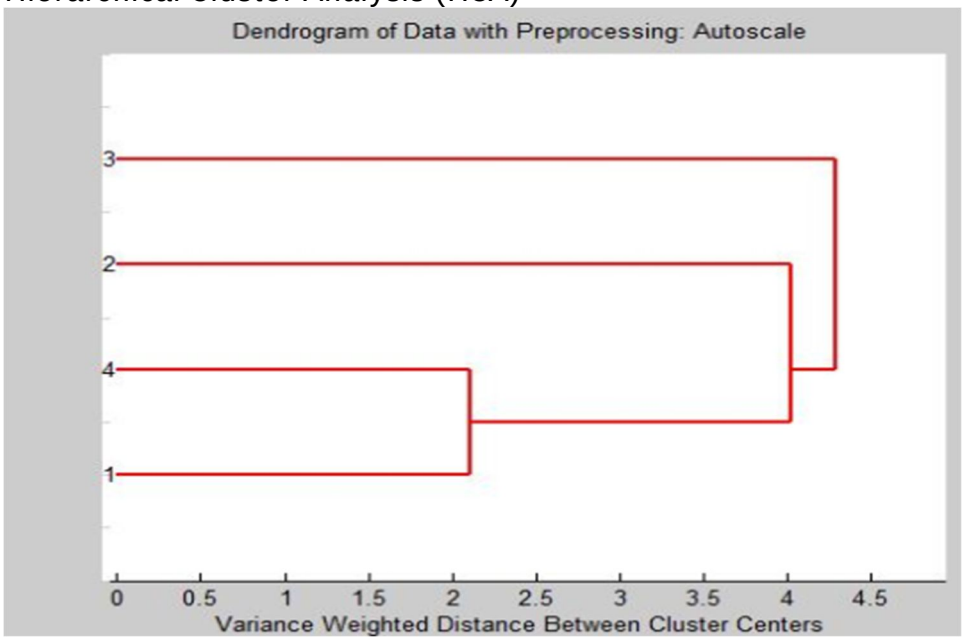


Key: 1:Fari, 2: Dan-Mali, 3: Daganlla, 4: Ajwa, 5: Bulk Density, 6:Water Absorption Capacity, 7: Emulsification Capacity, 8: Foam Capacity, 9:Foam Stability, 10: Oil Absorption Capacity, 11: Gelation Capacity.

Figure 3: PCA biplot for the food functional properties

The results of PCA showed in the figure 3 above indicate that PC1 account for 56.93% of the total variation and PC2 had 31.17 of the total variability. It can be seen that sample 1 and 4 (Fari and Ajwa) are characterized by high amount of Emulsion Capacity. Sample 2 (Dan-mali) is characterized by high Foam Stability (FS) and Water Absorption Capacity (WAC). Similarly, sample 3 (Dagalla) is characterized by low Water Absorption Capacity.

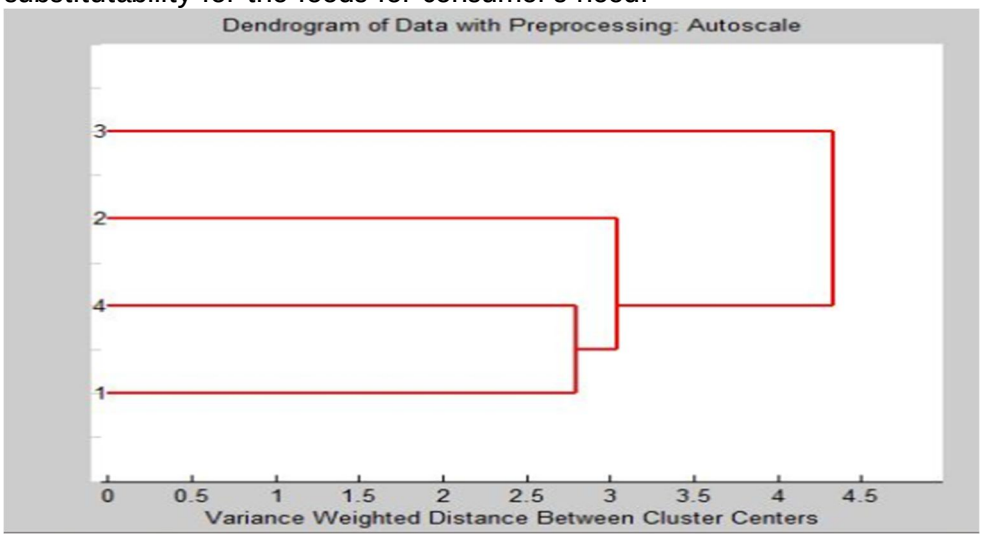
Hierarchical Cluster Analysis (HCA)



Key: 1: *Fari,* 2: *Dan-mali,* 3: *Daganlla,* 4: *Ajwa*

Figure 4: Hierarchical cluster analysis (HCA) result for the proximate composition

The dendrogram (figure 4) show that one major cluster can be identified which shows that all the studied date fruits (*Fari, Dan-mali, Dagalla and Ajwa)* have some similar proximate variables. Sub-clusters are observed and are as follows: clusters 1 and 4 (*Fari and Ajwa)* are joined which indicates that both samples are more similar in proximate composition than others. This is followed by single cluster 2 (*Dan-mali)* which shows a different in proximate variables, with a distance from Y- axis longer than that of clusters 1 and 4. The distance from the Y- axis of cluster 3 (*Dagalla)* is longer than that of cluster 2 indicating that the sample is more different in proximate composition from clusters 1 and 4 than cluster 2. Another significant observation on the dendrogram (Figure 4) is that the *Fari* and *Ajwa* date fruits can be used as a close substitute for each other in term of their proximate composition and substitutability for the foods for consumer's need.

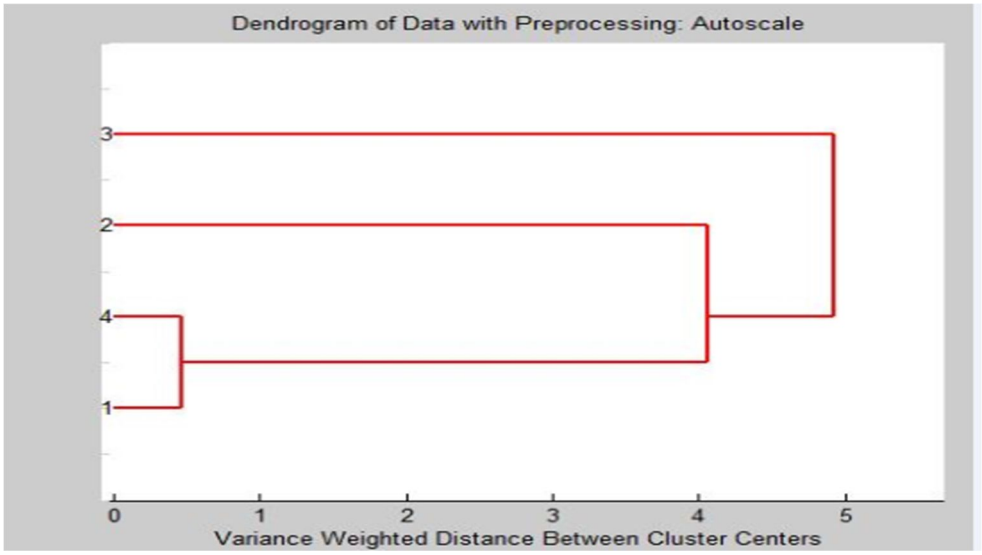


Key 1: *Fari*, 2: *Dan-mali*, 3: *Daganlla*, 4: *Ajwa*

Figure 5: Hierarchical cluster analysis (HCA) result for the mineral contents

The dendrogram (Figure 5) shows that one major cluster can also be identified. This shows that all the date fruits (*Fari, Dan-mali, Dagalla and Ajwa*) have some similar mineral contents. Sub-clusters are observed as follows: clusters 1 and 4 (*Fari and Ajwa*) are group together which indicate that both samples have more similar in mineral contents. This is closely followed by single cluster 2 (*Dan-mali*) which shows a slightly different in mineral contents with a distance from Y- axis slightly longer than that of clusters 1 and 4.

The distance from the Y- axis of cluster 3 (*Dagalla*) is longer than that of cluster (1 and 4) and that of cluster 2 indicating that the sample is more different in mineral contents. Another significant observation on the dendrogram above is that the *Fari* and *Ajwa* date fruits that are group together can be used as a close substitute for each other in term of their mineral contents and substitutability for the foods for consumer's need.



Key 1*: Fari,* 2: *Dan-mali,* 3: *Daganlla,* 4: *Ajwa*
Figure 6: Hierarchical cluster analysis (HCA) result for the food functional properties

The dendrogram (Figure 6) shows that four sub-clusters can be identified. From the bottom, cluster 1 and 4 which consist of *Fari* and *Ajwa* are grouped together indicating that both samples have similar functional properties. This is followed by cluster 2 (*Dan-mali*) which shows a wide different in functional properties from cluster 1and 4 with a distance from y-axis longer than that of cluster 1 and 4.
The distance from Y-axis of cluster 3 (*Dagalla*) is longer than that of cluster (1 and 4) and cluster 2 indicating that the sample is more different from cluster 1 and 4.

Conclusion

From the results of the present study, it can drown that the four date fruits are an ideal high-energy food, rich in carbohydrates, dietary fiber and minerals like Ca, Mg, Mn, K, Na, and Cu.

Hierarchical Cluster Analysis (HCA) established the substutability of *Fari* variety from Nigeria and *Ajwa* variety from Saudi Arabia. The consumption of *Fari* date is of similar content as consumption of *Ajwa* date in term of mineral contents, proximate compositions and functional properties.

Principal Components Analysis (PCA) revealed that *Ajwa* date is characterized by unique Fibre, protein content, mineral contents like K, Na, Ca, Mg and Cu and high amount of emulsification

capacity. *Fari* date is characterized by high Ca, Fe, and Mg. It has unique carbohydrates and protein contents. High emulsification capacity was also found to be unique property of the *Fari* dates.

The PCA results also reveal that *Dan-mali* is characterized by high Foam Stability, Water Absorption Capacity, K, fat and energy contents. Similarly, the *Dagalla* variety is characterized by high carbohydrate and Ash contents, and low Water Absorption Capacity.

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