Vol. 18(19), pp. 408-415, 8 May, 2019
DOI: 10.5897/AJB2018.16551
Article Number: FA10BA860944
ISSN: 1684-5315

http://www.academicjournals.org/AJB

ACADEMIC JOURNALS
expand your knowledge

African Journal of Biotechnology

Full Length Research Paper

Chemical composition of *Cyperus esculentus* nut and *Phoenix dactylifera* fruit

Chinedu Imo[1]*, Friday O. Uhegbu[2], Kayode A. Arowora[1], Chukwuma S. Ezeonu[1], Ifeoma J. Opara[3], Caleb J. Nwaogwugwu[2] and Chigozie J. Anigbo[1]

[1]Department of Biochemistry, Faculty of Pure and Applied Sciences, Federal University Wukari, Taraba State, Nigeria.
[2]Department of Biochemistry, Faculty of Biological and Physical Sciences, Abia State University, Uturu, Abia State, Nigeria.
[3]Department of Chemical Sciences, Faculty of Pure and Applied Sciences, Federal University Wukari, Taraba State, Nigeria.

Received 12 June, 2018; Accepted 10 August, 2018

This study investigated the chemical composition of *Cyperus esculentus* nut and *Phoenix dactylifera* fruit. The nuts and fruits were purchased as commonly sold in Wukari, Nigeria. They were cleaned, sorted for healthy parts, sun-dried and milled into fine powder. The AOAC, AAS and GC-MS methods were adopted for the proximate, mineral and phytochemical analysis, respectively. The results show that *C. esculentus* nut is higher in percentage moisture, crude protein, crude fiber and lipid compared to *P. dactylifera* fruit, while *P. dactylifera* fruit is higher in percentage dry matter, ash and carbohydrates. *C. esculentus* nut contain higher level (ppm) of magnesium, manganese, copper, zinc and phosphorus than *P. dactylifera* fruit. Potassium, sodium, calcium, chromium and iron are more abundant in *P. dactylifera* fruit. The phytochemical result shows the presence of varieties of chemicals. *C. esculentus* nut and *P. dactylifera* fruit contain certain phytochemicals that are food additives and some that are known to possess anti-inflammatory, hypotensive, antimicrobial, antioxidant, lipid moderating properties and immune booster. Both plant materials contain appreciable amount of macronutrients which are very essential for provision of energy and nourishment of human body system. *C. esculentus* nut and *P. dactylifera* fruit are recommended in general nutrition.

Key words: *Cyperus esculentus,* mineral, nutrition, *Phoenix dactylifera,* phytochemical, proximate.

INTRODUCTION

The use of many plant materials which are consumed raw or processed in different forms before consumption as food in human daily food is already on the increase. Most of these plant materials are widely known to be efficient in treatment and management of different forms of diseases. Many are used to improve human health or immune system.

Phoenix dactylifera L, commonly known as Date palm is a member of palm family Arecaceae, and it is one of the major staple crops in Africa and parts of Asia. Date palm grows in many parts of the world. The fruit contains a single seed. It has been reported to grow in South America, parts of the United States, Mexico, Africa and Australia (Al-Harrasi et al., 2014; Hazzouri et al., 2015).

*Corresponding author. E-mail: chinedu04@yahoo.com. Tel: +2348037505543.

Figure 1. Photographs of *Cyperus esculentus* nuts (A) and *Phoenix dactylifera* fruits (B).

In Nigeria, it is referred to as “dabino” by the Northerners who often sell it at different markets and strategic locations. The fruit is sweet, oval-cylindrical in shape and serve as energy booster. The name (*dactylifera*) of the species is used to explain the clustered nature (usually referred to as “finger-bearing”) of the fruits produced by the plant. The production of the fruits has increased over the years because of its increasing demand and because it is economical. The fruit is believed to possess lots of medicinal properties. The fruits may be eaten alone or in conjunction with other food materials. Date fruit has been reported to be of high nutritional value and also a good source of vitamin B complex (Eoin, 2016). Therapeutic properties of date fruits, such as anti-proliferative, antibacterial, antioxidant and antifungal have been reported by Al-Alawi et al. (2017). It is believed to be a good aphrodisiac.

Cyperus esculentus L. (Tiger nut) is an edible tuber crop of Cyperaceae family that produces rhizomes which are usually spherical (Devries and Feuke, 1999). Tiger nut is used widely in Africa, America, Arabian Peninsula and parts of Europe for human and other animal consumption (Abaejoh et al., 2006; Sanchez-Zapata et al., 2012). It grows freely and is usually cultivated in Northern Nigeria. In Nigeria, it is called “Aki Hausa” in Igbo, “Aya” in Hausa and “Ofio” in Yoruba. There are two major varieties that are commonly sold in the market: the fresh (yellow/milky colour) and dried (brown colour). These varieties can be processed and eaten in different forms. They can be processed into flavouring agent, milk, yoghurt and other forms of drink (Ezeonu et al., 2016). It can also be used in preparing livestock feed.

Phytochemical analysis of plant materials helps in revealing the medicinal and pharmacological properties of plant, while proximate composition of plant samples contributes to the overall level of acceptance of plant materials as good sources of food in general nutrition. *C. esculentus* nut and *P. dactylifera* fruit are widely eaten in its raw form as food in many parts of the world and also used in preparation of different drinks. They are the major ingredients in the popular nutritious drink in Nigeria known as “Kunun aya.” Investigation into the phytochemical, mineral and proximate composition of *C. esculentus* nut and *P. dactylifera* fruit will guide in knowing their possible diverse physiological and pharmacological effects as well as the nutritional value and overall acceptance of the plant parts from the users’ stand point. This therefore warrants study into the chemical composition of *C. esculentus* nut and *P. dactylifera* fruit.

MATERIALS AND METHODS

Plant

C. esculentus nut and *P. dactylifera* fruit were bought at New Market, Wukari, Nigeria. They were identified at the Biological Science Department, Federal University Wukari, Nigeria. The seeds in the fruits of *P. dactylifera* were removed and discarded. The plant materials (Figure 1) were sun-dried, milled with manual blender and stored in air-tight containers until required for analysis.

Preparation of plant extracts

Each plant powder was macerated in 70% ethanol for 48 h with occasional shaking, thereafter filtered and the filtrate concentrated to eliminate the ethanol. The crude plant extracts were then used for phytochemical analysis.

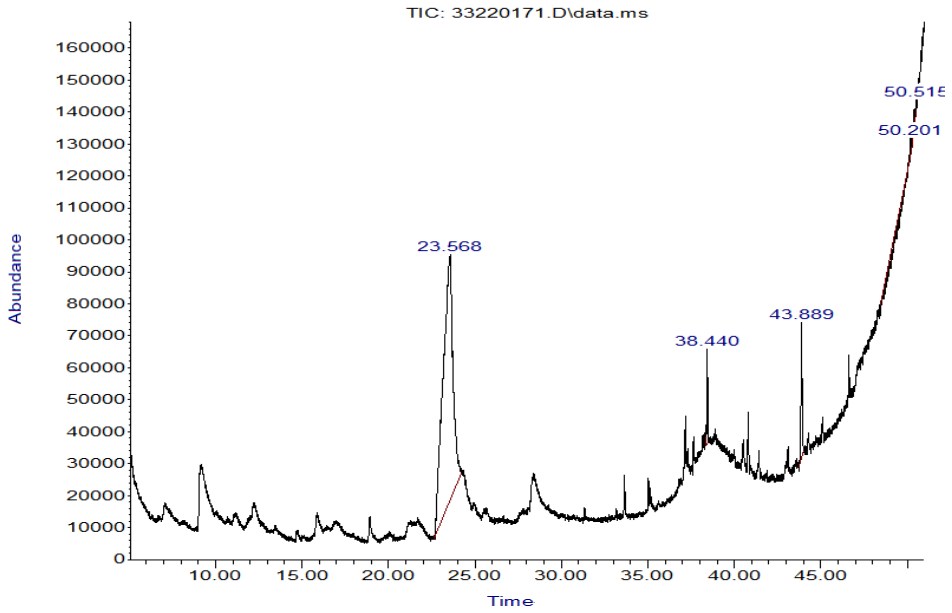

Figure 2. GC-MS chromatogram of ethanolic extract of *Cyperus esculentus* nut (Tiger nut)

Determination of proximate and mineral composition of *C. esculentus* nut and *P. dactylifera* fruit.

The percentage protein, lipid, fiber, ash, moisture, carbohydrates and dry matter of both plant materials were determined using the method of AOAC (2010), while the amount of magnesium, calcium, manganese, chromium, copper, zinc, iron, potassium, sodium and phosphorus in both plant samples were carried out using atomic absorption spectroscopy (model AA280FS), product of Agilent Technologies, U.S.A. The temperature and the inert argon gas flow followed were as recommended by the manufacturer.

Determination of phytochemical composition of *C. esculentus* nut and *P. dactylifera* fruit.

The phytochemical analysis of ethanolic extracts of both plant materials were carried out using gas chromatography-mass spectrometry (GC-MS). The GC (model no 7890B) and MS Detector (model 5977A) were products of Agilent Technologies, U.S.A. It was equipped with column: Agilent HP 5MS ultra Inert (350°C) 30 m × 250 µm × 0.25 µm. The gas used was Helium (He) with flow: 0.7 ml/min, pressure: 4.4867 psi, average velocity: 30.641 cm/s. The injection volume was 1 ml; inlet temperature 250°C; split ratio 20:1, and split flow 14 ml/min. Oven temperature was 60°C with equilibrating time of 1 min; maximum oven temperature 350°C and total run time 35.857 min. The MS tune type is E1; start mass 50; stop mass 550; threshold 150; acquisition type: scan and frequency (scan/s) 2.9. The constituent phytochemicals were identified after matching the spectra with the mass spectra of reference compounds contained in the database of the National Institute of Standards and Technology (NIST 14). The amounts of individual chemical components suggested were expressed as area percent comparable to the total peak area.

Statistical analysis

After the proximate analysis, the results were analyzed statistically using ANOVA and Paired-Samples T Test using Statistical Package for Social Sciences (SPSS) version 21. Means for each parameter were compared for significance at $p \leq 0.05$ and result presented as mean ± standard deviation (SD).

RESULTS

The result of proximate analysis shows that *C. esculentus* nut has higher percentage of moisture (4.31 ± 0.11), crude protein (6.06 ± 0.11), crude fiber (10.12 ± 0.28) and lipid (7.46 ± 0.13) compared to *P. dactylifera* fruit, while *P. dactylifera* fruit has higher percentage of dry matter (96.95 ± 0.06), ash (1.97 ± 0.02) and carbohydrates (85.10 ± 0.60) compared to *C. esculentus* nut.

C. esculentus nut contain higher level of magnesium (6.520 **±** 0.0006 ppm), manganese (0.084 **±** 0.0004 ppm), copper (0.047 **±** 0.0002 ppm), zinc (0.763 **±** 0.0001 ppm) and phosphorus (2.060 ± 0.0394 ppm) than *P. dactylifera* fruit. Potassium and sodium are more abundant in *P. dactylifera* fruit with 7.067 ± 0.0817 and 4.300 ± 0.1225 ppm, respectively. Calcium, chromium and iron are also more abundant in *P. dactylifera* fruit than in *C. esculentus* nut.

DISCUSSION

This study shows important chemicals present in tiger nut (Table 3 and Figure 2). Some of the phytochemicals are used for discovery of drugs (as starting materials) and also in modern and traditional medicine (Imo and Uhegbu, 2015). 9-Octadecenoic acid is believed to possess hypotensive effect. It is also associated

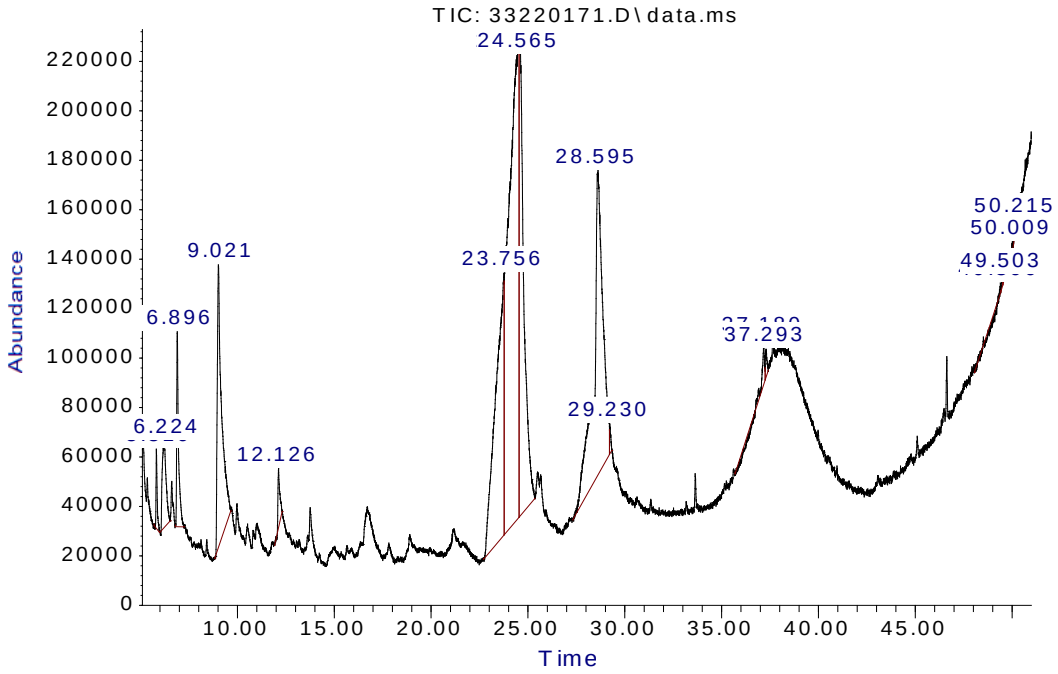

Figure 3. GC-MS chromatogram of ethanolic extract of *Phoenix dactylifera* fruit (Date fruit).

with increased high-density lipoprotein (HDL) cholesterol and possibly reduced low-density lipoprotein (LDL) cholesterol. Octasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15-hexadecamethyl is an organic compound that possess antimicrobial activity (Kumaradevan et al., 2015). Hexadecane, 1-(ethenyloxy)- is a component of essential oil. Hexadecane has been reported to exhibit beta-oxidant, thermogenic and anti-inflammatory properties (Callaghan et al., 2009). A variety of hexadecane, 1-(ethenyloxy)- known as Cis-9-Tetradecenoic acid, heptyl ester is a component of adipose tissue triacylglycerol in human (Jiang et al., 1999). It has been reported that it may be used for the treatment of prostate cancer due to its cell death inducer and cytotoxic effect (Iguchi et al., 2001). 9-Octadecenal, (Z)- is a food additive. Oxalic acid, monoamide, n-propyl, dodecyl ester: the conjugate base of oxalic acid (oxalate) is a competitive inhibitor of lactate dehydrogenase, while monoamide is believed to be a neurotransmitter. Its variety known as 2-Ethyl-oxetane is used in drug development, while certain derivatives of it possess antibiotic activity. The properties of these various phytochemical component show that *C. esculentus* nut (tiger nut) may possess anti-microbial, anti-inflammatory, antioxidant, lipid moderating and immune boosting effects. The vitamin E content of tiger nut is reported to collaborate against “the bad cholesterol” because of its antioxidant effect over fats, which is important for coronary heart disease (Chukwuma et al., 2010). Tiger nut has also been documented to aid in activating the circulation of blood, prevention of heart disease, treatment of bacterial infection and urinary tract infection (Adejuyitan et al., 2009).

Certain chemicals present in date fruit (Table 4 and Figure 3) possess important properties such as anti-microbial and anti-oxidant. 1-Pyrrolidinecarbonitrile has been reported to exhibit potent anti-hyperglycaemic activity (Villhauer et al., 2002). Palmitoleic acid possesses anti-apoptotic activity. 2(1H)-Pyrimidinone which is a variety of 1-Pyrrolidinecarbonitrile has been reported to possess antitumor properties (Driscoll et al., 1991), while (S)-(+)-2-Amino-3-methyl-1-butanol is used for synthesis of benanomicin-pradimicin antibiotics (Tamiya et al., 2007). Some derivatives of 2-Ethyl-oxetane have antibiotic activity. 2R,3S-9-[1,3,4-Trihydroxy-2-butoxy methyl] guanine possess anti-tumour, anti-inflammatory, anti-microbial and anti-oxidant activities (Teoh and Mashitah, 2013). 5-Eicosene (E)- possesses antibacterial property. 2(5H)-Furanone, 5-methyl-; propanoic acid, 2-propenyl ester, 2-ethylhexanal; and butanoic acid, 3-oxo-, propyl ester are used as flavouring agents.

Proximate analysis of *C. esculentus* nut (Tiger nut) showed the percentage abundance of the parameters evaluated to be dry matter (95.70 ± 0.11) > carbohydrates (70.17 ± 0.11) > crude fiber (10.12 ± 0.28) > lipid (7.46 ± 0.13) > crude protein (6.06 ± 0.11) > moisture content (4.31 ± 0.11) > ash content (1.90 ± 0.04). Proximate analysis for *P. dactylifera* fruit (date fruit) showed the percentage abundance of the parameters evaluated to be dry matter (96.95 ± 0.06) > carbohydrates (85.10 ± 0.60) > lipid (3.57 ± 0.16) > crude

Table 1. Proximate composition of *Cypercus esculentus* nut and *Phoenix dactylifera* fruit (%).

Composition	*C. esculentus* nut (Tiger nut)	*P. dacylifera* fruit (Date fruit)
Moisture content	4.31 ± 0.11[a]	3.08 ± 0.03[b]
Dry matter	95.70 ± 0.11[a]	96.95 ± 0.06[b]
Crude protein	6.06 ± 0.11[a]	3.10 ± 0.13[b]
Crude fiber	10.12 ± 0.28[a]	2.99 ± 0.23[b]
Lipid	7.46 ± 0.13[a]	3.57 ± 0.16[b]
Ash content	1.90 ± 0.04[a]	1.97 ± 0.02[a]
Carbohydrates	70.17 ± 0.11[a]	85.10 ± 0.60[b]

Values are mean ± standard deviation (n=3). Mean in the same row, with different letters of the alphabet as superscript are statistically significant ($p<0.05$).

protein (3.10 ± 0.13) > moisture content (3.08 ± 0.03) > crude fiber (2.99 ± 0.23) > ash content (1.97 ± 0.02) (Table 1).

Carbohydrate is very essential for energy provision to animals and also for the nourishment of plants and animals (Edeoga et al., 2005). The high carbohydrates and lipid content imply that tiger nut and date fruit are good sources of energy. Therefore, they can play vital roles in the sustenance and nourishment of animal body. This is the reason why there is energy gain after their consumption. Date fruit is highly consumed by those who engage in fasting prior to and at the end of their fasting period because of its high energy supply which is as a result of this high carbohydrates content. The carbohydrates are readily hydrolysed to reducing sugar: a good source of ATP generation. Comparative analysis shows that date fruit contains higher amount of carbohydrates than tiger nut, but lower lipid content than tiger nut. These two plant products are commonly used in preparation of a nutritious drink known as “kunun aya” in Northern Nigeria. Their high carbohydrates and lipid content confirm the reason why the drink made from date fruit and tiger nut could quench hunger after consumption and could supply the needed glucose to produce ATP for work. Date fruit has been reported to possess potential health benefits (Chao and Krueger, 2007; Al-Harrasi et al., 2014).

Tiger nut possesses significant higher fiber content than date fruit. The high fibre content of tiger nut suggests it will aid in the reduction of constipation and can enhance frequent bowel content elimination. However, consumption of high fibre may decrease nutrient utilization, cause intestinal irritation and lower digestibility. This is why excessive consumption of tiger nut may cause stomach discomfort to some consumers. The protein content of tiger nut is almost twice of that in date fruit. Combination of the two plant products in nutrition could complement each other. In biological systems, proteins perform several pharmacological and physiological roles. The protein content of tiger nut suggests it could be a better source of various vital amino acids, but both plant materials can play important role in growth regulation, immunological protection, enzymatic catalysis and general nutrition. This is because protein is required in these processes.

Both fresh plant materials (as commonly sold in the market) show tiger nut possesses higher moisture content than date fruit. The result shows that date fruit will last longer than tiger nut when stored. The moisture content of the fresh tiger nut which is 4.31% may contribute to the reason why it does not have a long shelf life when stored afresh and also why it usually deteriorate fast (within few days). This is believed to be one of the major reasons why some traders process some of the fresh materials into dried form. This helps to preserve and elongate its shelf life by reducing the condition that may permit increased microbial activities which usually result to its deterioration. There is no statistical difference between the ash content of both plant materials, although date fruit has mildly higher ash than tiger nut. The ash content shows the possible corresponding mineral level in date fruit and tiger nut, which have been elucidated in this study. The proximate results show the important need for the use of date fruit and tiger nut in general nutrition.

The mineral analysis showed appreciable levels of the different mineral elements evaluated (Table 2). Mineral analysis of *C. esculentus* nut (tiger nut) showed the abundance (ppm) of the different minerals evaluated to be in magnesium (6.520 ± 0.0006) > potassium (5.567 ± 0.1206) > sodium (4.000 ± 0.0866) > calcium (2.155 ± 0.0007) > phosphorus (2.060 ± 0.0394) > iron (1.846 ± 0.0015) > zinc (0.763 ± 0.0001) > chromium (0.201 ± 0.0003) > manganese (0.084 ± 0.0004) > copper (0.047 ± 0.0002) order. The mineral analysis for *P. dactylifera* fruit (date fruit) showed the abundance (ppm) of the different minerals evaluated to be in potassium (7.067 ± 0.0817) > magnesium (4.922 ± 0.0004) > sodium (4.300 ± 0.1225) > calcium (4.021 ± 0.0006) > iron (2.238 ± 0.0007) > phosphorus (0.980 ± 0.0430) > zinc (0.229 ± 0.0004) > chromium (0.210 ± 0.0007) > manganese (0.051 ± 0.0003) > copper (0.037 ± 0.0002) order.

Mineral elements are inorganic substances which are very necessary for proper immune function and proper

Table 2. Mineral composition of *C. esculentus* nut and *P. dactylifera* fruit (ppm).

Mineral	*C. esculentus* nut (Tiger nut)	*P. dactylifera* fruit (Date fruit)
Magnesium	6.520 ± 0.0006	4.922 ± 0.0004
Calcium	2.155 ± 0.0007	4.021 ± 0.0006
Manganese	0.084 ± 0.0004	0.051 ± 0.0003
Chromium	0.201 ± 0.0003	0.210 ± 0.0007
Copper	0.047 ± 0.0002	0.037 ± 0.0002
Zinc	0.763 ± 0.0001	0.229 ± 0.0004
Iron	1.846 ± 0.0015	2.238 ± 0.0007
Potassium	5.567 ± 0.1206	7.067 ± 0.0817
Sodium	4.000 ± 0.0866	4.300 ± 0.1225
Phosphorus	2.060 ± 0.0394	0.980 ± 0.0430

Values are mean ± standard deviation (n=3).

Table 3. Phytochemical constituents of *C. esculentus* nut (Tiger nut).

Name of compound	RT (min)	Area (%)
Oxalic acid, monoamide, n-propyl, dodecyl ester	23.568	84.500
9-Octadecenoic acid	38.440	3.380
9-Octadecenal, (Z)-	43.889	6.220
Hexadecane, 1-(ethenyloxy)-	50.201	4.370
Octasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15- hexadecamethyl	50.515	1.530

Table 4. Phytochemical constituents of *P. dactylifera* fruit (Date fruit).

Name of compound	RT (min)	Area (%)
1-Pyrrolidinecarbonitrile	5.819	0.600
(S)-(+)-2-Amino-3-methyl-1-butanol	6.224	2.320
2(5H)-Furanone, 5-methyl-	6.896	2.540
Propanoic acid, 2-propenyl ester	9.021	8.730
2-Ethylhexanal	12.126	0.730
2-Ethyl-oxetane	23.756	15.290
d-Mannitol, 1,4-anhydro-	24.483	32.840
Acetamide, N-butyl-	24.565	15.910
Butanoic acid, 3-oxo-, propyl ester	28.595	19.620
2R,3S-9-[1,3,4-Trihydroxy-2-butoxy methyl]guanine	29.230	0.230
5-Eicosene, (E)-	37.180	0.210
Palmitoleic acid	37.293	0.300
Cyclotetradecane	49.399	0.330
3-Quinolinecarboxylic acid, 6,8-difluoro-4-hydroxy-, ethyl ester	49.503	0.080
Hexadecane, 1-(ethenyloxy)-	50.009	0.170
Hexasiloxane, 1,1,3,3,5,5,7,7,9,9, 11,11-dodecamethyl-	50.215	0.100

maintenance of some biological processes that are required to sustain the life of human and other vertebrates (Soetan et al., 2010). The minerals do not yield energy but are essential for vital life processes. They are grouped into two major classes: micro and macro elements. Macro-minerals analysed in tiger nut and date fruit include phosphorus, calcium and sodium, while the micro-minerals include potassium, iron, manganese, copper, magnesium, chromium and zinc. When these essential minerals are deficient in certain

animals such as human, it usually predisposes the animal to certain disease conditions. However, if these minerals are taken in excess, they may cause disruption of homeostatic balance and may also induce some dangerous side effects.

The moderate levels of sodium and potassium show that consumption of date fruit and tiger nut is suitable for maintenance or regulation of osmotic balance between interstitial fluid and bodily cells. The sodium and potassium level of date fruit is slightly higher than tiger nut. Calcium and phosphorus are required by humans and some other vertebrates in appreciable (large) amounts for proper muscle and nerves function, and also for maintenance and construction of bone and teeth. Phosphorus is also essential since it is a component of nucleic acid and adenosine triphosphate (Soetan et al., 2010). Consumption of date fruit and tiger nut could help in supplying calcium and phosphorus to the body system for these important functions. Phosphorus content of tiger nut is higher than that of date fruit.

Iron is required in small amount by humans. Its levels in date fruit and tiger nut are low compared to the macro-minerals evaluated. This shows the use of date fruit and tiger nut in nutrition could help supply iron which is required for the synthesis of haemoglobin (pigment carrying oxygen) needed for proper functioning of red blood cells and for active cellular respiration. The higher level of iron in date fruit shows it will play these important roles more than tiger nut. The cytochromes are known to require iron as a crucial component.

Magnesium, zinc, manganese, chromium and copper are important micro-minerals required by some enzymes by acting as co-factors required for various biochemical processes or pathways. Although, these micro-minerals are low in amounts (except magnesium) in date fruit and tiger nut. Their levels are moderate in regards to the amounts required by humans, since humans require them in small quantities. The result shows that tiger nut and date fruit could aid the proper function of some enzymes required for certain important biochemical processes. However, adequate caution should be taken in the consumption of foods that contains these minerals, since excess or accumulation of some of the minerals could result to toxicity which could be accompanied with many side effects.

Conclusion

Cyperus esculentus nut contains phytochemicals that function as food additives and some that possess anti-inflammatory, hypotensive, antimicrobial, antioxidant, lipid moderating and immune boosting effects. *P. dactylifera* fruit contains phytochemicals that are food additives and possess important properties such as anti-microbial and anti-oxidant, anti-apoptotic, antitumor and anti-hyperglycaemic activities. Both plant materials contain appreciable amount of carbohydrates, proteins and lipids which are very essential for energy provision to animals, nourishment of human body system and other vertebrates, repair and replacement of dead cells, worn tissues and hormone production. Mineral elements present in date fruit and tiger nut are very essential for proper immune function and proper maintenance of some biological processes that are required for sustenance of life. Consumption of these plant materials will supply some of the minerals which aid maintenance of homeostatic balance, proper nerves and muscle function, maintenance of bone and teeth, and required by some enzymes as co-factors for various biochemical processes. The use of tiger nut and date fruit is recommended in general nutrition and will help improve human health system.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENT

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

Abaejoh R, Djomdi I, Ndojouenkeu R (2006). Characteristics of tiger nut (*Cyperus esculentus*) tubers and their performance in the production of a milky drink. Journal of Food Processing and Preservation 30(2):145-163.

Adejuyitan JA, Otunola ET, Akande EA, Bolarinwa IF, Oladokun FM (2009). Some Physicochemical properties of Flour obtained from fermentation of tiger nut (*Cyperus esculentus*) souced from a market in Ogbomoso, Nigeria. African Journal of Food Science 3(2): 51-55.

Al-Alawi RA, Al-Mashiqri JH, Al-Nadabi JSM, Al-Shihi BI, Baqi Y (2017). Date Palm Tree (*Phoenix dactylifera* L.): Natural Products and Therapeutic Options. Frontiers in Plant Science 8:845.

Al-Harrasi A, Rehman NU, Hussain J, Khan AL, Al-Rawahi A, Gilani SA (2014). Nutritional assessment and antioxidant analysis of 22 date palm (*Phoenix dactylifera*) varieties growing in Sultanate of Oman. Asian Pacific Journal of Tropical Medicine 7S1:S591-S598.

AOAC (2010). Official methods of proximate analysis. AOAC International, Gaithersburg, MD, p.15

Callaghan AV, Tierney M, Phelps CD, Young LY (2009). Anaerobic biodegradation of n-hexadecane by a nitrate-reducing consortium. Applied and Environmental Microbiology 75(5):1339-1344.

Chao CCT, Krueger RR (2007). The date palm (*Phoenix dactylifera* L.): overview of biology, uses, and cultivation. Hortscience 42(5):1077-1082.

Chukwuma ER, Obiama N, Christopher OI (2010). The phytochemical composition and some Biochemical effect of Nigerian Tiger nut (*Cyperus esculentus*. L) Tuber. Pakistan Journal of Nutrition 9(7):709-715.

Devries F, Feuke T (1999). Chufa (*Cyperus esculentus*), a weedy cultivar or cultivated weed? Economic Botany 45(1): 27-37.

Driscoll JS, Marquez VE, Plowman J, Liu PS, Kelley JA, Barchi JJ Jr (1991). Antitumor properties of 2(1H)-pyrimidinone riboside (zebularine) and its fluorinated analogs. Journal of Medicinal

Chemistry 34(11):3280-3284.
Edeoga HO, Okwu DE, Mbaebie BO (2005). Phytochemical constituents of some Nigeria medicinal plants. African Journal of Biotechnology 4(7):685-688.
Eoin LN (2016). Systematics: blind dating. Nature Plants 2:16069. https://www.nature.com/articles/nplants201669
Ezeonu CS, Tatah VS, Nwokwu CD, Jackson SM (2016). Quantification of Physicochemical Components in Yoghurts from Coconut, Tiger Nut and Fresh Cow Milk. Advances in Biotechnology and Microbiology 1(5):555573. DOI:10.19080/AIBM.2016.01.555573
Hazzouri KM, Flowers JM, Visser HJ, Khierallah HS, Rosas U, Pham GM (2015). Whole genome re-sequencing of date palms yields insights into diversification of a fruit tree crop. Nature Communications 6:8824.
Iguchi K, Okumura N, Usui S, Sajiki H, Hirota K, Hirano K (2001). Myristoleic acid, a cytotoxic component in the extract from Serenoa repens, induces apoptosis and necrosis in human prostatic LNCaP cells. Prostate 47(1):59-65.
Imo C, Uhegbu FO (2015). Phytochemical Analysis of *Gongronema latifolium* Benth Leaf Using Gas Chromatographic Flame Ionization Detector. International Journal of Chemical and Biomolecular Science 1(2):60-68.
Jiang J, Wolk A, Vessby B (1999). Relation between the intake of milk fat and the occurrence of conjugated linoleic acid in human adipose tissue. American Journal of Clinical Nutrition 70(1):21-17.
Kumaradevan G, Damodaran R, Mani P, Dinesh KG, Jayaseelan T (2015). Phytochemical Screening and GC-MS Analysis of Bioactive Components of Ethanol Leaves Extract of *Clerodendrum phlomidis* (L.). American Journal of Biological and Pharmaceutical Research 2(3):142-148.
Sanchez-Zapata E, Fernández-López J, Pérez-Alvarez JA (2012). Tiger nut (*Cyperus esculentus*) commercialization: health aspects, composition, properties, and food applications. Comprehensive Reviews in Food Science and Food Safety 11(4):366-377.
Soetan KO, Olaiya CO, Oyewole OE (2010). The importance of mineral elements for humans, domestic animals and plants: A review. African Journal of Food Science 4(5):200-222.
Tamiya M, Ohmori K, Kitamura M, Kato H, Arai T, Oorui M, Suzuki K (2007). General synthesis route to benanomicin-pradimicin antibiotics. Chemistry 13(35):9791-9823.
Teoh YP, Mashitah MD (2013). Antifungal Activity of *In-vitro* Grown *Earliella scabrosa*, a Malaysian Fungus on Selected Wood-degrading Fungi of Rubberwood. Journal of Physical Science 24(2):21-33.
Villhauer EB, Brinkman JA, Naderi GB, Dunning BE, Mangold BL, Mone MD, Russell ME, Weldon SC, Hughes TE (2002). 1-[2-[(5-Cyanopyridin-2-yl) amino] ethylamino] acetyl-2-(S)-pyrrolidinecarbonitrile: A Potent, Selective and Orally Bioavailable Dipeptidyl Peptidase IV Inhibitor with Antihyperglycemic Properties. Journal of Medicinal Chemistry 45(12):2362-2365.