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Nutritive Value of Nigerian Tigernut (*Cyperus esculentus* L.)

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Abstract: The proximate, mineral, vitamin and amino acids composition of tigernut (*Cyperus esculentus*) flour were determined using standard analytical techniques. The physicochemical characteristics of the oil were also investigated. The proximate composition of the raw tubers was crude protein (8.07±0.37%), crude fat (24.3±0.58%), crude fiber (24.0±1.58%), ash (1.80±0.10%) and carbohydrate (30.0%) while that of the roasted tubers was crude protein (6.80±0.89%), crude fat (25.2±0.10%), crude fiber (23.3±0.58%), ash (1.78±0.10%) and carbohydrate (31.7%). The minerals (mg/100 g) of the raw tubers included sodium (34.13±1.53), calcium (100.0±2.65), iron (4.12±0.10), zinc (3.98±0.31), potassium (486.0±59.9), magnesium (94.4±1.28), copper (0.92±0.05), manganese (0.26±0.01) and phosphorus (219.0±10.0). The roasted tubers on the other hand contained (mg/100 g) sodium (34.1±1.44), calcium (99.9±2.86), iron (4.11±0.26), zinc (3.96±0.50), magnesium (96.0±0.68), copper (0.88±0.15), manganese (0.30±0.02) and phosphorus (217.0±12.1). The vitamins (mg/100 g) in the raw tubers included vitamin A (0.21±0.01), vitamin C (7.30±0.97), vitamin D (0.42±0.02) and vitamin E (0.21±0.01) while the roasted tuber contained vitamin A (0.20±0.01), vitamin C (4.59±0.09), vitamin D (0.41±0.01) and vitamin E (0.57±0.10). Amino acid analysis revealed that tigernut flour contained nutritionally important essential amino acids though in small quantities. The first and second limiting amino acids were leucine (0.07) and lysine (0.08).

Key words: Tigernut, *Cyperus esculentus*, nutritive composition, physicochemical characteristics, megnes

INTRODUCTION

The Cyperaceae are monocotyledonous plants which include up to 4000 species world wide (Dalziel, 1937; Purseglove, 1969). Members of the Cyperaceae family include *Cyperus dilalatus*, *Cyperus rotundus*, *Cyperus tuberosus*, *Cyperus papyrus* and *Cyperus esculentus*. These are of little economic value with the exception of *Cyperus papyrus* which is used in the manufacture of paper and *Cyperus esculentus* which is edible (Simpson and Inglis, 2001). *Cyperus esculentus* grows mainly in the middle belt and in the northern regions of Nigeria. It is a root crop which grows widely in wet places as a grass and is sometimes cultivated for its small and sweet tubers (Eteshola and Oraedu, 1996).

Cyperus esculentus is commonly known as earth almond, tigernut, chufa, yellow nutsedge and zulu nuts. It is known in Nigeria as Aya in Hausa, Ofio in Yoruba and Akihausa in Ibo where three varieties (black, brown and yellow) are cultivated (Umerie *et al*., 1997). Among these, only two varieties, yellow and brown are readily available in the market. The yellow variety is preferred to all other varieties because of its inherent properties like its bigger size, attractive color and fleshier body (Belewu and Abodurin, 2006). Tigernut can be eaten raw, roasted, dried, baked or be made into a refreshing beverage called tigernut milk (Oladele and Aina, 2007). In addition, it can be used as a flavoring agent for ice cream and biscuits (Cantalejo, 1997).

The present investigation was carried out to determine the proximate composition, vitamin concentration, elemental concentration as well as the physicochemical properties of the Nigerian tigernut tuber variety and its oil in order to augment the available information on tigernut research.

MATERIALS AND METHODS

Collection and preparation of tigernut tubers: Tigernut tubers were obtained from a local market in Katsina, Katsina state, Nigeria. The tubers were thoroughly screened to remove the bad ones and stones. About 300 g of the fresh tigernut tubers were roasted in an oven (Gallenkamp, England) at about 71°C (being the optimum temperature for roasting tubers) for 20 min to process the tubers by heat treatment. The fresh tubers and the roasted tubers were ground separately with a laboratory electric mill to pass through a 70 nm mesh sieve. The powdered samples were used immediately for proximate, mineral and vitamin analyses.

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Proximate analysis: Analysis of the samples for moisture, ash and crude fiber were carried out in triplicate using the methods described by AOAC (1990). The nitrogen was determined by the micro kjedahl method described by Pearson (1976) and the nitrogen content was converted to protein by multiplying by a factor of 6.25. Carbohydrate was determined by the difference.

Vitamin analysis: Vitamin A, C, D and E were estimated using the method described by AOAC (1990).

Mineral analysis: The method described by AOAC (1990) was used for mineral analysis. The ash was digested with 3 mL of HCl and made up to the mark in a 100 mL standard flask with 0.36 mL HCl before the mineral elements were determined by Atomic Absorption Spectrophotometer (AAS).

Amino acid determination: Fresh samples of tigernut tuber flour were subjected to acid hydrolysis using 6N HCl. The hydrozylate was recovered by removing the acid by evaporation in a rotary evaporator. Amino acids were performed in hydrozylate using amino acid analyzer (Technicon Sequenial Multi Sample Amino Acid Analyzer (TSM), Technicon Instruments Corporation, New York).

Oil extraction: Fresh tigernut tubers were crushed and pressed by laboratory press. The extracted oils were dried over anhydrous sodium sulphate, filtered through whatman no. 1 filter paper and kept in brown bottle at 4°C until used for analysis.

Physicochemical properties of the oil: Color, refractive index, specific gravity, acid value, saponification value, iodine value, peroxide value, free fatty acids, ester value were determined according to AOAC (1990).

Data analyses: Data generated were subjected to mean±standard deviation analysis with exception of amino acids data.

RESULTS AND DISCUSSION

Proximate composition: The results in the Table 1 of this study has established that tubers of *C. esculentus* which is the only edible member of the sedge (Cyperaceae) family and widely consumed in Northern Nigeria as very nutritious. The proximate composition of food is a major index of nutritious potentials of crops. The raw tubers gave proximate values (%) of 8.07, 24.3, 24.0, 1.80, 11.4 and 30.0 for protein, fat, fiber, ash, moisture and carbohydrate, respectively. The roasted seeds gave corresponding values of 6.80, 2.52, 23.3, 1.78, 11.2 and 31.7% for protein, fat, fiber, ash, moisture and carbohydrate, respectively. These were compared wit the proximate values of some widely consumed nuts already reported in literature (Table 2). The protein level of *C. esculentus* (both raw and roasted) is quite low and within range for other nuts like the hickory nut (3.60%), chest nut (4.53%), coconut (2.06%) and pine nut (6.81%). *Cyperus esculentus* has a fat content of 24.3 and 25.2% for both raw and roasted tuber which is comparable to values for some widely consumed nuts already reported in literature (Table 2). Fat is important in diets because it promotes fat soluble vitamin absorption (Bogert *et al*., 1994).

Cyperus esculentus gave relatively high levels of fiber (24.0 and 25.2% for raw and roasted samples) in comparison with the amounts given in Table 2 for some other nuts. The existence of a causal relationship between the absence of fiber in diet and the incidence of a wide range of diseases in man, notably diabetes mellitus, obesity and coronary heart disease has long been reported (Eastwood, 1974; Mendelhoff, 1978). The consumption of significant quantities of *C. esculentus* would therefore not constitute a risk factor to such pathologic states.

The ash content value of *C. esculentus* of 1.8 and 1.78% for raw and roasted tubers, respectively was within the range of 1.5-2.5% recommended by Pomeranz and Clifton (1981) for animal feeds. The percentage moisture value of *C. esculentus* (11.4 and 11.2 dry weight for raw and roasted tubers, respectively) is higher than the values reported for nuts like walnut (5.42%), brazil nut (4.68%), hazel nut (7.32%), hickory nut (0.76%), peanut (9.71) and pine nut (1.90%) but lower than the values reported for chest nut (51.9%) and coconut (37.6%) as reported in Table 2. The values obtained for carbohydrates (by difference method) (30.0 and 31.7% for raw and roasted tubers, respectively) is comparable with the acceptable mean values of widely accepted nuts in literature (Table 2). The calorific value of *C. esculentus* (369.39 and 379.10 Kcal/100 g for raw and roasted samples, respectively) showed that it could be a reliable

Table 1: The proximate composition of the tigernut tuber flour

Components	Raw	Roasted
Crude protein (%)	8.07±0.37	6.80±0.89
Crude fat (%)	24.3±0.58	26.2±0.10
Crude fiber (%)	24.0±1.58	23.3±0.58
Ash (%)	1.80±0.10	1.78±0.10
Carbohydrate (%)	30.0	31.7
Moisture (%)	11.4±0.12	11.2±0.20
[a]Fatty acids (%)	19.44	20.16
[b]Energy KJ/100 g	1546.3	1586.9

Values are mean±standard deviation of triplicate determinations. Calculated fatty acids (0.8×crude fat), [b]Calculated metabolizable energy (Kcal/100 g) (Protein×17×fat×37×carbohydrate×17 and converted to Kcal/100 g by dividing with 4.186)

Table 2: Nutritional composition (g/100 g) of some widely consumed nuts

Nuts/qty	Carbohy drate (g)	Protein (g)	Fat (g)	Fiber (g)	Water (g)	Calcium (g)	Zinc (g)	Iron (g)	Copper (g)	Calories (kcal)
Walnut	15.10	30.40	70.70	10.60	5.45	72.50	4.28	3.84	1.28	759
Brazil nut	17.00	20.10	92.70	12.50	4.68	24.60	6.42	4.76	2.48	919
Hazelnut	20.70	17.60	84.50	9.20	7.32	25.30	3.24	4.41	2.04	852
Hickory nut	5.17	3.60	18.30	0.92	0.76	17.00	1.22	0.60	0.21	187
Chestnut(roasted)	75.70	4.53	3.15	18.50	51.90	42.00	0.82	1.30	0.73	350
Coconut grated/fresh)	12.20	2.60	26.80	11.20	37.60	12.00	0.88	1.94	0.35	283
Peanut (dried)	23.60	37.50	71.80	12.70	9.71	85.00	4.78	4.72	1.46	827
Pine nut	4.03	6.81	14.40	0.50	1.90	7.39	1.21	2.61	0.29	146

Monago and Uwakwe (2009)

Table 3: The vitamin composition of the tigernut tuber flour

Components	Raw	Roasted
Vitamins		
A (mg/100 g)	0.21±0.01	0.20±0.01
C (mg/100 g)	7.30±0.97	4.59±0.09
D (mg/100 g)	0.42±0.02	0.41±0.01
E (mg/100 g)	0.74±0.09	0.57±0.10
Minerals		
Sodium (Na)	34.3±1.53	34.1±1.44
Calcium (Ca)	100.0±2.65	99.9±2.86
Iron (Fe)	4.12±0.10	4.11±0.26
Zinc (Zn)	3.98±0.31	3.96±0.50
Potassium (K)	486.0±59.9	491.0±48.9
Magnesium (Mg)	94.4±1.28	96.0±0.68
Copper (Cu)	0.92±0.05	0.88±0.15
Manganese (Mn)	0.26±0.01	0.30±0.02
Phosphorus (P)	219.0±10.0	217.0±12.1
Na/K	0.07	0.07
Ca/P	0.46	0.46

Values are mean ± standard deviation of triplicate determination

source of energy and can thus provide a large portion of the daily requirement of 2,500-3000 kilocalories for adults if large quantities are consumed, as is usually the case in northern Nigeria.

Vitamin composition: The result of the vitamin analysis (Table 3) showed that the raw *C. esculentus* tubers contain 0.12±0.01 mg/100 g vitamin A, 7.30±0.97 mg/100 g vitamin C, 0.420.02 mg/100 g vitamin D and 0.740.09 mg/100 g vitamin E. The roasted tubers contained 0.20±0.01 mg/100 g vitamin A, 4.59±0.09 mg/100 g vitamin C, 0.41±0.01 mg/100 g vitamin D and 0.57±0.10 mg/100 g vitamin E.

Mineral content: The result of the mineral composition (mg/100 g) of *C. esculentus* tuber showed that the least abundant minerals were zinc, iron, copper and manganese while potassium was the most abundant. Olaofe and Sanni (1988) and Aremu *et al.* (2005) had earlier reported that potassium was the most abundant mineral in Nigerian agricultural products.

The mean value for iron was 4.12 and 4.11 mg/100 g, respectively for raw and roasted tubers which is in agreement with the values for some widely consumed nuts reported in literature (Table 2). The mean value of zinc was 3.98 and 3.96 mg/100 g, respectively for raw and roasted tubers which is in close agreement with values reported for nuts like walnut (4.20%), brazil nut (6.42%), hazel nut (3.24%) and peanut (4.78%). The mean value of copper was 0.92 and 0.88 mg/100 g, respectively for raw and roasted tubers which are comparable with values reported for some nuts like hickory nut (0.21%), chest nut (0.73%) and coconut (0.35%).

Phosphorus was found to be the next highest mineral in *C. esculentus.* The mean values of phosphorus (219.0 and 217.0 mg/100 g for the raw and roasted tubers, respectively) were much higher than that of calcium.

Phosphorus is always found in the body with calcium contributing to the blood. Low Ca/P ratio facilitates calcination in the small intestine (Nieman *et al.*, 1992). Calcium mean values (100.0 and 99.9 mg/100 g in the raw and roasted tubers, respectively) in the present study are higher than the value reported for other nuts in literature (Table 2).

Calcium is important in blood clotting, muscle contraction and in certain enzymatic processes. The ratio of sodium to potassium in the body is of great concern for prevention of high blood pressure; Na/K ratio of <1 is recommended (Nieman *et al.*, 1992). The Na/K ratio for tigernut flour is under consideration, though <1. This is an indication that consumption of tigernut could probably reduce high blood pressure disease.

Amino acid composition: Table 4 showed the amino acids values of tigernut tuber flour (g/100 g protein). The major abundant amino acids were Aspartic acid (Asp), Methionine (Met), Glutamine acid (Glu) and Alanine (Ala), with the values 1.11, 0.84, 0.84 and 0.70 g/100 g protein, respectively. The sum of Asp and Glu amino acids was 1.95 g/100 g protein (24.4%).

This value is very low compared to values obtained from selected oil seeds (melon, pumpkin, gourd seeds and cashew nut) ranging from 24.2-29.5 (Olaofe *et al.*, 1994; Ige *et al.*, 1984; Aremu *et al.*, 2006). Table 5 shows many parameters. The Total Amino Acid (TAA) of 7.99 g/100 g protein indicated that tigernut tubers will not contribute significantly to the supply of amino acids in diet.

Table 4: The amino acids compositions of tigernut tuber flour

Amino acid	Concentration (g/100 g protein)
Serine (Ser)	0.31
Glutamic acid (Glu)	0.84
Proline (Pro)	0.31
Glycine (Gly)	0.43
Alanine (Ala)	0.70
Cystine (Cys)	0.05
Tyrosine (Tyr)	0.24
Lysine* (Lys)	0.42
Histidine* (His)	0.35
Arginine* (Arg)	0.42
Aspartic acid (Asp)	1.11
Threonine* (Thre)	0.35
Valine* (Val)	0.43
Methionine* (Met)	0.84
Isoleucine* (Ile)	0.37
Leucine* (Leu)	0.50
Phenylalanine* (Phe)	0.33
Tryptophan (Try)	ND

*Essential amino acids, ND: Not Detected

Table 5: Essential, non-essential, acidic neutral and basic amino acids (g/100 g) of tigernut tuber flour

Amino acid classification	Concentration (g/100g protein)
Total Amino Acid (TAA)	7.99
Total Non Essential Amino Acid (TNEAA)	4.75
TNEAA (%)	59.45
Total Essential Amino Acid (TEAA)	
With histidine	3.59
Without histidine	3.24
TEAA (%)	
With histidine	44.93
Without histidine	40.55
Essential Aliphatic Amino Acids (EAAA)	1.30
Total Neutral Amino Acids (TNAA)	2.43
TNAA (%)	30.41
Total Basic Amino Acids (TBAA)	0.84
TBAA (%)	10.51
Percentage of cystine in Total Sulphur Amino Acid (TSAA)	5.62

This value is lower than that of cashew nut (75.8 g/100 g protein) reported by Aremu *et al.* (2006), melon, pumpkins and gourds seeds (53.4, 38.3 and 53.6 g/100 g protein, respectively) reported by Olaofe *et al.* (1994), soybean, 44.4 g/100 g protein (Yuwai *et al.*, 1991), pigeon peas, 45.2 g/100 g protein (Nwokolo, 1987).

This is an indication that tigernut is very low in proteins. The percentage total essential amino acid (%TEAA) of 44.93 (with histidine) was an indication that the tigernut turber contained more essential amino acids.

The Leucine (Leu), Phenylalanine (Phe), Lysine (Lys), Methionine (Met), Valine (Val) and Threonine (Thre) values of 0.50, 0.33, 0.42, 0.84, 0.43 and 0.35 g/100 g protein, respectively are lower than the reference value of 4.2, 2.8, 4.2, 2.2, 4.2 and 17.5 g/100 g proteins, respectively (FAO, 1970). Table 5 showed that Essential Aliphatic Amino Acids (EAAA) which constitute the

Table 6: Amino acids scores of the tigernut tuber flour

Amino acid	Provisional amino acid scoring pattern[a] (g/100 g protein)	Current result (mg/100 g protein)	Amino acid scores
Ile	4.0	0.37	0.09
Leu	7.0	0.50	0.07
Lys	5.5	0.42	0.08
Met+Cys (TSAA)	3.5	0.89	0.25
Phe+Tyr	6.0	0.57	0.10
Thre	4.0	0.35	0.09
Try	1.0	ND	ND
Val	5.0	0.43	0.09
Total	36.0	3.53	0.10

[a]Belschant *et al.* (1975)

hydrophobic regions of proteins were not found in abundance in tigernut tuber flour (1.30 g/100 g protein). The quantity of dietary protein can be measured in various ways (FAO/WHO, 1991) but it is the ratio of available amino acid in food or diet compared with the needs expressed as a ratio (Bender, 1992). Using the data from Table 4 together with the scoring pattern from Table 6, the values of the amino acids in the sample were found as follows:

Amino acid score = g of amino acids per test proteins/ g of amino acid per g of reference pattern

As shown in Table 6, the scoring table revealed that first and second limiting amino acids are leucine (0.07) and lysine (0.08). Bingham (1997) had earlier reported Lys as one of the essential amino acids often acting in limiting capacity. Therefore in order to fulfill the day's needs for all the essential amino acids in tigernut tuber, 100/7 (for leucine) or 14.29 times as much tigernut tuber protein would have been eaten when it is sole protein in the diet. The physicochemical properties of tigernut tuber oil were shown in Table 7.

The golden brown color oil had a specific gravity of 0.965 indicating that it is less dense than water with refractive index of 1.464 which is in agreement with the value of 1.466 for olive oil (Arafat *et al.*, 2009). This showed that the oil is less thick when compared with most drying oils whose refractive indexes were between 1.475 and 1.485 (Duel, 1951). The saponification value of the oil was 210.15 mg KOH g^{-1} which is greater than the values obtained for some vegetable oils ranging from 188-196 mg KOH g^{-1}.

However, there are some vegetable oils with higher saponification values such as coconut oil (255 mg KOH g^{-1}), palm kernel oil (247 mg KOH g^{-1}) and butter fat (225 mg KOH g^{-1}). It has been reported by Pearson

Table 7: The physicochemical properties of tigernut tuber oil

Characteristics	Values
Color	Golden brown
Refractive index	1.464
Specific gravity (g cm^{-3})	0.965
Acid value (mg KOH g^{-1})*	0.81±0.03
Saponification value (mg KOH g^{-1})*	210.15±1.67
Iodine value (mg KOH g^{-1})*	89.33±1.46
Peroxide value ($MeqO_2$ kg^{-3})*	1.01±0.01
Free fatty acids (mg g^{-1})	0.41
Ester value (mg KOH g^{-1})	209.34

Values are mean±standard deviation of triplicate determination

(1976) that oils with higher saponification values contain high proportion of lower fatty acids. Therefore, the value obtained for tigernut tuber oil indicated that the oil contained high proportion of higher fatty acids. The oil had a very low acid value of 0.81 mg KOH g^{-1} when compared with *Plukenetia conophora* (11.5 mg KOH g^{-1}) as reported by Akintayo and Bayer (2002). The low saponification value and low acid value indicated that the oil may be suitable for soap making.

The iodine value (89.33 mg Iodine g^{-1}) of tigernut oil is higher than the values reported for cashew nut oil (44.4 mg Iodine g^{-1}) (Aremu *et al*., 2006) and *Citrillus vulgaris* with value of 38.1% (Oladimeji *et al*., 2001). In view of the fact that drying oils have an iodine value above 100 (Duel, 1951), tigernut tuber oil could only be categorized as non drying oil.

CONCLUSION

The result of the physicochemical properties of the tigernut tuber oil showed the color to be golden brown, refractive index (1.464), specific gravity (0.965), acid value (0.81±0.03 mgKOH g^{-1}), saponification value (210.15±1.67 mg KOH g^{-1}), iodine value (89.33±1.46 mg Iodine g^{-1}), peroxide value (1.01±0.01 $MeqO_2$ kg^{-1}), free fatty acids (0.41 mg g^{-1}), ester value (209.34 mg KOH g^{-1}). These values indicated that the tuber oil is edible, non-drying and suitable for soap making.

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