Continental J. Food Science and Technology 6 (2): 13 - 19, 2012 ISSN: 2141 – 422X

http://www.wiloludjournal.com
Printed in Nigeria doi:10.5707/cjfst.2012.6.2.13.19

ASSESSMENT OF THE PROXIMATE COMPOSITION, FOOD FUNCTIONALITY AND OIL CHARACTERIZATION OF MIXED VARIETIES OF *Cyperus esculentus* (TIGER NUT) RHIZOME FLOUR

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ABSTRACT
The rhizomes of yellow and brown varieties of Cyperus esculentus (Tiger nut) and equal proportion of their mixtures were obtained fresh and dried, washed, milled into fine flour. The oil contents were extracted by soxhlet extractor using petroleum ether as oil solvent. Food functional properties; proximate analysis as well as physico-chemical characterization of the oil were investigated. The results of the food functional analysis show the ranges: bulk density (0.47- 0.53g/cm^3), foam stability (93.50-96.30%).The oil absorption capacity and swelling power value compare favorably and are within the acceptable functional range for good food material. The varieties' mixture has remarkable value in terms of ash and fat content in the proximate analysis. The Oil analysis indicated the mean ranges as: pH(8.01-8.85), specific gravity(0.91-0.93), viscosity(80809.14-97126.86) centi-poise, iodine value(11,42-19.80), acid value(8.42-36.47)mg/g, peroxide value(2.3-3.4)mg/g and saponification value(2.81-12.62)mg/g. The Oil yields of 25, 28 and 34 (%) were obtained for the varieties' mixture. Inspite of the comparable good oil yield, elements of synergistic effect is quite noticeable in varieties' mixture samples. From the overall result, the mixing of the two varieties could be a wise option in exploring the food potential, food sausage combination and flour manipulation in food process industry.

KEYWORDS: functional properties, varieties' mixture, synergistic effect, characterization, food potential

INTRODUCTION
The *Cyperus esculentus* (Tiger nut) plant is common in Nigeria and known as *Aya* in Hausa, *Ofio* in Yoruba and *Akiausa* in Igbo. Three varieties black, brown and yellow are known to be cultivated. Among these only two varieties yellow and brown are readily available in the market. The yellow variety is eaten most because of its atractive colour, fleshy body and more milk yield upon extraction. It has been investigated to contain less anti-nutritional factors especially poly phenols (Cantalejo, 1997).

In the past it was considered an underutilized plant as it is shunned as mere weed in the majority of warm countries because of the creeping and rapidly expanding roots (Alias and Linden, 1999). Tiger nut is prepared medicinally as digestive tonic, having a heating and drying effect on digestive system and alleviating flatulence and also promote urine production and menstruation (Aremu *et al*., 2006). Tiger nut is also used in the treatment of flatulent, in digestion, colic, diarrhea, dysentery, debility and excessive thirst (Aremu *et al*., 2007).

Tiger nut can be eaten raw, roasted, dried, and baked or be made into a refreshing milk beverage. It is also used as a flavoring agent for ice cream and biscuit, as well as in making oil, soup, starch and flour (Bonanome and Grundy, 1988). A substantial work had been carried out on tiger nut (Cantalejo, 1997; Chevallier, 1996). However, in the existing literature, there is paucity of information on the mixture. This paper is therefore aimed at determining the proximate food composition, qualifying some food functional properties and evaluating the physicochemical properties of the oil with a view to comparing the values and investigating the synergistic effect of the mixture.

MATERIAL AND METHODS
Sampling and sample preparation
The two varieties of tiger nut rhizome (yellow and brown) used were obtained from different local markets in Lokoja, Ilorin and Minna cities, all in the North-Central zone of Nigeria. The nuts were cleaned, sorted, washed, drained in an oven for brown tiger nut and the yellow tiger nut was sun dried and then pounded into flour. The flour samples were passed through a 45μm mesh size sieve several times so as to get a fine and smooth powdery

form. The mixture of equal masses of the brown and yellow tiger nut seeds was grinded together into flour. The three samples are respectively tagged brown and yellow and mixture.

Proximate Analysis

Proximate analysis was carried out to determine the total ash content, crude fibre. The crude fat content which was obtained using soxhlet apparatus and extracting with petroleum ether was also determined. These analyses are in accordance with the methods cited in Association of Official Analytical Chemists (AOAC) methods (Chopra *et al*., 1986).The moisture content was not determined. The Nitrogen content was determined by micro Kjeldahl method as described in (Eteshola and Araedu, 1996). The Nitrogen content was converted to protein by multiplying by a factor of 6.2. Carbohydrate was determined by difference. The energy contents of the samples were determined (Chopra *et al*., 1986).

Functional properties

Bulk density (BD) was carried out as in (Cortes *et al*., 2005). Bulk density (g/cm^3) is expressed as mass of the sample (g) / Volume of the sample (cm^3).

Water absorption capacity (WAC) procedure is as in (Cortes *et al*., 2005) and was calculated as the product of the amount of water absorbed (total - free) and the density of water.

Oil absorption capacity (OAC) was carried out as described in (Cortes *et al*., 2005). It is calculated as product of amount of oil absorbed (total - free) and density of vegetable oil. The density of oil used is $0.87 g/cm^3$

Foam capacity (FC) method described in (Okafor *et al.,* 2003*;* Okoye *et al.,* 1999) was followed. Foam capacity (% volume increase) is $100(V_1 – V_2) / V_1$, where V_1 = Volume before whipping, V_2 = Volume after whipping

Foam stability (FS) method was described in (Okafor *et al.,* 2003*;* Okoye *et al.,* 1999) .Foam stability was computed as $100V_2 / V_1$, where V_2 = foam volume after time ‘t’, V_1 = Initial foam volume.

Fat emulsion capacity (FEC) procedure in (Ogawa *et al*., 2003) was used. Emulsion capacity is expressed as the amount of the oil emulsified and held per gram of sample. *Emulsion capacity* is calculated as *100 a / b,* where *a* is the height of the emulsified layer and *b* is the height of the whole solution in the centrifuge tube.

Swelling Power (SP): 0.5g of the flour samples of each of Brown, Yellow and the Mixture were weighed into a centrifuge tubes respectively, then mixed with 5ml distilled water in a centrifuge tube and heated at 80^oC for 30mins. This was continually shaken during the heating period. After heating, the suspension was centrifuge at $1000 \times g$ for 15mins. The supernatant was decanted and the mass of the paste was taken. The swelling power is determined as mass of the paste per mass of dry flour.

Gelation capacity was determined by applying the method of (Olaofe *et al*., 2006) and the modification by (Akintayo *et al*., 2004). The gelation capacity is obtained as the least gelation concentration which was the concentration when the samples in the inverted test tubes will not fall or creep out.

Determination of lipid content

The soxhlet extractor was used. This was set up on a heating mantle. 40g of each of the sample was weighed into the thimble. This was placed in the soxhlet apparatus and extracted using petroleum ether of 60-80 boiling range for 3hrs (Omoniyi, 2004). The thimble was removed and dried in oven, cooled in a desiccator and reweighed. The exact mixture was transferred into a beaker and evaporated till the lipid extract was free of the solvent.

Physico-chemical properties

The specific gravity, acid value, saponification value and peroxide values were in line with AOAC (Bonanome and Grundy, 1988). Common refractometer was used to determine the refractive index. The colour of the sample was determined by sighting and matching with standard colour. The viscosity was determined with aid of viscometer tube at room temperature. The pH meter (model *Metro Hm 632* pH) was used in determining the pH of the samples.

Statistical Analysis
The results obtained were subjected to statistical analysis.

RESULTS

Table 1: Functional properties of tiger nut flour

	Brown	Yellow	Mixture
BD (g/cm^3)	0.53	0.47	0.49
FC (%)	7.16	9.17	13.06
FS (%)	96.30	93.50	94.70
WAC (g/cm^3)	1.83	1.10	0.76
OAC (g/cm^3)	0.88	0.91	0.88
FEC (cm^3)	27.96	54.0	58.12
SP	2.49	2.54	2.36

*Values are mean of triplicates samples
BD = Bulk Density, FC = Foam Capacity, FS = Foam Stability, WAC = Water Absorption Capacity, OAC = Oil Absorption Capacity, FEC = Fat Emulsion Capacity, SP = Swelling Power

Table 2: Gelation Capacity (GC) % (w/v)*

	2.5	5	12.3	15	17.8	20
Brown	6.90	15.05	43.06	49.46	58.80	65.06
Yellow	6.91	15.46	41.46	48.06	62.86	64.24
Mixture	9.26	16.13	43.8	47.46	50.33	59.20

*Values are mean of triplicates samples % (w/v)

Table 3: Proximate composition (%)

	Brown	Yellow	Mixture
Crude Protein	9.15	5.54	11.52
Ash	22.33	21.66	24.33
Moisture	8.66	7.66	11.33
Fat	33.33	29.33	36.66
Crude Fibre	11.11	9.99	14.44
Carbohydrate	22.08	33.48	13.05
Energy Value	419.45	432.89	428.22

Values are mean of the triplicates % and KJ

Table 4: Lipid content of the tiger nut rhizomes

VARIETIES	% LIPID
Yellow	34
Brown	28
Mixture	25

Table 5: Physical properties of the tiger nut rhizomes oils

PROPERTIES	YELLOW	BROWN	MIXTURE
Colour	Pale yellow	yellow	Light yellow
Smell	pleasant	pleasant	pleasant
Specific gravity	0.92	0.91	0.93
Refractive Index	1.448	1.445	1.446
pH	8.85	8.01	8.03
Viscosity	97126.86	88377.14	80809.14
Physical state	Liquid	Liquid	Liquid

r = room temperature

Table 6: Chemical properties of the oils

PROPERTIES	YELLOW	BROWN	MIXTURE
Iodine Value	11.42	15.23	19.80
Acid Value (mg KOH/g oil)	14.03	8.42	36.47
Peroxide Value (mg/g oil)	3.4	2	2.3
Saponification Value (mgKOH/g oil)	2.81	9.82	12.62

DISCUSSION

Bulk density (BD): bulk density ranges between 0.43 to 0.71 g/cm^3. This low bulk density indicates tiger nut varieties and its mixture flour can be used in food and feeds formulation without the suspicion of retro-degradation. The mixture of the two varieties is particularly suitable. Foam capacity (FC), these ranges from 7.16 to 13.06, This is below the value of 18.0 of the benniseed (Bonanome and Grundy, 1988) but compares with the 6.0 reported by Aremu *et al* for Lima seed. The low foam capacity is often associated with presence of low protein in the flour. It is however useful in cake production.

The foaming stability (FS) the values ranges from 93.50% to 96.30% which is comparable with raw cowpea flour. Foaming stability is an important index in the suitability of a whipping agent in systems. Foaming produced by the tiger nut rhizome flour samples was more stable than that of its protein isolate. Product foam ability is related to the rate of decrease of the surface tension of air/water intercourse by absorption of protein molecules.

Water Absorption Capacity (WAC), the values ranges from 0.76g/cm^3 to 1.83g/cm^3.The WAC is a critical property of proteins in viscous foods like soups, gravies, dough and baked products. WAC describes flour – water association ability under limited water supply. This suggests that tiger nut flour may be finding application in baked products e.g. cookies. It is altruistic suggesting their incorporation in foods/feeds formulation especially incorporation into low-protein traditional foods such as maize gruel (pap), cassava and yam flour to enhance their nutritive values.

Oil Absorption Capacity (OAC), the values ranges from 0.88g/cm^3 to 0.91g/cm^3 lower compare with some other flour used. Changes in Oil Absorption Capacity were non-significant. The result shows that tiger nut may be lower flavour retainer flour. The lower oil absorption capacity of tiger nut flour might be due to low hydrophobic protein which show superior binding of lipids

Fat Emulsion Capacity (FEC) values ranges from 27.96cm^3 to 58.12cm^3. Also compared with some flour used, Yellow tiger nut flour is comparable with *Tilapia quineesis (*Aremu *et al*., 2007). This is a critical assessment of flavor retention, emulsion capacity are important attributes of additives for the stabilization of fat emulsion in the production of such foods as sausages, soups and cakes. The ability of proteins is to aid the formation and stabilization of emulsions is important in many applications including mayonnaise, milks, comminuted meats and salad dressings

Swelling Power (SP) values ranges from 2.34 to 2.54. The swelling ability of starch granules is largely responsible for the degree of paste viscosity observed when a starch suspension is heated, it has been suggested to use the starch and flour (including whole meal flour) swelling power as a simple test to assess the intercultivar differences in starch properties. Therefore, this result obtained for the three samples suggests that they may be useful in the production of food formulation and baked products.

Gelation concentration for Brown, Yellow and the mixture of the flour increases from 2.5-20%w/v with increase in gelation capacity in solution respectively. Variation in the value obtained might linked to the relative ration of different constituents, protein, carbohydrates, and lipid as suggested by (Flynn *et al*., 2002) that the interaction between such components may affect functional properties. Lowest gelation capacity is the lowest protein concentration at which the inverted tubes were used as an index of gelation capacity. The lower the LGC the better the gelating ability of the protein ingredient. This improves the gelation capacity of legume of flour (Rampon *et al*., 2003). This result obtained for the three samples suggests that the samples may be useful in the production of curd or as an additive to other materials for gel formation in foods products.

Crude Protein content, the values ranges from 5.54% to 11.52%. It was therefore observed that, the. Protein deficiency is the prevalent form of malnutrition in developing countries. Hence Can be used has foods and feeds formulation. Ash content the value ranges from 21.6% to 24.3%. It was therefore observed that, the ash content is high as a result of some minerals which are presents in the sample. The values of moisture content ranges from 7.66% to 11.33%, comparable to that of *Tilapia quineesis (*Aremu *et al*., 2007). Moisture is also of great importance for the safe storage of cereals and legume and their products regarding microorganisms, particularly certain species of fungi. Lower the flour moisture, the better its storage stability.

Fat content, the values ranges from 29.33 % to 36.66 %. It was therefore observed that, the fat content of the mixture is higher compared to the isolated ones. The high fat contents in tiger nut may be responsible for the reduction in the dough elasticity of the flour. Crude fibre, values ranges from 9.99% to 14.44%. The analysis shows that the mixture compared with the isolated ones. The insoluble high fibre content of its raw material (tiger nut) makes the product very healthy. The high fibre contents in tiger nut may be responsible for the reduction in the dough elasticity of the flour.

Carbohydrate content, values ranges from 13.05% to 33.48%. This is low compared with wheat flour. It's considered a good flour or additive for the bakery industry, as its natural sugar content but due to low carbohydrate in the mixture, it will involve addition of little extra sugar and energy. Energy value content values ranges from 419.45KJ to 432.89KJ. It was therefore observed that, the energy value of the mixture is lower than that of Brown and higher Yellow. Nevertheless it is still recommended for foods and feeds formulations.

The lipid content of yellow tiger nut in the highest (34%) followed by Brown tiger nut (28%) and then their mixture (25%). The value of oil yield from yellow tiger nut makes it potential oil crops value obtained for the yellow tiger nut is very close to that recorded by (Olaofe *et al.,* 2006), work on Bulina cotton (Bombacopsis glabra). This high value indicate that these nuts may be suggested as potential oil crop for the production of biodiesel (Dianel *et al.,* 2000) and are used in the treatment of debility (Chevalier, 1996). The oils are found to be liquid at room temperature, and all have a characteristic pleasant smell. Refractive index of the oils within the range shows the degree of purity of the oil. The oils of the yellow and brown show a very close high degree of clarity. The pH values of the oils are alkaline. The iodine value of the oil of the mixture is the highest and the yellow nut oil has the least iodine value. The high iodine value of the mixture indicates the presence of high amount of unsaturated fatty acids. The degree of unsaturation indicated by each sample confers their characteristic liquid state at room temperature. The greater the iodine values, the higher the oil or fat to become rancid by oxidation which implies that the oil of the mixture becomes most rancid by oxidation.

The peroxide value for yellow tiger nut oil is quite high compare to the other two oils which show that the oil is most susceptible to oxidative rancidity. This could be as a result of phospholipids which are associated with fats. Degumming is the method used in removing them by hydration and separation by centrifugation of the phosphotides (ISEO 2002). The low saponification value observed for the oils could be due to the low amount of the potassium hydroxide required to effectively saponify the oil during manufacture of soap, hence if and only if one of these oils is to be used in the manufacture of soap, the oil from the mixture is advisable to be used in the soap making.

CONCLUSION

Tiger nut flour is a rich source of oil and contains moderate amounts of protein. It could find useful application in baking industry because of its high level of dietary fibre, fat, protein and other inherent properties. Hence the mixture of two varieties of tiger nut rhizome flour Brown and Yellow were found to possess good proximate and functional properties. This is a good potential for dietary improvement in food industry. The solubility of the flour is high enough, making them potentially useful in some food and feeds formulations. The tiger nut flour does not lose any of its nutritious properties in the milling process.

The tiger nut flours are rich source of oil hence can be good source of oil for both domestic and industrial purpose. In addition, they can also be used in food formulation. The oil of the brown and yellow tiger nut rhizome flour can be stored for commercial purpose since they have low tendencies to oxidative rancidity. The oil of the mixture is good for edible purposes with high degree of unsaturation hence can be used as digestive tonic and in the promotion of urine production and menstruation.

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Received for Publication: 24/05/2012
Accepted for Publication: 01/08/2012

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