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Tiger Nut as A Functional Food, Pharmacological and Industrial Agent: A Mini Review

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Abstract

Tiger nut is a plant generally underutilized in many parts of the world where it grows mostly as a weed. It is loved by children and many adults for its milky sugary taste, without most consumers being aware of its nutritional and health benefits. The level of awareness on the importance of this wonderful and greatly enriched plant is indeed very low. This review is aimed at expounding some of the advanced scientific researches which authenticated the folk reports on the therapeutic potential of the plant. Research findings which present potential application of this wonderful plant in food industry, pharmaceutical formulation, agricultural production and biofuel generation are also elucidated.

Keywords: Tiger nut; phytochemicals; antioxidants; biofuel; aphrodisiac.

1.0 Introduction

Tiger nut *(Cyperus esculentus)* is a creeping perennial plant which belongs to the sedge family (*Cyperaceae*). It is commonly found populating wet marshes as well as stream and pond edges, where it grows in rough tufts (Arafat et al., 2009; Coskuner et al., 2002). It is an ancient plant commonly propagated in West Africa and South Europe. It produces sweet tubers that are consumed freshly or roasted. It can also be processed to obtain juice for beverage production and as animal feed (Udeozor, 2012). The tasty tubers from the plant has a length of 1-2 cm, with asymmetrical shape when dry and egg-like or round shape upon getting soaked in water (Coskuner et al., 2002). The structure of tiger nut is shown (Figure 1).

This plant is naturalized and cultivated in many parts of the world including Spain, Turkey, Thailand, India, Sierra Leone, Ghana, Togo, Mali, Senegal, Niger and Nigeria (Oyedepo and Odoje, 2014; Asante et al., 2014). It is known by many other names including chufa, zulu nut, edible galingale, yellow nutgrass, yellow nutsedge, earth chestnut, rush nut, edible rush as well as ground almond. Tiger nut is known by several names in Nigeria based on the various ethnic groups such as 'aya' (Hausa), 'aki-Hausa' (Igbo) and 'ofio' (Yoruba). (Bamishaiye et al., 2010; Adejuyitan, 2011; Ekeanyanwu and Ononogbu, 2010). Three varieties of the plant grow in Nigeria - the brown, black and yellow varieties. The yellow variety is larger in size, more attractive in colour and fleshy (Chukwuma et al., 2010).

Tiger nut consumption is regarded in some countries as treatment for dysentery, indigestion, flatulence and mouth ulcer. Additionally, there are claims that regular consumers of tiger nut might not suffer health complications such as diabetes, cardiovascular diseases, hyperlipidemia, prostate cancer, colon cancer, hernia, fibrosis, and abnormal menstruation. It also improves fertility in both male and female (Government of Ghana official portal).

This review attempts to integrate available information on the chemical composition and pharmacological potential of tiger nut. Its application in the food, pharmaceutical and agricultural industries is also espoused.

2.0 Chemical composition of tiger nut

Several studies affirmed that tiger nut is highly nutritious with virtually all the nutrients required for good growth and development of both old and young. Proximate composition analysis showed that tiger nut is packed with carbohydrate and fibre needed for proper digestion (Figure 2) (Adejuyitan, 2011; Ekeanyanwu and Ononogbu, 2010; Monago and Uwakwe, 2009; Arafat et al., 2009). All varieties of this plant are rich in essential minerals such as calcium, magnesium, sodium, phosphorous, and potassium, required for various metabolic processes in the body (Table 1) (Ekeanyanwu and Onogbugbu, 2010). It also contains vitamins A, C, and E as well as various amino acids (Ekeanyanwu and Onogbugbu, 2010; Shaker et al., 2009). Numerous reports have also indicated that *C. esculentus* oil has abundant saturated and unsaturated fatty acids (Yeboah et al., 2012; Muhammad et al., 2011; Eteshola and Oraedu, 1996).

The raw tuber has low amount of antinutrients such as saponins, tannins, oxalates, phytate, and cyanogenic glycosides in comparison with other fruits, nuts, vegetables and tubers. As such, the concentration of antinutrients present in the tuber is acceptable for consumption (Ezeh et al., 2014; Okafor et al., 2003). Report of preliminary investigation by Chukwuma et al., (2010) on the acute toxicity of tiger nut extract in experimental rats showed that the aqueous extract produced no toxicity in the animals at all concentrations tested. Phytochemical analysis reports showed that tiger nut is composed of alkaloids, flavonoid, sterols, saponins, tannins which are reported to be responsible for various biochemical activities of the plant (Imam et al., 2013). These findings indicated that tiger nut is rich in important phytochemicals and generally save for consumption.

Figure 1: *Cyperus esculentus* L. (a) Fresh tuber (b) Dried tuber.

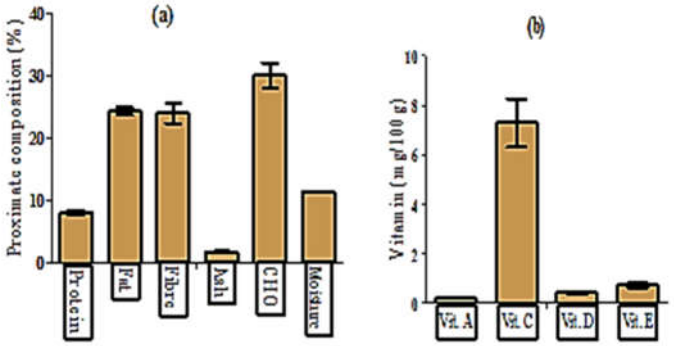

Figure 2: Proximate (a) and vitamin(b) composition of raw tiger nut flour. (**Source:** Ekeanyanwu and Ononogbu (2010))

3.0 Pharmacological potentials of tiger nut

Several studies have reported multiple pharmacological potentials of the tiger nut in different pathological conditions. These are summarized in Table 2.

3.1 Hepatoprotective activity of tiger nut

A study indicated that tiger nut exhibited a potential hepatoprotective action in experimental rats. Hepatotoxicity was induced in the rats through the intraperitoneal administration of carbon tetrachloride ($CC1_4$) leading to remarkable elevations of liver marker enzymes - aspartate and alanine transaminases, alkaline phosphatase as well as lipid peroxides. Pre-treatment of experimental rats for twenty-one days prior $CC1_4$ administration induced a significant reduction in the concentration of liver serum enzymes (Oyedepo and Odoje, 2014). Their result suggests that *C. esculentus* might provide protection against liver damage in rats. This result supports folkloric claim that tiger nut is a potent liver tonic.

3.2 Anti-sickling action of tiger nut

In vitro evaluation of the anti-sickling action of *C. esculentus* showed that methanol and aqueous extracts of tiger nut exhibited significant inhibition of the Haemoglobin-S (Hbs) gelatination. However, the methanol extract showed better anti-sickling property. This study revealed *C. esculentus* might be relevant in nutritionally-based therapeutic management of sickle cell patients (Monago and Uwakwe, 2009). This anti-sickling activity might be attributed to the presence of essential mineral such as iron and phosphorus as well as the presence of vitamin C and E in the plant. This finding buttress traditional claims that tiger nut milk is good for boosting of blood levels.

3.3 Aphrodisiac potential of tiger nut

Agbai and Nwanegwo, (2013) investigated the effect of *C. esculentus* on male reproductive hormones and some other androgenic parameters in mature male rats. Administration of methanol extract of tiger nut to Wistar rats elicited a significant increase in plasma level of male reproductive hormones as well as androgenic parameters in a dose dependent pattern.

Similarly, the report of Essawe and Almashhadani, (2010) established a link between the oral administration of tiger nut extract and sperm parameters in prepubertal mice. The experimental mice were treated with alcohol extracts of tiger nut for six weeks, which caused significant enhancement in the concentration and motility of the sperm. This finding is corroborated by the study of Oguike et al., (2008), in which the extract induced a significant effect on semen volume, testis weight, testis length and circumference, length of epididymis well as the overall weight of reproductive tract of matured experimental rabbits administered with the plant extract.

Al-Shaikh et al., (2013) also investigated the influence of *C. esculentus* tuber extract on reproductive abnormalities induced by the intraperitoneal administration of lead acetate. They reported that the extract relatively improved histopathological abnormalities in the testis of experimental rats. They concluded that the observed improvement might be due to the effect of the extract acting as an antioxidant or by instigating changes in sex hormones.

Results from the above studies suggested that tiger nut has a vital role to play in male reproductive functioning, as it improves the male reproductive parameters and protect it from any assault. This may be due to the chemical and phytochemical composition of tiger nut which confers antioxidant activity on the tissues.

3.5 Antioxidant effect of tiger nut

Oloyede et al., (2014) studied the antioxidant action of some extracts of *C. esculentus*. Both hexane and methanol extract exhibited strong antioxidant activity which is evidently comparable to standard antioxidant agents (ascorbic acid, α-tocopherol, and butylatedhydroxylanisole [BHA]). They opined that the observed radical-scavenging action of the plant may be linked to the occurrence of phytochemicals like flavonoids and phenolics in the plant. A similar study on the effect of tiger nut oil from Xinjiang China, on female experimental mice indicated that the oil displayed significant free

radical scavenging as well as antioxidant activity (Jing et al., 2013). Recently, much emphasis has been placed on the importance of plant materials in management of oxidative stress related diseases, it is pertinent that efforts are made towards production of nutraceutical agents from tiger nut and other plant materials after adequately confirming their efficacy.

3.6 Antimicrobial action of tiger nut

Adeniyi et al., (2014) studied the antimicrobial efficacy of *C. esculentus* root, inflorescence and shoots in comparison with standard antimicrobial drugs. The ethanol extract was active against *Salmonella typhi* and the result obtained was similar to that of ciprofloxacin (standard). The study showed the high antimicrobial activity of the plant extract and isolation of the bioactive compounds from it might lead to the advancement of novel antibiotic agents against *Salmonella typhi* infections.

Hasan et al., (2013) also studied the effect of ethanol extract of tiger nut tubers on *Escherichia coli*-induced endometritis in experimental mice. After seven days of administration, the decreased levels of haematological parameters; packed cell volume (PCV) and haemoglobin level (Hb), associated with endometritis showed significant improvement compared with the values upon induction. Conversely, the elevated concentration of white blood cells (WBC) due to bacterial invasion was also lowered after treatment with the extract. The results observed in the extract treated group is similar to that obtained in the group treated with the standard drug gentamicin (Hasan et al., 2013). This confirms the use of the leaves and tubers of tiger nut traditionally in the treatment of gastrointestinal infections.

3.7 Anti-atherosclerotic activity of tiger nut

A study investigated the effect of consumption of tiger nut-supplemented diet on atherosclerosis using apolipoprotein E knockout mice (ApoE$^{-/-}$ mice). The study revealed that feeding the mice with feeds containing tiger nut led to the reduction in growth of atherosclerotic lesion. The observed outcome was linked to a reduction in the quantity of monocytes and macrophages in the blood (Salem et al., 2005). This is an indication that the plant might be involved in the modulation of the amount and viability of inflammatory cells associated with atherosclerosis in the experimental mice.

3.8 Anti-inflammatory and anti-arthritic action of tiger nut

The anti-inflammatory, anti-convulsion and anti-arthritic potential of *C. esculentus* oil was investigated using Swiss albino rats. Administration of the oil caused a dose dependent anti-inflammatory effect on carrageenan-induced paw edema and decrease in extensor phase, clonus phase as well as stupor phase associated with convulsion (convulsion induced in the rats with maximal electroshock, MES). There was also a decrease in swelling on the hind paw of the rats due to induction of arthritis (by injection of formaldehyde) after treatment with doses of the oil as well as reduction of pain in the rat (determined by sum total of time spent on licking the paw injected with formalin) upon administration of the oil (Biradar et al., 2010). The result of this finding calls for further investigation to ascertain claims that consumption of tiger nut alleviates bone and joint pains.

There is need to study the biochemical and biological mechanisms which elicits the observed pharmacological activities. This may be by determining the effect of tiger nut on the expression of proteins and or genes associated with the pharmacological activities studied.

Table 1: Mineral composition of raw tiger nut flour

Mineral (mg/100g)	Composition
Sodium (Na)	34.3 ± 1.53
Calcium (C)	100.0 ± 2.65
Iron (Fe)	4.12 ± 0.12
Zinc (Zn)	3.98 ± 0.31
Potassium (K)	486.0 ± 59.9
Magnesium (Mg)	94.4 ±1.28
Copper (Cu)	0.92 ± 0.05
Magnesium (Mn)	0.26 ± 0.01
Phosphorus (P)	219.0 ± 10.0

Source: Ekeanyanwu and Ononogbu (2010)

4.0 Industrial uses of tiger nut

4.1 Tiger nut in food technology

Tiger nut oil has a characteristic rich nutty taste and is comparable with other good oils like corn oil, cotton seed oil, soybean oil and olive oil. In terms of proximate composition and quality, it is a good substitute for these oils when there is scarcity. Tiger nut oil is also very suitable for salad dressing due to its ability to remain liquid even at refrigeration temperature (Bamishaiye and Bamishaiye, 2011). The cold-pressed oil from tiger nut tuber is highly recommended for cooking due to it resistance to chemical decomposition at extreme temperature. The oil is also ideal for cooking because it forms a crust on the surface of the food making less fat to be absorbed into the food (Ezebor et al., 2006).

In Spain, 'horchata de chufa' (tiger nut milk) is made from tiger nut tubers, this is the most popular application in food technology. This non-alcoholic beverage with milky appearance is of immense economic importance in the Valencian region of Spain. It is produced by soaking tiger nut tubers in water for about 8 hours, grinding the nut, pressing to extract the milky juice and mixing with sugar. The beverage 'Horchata' has become very popular in many nations including France, Portugal, Argentina, and United Kingdom (Sanchez-Zapata et al., 2012). Many researchers have studied the palatability and quality of milk beverages from tiger nut tuber, and their findings indicated that the milk is comparable to that from other sources including cow's milk (Bamishaiye and Bamishaiye, 2011; Belewu and Belewu, 2007; Sanful, 2009). Tiger nut is also used as an alternative milk source in yoghurt and other fermented products (Akoma et al., 2004).

Belewu and Abodunrin (2008) revealed that tiger nut is very useful in the production of 'Kunnu', a non-alcoholic beverage traditionally made with cereals such as sorghum and millet. The tiger nut based 'kunnu' was discovered to be relatively cheaper and more nutritious than the one made traditionally from sorghum and millet. Additionally, research shows that tiger nut tuber processed into flour has a distinctive sweet taste which makes it valuable for various confectionary purposes. Its high natural sugar content helps in avoiding the need to add excessive additional sugar. More so, the flour has no gluten and thus ideal for individuals that are allergic to gluten (Bamishaiye and Bamishaiye, 2011).

Another study on the chemical and beneficial properties of two varieties of Nigerian tiger nut flours showed that the flour protein content compares favourably with that of wheat flour. The flour also has adequate quantity of calcium required for teeth and bone formation in infants as well as iron content vital for formation of red blood cells. The low bulk density, setback and breakdown viscosity also make tiger nut flour ideal in food formulation without fear of retrogradation (Oladele and Aina, 2007). The nutritional potential, antioxidant profile, as well as the sensory qualities of biscuits prepared with various concentrations of tiger nut flour were investigated by Ahmed et al. (2014). Tiger nut - enriched biscuit showed higher fibre and fat content in comparison with the control. There were also increase in the levels of zinc and iron in the supplemented biscuit as well as lower level of sodium. In addition, there was great improvement in the antioxidant profile of the enriched biscuit (higher polyphenols and flavonoids). The sensory evaluation result also indicated the supplemented biscuit exhibited better qualities in terms of softness and moistness. These observations led to the conclusion that addition of tiger nut flour will enhance the health and nutritional values of the snack.

Ukwuru and co-workers formulated two novel products from tiger nut tuber namely; Orange tiger nut beverage (OTB) and Tiger nut drink (TD). The OTB was made of a mixture of orange juice and tiger nut milk while TD was dehydrated milled tiger nut tuber reconstituted into cold water. Both products were assessed for proximate composition, sensory and microbiological status. The proximate analysis revealed that the products were contained acceptable levels of carbohydrate, protein, ash, moisture and fat. Sensory evaluation indicated the products were scored high acceptability in terms of colour, aroma as well as taste with the OTB having the higher acceptability. The products were also confirmed wholesome based on microbiological analysis (Ukwuru et al., 2011). Therefore, tiger nut has a great potential for the production of nutritive and refreshing beverages for human consumption.

4.2 Tiger nut in pharmaceutical industry

A study isolated starch from the tubers of *C. esculentus* and evaluated its physicochemical and binding properties. Scanning electron microscopy showed that tiger nut starch is made up of elliptical particles with even surface as well as narrow particle size distribution which conforms to the United States Pharmacopeia standards. The moisture sorption and flow properties of the starch were also comparable with maize starch. Additionally, tiger nut starch has lower swelling power than potato and maize, indicating tiger nut starch offer outstanding binding properties without conceding drug release characteristics and would be vital in pharmaceutical formulation (Manek et al., 2012).

Table 1: Pharmacological activities of *Cyperus esculentus* (Tiger nut)

Activities	Model	Extracts	Results	Reference
Hepatoprotective	*In-vivo* (Rats)	Flour	Tiger nut supplemented diet ameliorate hepatic damage	Oyedepo and Odoje, (2014)
Anti-sickling	*In-vitro*	Methanol, Water	Extracts have anti-HbS gelation activity especially methanol	Monago and Uwakwe, (2009)
Aphrodisiac	*In-vivo* (Rats)	Methanol	Extract increases concentration of male reproductive hormones like testosterone and sperm counts	Agbai and Nwanego, (2013)
	In-vivo (Mice)	Ethanol	Significant increase in sperm concentration and motility	Essawe and Almashhadani, (2010)
	In-vivo (Rabbits)	Aqueous	Improves semen volume and testis weight of rabbits	Oguike et al., (2008)
Anti-reproductive toxicity	*In-vivo* (Rats)	Ethanol	Ameliorates histopathological damage in the testis of lead acetate induced toxic rats	Al-Shaikh et al., (2013)
Antioxidant	*In-vitro*	Methanol, Hexane	Both extracts displayed significant antioxidant activities compared to standards	Oloyede et al., (2014)
	In-vivo (Mice)	Oil	The oil exhibited free radical scavenging abilities	Jing et al., (2013)
Antimicrobial	*In-vitro*	Ethanol	The extract inhibited the growth of *Salmonella typhi*	Adeniyi et al., (2014)
	In-vivo (Mice)	Ethanol	Ameliorates *Escherichia coli* induced endometritis	Hasan et al., (2013)
Anti-atherosclerotic	*In-vivo* (Mice)	Flour	Tiger nut supplemented diets reduced atherosclerotic lesions	Salem et al., (2005)
Anti-inflammatory	*In-vivo* (Rats)	Oil	Displayed dose-dependent anti-inflammatory and anti-arthritic activities	Biradar et al., (2010)

4.3 Tiger nut in agricultural production

The study of Onunkwo and Ugwuene (2015) demonstrated that tiger nut seed meal has good prospect as source of energy in the meal of broiler birds for good growth performance and economic viability at an inclusion of 75% dietary levels. Bamgbose and co-workers (2003) also showed that adding of 33.3% of tiger nut to the diet of cockerel starter marsh elicited an improvement in carcass yield as well as a reduction in the cost of feed consumed by the cockerel. Another study also investigated the nutritive value of alkaline-treated tiger nut meal (ATTNRM) in broiler chicken. The findings revealed that inclusion of 10% ATTNRM improved the growth of the chicken without producing any negative effect on their biochemical and haematological indices (Kwadwo et al., 2014). These reports indicate that the utilization of tiger nut in poultry diets will help poultry farmers to make animal protein available at a reduced cost and maximise their profit.

The effect of tiger nut-based meal on West Africa Dwarf (WAD) goats was studied by Belewu et al., (2007). Their result revealed that animals fed with tiger nut-based meals exhibited better weight gain and digestibility coefficient in comparison to the control. Inclusion of tiger nut in the meal of livestock animals will imperatively increase production and reduce cost. Oladele et al., (2010) also investigated the effect of replacing maize with tiger nut in the diet of catfish fingerlings (*Clarias garepinus*). Their findings revealed that the tiger nut meal enhanced the growth performance of the fish with no adverse effect on them, and suggested that the meal is an ideal replacement for maize meal in fishery in order to maximize output and minimize cost.

4.4 Tiger nut as biofuel source

Barminas et al. (2001) produced and characterised biofuel from tiger nut oil. The results indicated that trans-esterification of *C. esculentus* oil gave methyl and ethyl esters with similar fuel characteristics as

biofuels such as soybean oil and jatropha oil. Hence tiger nut oil could be a viable alternative as renewable source of energy. A similar study also showed that methyl esters produced by tiger nut oil met the biodiesel customary prerequisites with the exception of cold filter plugging point and oxidation stability (Makareviciene et al., 2013). The yield and performance of various blends of tiger nut oil and petro-diesel was investigated by Ofoefule et al., (2013), and they reported that appropriate blend of the oils gave performance very close to petro-diesel. These results showed that aside from the environmentally friendly benefit of tiger nut as source of biofuel, its utilization will greatly reduce cost of energy production.

5.0 Conclusion

Plant species are of diverse importance in different aspect of human life, however many of these are greatly underutilized. The foregoing review expounds some of the great nutritional, nutraceutical, pharmacological, agricultural and biofuel potentials of tiger nut which needs to be exploited. There is a dire need to encourage and intensify scientific research towards identification of active constituents of tiger nut responsible for the identified pharmacological potentials. Additionally, food industries and agricultural sector needs to tap from the abundant nutritional values attributed to this plant. Deliberate cultivation of tiger nut should be encouraged among farmers to make its tubers readily available for consumption and other applications.

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Authors contribution

Conception: AFA, MIK.

Design: AFA, MIK.

Execution: AFA, MIK.

Interpretation: AFA, MIK.

Writing of the paper: AFA, MIK.

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