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Chemical Analysis and Nutritional Assessment of Tiger Nut *(Cyperus Esculentus L.)* used as an Additive on the feed of African Catfish *(Clarias Gariepinus)*

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***Solomon, R. J. and Iluobe, A. G.**

Department of Biological Sciences, Faculty of Science, University of Abuja, Abuja, FCT, Nigeria.
*Corresponding Author E-mail: johnsol2004@yahoo.com

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The chemical and nutritional assessment of tiger nut (*Cyperus esculentus*) used as feed additives on the feed of African catfish (*Clarias gariepinus*) was investigated. The fingerlings of *C. gariepinus* were assigned randomly into 3 replicate aquaria at 15 fingerlings per treatment and fed at 3% of their body weight twice daily. The proximate composition showed that dry tiger nut had 4.63% moisture content, 2.89% ash, 26.73% lipid, 7.65% crude fibre, 6.92% crude protein and 58.84% carbohydrate. The mineral analysis on the other hand showed that the tuber of *C. esculentus* is made up of sodium (247 mg/100g), potassium (193 mg/100g), calcium (136 mg/100g), manganese (21.3 mg/100g), magnesium (18.3 mg/100g) and iron (0.91mg/100g). Fish feed experimental diet III showed significantly higher increase in length from the initial week 1 and week 2 ($p<0.05$). Fish feed experimental diet III showed significantly higher increase in length from the initial week, week 1 and week 2 ($p<0.05$). Fish fed experimental diets I and II had significant feed conversion efficiency ($p<0.05$) compared to control diet.

Keywords: African catfish, chemical analysis, feed additive, nutritional values, Tiger nut

INTRODUCTION

Fish is high in nutritional value with an array of amino acids, vitamins and minerals (Akinrotimi *et al*., 2007). Fish products are relatively cheap compared to other meat sources such as beef, pork and other animal protein sources in the country (Amao *et al*., 2006). According to the FAO (2007), fish contribute more than 60% of the world supply of protein, especially in the developing countries. *Clarias gariepinus* is considered as one of the most important tropical catfish species for aquaculture in West Africa. *C. gariepinus* is a benthopelagic, dioecious, omnivorous fish that is widely tolerant to extreme environmental conditions (Yalcin *et al*., 2001) and has an elongated body with long dorsal and anal fins, and is a typically air breathing scales catfish. The colour of the fish varies dorsally from dark to light brown and is often mottled with shades of olive and grey while the underside is a pale cream to white (Skelton, 2001). *Clarias gariepinus* has been reported to be very suitable for pond culture because it is relatively easy to reproduce in captivity, it can grow fast and efficiently (Esenowo and Ugwumba, 2010).

Tiger nut (*Cyperus esculentus* L.) is an underutilized tuber of family Cyperaceae, which produces rhizomes from the base of the tuber. It grows freely and is consumed widely in Nigeria, other parts of west Africa, east Africa, parts of Europe particularly Spain as well as in the Arabian Peninsula (Abaejoh *et al*., 2006). Tiger nut is a highly nutritious tuber and so have found many dietary application in Nigeria. It contains high amount of amino acids such as glutamic acid, serine methionine, aspartic acid, Leucine, Alanine and Arginine (Borges *et al.,* 2008; Shaker *et al*., 2009). The tuber is rich in carbohydrate, moisture and considerable amount of protein (Murniece *et al*., 2011; Lombardo *et al*., 2012). Meeting the basic human needs for animal protein is a challenge in an increasing population such as ours (Nigeria). The wild fish resource has become limited due to overfishing and other environmental factors (FAO, 2014). Depleting wild stocks is an increasing concern for fishermen and environmental organizations. In Nigeria, several factors militate against increased production of fish. Prominent among these are: high cost of feed, inadequate supply of good quality seed, lack of capital, poor management skills, lack of environmental impact consideration and marketing of products. High cost of input, lack of skilled manpower and lack of aquaculture extension service energy and water quality related problems arising from skills gap in the industry also contributes to the underdevelopment of aquaculture in the country (George *et al*., 2010; Oyakhilomen and Zibah, 2013). Feed formulations account for more than 50% of the total production cost in modern intensive aquaculture (Ibrahem *et al*., 2010). Increasing feed efficiency especially by improving the metabolic assimilation of dietary nutrients, is of high priority in contemporary animal production (Ibrahem *et al*., 2010). Fish production industry relies on the fishmeal which is the most preferred protein source for fish owing to excellent amino acid and fatty acid profile. Limited supply and high cost restrict its use for sustainable farming (Baruah *et al*., 2004). The replacement of fishmeal with extensively available plant or grain by-products is getting increasing attention for the development of low-cost fish feed (Gatlin *et al*., 2007). Studies have been carried out by several researchers to determine the growth performance of *Clarias gariepinus* fed supplemented plant based diets but literature of Tiger nut as fish feed additive is relatively scarce. *Clarias gariepinus* family Clariidae is generally considered to be one of the most important tropical catfish species for aquaculture in West Africa. It is a benthopelagic, dioecious, omnivorous fish and widely tolerant to extreme environmental conditions (Yalcin *et al*., 2001). *Clarias gariepinus* is a typical air-breathing catfish with a scaleless, bony elongated body with long dorsal and anal fins, and a helmet like head. Colour varies dorsally from dark to light brown and is often mottled with shades of olive and grey while the underside is a pale cream to white (Skelton, 2001). The suitability of *Clarias gariepinus* for pond culture is because it matures and is relatively easy to reproduce in captivity, it can grow fast and efficiently, it supports high population densities (Hogendoorn, 1979). The fingerlings are efficient opportunists and survivors, equipped to exploit whatever resources are available, they have a wide tolerance to environmental extremes and grows fast (Esenowo and Ugwumba, 2010). The aim of this study is to evaluate the chemical composition and the nutritional value of tiger nut as an additive to feed for African Catfish.

Habitat of *Clarias gariepinus*

Clarias gariepinus live in a variety of freshwater environments, including quiet waters like lakes, ponds, and pools; they are also very prominent in flowing rivers. They are very adaptive to extreme environmental conditions and can live in pH range of 6.5-8.0 (Teugels, 1986). They are able to live in very turbid waters and can tolerate temperatures of 8-35 degrees Celsius.Their optimal temperature for growth is 28-30 degrees Celsius. The presence of an accessory breathing organ enables this species to breath air when very active or under very dry conditions (Teugels, 1986).

Food and feeding habits of *Clarias gariepinus*

Clarias gariepinus are bottom feeders which occasionally feed at the surface (Teugels, 1986). The stomach examination of *Clarias* species typically comprise insects, worms, gastropods, crustaceans, small fish, aquatic plants and debris, but terrestrial seeds and berries, and even birds and small mammals, have equally been observed. Larvae are almost exclusively dependent on zooplankton for the first week of exogenous feeding. In *C. gariepinus*, four modes of feeding behaviour have been observed as described by Bruton, (1977) which are: feeding by grasping from surface in group or individually (e.g. *C. gariepinus* in poultry-fish integrated ponds), group feeding by forming a circle (e.g. zooplankton grazing), individual foraging of food, individual shovelling of feed, slow methodical searching for food is their normal tactic. *C. gariepinus* grasps suitable food item often by suction. A strong negative pressure (suction) is created by increasing the volume of the buccopharyngeal chamber. *C. gariepinus* is an omnivorous slow moving predatory fish which feeds on a wide variety of food items from zooplankton to fishes of half of its own length (Janssen, 1987). They show no parental care. They use their four pairs of barbels, to feel their way around in the dark and find food detected by the array of sensitive taste buds covering the barbels and head.

The use of plant materials in fish feed production

The use of plant materials as fish feed additives have been reported by several authors (Olaniyi *et al*., 2013). Olaniyi *et al*. (2013) fed 12.5% inclusion level of *Moringa oleifera* to *C. gariepinus* which resulted in highest final weight gain of 32.10g. This study revealed that *C. gariepinus* can tolerate up to 12.5% level of replacement without any adverse effect, this showed that *M. oleifera* leaf meal enabled the fish to increase in weight. Also, the value of carcass composition obtained from fish fed experimental feed was higher compared to the one fed control Diet. This further proved that the locally produced Diet can bring about good growth performance in the fish. Fish fed *Gliricidia sepium* leaf protein in evaluation of *Gliricidia sepium* and *Leucaena leucocephala* leaf protein concentrate as supplements to Bambara groundnut *Vignas subterranean* (L. Verdc) in the Diet of *Oreochromis* *niloticus* offered a better growth performance, nutrient utilization and digestibility than either groundnut or a mixture (1:4) of groundnut with Bambara groundnut. *Gliricidia sepium* Leaf Protein (LP) gave a higher growth performance in *O. niloticus* than *L. leucocephala* LP while fish fed *L. leucocephala* LP had a better protein gain. Conclusively, these leaf proteins would consequently be a good supplement in Bambara groundnut Diets for *O. niloticus* (Adeparusi and Agbede, 2005). Konyeme *et al*. (2006) elucidated that the highest total weight gain recorded was 52.0 g in fish fed 10% and 20% water hyacinth supplemented Diets. The weekly changes in weight suggests that 30% water hyacinth meal inclusion levels gave the final highest weight increase based on the final week result sampled although, there was no significant difference p>0.05 between the growths of fingerlings fed Diets containing 0 - 40% water hyacinth meal which inferred that inclusion of water hyacinth up to 40% significantly improved the growth of *C. gariepinus* (Konyeme *et al*., 2006).

According to Akinfala *et al*. (2003) fresh foliage and whole plant meal of cassava could be included in the Diet of weaned rabbits up to 45 % so as to replace maize grain, without any adverse effects on performances or apparent nutrient digestibility. The best growth response was obtained in isonitrogenous cassava leaf Diet fed to *Clarias gariepinus* (20% of the total Diet) (Bichi and Ahmad, 2010). The better growth performances and feed utilization obtained in fish fed boiled *M. oleifera* based-diets generally support the fact that wet heat processing of plant-based protein sources is more effective in reducing or eliminating various anti-nutrients contained in them (Amaefule and Nwagbara, 2004; Bamgbose *et al*., 2010). Fapohunda, (2012) reported on evaluation of processed soya bean meal in the feeding of *C. gariepinus* fingerlings and established that roasted soybean meal has comparable quality with fishmeal at an inclusion level between 35% and 40% which reflected in the overall growth performance. Therefore for optimum performance of the fish, 40% level of soya bean meal with 60% level of inclusion of fishmeal was most appropriate. Fagbenro *et al*. (2010) stated in the nutritional evaluation of sunflower and sesame seed meal in *C. gariepinus* that replacement of soya bean meal in *C. gariepinus* Diet with raw sunflower and sesame seed meal showed optimum growth response at a 30% replacement level. There was reduction in growth and feeding conversion ratio as the raw plant protein increased beyond 30%. The growth reduction observed at higher inclusion levels of sunflower meal and sesame seed meal was related not only to Dietary amino acid profile but also the presence of antinutritional factors, hence lower level of inclusion of both sunflower and sesame meals did not affect the growth and nutrient utilization of fish (Fagbenro *et al*., 2010).

Keremah *et al*. (2013) reported that the test fish groups fed the different commercial (Aluu, Roone and Coppens feed) and locally compounded Diets gained body weights and lengths progressively to the end of the experiment, thus showing that the fish responded positively to the Diets. High growth performance was obtained in fish fed Coppens compared to fish fed with other Diets (Aluu, Roone and locally compounded Diet). This was attributed to the adequate consumption and utilization of the feed by the test fish and recommended 40% and 35% crude protein (CP) for good growth performance in *Heterobranchus longifilis* fingerlings and juveniles in growth and feed utilization of catfish hybrid (*Heterobranchus longifilis* x *Clarias gariepinus*) fingerlings fed Aluu, Roone, Coppens and locally compounded Diets.

Oso *et al*. (2013) observed in growth response and feed utilization of *C. gariepinus* fingerlings fed with Bambara groundnut as protein source that fish fed 25%, 50%, 75% and 100% Bambara groundnut meal actively grew efficiently without external sign of nutritional deficiency. Since growth performance of fish fed Bambara groundnut meal Diets at various levels up to 75% replacement were similar to that obtained by fish fed the fish meal (control Diet), Bambara groundnut meal therefore contained all the necessary growth factors required by *C. gariepinus*. The fish showed good appetite to all the treatment Diets (25%, 50%, 75% and 100% Bambara groundnut meal) as attested to by the increase in body weight and standard length. The result obtained by Oso *et al*. (2013) therefore showed that the highest replacement of fish meal Diet with plant protein source up to 75% could replace the conventional fish meal in the absence of growth promoter without having significant effect on the overall growth performance and feed utilization of fish. *C. gariepinus* fingerlings were able to efficiently utilize Bambara nut Diet like conventional fish meal, as the fish showed high performance which may be as a result of better acceptance and digestibility of the Diet during the experimental period. Though, fish fed Diet containing 100% Bambara groundnut meal showed reduction in growth performance; this proved that Bambara groundnut meal cannot be used as a sole protein source for *C. gariepinus.* Also, according to Agbo *et al*. (2011) the growth of fish fed 75% Cotton seed meal was lower than those of control and the other Cotton seed meal based Diets. He reported that up to 50% Cotton seed meal protein could be used to replace fish meal protein in the Diet of Tilapia without affecting overall growth and feed utilization of fish. However, any replacement beyond that level will cause depression in growth.

Alegbeleye *et al*. (2012) explained that all feeds were accepted at the start of the feeding trial but feed intake was significantly higher in fish fed Diets with higher levels of fermented meal. The final weight of the fingerlings fed the 100% replacement Diet was significantly higher than those fed the control, 25% and 50% Diets. In growth performance and nutrient utilization of African mud catfish

(*C. gariepinus*) fingerlings fed different levels of fermented pigeon pea (*Cajanus cajan*) meal, all food efficiency factors were best in fish fed the 100% Diet but survival was lower than in fish fed the Diets containing a lower amount of fermented meal. Also, there was increase in carcass protein (33.3%) and lipid in all treatments compared to the initial contents and the highest and lipid (51.6%) gains were recorded in the group fed the 100% Diet. The group fed the 100% Diet had the highest weight gain (7.33 g), significantly superior to the control, while the group that received the 25% Diet had the poorest weight gain (5.29 g). The author noted that the process of fermentation can be easily adopted by rural small-scale fish farmers who could extend the method to other non-conventional resources of plant origin. Anyanwu *et al*. (2012) established in growth and nutrient utilization of *C. gariepinus* fed Dietary levels of jack bean (*Canavalia ensiformis*) meal that the Dietary levels up to 30% nutritionally measured well in improving the performance of the fish, also protein efficiency ratio of the 30% Jack Bean Meal (JBM) Dietary treatment was higher than other treatments (Abd Elhamid *et al*., 2009; Schuchardt *et al*., 2008) and therefore recommended that Jack bean meal up to 30% inclusion level under good processing, using the cracked, soaked and cooked (CAC) techniques, can be used in the Diet of *C. gariepinus*. Tiger nut is a tough erect (1 to 3 ft) fibrous-rooted perennial plant, reproducing by seeds and by many deep, slender rhizomes, which form weak runners above the ground, and small tubers or nutlets at the tips of underground stems (Kelly, 1990). The central stem is erect, 3-angled, and mostly covered by the sheaths of the leaves. The leaves tend to congregate toward the base of the plant. The leaf blades are up to 1½ inches long and 1/3 inches across; they are light green and glabrous, spreading outward from the stem. There is a conspicuous channel along the central vein of each leaf blade, especially the larger ones. The leaf sheaths are whitish green, closed, and hairless; sometimes they become pale red towards the base of the plant (Kelly, 1990). The central stem terminates in an umbel or compound umbel of floral spikes; the size and shape of the umbel is rather variable. Each umbel has 1-3 sessile spikes and 6-10 non-sessile spikes on straight branches of varying length. At the base of each umbel or compound umbel of spikelets, there are several leafy bracts of varying length; the largest bract is usually longer than the inflorescence (Plate 1). Each floral spike is about 2-3 inches long, consisting of 4 ranks of spikelets along its central stalk (or rachis). The central stalk is flattened and narrowly winged. The spikelets are perpendicular to this stalk and about ½–¾ inches long. The spikelets are yellow to golden brown, narrowly linear, and flattened in shape; they consist of 10-30 florets and their scales (Kelly 1990) (Plate 1).

Tiger nut is not really a nut but a tuber crop; although have been reported to share chemical composition and characteristics with tubers and nuts. The moisture content is lower than the moisture contents reported for true tubers such potato (Murniece *et al*., 2011; Lombardo *et al*., 2012), yam (Abara, 2011) yacon (Scher *et al*., 2009; Ojansivu *et al*., 2011), sweet potato (Olayiwola *et al*., 2009; Lai *et al*., 2011), and cassava (Maieves *et al*., 2012). Coskuner *et al*. (2002) have reported that tiger nut loses a considerable amount of water during drying and storage. The ash content is within the usual range for tubers and nuts (Coskuner *et al*., 2002). The principal components of tiger nut are carbohydrates. The oil content is about 24.5%. Some authors have reported that the oil content of tiger nut varies between 22.8 and 32.8 g/100 g (Coskuner *et al*., 2002). In general, tubers have a high content of carbohydrates: their profile and relative content change according to tiger nut varieties and ripening stage. The starch content of tiger nut tubers decreases and the reducing sugar (invert sugar) content increases during storage (Coskuner *et al*., 2002). The carbohydrates of tiger nut tuber are composed, mainly, of starch and dietary fiber. Tiger nut tubers contain almost twice the quantity of starch as potato or sweet potato tubers (Coskuner *et al*., 2002). However, if tiger nut is compared to real nuts, it can be observed that its fiber content is within the usual range for nuts (Ros, 2010), but its moisture and carbohydrate contents are much higher and the lipid and protein contents of tiger nut are lower than in tree nuts (Ros, 2010; Panahia and Khezri, 2011).

Plate 1. Fresh tiger nut (Mason, 2005).

Nutritional importance of tiger nut

The milk of Tiger nut contributes to the reduction in the cholesterol by diminishing the 'bad' cholesterol low density Lipoprotein (LDL), and increasing the 'good' cholesterol, high density Lipoprotein (HDL) (Belewu and Abodunrin, 2006). Its content of vitamin E also collaborates against the cholesterol because it has an antioxidant effect over fats, which are ideal for coronary heart disease (Chukwuma *et al*., 2010).

Tiger nut (*Cyperus esculentus*) was reported to help in preventing heart, thrombosis and activates blood circulation, responsible for preventing and treating urinary tract and bacterial infection, assist in reducing the risk of colon cancer (Adejuyitan *et al*., 2009). Tiger nut milk has been found to be good for preventing arteriosclerosis, since its consumption can help prevent heart problems and thrombosis and activate blood circulation (Chukwuma *et al*., 2010). Tiger nut without sugar can be used for diabetes for the carbohydrate content with best of sucrose and starch and due to its high content of arginine, which liberates the hormone insulin. Tiger nut milk is also a suitable drink for celiac patients, who are not able to tolerate gluten and also for the lactose-intolerant who stay away from cow milk and many dairy foods. It could also be recommended for those who have problems with digestion, flatulence, and diarrhea because it provides some digestive enzymes like catalase, lipase, and amylase (Adejuyitan, 2011). Tiger nut milk is also said to be recommended for those who have heavy digestion, flatulence, dysentery and diarrhea because it provides a lot of digestive enzymes diuretic, stimulant and tonic in addition to being thirst quencher (Abaejoh *et al.,* 2006). Tiger nut milk is said to be rich in minerals, like phosphorus, calcium and magnesium, iron and in vitamin C and E which are essential for body growth and development. Its energetic value (100 cal/100g) makes it a very good energetic drink. A very important point is that it does not contain lactose or gluten (Belewu and Abodunrin, 2006). Tiger nut has a unique sweet that is found to be ideal for use in the baking industry. It can be used to make delicious cakes and biscuits and also as component of fruit flavors. Through various analyses, there is a strong belief in the benefits of flour for health reasons as it has been found to be an alternative for diabetics and it is gluten free which in any case, is a positive alternative within the use of any type of flour. It is a good alternative to wheat flour, as it is gluten free and good for people who cannot take gluten in their diet. It is considered a good flour or additive for the baking industry, as its natural sugar (good option for diabetics). The high fiber content of its raw material (tiger nut) makes the product very healthy. Tiger nut flour does not lose any of its nutritional properties in the milling process (Salau *et al*., 2012).

Dakuwa is a snack produced majorly in northern Nigeria though consumed in other parts of the country. It is made of maize, groundnut, sugar and spices. The maize is sometimes replaced in full or in part with tigernut. During dakuwa processing the maize, tigernut and groundnut are usually roasted to achieve the desired quality. Oladele *et al*. (2009) reported that acceptability of dakuwa is dependent on the flavor, colour and taste of the product which are achieved through roasting. Ocheme *et al*. (2001) reported that dakuwa processing is an art rather than a science. Dakuwa is processed locally with no standardized processing procedure especially the roasting of the ingredients during its processing. Oladele *et al*. (2013) evaluated the effects of roasting temperature of tiger nut on the acceptability of dakuwa where temperature of 150, 160 and 170°C was used; Dakuwa produced with tiger nut roasted at 150°C was most preferred in terms of colour, texture and flavor and the one produced at 160°C was the most preferred in terms of taste.

MATERIALS AND METHODS

Study area

This study was carried out in the Biological Garden of the Biological Science Department, University of Abuja, FCT. The Federal Capital Territory experiences two major seasons wet and dry (Balogun, 2001). During the rainy season the maximum temperature is lower due to dense cloud cover. Diurnal annual range is also much lower sometimes not more than 7°C in July and August. Its temperature ranges from 30.4°C and 35.1°C. During the dry season, relative humidity falls in the afternoon. The rainy season usually begins in March and ends in the middle of October in the North and early November in the South. Mean annual rainfall is about 1400.

Fish housing and treatment

Clarias gariepinus (Catfish) fingerlings were purchased from local fish farmers in Gwagwalada and transported to the Biological Garden of the Biological Science Department in plastic bowls between 5-6 pm to reduce stress and mortality due to high temperature. They were assigned randomly into 3 replicate aquaria at 15 fingerlings per treatment. The fish were fed at 3% of their body weight twice daily. The fingerlings stocked in each aquarium are of the same sizes to avoid cannibalism. DE chlorinated tap water was used. No prophylactic treatment was given before acclimatization. The fingerlings were acclimatized for seven days and fed experimental floating diets at 2% body weight. The aquaria were well aerated. At the end of acclimatization period, the fishes were starved for 24 h to empty their gut content and prepare them for experimental feed. Water quality parameters monitored were temperature using mercury in glass thermometer. The plastic bowls were covered with nets to prevent the fish jumping out and avoid intrusion by other animals and insects.

Proximate analysis

The proximate composition such as moisture content, ash content, crude protein, carbohydrate and lipid contents were carried out on the Tiger nut and formulated feeds samples following the procedure described by AOAC, (2000).

Mineral element analysis

The mineral element content of Tiger nut was determined using an atomic absorption spectrophotometer as described by Onyeike and Acheru, (2002). The wet ashing method was used: 1.00 g of tiger nut powder was digested with 20 ml of concentrated HNO_3 and perchloric acid (1:1 v/v) and thereafter transferred to a 50 ml volumetric flask. It was diluted to volume with de-ionized water and stored in a clean polyethylene bottle. The mineral element content was then determined using an atomic absorption spectrophotometer.

Feeding and measurement

The feeding and measurement of *Clarias gariepinus* was carried out using the method described by Solomon and Ezigbo, (2010). Coppen feeds for aquaculture (floating diet) with 42% crude protein, 13% crude fat, 1.9% crude fibre and 8.9% ash was used as control feed for the first treatment which serves as control Treatment (Tank A). Fish in Tank B were fed 50% of fish meal and 50% experimental diet, and fishes in Tank C were fed 25% fish meal and 75% experimental diet. The fingerlings were fed 3% of their body weight twice daily, morning (8am-9am) and evening (5pm-6pm). The fingerlings were weighed in groups once a week. The standard length of the fish was taken to the nearest centimetre (cm) with the aid of a measuring board. This was done once a week. Depleted water was replaced with fresh water to an effective depth of 20cm after each cleaning.

Experimental fish feed

Formulation of experimental fish feed was formulated using method described by Solomon and Ezigbo, (2010). The experimental feed was composed of Tiger nut, rice bran, soya bean, and corn shaft.

Food utilization parameters

Specific growth rate (SGR)

This was calculated from data on changes of the body weight over the given time intervals according to the method of Brown, (1957) as follows:

$$SGR\% = \frac{\text{Ln } W_2 - \text{Ln } W_1 \times 100}{T - t}$$

Where W1 is the initial weight (gram at time t), W2 is the final weight gain (gram at time t) (Brown, 1957).

Feed conversion efficiency (FCE)

$$FCE = \frac{\text{Weight gain} \times 100}{\text{Feed intake}}$$

Weight gain

Weight gain (g) was calculated as the difference between the initial and final mean weights of the fish in the plastic bowl.
Weight gain (g) = final weight - initial weight.

Survival rate (SR)

The survival rate, SR was calculated as total fish number harvested / total fish number stocked expressed in percentage.

$$\text{Survival } (\%) = \frac{\text{Number of fish harvested} \times 100}{\text{Number of fish stocked}}$$

Percentage weight gain (%WG)

This is expressed by the equation:

$$\%\ WG = \frac{Wt - Wo \times 100}{Wo}$$

Where: Wo = Initial weight, and Wt = Weight at time t.

Statistical analysis

Data obtained were expressed as the mean ± standard deviation. The one-way analysis of variance (ANOVA) was used to determine significant differences of the treatments at $p < 0.05$. Duncan multiple range test was applied while all data were analyzed with SPSS version 16.0.

RESULTS

Proximate and mineral composition of *C. esculentus*

The proximate and mineral composition of *Cyperus esculentus* (Tiger nut) is indicated in (Table 1). The proximate composition showed that dry tiger nut had 4.63% moisture content, 2.89% ash, 26.73% lipid, 7.65% crude fibre, 6.92% crude protein and 58.84% carbohydrate. The mineral analysis on the other hand showed that the tuber of *C. esculentus* is made up of sodium (247 mg/100g), potassium (193 mg/100g), calcium (136 mg/100g), manganese (21.3 mg/100g),

Table 1. Proximate and mineral composition of *C. Esculentus*

Constituents	Comp. (%)	Mineral elements	Comp. (mg/100g)
Moisture	4.63	Sodium	247
Ash	2.89	Potassium	193
Lipid	26.73	Calcium	136
Crude fibre	7.65	Magnesium	18.3
Crude protein	6.92	Manganese	21.3
Carbohydrate	58.84	Iron	0.91

Table 2. Weekly Weight increase of *Clarias gariepinus.*

Duration	Diet I	Diet II	Diet III
Week 0	2.17 ± 0.54^{a}	2.45 ± 0.20^{a}	2.50 ± 0.15^{a}
Week 1	3.19 ± 0.06^{a}	3.74 ± 0.17^{a}	3.00 ± 0.12^{b}
Week 2	3.58 ± 0.40^{a}	4.05 ± 0.16^{a}	3.78 ± 0.23^{a}
Week 3	4.46 ± 0.83^{a}	5.00 ± 0.23^{a}	4.41 ± 0.24^{a}
Week 4	4.30 ± 0.32^{b}	5.67 ± 0.16^{a}	6.00 ± 0.29^{a}
Week 5	5.15 ± 0.45^{b}	7.11 ± 0.17^{a}	7.49 ± 0.42^{a}
Week 6	6.10 ± 0.22^{b}	8.95 ± 0.27^{a}	9.35 ± 0.50^{a}

Mean with different superscript along same row are significantly different (p<0.05).
KEY: Diet I (100% Coppen feed), Diet II (50% Coppen feed: 50% Experimental diet), Diet III (25% Coppen feed: 75% experimental diet).

Table 3. Weekly length increase of *C. gariepinus.*

Duration	Diet I	Diet II	Diet III
Week 0	3.37 ± 0.12^{b}	3.36 ± 0.19^{b}	3.87 ± 0.17^{a}
Week 1	3.91 ± 0.13^{b}	4.31 ± 0.23^{b}	5.68 ± 0.17^{a}
Week 2	4.59 ± 0.07^{c}	5.55 ± 0.2^{b}	6.63 ± 0.27^{a}
Week 3	4.56 ± 0.33^{c}	7.16 ± 0.27^{a}	6.83 ± 0.51^{b}
Week 4	5.90 ± 0.32^{b}	7.93 ± 0.28^{a}	7.41 ± 0.54^{a}
Week 5	6.57 ± 0.50^{b}	9.43 ± 0.27^{a}	8.74 ± 0.65^{a}
Week 6	8.21 ± 0.62^{b}	10.7 ± 0.27^{a}	8.95 ± 0.96^{b}

Mean with different superscript along same row are significantly different (p<0.05).
KEY: Diet I (100% Coppen feed), Diet II (50% Coppen feed: 50% Experimental diet), Diet III (25% Coppen feed: 75% experimental diet).

magnesium (18.3 mg/100g) and iron (0.91mg/100g).

Weekly growth performance of *C. gariepinus*

The weekly growth performance of *Clarias gariepinus* fed experimental diet is shown in (Table 2). There was no significant difference (p>0.05) in the growth of *C. gariepinus* across treatment at the initial week (week 0) and week 3, the fish performance for week 1 shows that diets I and diet II were significantly higher than diet III. At week 4, 5 and 6, the experimental diets II and diet III showed higher (p<0.05) growth performance than the control diet (diet I). Growth performance of *C. gariepinus* measured in fish length is shown in (Table 3). Fish feed experimental diet III showed significantly higher increase in length from the initial week, week 1 and week 2 (p<0.05). *C. gariepinus* fed experimental diet II and diet III showed significantly higher (p<0.05) increase in length compared to fish fed control (diet I) (Table 3).

Growth performance of *C. gariepinus*

The mean growth performance of *Clarias gariepinus* fed experimental diets is indicated in Table 4. The Specific growth rate (SGR) and weight gain (WG) of fish fed experimental diets II and diets III was significantly higher

Table 4. Production parameters of different experimental diets.

Parameters	Diet I	Diet II	Diet III
SGR	2.95 ± 0.05[b]	3.72 ± 0.06[a]	3.78 ± 0.42[a]
WG	3.93 ± 0.03[b]	6.52 ± 0.03[a]	6.85 ± 0.89[a]
SR (%)	93.3 ± 0.80[a]	86.7 ± 0.81[b]	88.9 ± 0.21[b]
WG (%)	55.4 ± 0.90[a]	37.3 ± 0.80[b]	36.0 ± 0.10[b]
FCE (%)	7.85 ± 0.11[b]	13.0 ± 0.08[a]	13.7 ± 0.10[a]
Length (cm)	8.21 ± 0.21[b]	10.7 ± 0.15[a]	8.95 ± 0.15[b]

Mean with different superscript along same row are significantly different ($p<0.05$).
KEY: Diet I (100% Coppen feed), Diet II (50% Coppen feed: 50% Experimental diet), Diet III (25% Coppen feed: 75% experimental diet).

($p<0.05$) than fish fed control diet (diet I). Fish fed control diet (diet I) had significantly higher ($p<0.05$) survival rate compared to diet II and Diet II. The fish fed control diet showed significantly higher percentage weight gain. Fish fed experimental diets I and II had significant feed conversion efficiency (FCE) ($p<0.05$) compared to control diet.

DISCUSSION

The proximate composition of Tiger nut tuber (*Cyperus esculentus* Lam) in this study (Table 1) is nearly similar to composition reported by El-Naggar, (2016). The author reported that moisture content was 4.40%, protein content was 5%, carbohydrate content was 47%, ash content was 4.3 % and crude fiber was 6.5%. The mineral composition of Tiger nut (*Cyperus esculentus*) observed in this study was similar to report of Shaker *et al*. (2009) who reported that tubers of *C. esculentus* (Chufa tubers) have high calcium, sodium and phosphorus and low magnesium, manganese, iron, zinc and copper mineral contents. According to Oladele and Aina ((2007), *C. esculentus* tuber flour could be used as a supplementation for cereal floor due to its high calcium content. The efficiency of inclusion of *Cyperus esculentus* in fish meal could also be as a result of the high value of calcium (135 mg/100g) and iron (0.91 mg/100g).

Fish fed the control Diet (Diet I) had the least growth performance probably because of the effect of heat on the bioavailability of nutrients. Thermal treatment can reduce the solubility of nutrients through the formation of protein complexes with polyphenols, carbohydrates, and general denaturation of protein. This factor may be partly responsible for the comparatively low digestibility of the control Diet (Alegbeleye *et al*., 2012). This result disagrees with report of Keremah *et al*. (2013) who reported high growth performance was obtained in fish fed Coppens compared to fish fed Aluu, Roone and locally compounded Diet. The authors attributed their finding to the adequate consumption and utilization of the feed by the test fish and therefore recommended 40% and 35% crude protein (CP) for good growth performance in *Heterobranchus longifilis* fingerlings and juveniles. The Specific growth rate (SGR) and weight gain (WG) of fish fed experimental diets II (50% experimental diet and 50% fish meal) and diets III (25% fish meal and 75% experimental diet) was significantly higher ($p<0.05$) than fish fed control diet (diet I). Olaniyi *et al*. (2013) fed 12.5% inclusion level of *Moringa oleifera* to *C. gariepinus* which resulted in highest final weight gain of 32.10g. This study revealed that *C. gariepinus* can tolerate up to 12.5% level of replacement without any adverse effect, this showed that *M. oleifera* leaf meal enabled the fish to increase in weight. Nnaji *et al*. (2010) reported that cassava leaf meal included at 10% in the Diet of tilapia fingerlings gave the best growth, feed conversion ratio and survival compared to the control Diet and other test Diets (leaf meals of *Gliricidia sepium* and *Stylosanthes humilis*). Fish fed control diet (diet I) had significantly higher ($p<0.05$) survival rate compared to diet II (86.7%) and Diet II (88.9%). The survival rate observed herein is higher than survival rate reported by Idi-Ogede (2012). The author reported 39% mortality in tap water set-up in a study of stream and tap water effect on *C. gariepinus*, the high mortality in tap water may be due to sharp changes in water quality parameters.

Conclusion

Based on the findings of this study there was significant difference between growth and nutrient utilization of *C. gariepinus* fingerlings fed varying inclusion levels of *C. esculentus* meal. The present study has demonstrated that *C. esculentus* have the potential to be used as an inclusion in fish meal. This would considerably reduce expenditure by local farmers who can't always afford fish meal without compromising growth performance and feed utilization of *Clarias gariepinus*.

Recommendation

Based on the findings in this study, it is recommended that 50% and 75% inclusion level of *C. esculentus* tuber meal can be adopted in the formulation of feed for *C. gariepinus*. Due to the reduction in fish survival rate observed in group fed experimental diet, further studies is recommended to ascertain if reduced survival rate was a result of the diet or other environmental factors.

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