THE CONCEPT OF VALUE CHAINS IN AGRICULTURE, CLIMATE ACTION AND ENVIRONMENTAL RESOURCES

GLOBAL ISSUES & LOCAL PERSPECTIVES

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Preface

This book adopts an exegetical approach as well as a pedagogic model, making it attractive agriculture and environmental economics teachers, professional practitioners and scholars. It is eschews pedantry and lays bars the issues in such clarity that conduces to learning. The book elaborates on contemporaneous ***The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources*** issues of global significance and at the same time, is mindful of local or national perspectives making it appealing both to international and national interests. The book explores the ways in which climate change, food security, national security and environmental resources issues are and should be presented to increase the public's stock of knowledge, increase awareness about burning issues and empower the scholars and public to engage in the participatory dialogue climate change, food security, national security and environmental resources necessary in policy making process that will stimulate increase in food production and environmental sustainability.

The Concept of Value Chains in Agriculture, Climate Action and Environmental Resources: Global issues and Local Perspectives is organized in three parts. Part One deals with The Concept of Value Chains in Agriculture, Part Two is concerned with The Concept of Climate Actions and Part Three deals with the Concept of Value Chains and Environmental Resources.

Eteyen Nyong/ Ignatius Onimawo

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Chapter Twenty Six

Effect of Tigernut on Reproductive Indices of *Clarias Gariepinus*

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1.0 Introduction

Aquaculture plays a leading role in the fight against food insecurity, malnutrition and poverty globally. Aquaculture productivity requires adequate nutrition, which necessitates supplementary feeding of the fish that are been reared in addition to the natural food present in the water. To meet various nutritional and energy requirements, maximize growth and reproductive efficiency, a balance nutritional supplementary feed is require which will resulting in a significant increase in fish production (Abhed, 2022). Both fisheries and aquaculture sectors are facing major economic changes driven by increasing global demand for fish and the subsequent growth in international fish trade (Food and Agriculture Organization of the United Nations, 2016). African catfish (*Clarias gariepinus*) is the most popularly cultured fish in Nigeria (Sogbesan and Ugwumba, 2008). This species has drawn attention of aqua culturists because of its biological attributes that include faster growth rate, resistance to diseases and high stocking density (Sabah, Shaker, Mohamed and Fawzia, 2019). In the last decade, significant growth has been recorded in

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Catfish fingerlings production through artificial propagation although, the demand for the seeds still outstretch the supply (Madu, Okwuegbo and Madu 2003). Global fish production from aquaculture currently stands at 76.6 million tonnes representing 45% of the total fish production (FAO 2019). Fish is considered to be highly nutritive and rich source of animal proteins (Dauda, Ibrahim, Bichi, and Tola-Fabunmi, 2017).

Aquaculture production of finfish has seen rapid growth in production volume and economy impact in the world, supplying 50% of all fish consumed globally today, and it is predicted that aquaculture will be the prime source of fish by 2030 due firstly to demands from consumers and secondly to depletion of wild capture fisheries (FAO, 2019).The fisheries sector contributed 1.09% GDP of the country total GDP in the year 2021(National Bureau for Statistics, 2022). The recent rapid growth of aquaculture indicates high demand of quality fingerlings for the commonly cultured species. A good fish breeds will contribute to increased fish production, while ensuring protection of biodiversity and the environment, as one of the key solutions to solve food demands of the growing world population (Nyonje, 2018). The high demands for fish fingerlings in the aquaculture industry necessity for artificial propagation for the increase production of fingerlings which is the only reliable and dependable source (FOA, 2019). Reproductive indices are paramount in fish production and provide vital information on the performance of the fish (Tusayi, 2023). Boosting of reproductive indices of cat fish during feeding is an important aspect that should be considered for effective utilization and management of fish resources to produce viable fingerlings **(Lind, Brummett and Ponzoni,** 2012). To develop fisheries sector and to achieve maximum yields, it is paramount to formulate feed using plant sources to improve the reproductive biology of cat fish which lead to high fingerlings, fast growth and attains maximum weight in shortest possible time without environmental effects (Dada and Ejete-iroh, 2015). Provision of fingerlings is unsustainable due to poor-quality brood stock and impure strains (Dada and Ajilore, 2009). Different researches have been done on variety of fish

species for several years on the digestibility for most nutrients (FOA, 2016). Due to the detrimental effects associated with the use of synthetic pro-fertility drug substances in fish production, other safer and effective natural plant sources are now been harnessed as an alternative in recent years. Many medicinal plants have been used to enhance fertility and research has confirmed pro-fertility effects in some of the herbs tested in animals and fish. Plants with very potent pro-fertility activities has also been reported, *Azanza garckena* has been reported by Onyia, Ochokwu, Diyaware and Michael, (2015) which enhanced both egg and sperm qualities of *Clarias gariepinus*, also plant enhance ovulation and sperm quality in *C. gariepinus* (Adeparusi, Dada and Alale, 2010). *Garcinia kola* seed, a tropical plant, have anti-inflammatory, anti-microbial, anti-diabetic and antiviral properties was reported to enhance fertility and increase egg quality in *Clarias gariepinus* (Dada and Ajilore, 2009). According to Oluyemi, Jimoh, Adesanya, Omotuyi, Josiah, and Oyesola, (2007) studies have shown that antioxidants can enhance fertility either directly or indirectly and that most plants rich in antioxidants have the tendency to increase sperm count, motility, and enhance sperm morphology. Tigernut acts as an antioxidant and tend to increases serum testosterone levels in male rats (Bassey, Ikpi, Isong, Akpan, Onyeukwu, Nwankwo and Udofia, 2022). Fish is one of the most efficient converters of feed into high quality food (HLPE, 2014). Medicinal plants/herbs can be used as natural additives in fish diets to enhance reproductive performance (Dada and Ejeteiroh, 2015). The digestibility of protein, energy and individual amino acids are considered paramount as the basis for feed formulation in fish, with information gained for different raw materials, such as plant by-products commonly utilized in the feed manufacturing industry.

Medicines derived from plant products are safer and effective than their synthetic counterparts (Oluyemi *et al*., 2007). Plants are discovered to be associated with new beneficial therapeutic agents and have received significant focus because of their bio- active substances (Madhu, Sailaja, Satyadev, and Satyanarayana, 2016). Studies had been conducted on the effect of

tiger nut on reproduction of some animals which improve the reproductive indices in animals and increase reproduction. The methanol extract of tiger nuts has a very positive effect on reproductive hormones, sperm motility, and sperm count (Bassey, *et al.*, 2022). Aqueous extract of Tiger nut is an antioxidant and has androgenic properties with the capability of increasing the weights of the testes and epididymis, sperm count, sperm quality and testosterone level of rat (Ekaluo, 2015). Therefore, this present chapter elucidates the potentials of *Cyperus esculentus* L. seed meal on the reproductive indices of *Clarias gariepinus.*

2.0 Reproductive Indices of *Clarias gariepinus*

One way to address the challenges of fingerling production is to improve the reproductive indices of the brood stock (Nadio, 2015). According to Safira Zairin and Widanarni, (2020) improving reproductive performance of fish by accelerating the gonad maturation plays a vital role in production of viable fingerlings. The maturation processes of *C. gariepinus* in nature are generally influenced by annual changes in water temperature and photoperiodicity and the final triggering of spawning is usually caused by a rise in water level due to rainfall (de Graaf, Galemoni and Banzoussi, 1995).

Growth is a complex process and can be defined as an increase in size (length, volume, mass and body composition) of an organism over time and can differ between species, strains or populations within the same species and different individuals within the same population (Dada and Ajilore, 2009). According to Megbowon (2013) female and male *Clarias gariepinus* usually have a protruded stomach and a red genital papillae while mature female with developed ovary contains eggs throughout the year, if rear in ponds with water temperature kept above 22 ^{0}C and they can produce between 10,000 and 150,000 eggs, depending on the size and age of the female. According to Charles, James and Bethuel (2007) some of the characteristics feature of *C. gariepinus* onset of maturation influenced by changes in temperature and photoperiodicity. It

occurs widely in fishes under natural conditions and is observed in fish more commonly than in other vertebrate animal groups. According to Gupta and Acosta, (2001) it is utilized in breeding programs aimed at identifying mating between different populations of fish which produce hybrid off springs that will increase grow rate there by exhibiting hybrid vigor.

Widanarni, Ekasari and Maryam (2012) stated that diets formulate with some fertilization booster proven to produce more fecundity and gonad somatic index value twice than the control. Gonad somatic index (GSI) reflects the relationship between gonad and the body weight of the fish. Safira *et al.*, (2020) stated that feed that has reproductive improve ingredient can increase the estradiol level in blood plasma which increase the vitellogenins thereby improving the fecundity. Fecundity is the brood stock capability of producing eggs that are ready to be spawned and affect the egg yolk which synthesis and filling the egg size (Gioacchini, Maradonna, Lombardo, Bizzaro, Olivotto and Carnevali, 2010). According to Aminur (2018) hybrid with favored characteristics from each of the parent is the main target hybridization and it makes it have characteristics superior to both parents and also refer to have hybrid vigor or positive heterocyst. Fecundity in fish refers to the number of eggs a female fish produce in a single spawning event (Aminur, 2018). The fecundity of fish can vary greatly between species and even within different population of same species. It is also important to note that fecundity can vary greatly within same species due certain environmental factors such as degradation, management practices, diet and habitat (Gioacchini *et al.*, 2010).

In aquaculture, catfish milt is collected from the males and used to fertilize the eggs of the females during artificial propagation and the collected milt is then used to fertilize the eggs of the female catfish (Onada and Ogunola, 2017). The fertilized eggs are then incubated until they hatch into fry, which can be reared in nursery ponds or tanks until they are large enough for grow-out in commercial production systems (Charles *et al.*, 2007).

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Improving growth through nutritional diets rate will decrease the time it takes to grow a fish to marketable size which is advantageous for fish farmers (Ishaku, Onyia, and Tusayi, 2022). Increased productivity of fry and fingerlings with attributes of faster growth rates and better environmental tolerance is in line to ensuring fish food security in the globe (Abhed, 2022). A good quality fingerling production and supply is essential for aquaculture growth. Many hatcheries in Nigeria use male and female brood stock developed from the same parents that have been used several times over for many years (Onada and Ogunola, 2017). Increased growth rate is the most desirable trait for stock improvement in aquaculture and growth increase may result from dominant variance (Aminur, 2018). Thus, brood stock in most hatcheries do not benefit from intraspecific exchange of genes thereby leading to reduction in overall productivity of fingerlings (Aluko and Shaba 1999). Development of fisheries and to achieve maximum yields from resources of fresh water, it is paramount to formulate feed using plant sources to improve the reproductive biology of cat fish which lead to high fingerlings, fish grows rapidly and attains maximum weight in shortest possible time without environmental effects (Dada and Ejete-iroh, 2015). This can be achieved when farmers raise brood stock all year round with adequate milt and eggs which can produce viable fingerlings. According to Izunwanne *et al.*, (2020) tiger nuts provide the novel treatment for infertility in rat which tends to boost sperm count and egg quality. Ekaluo *et al.*, (2015) stated that extract from tiger nut has antioxidant and androgenic properties capable of increasing the weight of the testes and epididymis, sperm count, sperm quality testosterone on rat and also, boosts egg viability. Tigernut is a non-conventional feedstuff that is cultivated primarily for its oil that is rich in omega 3 fatty acid and the vegetable milk. *C.esculentus* is relatively cheap compare to maize and the crude protein content range between 7% and 9.2% depending on the variety (Oladele, 2009). Hence, this necessitate the present study which tend to investigate the dietary effect of *Cyperus esculentus* on the reproductive performance of catfish with the aim of finding ways to increase fish production using the plant source. Tigernut like other plants has

contain some Phytotoxins that are deleterious when fed in moderate dosage increase fertility in animals (Ofem, Udonkang, Iya, Bassey, Obioma and Okechi, 2023). Tiger nuts boost fertility due to its rich nutrients consisting of fats, carbohydrates, minerals, and vitamins E and C. which are essential for fertility in both men and women (Innih, Eluehike and Francis, 2021). Fish farming required high-quality fish seed which can be carried out using various plants additive in the brood stock feed to improve milt quality and eggs with the aim of increasing fish reproduction.

3.0 Artificial propagation of fish

Artificial propagation methods constitute the major practicable means of providing enough quality seed for rearing in confined fish enclosure waters such as fish ponds, reservoirs and lakes (Charo, 2000). One of the major problems identified that continually hinders the promotion and development of the aquaculture industries is the scarcity of fish fingerlings of a desired cultured species (Adewolu and Adeoti, 2010). Fish seed production is an important aspect of aquaculture that has recorded continuous research and innovation. One of the most significant impediments to the development of aquaculture is the scarcity of seed (Abhed, 2022). Catfish fish production is a valuable fish species reared by farmers most especially in Africa (Onada and Ogunola, 2017)

According to Adewolu and Adeoti, (2010) artificial reproduction by induced breeding through hormone treatment followed by artificial fertilization and incubation of fertilized eggs and the subsequent rearing of larvae to fingerling size has several advantages which includes

·Better rates of fertilization and hatching.

·Protection against enemies and unfavourable environmental conditions.

· Better conditions for growth and survival.

Artificial propagation remains the major means to provide a continue supply of fish species of good quality of *Clarias gariepinus* (Onada and Ogunola 2017). Production of fish in captivity has necessitated artificial means of propagating fish species. Environmental and hormonal

manipulation of ovulation in fish have become of practical importance in the fish farming industry for several reasons. It is important to solve the problem of spawning asynchrony which necessitates frequent brood stock handling. Moreover, induced breeding makes possible hybridization between closely related species (Park, Chung and Hong 1996). The testis of a male is fully developed at an age of 8 to 12 months once they reach a weight of approximately 200 g (Lin and Peter, 1996). Male brood-stocks examined for rigid and reddish infusion of the genital papillae and female genital orifice shows for reddish infusion, distension of the belly and release of eggs when gentle pressure is applied on the abdomen (Onada and Ogunola, 2017). Artificial fertilization involves the collection of gametes from the male and female fish with hormones induce ovulation and permeation (Adewolu and Adeoti, 2010). Different types of hormones have been used to induce breeding, including human hormone analogues, fish and amphibian pituitary extracts (Ekaluo *et al.*, 2015).

Doses of hormones could be administered either once or twice in which, the first is termed the priming dose and the second dose is called the resolving dose. The choice and dosage of hormone depends on certain factors ranging from efficacy of hormone, species of fish and cost to availability of hormone. Induced breeding through the use of hormones has to do with the assessment of the maturity of breeders as the success of such technology to a large extent depends on adequate and accurate information about the state of the gonad. Gravid fish can be ascertained by examining the external features and appearance. Success in induced spawning depends largely on the knowledge of the optimum dose of hormone to be used and latency period (Tusayi, Onyia and Ishaku 2023).

4.0 Origin and geographical distribution of Tiger nut

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Tigernut (*Cyperus esculentus* L.) is an under-utilized sedge belonging to the family *Cyperaceae* (Oladele, Alatise and Ogundele, 2010). The genus name *Cyperus* is derived from an ancient Greek name *Cypeirus* whereas the species name *esculentus* originate from a Latin word which means edible (Asmah, 2014). According to Sánchez, Fernández and Pérez, (2012) and Ahmed and Hussein, (2014) *Cyperus esculentus* can be found as a weed and can be cultivated as crop which is traced in Egypt since the sixth millennium BC, and for several centuries in Southern Europe. In Southern Europe and West Africa, the cultivation of tiger nuts had been practiced since early times (Udeozor and Awonorin, 2014). Cultivation of tiger nut in Southern Europe was made possible by the Arabs in the middle ages when they travelled beyond Northern Africa (Maduka and Ire, 2018). It is found in most of the Eastern Hemisphere, including Southern Europe, Africa, as well as the Middle East and the Indian subcontinent (Sanche *et al.*, 2012). Tigernut is one of the widely distributed plants in subtropical and tropical regions cultivated for human and livestock production. In Nigeria, it is cultivated mainly in the Middle belt and Northern regions (Oluwakemi, AA, Irewunmi, AF, Sholotan Kazeem Joshua, Nwaemeke David Iweunor, 2021). The tubers are believed to have been a source of food for those Paleo-Indians (Suleiman, Olajide, Omale, Abbah and Ejembi, 2018). According to Oluwakemi *at el*., (2021) tiger nut is not really a nut but a tuber which belongs to the family *Cyperaceae* and produces rhizomes from the base and tubers that are somewhat spherical. Tiger nut is a tough erect fibrous-rooted perennial plant, 1 to 3 ft high, reproducing by seeds and by many deep, slender rhizomes, which form weak runners above the ground, and small tubers at the tips of underground stems (Consejo, 2009). Young tubers are white, while older tubers are covered by a yellow outer membrane. They are usually found within six inches of the ground surface (Bamishaiye and Bamishaiye 2011).

5.0 The proximate composition of *Cyprus esculentus* nuts

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Tiger nut has been considered a foodstuff since ancient times (Pascual, Maroto, Lopez-Galarza, Sanbautista, and Alagarda, 2000). *C. esculentus* had been reported to be a "health" food, since its consumption can help prevent heart disease and thrombosis and is said to activate blood circulation (Chukwuma, Obioma, and Cristopher, 2010). Tigernuts are nutritious and flavorful snacks that offer a variety of health benefits due to their high phytochemical content Tiger nut tubers are an interesting healthy food such as imitation milk (Sabah, *et al*., 2019).

Tiger nut consist of three main varieties which differ in the proximate composition (Table 1). The brown tigernut contents high amount of carbohydrate, protein, fibre and ash content. Tiger nut composition is suitable for diabetics and for that intent on losing weight (Borges, Goncalves, Sgeoeiro, Correia, and Silva, 2008). According to Belewu and Belewu (2007) Tiger nut is rich in energy content (starch, fat, sugar and protein), minerals (mainly phosphorus and potassium), and vitamins E and C. The tubers contain about 25 % oil, which are resistant to peroxidation, 50 % digestible carbohydrates, 4 % protein and 9 % crude fiber (Sabah, *et al*., 2019). Prasad, Syamala, Chadha, Sawant, Xavier, and Gireesh-Babu, (2022) studied effect of different dietary protein levels on physio-metabolic response during stunting of milkfish reared under pond conditions and concluded that dietary protein level has a significant role in producing quality milkfish fingerlings. Tiger nut is a good source of protein which contains essential amino acids occurring in limiting concentration when compared to recommended levels (FAO, 2005). It was reported that tiger nut tubers contain almost twice the quantity of the starch as potato or sweet potato tubers. Mineral compositions of tiger nut are K, Na and Ca were the major in organic constituents of the ash in all studied samples. Among the trace elements (expect zinc, copper and iron) the valves found in chufa nut are low and within the limits advised for nutrition (Sabah, *at el.*, 2019). Oladele and Aina, (2007) stated that tiger nut tuber have high calcium, sodium and copper and low magnesium, manganese, phosphorus, iron, zinc and Copper mineral contents and the high values of calcium found in the tiger nut are adequate for bone and teeth development in infants and the presence of

other minerals such as iron is highly important because of its requirement for blood formation. *Cyprus esculentus* chemical composition shares characteristics with tubers and with nuts. According to Sabah, *at el.,* (2019) the tuber is rich in energy content (starch, fat, sugar, and protein), and dietary minerals (mainly phosphorus and potassium).

The starch, dietary fibre and digestible carbohydrate (monosaccharides, disaccharides and polysaccharides) content of tiger nut tubers are quite high and moisture content is about 50%, fat 12%, crude fibre 8%, protein 4%, ash 1.80% and carbohydrate 34% (Maduka and Ire, 2018). Tigernuts are a good source of resistant starch, which is a type of carbohydrate that resists digestion in the small intestine and can help promote healthy gut bacteria (Bamishaiye and Bamishaiye, 2011). According to David (2009), Tigernuts are nutritious and flavorful snack that offer a variety of health benefits due to their high phytochemical content (Tusayi *et al.*, 2021). Tiger nuts are incredibly rich in minerals and vitamins and have high content of vitamin E and C in them as well as such essential minerals as potassium and phosphorous (Sánchez e*t al.*, 2012). According to Sabah (2019) tiger nut tuber have high calcium, sodium and copper and low magnesium, manganese, phosphorus, iron, zinc and Copper mineral contents also, the high values of calcium found in the tiger nut are adequate for bone and teeth development in infants. Additionally, tiger nuts contents more iron than cow milk, red meat, or liver therefore, tiger nuts serve as a source of vitamins which will strengthen the body (Asante, 2014). Proper dietary composition is fundamental to nourishment of brood stock which is key sustainability to aquaculture system (Hernandez de-Dios, Tovar-Ramırez, Garc´ ıa, Galaviz-Espinoza, Zarco and Maldonado, 2022)

The Proximate Composition indicated that *Cyprus esculentus* qualifies as a good fish feed ingredient being rich in protein and lipid (Agbabiaka, Madubuiko and Anyanwu, 2012). According to Tusayi *at el*., (2023) the Proximate Composition indicated that *Cyprus esculentus* contained good amount of energy which can serve as source of energy when included in the fish feed and the

proximate composition of *Cyprus esculentus* showed the presence of Lipid, Crude fibre, Crude protein, Moisture and Ash content which has the lowest value which is similar to research carried out by Sabah *et al.*, (2019). However Agbabiaka and Ezeafulukwe (2013) reported a different result in terms of the quantitative constituent of Lipids, Crude Fibre, Crude Protein, Moisture and Ash percentage contain of *Cyprus esculentus* proximate composition which had more fibre than protein, this could be as a result of difference in environmental factors. Agbabiaka and Ezeafulukwe (2013) stated that lipid is a source of energy and tend to provides fish with energy. A right amount of fat can improve taste and texture but excessive fat may pose a health hazard to fish (AFCD, 2009). Protein provides energy and builds muscles however; deficiency means slower growth whereas excessive protein will increase cost of feed and can easily pollute the water in the pond. Tiger nut is a good plant-based ingredient for aquaculture feed due to its rich nutrients and elemental composition which is needed by fish for good health and fast growth (Bassey, Paul, and Arit, 2018). The composition of the nutrient in the tiger nut makes it suitable to be used as fish feed ingredient.

Tigernuts, also known as chufa or earth almonds, are small root vegetables that are popular in many parts of the world (Amaal and Essraa, 2010). They are a good source of several nutrients and have a unique flavor and texture that make them a popular ingredient in many dishes. The oil extracted from tiger nut can be used as food oil as well as industrial purposes (Barninas, Maina, Tahir, Kubmarwa and Tsware, 2001). The oil extract from tiger nut is use as food oil and milk production (Okafor *et al.*, 2003), flavoring agent in ice cream, biscuits and other bakery products (Cos kuner, Ercan, Karababa and Nazlican, 2002), also in making oil, soap, and starch extracts (Adejuyitan, 2011). Tiger nut meal could be used as supplementation for cereal flour to improve its content from Ca (Oladele and Aina, 2007). Study on brood stock nutrition which effect egg production and quality is paramount because it leads to good spawning, growth and health of the

progeny (Ekanem, Nlewadim and Uka, (2024). There is a need to establish the effect of feed quality and feeding level on the reproductive performance of brood stocks

6.0 Phytochemical Analysis of *Cyprus esculentus* Nuts

The Phytochemicals (Table 2) in *Cyprus esculentus* confirmed their presence and the results were similar with those obtained by Imam *et al.,* (2013). The quantitative result shows the present of some active phytochemical constituent. Quantitative Phytochemical analysis of C*yprus esculentus* recorded high presence of Steroid similar to Dada, Oluwagbohunmi, Adeola and Opeyemi, (2019). Plants have been used as sex stimulants or sexual performance enhancer in traditional systems of medicine due to presence of steroid stimulants (Chukwuma *et al.,* 2010). Saponins, Phyates and Alkaloids were also recorded in good amount during the study which agreed with the findings by Sabah *et al.,* (2019). Alkaloids are organic and natural ingredient that have nitrogen and are mostly found in plants. Phytochemicals Phenols, Oxalate, Tannins, and Flavonoids were found in *C. esculentus* which agreed with the work by Agbabiaka and Ezeafulukwe (2013). According to Jones e*t al.,* (1994) Phenolic compounds are some of the most widespread molecules among plant secondary metabolites which are known to act as natural antioxidants.

Tiger nut like other plants has been reported to contain some phytotoxins such as alkaloids, trypsin inhibitors, tannins, phytase and saponins that are deleterious to animals including fish when fed in high dosage but they can be reduce through processing such as toasting and fermentation (Ekanem *et al*., 2010).

Medicinal plants or herbs have been used to enhance fertility and modern scientific research has confirmed the pro-fertility effects in some of the herbs tested in fish (Onyia *et al.*

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2015), Adeparusi (2010), Sule and Onyia *et al*., (2015). *C. esculentus* seed powder influenced and increased sperm quality of *C. gariepinus* such as the length of the testes, sperm volume, sperm count and sperm mortlity (Tusayi *et al.*, 2021). According to Chauhan, (2014) plants have been tested and evaluated for their effects on sexual functions and reproductive parameters.

7.0 Effect of Tiger nut on the Reproductive Indices of *Clarias gariepinus*

7.1 Effect on milt

Ogbuagu and Airaodion, (2020), stated that with Tiger nut produced a dose-dependent increase in sperm count and motility of animals treated when compared with those in the control group. The reproductive performance of African catfish fed diets of *T. conophorum* seed powder was better than those not fed diets with *T. conophorum* seed powder (Dada and Aguda, 2015). Onyia *et al*., (2015) stated that active Phytochemicals present in plant are responsible for enhancing sexual activity thereby increase the milt quantity. Ofem, (2023) report similar increase in testicular weight was reported to occur due to the production of a high amount of spermatozoa as a result of the increase in testosterone levels in rats. The increase in the milt density of *C. gariepinus* obtained in the research could be as a result of the presence of steroid in the plant which is a known main fertility agent (Nwaoguikpe and Ujowundu, 2012) in plants. The compound is potent antioxidant which is capable of playing a major role in scavenging free radicals that might accumulate to reduce the number of sperm cells thereby leading to an increase in the sperm counts (Ikpeme, Ekaluo, Udensi, Ekerette, Ekpo and Asuquo, 2014). However Ofem *et al*., (2022) suggested that the increase in testosterone by tiger nut is enabled by zinc which works to facilitate the production of testosterone. The *C. gariepinus* possessed the capacity to boost fertility in male as indicated in the table 2 in agreement with the conclusion made by Ogbuagu and Airaodion, (2020). Over the years it has been consumed as a traditional medicine to increase of sperm

concentration and sperm anomalies (Tocharus, Jeenapongsa, Teakthong, and Smitasiri, 2005). The presence of steroid in Tigernut might have enhance the milt contain in the male fish. Airaodion, Ogbuagu, Ekenjoku, Okoroukwu, Ogbuagu and Airaodion, (2019) stated that tiger nut administration stimulated steroid hormone biosynthesis, which resulted in increased spermatogenesis. Perturbations in steroid hormone biosynthesis as well as spermatogenesis may affect the sperm quality of animals (Ogbuagu and Airaodion, 2020). Izunwanne, Egwurugwu, and Emegano, (2020) stated that increase of tiger nut meal significantly increased the testosterone levels and hence increased the sperm count as indicated in table 3. Testosterone is a requirement for the production of sperms (Airaodion *et al.*, 2020). Dada *et al.*, (2019) reported that tiger nut positively influenced sperm count in catfish. The tiger nut used in this study might have elevated serum levels and testosterone by decreasing steroid catabolism and elimination or directly stimulated steroid hormone production (Ogbuagu and Airaodion, 2020).

The sperm motility of *Clarias gariepinus* tend to reduce with increase inclusion level of *C. esculentus* and sperm motility increase significantly as shown in table 3 (Tusayi *et al.*, 2021). The increased sperm motility observed at these doses might be an indicator that tiger nut has the ability to stimulate the ATPase activity in all tissues of the animals (Hasim *et al.*, 2013). According to Ogbuagu and Airaodion, (2020) when ATPase activity is increased, it could elevate the motility rate of sperm, as ATP is the main energy source of sperm and directly related to sperm motility. The result collaborates with Abd El-Rahman *et al*., (1999) which stated that aqueous extract of *Cynomorium coccineum* induced significant increase in the sperm count, improved the percentage of live sperm and their motility, and decreased the number of abnormal sperm. It is now possible that spermatogenesis can be modulated and manipulated by various factors such as diet to get maximum viable sperms for aquaculture practice (Routray *et al*., 2011). The length of the lobe showed increase with increase in inclusion level *C*. *esculentus* seed powder. Tiger nuts enhance

testosterone levels which is attributed to its phytochemicals such as quercetin and zinc (Ofem, 2023)

7.2 Effect on egg fertilization, percentage of hatchability and percentage of survival

The reproductive indices of the female catfish fed with different inclusion level of *C. esculentus* indicated an increase in terms of number of eggs, fertilization, hatchability and Gonad Somatic Index as shown in Table 4. Difference in egg and sperm quality as a consequence of diet, especially lipid content, is one of the most researched aspects concerning egg quality (Ochokwu *et al*., 2015). Nutritionally supplementary feed is required to meet various nutritional and maximise growth and reproductive efficiency, resulting in a significant increase in fish production (Abhed, 2022). Table 3 in the study indicates a significant difference in the number of eggs with the lower inclusion level of *C. esculentus* and subsequent increase with increase in the inclusion level in the feed. This is similar with Dada *et al.,* (2019) which stated that medicinal and wild fruits have the potentials to enhance increase of egg size which may affect the reproductive indices of *C. gariepinus* brood stock. The higher the inclusion level of Composite Medicinal Plant Powder, the higher the fecundity rate of *C. gariepinus* eggs (Onyia *et al*.,2019). Also, Dada *et al.*, (2013) and Onyia *et al.*, (2015) reported that bioflavonoid in plant is a potent antioxidant that can possibly increase the production of estrogen which is the major hormone necessary in the production of matured and viable eggs in the ovary of the female fish and present in *C. esculentus*. The diameter of the eggs ranges between 1mm and 0.8mm in the parent stock fed *C. esculentus.* Nutritional composition of the diet contributes to egg size, viability, fertilization success, and larval quality (Rohani, Bristy, Hasan, Hossain and Shahjahan, 2022). However Carillo (1995) stating that egg diameter is not a good indicator of egg and larval quality. Ejete-Iroh and Dada (2015) reported that fish with lower egg size has high fecundity therefore, importance of egg size has been difficult to ascertain because of conflicting results from various studies and because of problem in separating

the effect of other factors such as age, strain, and nutritional status of the fish. Ecological explanations for differences in egg size of fish in different populations include temporal and spatial changes in food particle size and in food quality availability (Ochokwu *et al.*, 2015). Dada and Aguda, (2015) stated that larger eggs did produce larger fry, but this size advantage masked by other environmental factors determinants of growth. According to Ochokwu *et al.*, (2015) egg size does not appear to be an important indicator of egg quality.

The phytochemical of tiger nut that showed the presence of several components (Steroid, flavoid, and Phenol) could have positively contributed to oestrogen synthesis and as such, improve the reproductive function (Izunwanne *et al.*, 2020). Similarly, the increase in the number of eggs obtained in the study could be due to presence of flavoid in *C. esculentus* (Dada, Ibrahim, Bichi, and Tola-Fabunmi, (2017). They are potent antioxidants which increases the production of oestrogen hormone responsible for the production of mature eggs. The fertilization and hatchability showed increase with increased additive level which indicates effect of *C. esculentus* similar to report by Dada *et al*., 2019. High fecundity values were obtained in the fish fed dietary *C. esculentus* (Tusayi, 2023). Similar results were also reported by Adeparusi *et al*., (2010), on the use of medicinal herb *Kigelia africana* as fertility enhancing agent for catfish *C. gariepinus.* Dada *et al.*, (2019) also reported that catfish *C. gariepinus* brood stocks fed diets supplemented by medicinal plants, exhibited improved reproductive performance than those fed with the control diet. The results of this study agree with the findings of other authors, including Ekanem *et al*., (2024), who found that the fecundity of *C. gariepinus* significantly affected by the nutrional contents in the feed. The result agrees with Izunwanne *et al.*, (2020) that observed significant increase in the fecundity following the administration of *C. esculentus* meal to animals that had induced infertility. There is significant increase in percentage of fertilization, percentage of hatchability and percentage of survival in the fry of fish fed dietary *C. esculentus* seed powder (Table 4). Adeparusi *et al*., (2010) reported that *C. gariepinus* broodstock fed dietary *Kigelia*

africana seed meal had higher percentage hatching and larval survivals. *C. esculentus* has significant impact on the percentage fertilization and hatchability with increased dietary inclusion levels of *C. esculentus* seed powder. The fertilization percentage increase with increase in inclusion levels of *C. esculentus* seed powder in the diet as shown (table 4). This is similar to studies reported by Mohammed, (2022) stating fertilization percentage increase with increased level of African fan palm meal in the meal of brood stock fish feed of plant source. *C. esculentus* have effect on the percentage fertilization and hatchability during the study as reported by Dada *et al*., (2019). Table 4 indicates changes in the Gonad-Somatic Index in *C. gariepinus* with increase in additive level in the diet which agrees with Engdaw and Geremew (2024) on Nile tiliapia embryonic development of fertilized eggs due to essential dietary nutrients which is important. The Gonad-Somatic Index increase as the inclusion level of *C. esculentus* inclusion in the feed increased and agrees to result obtained by Dada and Adeparusi (2012). There is a strong association between egg quality, GSI, and the essential fatty acid content of a diet (Engdaw and Geremew, 2024). Tiger nut inclusion in the feed showed an influence on the Gonad-somatic Index obtained as reported by Ofem *et al.*, (2023) that Gonad-somatic index value relates or influenced the amount and type of food consumed. This may be due to the present of steroid in *C.esculentus* use as additive in the fish feed. The phyto-chemical screening of *C. esculentus* seeds reveals presence of active constituent of flavonoid, tannins and steroids which may have positive influence of on reproductive indices of *C. gariepinus* broodstock (Dada *et al*., 2019). Similarly Bello, (2023), Elkanem (2024) reported positive effect of nutrition on Gonad-somatic- index of *Clarias gariepinus* fed with *Azanza garckeana* pulp meal. This agrees with Ekenem *et al.*, (2024) the results of the present study indicating that *C. gariepinus* responded positively to brood stock nutritional diets, as was seen in their reproductive performance.

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8.0 Conclusion

Studies showed tiger nut is a good plant-based ingredient for aquaculture which its rich nutrients and elemental composition can be used by farmers by fish for good health and fast growth. The quantitative estimation also revealed the present of some active phytochemical constituent. *Cyprus esculentus* content the presence of steroid, Saponins, Phyates and Alkaloids which were recorded in good amount during the research. Also, during the research, the following Phytochemicals Phenols, Oxalate, Tannins, and Flavonoids were observed in *Cyprus esculentu.* The use of *Cyprus esculentus* as inclusion in feed improved the reproductive performance of African catfish brood stock which will yield an improved result in terms of production. The composition of the nutrient in the tiger nut makes it suitable to be used in fish feed. *Cyprus esculentus* in fish feed showed that the good results in terms of the reproductive indices for both male and female African mud cat fish. *Cyprus esculentus* has promising effect on the growth and pro-fertility properties that can be exploited in aquaculture to increase the production of fish.

Table 1 Proximate composition of nuts of some varieties of *C. esculentus*

	Tiger nut varieties and Composition (**indicate unit here mg)**		
Composition	Yellow	Brown	Black
Protein	4.3	4.8	4.4
Fat	18.4	23.2	23.4
Ash	7.55	7.85	7.06
Carbohydrate	59.4	65.4	64.7
Crude fibre	7.3	10.1	8.6

Source: Tusayi *et al.* (2021).

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Table 2. Qualitative and Quantitative Phytochemical Analysis of *Cyprus esculentus* Nuts

Parameter	Quality	Quantity (mg/100g)
Steroids	+++	526
Saponins	+++	350.15
Tannins	+	13.81
Phenols	++	33.17
Phytates	+	106.5
Oxalate	+	29.45
Alkaloids	+	41.73
Flavonoids	+	0.39

Source: Tusayi, 2023. Key: +++= highly present, ++= moderately present, += low present

Table 3

Mean (± SEM) Milt Quality Of Male *Clarias gariepinus* Broodstock Fed TNM-Base diet.

Parameter	0	5	10	15	20
Weight of Right lobe (g)	1.41 ± 0.03^{b}	1.02 ± 0.06^{b}	1.41 ± 0.08^{b}	2.43 ± 0.05^{a}	2.77 ± 0.02^{a}

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Weight of Left lobe (g)	1.11±0.42^{b}	1.30±0.08^{b}	1.23±0.03^{b}	1.74±0.10^{a}	1.90±0.07^{a}
Length of Right lobe (cm)	2.1±0.11^{b}	3.6±0.04^{b}	5.4±1.03^{a}	5.8±0.33^{a}	5.5±0.21^{a}
Length of Left lobe (cm)	3.8±0.13^{b}	3.6±0.21^{b}	4.4±0.11^{ab}	4.6±0.03^{ab}	5.8±0.63^{a}
Milt volume(ml)	2.4±0.32^{b}	3.2±0.18^{ab}	3.3±0.13^{ab}	3.4±0.14^{ab}	4.3±0.31^{a}
Sperm count(x10^{6}/ml)	108±6.13^{b}	340±10.43^{ab}	341±0.13^{ab}	364±15.13^{ab}	411±10.03^{a}
Sperm motility (%)					
Active	20	30	40	40	50
Sluggish	30	20	20	20	20
Dead	50	50	50	40	30
(TMS)	50^{b}	50^{b}	60^{ab}	60^{ab}	70^{a}

Source. Tusayi, (2023) Means having same superscripts are not significantly different ($p<0.05$)

Key: TMS-Total Motile Sperm..

Table 4. Mean (±SEM) fertilization and hatching rates of *Clarias gariepinus* Broodstock Fed TNM-Base diet.

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Parameters	0	5	10	15	20
Wt of eggs (g)	91.00±05.22^{b}	106.91±12.00^{ab}	112.80±18.08^{a}	84.90±21.01^{b}	125.71±18.10^{a}
Num of eggs in 1g	458±21.10^{a}	420±19.02^{a}	398±29.04^{b}	437±14.06^{a}	400±10.08^{b}
Tol. num of eggs	41,678±33.02^{ab}	44,902±20.00^{ab}	44,984±9.92^{ab}	32,101±8.64^{b}	50,284±12.52^{a}
Egg diam.(mm)	1.00±0.01^{a}	0.80±0.02^{a}	0.80±0.01^{a}	1.0±0.0^{a}	1.0±0.01^{a}
Fecudity	2122±30.07^{b}	3513±11.0^{a}	3485±27.11^{a}	3426±25.00 ^{a}	3830±24.08^{a}
Fertilized %	76.02±2.11^{b}	76.00±4.03^{b}	92.06±2.10^{a}	82.02±7.01^{ab}	94.00±9.01^{a}
Hatched %	68.48±10.11^{b}	68.42±03.22^{b}	91.30±2.11^{a}	78.04±4.05^{b}	93.61±8.24^{a}
GSI (%)	11.50±0.61^{b}	12.88±0.21^{b}	14.85±5.21^{a}	13.70±4.22^{ab}	15.71±1.02^{a}

Source. Tusayi, 2023. Means in some rows having different superscripts are significantly different ($p<0.05$)

Key; T1=0.0, T2=5, T3=10.0, T4=20, T5=20GSI= Gonadosomatic index

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