بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Animal Production Science & Technology

Effect of Replacing Fishmeal with Baobab seed meal (*Adansona digitata*) on Growth, Feed Conversion and Carcass Chemical Composition for Nile Tilapia fry(*Oreochromis niloticus*)

أثر إحلال مسحوق السمك بمسحوق بذور التبلدي على نمو ومعدل التحول الغذائي و التركيب الكيميائي لسمكة البلطي النيلي

A dissertationSubmitted to the College of Animal Production Science & Technologyin Partial Fulfillment of the Requirements for the Degree of

Bachelor of Science in Fisheries & Wildlife Science (B.Sc. Hon.)

By

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Supervisor

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October, 2018

ا لايــة

بسم الله الرحمن الرحيم

قال تعالي:

(وهو الذي سخر البحر لتأكلوا منه لحما طريا وتستخرجوا منه حلية تلبسونها وتري الفلك مواخرة فيه ولتبتغوا من فضله ولعلكم تشكرون**)**

صدق الله العظيم

سورة النحل الأية (14)

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DISSERTATION

Submitted in Partial Fulfillment of the Requirements for the Bachelor Degree (B.Sc. Hon.) in Fisheries and Wildlife Science, which was approved by the Team of Examination on the date mentioned below
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DECLARATION OF THE STATUS OF THESIS

BY STUDENTS

The work described in this graduation projectthesis was carried out in the Fish Hatchery in the Department of Fisheries & Wildlife Science at the College of Animal Production Science & Technology, Sudan University of Science & Technology from June 2018 to September2018 under the supervision of Dr. Ramzy Ahmed Yousif.

The experimental work is original and the thesis has not been submitted partially or fully to any other University.

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October, 2018

DECLARATION OF THE STATUS OF THESIS

BY SUPERVISOR

The work described this graduation project dissertation was carried out in the fish hatchery in the Department of Fisheries & Wildlife Science at the College of Animal Production Science & Technology, Sudan University of Science & Technology from June2018 to September 2018 under my supervision.

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Dr. RAMZY AHMED YOUSIF

Supervisor

October, 2018

DEDICATION

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To our fathers

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To our kind unfailing support mothers

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To our brothers

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For those who were in our heart and are still there

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Thank you for your support

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First of all, thanks to Allah to whom would be ascribed all perfection and majesty, and praise to Almighty Allah again for giving us the strength and stamina to finish this work. We would like to express our grateful thanks to our supervisor Dr. Ramzy Ahmed Yousiffor his keen supervision and unlimited help.

Thanks and gratitude are further extended to all the staff of the Department of Fisheries & Wildlife Science.

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ABSTRACT

The experiment was conducted at the Fish Hatchery of Department of Fisheries Science and Wildlife , College of Animal Production Science and Technology , Sudan University of Science and Technology during the period 15/7-2/9/2018 to determine the effect of replacing fishmeal with baobab seed meal in the formulation of diets for Nile Tilapia(*O. niloticus*) fish and determining effect on the growth rate,to investigate the effect of baobab seed meal on water quality. The experiment was include 12 plastic aquariums, Fish were distributed randomly in aquariums and placed in each one 10 fish. Acclimatized to the hatchery conditions for 3 days. Before the beginning of the experiment. The experiment included 4 treatments with 3 replicated aquariums for each. Feeds T0,T1,T2 and T3 (The diets replacing 0, 25, 50 and 75% of fish meal protein content by baobab seed meal. Results indicated that final body weight (BW), weight gain (WG) and specific growth rate (SGR) of *O. niloticus* increased with increasing level of fish baobab seed meal in diets. WG was found 20.10, 28.23 and 37.90 for T1, T2 and T3 respectively. Results indicated no effect to baobab seed meal use in water quality. The data were analyzed by one-way analysis of variance (ANOVA, F test) and LSD for significantly different means at a significance level of 0.05 using SPSS version 16.

Keywords: Fishmeal, Baobab (*Adansonia digitata*), Nutrient Requirements, Environmental Requirements, Fish nutrition, Thermometer

ملخص البحث

اجريت التجربة في مفرخ الاسماك التابع لقسم علوم وتكنولوجيا الاسماك والحياة البرية بكليةعلوم وتكنولوجيا الانتاج الحيواني جامعة السودان للعلوم والتكنولوجيا في الفترة من 15/7-2/9/2018 وذلك لمعرفة اثر استبدال مخلفات مسحوق السمك بمسحوق بذور التبلدي في عليقة اسماك البلطي النيلي وتحديد اثره علي معدل نمواسماك البلطلي وايضا دراسة اثره علي جودة الماء .

احتوت التجربة علي12حوض بلاستيكي ,ووضع في كل حوض 10سمكة وقسمت الاسماك بشكل عشوائي في الاحواض البلاستيكية وتمت اقلمتها لمدة ثلاث ايام قبل بدء التجربة ، ومن ثم قسمت التجربة الي اربعة معاملات (T0.T1.T2.T3).حيث تمثل T0التجربة الضابطة بلا اضافة ، و T1 التجربة المضاف اليها 25%من مسحوق بذور التبلدي ،وتمثل T2التجربة المضاف اليها 50%من بذورالتبلدي ،وT3تمثل التجربة المضاف اليها 75%من بذور التبلدي .

اظهرت الدراسة ان الوزن المكتسب وجد كالاتي 20.10 بالنسبة للتجربة T3 و28.23بالنسبة للتجربة T2وكانت افضل النتائج في التجربة T1 حيث سجلت اعلي وزن مكتسب 37.90, وكذالك اظهرت التجربة انه لا يوجد اي تاثير علي جودة الماء في استخدام مسحوق بذور التبلدي.

استخدم لتحليل البيانات احصائيا برنامج SPSS واستخدم اختبار ANOVA-FTEST بمستوي معنوية 0.05.

كلمات مفتاحية: مسحوق سمك – التبلدي– المتطلبلت الغذائية– المتطلبات البيئية–*تغذية السمك–مقياس حرارة.*

CHAPTER I

1.INTRODUCTION

Fish and shellfish (including crustaceans and mollusks), are important contributors to the intake of many nutrients worldwide, especially in coastal areas. The nutritional importance of fish was also recognized in 2013 by the COFI sub-committees on aquaculture and trade **(FAO, 2014 & 2015).**

In 2012, world aquaculture production, for all cultivated species combined, was 90.4 million tons (live weight equivalent and 144.4 billion dollars in value). This includes 44.2 million tons of finfish (87.5 billion dollars), 21.6 million tons of shellfish (crustacean and mollusks with 46.7 billion dollars in value) and 23.8 million tons of aquatic algae (mostly seaweeds, 6.4 billion dollars in value). Seaweeds and other algae are harvested for use as food, in cosmetics and fertilizers, and are processed to extract thickening agents used as additives in the food and animal feed industries. Finally 22,400 tons of non-food products are also farmed (with a value of 222.4 million dollars), such as pearls and seashells for ornamental and decorative uses **(FAO, 2014).**

Aquatic animals are produced in an array of farming systems operated as extensive, semi-intensive and/or intensive production practices. Aquaculture is practiced in all aquatic environments; freshwater, brackish water and marine. Systems range from small-scale, backyard-type low technology operations to sophisticated, high technology industrial systems. Since both land and water are becoming scarce for aquaculture, almost worldwide, due to many sectors are competing for these primary resources, sustainable intensification has become the mantra for aquaculture development. The increased production per unit land, water and/or energy has become the formula for economic viability inaquaculture worldwide. This is truly reflected in the increasing trend of modernization and intensification of aquaculture, globally FAO Fisheries and Aquaculture Database **(FAO, 2017).**

Tilapia are the third most important cultured fish group in the world, after carps and salmonids, Tilapia culture is also one of the fastest growing farming activities, with an average annual growth rate of 13.4% during 1970–2002. They are widely cultured in about 100 countries in the tropical and subtropical regions. As a result, the production of farmed tilapia has increased from 383,654 mt in 1990 to 1,505,804 mt in 2002, representing about 6% of total farmed finfish in 2002 **(El-Sayed, 2002).**

It is well known that tilapia can tolerate hypoxic and even anoxic conditions for short periods and are thus better suited than other species to hypereutectic conditions that may exist in static water aquaculture systems **(Chorn*et al.*,2006).** It is also known that fish found both in the tropics and temperate waters have incipient limiting oxygen levels which may occur as in hypoxia. Incipient limiting levels generally average at 73 mmHg (2.29 g/l at 28C for warm water fish and 90 mmg/l at 6.17 mg/l for cold water fish such as the salmonids) fishmeal commercial product mostly made from fish that are not generally use for human. The benefited of fish meal in aquaculture diet the fish meal carries large quantities of energy par unit weight and is an excellent source of protein. lipids, minerals, and vitamins **(JACOBS, 2017),** any complete diet to amino acid composition and digestibility .high quality fish meal normally contains between 60% and 70% crude protein by weight, typical diets from many contain form 32% to 45% total protein by weight, fish meal used in compound feed in poultry feed and formed fish or aquaculture **(CHAPMAN, 2015).**

The baobab seed and pulp were analyzed for proximate composition, mineral content, and amino acid composition. The seed oil and protein were evaluated for their fatty acid profile and protein solubility, the seed was found to be a good source of energy, protein, fat .both the kernel and the pulp contain substantial, quantities of calcium potassium, and magnesium **(Osman, 2004).**

1.2.OBJECTIVES

The present study was designed to achieve the following goals:

1- To determine the effect of replacing fishmeal with Baobab *(Adansonia digitata)*seed meal in the formulation of diets for Nile tilapia (*O.niloticus*)
2- To investigate the effect of Baobab *Adansonia digitata* seed meal on water quality.

CHAPTER II

LITERATURE REVIEW

Fisheries and aquaculture remain important sources of food, nutrition, income and livelihoods for hundreds of millions of people around the world. World per capita fish supply reached a new record high of 20 kg in 2014, Moreover, fish continues to be one of the most-traded food commodities worldwide with more than half of fish exports by value originating in developing countries. Recent reports by high-level experts, international organizations, industry and civil society representatives all highlight the tremendous potential of the oceans and inland waters now, and even more so in the future, to contribute significantly to food security and adequate nutrition for a global population expected to reach 9.7 billion by 2050 **(FAO, 2016).**

Fish and fisheries products make an appreciable contribution to human well-being, food security and poverty alleviation in Asia-Pacific. The more detailed our understanding of consumption patterns, the more effective our management actions will be, potentially to the benefit of millions**(FAO, 2015).**

2.1 Fish nutrition

With the continuing growth of the aquaculture industry, more attention to fish meal fare must be given as it has significant impacts on stress response, health and resistance to diseases, with consequences on the sustainable development of this industry **(Ashley, 2007).** Diets, among other factors, have strong effects on stress tolerance and health, and therefore, for an adequate growth and resistance to stress and disease problems, fish must be fed adequate quantities of diets that meet all their nutrient requirements **(Trichet, 2010).**

Feeding animals with diets that do not meet nutrient requirements not only affects growth and feed efficiency but also increases susceptibility to disease and induces the appearance of deficiency signs, including altered behavior and pathological changes. Unbalanced diets may also induce negative interactions or antagonism among nutrients that provoke signs similar to deficiency of nutrients. At very high levels of nutrient, which are unusual in practical diets, toxicity signs may occur. Several dietary factors, including essential and non-essential nutrients, have also been shown to have specific actions on the immune response when provided at pharmacological doses **(Trichet, 2010).** Therefore, before considering the potential benefits of diet supplementation with any specific nutrient, it is of paramount importance to ensure that are fed adequate amounts of balanced diets that meet all nutrient requirements for the specific physiological stage of development of the species under consideration

Proteins, carbohydrates and lipids are distinct nutrient groups that the body metabolizes to produce the energy it needs for numerous physiological processes and physical activities. There is considerable variation in the ability of fish species to use the energy-yielding nutrients. Fish variation is associated with their natural feeding habits, which are classified as herbivorous, omnivorous or carnivorous. Fish, there is a relationship between natural feeding habits and dietary protein requirements. Herbivorous and omnivorous species require less dietary protein than some carnivorous species **(NRC, 1993).** Carnivorous species are very efficient at using dietary protein and lipid for energy but less efficient at using dietary carbohydrates. The efficient use of protein for energy is largely attributed to the way in which ammonia from delaminated protein is excreted via the gills with limited energy expenditure. Fish foods carnivorous species eat contain little carbohydrate, so they use this nutrient less efficiently. Minerals fish nutrient group consists of inorganic elements the body requires for various purposes. Fish require the same minerals as terrestrial animals for tissue formation, osmoregulation and other metabolic functions **(Lall, 2002).** However, dissolved minerals in the water may satisfy some of the metabolic requirements of fish. Vitamins Fifteen vitamins are essential for terrestrial animals and for several fish species that have been examined to date **(Halver, 2002).** Vitamins are organic compounds required in relatively small concentrations to support specific structural or metabolic functions. Vitamins are divided into two groups based on solubility.

2.1.1 Fishmeal

Feed representing a major part of the operational costs in the fish and crustacean farming, the protein component is the single most important and the most expensive dietary component. Fish meal (FM) is one of the main protein sources in the conventional aquaculture sector due to its high protein content (30-72%), being a good source of essential amino acids (EAA), essential fatty acids (EFA) as well as it is highly digestible and palatable to most fish **(NRC, 1993; El-Sayed&Tacon, 1997; NRC,**

2011). In general the fish diet contents 20-60 % of FM **(Leal *et al*., 2010; Watanabe, 2002)**. In the fishing industry, the fish not used for direct human consumption are processed into FM and fish oil. These two products are widely used in animal feeds not only in the aquaculture but also to livestock animals, chicken and pigs etc. **(FAO, 2014).** Fish meal produced from waste products containing high levels of bone is most likely to have a lower percentage of high-quality protein than the meal from input material without bone or of whole fish. The waste products containing lots of bone usually contains high amounts of ash which may lead to mineral imbalance **(NRC, 1993).**

Explained how animal products, plant protein derivatives and single cell proteins can be possible FM replacers in tilapia feeds, it is important to know whether these alternatives can completely replace FM without compromising production. This subject has been discussed by aquaculture nutritionists, fish biologists and fish farmers albeit with limited consensus. According to **Jackson's (2009)**

2.1.2. Baobab (*Adansonia digitata*)

Scientific classification:

Kingdom: Plantae

(unranked): Angiosperms

(unranked): Eudicots

(unranked): Rosids

Order:Malvaes

Family: Malvaceae

Genus: Adansonia

Species: *A.digitata* **(Grove,2011).**

The baobab is a traditional food plant in Africa, but is little-known elsewhere. The vegetable has been suggested to have the potential to improve nutrition, boost food security, foster rural development, and support sustainable land care. **(NRCNational Research Council, 2006)**.In 2008, the European Union approved the use and consumption of baobab fruit as an ingredient In smoothies and cereal bars **(Advisory Committeeon Navel Foods and Processes, 2008).** The United States Food and Drug Administration granted generally recognized as safe status to baobab dried fruit pulp as a food ingredient **(Lauram. Tarantion, 2009)**.Baobab leaves are sometimes used as forage for ruminants in dry season. The oil meal which is a byproduct of oil extraction can also be used as animal feed**. (Heuzem *et al.*,2013).** In times of drought elephants consume the juicy wood below its bark **(Sheehan, 2004).**

2.2. Nutrient Requirements

2.2.1. Protein

Fish do not have a specific requirement for crude protein (CP), but rather they need a combination of essential amino acids. Therefore, profile of dietary protein is important when formulating diets for tilapia. Dietary proteins are used continuously by fish maintenance, growth, and reproduction functions. When fed in excess, protein may be used as energy; however, the latter function is not desirable because of the expensive cost of proteins. The protein requirement of tilapia decreases with age and size, with higher dietary CP concentrations required for fry (30–56%) and juvenile (30–40%) tilapia but lower protein levels (28–30%) for larger tilapia **(Winfreeand Stickney, 1981; Jauncey, 1982; Al Hafedh, 1999; Siddiqui *et al.*, 1988; Twibell and Brown, 1998)**. As with other warm water fish, tilapia require 10 essential amino acids that need to be supplied by the diet. Essential amino acid requirements can be met by the use of a balance of both plant and animal proteins, and if necessary, by the inclusion of synthetic amino acids in the complete feed.

2.2.2 Lipids

Lipids (fats) are high-energy nutrients that can be utilized to partially spare (substitute for) protein in aquaculture feeds. Lipids have about twice the energy density of proteins and carbohydrates. Lipids typically make up about 7-15 percent of fish diets, supply essential fatty acids, and serve as transporters for fat-soluble vitamins. A recent trend in fish feeds is to use higher levels of lipids in the diet. While increasing dietary lipids can help reduce the high costs of feed by partially sparing protein in the feed, problems such as excessive fat deposition in the liver can decrease fish health, quality, and shelf life of the all product. Simple lipids include fatty acids and triacylglycerols.

Fish typically require fatty acids of the omega-3 and -6 (n-3 and n-6) families. Fatty acids can be (a) saturated fatty acids (no double bonds), (b) polyunsaturated fatty acids (>2 double bonds), or (c) highly unsaturated fatty acids (>4 double bonds). Marine fish and algal oils are naturally high in omega-3 highly unsaturated fatty acids (>30 percent) and are excellent sources of lipids for the manufacture of fish diets. Lipids from these sources can be deposited into fish muscle. People who then consume these lets could enjoy the health benefit of consuming foods rich in omega-3 fatty acids, such as reduced symptoms of depression and improved cardiovascular health **(Steven Craig**, **2017)**

2.2.3 Carbohydrates

Carbohydrates are a cheap source of energy for the fish and are used to provide energy in place of more expensive proteins. Starch is easily digested by fish and is composed of glucose. Complex carbohydrates such as cellulose can only be digested by bacteria (which live in the fish's gut) so it is important not to supply more than can be digested. Carnivorous species can be fed diets with lower carbohydrate levels compared to herbivorous species. Carbohydrates are also important in the making of artificial diets as they help to bind (glue) the food together. Since carbohydrates are the cheapest part of the diet it is best to use as much carbohydrate as the fish can use and in that way reduce the amount of protein required **(WRC 2010)**

2.2.4 Vitamins&Minerals

Vitamins are complex compounds required for things such as energy production, blood coagulate and cell repair. Vitamins occur in trace (very small) amounts in most natural foods; however, because the fish cannot make them themselves, they must be provided in the feed. Low levels of vitamins (vitamin deficiency) results in poor growth. These dietary ingredients (particularly calcium, phosphorus, magnesium, sodium, potassium and chlorine) are required for the formation of many parts of the fish. Fishmeal is considered an adequate source of necessary minerals; however, additional amounts may be added to the diet to maximize fish growth, survival and health**(WRC 2010)**

2.3. Environmental Requirements

Water quality parameters (such as water temperature, pH, dissolved oxygen, nitrite and ammonia) are factors effecting the growth and health of the animals in aquaculture practice **(El-Sayed, 2006).**

2.3.1 Temperature

Temperature is the hotness or coldness of something and is probably the most important water-quality variable. Unlike mammals, fish are not able to regulate their own body temperature and therefore have a body temperature similar to that of the water around them. Therefore, all fish have a minimum and maximum lethal temperature limit. Temperature effects growth rate and feed conversion rate, with each species having an optimal temperature for growth. Temperature also effects the metabolism and reproductive ability of fish, optimal temperature range20–35˚C**(WRC 2010)**

2.3.2 pH

The degree to which water is acid or alkaline is described by the pH scale, which ranges from 0-14. Acid substances have a pH from 0-7; 7 is neutral (neither acidic nor alkaline), and alkaline is between7-14. A change in one pH unit represents a large change in water quality and fish generally prefer water that is neither too acidic or alkaline and should be maintained within one unit from neutral (pH 6-8)**(WRC 2010)**

2.3.3 Dissolved Oxygen

Aquatic organisms need dissolved oxygen to breath and prevent the mortality. Fish required oxygen for respiration. The amount of oxygen required by fish is depends on the metabolic rate of the fish, where small fish consumed more oxygen than the larger fish. In freshwater system, normally the level of dissolved oxygen is around 6 ppm at 250C environment temperature **(Musa*et al.*, 2008).** Every single species of fish required different level of dissolved oxygen. For example, carps required 6 -7 ppm of dissolved oxygen in its medium culture **(Yadav, 2006).** To obtained good growth and production of fish culture, the optimum level of dissolved oxygen in culture system must be maintained at least at 5 ppm.

2.3.4 Ammonia

Ammonia (NH_3) Ammonia exists in two forms in the tank environment, un-ionized NH3 (highly toxic) and ionized NH^{4+}(less toxic). Avoid concentrations of un-ionized ammonia greater than 1.0 mg/L. Consult other sources to understand the relationship between pH and the toxicity of Total Ammonia Nitrogen (TAN), un-ionized ammonia and ionized ammonia**. (Dennis et al 2009)**

2.3.5 Nitrate and Nitrite

Nitrate or NO_3^-:Nitrate toxicity can occur if levels in water reuse systems exceed the 300 to 400 mg/L nitrate-nitrogen range. Normal water exchanges during filter backwashing or solids removal generally control nitrate concentrations. Water exchange or a denitrification process may be required**. (Dennis et al 2009)**

Nitrite, or NO_2^-: Avoid concentrations greater than 5 mg/L nitrite-nitrogen if chloride (Cl^-) is low (less than 10 mg/L). Add rock salt to maintain chloride concentration of 150 to 200 mg/L under normal operating conditions, and increase chloride concentration when nitrite is elevated. The chloride ion alleviates nitrite toxicity and can be added as sodium chloride (NaCl) or calcium chloride ($CaCl_2$)**(Dennis et al 2009)**

CHAPTER III

MATERIALS AND METHODS

3.1 Study Area

The experiment present study was carried in fish hatchery at Department of Fisheries & Wildlife, College of Animal Production Science and Technology, Sudan University of Science and Technology.

3.2 Materials:

1. Sieve
2. Basin
3. Big plate
4. Chopper
5. Sensitive balance
6. Mill
7. Small net
8. Crucible
9. Air pump
10. 12 Plastic aquaria
11. Heater
12. Thermometer

3.3. Experimental design and conditions:

One hundred and Twenty Nile tilapia frying (average weight 0.25 gm.) Fry of *Oreochromis niloticus* were procured from Hussien Fadoul Fish Farm, Soba-Khartoum, Sudan. These were transported to hatchery of the Department of fisheries and Wildlife Science, Sudan University of Science& Technology, Khartoum, Sudan.Fish were distributed in flow through system of 12 plastic aquaria acclimatized to the hatchery conditions for 3 days. Before the beginning of the experiment, weak and abnormal fish were excluded and the remaining fish redistributed on aquariums at 10 Frying/aquarium. The experiment included four treatments with three replicated aquariums for each. Feeds T0, T1, T2 and T3 (The diets replacing 0, 25, 50 and 75% of fish meal protein content by baobab seed meal.

The fish were fed by degree of satiation two times a day. The siphoning of the water daily in aquaria by small water spout-wast and feed and the time of feeding in the day time 9:00 a.m and 4:00 p.m. in some days according of weather condition and climate particularythe temperature.

Fish were weighed and measured every seven days and feed ration was adjusted accordingly(including water quality and fish body weight in any aquaria).

Table (1): Formulation and composition of the experimental diets:

Ingredients(g/ 100 g dry diet)	Control	T1	T2	T3
Fish meal[1]	40.00	30.00	20.00	10.00
Tabaldi[2]	0.00	10.00	20.00	30.00
Groundnut Cake[3]	20.00	20.00	20.00	20.00
Cottonseed Meal[4]	3.00	3.00	3.00	3.00
Wheat flour[5]	20.00	20.00	20.00	20.00
Wheat bran[6]	11.00	11.00	11.00	11.00
Vig-Oil	3.00	3.00	3.00	3.00
Mineral premix[7]	1.50	1.50	1.50	1.50
Vitamin premix[8]	1.50	1.50	1.50	1.50
Total	**100.00**	**100.00**	**100.00**	**100.00**
Protein (%)	32.0±0.3	29.6±0.0	28.2±0.2	25.8±0.05
Fat (%)	12.87±0.3	16.83±1.5	14.56±2.1	14.71±2.3
Ash (%)	6.99±0.19	7.62±0.19	7.34±0.44	6.82±0.09
Moisture (%)	42.33±0.8	31.87±0.5	30.87±0.6	27.89±0.3
Calculated gross energy (kJ g^{-1}, dry diet)	15.22	15.07	14.91	14.76

[1]Fishmeal 45% CP; [2]baobab17%; [3]Groundnut Cake43.7% CP; [4]Cottonseed Meal 38%; [5]Wheat Middling 17% CP and [6]Wheat bran 13.7%.[7]Mineral mixture (g/100g dry diet) calcium biphosphate 13.57; calcium lactate 32.69; ferric citrate 02.97; magnesium sulphate 13.20; potassium phosphate (dibasic) 23.98; sodium biphosphate 08.72; sodium chloride 04.35; almunium chloride.$6H_2O$ 0.0154; potassium iodide 0.015; cuprous chloride 0.010; mangnous sulphate H_20 0.080; cobalt chloride. $6H_2O$ 0.100; zinc sulphate. $7H_2O$ 0.40 (Halver, 2002). [8]Vitamin mixture (g/100 dry diet) choline chloride 0.500;inositol 0.200; ascorbic acid 0.100; niacin 0.075; calcium pantothenate 0.05; riboflavin 0.02; menadione 0.004; pyridoxine hydrochloride 0.005; thiamin hydrochloride 0.005; folic acid 0.0015; biotin 0.0005; alpha-tocopherol 0.04; vitamin B_{12} 0.00001; LobaChemie, India (Halver, 2002).

3.4. Water quality measurement:

Temperature, pH, dissolved oxygen (DO) and ammonia were estimated by aqua sol kits during the experimental period according to APHA (1995). Physico-water as follows

3.4.1. pH:

A clean test tube was filled with 5 ml of water to be tested (to the line on the tube).Five drops of high range pH Test solution were added, holding dropper bottle upside down in a completely vertical position to assure uniformity of drops. The test tube was caped and inverted tube several times to mix solution.

The test result was readied by comparing the color of the solution to the appropriate High Range pH Color Card (freshwater). The tube was viewed in a well- lit area against the white area of the card. The closest match indicators the pH of water sample.

3.4.2 Dissolved Oxygen:

1.D.O. Fixing: the dissolved Oxygen requires to be fixed before testing.

The **D.O**. test bottle was rinsed 2–3 times with sample water .and filled till it overflows with the sample water then stoppered the bottle and ensure that no air bubbles were trapped inside. Ten drops of **D.O.1**were added and were followed by 10 drops of **D.O.2**. And mixed well. Waited for a minute. A brown precipitate was formed and setted. The bottle was firmly stoppered and shacked thoroughly. The bottle was kept in a safe place for a minimum 20 minutes. Ten to twelve drops of **D.O.3**were added. And the bottle was shacked till the precipitate dissolved. More drops were added if required to dissolve the precipitate. Sample was used for tested.

Proceed for D.O. determination as described in **Π**

Π.D.O. determination:

Ten ml. of sample (from step 3 of **D.O**. fixing) in the test jar was taken. Four drops of D.O.4were added .and mixed well.**D.O.5**was added, counted the number of drops while mixing, until the blue color disappears.

Calculation:

Dissolved Oxygen ppm = 0.65 × [No. of drops of **D.O.5**]

3.4.3. Total ammonia (NH_3/NH_4):

A clean tube was filled with 5 ml of water to be tested (to the line tube).Eight drops from Ammonia Test Solution Bottle #1were added, holding the dropper bottle upside down in a completely vertical position to assure uniform drops. Eight drops from Ammonia Test Solution Bottle #2were added, holding the bottle upside down in a completely vertical position to assure uniform drops. The test tube was caped and shacked vigorously for 5 seconds.

Five minutes were waited for the color to develop. The test result was readied by compared the color of the solution to the appropriate ammonia Color Card (the fresh water color card was used). The tube was viewed in a well – lit area against the white area of card. The closest match indicates the ppm (mg/l) of ammonia in the water sample.

3.5 Growth and feed utilization:

Initial body weight (IBW), final body weight (FBW), specific growth rate (SGR), feed intake (FI), feed conversion ratio (FCR), survival rate, protein efficiency ratio (PER), protein productive value (PPV) and energy retention (ER) were measured using the following equations:

Weight gain (g) = final weight – initial weight;

Weight gain % = 100 x weight gain / initial weight;

Specific growth rate (SGR; %/day) =100 (Ln final weight – Ln initial weight) / days;

Feed intake (g fish/day) = $\frac{total\ feed\ intake\ per\ fish}{number\ of\ days}$

Feed conversion ratio (FCR) = feed intake (g) / weight gain (g);

Survivor Rate % = $\frac{initial\ number\ of\ fish\ stocked\ - mortality}{number\ of\ days} \times 100$

3.6.1 Moisture Content Determination:

The samples were first weight (Initial weight) then dried in an electric oven at 1050C for 24-30 hours to obtain a constant weight. The moisture content was calculated as follows:-

Moisture content (%) = $\frac{\text{Initial weight} - \text{Dry weight} \times 100}{\text{Initial weight}}$

3.6.2 Crude Protein Determination:

The Kjeldal method for estimation of nitrogen was applied. Nitrogen content was converted to protein percentage by multiplying by 6.25 as follows:

$$\textbf{Protein \%} = \frac{(Va - Vb) \times N \times 14 \times 6.25}{1000 \times Wt} \times 100$$

Whereas:

Va = volume of HCL used in titration
Vb = volume of sodium hydroxide of known normality used in back titration
14 = conversion factor of ammonium sulfate to nitrogen
6.25= conversion factor of nitrogen to protein
Wt= weight of sample
N= normality of NaoH

3.6.3 Crude Fat Determination:

Fat content of each sample was determined according to Soxhlet method by ether extract using 2 gm of fish samples. Extraction continued for 5 hours at 100^0C before finding the weight of the extract fat. Fat percentage was then calculated as follows:

$$\textbf{Fat \%} = \frac{\text{Extracted fat weight} \times 100}{\text{Sample weight}}$$

3.6.4. Ash Content Determination:

Ash was determined by heating 1 gm at 5500C in muffle furnace until a constant weight was obtained. Ash content percentage was given by the following formula:

$$\textbf{Ash \%} = \frac{\text{Ash weight} \times 100}{\text{Sample weight}}$$

3.7. Statistical analysis

The data were analyzed by one-way analysis of variance (ANOVA, F test) and LSD for significantly different means at a significance level of 0.05 using SPSS version 16.

CHAPTER IV

RESULTS

Table 2: Comparment of weekly weight of all treatments for seven weeks (g/fish)

Treatment	Control	T1	T2	T3	Sig
Initial weight(g/fish)	2.50±0.10	2.50±0.10	2.50±0.20	2.40±0.34	NS
W1	5.93±0.55^{a}	4.96±0.64^{b}	4.36±0.23^{b}	3.84±0.28^{b}	*
W2	8.43±0.45^{a}	7.33±1.42^{b}	6.53±0.90^{c}	5.50±0.70^{c}	*
W3	13.33±0.49^{a}	11.46±1.61^{b}	8.53±0.40^{c}	7.20±1.12^{c}	**
W4	17.20±1.41^{a}	16.76±2.70^{b}	11.93±1.02^{c}	9.80±1.70^{c}	*
W5	23.53±1.79^{a}	22.93±3.93^{b}	17.43±1.58^{c}	13.66±2.12^{c}	*
W6	31.26±3.49^{a}	33.70±7.01^{a}	24.90±2.40^{b}	18.36±3.09^{b}	*
W7	36.83±7.29^{b}	40.40±6.51^{a}	30.73±2.36^{c}	22.50±3.93^{d}	*

*The mean difference is significant at the 0.05 level

Table (3): Growth performances of different treatments fed with feed contain difference level of Tebaldi seed meal:

Treatments **Parameters**	Control	**T1**	**T2**	**T3**	SIG
IW(g/fish)	2.50±0.10	2.50±0.10	2.50±0.20	2.50±0.34	NS
FW(g/fish)	36.83±7.29^{b}	40.40±6.51^{a}	30.73±2.36^{c}	30.73±2.36^{c}	*
WG (g)	34.33±7.25^{b}	37.90±6.60^{a}	28.23±2.20^{c}	20.10±3.59^{d}	*
FCR	2.97±0.67^{b}	2.67±0.51^{a}	3.52±0.28^{c}	5.02±0.82^{d}	*
SGR	5.95±0.43^{b}	6.16±0.85^{a}	5.49±0.20^{b}	4.97±0.09^{c}	*
PER	0.33±0.07^{ab}	0.39±0.07^{a}	0.32±0.03^{ab}	0.26±0.04^{b}	*
LWG (%)	1.73±271.16^{b}	1.52±310.34^{a}	1.25±383.13^{c}	8.35±35.58^{d}	*
Survivor rate	93%	100%	93%	90%	*

$^{a.b.c.d}$ Means in the same row with superscript are significant different at level (p<0.05).

Parameters for growth performance and survival rate of Nile tilapia are presented in table 2. Growth performance it had differ (P>0.05) between tilapia fed with the control diet and the diet with (BSM) in terms of final weight, Highly weight gain (WG T_1 37.90) low weight gain (WG T_3 20.10), Highly specific growth rate (SGR T1

6.16) low specific growth rate (SGR T3 4.97), diets had significant highly (P<0.05) Highly final weight(WG T_1 40.40)and low final weight(WG $T_{2.}T_3$ 30.73), weight gain, specific growth rate compared to the control diet. The values of feed conversion ratio high (FCR $T_1$2.67) and low(FCR T_3 5.02) showed had significant difference (P>0.05) between the dietary treatment fed to the fish, also had significant difference (P>0.05) between the dietary treatment fed to the fish in protein efficiency ratio(PER)and life weight gain(LWG).

Table (4) Hydro chemical parameters of water quality of different treatments

Treatments / **Parameters**	Control	**T1**	**T2**	**T3**	SIG
Temperature	27.0±1.63	27.0±1.63	27.0±1.63	27.0±1.63	NS
pH	8.11±0.10	8.07±0.09	8.10±0.10	8.15±0.07	NS
NO_2	30.0±14.14	30.0±14.14	30.0±14.14	30.0±14.14	NS
NO_3	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	NS
DO	5.55± 2.29	4.06±0.33	5.09±1.63	5.42±1.90	NS
NH_3/NH_4	0.22±0.19	0.22±0.19	0.22±0.19	0.22±0.19	NS

NS: no significant differences

The results from the water quality monitoring are presented in table (4). The parameters d, pH, and nitrite were measured bi-weekly throughout the experiment. The water temperature was recorded every week, showing no vital difference in temperature between weeks or tanks, after the initial period the water temperature were only measured once a week only. The water parameters did not reflect any differences among the treatments, also no significant differences in nitrite, nitrate and pH during the experimental period.

Table (5). Carcass Chemical Composition of *Oreochromis niloticus* fed with different level of Babab Seed Meal

	Experimental diets			
	Control	**T_1**	**T_2**	**T_3**
DM%	25.72±0.31	26.49±0.40	26.18±0.20	26.81±0.30
Fat%	6.41±0.42	9.33±0.75	14.81±0.34	6.90±0.90
CP%	70.0±0.23	69.65±0.50	55.13±0.50	62.20±0.80
Ash	5.926±0.45	5.71±0.20	7.69±0.57	3.70±0.17

Means in the same row with different superscripts are significantly (P<0.05) different.

From the above table the highly dry mater in(T_2 26.81) and low dry mater in treatment (T_0 25.72). Highly crude protein in treatment (T_0 70) and low crude protein in treatment (T_3 55.13) highly fat in treatment(T_3 14.81)and low fat in treatment(T_0 6.41). Highly ash in treatment(T_3 7.69), and low ash in treatment(T_2 3.70).

Table (6): Amino acid Profile of the diets

	Control	**T1**	**T2**	**T3**
Arginine, %	2.43	3.16	3.35	3.8
Histidine, %	2.22	1.27	1.31	1.36
Isoleucine %	0.78	1.36	1.74	1.86
Leucine %	2.52	2.81	3.13	3.45
Lysine %	17.74	2.53	2.6	2.68
Methionine %	0.78	1.73	0.68	0.64
Cystine %	0.38	1.48	0.58	0.69
Phenylalnine %	9.44	2.59	1.77	1.96
Tyrosine %	1.05	2.03	1.00	0.92
Threonine %	1.43	1.58	1.73	1.79
Tryptophan %	2.42	0.31	0.25	0.74
Valine %	0.88	7.5	2.5	1.23

CHAPTER V

DISCUSSION

Selection of feed ingredients is one of the most important factors for the formulation and commercial production of supplemental quality feed for any aquatic species **(Zamal *et al.*, 2008;Koumi *et al.*, 2009).**

These differences might be due to different environmental conditions such as soil type, local varieties, and processing methods. All the experimental feeds were actively fed upon and accepted by the Animal throughout the experimental period which could be as a result of palatability of the feed indicating that the levels of incorporation of baobab did not affect the palatability of the diets. Beside this, the availability of fish meal is decreasing day by day due to its high demand in other than aquaculture industry like livestock, poultry etc. The decreased supply of fish meal in future will dramatically affect the fish production. Considering this, it is essential to partially reduce or eliminate fish meal in fish diet. One approach to reduce fish meal from fish diets is to replace it with alternative less expensive and easily available plant protein, which will allow for continued expansion of aquaculture. In view of this, a number of plant protein source has been evaluated for the replacement of fishmeal **(Alceste and Jory, 2000; Yue and Zhou, 2008; Francis *et al.*,2001).**

The result of feeding graded levels of baobab seed meal(0, 25, 50, 75%) on the performance of Nile tilapia (*O.niloticus*) are presented in table (3).The results showed that there were significant differences in the total feed intake, this finding was agreed with those of **(abdala *et al.*, 2017*),*** they found that there were significant differences in the total feed intake of broiler chicks. Chimvuramahwe., *et al*.,(2011) found results conflating with this result they noticed the inclusion of baobab seeds meal on broiler reduced the broiler chicks performance.

The total weight gain (g), final body weight (g), and feed conversion ratio (g feed/g gain),protein efficiency ratio (g weight gain/g protein intake) and specific growth rate (SGR) were significantly ($p<0.05$) effected by the inclusion of baobab seed meal, its improved by feeding of the baobab seed meal, so that the best results were obtained by fish fed 10% baobab seed meal followed by those fed the other tested diets. This results were agreed with those of **(abdala *et al.*, 2017).**They reported the birds fed graded levels of baobab seed meal were recorded significant improvement in weight gain, final body weight and feed conversation ratio. These results were agents those of (**Chimvuramahwe *et al.*, 2011)** whose reported that the inclusion of baobab seeds meal on broiler reduced the broiler chicks performance.

The results showed that there were significant differences in crude protein content between tested groups were the control recorded highest protein content. The fat content was significantly affected by inclusion of baobab seeds mail were T2 recorded high fat content flowed by T1. The results showed there were significant differences Ash content were T2 recorded high ash content flowed by T1. The results showed there were no significant differences in dry mater content.

CONCLUSION AND RECOMMENDATION

Conclusion:

Fish fed different level of baobab seed meal exhibited numerically good growth performance and better feed utilization efficiency moreover, diets with baobab seed meal were comparable to the positive control diet, as these were found to be efficiently utilized be *O.niloticus* fry as well .therefore, baobab seed meal may pose as a potential candidate ingredient for fish meal replacement in *O.niloticus* feeds.

Recommendations:

For further study, it is recommended that:

1. Conduction more experiment on baobab seed meal diets to confirm this result

2. Use baobab seed meal method utilize remnants of fish

3. Use baobab seed meal included as a substitute fish meal

REFERENCES

abdala Ayuob Mohammad, Ibrahim Ekram Adam, Abdelazez Rayan Ahmed. Adam Rayan Khalil, Abdala Tawdod Hamad (2017). Effect of feeding graded levels of baobab seed (*Adansonia digitata*) on the productive proilte finisher performance.

Advisory Committee on Novel Foods and Processes(2008). Archived from the original on 2008-06-03.

Al Hafedh, Y. S. (1999). Effects of dietary protein on growth and body composition of Nile tilapia, *Oreochromis niloticus* L. Aquaculture Research. 30: 385–393.

Alceste CC, Jory DE. (2000). Tilapia- Alternative protein sources in tilapia feed formulation. Aquaculture Magazine, 2000; 26(4):199-1388

Ashley P.J. (2007). Fish welfare: current issues in aquaculture. Applied Animal Behaviour Science 104, 199–235.

Chimvuramahwe, 1J.P Musara, 1L. Mujuru, 1C.T. Gadzirayi, 1I.W. Nyakudya, , 1L. Jimu , 1C.A.T. Katsvanga, J.F Mupangwa and R. Chivheya (2011). Effect of feeding graded levels of Adansonia digitata(baobab) seed cake on the performance of broilers Vol. 11, Issue 3: 1442-1449. Journal of Animal & Plant Sciences

Chorn E. Lim.(2006). Feeding Practices. The Hawthorn Press.547-559.

Chpman,F.A.&Miles(2105).fisheries and aquatic sciences department. UF/IFAS extension. Orginal publication date November 2005.Revewed January, 2015.

Dennis P. DeLong,1 Thomas M. Losordo1 and James E. Rakocy2(2009). Tank Culture of Tilapia southern regional aquaculture center.

El-Sayed A.F.M. &Tacon A.G.J., (1997). Fish meal replacer for tilapia: A review. *In* Tacon, A.G.J. (ed.) Basurco B. (eds.) Feeding tomorrow´s fish. Zaragoza: CIHEAM, 1997. Page: 205-224 (Cahiers Options Méditerranéennes, 22).

El-Sayed A.M (2002). Effects of Stocking Density and Feeding Levels on Growth and Feed Efficiency of Nile Tilapia (*Oreochromis niloticus)* Fry. Aqua Res 32:621-625.

El-Sayed, A.F.M., (2006). Tilapia culture. Edited by CABI Publishing, Cambridge, USA.

FAO (2014)b. The state of world fisheries and aquaculture, Opportunities and challenges. Food and aquaculture organization of the United Nations, Rome 2014. http://www.fao.org/3/a-i3720e.pdf (Online: 2016-01-21)

FAO. (2015). FAO's blue growth initiative and aquaculture (COFI Sub-Committee on Aquaculture.EightSession.Brasilia,Brazil,5_9October2015.COFI:AQ/VIII/2015/7).Retrievedfromhttp://www.fao.org/cofi/30795045b188b4c734e56986ed853cfb66_88.pdf

FAO.(2014)a. Fish trade and human nutrition (COFI Sub-Committee on Fish Trade, 14th Session. Bergen, Norway, 24-28 February 2014. COFI:FT/XIV/2014/4). Retrievedfromhttp://www.fao.org/cofi/29401083ff934c3ccfd8576005d8d0c19b04d6.pdf.

Francis G, Makkar HPS, Becker K. (2001). Anti nutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture. 2001; 199(3-4):197-227.

Grové, Naas. (2011). Redaksionele Commentary Dendron (43): 14.

Halver J.E. (2002). The vitamins. In: Fish Nutrition, 3rd edn (ed. by J.E. Halver& R.W. Hardy), pp. 61–141. Academic Press, San Diego, CA.

Heuzé, mV.; Tran, G.; Bastianelli, D and Archimède, H. (2013). Oil meal, which is a byproduct of oil extraction, can also be used as animal feed. ISBN: 978-1-4082-0423-8 Animal nutrition Seventh Edition.

Jackson, A. (2009). How much fish to produce 1kg of salmon? Fish in Fish Out ratios explained. Aquaculture Europe, 34 (3): 1-10.

Jacobs, Andrew*(*2107). Chines Appeititepushses Fisheries to The Brink.,(the New York Time.

Jauncey, A. (1982). The effect of varying dietary protein level on the growth, food conversion, protein utilization and body composition of juvenile tilapias (*Sarotherodonmossambicus*). Aquaculture. 27: 43–54.

Koumi, A.R., Atse, B.C. and Kouame, L.P., (2009). Utilization of soya protein as an alternative protein source in *Oreochromis niloticus* diet: Growth performance, feed utilization, proximate.

Lall S.P. (2002). The minerals. In: Fish Nutrition, 3rd edn (ed. by J.E. Halver& R. W Hardy), pp. 259–308. Academic Press, San Diego, CA.

Lauran, M; Tarantino, (2009). The United States Food and Drug Administration granted generally recognized "Agency Response Letter GRAS Notice No. GRN 000273".FDA.

Leal, A.L.G., de Castro, P.F., de Lima, J.P.V., de Souza Correia, E. and de Souza Bezerra R., (2010). Use of shrimp protein hydrolysate in Nile tilapia (*Oreochromis niloticus*) feeds. Aquaculture International, 18, page: 635-646.

Najiah, M.,Wendy, W., Ruhil, H., Wei, L.S., Leong, L.K., Noorasikin, H. (2008). BakteriadanIkan.PenerbitanUniversiti Malaysia Terengganu.

National Research Council (2006)."Baobab". Lost Crops of Africa: Volume II: Vegetables. Lost Crops of Africa. 2. National Academies Press. ISBN 978-0-309-10333-6.

NRC (1993)a. Nutrient Requirement of Fish. National Academy Press: Washington, DC, USA.

NRC(2011)b. National Research Council.Nutrient Requirements of Fish and Shrimp.Pages. 392. The National Academies Press, Washington, DC, 2011. Doi: 10.17226/13039. ISBN: 978-0-309-16338-5.

Osman(2004). Chemical and Nutrient Analysis of Baobab (*Adansonia digitata*) Fruit and Seed Protein Solubility Plant Foods for Human Nutrition59: 29–33, 2004. Springer Science+ Business Media, Inc.

Sheehan, Sean (2004). Benchmark Books/Marshall Cavendi Zimbabwe (Vol. 6 of Cultures of the World) (2nd ed.). New York: p. 13. ISBN 9780761417064.

Siddiqui, A. Q., M. S. Howlander, and A. A. Adam. (1988). Effects of dietary protein levels on growth, diet con-version and protein utilization in fry and young Nile tilapia, *Oreochromisniloticus*. Aquaculture. 70: 63–70

Steven Craig(2017). Understanding Fish Nutrition, Feeds, and Feeding. Virginia Cooperative Extension.

Trichet V.V. (2010). Nutrition and immunity: an update. Aquaculture Research 41, 356–372.

Twibell, R. G., and P. B. Brown (1998). Optimal dietary protein concentration for hybrid tilapia (*Oreochromis niloticus* × *Oreochromis aureus*) fed all-plant diets. J. World Aquacult. Soc. 29: 9–16.

Winfree, R. A., and R. R. Stickney (1981). Effects of dietary protein and energy on growth, feed conversion efficiency and body composition of Tilapia aurea. *J. Nutr*. 111: 1001–1012.

WRC (Water Research Commission) (2010). A Manualfor Rural Freshwater AquacultureRural Fisheries Programme Department of Ichthyology and Fisheries Science Rhodes University and Department of Agriculture, Forestry and FisheriesWRC REPORT NO. TT 463/P/10orders@wrc.org.za

Yadav, B.N. 2006. Fish & Fisheries.Daya Publishing House http://www.nanoos.org

Yue YR, Zhou QC. (2008). Effect of replacing soybean meal with cottonseed meal on growth, feed utilization, and hematological indexes for juvenile hybrid tilapia, *Oreochromis niloticus* × *O. aureus*. Aquaculture, 284(1/4): 185–189.

Zamal, H., Barua, P., Uddin, B. and Islam, K.S., (2008). Application of ipil-ipil leaf meal as feed Ingredient for monosex tilapia fry (*Oreochromis niloticus*) in terms of growth and economics. Aquaculture Asia magazine, April-June, 31-33.

FIGURES

Plate of sample weight in weekly

Plate of water quality kids

FIGURES

Plate of sensitive blance

Plate of chemical analyses