Sudan University of Science and Technology
College of Graduate Studies

Factors Affecting Growth Performance of Nile Tilapia (*O. niloticus*) Fingerlings Cultured in Tanks

العوامل المؤثرة على أداء نمو أصبعيات أسماك البلطي النيلى المستزرعة في الأحواض (*O. niloticus*)

By
Mohamed Awad Abd Alla Salih

A Thesis Submitted in Fulfillment for the Requirements for the Degree of Philosophy Doctor (PhD) in Fish Science and Technology

Supervisor
Prof. Tamador-ELKhansaa ELNour Angara
Co-supervisor
Dr. Asaad Hassan M. Wedaa

July 2019

DEDICATION

This thesis is dedicated

To my parents, father "*Awad*" and mother "*Awatif*" for their endless love, support, encouragement and prayers

To my wife, and the kind and companionate human

"*Neamat*"

To my lovely sons, the beautiful things in my life

To the dears always, my brother

"*Mammoun*" and my sisters

To the all kind people in the

Sudan

ACKNOWLEDGEMENTS

First, praise e to *Alla*, who with his grace, good deeds, prayers and peace be upon our profit *Mohamd* peace be upon him.

I express my heartiest gratitude to my supervisor of my PhD thesis prof. *Tamador E. E. Angara*, which began with me this long journey and exceeded all the difficulties and problems that I met until our efforts culminated in success.

I extend a great thanks to Dr. *Ahmed H. EL-Aabed* whom suggest the idea of this research and start with me as a Co-supervisor. Thanks unplugged to Dr. *Asaad H. M. Wedaa* whom continued with me this journey as a second Co-supervisor.

Sincerely and respectfully to the workers of the fish farm and fish hatchery at the collage of Science and Technology of Animal Production and the Lecturer *Abu-Baker* (Sudan University of Science and Technology- Koko camp).

Finally yet importantly best thank and gratitude to the member staff of the *Central Veterinary Research of "Soba"* in Khartoum.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOS

ABSTRACT

This study conducted in the farm and the fish hatchery at Sudan University of Science and Technology, in order to study some biological factors affect the successful of cultivation Nile tilapia (*Oreochromis niloticus*) fingerlings in tanks culture. Plastic tanks used for easy observation and periodic measurements. A trial was conduct to study the growth performance of *O. niloticus* fingerlings under three stocking densities; 10 fish $tank^{-1}$ (SD1), 15 fish $tank^{-1}$ (SD2) and 20 fish $tank^{-1}$ (SD3). The results of the trial with respect to growth performance showed a significant preference ($P< 0.05$) for the medium stocking density (15 fish/tank), while the effect of the stocking densities on survival rate show non-significant difference ($P> 0.05$). A trial was conduct to study the effect of different feed frequencies (FF) on the growth rates of *O. niloticus* fingerlings. The results indicated that, there is no significant difference ($P> 0.05$) due to repeated feeding frequency twice/day (FF1), three times/day (FF2), and four times/day (FF3), with no effect on survival rate by changes daily feeding frequencies. A trial was conduct to study the growth efficiency of *O. niloticus* fingerlings under influence of three feeding ratio; 5% (FR1), 9% (FR2), and 13% (FR3) from body weight. The results of the trial showed that, there is no significant benefit for daily weight gain due to different daily feeding ratios, with a significantly higher ($P< 0.05$) in feeding conversion rate at the daily feeding ratio 5% (FR1) than the rest, while with the survival rates there is no significance influence due to different daily feeding rates. As a result of this experiment done during a period of significant reduction in temperature (November 2015 to January 2016), the three temperature levels which were recorded had a clear relation to the fish daily weight gain during the study period, where for the three trials; different stocking densities, daily feed frequencies and daily feed ratio, the best daily weight gain was recorded with water temperature level "1" (18-20 °C), followed by water temperature level "3" (17-22 °C), and lastly water temperature level "2" (17-16°C), confirming the negative effect of temperature degree outside the optimum range of *O. niloticus* fishes. Concerning water physiochemical parameters study, the result indicate non-significance difference ($P> 0.05$) in DO, temperature, pH, P, No_2, No_3 and ammonia concentrations due to

cultivation *O. niloticus* fingerlings in tanks within different stocking densities trial, different feed frequencies trial and different daily feed rates trial. The study of the proximate chemical analysis of *O. niloticus* fingerlings body showed a significance difference ($P< 0.05$) in crude protein due to different stocking densities and in NFE within different daily feed rates, while for moisture, dry meat, ash and crude fat contents, the study indicate none significance difference ($P> 0.05$) within different stocking densities, different feed frequencies and different feed rates trials.

الخلاصة

تم أجراء هذه الدراسة في المزرعة التجريبية وفقاسة الأسماك بجامعة السودان للعلوم والتكنولوجيا وذلك بهدف دراسة تأثير بعض العوامل ذات الأثر البيولوجي في نجاح عمليات إستزراع أصبعيات البلطي النيلى (*Oreochromis niloticus*) في الأحواض. تم إستعمال أحواض بلاستيكية وذلك لسهولة المراقبة وأجراء القياسات الدورية. تمت تجربة لدراسة كفاءة النمو لأصبعيات أسماك البلطي النيل تحت ثلاث كثافات تخزينية مختلفة: 10 أصبعيات للحوض (SD1)، 15 أصبعية للحوض (SD2) و 20 أصبعية للحوض (SD3)، أظهرت نتائج الدراسة فيما يتعلق بكفاءة النمو أفضلية معنوية ($P< 0.05$) للكثافة التخزينية الوسطى (15 أصبعية للحوض)، بينما دلت دراسة أثر الكثافات التخزينية على نسب البقاء عدم وجود فروقات معنوية ($P> 0.05$). تمت تجربة لدراسة أثر تكرارات التغذية اليومية على معدلات النمو لأصبعيات البلطي النيلى، أوضحت نتائج التجربة عدم وجود أفضلية معنوية ($P> 0.05$) نتيجة لتكرار التغذية مرتين في اليوم (FF1)، ثلاث مرات في اليوم (FF2) وأربعة مرات في اليوم (FF3)، مع عدم تأثر نسب البقاء بتغير تكرارات التغذية اليومية. تمت تجربة لدراسة كفاءة النمو لأصبعيات البلطي النيلى تحت تأثير معدلات تغذية يومية مختلفة وهى 5% (FR1)، 9% (FR2) و13% (FR3) من الوزن الكلى، أشارت نتائج التجربة لعدم وجود أفضلية معنوية للوزن المكتسب اليومي ناتجة من إختلاف نسب التغذية اليومية، مع وجود معدل تحول غذائي أفضل معنويا عند نسبة التغذية اليومية 5% عن بقية معدلات التحول الغذائي لنفس التجربة، مع عدم تأثر نسب البقاء بتغير نسب التغذية اليومية. نتيجة لأجراء هذه الدراسة في فترة إنخفاض كبير لدرجات الحرارة (نوفمبر 2015 حتى يناير2016)، فقد كان للثلاث مديات الحرارة المسجلة علاقة واضحة بمعدلات النمو والوزن المكتسب اليومي أثناء الدراسة، حيث أنه فى كل من تجربة أثر الكثافات التخزينية المختلفة، تكرارات التغذية اليومية ونسبة التغذية اليومية، كان أفضل معدل وزن مكتسب يومى يقابل المدى الحراري "1" (18-20م°) للماء، يليه المدى الحرارى "3" (17-22م°) وبفارق كبير عن المدى الحرارى"2" (16-17م°)، مؤكدا على التأثير السلبى لدرجة الحرارة خارج المدى الحرارى الأمثل لأسماك البلطي النيلى. فيما يتعلق دراسة الخصائص الفيزيوكيميائية للماء، أوضحت التجربة عدم وجود فروقات معنوية ($P> 0.05$) لتراكيز كلا من الأكسجين الذائب، درجات الحرارة، الأس الهيدروجيني، الفوسفور (P)، النتريت (No2)، النترات (No3) والأمونيا (NH_3) نتيجة لأستزراع أصبعيات البلطي النيلى في كثافات تخزينية مختلفة، في تكرارات تغذية يومية مختلفة وفى معدلات تغذية يومية مختلفة. أوضحت دراسة التحليل الكيميائي لمكونات الجسم لأصبعيات البلطي النيلى وجود فروقات معنوية ($P< 0.05$) لقيم البروتين عند الكثافات التخزينية المختلفة و للمستخلص الحر

للنتروجين (NFE) عند معدلات تغذية يومية مختلفة ، بينما لمحتوى الجسم من الرطوبة، المادة الجافة، الرماد والدهون فلم تظهر فروقات معنوية (P> 0.05) ناتجة من إختلاف الكثافات التخزينية، إختلاف تكرارات التغذية اليومية و إختلاف معدلات التغذية اليومية.

ABBREVIATION AND ACRONYMS

DO	Dissolved oxygen
DWG	Daily Weight Gain
FAO	Food And Agriculture Organization Of The United Nations
FCE	Feed Conversion Efficiency
FCR	Feed Conversion Ratio
FF	Feed Frequency
FR	Feed Rate
GDP	Gross Domestic Product
IIRR	International Institute Of Rural Reconstruction
LSU	Lowa State University
NT	Nile Tilapia
RT	Red Tilapia
SD	Stocking Density
SGR	Specific Growth Rates
SP	Sudanese Pound
TAmm	Total Water Ammonia
TWB	The World Bank
US$	US Dollar (United States Of America)
USAID	United State Agency International Development
WFC	World Fish Center

CHAPTER ONE

1. INTRODUCTION

1-0: General Introduction

Now, the global community faces multiple and interlinked challenges ranging from the impacts of the ongoing financial and economic crisis to greater climate change vulnerabilities and extreme weather events. At the same time, it must also reconcile meeting the pressing food and nutrition needs of a growing population with finite natural resources (FAO, 2012). Fisheries and aquaculture make crucial contributions to the world's wellbeing and prosperity. In the last five decades, world fish food supply has outpaced global population growth, and today fish constitutes an important source of food and animal protein for much of the world's population. Today, fish farming is the world's fastest growing sector of food production, currently accounting 46.8 percent of total production from capture fisheries and aquaculture in 2016, up from 44.5 percent in 2014. In addition, this sector provides livelihoods and income, both directly and indirectly for a significant share of the world's population (FAO, 2018).

Fish and fishery products are among the most traded food commodities worldwide, with trade volumes and values reaching new highs in 2013 and expected to carry on rising, with developing countries continuing to account for the bulk of world exports. While capture fisheries production remains stable, aquaculture production keeps on expanding (SADA, 2014). Today, total production from both capture and aquaculture will exceed that of beef and poultry (FAO, 2014).

Capture fisheries and aquaculture supplied the world with about 169, 171 million tons of fish in 2015, 2016 of which about 151, 148 million tons was utilized as food for people respectively. Fish and fishery products represent a very valuable source of protein and essential micronutrients. Now, fish accounted for 17 percent of the world population's intake of animal protein (FAO, 2018), however, this share can exceed 60 percent in some countries like Bangladesh (Baqui and Bhujel, 2011). Globally, fish

provides about 3.2 billion people with almost 20 percent of their intake of animal protein, and 4.3 billion people with about 15 percent of such protein (FAO, 2014). In the last three decades (1980-2010), world food fish production of aquaculture has expanded by almost 12 times, at an average annual rate of 8.8 percent (FAO, 2012). Apart from the primary production sector, fisheries and aquaculture provide numerous jobs in ancillary activities such as processing, packaging, marketing and distribution, manufacturing of fish processing equipment, net and gear making, ice production and supply, boat construction and maintenance, research and administration. All of this employment, together with dependents, is estimated to support about 10-12 percent of the world's population (FAO, 2014). Today, finfishes dominate global aquaculture production with 68 percent, followed by mollusks 21% and crustaceans 10 percent (FAO, 2018).

For the Sudan fisheries, statistics on fish production are difficult to calculate. The last submission of official fisheries production information to FAO took place in 2009. Since then statistics have been estimated. According to information provided to FAO, fish production in 2014 totaled 35 988 tons, and was comprised of inland capture fisheries (81 percent), marine capture fisheries (14 percent) and aquaculture (5 percent). Presently, the contribution of fisheries to the gross domestic product (GDP) is marginal. However, their contribution to national food security is increasing day by day (Anton and Curtis, 2017). FAO (2013) reported that, the annual per capita fish consumption in Sudan is exceedingly low, at approximately 0.95 kg per year compared with the African average of about 10.7 kg per year and the Near East and North Africa average of 12 kg per year.

1-1: The Statement of the Problem

Although Sudan is characterized as a source of livestock with a pretty share in export, yet large population suffer from protein insufficiency even in the production areas like Kordofan. Fish constitutes a best alternative as a source of animal protein. It is now cheaper than red meat, and the consumer's taste is changing towards fish meat consumption. Fish culture is rapidly gaining over the world, but fish culture on a

small-scale basis especially in Sudan has often failed due to inadequate knowledge regarding ideal some biological factors that affecting fish growth and production as; a specific stocking density (Osofero *et al*., 2009), feeding frequency and feeding rate. However, to develop fish culture section at commercial level, it is important to establish an appropriate feeding management strategy that is based on identification of the feeding patterns or rhythms.

1-2: The Main Objective

This study aimed to know how the variances in stocking density, daily feeding frequency and daily feeding rate affected weight gain, feed conversion ratio, specific growth rate, survival rate and body composition of *Oreochromis niloticus* (Nile tilapia) fingerlings cultured in tanks, also to monitoring and identification the variables in physiochemical parameters in *O. niloticus* fingerlings tanks culture environment.

1-3: Specific Objectives

- To study the effects of stocking densities on growth performance and water quality of *O. niloticus* fingerlings cultured in tanks.
- To study the effects of feed frequencies on growth performance and water quality of *O. niloticus* fingerlings cultured in tanks.
- To study the effects of feed ratio on growth performance and water quality of *O. niloticus* fingerlings cultured in tanks.
- To study the effect of different stocking densities, feed frequencies and feed ratio on the chemical composition of *O. niloticus* fingerlings cultured in tanks.
- To identify the optimal stocking density, feed frequency and feed rate of *O. niloticus* fingerlings cultured in tanks.

CHAPTER TWO

2. LITERATURE REVIEW

2-0: General Overview

The resources for food agriculture, fisheries and forestry were under stress and threatened by problems such as desertification, overfishing, deforestation, loss of biodiversity, inefficient use of water and climate change. For this, climate change which remains one of the main factors behind the inter-annual instability of food production (FAO, 2010).

Fisheries and aquaculture remain important sources of food, income and livelihoods for hundreds of millions of people around the world. World per capita fish supply reached a new record high of 20kg in 2014; vigorous growth in aquaculture provides half of all fish for human consumption (FAO, 2016). Women play a vital role in fisheries and aquaculture, particularly in post-harvest activities; they represent almost half of the people working in small-scale fisheries (FAO, 2010). In Africa, aquaculture production increased by 56 percent in volume and more than 100 percent in value between 2003 and 2007. This growth was due to the increasing prices for aquatic products along with the emergence and spread of small and medium enterprises, and to a significant investment in cage culture accompanied by the expansion of larger commercial ventures. (FAO, 2010).

UNDPI (2010) reported that, in 2007, about 28 percent of fish stocks monitored by FAO were overexploited, either depleted or recovering from depletion and thus yielding less than their maximum potential owing to excess fishing pressure, and further 52 percent of stocks were fully exploited and, therefore, producing catches that were at or close to their maximum sustainable limits. Only about 20 percent of stocks were moderately exploited or underexploited with perhaps a possibility of producing more. Before that, Casal (2006) published that, the increasing in global population and demand for fish protein cannot be met by capture fisheries alone. Aquaculture

production is increasing and nowadays cage culture has an important role in meeting the world's fish demand (Olivares, 2003).

Aquaculture, also known as aqua farming, is the farming of aquatic organisms such as fish, crustaceans, mollusks and aquatic plants. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish. Global aquaculture production (excluding plants) increased from 32.4 million tons in 2000 to 90.4 million tons in 2012, while the contribution of aquaculture to global food fish consumption rose from 33.8 percent to 45.7 percent in the same period. It is estimated that aquaculture will meet more than 50 percent of global food fish consumption (FAO, 2014).

2-1: The State of World Aquaculture

The world's fisheries have remained relatively stable over the last 15 years: about 50 percent are being fished at full capacity, 25 percent are under fishing, and the remainder is overexploited. As a result, the food and agriculture organization (FAO) predict that, maximum wild fish capture has already been reached. Most of the stocks of the top 10-fished species are being fully fished or are overexploited, and studies have indicated that even in the most stable fisheries there have been declines in the most valuable species (FAO, 2016).

The term "Aquaculture" covers all forms of cultivation of aquatic animals and plants in fresh, brackish and saltwater. Aquaculture has the same objective as agriculture, namely, to increase the production of food above the level that would be produced naturally. Today, aquaculture is responsible for an ever-increasing share of global aquatic food production (Carballo *et al*., 2008). Fish farming is the world's fastest growing sector of food production, currently accounting for nearly 50% of the world's food fish. Today more than 40 percent of the world's seafood (food from water) comes not from wild catches but from land-based and off shore farms (FAO, 2016). Asia and the Pacific region dominate global aquaculture production, accounting for more than

90 percent. China is by far the world leader, with about 70 percent of global output and more than half of the total global value from aquaculture. The next closest producer is India. The only country outside this region in the top 10 producing countries is Chile (FAO, 2012). In historical fish, culture became an affirmed technology in china between 2000-1500 B.C and has never ceased to be source of food. Chinese named Fan Li (Santhanam and Saravanan, 2008) wrote the first trend on carp culture around 750 B.C. By early in the 20th century, several forms of fish culture were fairly well established, such as milkfish farming in Southeast Asia, carp polyculture in China, carp monoculture in Europe, tilapia culture in Africa (Lovell, 1989).

Today, there are many reasons why fish culture is done: for food; for restocking nature or others ponds; In order to study life history development; and today, let's not forget for home aquaria (Sharp, 2000). Added to the above, WWI (2009) documented that, historically most of the world's aquaculture has focused on species that are relatively low on the food chain, including seaweeds, shellfish, and herbivorous or omnivorous species, however, recent trends indicate stronger growth rates in carnivorous species like shrimp and salmon will continue, especially as demand increases, due in part to this trend, growth in aquaculture now drives global fishmeal and fish oil production. Until recently, fishmeal and fish oil were used primarily for pigs and poultry production; today nearly 50 percent of fishmeal and 87 percent of fish oil is used from aquaculture (FAO, 2016).

FAO (2010) informed that, growing fish in small holder farming systems including enhanced rural employment and income through additional or off-season production; improved food security; increased availability of high value protein food; decreased risk through diversification; improved water availability and nutrient recycling; environmental benefits through enhanced resource flows; to preserve aquatic biodiversity through restocking; to reduce pressure on fishery resources. Carballo *et al.*, (2008) made clear that, fish culture or fish farming can be combined with agriculture, animal husbandry and irrigation practices which can lead to a better utilization of local resources and ultimately to higher production and net profits.

2-2: The State of Sudan Fisheries

Sudan has a water area: 129 810 km^2, shelf area: 22 300 km^2, length of continental coastline 853km (FAO, 2008). The estimated annual sustainable potential of fish in Sudan in 2012 is 34000 tons year-^{1}, 29000 tons from inland water and 5000 tons from marine catches (FAO, 2014). Anton and Curtis (2017) write that, Sudan's inland capture fisheries produced approximately 29 000 tons in 2014 (FAO, 2016), which represent 85 percent of the country's total production of fish. While Mohammed (2012) reported that, the estimated annual sustainable potential is 50,000~60,000t year^{-1}, and the actual level of production is 30000 tons year-^{1}, with a consumption rate of 1.1 kg. year-^{1} (people in China eat an average of 25.8kg live weight equivalent for a person per year of fish meat (WWI, 2009)). Elawad, (2013) reported that, the total annual finfish production in Sudan is around 140000 tons from fresh water and 8000 tons from marine water. Mohammed (2012) cited that, Sudan`s fisheries resources depends mainly on inland water network.

Sudan's fisheries section is known to have a rich resources base, and is mainly derived from the following diverse water: off shores water, inshore waters, the Blue Nile, the White Nile, other in land water including rivers tributaries and floodplain, lakes, man-made reservoirs designed for water supply (in Western Sudan the small reservoirs or rainwater impoundments with 1-3 meter depth called "Haffirs"), irrigation and electricity generation like; "Sennar" dam, "Roseires" dam (FAO, 2014) and "Jable Awlia" reservoir which can product about 15000 tone/year (Mohammed, 2012).

Although there is potential for increasing fish production in Sudan, fisheries presently make only a marginal contribution to the Sudanese economy where FAO (2014) mention that, the contribution of fisheries in Sudan to the gross domestic product (GDP) is currently marginal, this may be due to some reasons; the lack of or inadequate fisheries policies and management, lows and regulation, monitoring and statistics, infrastructure and institutions, investments and financing, capacity and training, processing and marketing.

FAO (2008) mention that, although the fishery sectors contribution to national income in Sudan is small i.e. 0.4 % of GDP, fishing is the source of employment and livelihood for large communities. It is estimated that the sector provides employment to more than 64 500 people, supplying more than 64 thousand tons of fish every year, and 90% of the estimated production potential of the country from inland waters, the inland waters of Sudan are populated with over 126 fish species in various localities in the country, generally, the fishery sector in Sudan is characterized by its traditional technology and poor performance attributed to many factors (Abusin, 2012).

2-2-1: Aquaculture and fish culture in Sudan

Fish culture in Sudan is therefore still in its infancy and the annual production was estimated at 2000 tons in 2012 and only 140 jobs were created by the subsector in 2009. Although there is a long history of aquaculture in Sudan, the lack of trained personnel and inadequate planning have been major impediments to its development (FAO, 2014). For fresh water fish culture, emphasis was placed on extensive and semi-intensive pond culture of the indigenous Nile tilapia (*O. niloticus*) in monoculture or polyculture systems. FAO (2008) reported that, in Sudan fresh water fish culture is primary based on pond culture of the indigenous species *O. niloticus*, other local species, such as *L. niloticus*, *Labio spp*., and *C. lazira* have been tried, but not yet released to farmer. Some trials of pen culture were conducted together with seeding of some rainwater impoundments and dams with tilapia species as a form of rural fisheries-based.

Recently, there is some modern tilapia cages has been cited in “EL-Kalakala” area at the White Nile south Khartoum belong to the ministry of agriculture, animal resources and irrigation-Khartoum state [Photo -1], and in “Nubian” lake (North state) owned by the fisheries societies.

Table 1- Fish production in Sudan by location (inland capture fishing) in 2008

Zone	State	Production (tons)
Jable Awlia Dam	Khartoum	7000
Lake Nubia	Northern	3000
White Nile	White Nile	8000
Sennar Reservoir	Sennar	1000
Roseires Reservoir	Blue Nile	1500
Khashm el-Girba Reservoir	Kassala	800
River Nile	River Nile	3000
El Gezira	El Gezira	700
Northern Sudan*	Northern	4000
Total		**29000**

*Excluding Lake Nubia (which is already mentioned in the table as 3000 tons)
Source: Ministry of livestock, fisheries and rangelands [webpage accessed Dec 2016].

Table 2- Establishment of freshwater aquaculture farms in Sudan

State	Total aquaculture area (ha)	As percentage of total
Khartoum	53.9	59.3
Gezira	10.7	11.8
River Nile	10.5	11.6
White Nile	8.6	9.5
Kassala	4.2	4.6
Sennar	2.01	2.3
Greater Darfur	8.8	0.9

Source: (FAO, 2008)

2-2-2: Marine culture in Sudan

Hamad *et al*., (2014) write that, in Sudan marine environment, no fin fish aquaculture, only oyster culture is practiced in Red Sea "Dongonab" bay considered the natural breeding ground for (*pinctada margritifera*), the government established demonstration farms and the farmers established their farms. The production increased rapidly. However, for undisclosed reasons, mass mortality destroyed the project (The

Red Sea Fishes Research Center and the Canadian Development Research Center related the oyster mortality in "Dongonab" bay to badness administration (Farah, 2019)). "Baabood" Company initiated the first commercial shrimp farming in Sudan in 2002. The total farm area is 20ha and it is located 40km south Port Sudan on the Red Sea coast. Both of *P. monodon* and *P. indicu*s, are spawning in the hatchery. Fish farming is a recent development in Sudan; proper extension of fish culture practices has been greatly hampered and the area utilized remains very small when compared to the available cultivable inland waters.

Photo 1- Modern tilapia cages at the White Nile south Khartoum belong to the Ministry of Agriculture, Animal Resources and Irrigation, - Khartoum state

2-3: Tilapia Fishes

The Nile tilapia *Oreochromis niloticus* (Linnaeus 1758) belong to the family Cichilidae, genus Oreochromis is one of the most important species of fish in tropical and subtropical aquaculture (Blow and Leonard, 2007). This family provides one of the major sources of animal protein and income throughout the world (Sosa *et al*., 2004). *O. niloticus* is currently ranked second only to carps in global production and is likely to be the most important cultured fish in the 21st century (Ridha, 2006). Thus, tilapia and other cichlids totally contribute about 5.6% of total aquaculture production (Chowdhury, 2011). The Nile tilapia is preferred due to its fast growth, efficient conversion of food, high fecundity, tolerance to a wide range of

environmental parameters, and good product quality. Tilapia can tolerate a wider range of environmental conditions-including factors such as salinity, dissolved oxygen (DO), temperature, pH, and ammonia levels than most cultured freshwater fishes (Mjoun *et al*., 2010). Tilapia production reports impressive growth, making it, after salmon and shrimp, one of the most successful aquaculture products entering international trade. Tilapias are hardy and omnivorous, feeding at a low strophic level. This makes them relatively inexpensive to feed within extensive systems and suitable for farming under less optimal environmental conditions (Rojas and Wadsworth, 2007).

Tilapia, especially Nile tilapia, better known as aquatic-chicken. Although it native to Africa, tilapia have been introduced around the globe and its farming is growing rapidly especially in Asia because of their fast growth, ease of breeding and accept a wide range of feeds including planktons from natural sources, high disease-resistance and tolerance to poor water quality and low DO levels. Tilapia is gaining popularity in the west as well because of its white muscle with mild flavor with no intra-muscular bones. Tilapias are a good source of protein and a popular target for artisanal and commercial fisheries (Bagui and Bhujel, 2011).

2-3-1: Tilapia fishes culture

Tilapia is one of the most widely cultured fish in the world (TWB, 2013). Several factors have contributed to the rapid global growth of tilapia. Adult tilapias are principally herbivorous but readily adapt to complete commercial diets based on plant and animal protein sources (Mjoun *et al*., 2010**)**. Tilapia grows and reproduces in a wide range of environmental conditions and tolerates stress induced by handling (Tsadik and Bart, 2007). El-Sayed (2006) write that, according to FAO statistics, 16 tilapia Cichlid groups in addition to unidentified Cichlids have been used for aquaculture production. Nile tilapia is by far among the most important farmed tilapia species in the world it represented more than 80% of total tilapia production in during 1970-2002.

Nandlal and Pickering (2004) reported that, tilapia farming is expanding world-wide in both developed and developing countries because this group of fishes can be cultured under very basic conditions and so is ideal for rural subsistence farming, yet is amenable to more sophisticated, market-oriented culture programs. Tilapia culture requires minimal management and energy inputs. These fish have high reproductive and growth rates, are relatively disease free. Rojas and Wadsworth (2007) informed that, tilapia can be cultured at high densities in cages that maintain free circulation of water. Ofori *et al*., (2009) reported that, Tilapia first gained popularity as an easily farmed fish that could supply cheap but high-quality animal protein in developing countries. Demand has also began to rise in major export markets. Problems common for many tilapia culture systems are the reduction of growth rates at the onset of sexual maturity and precocious and excessive reproduction (Chakraborty *et al*., 2011).

2-3-2: Tilapia fishes growth efficiency in culture

The success of the culture methods applied for tilapia farming depend on various factors and determination of the optimal method under a cert condition can be quite complex (Graaf *et al*., 2005). Mridha *et al*., (2014) examined the effects of stocking density on the growth, production, and economics of all-male *O. niloticus* in a rain-fed rice-fish ecosystem for a period of 120 days. Fish were stocked at the rate of 4000, 5000, and 6000 ha^{-1} in treatments T_1, T_2, and T_3, respectively. Significantly, higher growth observed in T_1 as compared to other treatments. Specific growth rate ranged from 1.26 to 1.51, treatment T_1 producing the highest survival. The highest benefit was obtained in T_2 followed by T_1.

Ofori *et al*., (2009) said that, the advantage of using all males is that they grow about 40% faster than mixed sexes when producing fish over 250g. Barman and Little (2011) tested the production of Nile tilapia (*O. niloticus*) in nylon mesh net cages (hapa), most of the households produced tilapia fry from hapa for 4-5 months. Klanian and Adam (2013) evaluated the performance of Nile tilapia (*O. niloticus*) fingerlings raised at hyper intensive stocking density in a recirculated aquaculture system (RAS).

Fish (2.07± 0.04g) were stocked in triplicate at 400 (T1), 500 (T2) and 600 (T3) fish m^{-1}. Stocking density did not affect significantly the survival. The growth rate of (T1) and (T2) was significantly higher than (T3). The SGR of (T1) was 41% influenced by temperature. For (T2) and (T3) the SGR influenced by the variation of DO, the SGR of (T3) also affected by the concentration of ammonia nitrogen. Jegede and Olorunfemi (2013) study the effects of feeding frequency on growth and nutrient utilization of *O. niloticus* fingerlings. A 58-day feeding trial was conducted in concrete tanks of 400L capacity to determine the effects of *O. niloticus* (3.40g± 0.04) at different feeding frequencies; once, twice, three and four times daily respectively. Fish fed with 35% protein diet at 5% body weight. There was a significant increase ($P< 0.05$) between feeding frequency of three times daily and other feeding frequencies, with respect to final mean weight. In addition, Feed Conversion Ratio of the fish fed feeding frequency of three times daily is the best of the four feeding frequencies; *O. niloticus* survival not affected by the different frequencies.

Alemayehu and Getahun (2017) study the growth performance and survival rate of Nile tilapia (*O. niloticus*) subjected to different feeding frequencies evaluated in cage culture. Juveniles with mean initial weight of 35.99 stocked in one cubic meter net. T1 (four equal meals per day), T2 and T3 were fed at frequency of (four and two feedings/day, respectively), throughout the experiment. Feed was given once a day (without dividing) for T4 and once every other day (without dividing) for T5 throughout the experiment. The mean specific growth rates (SGR), Feed conversion ratio (FCR) and Feed conversion efficiency (FCE) were statistically similar for T1 and T2, but they were higher than T3, T4 and T5. In conclusion, growth performance and net yield increased with increased feeding frequency, so frequent feeding was recommended for optimum result of *O. niloticus*.

Chakraborty *et al*., (2011) study the growth rate in mono sex and mixed-sex tilapia fish in cistern, flow-through, pen and pond systems, they found that, Mono sex tilapia showed significantly higher weight, length, daily weigh gain (DWG), SGR and protein content than mixed-sex fish. Fish in Pond culture showed significantly higher weight, DWG and protein content than fish in other three culture systems.

2-4: Some Main Factors Affect Growth Performance in Fish Culture

2-4-1: Effect of different stocking densities on *O. niloticus* fish in culture

Fish culture on a small-scale basis has often failed due to inadequate knowledge regarding ideal some vital biological factors like stocking density of fish (Osofero *et al*., 2009). Stocking density (SD) is considered one of the important factors affecting fish growth, feed utilization and gross fish yield. Stoking density directly influence survival, growth, behavior, water quality and feeding. In culture system, stocking density is the concentration which fish stocked into a system (Gomes *et al*., 2006; De Oliveira *et al*., 2012).

High density culture of tilapia has been shown to be successful, but comparing results with studies conducted on tilapia maintained at lower stocking densities is difficult because individual studies do not address difficulties that arise when there are so many interactive factors involved (Ali *et al*., 2006). SD is a key factor determining the productivity of fin fish aquaculture systems, mainly through the way it maximizes water use. However, high Stocking densities are also a potential source of stress that may limit growth and be harmful for fish welfare when physiological and spatial needs are not adequately met. (Le Ruyet *et al*., 2008).

Generally, increase in SD results in directly increase on stress condition, causing a reduction in growth rate and food utilization effecting. On the other hand, in very low densities, fishes may not form shoal and may unprotected (Chambel *et al*., 2015). The effect of stocking density on growth, survival and yield on aquaculture are well known for a divert of species, and seemed to influence production differently (Garr *et al*., 2011). Consequently, identifying the optimum stocking density for a species is a critical factor not only to enable efficient management and to maximize production profitability, but also for optimum husbandry practice (Chambel *et al*., 2015). In general, SD and growth of fish are very much related. The optimum stocking density ensures sustainable aquaculture providing proper utilization of feed, maximum production, sound environment and health. In comparison to low stocking density, high stocking density exerts many negative impacts such as competition for food and

shelter and rapid outbreak of disease if occurred. Therefore, it is important to optimize the stocking density for the target species in aquaculture for desired level of production (Ferdous *et al*., 2014).

Tilapia is an important species throughout global, but knowledge of its appropriate stock density which can immensely affect production and efficiency of tilapia has been inadequate (Chakraborty *et al*., 2011). For Nile tilapia (*O. niloticus*), a need for systematic effort to secure and to further improve the genetic quality of farmed stock is widely recognized (Santos *et al*., 2013). High fish density in fiberglass tank disrupts breeding behavior and allows male and female tilapia to grown together to marketable size. Flow-through system allows the fish culturist to easily manage stocks and to exert a high degree of environmental control over parameters such as water temperature, DO, pH, waste that can be adjusted to maximize production in a flow through system, this may translate to better growth and fish yield for *O. niloticus* (Yakubu *et al*., 2014).

An experiment was conducted on 16 floating cages; each of water volume of $1m^3$ stocked with Nile tilapia fingerlings weighing 30g. The 16 cages represented four stocking densities (80; 100; 120 and 140 fish m^3). Results obtained that, increasing the stocking density resulted in significant decreases in body weight and length (Abdel-Hakim *et al*., 2001). Araujo *et al*., (2010) evaluated the effect of stocking density on the weight growth of *O. niloticus* cultured in 3.14 m^3 round net cages. Stocking densities of 100, 150 and 200 fish m^{-3}. Data analyses showed a significantly higher weight growth for the density of 100 fish m^{-3}, which demonstrate a better development of Nile tilapia in circular net cages using low stocking densities. Bwanika *et al*., (2007) found that, in sex-specific differences in growth were significant in *O. niloticus* where males grow significantly faster, larger and more uniform in size than females.

Mainar *et al*., (2011) test the viability of the use of low-volume cages ($1m^3$) placed in farm ponds and evaluates the productivity of Thailand and red tilapia submitted to different stocking densities (200, 250, 300 fish m^3), he found that, the stocking density

tested in the experiments did not affect the growth of tilapia (P> 0.05). Emmanuel *et al*., (2013) explained that, when fish are crowded, stressed and executed, water quality can deteriorate rapidly. Ali *et al*., (2006) reported that, Ammonia level increased with increasing stocking density and without water exchange, and when fish reared at higher stocking densities then water exchange must be taken in to consideration so as to help avoid environmental and physiological stress to the fish.

2-4-2: Effect of different feed frequency on *O. niloticus* fish in culture

In tilapia fish culture thus, it is important to consider the factors that influence its production such as feed type, ration size, various feeding frequencies and how they may influence on growth and feed utilization. Feeding frequency (FF) is important to ensure a maximal food conversion ratio and weight of cultured organisms (Ferdous *et al*., 2014). Higher feeding frequencies decrease aggressive behavior may resulting the faster growth and uniformity in size. Moreover, feeding frequency can affect growth performance, survival, body composition (Zhou *et al*., 2003) and water quality (Zakes *et al*., 2006) furthermore, as we know the feed cost is one of the largest operational costs in the aquaculture industry (Ferdous *et al*., 2014).

An important approach for reducing feed costs in commercial aquaculture is to develop proper feed management, husbandry strategies (Lovell, 1989) and efficient broadcasting of the predetermined ration to the culture system. Hence, the act of feeding may be pointed as one of the most vital element in the culture practice (Ferdous *et al*., 2014).

In aquaculture, like other form of husbandry, feeding is crucial for its viability and success. Feed cost is one of the largest operational costs in aquaculture. The practice of feeding in an aquaculture system involves selection of appropriate ration sizes, (the amount of feed supply), determining the feeding frequency (how many times the organism should be fed in a day), and timing of meal and efficient broadcasting of the predetermined ration to the culture system Anderson and De Silva (1995). Feeding frequency mainly depends on species cultured, age, size, feed quality and

environmental factors. Sometimes excellent quality feeds do not perform satisfactorily unless correct feeding practices and proper feeding rates are used. It is essential to recommend the optimum feeding rate for economic production of fish. In general, the feeding regime and growth of fish are very much related. Thus, the feeding strategy may provide clue for maximum growth because the feeding frequency contribute to feed efficiency and growth response.

Feeding frequency is important to ensure best FCR and weight gain of cultured organism (Emranul, 2009). Add to the above, Emranul (2009) determine the effect of feeding frequency on the growth and production performance of Tilapia, *O. niloticus* (34.4g) were fed a commercial diet once, twice, three, or five times a day for 29 days. Consumption, growth, and feed utilization were evaluated. No significant differences in growth, feed efficiency, or protein utilization were detected among the fish fed two, three, or five times daily, but all were significantly better than in fish fed only once. Fish fed three meals had significantly higher gross energy and lipid and lower crude protein contents than fish in the other treatments ($P< 0.05$).

Kaya and Bilguven, (2015) study the effects of four different feeding frequency (once, twice, three, or six meals a day) on the growth performance, feed consumption, feed conversion ratio and proximate composition of Nile Tilapia. The average live weight used in this experiment were 9.39 ± 0.19g. At the end of the study, it was observed that there were important differences among the groups in terms of average live weight, live weight gain, feed consumption, feed conversion ratio (FCR), and specific growth ratio (SGR) were found statistically significant ($P< 0.05$). Moreover, the difference in the composition of carcass among the groups is found statistically significant ($P< 0.05$).

Correctly feeding the proper amount of feed is very important. Overfeeding wastes feed and money, and can cause water quality deterioration leading to stress and potential secondary diseases or parasites. Fish in cages should be fed at least 6 days a week. The daily amount of feed fed will need to be increased as the fish grow. Feeding

should be discontinued during periods of heavy overcast weather and if water temperatures exceed 90 °F (LSU, 2009). Riche and Garling (2003) evident that, increased feeding frequencies decrease aggressive behavior in some fish species. This result in faster growth and less size variation. However, there is a limit to the frequency that will result in benefits.

There are many fish species that are less efficient when fed at short intervals. Evidence suggests tilapia fed too frequently utilize feed less efficiently. The optimal interval between feedings will depend on the return of appetite. Fish eat available food depending on stomach fullness and at intervals determined by the time it takes to empty the stomach. The speed the stomach empties depends on temperature, fish weight, meal size, feed composition and feeding frequency.

2-4-3: Effect of different feed rate on *O. niloticus* fish in culture

Most wild tilapia are omnivorous, meaning they will eat a variety of things, including both plants and animals. This is in contrast to many other fish that are more specialized. However, like other animals, tilapia has specific requirements for nutrients such as amino acids from protein, fats, minerals and vitamins. Fish reared in intensive recirculating systems have different nutritional requirements than those in the wild. Wild tilapia grazes on blue-green algae and bacteria. This type of feeding requires a lot of energy due to finding and digesting this type of food.

To meet the energy required for feeding and growth, they must consume more food relative to farm raised fish. In intensive tank culture, natural food is limited. Therefore, all nutrients must be supplied in a complete pelleted diet. An advantage to feeding a pelleted diet is the higher quality and consistency of the diet (Riche and Garling, 2003). Feeding rates will vary with fish size and water temperature. The appropriate amount is measured as a percent of the average body weight. As the fish weight increases, the percent body weight fed decreases (Table 3). The daily feed ration must be adjusted to compensate for growth (Riche and Garling, 2003).

Table 3- Example of daily feeding allowances for different sizes of tilapias at 28 °C

Size of fish (gram)	Feeding allowance of fish weight (%)	Feed frequency/day
2 days old to 1g	30-10	8
1-5	10-6	6
5-20	6-4	4
20-100	4-3	3-4
larger than 100	3	3

Source: Jauncey and Ross (1982).

2-5: Water Quality in Fish Culture

The physical, chemical and biological characteristics of the water have a great importance due to its essential and principal role in distribution and behavior of the aquatic organisms. (Chaudhuri *et al*., 2012). Water quality in fish culture influences feeding, growth, disease burdens, and survival rates (Chainark and Boyd, 2010). Water quality is controlled by a complex interplay of many factors, including weather conditions. For example, dissolved oxygen (DO) is related to phytoplankton production and respiration; nitrogen waste such as ammonia is related to the amount of organic matter inputs and ammonium excretion by fish; and, water temperature and thermal stratification are controlled by sunlight and air temperature (Sriyasak *et al*., 2015).

De Long *et al*., 2009 reported that, poor water quality is the cause of the problem. The fish may not be eating aggressively due to the stresses of high ammonia levels, nitrite toxicity, low dissolved oxygen, high levels of carbon dioxide, or other water quality problems. Poor water quality, e.g., lack of oxygen, can cause a loss of cultured fish. (Dias *et al*., 2012).

While a number of studies have examined growth, survival, and production of various tilapia species under different stocking densities, little information is available on the relationships between water quality such as dissolved oxygen and ammonia excretion with growth performance, stocking density, and size variation (Ali *et al*., 2006). Gorlach *et al*., (2013) explained that, physico-chemical parameters of the water, such

as pH, nutrients and presence of toxic compounds might influence the density of bacterial populations in fish culture. At the same time, fish farmers in many areas are facing increasing problems of maintaining adequate water quality in fish ponds (Sriyasak *et al*., 2014).

De Long *et al*., (2009) explained that, tilapia are some of the hardiest fish being cultured; they can withstand water quality conditions and physical handling that would create serious challenges for other species. However, tank culturists need equipment that analyzes the minimum basic water quality parameters of dissolved oxygen, temperature, pH, ammonia, nitrite, alkalinity, chloride concentration, and calcium hardness. The equipment should be of good enough quality to allow daily measurements.

Generally as reported by De Long *et al*., (2009), strict water quality parameters for tilapia culture are difficult to define. Experience at one site may not reflect the same results as those reported in a scientific publication or from another system at another location.

2-5-1: Water temperature

Tilapias are plastic animals because their growth and maximum obtainable size can be seriously influence by the physical and biological composition of their environment (Olurin and Aderibigbe, 2006). Because the environment in aquaculture system is complex, water quality parameters such as temperature must be monitored. Of all the biotic factors, changes in ambient water temperature has the largest effect on physiological properties in fish. Since fish in general are ectoderms, increases in ambient temperatures will lead to increases of their metabolic rates and these will translate to a need to increase their consumption rates to meet these demands (Shackleton, 2012).

Temperature will also affect all aspects of fish physiology and dictate fundamental properties of the energy budget, metabolic demands, digestion rates and assimilation efficiencies (Byström *et al*., 2006). Just as temperature affects consumption rates,

growth rates of fish are intimately connected to ambient temperature levels. For most fish species increases in growth rates with increasing temperatures will be seen, up to a certain point, only to decline abruptly once the critical limit. However, patterns of growth are strongly correlated to the available food supply and restricted feeding possibilities will have a marked influence on growth rates at any observed temperature (Shackleton, 2012).

Fish generally show temperature optima for growth and survival, these may change with age and size, as juveniles of many species prefer warmer temperatures than adults do. Early life stages may also have different optimal temperatures, which may reflect temporal and spatial field distributions further, the combined effects of size and temperature on growth have been described for several fish species (Handeland *et al*., 2008). Nehemia *et al*., (2012) mention that, optimal temperature for growth of tilapia ranges from 29 °C to 31°C. Growth declines greatly with decreasing temperature and at 20° to 22 °C, growth is about 30% of optimum. The lethal minimum temperature for most species of tilapia is 10°C or 11°C, while at 37- 38 °C stress and diseases tend to attack most of them.

Mirea (2013) reported that, Nile tilapia (*O. niloticus*) with average weight of 33.5g were used to study the effect of different temperatures on growth performance, survival rate and biochemical parameters. They were stocked in 12 rearing units at 20, 24, 30 and 28ºC (control) water temperature for 30 days. Results showed that growth performance was not significantly (P> 0.05) decreased at 20 and 24 ºC. Survival rate was the same for the treatments. The feed conversion ratio for fish increased with the temperature, but the difference between the high temperature (28 and 30 ºC) was not significant. Results showed that the thermal range 20-30 ºC was suitable for intensive culture of Nile tilapia regarding the optimum growth performance and survival rate.

Mjoun *et al*., (2010) reported that, temperature is a major metabolic modifier in fish, and the optimal growing temperatures for tilapia fishes are typically between 22 °C and 29°C; spawning normally occurs at temperatures greater than 22 °C. Water

temperature affects the amount of DO and other gases that water can hold at specific atmospheric pressure. Arise of temperature decreases the ability of water to hold oxygen molecules (Kreger, 2004). Growth of juvenile Nile tilapia was studied under laboratory conditions. Four thermal regimes (22°, 26°, 30°, and 34°C) were tested. Significant ($P< 0.05$) effects of temperature on growth were observed. Results showed that the final mean weight was significantly higher at 26 °C and 30 °C than at 22°C and 34 °C. Both FCR and DWG were better at 26°C and 30°C. At all temperatures, survival rates were not affected. These results suggest that the best growth and feed utilization of *O. niloticus* juveniles may be higher at 26°C and 30°C (Azaza *et al*., 2008).

2-5-2: Dissolved oxygen concentration

Low dissolved oxygen (DO) concentration is recognized as a major cause of stress, poor appetite, slow growth, disease susceptibility and mortality in aquaculture animals. It is generally accepted that the minimum daily DO concentration in pond culture systems is of greatest concern. Some study review indicated that, at concentrations below 50% of saturation, growth rates declined and became progressively less as the minimum DO concentrations decreased. Tilapia tolerate lower dissolved-oxygen levels, but concentrations should not fall below 1 mg/L in tilapia pond (Boyd, 2010). Mjoun *et al*., (2010) reported that Tilapia are, in general, highly tolerant of low DO concentration, even down to 0.1 mg L^{-1} but optimum growth is obtained at concentrations greater than 3 mg L^{-1}. Though other factors are important, oxygen is more essential for growth and survival of a fish because it affects fish respiration as well as nitrite and ammonia toxicity. The minimum DO requirements of tilapia species is 5mg L^{-1} and if the concentration of DO decreases respiration and feeding activities also decrease (Mallya, 2007). As a result, the growth rate is reduced and the possibility of disease outbreak increases. Furthermore, fish are unable to assimilate the food consumed when DO is low (Nehemia *et al*., 2012).

Fish are sensitive to water quality. Feeding should be reduced or stopped if water quality falls below certain levels. Shortly after feeding, DO levels decline rapidly. DO levels should be maintained above 5.0 ppm for best growth. At DO levels between 3-5ppm, feeding should be reduced, and feeding should be stopped at DO levels below 3ppm (Riche and Garling, 2003). De Long *et al*., (2009) mentioned that, operating levels of dissolved oxygen for tilapia in tanks culture between 5.0 and 7.5mg/L are recommended. Growth and feed conversion will be affected by chronically low DO concentrations below 3.5 mg/L. Survival and recovery are possible with short-term exposure (less than 10 minutes) to DO concentrations as low as 0.8 mg/L. Sriyasak *et al*., (2015) recommends of using aeration and mechanical mixing interventions at critical times to reduce stress on fish from low DO concentrations, and thus avoid risks of mass mortality events.

2-5-3: Water pH degree

The pH of natural water depends on several factors; the carbonate system, type of rock, type of soil, and nature of discharged pollutants, the concentration of carbonates (CO_4^2, HCO_3^{-1}) and carbon dioxide (Co_2) is the main influence on the pH of clean water. High concentration produce alkaline water (High pH), while low concentrations usually produce acidic water (low pH) (Kreger, 2004).

Another consequence of changing pH in the aquatic system is to change the concentration of phosphates, nitrates, and organic materials dissolved in the water, which are used by the primary producers (plants and algae). Thus, changing in the concentrations of inorganic and organic molecules may have cascade impact on all the species in that system by reducing plant production (Amico, 2000). White *et al*., (2014) recorded that, the animal physiology works within certain species-specific environmental conditions. The water pH variations that deviate from the ideal range for the species may affect fish survival and performance. Fish try to adapt its behavior and physiology when subjected to stressful pH conditions.

Other water quality characteristics relevant to tilapia culture are hydrogen ion concentration (PH) and ammonia. In general, tilapia can tolerate a pH range of 3.7 to 11, but best growth rates are achieved between 7 to 9 (Kurt, 2012). El-Sherif and El-Feky (2009) study the performance of Nile Tilapia (*O. niloticus*) fingerlings in different pH levels (6, 7, 8 and 9). Results showed that growth performance was significantly ($P< 0.05$) decreased at pH 6 and pH 9, while the differences between pH 7 and 8 were not significant. No mortality occurred during the whole experiment. FCR increased at pH 6 and 9, since its value at the pH 6 was significantly ($P< 0.05$) higher than pH 9.

Although freshwater fish can adapt to stressful water pH, the farming of those animals should be conducted in their optimal environmental conditions to prevent metabolic stress (Reboucas *et al*., 2015). According to El-Sherif and El-Feky (2009), the optimal range of water pH for rearing Nile tilapia is between 7 and 8. However, recent data by Nobre *et al*., (2014) suggest that the optimal range of water pH for farming Nile tilapia juveniles in green waters is wider than that reported by El-Sherif and El-Feky (2009), ranging from 5 to 8.

In general, small increases or decreases in water pH do not change the diversity in aquatic ecosystems, although they may have a significant impact on the abundances of species that are pH sensitive. Large change in pH however, can drastically decrease species diversity and change species composition in fresh water system, as fewer species can tolerate such harsh environmental condition. Fish in particular, tend to be especially sensitive to change in pH concentration. (Salih, 2007).

2-5-4: Ammonia (NH_3), nitrite (NO_2) and Nitrate (NO_3) concentration

Ammonia is a dissolved gas present naturally in surface and waste water, and in some well waters. It is the major nitrogenous waste product of fish and results from the decomposition of organic matter. It is quite soluble in water, especially at low pH, and ordinarily is removed by plants or bacteria (as a nutrient or energy source). Ammonia in water is present in two forms; un-ionized ammonia (NH_3) and the

ionized form (NH_4+), and the relative proportion of each type depends on pH and temperature. As pH increases, there is an increasing proportion of un-ionized ammonia, which is very toxic to fish (Stone and Thomforde, 2004). During phytoplankton busts, both ammonia and carbon dioxide are liberated in to the water column. Because freshwater has low buffering effect, carbon dioxide can accumulate in the water, thus lowering the pH in ponds considerably and reducing the amount of un-ionized ammonia. Marine fishponds have large carbonate alkalinity which buffers its effect resulting in relatively higher levels of un-ionized ammonia, which is toxic.

Generally at pH 7 only less than 1% of the total ammonia is in the toxic un-ionized form, at pH 8 about 5 to 9%, at pH 9 about 30 to 50%, while at pH 10 is about 80-90%. The first mortalities from prolonged exposure to toxic ammonia begin at concentration as low as 0.2mg/L and this un-ionized form of ammonia begin to depress appetite of tilapia at concentration as low as 0.08mg/L (Nehemia *et al*., 2012).

El-Sherif and El-Feky (2008) cited that, Ammonia is toxic to tilapia at concentrations of 7.1 mg/L as unionized ammonia for Nile tilapia and depresses feed intake and growth at concentrations as low as 0.1mg/L. Optimum concentrations are estimated to be below 0.05 mg/L (El-Sherif and El-Feky, 2008). Morrow (2009) investigates the growth and oxygen consumption of juvenile Nile tilapia exposed to high (sub-lethal) and low levels of total water ammonia (TAmm), the study demonstrates that high levels of TAmm (1000, 2000 and 4000 μM) negatively affect oxygen consumption and ventilation rates, with reduced respiratory efficiency at 4000 μM, and it significantly impair tilapia whole-body growth. Furthermore, low levels of TAmm (≤ 300 μM) do not appear to affect growth. Normally, warm water fish are more tolerant to ammonia toxicity than cold-water fish (Timmons, 2002).

Sriyasak *et al*., (2015) write that, acute toxicity of ammonia is due to its effect on the central nervous system; ammonia concentrations of 7.40 mg/L have been shown to

cause mass mortality in tilapia fingerling within 24 hours. Fish exposed to toxic levels of ammonia cannot excrete ammonia efficiently; as a result, ammonia levels in blood and tissues increase along with pH levels, therefore affecting enzyme activity. This can lead to poor feed conversion, slower growth rates, and reduced resistance to diseases (Gandhi, 2012).

Ammonia is more toxic to aquatic life at higher temperature and pH values. As pH increases, so does the fraction of unionized ammonia. The ratio of NH_3 to NH_4 increases by 10 times for each one-unit rise in pH, and by approximately 2 times for each 10 rise in temperature from zero °C to 30°C (Levit, 2010). WWI (2009) reported that, fish farms themselves, especially ones that raise carnivorous fish, can be a large source of water pollution, including nitrogen and excess nutrients that can create toxic blooms and dead zones.

Because fish are often raised in high densities to maximize profit, they can require antibiotics and other treatments for diseases, most of which end up in the water. Nitrite enters a fish culture system after fish digest feed and the excess nitrogen is converted into ammonia, which is then excreted as waste into the water. Total ammonia nitrogen (TAN; NH_3 and NH_4 is then converted to nitrite (NO_2) which, under normal conditions, is quickly converted to non-toxic nitrate (NO_3) by naturally occurring bacteria (Masser, 1997).

Ali *et al*., (2006) study the effects of stocking density (10, 15, 50 and 75 fish in 65liter per tank) and ammonia excretion on the growth of Nile tilapia (*O. niloticus*) (12.19 ± 1.21g). The result show that, increasing stocking density of *O. niloticus* from 15 fish/tank (2.81g fish/liter) to 75 fish/tank (14.07g fish/liter) resulted in associated increase in ammonia level (1.48 ± 0.87 mg/liter to 26.44 ± 11.4 mg/liter) and significantly lower growth rates and significantly better feed conversion ratios were found for fish reared at lower (15 fish/tank) stocking densities compared to higher (75 fish/tank) stocking densities.

2-6: Food and Feeding in Fish Culture

Knowledge about the optimum feeding is important not only for regulating the feed intake, growth and chemical composition of fish but also for preventing water quality deterioration as a result of overfeeding (Ertan *et al*., 2015). The commercial feasibility of any intensively cultured fish species depends on market demand and cost of production. The largest section of the production cost lies in feed (Daudpota *et al*., 2016).

Nutrition is one of the most important factors influencing performance of cultured fish and is influenced by factors such as behavior of fish, stocking density, quality of feed, daily ration size, feeding frequency and water temperature (Alemayehu and Getahun, 2017). After proper stocking, the most important aspect of fish culture is providing good quality feed in the correct amounts to the fish. The diet should be nutritionally complete, containing vitamins and minerals. Commercial pellet diets for tilapia are best. Protein content should be 32 to 36 percent for 1gram to 25g tilapia and 28 to 32 percent for larger fish. Feeds and feeding are the major costs of production (Mc Ginty and Rackocy, 2005). Overfeeding wastes feed and money, and can cause water quality deterioration leading to stress and potential secondary diseases or parasites. Underfeeding reduces the growth rate, production, and profit (LSU, 2009).

In the same side, Daudpota *et al*., (2016) cited that, overfeeding of fish can over load the stomach and intestine, leading to decreases in digestive efficiency and reductions in feed utilization . Thus, the diet amount fed each time, or feeding frequency, may influence diet utilization. This is due to the fact that diet is directly applied to water and the non uptaken portion will be dissolved and lixiviated. Feed conversion ratio increase and environmental pollution are the results. Since fish juveniles uptake a high daily diet ratio to meet their nutritional requirement and thus ingest adequate amount of diet, and since high feeding frequency results in high daily diet intake ratio and small amounts of diet per feeding.

Sriyasak *et al*., (2015) cited that, fish farmers should take care to avoid over-feeding and manage water and sediments to prevent excessive accumulation of organic matter and waste at the bottom of ponds, which can influence other water quality parameters. Faulty feeding practices that are common in fish culture include: poor quality feed, incomplete feed, inadequate feeding, overfeeding, and feeding at the wrong time of the day. Many of these problems have no simple solution and some degree of stress will occur. In most cases, the management goal must simply be to reduce the total stress placed on the fish by handling and feeding practices (LSU, 2009).

The feed conversion ratio is the amount of feed required to produce 1 kg of fish; the lower the FCR, the better. The FCR in tilapia cage aquaculture systems in Africa is typically between 1.4 and 2.5. An FCR higher than normal can be the result of a high percentage of "fines" (feed dust) in the feed, variability in the reported nutrient content of the feed and/or a miscalculation of the number of fish remaining in the cage because of unrecorded mortality (Ofori *et al*., 2009). Generally, one of the characteristics that make tilapias suitable for simple hatchery production is that new fry do not need specialized live feeds such as artemia, rotifers or microalgae. They can be given commercial dry feeds (De Long *et al*., 2009).

Table -4 Suggested feed size and feeding rate of tank-cultured tilapia

Average weight (grams)	Standard feed size	Range of feeding rate (% biomass/day)
Post-hatch- 0.5	00, 0 and 1 crumble*	20-15
0.5-5	2 crumble	15-10
5-18	3 crumble	10- 5
18-75	4 crumble (1mm)	5-3
75-150	⅛ inch (3 mm)	3-1.5
150 to market	5mm	3-1.5

*Crumble; granulate with nutrient-rich for fry fish diet.
Source: De Long *et al*., (2009).

2-6-1: Food and feeding cost in fish culture

In aquaculture and fish culture, the major factors for fish production limiting production are fish nutrients, dissolved oxygen, pH, Co_2, N_2 and waste product accumulation (Alamin *et al*., 2017). In aquaculture, feed accounts for over 50 percent of the production cost (FAO, 2009). Feed is the major operational cost for most fish farms, accounting for 50-70% of the variable cost depending on farming intensity. De Silva and Hasan (2007) mention that, in semi-intensive and intensive aquaculture systems, feed costs typically account between 40 and 60% of production costs. The rising cost of commercial tilapia feed is therefore inducing some farmers to opt for alternative feeds. Some rotate commercial feed with kitchen and restaurant waste or chicken byproducts. Others replace tilapia feed with cheaper chicken or duck feed. Still others have begun formulating farm-made tilapia feed pellets (Ofori, 2009).

Today the science of fish nutrition has progressed to the point that balanced and complete diets can be formulated for the important commercial species. These complete diets are available from commercial feed mills and are essential to the health and growth. In fish cultures patterns like a small tanks and caged culture, fish in most cases will receive no natural food and, therefore, must have a nutritionally complete diet that has adequate protein and energy levels, is balanced in amino acids and in essential fatty acids, and is supplemented with a complete array of vitamins and minerals. Many commercial feed mills manufacture both complete and supplemental diets. The fish farmer must purchase a complete diet-one that is suitable for the species being cultured (LSU, 2009).

Fish culturists prefer to estimate feeding rates. There are two methods commonly used to determine proper feed amounts. One method estimates growth based on feed conversion and adjusts feeding rates weekly to this estimate. The second method estimates growth based on a sample of fish from the cage and adjusts feeding rates based on this sample (LSU, 2009). Fish will feed most aggressively near their preferred or optimum temperature and when oxygen levels are high. From a

temperature standpoint, warm water fishes will feed better as the temperature rises in late afternoon in the spring, but prefer mid-morning during the heat of the summer. Generally, fish will adapt to any feeding time as long as it is consistent (Masser, 1997).

Add to the above, Masser (1997) cited that, most studies have shown that fish will grow faster and have better feed conversion if their daily feed ration is divided into two feedings given at least 6 hours apart. Feeding rates for fish are calculated on a percent of body weight per day basis, based on the fish size and water temperature. Small fish consume a larger percentage of their body weight than larger fish, and all fish increase consumption as water temperature rises approaching optimum temperature. Small fingerlings will usually eat 4 to 5 percent of their body weight. After they reach advanced fingerling size, the rate will decrease to 3 percent and nearing harvest size will drop to only 2 percent or less.

Feed fish with locally available grasses, vegetation and other easily available items, like garlic, which contains disease prevention/control properties. Most households produce feed as byproducts of their daily activities: leaves of maize, cassava, banana, rice bran, sweet potato, duckweed, etc. Initially, when the fish are small, chop grass and vegetation into small pieces for feeding (IIRR *et al*., 2001). Soltan (2016) reported that good results can be obtained from sinking pellets, but extra care must be taken to ensure they are not wasted. Sinking pellets disintegrate quickly in water and have a greater tendency to be swept through the cage sides.

Mc Ginty and Rakocy (2005) write that, more than one feeding is needed each day; tilapia cannot consume their daily requirement of feed for maximum growth in a single meal of short duration. Fish less than 25 grams should be fed at least three times daily. Ofori *et al*., (2009) reported that, fish in cages should be fed with pelleted fish feed containing approximately 28-32% crude protein. Optimal feeding requires that smaller fish receive somewhat higher protein levels, but these feeds are not generally available in the region at this time. In many causes, fish were fed at a declining rate of

10% down to 1% of estimated average body weight based on the weekly or monthly average weight of a sample.

Generally in fish culture, the total daily ration should be divided over 2-3 feedings administered by hand, using either floating or sinking feed. Floating feed is usually more expensive than sinking but facilitates monitoring the feeding response. However, floating pellets are more expensive to prepare than sinking pellets. If sinking pellets are to be used, a tray can be placed into the cage and the pellets can be poured into the tray (Soltan, 2016).

2-7: Tilapia Fishes Culture in Tanks

Intensive tank culture offers several advantages over pond culture. High fish density in tanks disrupts breeding behavior and allow male and female tilapia to be grown together to marketable size, allow the fish culturist to easily manga stock, to exert relatively high degree of environmental control over parameter and else (Yakubu *et al*., 2012). De Long *et al*., (2009) mention that, using tanks allows the fish culturist to manage stocks and have a good deal of control over environmental parameters e.g., water temperature, DO concentration, pH, and waste that can be adjusted to promote maximum production. In addition, feeding and harvesting operations require less time and labor than in ponds. In small tanks, it is practical and economical to treat diseases with therapeutants applied to the culture.

Riche and Garling (2003) write that, tilapia are well suited for culturing in ponds, cages, tanks, or raceways. Tank culture has the added benefit of reducing time and labor required for harvesting and feeding. Indoor tank culture is the preferred method when sufficient warm water is not available due to climatic conditions. De Long *et al*., (2009) told that, Tilapia have a number of characteristics that make them attractive for tank culture, they can tolerate the crowding and handling that is required in a tank-based facility, their heavy slime coat protects them from abrasion and bacterial infections that would adversely affect many other fish. Tilapias grow well at high

densities in the confinement of tanks when good water quality is maintained, but they are also amazingly tolerant of poor or variable water quality.

Ali *et al*., (2006) told that, stocking density and, therefore, the volume of water per fish is a significant factor in determining optimum production in tank culture systems. Alamin *et al*., (2017) write that, in fish culture in tanks, it is indispensable to prepare the tanks before starting the work. Better condition of aquarium is essential for the better as well as survibility of fishes and the aquarium (tanks) must be set where sunlight penetration was available.

Although Alamin *et al*., (2017) explained that, green water indoor tank culture of tilapia is an appropriate method for commercially producing of tilapia in substitutional of different water bodies likes ponds, lakes, cages and reservoirs etc. that have environmental constraints such as land use conflicts, source of water, water quality and sub optimal temperatures, where a greenhouse could be used to control temperature with minimizing the all possible constrain.

Alamin *et al*., (2017) use a green water technology (GWT) system in indoor tanks to stock Nile tilapia, rui, catla and common carp, with no artificial feed was provided from stocking to harvest. GWT culture of tilapia with Indian major or exotic carps indicates that GWT has potential profit due to high productivity; average 150.99± 0.5g/tilapia within 120 days and no fertilization and feeding costs. In the other side, in some tank culture, the cost of pumping water and aeration or oxygenation increase unit production (De Long *et al*., 2009).

2-8: Effect of Stocking Densities, Feed Frequencies and Feed Rates on Chemical Composition of *O. niloticus* in Culture

Yakubu *et al*., (2013) study the effect of stocking density on survival and body composition of *O. niloticus* in semi flow-through culture system. He fined that, there was significant difference only in dry matter composition (DM) among the three stocking densities. Khattab *et al*., (2004) study the growth response and body composition of *O. niloticus* (1.8-2.5 g/fish) at two stocking densities (15 and 30

fish/100 liters). He found that, crude protein, total lipids and ash were significantly affected by stocking density.

Daudpota *et al*., (2016) investigate the effect of feeding frequency on growth performance, and body composition of juvenile *O, niloticus* (initial body weight 1.0g) reared in low salinity water. Fish were fed at four frequencies: two, three, four and five times a day. Results showed that significantly higher weight gain, specific growth rate and feed conversion ratio were observed at feeding frequency of four to five times daily. Moisture, protein and ash contents of whole body were not affected by feeding frequency. Lipid content of fish fed four and five times daily was significantly higher than that of the fish fed one and two times daily.

El-Saidy and Gaber (2005) examined the effect of three feeding levels (1%, 2% and 3% body weight (BW) day $^{-1}$) on growth performance and body composition of *O. niloticus* average initial weight 61.9± 6.03g per fish in concrete tanks. The results revealed that there was significant increase in growth rate with increasing feeding levels. The same trend was also observed for mean BW (g), specific growth rate (% day^{-1}), feed conversion ratio and survival rate (%). Whole fish fat and energy contents were not significantly influenced ($P > 0.05$) by feeding levels. Protein and ash contents were significantly ($P \leq 0.05$) influenced by feeding level.

CHAPTER THREE

3. MATERIALS AND METHODS

3-0: Study Area

The study was conducted at the fish and aquatic organisms research center (fish hatchery) in the college of science and technology of animal production at Sudan University of Science and Technology (Kuku comp), for a period of seventy (70) days from 13Nov. 2015 to 21Jan. 2016. Twenty seven (27) rectangle plastic tanks used, the tanks were set indoor and arranged in rows. (Photo 2).

3-1: Experimental Design

3-1-1: Effects of stocking densities on growth performance of *O. niloticus* fingerlings in tanks culture

Fingerlings of mixed sex of *O. niloticus* 1.32 ± 0.28g (mean weight ± standard deviation) obtained from the fish hatchery. Prior to start of the experiment, fingerlings were acclimated in the plastic tanks for two days. Three stocking densities (SDs) established; SD1 (10 fish/tank), SD2 (15 fish/tank) and SD3 (20 fish/tank), all tanks measuring (40×46×64cm, W×H×L) containing proximately 100 liters (L) (Ali *et al*., 2006) and (Khattab *et al*., 2004) of tap water with three replicated per treatment (Yakubu *et al*., 2012).

Commercial floating pellets of 35% protein taken from a commercial feed company used. Feeding done by hand during two feeding period 10:00 and 16:00 (each daily ration divided in to two portion (Wang *et al*., 2006) at 9% body weight (Riche and Garling, 2003) for five days a week (Khattab *et al*., 2004). 30% of the water volume from each tank replaced twice daily by siphoning out residual feed and fecal matter (Aderolu *et al*., 2010). Supplemental aeration by air stones was providing to maintain in every tank. Fish mass increase was estimated every 10 days by weighting all number in each tank (Yakubu *et al*., 2012), and the feed rations adjusted accordingly (Riche and Garling, 2003). During the study period, dead fish (mortality) recorded and removed quickly. Seventy days post-stoking, all fish harvested, each stocking density

were weight and counted. By the end of the experiment, a proximate chemical composition of *O. niloticus* fingerlings for every stock density (SD1, SD2 and SD3) made.

Photo 2– Plastic tanks used to study growth performance of *O. niloticus* fingerlings at the fish hatchery in Sudan University of Science and Technology (Kuku camp)

3-1-2: Effects of feed frequencies on growth performance of *O. niloticus* fingerlings in tanks culture

The objectives of this experiment are to establish the optimum number of feeding frequencies of *O. niloticu*s fingerlings in a small tank culture; find out how feeding frequency affected growth performance and body compositions. *O. niloticus* fingerlings initial size (1.44 ± 0.33g) was distributed in nine experimental tanks (40×46×64cm) containing proximately 100 liters of tap water, at a density of 15 fingerlings per tank. After that, tanks were divided in to three treatments (Yakubu *et al*., 2012) based on feeding frequency (FF), such as feed frequency twice time a day^{-1} (FF1), three time a day^{-1} (FF2) and four time a day^{-1} (FF3) at three replications.

During study period, in case of FF1 feed provided two times per day at 10:00 and 16:00 hours, in FF2 feed provided three times per day at 10:00, 14:00 and 16:00 hours and in FF3 feed provided four times per day at 10:00, 12:00, 14:00 and 16:00 hours. During the this experiment, *O. niloticus* fingerlings were fed handily commercial

floating pellets of 35% protein taken from a commercial feed company used for five days a week (Khattab *et al*., 2004) with a diet counted 9% of their body weight. Two times per day about 30% of the water volume from each tank replaced (siphoning out residual feed and fecal matter) as in (FAO, 2014) and oxygen pump with air stones used to create DO. Fish mass increase estimated every 10 days and the feed rations adjusted accordingly. Dead fish were recorded and removed quickly. Seventy days post-stoking, all fish harvested, each feed frequencies were weight and counted. By the end of the experiment, a proximate chemical composition of *O. niloticus* fingerlings for every feed frequency made.

3-1-3: Effects of feed ratio on growth performance of *O. niloticus* fingerlings in tanks culture

Three feeding trials were created to evaluate the effects of feeding ratio (FR) on growth performance of *O. niloticus* fingerlings. The objectives of this study are firstly, to establishing the optimum amount of feed ratio of *O. niloticus* fingerlings in a small tank culture. Secondly, to study the effect of feed rate on growth performance and body chemical compositions of *O. niloticus* fingerlings in a small tanks culture.

Fingerlings of *O. niloticus* with average weight of (1.49 ± 0.28g) were obtained from the concrete pond in the hatchery and they were transport to the experimental tanks. *O. niloticus* fingerlings were acclimatized for two days in the plastic containers (tanks) before commencing the experiment. Nine plastic tanks 40×46×64cm containing proximately 100 liters of tap water were divided into three treatments based on feed rate (FR). A diet counted 5%, 9% and 13% of *O. niloticus* fingerlings body weight represent FR1, FR2 and FR3 respectively, each treatment having three replications, each daily ration divided into two portion at 10:00 and 16:00. During the exponential period (70 days), fingerlings were fed by hand a commercial floating pellets containing 35% protein for five days a week (Muin *et al*., 2015). Two times per day about 30% of the water volume from each tank replaced siphoning out to residual feed and fecal matter (Aderolu *et al*., 2010) and oxygen pump with air stone used to create DO. Fish mass increase estimated every 10 days and the feed rations adjusted

accordingly to the increasing in body weight in every tank. Dead fish recorded and removed quickly. Seventy days post-stoking, all fish harvested, each feed ratio were weight and counted. By the end of the experiment, a proximate chemical composition of *O. niloticus* fingerlings for every feed rate made.

3-2: Growth Performance Analysis:

Fish growth performance for each above treatment (stocking densities, feed frequencies and feed ratio) was evaluated basing on specific growth rate (SGR), daily weight gain (DWG), food conversion ratio (FCR), feed conversion efficiency (FCE), and survival rate (SR) using the following formulas:

i. SGR (%) day^{-1} = [(Ln. final weight – Ln. initial weight)/time (days)] ×100 (Brown, 1957).

ii. Weight gain (WG) = final weight – initial weight (Schmalhousen, 1926)

iii. Daily Weight Gain ($gday^{-1}$) = $\frac{\text{mean final weight (g) – mean initial weight (g)}}{\text{duration of nursing (days)}}$

iv. FCR = $\frac{\text{amount of dry food intake (g)}}{\text{fresh weight gain in fish (g)}}$ (Utne, 1978)

v. Feed conversion efficiency = $\frac{\text{weight gain (g)}}{\text{total feed given (g)}} \times 100$ (Uten, 1978)

vi. Survival rate (SR) (%) = (final number of fish/ initial number of fish) ×100

3-3: Water Physiochemical Parameters

3-3-1: Physical measurements

During the study period physical parameters of the water in tanks as water temperature (°C) which recoded by using a Celsius thermo meter, was recorded daily at 11: 00 am during study period. The water pH recorded with a portable digital pH meter (MICRO- TEMP, pH 500) every ten days at 11:00 am during the whole cultured period. These parameters done for all of the stocking densities feed frequencies and feed rates experiments.

3-3-1-1: Temperature levels in water tanks

Concerning water temperature which measuring daily during study period at 11:00am, three temperature levels were established or created in water tanks during study period; temperature degree from 18- 20°C (temperature level "1"), which recorded on the first thirty days of the study, temperature degree from 16- 17 °C (temperature level "2"), which recorded from day 31^{th} to day 50^{th}, and temperature degree from 17- 22 °C (temperature level "3"), which recorded from day 51^{th} to the end of the experiment (day 70^{th}).

3-3-2: Chemical measurements

Dissolved oxygen (DO) concentrate in water tanks measured by a digital DO meter (DO-5509, Lurton Electronic Enterprise Co. Ltd., Taipei, Taiwan). Other chemical parameters such as ammonia (NH_3), phosphorus (P), nitrite (No_2) and nitrate (No_3) measured using API saltwater master test kit (model RM000741-00-0310, USA). These water parameters regularly monitored every ten days at 11:00 am during the whole culture period. These above parameters done for the three experiments.

3-4: Proximate Chemical Composition of Whole *O. niloticus* Body

At the end of the three experiments (stock densities, feed frequencies and feed rates), about nine fish from each treatment (3×3 replicate) were attended randomly for total body chemical composition analyses. The chemical compositions of the fish meat (Nile tilapia fingerlings) as moisture content was obtained by drying the sample overnight at 105 ºC, ash was quantified after combustion for 16 h at 550 ºC, crude protein content was determined by the Kjeldahl method (AOAC, 2000) using a conversion factor of 6.25, and crude lipid was determined with the soxhlet extraction method (AOAC, 2000) using ethyl ether and nitrogen free extract (NFE) of diet contents were analysis according to ISO 1442 (1973).

3-5: Statistical Analysis

The mean final body weights and weight gain, the mean water physiochemical parameters and the proximate chemical composition of whole *O. niloticus* fingerlings

body in each experiments; stocking densities, daily feed frequencies and daily feed rates were subjected to statistical comparisons using one-way ANOVA. All statistical analyses were carried out using the SPSS program (SPSS v7.5 Inc. 1997). Results and Mean differences between treatments were tested for significance at the 5% probability level using Duncan's new multiple range test (Duncan, 1955).

CHAPTER FOUR

4. RESULTS

4-1: Factors Affecting Growth of *O. niloticus* in Tanks Culture

4-1-1: Effects of stocking densities and physiochemical parameters on growth performance of *O. niloticus* fingerlings in tanks.

The effects of different levels of stocking densities on growth and some other biological indices of Nile tilapia *O. niloticus* fingerlings rearing for seventy days are shown in (Fig. 1) and. The graphic curve of the three stocking densities 10 fish/ tank (SD1), 15 fish/ tank (SD2) and 20 fish/ tank (SD3) during the study period obvious show isometric growth rates among this population densities under study, with a clear indication of low growth rate in the period between sampling 3 to sampling 5 (about 20 days), and then returned to the relative rise in growth rate until the end of the experimental for the SD1, SD2 and SD3.

The study pointed out, there is a significant difference (Duncan's, 1955) in term of final weight (FW) (harvested weight) between the SD1, SD2 and SD3, in which SD2 score the highest value (38.67 ± 7.15g) following by SD3 (31.03 ± 3.48g) and finally SD1 (26.67 ± 3.23g) (Fig. 2). For the daily weight gain (DWG) (Fig. 3), appeared higher values for SD2 0.28g. day-^{1}, SD3 0.21g. day-^{1} and SD1 0.19g. day-^{1} respectively, while there is no significant difference ($P > 0.05$) for feed conversation ratio (FCR) (Fig. 4), specific growth rate (SGR) (Fig. 5) and feed conversion efficiency (FCE) (Fig. 6), in which in all factors above, the highest value score with SD2, SD1 and SD3 respectively. Concerning the survival rate (SR) are similar and there is no significant difference ($P > 0.05$) between the three treatments SD1, SD2 and SD3 (Fig. 7).

The analysis of the physiochemical parameter within the three stocking densities trial SD1, SD2 and SD3 as dissolved oxygen (DO), temperature (°C), pH degree,

phosphors (P), nitrite (No_2) nitrate (No_3) and ammonia (NH_3) indicted no any significant difference (P> 0.05) within the three stocking densities (Table 5).

As result of the great influence of temperature on feed rate and the efficiency of growth, three temperature levels were found during the study period, the amount of daily weight gain for these temperature levels showed clear differences. The highest value of the DWG extent to temperature level "1" (18- 20 °C), then temperature level "3" (17- 22 °C) and finally temperature level "2" (16- 17 °C) obtained 0.91g/day, 0.85g/day and 0.25g/day respectively (Fig. 8).

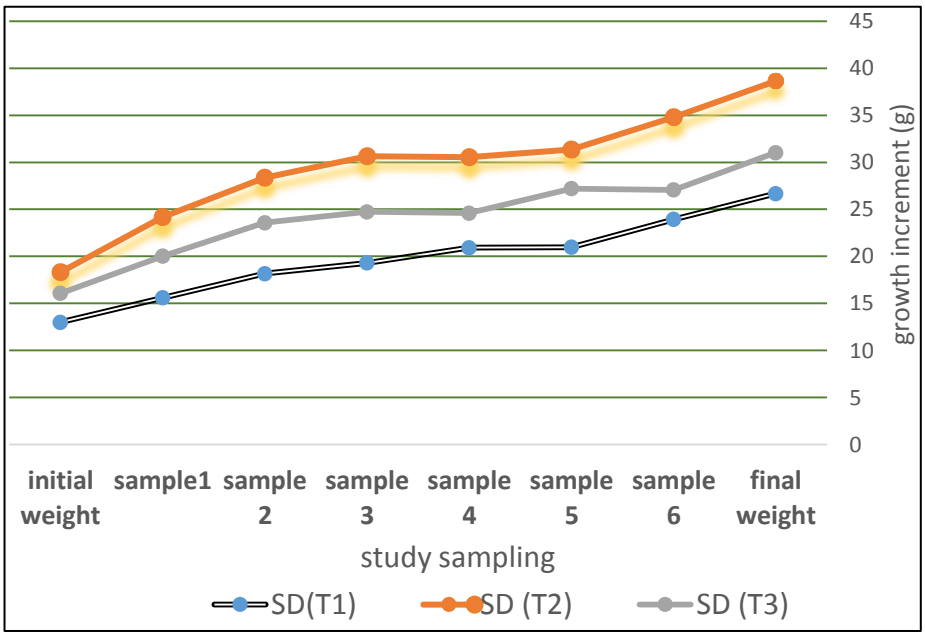

Fig. 1- Growth increment (g) of *O. niloticus* fingerlings at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish/ tank for 70 days

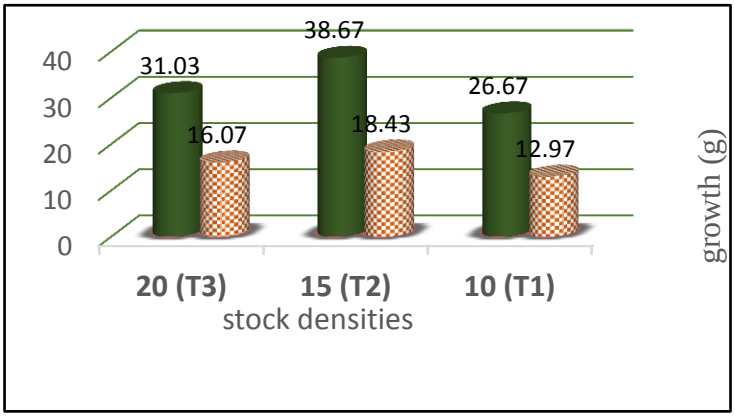

Fig. 2- Initial weight and final weight (g) of *O. niloticus* fingerlings at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish/ tank for 70 days

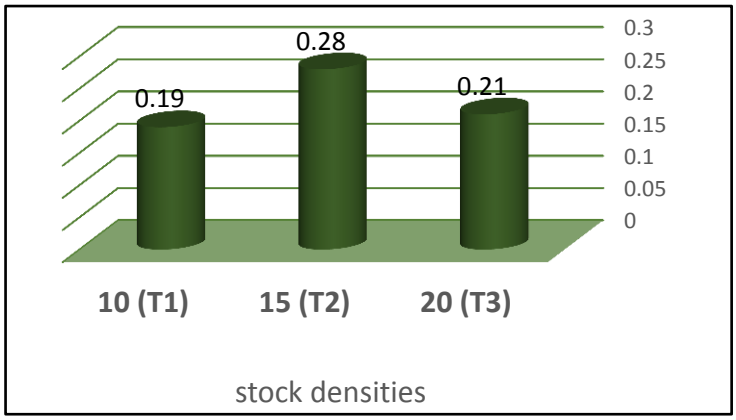

Fig. 3- Daily weight gain (g day-[1]) of *O. niloticus* fingerlings at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish/ tank for 70 days

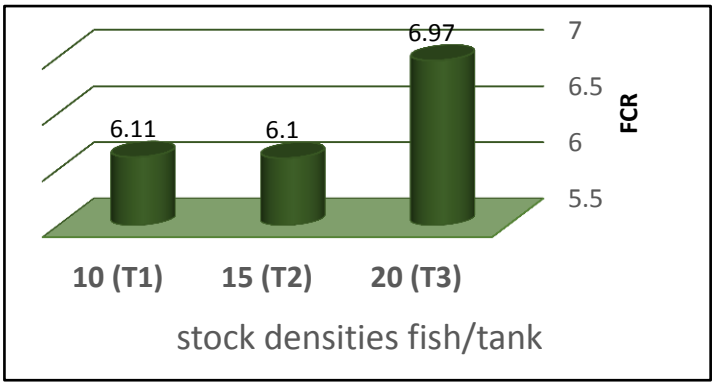

Fig. 4- Feed conversion ratio of *O. niloticus* fingerlings at three stocking densities; 10 fish (SD1), 15 (SD2) and 20 (SD3) fish/ tank

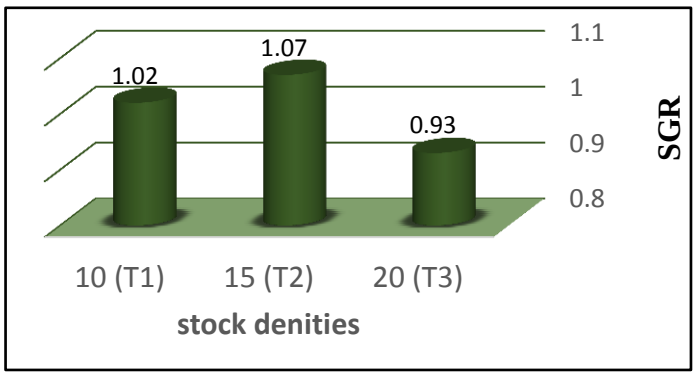

Fig. 5- Specific growth rate of *O. niloticus* fingerlings at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish/ tank for 70 days

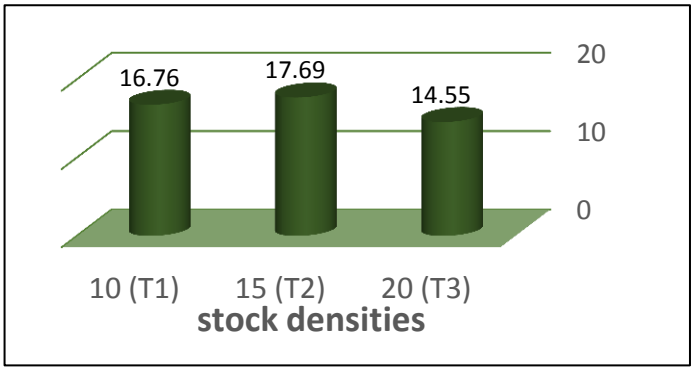

Fig. 6- Feed conversion efficiency of *O. niloticus* fingerling at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish/ tank for 70 days

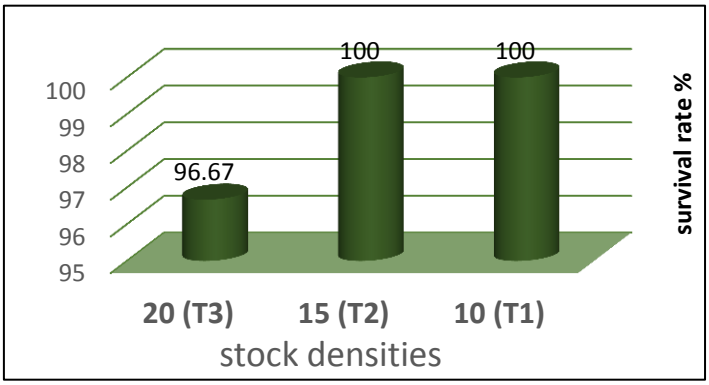

Fig. 7- Survival rate of *O. niloticus* fingerlings at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish/ tank for 70 days.

Table 5- Mean physiochemical parameters at stocking densities; 10 fish/tank (SD1), 15 fish/tank (SD2) and 20 fish/tank (SD3) for 70 days

	DO mg/L	pH	Tem. (°C)	P mg/L	NO2 mg/L	NO3 mg/L	NH3 mg/L
SD1	7.6	7.6	18.6	0.1	0.3	0.3	0.8
SD2	7.7	7.5	18.4	0.3	0	0.2	1.3
SD3	7.4	7.5	18.6	0.2	0.1	0.1	1.4

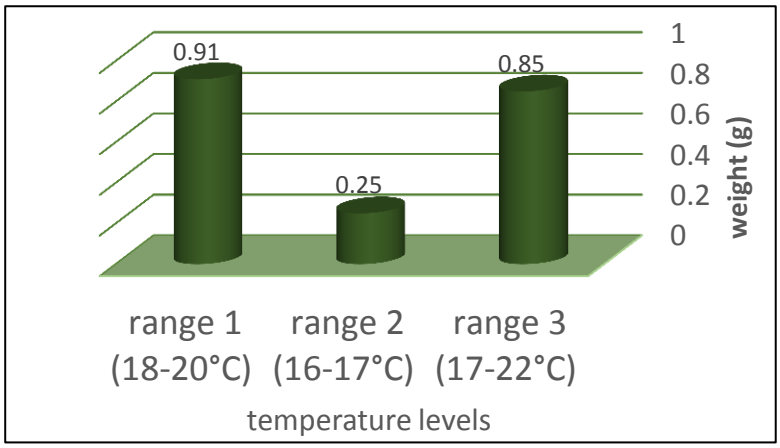

Fig. 8- Daily weight gain (g. day-^{1}) in the three temperature levels; level "1" (18-20°C), level "2" (16-17°C) and level "3" (17-22°C) for all stocking densities groups

4-1-2: Effects of feed frequencies and physiochemical parameters on growth performance of *O. niloticus* fingerlings in tanks culture.

The figure below demonstrating the growth of Nile tilapia fish (*O. niloticus*) fingerlings in three different levels of feed frequency illustrated existence of higher growth rate in the treatment FF2 (three times a day) of the initial weight and sample 2 with rate exceeding both FF3 (four time day-^{1}) and FR1 (two time a day). Then an increase occurred in growth rate relatively slow between sample "2" and sample "3" in all treatment feed frequency. A limited decrease occurred in growth rate of all feed frequency between the sample "3" and ample "4", then this is followed by relatively limited increase in growth rate in feed frequencies FF1, FF2 and FF3 tell end of the study. Generally, the figure shows a relative significance in the treatment FF2 compare with FF1 and FF3, along with a significant difference in initial weight between treatments FF1 and the other two treatments FF2 an FF3 (Fig. 9).

The study of fig. 10 which shows the relation between initial weight and final weight, no significant difference ($P > 0.05$) appears in final weight for each treatments FF1, FF2 and FF3; along with considerable increase in initial weight of FF1 ($P < 0.05$) over the other treatments, this indicates the significance of the treatment FF2 and FF3 over the rest treatment. Daily weight gain (Fig. 11) showed absence of significance difference among all the treatments ($P > 0.05$). Food conversion ratio generally is

lower (Fig. 12) illustrate the decrease in the value of this factor along with the existence of non-significant difference for FF1, FF2 and FF3. For specific growth rate (SGR), they is no significant difference (P> 0.05) among different feed frequency models FF1 (two time a day), FF2 (three time day-^{1}) and FF3 (four times a day-^{1}), but there are some preferences (P> 0.05) for the feed frequency model FF2 compared with the other feed frequency models (Fig. 13).

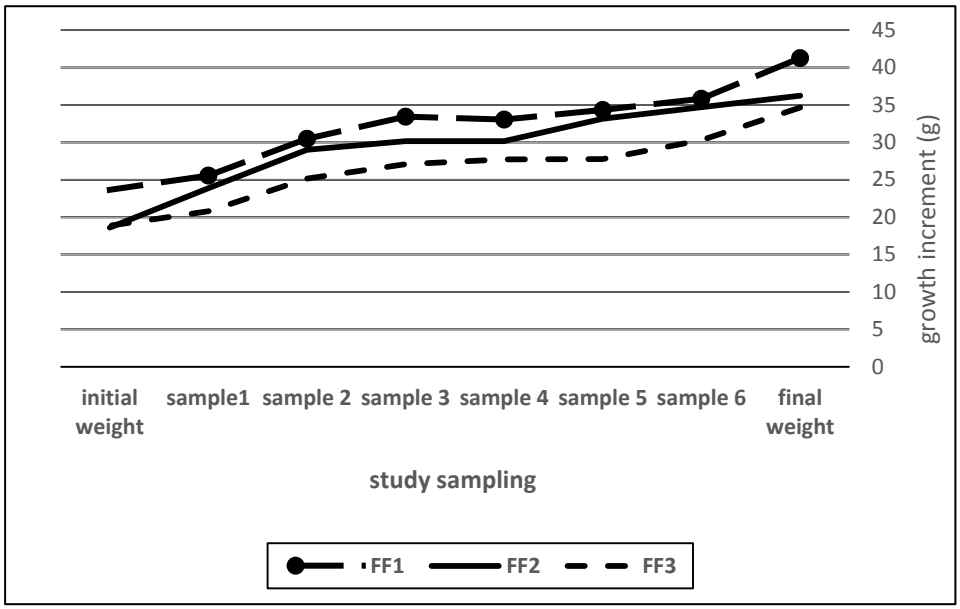

Fig. 9- Growth increment (g) of *O. niloticus* fingerlings fed at; two times/day (FF1), three times/day (FF2) and four times/day (FF3) for 70 days

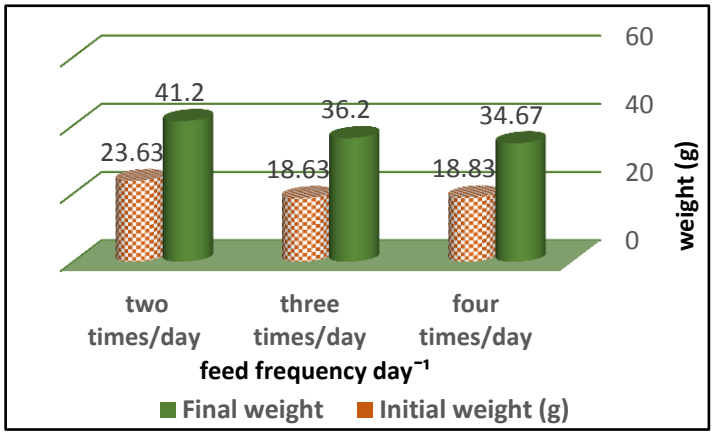

Fig. 10- Initial weight and final weight (g) of *O. niloticus* fingerlings fed at; two times/day, three times/day and four times/day for 70 days

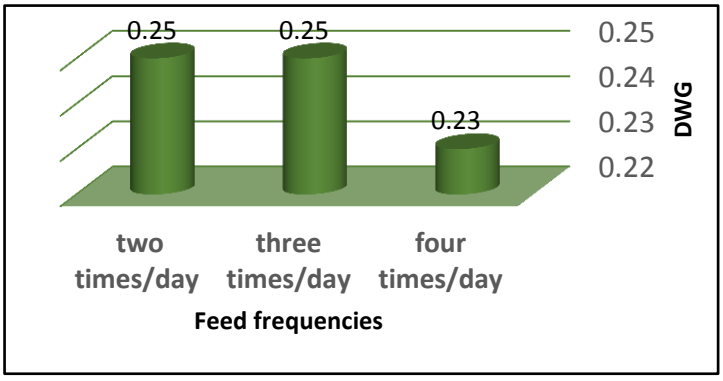

Fig. 11- Daily weight gain (DWG) (g) of *O. niloticus* fingerlings fed at; two times a day^{-1} (FF1), three times a day^{-1} (FF2) and four times a day (FF3) for 70 days

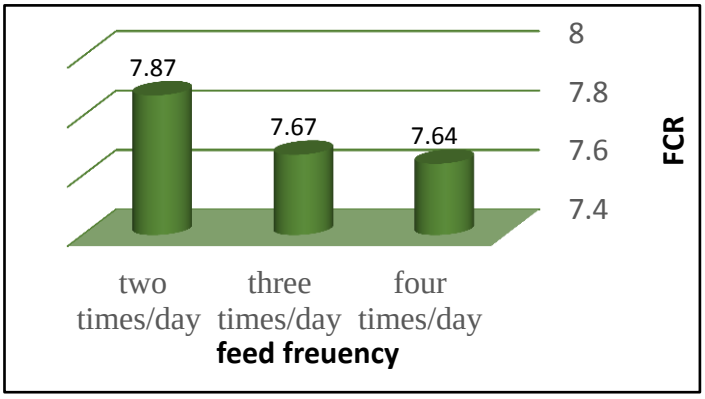

Fig. 12- Feed conversion ratio (FCR) of *O. niloticus* fingerlings fed at; two times (FF1), three times (FF2) and four times (FF3) a day for 70 days

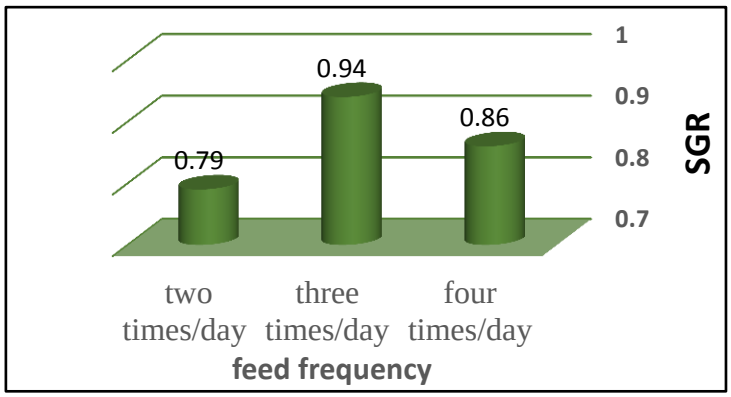

Fig. 13- Specific growth rate of *O. niloticus* fingerlings fed at; two times (FF1), three times (FF2) and four times (FF3) a day for 70 day

Like a specific growth rate, the result of the food conversion efficiency (FCE) indicates that there is no significant difference (P> 0.05) among different feed frequency models FF1, FF2 and FF3, with some preferences (P> 0.05) for the feed frequency model FF3 compared with the other feed frequency models (Fig. 14). Survival rate result (Fig. 15) declares no significant differences (P> 0.05) among feed frequency model due to different feed frequency treatments two, three and four times a day-^{1} respectively.

The analysis of the physiochemical parameter within the daily feed frequencies trials FF1, FF2 and FF3 as DO, temperature, pH degree, phosphors, nitrite, nitrate and ammonia show no any significant difference (P> 0.05) within the three trials (Table 6). For the three temperature levels; temperature levels; level "1" (18- 20 °C), level "2" (16- 17 °C) and level "3" (17- 22 °C), the results bring out the great influence of temperature degree on daily weight gain, in which the temperature level "1" get the highest value in daily weight gain 0.98g./day, followed by temperature level "3" 0.84g/day. The great decline in daily weight gain observed in temperature level "2" (16-17 °C) 0.23g per day (Fig. 16).

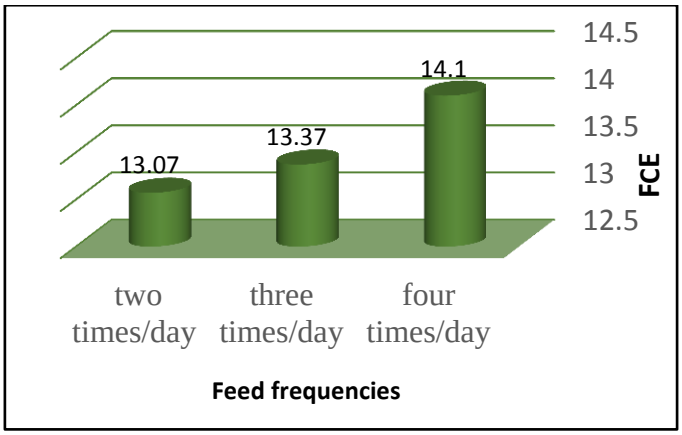

Fig. 14- Food conversion efficiency of *O. niloticus* fingerlings fed at; two times/day (FF1), three times/day (FF2) and four times/day (FF3) for 70 days

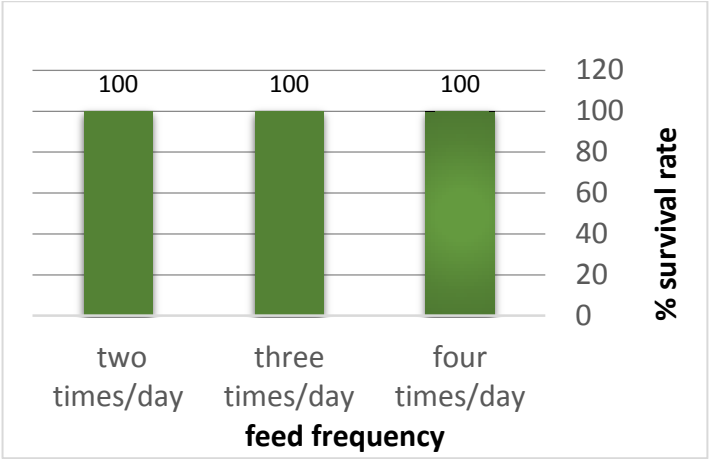

Fig. 15- Survival rate (SR) of *O. niloticus* fingerlings fed at; two times day-¹ (FF1), three times day-¹ (FF2) and four times day-¹ (FF3) for 70 day

Table 6- Mean physiochemical parameters at feed frequencies; two time a day (FF1), three time a day (FF2) and four time a day (FF3)

	DO mg/L	pH	Temp. (°C)	P mg/L	NO2 mg/L	NO3 mg/L	NH3 mg/L
FF1	7.8	7.5	18.6	0.2	0.1	0.3	1.1
FF2	8	7.5	18.6	0.1	0.1	0.3	1.1
FF3	8.2	7.5	18.5	0.1	0	0.4	1.2

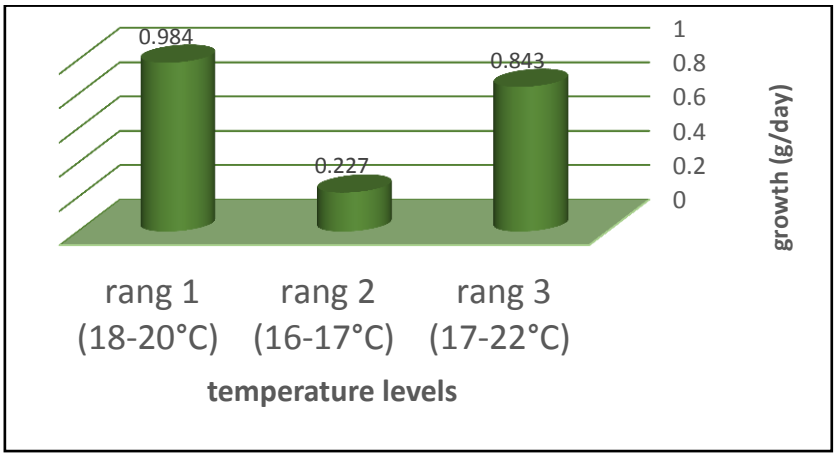

Fig. 16- Daily weight gain (g. day-¹) in three temperature levels; temperature level "1" (18-20 °C), level "2" (16-17 °C) and level "3" (17-22 °C) for all feed frequencies

4-1-3: Effects of feed rates and physiochemical parameters on growth performance of *O. niloticus* fingerlings in tanks culture

The growth curve transecting of feed rates models; 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3) showed increasing in growth rate from initial weight even sample 3 for all feed models FR1, FR2 and FR3, between sample "3" and sample 5 a decline in growth rate curve is notice for feed models FR2 and FR3 compared to feed model FR1 which continue increasing to a constant growth rate. From sample "5" to final weight (sample 7), growth rate return to a greater increase than the previous period (sample 3 to sample 5) of all three feed rate models (Fig. 17). Concerning initial weight (IW), final weight (FW) of the three feed rate models, the result showed that there is significant difference ($P< 0.05$). In the side of the final weigh, there is a significant difference ($P< 0.05$) between the three feed rate models FR1, FR2 and FR3 in which the feed rate 13% (FR3) score the highest value (46.1g) flowed by the feed rate 9% (42.3g) (Fig. 18). For the total feed given (TFG), the study pointed out that there is a significant differences ($P< 0.05$) among feed rate models, where was the higher value return for treatment FR3 (215.9g) followed by treatment FR2 (136.4 g), then treatment FR1 (69.2g) (Fig. 19).

For the DWG, the statistical analysis proved that, there is no significant difference ($P> 0.05$) among feed rate models FR1, FR2 and FR3 (Fig. 20). The study of food conversion ratio (FCR) indicated a decline in this factor value to all feed rate models; 5% (FR1), 9% (FR2) and 13% (FR3) with a significant difference ($P< 0.05$) to the feed rate model 5% which gain the best value 5.11 compared to others (Fig. 21). The analysis of SGR observed there was no significant differences ($P> 0.05$) among the feed rate model FR1, FR2 and FR3, but the supreme values 0.87, 0.83 score with the treatments 13% (FR3), 9% (FR2) respectively (Fig. 22).

The study of the feed conversion efficiency (Fig. 23) for the three feed rate models FR1, FR2 and FR3, pointed out that is a significant difference ($P< 0.05$) between the three feed rate models, in which the highest value observed with 5% (FR1). The result

of survival rates indicate that, there is no significant differences (P> 0.05) between the three feed rate models under this study (Fig. 24).

Like the above two treatments, physiochemical parameter within the daily feed ratio trials FR1, FR2 and FR3 demonstrated no any significant difference (P> 0.05) within the three trials (Table 7). For the same three temperature levels above, the result show the great influence of temperature degree on daily weight gain, in which the temperature level "3" (17-22 °C) gain the highest value in daily weight gain 1.08g per day, followed by temperature level "1" (18-20 °C) 0.86g. per day. The great decline in daily weight gain observed in temperature level "2" (16-17 °C) 0.31g per day (Fig. 25).

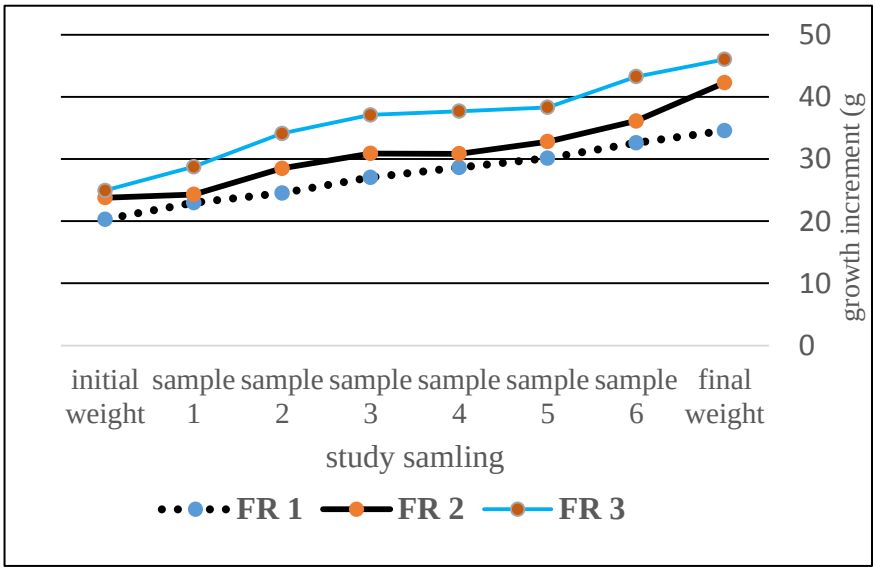

Fig. 17- Growth increment (g) of *O. niloticus* fingerlings fed at 5% (FR1), 9% (FF2) and 13% (FF3) from body weight for 70 days

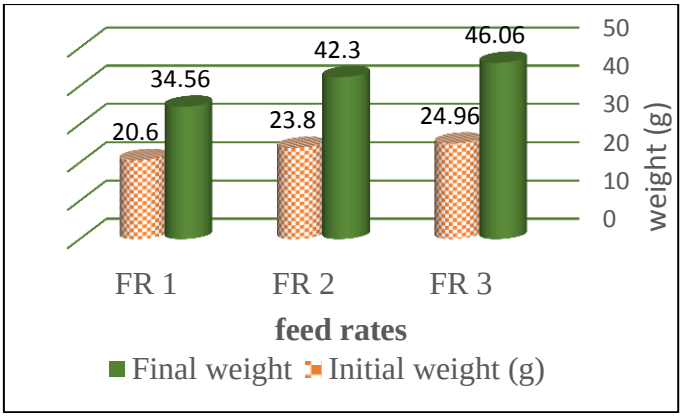

Fig. 18- Initial weight and final weight (g) of *O. niloticus* fingerlings fed at 5% (FR1), 9% (FR2) and 13% (FR3) from body weight

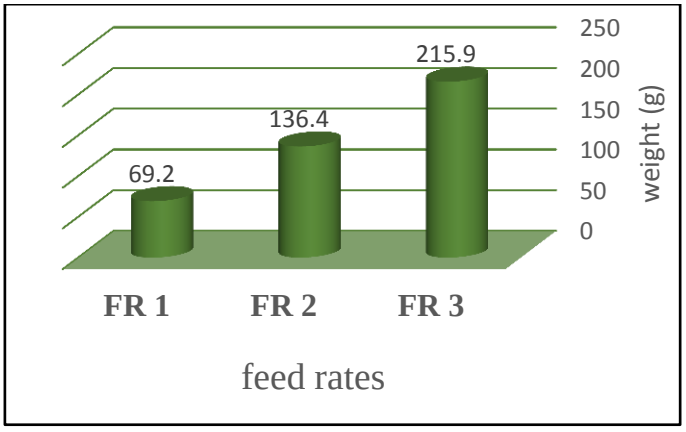

Fig. 19- Total feed given (g) of *O. niloticus* fingerlings fed at; 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3)

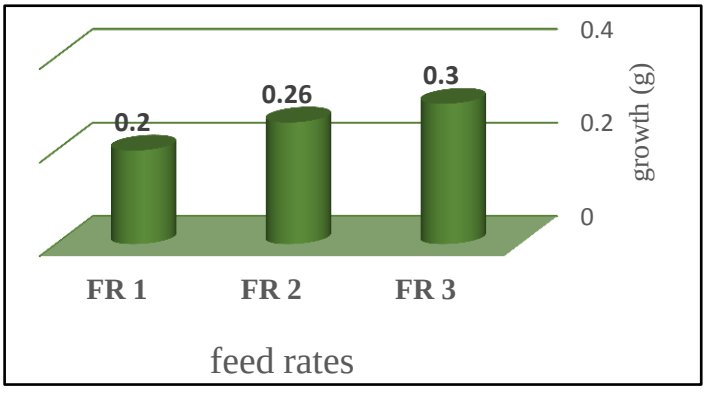

Fig. 20- Daily weight gain (g) of O. *niloticus* fingerlings fed at; 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3)

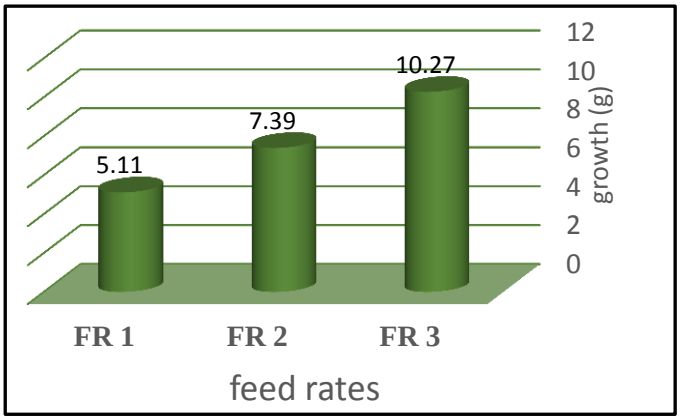

Fig. 21- Feed conversion rate of *O. niloticus* fingerlings fed at 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3)

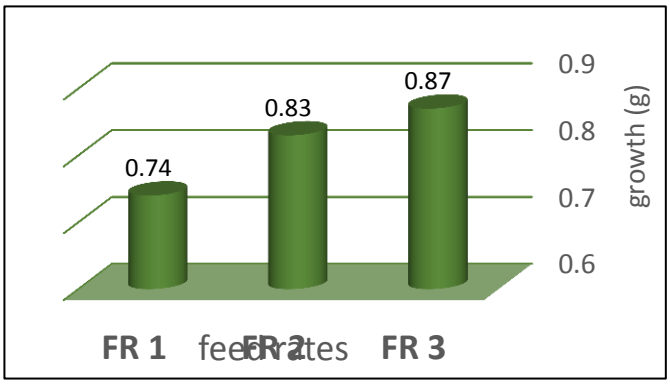

Fig. 22- Specific growth rate (SGR)) of *O. niloticus* fingerlings fed at 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3)

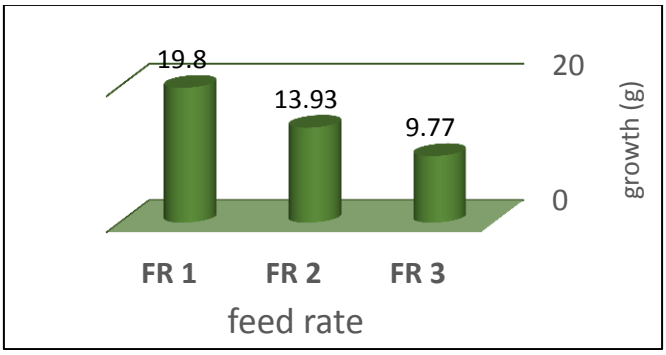

Fig. 23- Food conversion efficiency (FCE) of *O. niloticus* fingerlings fed at 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3)

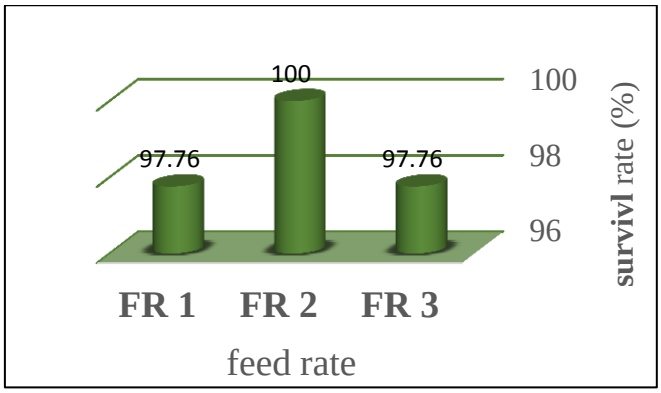

Fig. 24- Survival rate (SR) of *O. niloticus* fingerlings fed at 5% from body weight (FR1), 9%from body weight (FR2) and 13% from body weight (FR3) for 70 days

Table 7- Mean physiochemical parameters at feed rates; 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3)

Mean physicochemical parameter							
	DO mg/L	**pH**	**Temp. (°C)**	**P mg/L**	**NO2 mg/L**	**NO3 mg/L**	**NH3 mg/L**
FR1	8.1	7.5	18.5	0.2	0	0.4	1.1
FR2	8.1	7.5	18.7	0.2	0.1	0.2	1.1
FR3	8.1	7.4	18.7	0.2	0	0.3	1.5

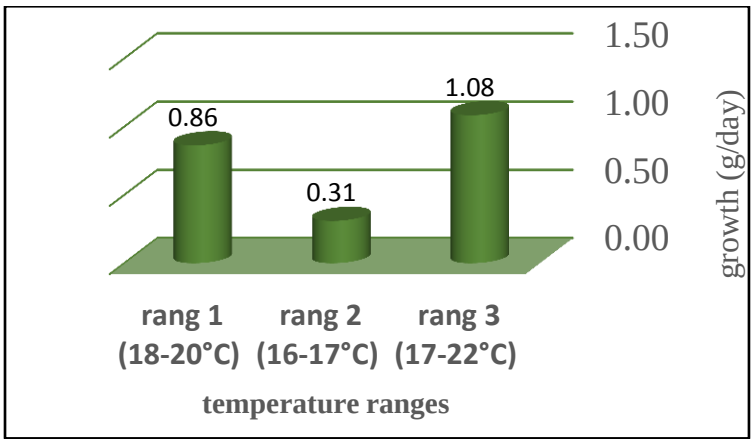

Fig. 25- Daily weight gain (g. day-¹) in three temperature levels; level "1" (18-20°C), level "2" (16-17°C) and level "3" (17-22°C) for all feed rates groups

Table 8- Physiochemical parameters values (average and means) at the three treatments; stock density, feed frequency and feed rate during the study period

Physiochemical parameter (average and means)			
	Stocking density	**Feed frequency**	**Feed ratio**
DO (mg/L)	(7.4- 7.7) **7.6**	(7.8- 8.2) **8**	**8.1**
pH	(7.5- 7.6) **7.5**	**7.5**	(7.4- 7.5) **7.5**
Temperature (°C)	(18.4- 18.6) **18.5**	(18.5- 18.6) **18.6**	(18.5- 18.7) **18.6**
P (mg/L)	(0.1- 0.3) **0.2**	(0.1- 0.2) **0.13**	**0.2**
No_2 (mg/L)	(0.0- 0.3) **0.13**	(0.0- 0.1) **0.1**	(0.0- 0.1) **0.3**
No_3 (mg/L)	(0.1- 0.3) **0.2**	(0.3- 0.4) **0.3**	(0.2- 0.4) **0.3**
NH_3 (mg/L)	(0.8- 1.4) **1.2**	(1.1- 1.2) **1.1**	(1.1- 1.5) **1.2**

4-2: Proximate Chemical Composition of *O. niloticus* Fingerlings Body

4-2-1: Effect of stocking density on chemical composition of *O. niloticus* fingerlings in tanks culture

The whole body of *O. niloticus* fingerlings cultured in tanks under three stocking densities trials;10 fish tank-¹ (SD1), 15 fish tank-¹ (SD2) and 20 fish tank-¹ (SD3) was analyzed to determine the moisture, dry meat, ash, crude protein, ether extract (total fats) and nitrogin free extract (NFE). For all above chemical composition except crude protein, the result showe no significant differences ($P > 0.05$) due to different stocking densities, while for crude protein there is significant differences ($P < 0.05$). The highest value obtaine in group with 10 fish tank-¹ (SD1) as acheived (31.15 ± 0.21g/kg), while the lowest value was recorded in group with 15 fish tank-¹ as (30.1 ± 0.1g/kg) (Table 9).

4-2-2: Effect of feed frequencies on chemical composition of *O. niloticus* fingerlings in tanks culture

The analysis of the chemical composition of *O. niloticus* fingerlings at three feed frequency levels in tanks culture indicated that, there is no significant differences (P> 0.05) for all of the moiture, ash, dry meat, crude protein and crude fat due to feed frequency two (FF1), three (FF2) and four (FF3) time per day. Concerning nitrogen free extract (NFE) concentrate in the three frequency levels, the result obesrved that NFE was a significantly higher (P< 0.05) in trials FF1 (28 ± 0.14%) and FF2 (27.2 ± 1.63%) than in FF3 (18.25 ± 0.92%) (Table 10).

4-2-3: Effect of feed rates on chemical composition of *O. niloticus* fingerlings in tanks culture

The values of chemical compoition of Nile tilapia *O. niloticus* fingerlings fish meat under three feed rate levels; 5% from body weight (FR1), 9% from body weight (FR2) and 13% from body weight (FR3) was obtained as in (Table 11). Concerning all of the mioture, dry meat, ash, crude protein and crude fat, analysis obtain no significant differences among the three trials (P> 0.05), the only excepition was NFE concentrate which showed a significant different (P< 0.05) with a higher values seen in treatments modiles FR3, followed by FR2 and FR1 respectively.

Table 9- Chemical composition of *O. niloticus* fingerlings at stocking densities; 10 fish/tank (SD1), 15 fish/tank (SD2) and 20 fish/tank (SD3).

Chemical composition	Stocking densities		
	10 fish/ tank (SD1)	15 fish/ tank (SD2)	20 fish/ tank (SD3)
Moisture (%)	*66.5±2.12	67.5±0.71	68±0.00 $_n$
Dry matter (%)	33.5±2.12	33±1.41	32±0.00 $_n$
Ash , g (kg DM) $^{-1}$	2±0.00	1.9±0.14	1.95±0.07$_n$
Crude protein g(kg DM)$^{-1}$	31.15±0.21a	30.1±0.14b	31.1±0.21a
Crude fat, g (kg DM^{-1}	6.9±0.14	6.65±0.21	6.4±0.14 $_n$
NFE	26.45±2.19	27±1.41	28.6±0.14 $_n$
* Mean ± standard deviation & a, b superscript letters within the same row means significant difference according to Duncan's multiple range test, n = not significant difference. NFE = 100- (protein + lipid + ash + fiber)			

Table 10- Chemical composition of *O. niloticus* fingerlings at feed frequencies; two time a day (FF1), three time a day (FF2) and four times a day (FF3)

chemical composition	Feed Frequencies (FF)		
	two times per day	three times per day	four times per day
Moisture (%)	67±0.0	65.5±3.54	68.5±0.7n
Dry matter (%)	33±03	34.9±6	32.5±45n
Ash , g (kg DM) $^{-1}$	2.05±0.07	2±0.00	1.95±0.07n
Crude protein, g(kg.dm)$^{-1}$	30.6±0.28	31.45±0.49	31.3±0.14n
Crude fat, g (kg DM^{-1}	6.5±0.14	6.8±0.14	6.85±0.07n
NFE	28±0.14a	27.2±1.63a	18.25±0.92b
* Mean ± standard deviation & a, b superscript letters within the same row means significant difference according to Duncan's multiple range test, n = not significant difference. NFE = 100- (protein + lipid + ash + fiber)			

Table 11- Chemical composition of *O. niloticus* fingerlings in three feed rates; 5% (FR1), 9% (FR2) and 13% (FR3) from body weight

chemical composition	Feed rates (weight from body weigh)		
	5% g/day (FR1)	9% g/day (FR2)	13% g/day (FR3)
Moisture (%)	62.5±0.71	63±1.41	64.5±0.71n
Dry meat (%)	37.5±0.71	37.5±2.12	35.5±0.71n
Ash , g (kg DM) $^{-1}$	1.95±0.07	1.85±0.07	1.9±0.14n
Crude protein, g(kg DM)$^{-1}$	31.6±0.28	31.4±0.42	31.1±0.49n
Crude fat, g (kg DM^{-1}	6.7±0.14	6.5±0.28	6.25±0.07n
NFE	22.3±0.6b	23.6±1.5ab	25.3±0.14a
* Mean ± standard deviation& a, b superscript letters within the same row means significant difference according to Duncan's multiple range test; n= not significant difference. NFE = 100- (protein + lipid + ash + fiber)			

CHAPTER FIVE
5. DISCUSSION

5-0: Brief Introduction

Firstly, fisheries and aquaculture remain important sources of food, income and livelihoods for hundreds of millions of people around the world (FAO, 2016). fish culture remains the fastest growing animal food producing. The successful of any fish culture system depend on defining or pointed the optimum degree of some factors that led to more fish production in low cost which including; fish stocking density, daily feed frequency and daily feed rate, which represent the base of any advancement in this sector as mention by (Osofero *et al*., 2009), add to that, the environmental parameters values also have a vital impact for any successful in this sector.

In this chapter, we shall discuss the two point above, and show around and analyze the results of this study and compared it with other studies to determine all of the benefit and the circumspection that must be taken to succeed and improve fish farming to reach the best growth performance in fish tanks culture.

5-1: Factors Affecting Growth of *O. niloticus* Cultured in Tanks

5-1-1: Effect of stocking density on growth of *O. niloticus* fingerlings in tanks

Nile tilapia (*O. niloticus*) provides one of the major sources of protein and income thro5ughout the world. Farmed tilapia production throughout the world increased dramatically in recent year. The effect of stocking density on growth, survival and yield on aquaculture are well known for different species, and seemed to impact production differently. Consequently, identifying the optimum stocking density for a species is a critical factor not only to enable efficient management and to maximize production profitability, but also for optimum husbandry practices Intensification of tilapia culture is a good solution for increasing fish production, and

to optimize fish intensification, both feed quality and stocking density should be considered (Salih *et al*., 2016).

The experiment design base on *O. niloticus* fingerlings cultured at three stocking densities; 10 fish/tank (SD1), 15 fish/tank (SD2) and 20 fish/tank (SD3), the result which declare that, there is a significant differences in daily weight gain between various stocking densities, which is agree with (Ronald *et al*., 2014), (Klanianin and Adam, 2013) and (Araujo *et al*., 2010), but this study go against them in which they believe that the higher weight gain accrue at the fewer stocking density, where in this study the higher gain weight accrue at the medium stock density SD2 (15 fish tank-^{1}), in which it my related to the few numbers of fish tank-^{1} in the three stocking densities, taking in considering the result of (Cleide *et al*., 2011).

While there is no significant difference for the values of feed conversation ratio, specific growth rate and feed conversion efficiency due to various stocking densities. Concerning feed conversation ratio, a low FCR is a good indication of a high quality feed, FCR can be influenced by things like water quality, temperature, how and when feed is presented to the fish, and the health of the fish, all of which can alter the FCR of a feed (USAID, 2011), and due to the low water temperature during study period (16-22 °C) we can related the very low FCR (6.1- 6.79) in three stocking densities.

Other probability of a low FCR that led to low growth rate in *O. niloticus* fingerlings during study period is hypothes of (Ofori *et al*., 2009) who said that, "An FCR higher than normal can be the result of a high percentage of "fines" (feed dust) in the feed, variability in the reported nutrient content of the feed". Add to that above, the use of tap water which content less or no natural nutrients to fell the trials tanks during the study compared with a bioflocs or green water technology as reported by Cavalcante *et al*., (2017) and Alamin *et al*., (2017) may be a strong reason led to the recoded low growth rate.

In this study, stocking density did not affect significantly the survival, a result agree with many researches; Chowdhury (2011) who reported that, in some cases the combination of fish density was not sufficient to deteriorate water quality to a level

where the tilapia suffered notable health problems, although with (Calumby *et al*., 2014), (Klanian and Adam, 2013) and (Khattab *et al*., 2004).

5-1-2: Effect of feed frequency on growth of *O. niloticus* fingerlings in tanks culture

In tilapia fish culture thus, it is important to consider the factors that influence its production such as feed type, ration size, various feeding frequencies. Feeding frequency is important to ensure a maximal food conversion ratio (Ferdous *et al*., 2014). Moreover, feeding frequency can affect growth performance, survival, body composition (Zhou *et al*., 2003). Correctly feeding the proper amount of feed is very important. Overfeeding wastes feed and money (LSU, 2009).

This study find that, there is non-significance differences in term of daily gain weight due to different feed frequencies, a result same to (Ahsan *et al*., 2009), the reason may be that restrictions in feeding frequencies were not enough for feed triggering cannibalism behavior due to all the three feed frequencies done during six hours), this is agree with Riche and Garling (2003) whom reported that, "fish fed at 2 to 3 hour intervals eat more feed than their stomachs can hold. The extra feed eaten passes over the stomach and is considered wasted", while in other side, fish fed two and three times daily were non-significantly better daily gain weight than fish fed four times daily, and this may related to the suggest of Riche and Garling (2003) whom suggests that, tilapia fed too frequently utilize feed less efficiently.

Generally, I return the result of non-significance differences in term of daily gain weight due to different feed frequencies to the theory of Riche and Garling (2003) "Fish eat available food depending on stomach fullness, and at intervals determined by the time it takes to empty the stomach. The speed the stomach empties depends on temperature and some other fetors" taking in mind the very low temperature degree (16 to 22 °C) during study period.

Other factors affect the feed frequencies of tilapia, that is the types/nature of the additional feed (pellets) as mention by Mc Ginty and Rakocy (2005) "floating feeds, since it takes about 24 hours for high quality floating pellets to disintegrate, fish may be fed once daily in the proper amount, but twice-daily feedings are better tilapia cannot

consume their daily requirement of feed for maximum growth in a single meal of short duration. Fish less than 25 grams should be fed at least three times daily.

For the feed conversion ratio, there is no significance differences due to different feed frequencies, but the fewer good result score with the feed frequency of four-time day-^{1} and three time day-^{1}, a result agree with (Yousif, 2004). Survival rate result declares no significant differences among feed frequency model due to different feed frequency treatments, a result suitable with Jegede and Olorunfemi (2013) and disagreement with (Zhou *et al*., 2003).

5-1-3: Effect of feed rate on growth of *O. niloticus* fingerlings in tanks culture

The study of variance feed rates on growth performance indicate that they is no significance differences in daily weight gain due to different feed rates a result agree with (Chowdhury, 2011), although there is a significance differences in the side of feed given, which indicate that over feeding does not support for the growth as mention by (Chowdhury, 2011) and it support the other study where fish fed with higher than optimum feeding do not necessarily benefit from excess feed (Abdelghany and Ahmad, 2002), but we must give more attention when we notice the results of the FCR in which show a significance differences among the three feed rates, and the higher value (the more best) score with the treatments of 5% from the body weight a result matching to that reported by (El-Saidy *et al*., 2005) "figestibility decreased with increasing feeding rate", and it similar to (Clark *et al*., 1990) when he write that "feed conversation ratio improved at lower feeding rate".

In this study, while there is no significance differences in daily weight gain due to different feed rates, we record a significance differences in the side of feed given, a result seemed to be disagree with Garduño-Lugo *et al*., (2003), but we must not forget that when we speak about FCR vale of specific fish species e.g. *O. niloticus*, there is multiple factors involve positively or negatively determining FCR value.

Concerning the effective of the feed rates on fish survival, the result show that feeding rate did not influence any mortality in any of the experiments, a result conformable with Chowdhury (2011), although he mention that, juvenile tilapia is more sensitive to feeding rate than larger tilapia.

5-2: Water Physiochemical Parameters

Concerning water parameter analysis within the three stocking densities, the result indicted no any significant difference ($P > 0.05$). Although for ammonia (NH_3) concentration there is more increasing but not significance ($P < 0.05$) in (1.4 mg/L) the highest stocking density, a result agree with (Boyd, 2010); (Mjoun *et al*., 2010); and (Mallya, 2007). Generally, except temperature (18.5 °C) the mean values of the above water parameters in this trial ranged within the acceptable and suitable range for tilapia culture as cited by (El-Sherif and El-Feky 2008); (Nehemia *et al*., 2012); (Kurt, 2012 and Mirea, 2013).

In the feed frequencies trial, water parameter analysis within the three feed frequencies trial showed no significant difference ($P > 0.05$). The mean values of the above water parameters in this treatment ranged within the natural limited for tilapia culture except temperature (18.5 °C) as mentioned by (Nehemia *et al*., 2012); (Kurt, 2012) and (Sriyasak *et al*., 2015).

Within the feed ratio treatment, the values of the DO, temperature, pH, P, No_2, No_3 and NH_3 showed no significant difference ($P > 0.05$). Although ammonia concentrated showed higher value ($P < 0.05$) (1.5 mg/L) in the higher feed rate (FR3), but it were

still lower than standard toxicity level for tilapia as cited by (El-Sherif and El-Feky, 2008).

In addition, the mean values of the water parameters in this treatment except temperature (18.6 °C), situated within the normal limited for tilapia culture as cited by (Mirea, 2013) and (Sriyasak *et al*., 2015).

For ammonia and pH, and as it reported by (Nehemia *et al*., 2012) "at pH 7 only less than 1% of the total ammonia is in the toxic un-ionized form", and Mjoun (2010); El-Sherif and El-Feky (2008) "Ammonia is toxic to tilapia at concentrations of 7.1 mg/L as unionized ammonia for Nile tilapia", so from the above indicators we can said that there is no any negatively impact on *O. niloticus* fingerlings growth rate due to ammonia concentration in tanks during the study periods.

5-2-1: Temperature levels in water tanks

As reported by Baccarin and Camargo (2005), water quality is a constant concern in fish culture. When its quality is low, fish may present impaired productive performance and increased mortality, leading to lower production and profit, and Semyalo *et al*., (2010) whom write that, Successful fish farming in ponds depends on the physical, chemical and biological characteristics of the water.

In this study, the average of the record temperature degree is between 16° C to 22° C, while the mean is 18.6 °C, these temperature values which is out the ideal range of the optimum growth of tilapia as mention by Nehemia *et al*., (2012) "optimal temperature for growth of tilapia ranges from 29° to 31°C, and Mjoun *et al*., (2010) who reported that, temperature is a major metabolic modifier in fish, and the optimal growing temperatures for tilapia fishes are typically between 22° C and 29° C, so due to these very fallen water temperature we regarded the low growth rate of *O. niloticus* fingerlings during the study.

The impact of temperature on growth rate observer clear when we look to the growth rate even in the three treatments of; different stocking densities, different feed frequencies and different feed rates, in which in all above treatments the best growth

rate as a mode of daily weight gain seen with temperature level “1” (18- 20° C), temperature level “3” (17- 22° C) and temperature level “2” (16- 17° C) respectively, a result agree with many studies like (Byström *et al*., 2006; Englund *et al*, 2011), add to that the study of Azaza *et al*., (2008) who write that, growth of juvenile Nile tilapia (*O. niloticus*) is higher at 26° C and 30° C than at 22° C. The seriously influence of tilapias growth and maximum obtainable size by the physical and biological composition of their environment is reported by (Olurin and Aderibigbe, 2006).

Concerning the effect of temperature on feed conversion ratio (FCR), and as mention by (Ofori *et al*., 2009) "the lower the FCR, the better, the FCR in tilapia culture systems in Africa is typically between 1.4 and 2.5". Compared with FCR record values of 6.4, 7.7 and 7.6 for the means of the three treatments during this study; stocking densities, feed frequencies and feed rate respectively, so these higher values may be return to many reasons; firstly, the environment factors, mainly the water temperature as said by Handeland *et al*., (2008) "fish appetite varies throughout the day, mainly in function of water temperature. The low water temperature degree during this study (16- 22° C), has a great impact on FCR as written by (Mirea, 2013; Englund *et al*, 2011; Mjoun *et al*., (2010); Azaza *et al*., 2008), secondly, the chemical composition of experimental diet (pellets) in which I thought it's in good condition due to it compose of 35% protein, a parentage agree with a lot of studies like as Jegede and Olorunfemi (2013); Araujo *et al*., 2010, and Riche and Garling (2003) who recommended that "protein levels for tilapia diets range from 32 to 36 percent in fingerling feed".

The effect of temperature levels on fish survival, as the result indicated that there is no any impact (no mortality) due to low temperature degree, and survival rate was the same with in all three treatments; stocking densities, feed frequencies and feed rate respectively, a result agree with Mirea (2013), taking in mind that, juveniles of many species prefer warmer temperatures than adults do as written by Handeland *et al*., (2008).

5-3: Proximate Chemical Composition of *O. niloticus* Fingerlings

The chemical composition of *O. niloticus* fingerlings in different treatments were investigated. The result indicated that, moisture, dry meat, ash, crude fat and nitrogen free extract (NFE) contents of whole *O. niloticus* fingerlings body were not affected by stocking densities 10, 15 and 20 fish/tanks of average weight 1.32 ± 0.28g except crude protein. While these above parameters although were not affected by feed frequencies two, three and four feed time/day for *O. niloticus* fingerlings average weight of 1.44 ± 0.33g and feed rates 5%%, 9% and 13% from fish body weight with average weight 1.49 ± 0.28g except NFE. A result agree to Daudpota *et al*., (2016) concerning feeding frequency.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- When using plastic tanks (100L) to cultivation Nile tilapia (*O. niloticus*) fingerlings starting weight of 1.32 ± 0.28g for seventy days, the stoking density of 15 fish/tank give a significantly better growth rate and daily weigh gain than the lower (10 fish/tank) or higher (20 fish/tank) stoking densities.
- Cultivation *O. niloticus* fingerlings starting weight of 1.44 ± 0.33g in plastic tanks (100L) at daily feed frequencies of two, three and four times/day, don't affect significantly neither growth rate nor daily weigh gain due to different feed repeats.
- There is non-significant different in growth rate and daily weigh gain due to cultivation *O. niloticus* fingerlings starting weight of (1.49 ± 0.28g in plastic tanks (100L) at daily feed rates of 5%, 9% and 13% from body weight, with a better FCR matching the feed rate of 5% from body weight.
- The effective of temperature on growth rate and daily weight gain during the study period seen clear, the lower recorded temperature levels meet with the lower daily weight gain in all treatments.
- The differences within the stocking density trials, feed frequency trials and feed rate trials, do not effect significantly water physiochemical parameters and a lot of chemical composition of *O. niloticus* fingerlings within every treatments.

Recommendations

- There is many advantages of using tanks in fish production, of this; the cultivation system of *O. niloticus* in tanks enable to stop the early reproduction of this fish, plastic tanks culture can be used as culture system in any limit available space. On the other side, plastic tanks fish culture request both a high level of infrastructures and technic.
- Increasing productivity in *O. niloticus* fish tank culture be linked with the identification of specific ratios of fundamental factors affecting production and

growth, of the most important; optimal stocking densities, daily feed frequencies and daily feed ratio.

- To obtain a complete result on growth rate and daily weight gain for *O. niloticus* fingerling in tanks culture, a study like this must be done during all year seasons with recording result system.

REFERENCES

Abdelghany, A. E., and Ahmad, M. H. (2002). Effect of feeding rates on growth and production of Nile tilapia, common crap and silver rap polyculture in fertilized pond. *Aquaculture Research* 33 (6): 415-423.

Abdel-Hakim, N. F., Hussein, M. S., Bakeer, M. N., and Soltan, M. A. (2001). Effect of protein level and stocking density on growth performance of Nile tilapia cultured in tanks. *Egyptian Jour. of Nutrition and Feeds* (special issue):763-780.

Abusin, S. A. (2012). Deterrence analysis of compliance with fishery regulation among artisanal fishers in Sudan. PhD environment economic. Central for environmental. Economic and policy in Africa. University of Pretoria, South Africa (Unpublished).

Aderolu, A. Z., Seriki, B. M., Apatira, A. L., and Ajaegbo, C. U. (2010). Effects of feeding frequency on growth, feed efficiency and economic viability of rearing African catfish fingerlings and juveniles. *African Jour. of food Science* 4 (5): 286-290

Alamin, H. Md., Hasan, Md. S., Mondal, S., and Hossain, Md. M. (2017). Fish culture in indoor-tank using green water technology. *Jour. of Entomology and Zoology Studies*5 (6): 2498-2502

Alemayehu T. A., Getahun A. (2017). Effect of feeding frequency on growth performance and survival of Nile tilapia in a cage culture system in Lake Hora-Arsedi, Ethiopia. *Jour. of Aquaculture Research Development* 8: 479. doi: 10.4172/2155-9546. 1000479.

Ali, M. S., Stead, M., and Houlihan, D. F. (2006). Effects of socking density on ammonia excretion and the growth of *O. niloticus. Bangladesh Fisheries Research*, 10 (1):13-24.

Amico, C. (2000). What are the effects of high-level pH on freshwater ecosystems (pH 7 and 8). University of California. P 1:6 Santa Cruz.

Anderson, T. A., and De Silva, S. S. (1995). Fish nutrition in aquaculture. Chapman and hall, 2-6 Boundary Row, London SE1 8HN.

Anton, P., and Curtis, L. (2017). Livelihoods of small-scale fishers along the Nile River in Sudan. Food and Agriculture Organization of the United Nations. FAO Regional Office for Near East and North Africa. Cairo.

AOAC, (2000). Official Methods of analysis of AOAC international, 17th edition. William horwitz (ed.). AOAC International, 2200 p.

Araujo, G. S., Rodrigues, J. A. G., and Farias, W. R. L. (2010). Cultivation of Nile tilapia at different stocking densities in round net cages. *Bioscience Jour*. 26 (3): 428-434.

Azaza, M. S., Dhraïef, M. N., and Kraïem, M. M. (2008). Effects of water temperature on growth and sex ratio of juvenile Nile tilapia reared in geothermal waters in southern Tunisia. *Tunisia Jour. of thermal biology* 33 (2): 98-105.

Baccarin, A. E., and Camargo, A. F. (2005). Characterization and evaluation of the impact of feed management on the effluents of Nile tilapia culture. *Brazilian Archive of Biology and Techn.* 48 (1): 81-90.

Baqui, Md. A., and Bhujel, R. C. (2011). A Hands-on Training Helped Proliferation of Tilapia Culture in Bangladesh. Fisheries Training Institute Chandpur, Department of Fisheries (Dof), Bangladesh.

Barman, B. K., and Little, D. C. (2011). Use of hapas to produce Nile tilapia seed in household food fish ponds. The World Fish Center Bangladesh. *Jour. of Aquaculture* 317 (1-4): 214-222.

Blow, P. and Leonard, S. (2007). A review of cage aquaculture: Latin America and the Caribbean. Cage aquaculture- Regional reviews and global overview, pp. 188-207. FAO Fisheries Technical Paper. No. 498. Rome

Boyd, C. E. (2010). Dissolved-Oxygen Concentrations in Pond Aquaculture, Global Aquaculture Alliance. Global aquaculture advocate January/February 2010.

Brown, M. E. (1957). Experimental studies on growth. In: *The physiological of fishes*. 1 (9): 361-400.

Bwanika, G. N., Murie, D. J., and Chapman, L. J. (2007). Comparative age and growth of Nile tilapia in lakes Nabugabo and Wamala, Uganda. Hydrobiologia, 589: 287-301.

Byström, P., Anderson, J., Kiessling, A., and Eriksson, L. (2006). Size and Temperature Dependent Foraging Capacities and Metabolism: Consequences for Winter Starvation Mortality in Fish. Oikos 115: 43-52.

Calumby, J. A., dos Santos, M. M., Filho, P. C., Emerson C. S., and Gentelini, S. A. (2014). Determinal the economic viability of cultivation of fingerlings of the Nile tilapia in cages stocked at different densities. *Brazilian Jour. of Agri*culture *Science* 9 (3): 459-464.

Casal, C. M. (2006). Global documentation of fish introductions: the growth crisis and recommendations for action. *Biological invasion* 8 (1) 3-11.

Cavalcante, D. H., Lima, F. R., Rebouças, V. T., and Carmo M. V. (2017). Nile tilapia culture under feeding restriction in bioflocs and bioflocs plus periphyton tanks. Acta Scientiarum. *Animal Sciences*. *Maringá*, 39 (3): 223-228.

Chainark, S., and Boyd, C. E. (2010). Water and sediment quality, phytoplankton communities and channel catfish production in sodium nitrate-treated ponds. *Jour. of Appl. Aquaculture* 22 (10):171-185.

Chakraborty, S. B., Mazumdar, D., Chatterji, U., and Banerjee, S. (2011). Growth of Mixed-Sex and Monosex Nile tilapia in different culture systems. *Turkish Jour. of Fish and Aquaculture Science* 11: 13-138.

Chambel, J., Severiano, V., Baptista, T., Mendes, S., and Pedrosa, R. (2015). Effect of stocking density and different diet on growth of Percula clown fish, (*A. percula*) Marine and environment Science center, intituto politecnico de leirir, 2520-641, peniche, Portugal. doi:10.1186/s40064-015-0967-x.

Chaudhuri, K., Manna, S., Sarma, K. S, Naskar, P., Bhattacaryya, S., and Bhattacaryya, M. (2012). Physiochemical and biologic. Factors controlling water column metabolisms in Sundarbans estuary, India. Aqua. Bio sys. 2012 8:26.

Chowdhury, D. K. (2011). Optimal feeding rate for Nile tilapia. MSc. thesis. Depatment of Animal and Aquatic Science, Norwegian University of Life Science.

Clark, J. H., Watanabe, W. O., Ernst, D. H., Wicklund, R. I., and Olla, B. L. (1990). Effect of feeding rate on growth and feed conversation of Florida red tilapia reared in floating marine cages. *Jour. of World Aquatic Science* 21(1):16-24.

Cleide, S. R., Patricia, P., Jose, V., Joao, D., and Aleandere, L. (2011). Growth performance of Thailand tilapia and Florida Red tilapia raised at different stocking densities in cage placed in fish farm pond. Boletim do Instituto de Pesca. 37. 225-234.

Daudpota, A., Abbas, G., Kalhoro, I. B., Shah, S. S., Kalhoro, H., Hafeez-ur-Rehman, M., and Abdul Ghaffar (2016). Effect of feeding frequency on growth performance, feed utilization and body composition of juvenile Nile tilapia, reared in low salinity water. *Pakistan Jour. of Zoology* 48(1):171-177.

De Long, D. P., Losordo, T. M., and Rakocy, J. E. (2009). Tank culture of tilapia. Southern Regional aquaculture center (SARC) Publication No. 282. Education and Extension Service Grant. SRAC No. 2007-38500-18470.

De Silva, S. S., and Hasan, M. R. (2007). Feeds and fertilizers: the key to long-term sustainability of Asian aquaculture. In M.R. Hasan, T. Hecht, S.S. De Silva and A.G.J. Tacon, eds. Study and analysis of feeds and fertilizers for sustainable aquaculture Development. pp. 19-47. FAO Fisheries Technical Paper No. 497. Rome.

Dias, J. D., Simões, N. R., and Bonecker, C. C. (2012). Zooplankton community resilience and aquatic environmental stability on aquaculture practices: A study using net cages. *Brazilian Jour. of Biology* 72 (1):1-11.

Duncan, D. B. (1955). Multiple rang and multiple F test. Biometrics, 11:142.

Elawad, A. N. (2013). Sudan National Report to the Scientific Committee of the Indian Ocean Tuna Commission, 2013. National Report to the IOTC Scien. Committee in 2013.

El-Saidy, D. M. and Gaber, M. M. (2005). Effect of dietary protein levels and feeding rates on growth performance, production traits and body composition of Nile tilapia cultured in concrete tanks. *Aquaculture research* 36 (2):163-171.

El-Sayed, A. F. M. (2006). Tilapia Culture. CABI Publishing, CAB International, Wallingford, Oxford shire, UK, 277 pp.

El-Sherif, M. S., and El-Feky, A. M. (2008). Effect of ammonia on Nile Tilapia performance and some hematological and histological measures. Eighth Inter. Symp. on Tilapia in Aquaculture. Cairo, Egypt. 2008.

El-Sherif, M. S., and El-Feky, A. M. (2009). Performance of Nile tilapia fingerlings. Effect of pH. *Intertonal Jour. Agriculture and Biol*ogy 11: 297-300.

Emmanuel B. E., Fayinka, D. O., and Aladetohun, N. F. (2013). Transportation and the effects of stocking density on the survival and growth of Nile tilapia. World *Jour. of Agricultural Sciences* 1(1): 001-007.

Emranul, A. Md. (2009). Effect of feeding frequency on the growth and production performance of Monosex *O. niloticus*. *Jour. of Agroforety and environment* 3: 183-186.

Englund, G., Öhlund, G., Hein, C. L., and Diehl, S. (2011). Temperature dependence of the functional response. Ecology Letters 14: 914-921.

Ertan, E., Agrali, N., and Tarkan, A. S. (2015). The effects of salinity, temperature and feed ratio on growth performance of European sea bass in the water obtained through reverse osmosis system and a natural river. *Pakistan Jour. of Zoology* 47: 625-633.

FAO (2009). Impact of rising feed ingredient price on aqua feeds and aquaculture production. FAO Fisheries and Aquaculture Technical paper 541.

FAO (2010). The State of World Fisheries and Aquaculture. FAO, Roma.

FAO (2012). The state of the world fisheries and aquaculture. FAO, Roma.

FAO (**2013)**. Mainstreaming gender in fisheries and aquaculture. A stock-tacking exercise.

FAO (2014). The State of World Fisheries and Aquaculture. FAO, Roma. (Online: 2016-01-19).

FAO (2016). The State of World Fisheries and Aquaculture. FAO, Roma.

FAO (2018). The State of World Fisheries and Aquaculture, FAO, Roma.

FAO (UN Food and Agriculture Orgniation) (2008). Sudan Fishery Country Profile, FID/CP/SUD, [Online] Available: www.fao.org (accessed: 2011-10-24).

Farah, O. M. (2019). Head office of the Red Sea Fishes Research Center. Port Sudan. Personal communication, July 30, 2019. Tel. +249 124525293.

Ferdous, Z., Nahar, N., Hossen, Md. Sh., Sumi, K. R. and Ali, Md. M. (2014). Performance of Different Feeding Freq. on Growth Indices and Survival of Monosex Tilapia Fry. *International Jour. of Fisheries and Aquaculture* 1(5): 80-83.

Gandhi, K. T. (2012). A study of water quality parameters to better manage our ponds or lakes. *International Jour. of Late Res Science Technology* 1:359-363.

Garduño-Lugo, M., Granados-Alvarez, I., Olvera-Novoa, M. A., and Muñoz-Córdova G., (2003). Comparison of growth, fillet yield and proximate composition between Stirling Nile tilapia (wild type) and red hybrid tilapia (Florida red tilapia× Stirling red (*O. niloticus*) males. *Aquaculture Research* 34:1023-1028.

Garr, A. L., Lopez, H., Pierce, R., and Davis, M. (2011). The effect of stocking density and diet on the growth and survival of cultured Florida apple snails. *Aquaculture* 311 (1-4): 139-145.

Gomes, L. C., Chagas, E. C., Martins, H., Roubach, R., Ono, E. A., and dePaula Loureco JN. (2006). Cage culture of tambagui in central Amazon floodplain lake Aquaculture. 2006; 253 (1-4):74-384.

Gorlach, K., Pachecoa, C., Carvalhoa, L. C., Júnior, M. and Crispimc, M. (2013). The influence of fish culture in floating net cages on microbial indicators of water quality. *Brazilian Jour. of Biology* 73 (3): 457-63.

Graaf, G. J., Dekker, P. J., Huisman, B. and Verreth, J. A. J. (2005). Simulation of *O. niloticus* culture in pond, through individual–based modeling, using a population dynamics approach. Aquaculture Research, 36: 455-472.

Hamad, A., Yousif, O. and Osman, A. (2014). Shrimp farming trial on the red sea coast of Sudan. LAP Lambert Academic Publishing. 2014

Handeland, S. O., Imsland, A. K., Stefansson, S. O. (2008). The effect of temper. and fish size on growth, feed intake, food conversion Efficiency and stomach evacuation rate of Atlantic Salmon. *Jour. of Aquaculture* 283 (1-4):36-42.

IIRR (**International Institute of Rural Reconstruction**)**, IDRC, FAO, NACA and ICLARM. (2001).** Utilizing Differ. Aqua. Resources for Livelihoods in Asia. Inter. Inst. of Rural Recons., Inter. Devel. Rese. Cent. **(IDRC)**, (**FAO**), Network of Aqua. Center in Asia-Pacific **(NACA)** and Inter. Cent. for Living Aqua. Reso. Manageme. **(ICLARM)**. 416 p.

ISO, (1973). Meat and meat products. Determination of moisture content. ISO 1442. International Organization for Standardization, Geneva, Switzerland.

Jauncey, K. and Ross, B. (1982). A guide to tilapia feed and feeding. Unite of aquatic pathology. University of Stirling, Stirling, Scotland. 111p**.**

Jegede, T. and Olorunfemi, O. T. (2013). Effects of Feeding Frequency on Growth and Nutrient Utilization of (*O. niloticus*) fingerlings. *Global Jour. of Science Frontier Research Agriculture and Veterinary* 13 (13) Version 1.0.

Kaya, G. K. and Bilguven, M. (2015). The Effects of Feeding Frequency on Growth Performance and Proximate Composition of Young Nile Tilapia Jour. of Agricultural Faculty of Uludag University. U. Ü. ZİRAAT FAKÜLTESİ DERGİSİ, 2015, Cilt 29, Sayı 1, 11-18

Khattab, Y. E., Abdel-Tawwab, M., and Ahmad, M. H. (2004). Effect of protein level and stocking density on growth performance, survival rate, feed utilization and body composition of Nile tilapia fry. Six symposium on Tilapia on aqua. Manila, Philippines. 2004; 264-276.

Kjeldahl, J. (1883). New method for determination of nitrogen in organic substances, Zeitschrift fur analytische Chemie, 22 (1): 366-383.

Klanian, M. G., and Adame, C. A. (2013). Growth performance of Nile tilapia fingerlings in hyper-intensive recirculating aquaculture system with low water exchange. *Jour. of Aquaculture Research* 41(1):150-162.

Kreger, C. (2004): Exploring the environment water quality. Wheeling Jesuit University /NASA-supported classroom. Paper p. 1-6.

Le Ruyet, J. P., Labbe, L., Le Bayon, N., Severe, A., Le Rou, A., Le Delliou, H., and Quemener, L. (2008). Combined effects of water quality and stocking density on welfare and growth of rainbow trout. *Aquatic Living Resources* 2:185-195.

Levit, S. M. (2010). A Literature Review of Effects of Ammonia on Fish. The nature conservancy. Protecting nature. Preserving life. Nature. org.

Lovell, R. T. (1989). Nutrition and feeding of fish. Van Nostrand Reinhold, New York, p. 260.

LSU (Lowa State University) (2009). Cage Fish Culture. Lowa fisheries extension Issued in furtherance of Cooperative Extension work, with U.S. Dep. of Agri., director, Cooperative Exte. Service, LSU. of Science and Technology, Ames, Iowa.

Mainar, C. S., de Paiva, P., Verani, P. and de Silva, A. L. (2011). Growth performance of Thailand tilapia and Florida red tilapia raised at different stocking densities in cage placed in fish farm pond. *Bulletin do institute de Pesca* 37 (3):225-234.

Mallya, Y. J. (2007). The effects of dissolved oxygen on fish growth in aquaculture, Kingolwira National Fish Farm Center UNU-Fisheries Training Programme, 30 pp.

Masser, M. P. (1997). Cage Culture. Species suitable for cage culture. SRAC, US. Publication No. 163. 4 pp.

McGinty, A. S., and Rakocy, J. E. (2005). Cage culture of tilapia. Southern Regional Agriculture Center (SRAC) US. Publication No 281.

Mirea, E. T. (2013). Influence of different water temperature on intensive growth performance of nile tilapia in a recirculation aquaculture system, lorena dediu university of agriculture science and veterinary medical vol. 60.

Mjoun, K., Rosentrater, K., and Broun, M. (2010). Tilapia: environmental biology and nutritional requirements. Fact sheets. P. 164.

Mohammed, H. A. O. (2012). Sudan national report to the scientific committee of the Indian Ocean tuna commission. Indian Ocean tuna commission. IOTC-SC15-NR26.

Morrow, R. J. (2009). Effects of Ammonia on Growth and metabolism in Tilapia. MSc thesis. Department of Biology. Queen's Uncivility Kingston, Ontario, Canada. Aug. 2009.

Mridha, M. A., Hossain, M. A., Shah, A. K. M., Uddin, M. S. and Nahiduzzaman, M. (2014). Effects of stocking density on production and economics of all-male tilapia (*O. niloticus*) culture in a rain fed rice-fish ecosystem. *Jour. of Applied* Aquaculture 26 (1): 60-70.

Muin, H., Taufek, N. M., Aioddun, R. A., Yusof, H. M., and Rak, A. (2015): Effect of partial and complete replacement of fishmeal with mushroom stalk meal and soy bean meal on growth performance of Nile Tilapia, *O. niloticus* fingerlings. *Sains Malaysiana* 44 (4): 511-516.

Nandlal, S., and Pickering, T. (2004). Tilapia fish farming in pacific island countries. Vol. 2. Tilapia grow-out of ponds. Noumea, New Caledonia. Aquaculture technical P. 49

Nehemia, A., Maganira, J. D., and Rumisha, C. (2012). Length-weight relationship and condition factor of tilapia species growth in marine and fresh water ponds. *Agriculture Boil. J. N. Am.*3 (3):117-124.

Nobre, M. K. B., Lima, F. R., and Magalhães, F. B. (2014). Alternative liming blends for fish culture. *Acta Scientiarum. Animal Sciences*, 36 (1): 11-16.

Ofori, J. K., Dankwa, H. R., Brummett, R., and Abban, E. K. (2009). Producing tilapia in small cage in West Africa. World fish center technical manual No. 1952. The WFC, Penang, Malaysia. P.16.

Olivares, A. E. (2003). Design of cage culture system for farming in Mexico. The United Nation University. Fisheries training programme. Reykjavik. Iceland.

Olurin, K., and Aderibigbe, O. A. (2006). Length-weight relationship and condition factor of pond reared juvenile *O. niloticus*. *Jour. of Zoology* 1:82-85.

Osofero, S. A., Otubusin, S. O., and Daramola, J. A. (2009). Effect of stocking density on tilapia *O. niloticus* growth and survival in bamboo-net cages trial. *Africal Jour. of Biotech* 8 (7):1322-1325.

Reboucas, V. T., dos Santos Lima, F. R., Cavalcante, D. D. and do Carmo, M. V. (2015). Tolerance of Nile tilapia juveniles to highly acidic rearing water. *Acta Scientiarum. Animal Sciences* 37 (3): 227-233.

Riche, M., and Garling, D. (2003). Feeding tilapia in intensive recirculating systems. North central regional aquaculture. Center. Fact sheet series #114. Aug. 2003.

Ridha, M. T. (2006). Comparative study of growth performance of three strains of *O. niloticus* at two stocking densities. *Aquatic Research* 37:172-179.

Rojas, A., and Wadswarth, S. (2007): A review of cage aquaculture: Latin America and the Caribbean. Cage aquaculture-Regional reviews and global overview, pp. 70-100. FAO Fisheries Technical Paper No. 498.

Ronald, N., **Gladys, B., and Gasper, E. (2014)**. The effect of stocking density on the growth and survival of Nile tilapia fry at Son fish farm, Uganda. *Jour. of Aqua. Research and develop. 5: 222.*

SADA (Strategic Assessment of Development of the Arctic) (2014).Ganging nature of the Arctic Fisheries [factsheet],-URL:wwww. arcticinfo.eu.

Salih, M. A. A. (2007). Ecology and Fisheries of El-Rahad Lake Turda. Master Thesis. Department of Zoology. University of Kordofan. Sudan. (Un published).

Salih, M. A. A., El-Noor, T. E., and Mohamed, A. H. (2016). Effects of varying stocking density and temperature on growth performance of *O. niloticus* fingerlings Cultured in semi-closed sys. Inter. *Jour. of Advance Science and Research* 1(11): 19-23.

Santhanam, K. L., and Saravanan, M. R. (2008). International encyclopedia of fishery science and technology. Mittal Publications. New Delhi (2008).

Santos, V. B, Mareco, E. A., and Silva, M. D. (2013). Growth curve of Nile tilapia strains cultured at different temperature. *Acta scientiarum. Anim. Sci. Maringa* 35 (3):235-242.

Schmalhousen, L. (1926). Studienuberwashstub and different zierung 111 die embryonic washtub skurvedeshiichen. Wilhem Roux. Arch. entklungsmech. org: 322-387

Semyalo, R., Rohrlack, T., Naggawa, C. and Nyakairu, W. G. (2010). Microcystin concentrations in Nile Tilapia caught from Murchison Bay, Lake Victoria and Lake Mburo: Uganda. Hydrobiologia, Vol. 638, P. 235-244.

Shackleton, E. (2012). Effects of temperature and terrestrial carbon on fish growth and pelagic food web efficiency, Umeå University: 978-91-7459-412-6 Printed Print & Media.

Sharp, G. D. (2000). A Brief overview of the history of fish culture and its relation to fisheries science. Gary D. Sharp, Ph.D. center for climate/ocean resources study, Monterey, CA.

Soltan, M. (2016). Cage culture of freshwater fish. Technical report. Jan. 2016. DOI:10.13140/RG.2.1.4802.2803.

Sosa, I. D., Adillo, M. D., Ibanez, A. L., and Figueroa, J. L. (2004). Variability of tilapia (*Oreochromis spp*.) Introduced in Mexico: Morphometric, meristic and genetic characters. *Jour. Appl. Ichth*. 20: 7-4.

Sriyasak, P., Chitmanat, C., Whangchai, N., Promya, J., and Lebel, L. (2015). Effect of water de-stratification on dissolved oxygen and ammonia in tilapia ponds in Northern Thailand. Inter. Aquatic Research (2015) 7:287–299.

Sriyasak, P., Whangchai, N., Chitmanat, C., Promya, J., and Lebel, L. (2014) Impacts of climate and season on water quality in aquaculture ponds. *KKU Res. Jour*. 19 (5):743-751.

Stone, N. M., and Thomforde, H. K. (2004). Understanding your fish pond water analysis report. Cooperative extension program, Univ. of Arkansas at Pine Bluff Aquaculture/ Fisheries

Timmons, M. B., Ebeling, J. M., Wheaton, F. W., Summerfelt, S. T., and Vinci, B. J. (2002). Recirculating aquaculture systems, 2nd Edition. Cayuga Aqua Ventures, Ithaca, NY 14850, USA. 800 P. NRAC Publication No. 01-002.

Tsadik, G. G., and Bart, A. N. (2007). Effects of feeding, stocking density and water-flow rate on fecundity, spawning frequency and egg quality of Nile tilapia, Aqua., 272: 380-388.

TWB (The World Bank) (2013). Fish to 2030. Prospects for fisheries and agricultures. World Bank report number 83177-GLB.

UNDPI (United Nations Department of Public Information) (2010). General facts regarding world fisher. Resumed review conference on the agreement relating on the conservation and management of straddling fish stock and highly migratory fish stocks. New York.

USAID (United State Agency International Development) (2011). Feed conversion ratio (FCR). Technical bulletin # 07. December 2011.

Utne, F. (1978). Standard methods and terminology in Fin Fish nutrition from: Proc. World Sump. on Fin Fish Nutrition and Fish feed technology. Hamburg. 20-23. June 1978. Vol. 11 Berlin, 1979

Wang, Y., Guo, J., Li, K., and Bureau, D. P. (2006). Effects of dietary protein and energy levels of growth, feed utilization and body composition of cuneate drum *(N. miichthioides*) Aqua. P. 421-428.

White, R. S., McHugh, P. A., Glover, C. N. and McIntosh, A. R. (2014). Multiple environmental stressors increase the realised niche breadth of a forest-dwelling fish. *Ecography*, 38 (2): 154-162.

WWI (World Watch Institute) (2009). Fish Farming Continues to Grow as World Fisheries Stagnate, Product Number: VST124. wemaster@worldwatch. org.

Yakubu, A. F., Nwogu, N. A., Apochi, J. A., Olaji, E. D., and Adams T. E. (2014). Economic Profitability of Nile Tilapia in Semi Flow through Culture System *Jour. of Aquatic Science* 2 (1):1-4.

Yakubu, A. F., Obi, A., Okonji, V. A., Ajiboye, O. O., Adams, T. E., Olaji, E. D., and Nwogu, N. A. (2012). Growth Performance of Nile Tilapia as Affected by Stocking Density and Feed Types in Water Flow through System. *World Jour. of Fish and Marine Science* 4 (3): 320-324.

Yakubu, A. F., Okonji, V. A., Nwogu, N. A., Olaji, A. D., Ajiboye , O. O., and Adams, T. E. (2013). Effect of Stocking Density on Survival and Body Composition of *O. niloticus* Fed Multi Feed and Niomr Feed in Semi Flow-Through Culture System. *Jour. of Natural Sciences Research* 3 (14).

Yousif, O. M. (2004). Apparent nutrient digestibility, Growth performance and feed utilization of juvenile Nile tilapia, as influenced by stocking density and feeding frequency. Emir. *Jour. of Agriculture Science* 16 :27-38.

Zakes, Z., Demska-Zakes, K., Jarocki, P., and Stawecki, K. (2006). The effect of feeding on oxygen consumption and ammonia excretion of juvenile tench *T. tinca* (L.) reared in a water recirculation system. *Aqua*. *Inter*.14 (1-2):127-140.

Zhou, Z., Cui, Y., Xie, S., Zhu, W., Lei, W., and Xue, M. (2003). Effect of feeding frequency on growth, feed utilization, and size variation of juvenile gibel carp (*C. auratus gibelio*). *Jour. of Applied Ichthyology* 19 (4): 244-249.

Appendixes

Table 1- Growth increment (g) of *O. niloticus* fingerlings at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish tank^{-1} for 70 days

final weight	sample "6"	sample "5"	sample "4"	sample "3"	sample "2"	sample "1"	initial weight	
23.7	21.1	18.5	15.4	15.42	15.2	12.7	10.3	SD- "A1"
30.1	27.6	23.3	23.4	22.3	20.2	17.1	14.2	SD- "A2"
26.2	23.1	21.1	24	20.17	19.1	17	14.4	SD- "A3"
80	**71.8**	**62.9**	**62.8**	**57.89**	**54.5**	**46.8**	**38.9**	**total SD-"A"**
37.3	32.1	29	29	28.68	26	22.2	13.6	SD- "B1"
46.4	42.1	39.2	38	38.46	35.2	29.6	24.1	SD- "B2"
32.3	30.2	25.9	24.7	24.89	24	20.8	17.6	SD- "B3"
116	**104.4**	**94.1**	**91.7**	**92.03**	**85.2**	**72.6**	**55.3**	**total SD-"B"**
31.9	29.4	28.5	25.4	25.17	23.3	19.3	14.8	SD- "C1"
27.2	25.5	22.3	19.2	19.5	19.7	16.6	14.4	SD- "C2"
34	32.3	30.8	29.2	29.52	27.7	24.2	19	SD- "C3"
93.1	**87.2**	**81.6**	**73.8**	**74.19**	**70.7**	**60.1**	**48.2**	**total SD-"C"**

Table 2- Growth performance factors of *O. niloticus* fingerlings at three stocking densities; 10 (SD1), 15 (SD2) and 20 (SD3) fish tank^{-1} for 70 day

Survival (mean) (%)	Survival (%)	Total Weight Gain % (g)	Mean SGR (%)	SGR (%)	FCR (MEAN)	FCR	Total weight given (g)	mean weight Gain/day(g)	Total weight Gain/day(g)	Total Weight Gain(g)	Total Weight Harvested	Total weight stocked (g)	Stocking density (fish/aquaria)	Treatment	Exper. No.
	100	130.09		1.19		5.092	68.23		0.189	13.4	23.7	10.3	10	SD- "A1"	1
100	100	111.97	**1.04**	1.073	**6.1**	5.857	92.96	**0.2**	0.224	15.9	30.1	14.2	10	SD- "A2"	2
	100	81.94		0.855		7.386	87.15		0.166	11.8	26.2	14.4	10	SD- "A3"	3
							248.34		**0.579**	**41.1**	**80**	**38.9**	**30**	**Total**	
	100	174.42		1.441		4.136	95.55		0.334	23.7	37.3	13.6	15	SD- "B1"	4
100	100	92.53	**1.08**	0.936	**6.1**	6.956	155.12	**0.28**	0.314	22.3	46.4	24.1	15	SD- "B2"	5
	100	83.35		0.867		7.195	105.76		0.207	14.7	32.3	17.6	15	SD- "B3"	6
							356.43		**0.855**	**60.7**	**116**	**55.3**	**45**	**Total**	
	100	115.54		1.097		6.095	104.23		0.241	17.1	31.9	14.8	20	SD- "C1"	7
96.7	95	88.88	**0.94**	0.91	**7**	6.732	86.17	**0.21**	0.18	12.8	27.2	14.4	**19**	SD- "C2"	8
	95	78.94		0.83		8.078	121.17		0.211	15	34	19	**19**	SD- "C3"	9
							311.57		**0.632**	**44.9**	**93.1**	**48.2**	**58**	**Total**	

Table 3- Growth increment (g) of *O. niloticus* fingerlings fed at; two times (FF1), three times (FF2) and four times (FF3) a day^{-1} for 70 days

final w.	Sample 6	sample 5	Sample 4	sample 3	sample 2	sample 1	initial w.	No.
22 Jun.016	12Jun.016	2Jun. 016	23Des.015	13Des.015	3Des.015	23Nov.015	13Nov. 015	
42.6	35.7	33.6	32.5	32.69	30.4	24.9	22.5	FF A1
38.8	33.7	30.2	28.9	29.57	26.5	23.2	21.8	FF A2
42.2	38	39.1	37.6	38	34.5	28.5	26.6	FF A3
38.6	**37**	**34.4**	**31.2**	**31.04**	**29**	**24.2**	**20.9**	FF B1
29.7	**29.9**	**26.9**	**25.7**	**25.63**	**25.2**	**20.6**	**16.6**	FF B2
40.3	**37.2**	**38.1**	**33.9**	**33.83**	**32.8**	**26.8**	**18.4**	FF B3
36.7	31.7	29.4	27.2	27.75	26.2	22	18.8	FF C1
30.4	27.9	25.6	25.3	25.13	23	19.3	20.6	FF C2
36.9	31.5	28.8	27.6	28.34	26.3	21.1	17.1	FF C3

Table 4- Growth performance factors of *O. niloticus* fingerlings fed at; two times (FF1), three times (FF2) and four times (FF3) a day^{-1} for 70 days

Survival (mean) (%)	Mean relative growth rate (RGR)	Relative growth rate (RGR)	Feed efficiency (FE)	Mean SGR (%)	SGR (%)	FCR (MEAN)	FCR	Total feed given (g)	Mean daily weight gain (DWG) (g)	Daily weight gain (DWG) (g)	Total Weight Harvested	Total weight stocked (g)	Stocking density (fish/aquaria)	Treatment
		89.3			**0.91**					0.287	42.6	22.5	15	FF- "A1"
100	**75.3**	78	**12.9**	**0.79**	**0.82**				**0.251**	0.243	38.8	21.8	15	FF- "A2"
		58.65			**0.65**					0.223	42.2	26.6	15	FF- "A3"
							7.74	**408**		**0.752**	**123.6**	**70.9**		**Total**
		84.69			**0.87**					0.253	38.6	20.9	15	FF- "B1"
100	**94.2**	78.92	**13.9**	**0.95**	**0.83**				**0.251**	0.187	29.7	16.6	15	FF- "B2"
		119.02			**1.12**					0.313	40.3	18.4	15	FF- "B3"
							7.16	**377.4**		**0.752**	**108.6**	**55.9**		**Total**
		95.21			**0.95**					0.256	36.7	18.8	15	FF- "C1"
100	**86.2**	47.57	**14.2**	**0.87**	**0.55**				**0.226**	0.14	30.4	20.6	15	FF- "C2"
		115.79			**1.09**					0.283	36.9	17.1	15	FF- "C3"
							7.032	**334.04**		**0.679**	**104**	**56.5**		**Total**

Table 5- Growth increment (g) of *O. niloticus* fed at feed rates; 5% (FR1), 9% (FF2) and 13% (FF3) from body weight

final w.	sample 6	sample 5	sample 4	sample 3	sample 2	sample 1	initial w.	**No.**
22 Jun.016	12Jun.016	2Jun. 016	23Des.015	13Des.015	3Des.015	23Nov.015	13Nov. 015	
30.5	29.5	27.9	26.2	26.3	25.3	21.9	18.1	FR- A1
39.2	38.1	35	33	28.7	23	21.9	20.1	FR- A2
34	30.2	27.5	26.7	26.2	25.3	25.2	23	FR- A3
40.5	36.7	33.6	32.4	31.72	29.3	24.8	25	FR- B1
39.7	28	25.3	22.9	23.45	22.8	19.6	21.8	FR- B2
46.7	43.7	39.5	37.3	37.55	33.4	28.5	24.6	FR- B3
46.7	43.6	36.9	34.3	34.81	32.3	26.7	24.3	FR- C1
42.5	39.8	36	37.8	35.98	32.8	28.3	24.2	FR- C2
49	46.4	42.1	41	40.5	37.3	31.3	26.4	FR- C3

Table 6- Growth performance factors of *O. niloticus* fed at feed rates; 5% (FR1), 9% (FF2) and 13% (FF3) from body weight

Survival (mean) (%)	*Survival (%)*	*Mean relative growth rate (RGR)*	*Relative growth rate (RGR)*	*Feed Effeiciency (FE)*	*Mean SGR (%)*	*SGR (%)*	*FCR (MEAN)*	*FCR*	*Total feed given (g)*	*mean weight Gain/day(g)*	*Total weight Gain/day(g)*	*Total Weight Gain(g)*	*Total Weight Harvested*	*Total weight stocked (g)*	*Stocking density (fish/aquaria)*	*Treatment*
	93.3		67.403			0.699					0.169	11.8	30.5	18.7	14	FR- "A1"
97.8	100	**70.09**	95.025	**11.9**	**0.74**	0.954				**0.2**	0.273	19.1	39.2	20.1	15	FR- "A2"
	100		47.826			0.559					0.157	11	34	23	15	FR- "A3"
								8.3	**352**		**0.599**	**41.9**	**103.7**	**61.8**		**Total**
	100		62			0.689					0.221	15.5	40.5	25	15	FR- "B1"
100	100	**77.98**	82.11	**14.2**	**0.8**	0.856				**0.264**	0.256	17.9	39.7	21.8	15	FR- "B2"
	100		89.837			0.916					0.316	22.1	46.7	24.6	15	FR- "B3"
								7.06	**391.8**		**0.807**	**55.5**	**126.9**	**71.4**		**Total**
	100		91.77			0.933					0.319	22.3	46.7	24.3	15	FR- "C1"
97.8	93.3	**83.33**	75.62	**13.7**	**0.87**	0.805				**0.301**	0.261	18.3	42.5	24.2	14	FR- "C2"
	100		85.606			0.884					0.323	22.6	49	26.4	15	FR- "C3"
								7.305	**461.65**		**0.835**	**63.2**	**138.2**	**74.9**		**Total**

Table 7- Mean pH values recorded during study period in the three experiment; socking densities, feed frequencies and feed rates

Samp. "7"	*samp. "6"*	*samp. "5"*	*samp. "4"*	*samp. "3"*	*samp. '2"*	*Samp. "1"*	
22 Jun. 16	*12 Jun.16*	2Jun. 2016	*23 Des.15*	*13Des.2015*	*3Nov.15*	*23Nov.15*	
7.5	7.1	**7.1**	7.2	**8.4**	8.4	**7.7**	*Mean SD "A"*
7.3	7	**7.1**	7.1	**8.2**	8.3	**7.4**	*Mean SD "B"*
7.4	7.1	**7.2**	7.1	**8.4**	8.3	**7.3**	*Mean SD "C"*
7.3	7.1	**7.3**	7.1	**8.1**	8.3	**7.3**	*Mean FF (A)*
7.3	7.1	**7.1**	7.1	**8.1**	8.3	**7.3**	*Mean FF (B)*
7.3	7.1	**7.1**	7.1	**8.1**	8.2	**7.3**	*Mean FF (C)*
7.3	7.1	**7.2**	7.1	**8.2**	8.1	**7.3**	*Mean FR (A)*
7.3	7	**7.2**	7.1	**8.2**	8.2	**7.3**	*Mean FR (B)*
7.2	6.9	**7**	7	**8.1**	8.3	**7.1**	*Mean FR (C)*

Table 8- Mean water temperature (°C) values recorded during study period in the three experiment; socking densities, feed frequencies and feed rates

Samp. "7"	*samp. "6"*	*sam. "5"*	*samp. "4"*	*samp. "3"*	*samp. '2"*	*Samp. "1"*	
22 Jun. 16	*12 Jun.16*	*2Jun. 16*	*23 Des.15*	*13 Des.15*	*3 Nov.15*	*23 Nov.15*	
17	22	**17**	16	**19**	20	**19**	*Mean SD (A)*
17	22	**17**	16	**18**	20	**19**	*Mean SD (B)*
17	22	**17**	16	**18**	21	**19**	*Mean SD (C)*
17	22	**17**	16	**19**	20	**19.5**	*Mean FF (A)*
17	22	**17**	16	**18**	20	**20**	*Mean FF (B)*
17	22	**17**	16	**18**	20	**19.5**	*Mean FF (C)*
17.5	22	**17**	16	**18**	20	**19**	*Mean FR (A)*
17.5	22	**17**	16	**18.8**	20	**19.5**	*Mean FR (B)*
17	22	**17**	16	**18**	21	**20**	*Mean FR (C)*

Table 9- Mean dissolved oxygen (mg/L) values recorded during study period in the three experiment; socking densities, feed frequencies and feed rates

samp. "7'	*Samp. "6"*	*Samp. "5"*	*samp. "4"*	*samp."3'*	*samp. '2"*	*sam. "1"*	
O2 pump	*O2 pump*	*O2 pump*	*O2 pump*	*O2 pump*	*12.Nov.15*	*23.Nov.15*	Mean
8	8.1	**8.5**	8.4	**5.9**	6.3	**7.8**	*ST (A)*
6.8	8	**8.3**	8.5	**6.7**	7.3	**8**	*ST (B)*
8.2	7.9	**7.8**	8.5	**5.6**	6.8	**7.3**	*ST (C)*
8.2	7.8	**7.8**	8.6	**7.8**	7.2	**7.3**	*FF (A)*
7.9	8	**8**	8.6	**8.5**	7.7	**7.6**	*FF (B)*
8.5	8.4	**8.2**	8.6	**8.5**	7.5	**7.8**	*FF (C)*
8.4	8.2	**8.1**	7.7	**8**	8	**8.3**	*FR (A)*
8.9	7.8	**8**	7.9	**8.3**	8.1	**8**	*FR (B)*
9.4	8.3	**8.2**	8.4	**8.3**	7.9	**7.8**	*FR (C)*

Table 10- Mean ammonia concentration (mg/L) values recorded during study period in the three experiment; socking densities, feed frequencies and feed rates

Samp. "7"	*samp. "6"*	*sam. "5"*	*samp. "4"*	*samp. "3"*	*samp. '2"*	*Samp. "1"*	
23 Jun. 16	*13 Jun.16*	*3 Jun. 16*	*23 Des.15*	*13 Des.15*	*12 Nov.15*	*23 Nov.15*	*Mean*
0.15	0.16	**0.68**	1	**1**	2	**0.5**	ST (A)
0.98	0.48	**1.91**	2	**0.5**	3	**1**	ST (B)
0.29	1.5	**2.34**	2	**1**	2	**1**	ST (C)
0.23	0.22	**1.32**	2	**2**	3	**0.5**	FF (A)
0.11	0.13	**0.5**	2	**2**	3	**1**	FF (B)
0.19	0.15	**1.13**	2	**1.5**	3	**1**	FF (C)
0.17	0.22	**1.16**	2	**1**	2	**1**	FR (A)
0.28	0.23	**2.12**	1	**1**	2	**1**	FR (B)
0.61	1.3	**2.24**	2	**2**	3	**1**	FR (C)

Table 11- Mean phosphate concentration (mg/L) values recorded during study period in the three experiment; socking densities, feed frequencies and feed rates

Samp. "7"	*samp. "6"*	*Samp. "5"*	*samp. "4"*	*samp. "3"*	*samp. '2"*	*sam. "1"*	
13.Jun.16	*13.Jun.16*	*3.Jun. 16*	*23.Des.15*	*13.Des.15*	*3 Des. 15*	*23.Nov.15*	
0.5	0	**0.25**	0.25	**0.25**	0.1	**0**	*ST (A)*
0.25	0	**0.5**	0.25	**0.25**	0.5	**0**	*ST (B)*
0.25	0.25	**0.25**	0.5	**0.25**	0.25	**0.5**	*ST (C)*
0.5	0	**0.25**	0.25	**0.25**	0.25	**0.25**	*FF (A)*
0.5	0	**0.1**	0.25	**0.4**	0.25	**0.25**	*FF (B)*
0.25	0	**0.25**	0.5	**0.25**	0.5	**0.25**	*FF (C)*
0.25	0.25	**0.25**	0.25	**0.25**	0.5	**0.25**	*FR (A)*
0.5	0	**0.5**	0.25	**0.25**	0.25	**0.25**	*FR (B)*
0.25	0.25	**0.5**	0.25	**0.25**	0.5	**0.25**	*FR (C)*

Table 12- Mean nitrite (No2) concentration (mg/L) values recorded during study period in the three experiment; socking densities, feed frequencies and feed rates

Samp. "7"	*samp. "6"*	*Samp. "5"*	*samp. "4"*	*samp. "3"*	*samp. '2"*	*sam. "1"*	
13.Jun.16	*13.Jun.16*	*3.Jun. 16*	*23.Des.15*	*13.Des.15*	*3 Des. 15*	*23.Nov.15*	
0	0	0.1	0.1	0	0	0	*ST (A)*
0	0	0	0	0	0	0	*ST (B)*
0.1	0	0	0	0	0	0.1	*ST (C)*
0.1	0	0	0.1	0.1	0	0.1	*FF (A)*
0	0.1	0	0.1	0.1	0.1	0	*FF (B)*
0	0	0	0	0.1	0	0	*FF (C)*
0	0	0	0	0	0.1	0.1	*FR (A)*
0.1	0	0.1	0	0	0	0	*FR (B)*
0	0.1	0	0	0	0.1	0	*FR (C)*

Table 13- Mean nitrate (No3) concentration (mg/L) values recorded during study period in the three experiment; socking densities, feed frequencies and feed rates

Samp. "7"	*samp. "6"*	*sam. "5"*	*samp. "4"*	*samp. "3"*	*samp. '2"*	*Samp. "1"*	
23 Jun. 16	*13 Jun.16*	*3 Jun. 16*	*23 Des.15*	*13 Des.15*	*12 Nov.15*	*23 Nov.15*	
0.15	0.16	0.68	1	1	2	0.5	*ST (A)*
0.98	0.48	1.91	2	0.5	2	1	*ST (B)*
0.29	1.5	2.34	2	1	2	1	*ST (C)*
0.23	0.22	1.32	2	2	3	0.5	*FF (A)*
0.11	0.13	0.5	2	2	3	1	*FF (B)*
0.19	0.15	1.13	2	1.5	3	1	*FF (C)*
0.17	0.22	1.16	2	1	2	1	*FR (A)*
0.28	0.23	2.12	1	1	2	1	*FR (B)*
0.61	1.3	2.24	2	2	3	1	*FR (C)*

Total Protein (Kjeldahl method)

Reagents

a) Kjeldahl catalyst:- 15gm Pot. Sulphate + 0.5gm Copper sulphate
b) Sulphuric Acid - Concentrated
c) NaOH solution- 50% (1+1). Let stand until clear
d) Standard NaOH solution-0.1 N=0.1 M (4.00gm/litre(
e) Standard acid solution- Prepare either HCl or H2SO4 solution HCl sol-0.1
f) N= 0.1 M (3.646gm/litre(
g) H2SO4 sol - 0.1N=0.05 M (4.9gm/litre(
h) Methyl Red Indicator - 0.5gm in 100ml ethanol

Procedure

Weigh 1-1.5 gm of prepared sample and transfer to a kjeldahl digestion flask. Add 15gm of Pot sulphate, 0.5gm of copper sulphate and 25-40ml of Sulphuric acid. Heat the flask gently in an inclined position until froathing ceases then boil briskly for 2 hours. Allow to cool. Add approx 200ml of water and 25ml of Sod. thiosulphate solution (80gm/l) and mix. Add a piece of granulated Zinc or anti bump granules and carefully pour down the side of the flask sufficient Sodium Hydroxide sol (1+1) to make the contents strongly alkaline (about 110ml). Before mixing the acid and alkaline layers connect the flask to a distillation apparatus incorporating an efficient

splash head and condenser. To the condenser fit a delivery tube which dips just below the surface of a pipetted vol of the digestion flask and boil until about 150ml of the distillate has been collected. Add 5 drops of methyl red indicator and titrate with 0.1N NaOH. Carry out a blank, l ml of 0.1 HCl or H2SO4 is equivalent to 0.0014 of N.

Total protein is equal to N X 6.25.

(Ref:- A.O.A.C 17th edition,2000, Official Method 928.08 Nitrogen in Meat (Alternative II)). I.S-5960 (Part 1) 1996/I.S.O 937-1978 Meat and Meat Products-determination of Nitrogen Content. Combustion Method (DUMAS Method) for Determination of Nitrogen Content validated ISO method (EN ISO 16634 series (2008)). Or by the macro-kjeldahl method using (Markham-semi micro kjeldahl distillation apparatus) and was calculated by applying the factor 6.25 to the nitrogen percentage in fish flesh.

$$\text{Nitrogen \%} = \frac{(V_2 - V_1) \times N \times 14 \times 100}{1000 \times Wt}$$

Where:

V_2 = volume of 0.1 Hcl used in titration.

V_1 = volume of 0.1 Hcl used in blank titration.

N = normality of Hcl used in the titration.

14/1000 = conversion factor of ammonium sulphate to nitrogen.

Wt = weight of sample which equals one

Table – show the average weight of the fishes during study period in green water produced (GWP) by *Hibiscus rosa sinensis* leaves and pond water (control)

Day	Average weight (gm) of the fish in green water tank	Average weight (gm) of the fish in pond water tank
1st	6.56±0.5	6.56±0.5
15th	9.95±0.5	9.06±0.5
30th	14.1±0.5	13.57±0.5
45th	26.96±0.5	23.10±0.5
60th	49.16±0.5	49.89±0.5
75th	81.52±0.5	79.98±0.5
90th	110.12±0.5	107.88±0.5
105th	138.92±0.5	136.38±0.5
120th	144.30±0.5	141.28±0.5

Source: Mohammed et al., (2017)

```
DATASET ACTIVATE DataSet1.
GET DATA /TYPE=XLSX
  /FILE='C:\Users\Mo_Awad\Desktop\ρ□89;□83;□85; □75;ل□76;ي□75;¿□75;□78;\fed rate+ chemical analysis.xlsx'
  /SHEET=name 'Denity'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet3 WINDOW=FRONT.
ONEWAY totalweightstocked totalweightharvest totalweightgain dailyweightgain totalfeedgiven FCR SGR FE RGR survivalrate BY st
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS
  /POSTHOC=DUNCAN LSD ALPHA(0.05).
```

Oneway

Notes

Output Created		18-OCT-2016 13:20:03
Comments		
Input	Active Dataset	DataSet3
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	99
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax		ONEWAY totalweightstocked totalweightharvest totalweightgain dailyweightgain totalfeedgiven FCR SGR FE RGR survivalrate BY stokingdensity /STATISTICS DESCRIPTIVES /MISSING ANALYSIS /POSTHOC=DUNCAN LSD ALPHA(0.05).
Resources	Processor Time	00:00:00.28
	Elapsed Time	00:00:00.34

		Sum of Squares	df	Mean Square	F	Sig.
totalweightstocked	Between Groups	48.080	2	24.040	4.991	.053
	Within Groups	28.900	6	4.817		
	Total	76.980	8			
totalweightharvest	Between Groups	70.036	2	35.018	2.083	.206
	Within Groups	100.867	6	16.811		
	Total	170.902	8			
totalweightgain	Between Groups	6.009	2	3.004	.170	.847
	Within Groups	105.760	6	17.627		
	Total	111.769	8			
dailyweightgain	Between Groups	.001	2	.001	.169	.849
	Within Groups	.022	6	.004		
	Total	.023	8			
totalfeedgiven	Between Groups	996.777	2	498.389	4.338	.068
	Within Groups	689.410	6	114.902		
	Total	1686.187	8			

dailyweightgain

stokingdensity		N	Subset for alpha = 0.05	
			1	2
Duncan[a]	10 fish/tank	3	.19333	
	20 fish/tank	3	.21000	.21000
	15 fish/tank	3		.28333
	Sig.		.655	.084

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

totalfeedgiven

stokingdensity		N	Subset for alpha = 0.05
			1
Duncan[a]	10 fish/tank	3	82.78000
	20 fish/tank	3	103.85667
	15 fish/tank	3	118.81000
	Sig.		.104

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

FCR

stokingdensity		N	Subset for alpha = 0.05
			1
Duncan[a]	15 fish/tank	3	6.10000
	10 fish/tank	3	6.11333
	20 fish/tank	3	6.97000
	Sig.		.466

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

SGR

stokingdensity		N	Subset for alpha = 0.05
			1
Duncan[a]	20 fish/tank	3	.93333
	10 fish/tank	3	1.02333
	15 fish/tank	3	1.06667
	Sig.		.492

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

FE

stokingdensity		N	Subset for alpha = 0.05
			1
Duncan[a]	20 fish/tank	3	14.54667
	10 fish/tank	3	16.76000
	15 fish/tank	3	17.69333
	Sig.		.402

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

RGR

stokingdensity		N	Subset for alpha = 0.05
			1
Duncan[a]	20 fish/tank	3	94.45333
	10 fish/tank	3	108.00000
	15 fish/tank	3	116.76667
	Sig.		.465

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

survivalrate

stokingdensity		N	Subset for alpha = 0.05
			1
Duncan[a]	20 fish/tank	3	96.66667
	10 fish/tank	3	100.00000
	15 fish/tank	3	100.00000
	Sig.		.056

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
totalweightstocked	Between Groups	48.080	2	24.040	4.991	.053
	Within Groups	28.900	6	4.817		
	Total	76.980	8			
totalweightharvest	Between Groups	70.036	2	35.018	2.083	.206
	Within Groups	100.867	6	16.811		
	Total	170.902	8			
totalweightgain	Between Groups	6.009	2	3.004	.170	.847
	Within Groups	105.760	6	17.627		
	Total	111.769	8			
dailyweightgain	Between Groups	.001	2	.001	.169	.849
	Within Groups	.022	6	.004		
	Total	.023	8			
totalfeedgiven	Between Groups	996.777	2	498.389	4.338	.068
	Within Groups	689.410	6	114.902		
	Total	1686.187	8			
FCR	Between Groups	.088	2	.044	.011	.989
	Within Groups	24.575	6	4.096		
	Total	24.663	8			
SGR	Between Groups	.032	2	.016	.401	.686
	Within Groups	.241	6	.040		
	Total	.274	8			
FE	Between Groups	1.696	2	.848	.082	.922
	Within Groups	61.753	6	10.292		
	Total	63.449	8			
RGR	Between Groups	538.036	2	269.018	.418	.676
	Within Groups	3865.347	6	644.224		
	Total	4403.382	8			
survivalrate	Between Groups	0.000	2	0.000		
	Within Groups	0.000	6	0.000		
	Total	0.000	8			

Homogeneous Subsets

totalweightstocked

FeedFreq		N	Subset for alpha = 0.05	
			1	2
Duncan[a]	Three times/day	3	18.63333	
	Four times/day	3	18.83333	
	Two times/day	3		23.63333
	Sig.		.915	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

totalweightharvest

FeedFreq		N	Subset for alpha = 0.05
			1
Duncan[a]	Four times/day	3	34.66667
	Three times/day	3	36.20000
	Two times/day	3	41.20000
	Sig.		.108

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

totalweightgain

FeedFreq		N	Subset for alpha = 0.05
			1
Duncan[a]	Four times/day	3	15.83333
	Two times/day	3	17.56667
	Three times/day	3	17.56667
	Sig.		.641

a. Uses Harmonic Mean Sample Size = 3.000.

totalfeedgiven

FeedFreq		N	Subset for alpha = 0.05	
			1	2
Duncan[a]	Four times/day	3	111.36667	
	Three times/day	3	130.29333	130.29333
	Two times/day	3		135.98667
	Sig.		.074	.539

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

FCR

FeedFreq		N	Subset for alpha = 0.05
			1
Duncan[a]	Four times/day	3	7.64033
	Three times/day	3	7.67000
	Two times/day	3	7.86333
	Sig.		.900

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

SGR

FeedFreq		N	Subset for alpha = 0.05
			1
Duncan[a]	Two times/day	3	.79333
	Four times/day	3	.86333
	Three times/day	3	.94000
	Sig.		.419

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

FE

FeedFreq		N	Subset for alpha = 0.05
			1
Duncan[a]	Two times/day	3	13.06667
	Three times/day	3	13.36667
	Four times/day	3	14.10000
	Sig.		.715

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 3.000.

RGR

FeedFreq		N	Subset for alpha = 0.05
			1
Duncan[a]	Two times/day	3	75.33333
	Four times/day	3	86.20000
	Three times/day	3	94.20000
	Sig.		.412

dailyweightgain

			Subset for alpha = 0.05
Feedrate		N	1
Duncan[a]	5% of body weight	3	.19967
	9% of body weight	3	.26433
	13% of body weight	3	.30100
	Sig.		.055

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

totalfeedgiven

			Subset for alpha = 0.05		
Feedrate		N	1	2	3
Duncan[a]	5% of body weight	3	69.21667		
	9% of body weight	3		136.43000	
	13% of body weight	3			215.85667
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

FCR

			Subset for alpha = 0.05		
Feedrate		N	1	2	3
Duncan[a]	5% of body weight	3	5.11200		
	9% of body weight	3		7.39900	
	13% of body weight	3			10.26900
	Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

SGR

			Subset for alpha = 0.05
Feedrate		N	1
Duncan[a]	5% of body weight	3	.73733
	9% of body weight	3	.82033
	13% of body weight	3	.87400
	Sig.		.289

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

FE

			Subset for alpha = 0.05	
Feedrate		N	1	2
Duncan[a]	13% of body weight	3	9.76667	
	9% of body weight	3	13.93333	
	5% of body weight	3		19.88000
	Sig.		.095	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

RGR

			Subset for alpha = 0.05	
Feedrate		N	1	2
Duncan[a]	13% of body weight	3	9.76667	
	9% of body weight	3	13.93333	
	5% of body weight	3		19.88000
	Sig.		.095	1.000

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

survivalrate

			Subset for alpha = 0.05
Feedrate		N	1
Duncan[a]	5% of body weight	3	97.76667
	13% of body weight	3	97.76667
	9% of body weight	3	100.00000
	Sig.		.434

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
totalweightstocked	Between Groups	30.669	2	15.334	4.897	.055
	Within Groups	18.787	6	3.131		
	Total	49.456	8			
totalweightharvest	Between Groups	206.242	2	103.121	6.920	.028
	Within Groups	89.413	6	14.902		
	Total	295.656	8			
totalweightgain	Between Groups	77.549	2	38.774	3.157	.116
	Within Groups	73.693	6	12.282		
	Total	151.242	8			
dailyweightgain	Between Groups	.016	2	.008	3.125	.118
	Within Groups	.015	6	.003		
	Total	.031	8			
totalfeedgiven	Between Groups	32329.517	2	16164.759	25.728	.001
	Within Groups	3769.737	6	628.289		
	Total	36099.254	8			
FCR	Between Groups	40.062	2	20.031	18.023	.003
	Within Groups	6.668	6	1.111		
	Total	46.730	8			
SGR	Between Groups	.028	2	.014	.734	.519
	Within Groups	.116	6	.019		
	Total	.145	8			
FE	Between Groups	155.003	2	77.502	11.674	.009
	Within Groups	39.834	6	6.639		
	Total	194.838	8			
RGR	Between Groups	155.003	2	77.502	11.674	.009
	Within Groups	39.834	6	6.639		
	Total	194.838	8			
survivalrate	Between Groups	9.976	2	4.988	.500	.630
	Within Groups	59.853	6	9.976		
	Total	69.829	8			

Homogeneous Subsets

totalweightstocked

'eedrate		N	Subset for alpha = 0.05	
			1	2
Duncan[a]	5% of body weight	3	20.60000	
	9% of body weight	3	23.80000	23.80000
	13% of body weight	3		24.96667
	Sig.		.069	.450

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

totalweightharvest

'eedrate		N	Subset for alpha = 0.05	
			1	2
Duncan[a]	5% of body weight	3	34.56667	
	9% of body weight	3		42.30000
	13% of body weight	3		46.06667
	Sig.		1.000	.277

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

totalweightgain

'eedrate		N	Subset for alpha = 0.05
			1
Duncan[a]	5% of body weight	3	13.96667
	9% of body weight	3	18.50000
	13% of body weight	3	21.06667
	Sig.		.054

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 3.000.

Homogeneous Subsets

moisture

chemstock		N	Subset for alpha = 0.05
			1
Duncan[a]	10 fish/tark	2	66.500
	15 fish/tark	2	67.500
	20 fish/tark	2	68.000
	Sig.		.327

Means for groups in homogeneous subsets are displayed

a. Uses Harmonic Mean Sample Size = 2.000.

drymeat

chemstock		N	Subset for alpha = 0.05
			1
Duncan[a]	20 fish/tark	2	32.000
	15 fish/tark	2	33.000
	10 fish/tark	2	33.500
	Sig.		.381

Means for groups in homogeneous subsets are displayed

a. Uses Harmonic Mean Sample Size = 2.000.

Ash

chemstock		N	Subset for alpha = 0.05
			1
Duncan[a]	15 fish/tark	2	1.900
	20 fish/tark	2	1.950
	10 fish/tark	2	2.000
	Sig.		.351

Means for groups in homogeneous subsets are displayed

a. Uses Harmonic Mean Sample Size = 2.000.

crudprotein

chemstock		N	Subset for alpha = 0.05	
			1	2
Duncan[a]	15 fish/tark	2	30.100	
	20 fish/tark	2		31.050
	10 fish/tark	2		31.150
	Sig.		1.000	.638

Means for groups in homogeneous subsets are displayed

a. Uses Harmonic Mean Sample Size = 2.000.

crudfat

chemstock		N	Subset for alpha = 0.05
			1
Duncan[a]	20 fish/tark	2	6.400
	15 fish/tark	2	6.650
	10 fish/tark	2	6.900
	Sig.		.059

Means for groups in homogeneous subsets are displayed

a. Uses Harmonic Mean Sample Size = 2.000.

NFE

chemstock		N	Subset for alpha = 0.05
			1
Duncan[a]	10 fish/tark	2	26.450
	15 fish/tark	2	27.000
	20 fish/tark	2	28.600
	Sig.		.248

Means for groups in homogeneous subsets are displayed

a. Uses Harmonic Mean Sample Size = 2.000.

```
DATASET ACTIVATE DataSet2.
GET DATA /TYPE=XLSX
  /FILE='C:\Users\Mo_Awad\Desktop\م□89;□83;□85; □75;ل□76;ى□75;ن□7
  /SHEET=name 'chem.tock'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet5 WINDOW=FRONT.
ONEWAY moisture drymeat Ash crudprotein crudfat NFE BY chemstock
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS
  /POSTHOC=DUNCAN LSD ALPHA(0.05).
```

Oneway

Notes

Output Created		18-OCT-2016 13:27:56
Comments		
Input	Active Dataset	DataSet5
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	6
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics for each analysis are based on cases with no missing data for any variable in the analysis.
Syntax		ONEWAY moisture drymeat Ash crudprotein crudfat NFE BY chemstock /STATISTICS DESCRIPTIVES /MISSING ANALYSIS /POSTHOC=DUNCAN LSD ALPHA(0.05).
Resources	Processor Time	00:00:00.16
	Elapsed Time	00:00:00.45

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
moisture	Between Groups	2.333	2	1.167	.700	.563
	Within Groups	5.000	3	1.667		
	Total	7.333	5			
drymeat	Between Groups	2.333	2	1.167	.538	.631
	Within Groups	6.500	3	2.167		
	Total	8.833	5			
Ash	Between Groups	.010	2	.005	.600	.604
	Within Groups	.025	3	.008		
	Total	.035	5			
crudprotein	Between Groups	1.343	2	.672	18.318	.021
	Within Groups	.110	3	.037		
	Total	1.453	5			
crudfat	Between Groups	.250	2	.125	4.412	.128
	Within Groups	.085	3	.028		
	Total	.335	5			
NFE	Between Groups	4.990	2	2.495	1.097	.439
	Within Groups	6.825	3	2.275		
	Total	11.815	5			

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
moisture	Between Groups	4.333	2	2.167	2.167	.262
	Within Groups	3.000	3	1.000		
	Total	7.333	5			
drymeat	Between Groups	5.333	2	2.667	1.455	.362
	Within Groups	5.500	3	1.833		
	Total	10.833	5			
Ash	Between Groups	.010	2	.005	.500	.650
	Within Groups	.030	3	.010		
	Total	.040	5			
crudprotein	Between Groups	.310	2	.155	.921	.488
	Within Groups	.505	3	.168		
	Total	.815	5			
crudfat	Between Groups	.203	2	.102	2.905	.199
	Within Groups	.105	3	.035		
	Total	.308	5			
NFE	Between Groups	9.370	2	4.685	5.344	.103
	Within Groups	2.630	3	.877		
	Total	12.000	5			

Homogeneous Subsets

moisture

chemrate		N	Subset for alpha = 0.05 1
Duncan[a]	5% of body weight	2	62.50000
	9% of body weight	2	63.00000
	13% of body weight	2	64.50000
	Sig.		.139

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 2.000.

drymeat

chemrate		N	Subset for alpha = 0.05 1
Duncan[a]	13% of body weight	2	35.50000
	5% of body weight	2	37.50000
	9% of body weight	2	37.50000
	Sig.		.235

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 2.000.

Ash

chemrate		N	Subset for alpha = 0.05 1
Duncan[a]	9% of body weight	2	1.85000
	13% of body weight	2	1.90000
	5% of body weight	2	1.95000
	Sig.		.388

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 2.000.

crudprotein

chemrate		N	Subset for alpha = 0.05 1
Duncan[a]	13% of body weight	2	31.05000
	9% of body weight	2	31.40000
	5% of body weight	2	31.60000
	Sig.		.271

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 2.000.

crudfat

chemrate		N	Subset for alpha = 0.05 1
Duncan[a]	13% of body weight	2	6.25000
	9% of body weight	2	6.50000
	5% of body weight	2	6.70000
	Sig.		.096

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 2.000.

NFE

chemrate		N	Subset for alpha = 0.05 1	 2
Duncan[a]	5% of body weight	2	22.25000	
	9% of body weight	2	23.55000	23.55000
	13% of body weight	2		25.30000
	Sig.		.259	.158

Means for groups in homogeneous subsets are displayed.
a. Uses Harmonic Mean Sample Size = 2.000.

One-way ANOVA test for the water physiochemical parameters in Table 5, 6 and 7 in pages; 43, 48 and 53 respectively

1- One- way of variance for the stocking density SD1 ,SD2 ,SD3

H_0: there is no significant difference $(P> 0.05)$ between mean groups.

H_1: there is significant difference $(P< 0.05)$ between mean groups.

One-way ANOVA test.

Sig.	F	Mean squares	df	Sum of squares	Source of Varian
0.940	0.236	12.371	5	61.854	Between groups
		52.320	15	784.804	Within groups
			20	846.658	Total

2- One- way of variance for the feed frequencies (FF); FF1 ,FF2 FF3.

H_0: there is no significant difference $(P> 0.05)$ between mean groups.

H_1: there is significant difference $(P< 0.05)$ between mean groups.

One-way ANOVA test

Sig.	F	Mean squares	df	Sum of squares	Source of Varian
0.955	0.206	10.946	5	54.728	Between groups
		53.155	15	797.322	Within groups
			20	852.050	Total

3- One- way of variance for the feed Ratio (FR); FR1, FR2 and FR3.

H_0: there is no significant difference ($P > 0.05$) between mean groups.

H_1: there is significant difference ($P < 0.05$) between mean groups.

One-way ANOVA test

Sig.	F	Mean squares	df	Sum of squares	Source of Varian
0.956	0.202	10.820	5	54.101	Between groups
		53.487	15	802.309	Within groups
			20	856.410	Total