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Specialty*: Animal production*

Title

Study of the zoo technical performances of Oreochromis sp, under a diet enriched with agri-food by-products

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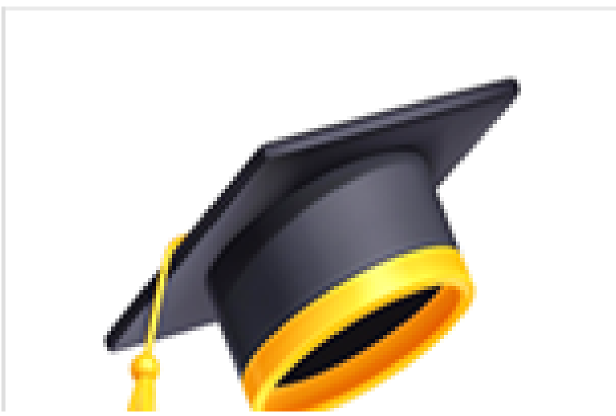

Dedication

- I dedicate this thesis to my dear parents who have always been by my side and supported me throughout these long years of study. In gratitude, may they find here the expression of my deep appreciation for all the efforts and sacrifices they have made to see me succeed in my studies. To all my family

-To my dear friends

In every chapter of my life, you've been a constant source of joy, support, and laughter. Thank you for your unwavering friendship and the countless memories we've created together. Here's to many more adventures ahead. You truly are a treasure in my life.

(ARBIA , REKAIA , AMANI , HOUDA , NOUR)

To my self

Last but not least, I wanna thank me ,I wanna thank me for believing in me , I wanna thank me for doing all this hard work , I wanna thank me for having no days off , I wanna thank me for, for never quitting , I wanna thank me for always being a giver , And tryna give more than

I receive , I wanna thank me for tryna do more right than wrong

I wanna thank me for just being me at all times

Ilhem

Résumé

L'objectif principal de cette étude est d'évaluer comment l'intégration d'aliments fabriqués à partir de produits locaux et de sous-produits (tels que le fève, pois, huile d'olive, œufs et larves de mouche soldat noire) dans les régimes alimentaires des Tilapias influence leur performance zootechnique. L'étude compare spécifiquement un aliment formulé à base de ces ingrédients avec un aliment témoin (ONAB). Les résultats préliminaires suggèrent une corrélation positive entre les paramètres de croissance, notamment le gain de poids, et l'utilisation du régime alimentaire à base de mouche soldat noire chez les Tilapias, montrant ainsi des améliorations significatives dans la performance de croissance des poissons.

Mots clés : Tilapia, alimentation, performance zootechnique, gain de poids

ملخص

هدف هذه الدراسة إلى تقييم تأثير إدماج الأطعمة المشتقة من المنتجات المحلية والنواتج الفرعية مثل الفول، البازلاء،

زيت الزيتون، البيض، ويرقات الذباب الأسود في أنظمة غذائية السمك تيلابيا على الأداء الزراعي. تستخدم هذه ا

الدراسة منهجاً مقارناً بين الأعلاف المصنوعة والأعلاف الضابطة (onab) بسن معايير ملحوظ تبرز النتائج ترابطاً النمواداء متفوقا خهصة زيادة الوزن . حيث ا ظهرت تحاليل التيلابيا التي تم اطعامها بالنظام الغذائي اساسه بروتين حيواني (يرقات الدباب الاسود) نتائج مبهرة حيث سجل زيادة وزن سريعة خلال فترة وجيزة

كلمات البحث: سمك البلطي- الغذاء-قدرات انتاجية-زيادة الوزن

Abstract

This study aims to assess the impact of incorporating feeds derived from local products and by-products (including beans, peas, olive oil, eggs, and black soldier fly larvae) into Tilapia diets on their zootechnical performance. It employs a comparative methodology, contrasting a formulated feed with a control feed (ONAB). The findings underscore a notable correlation between growth parameters, specifically weight gain, indicating that Tilapia fed the black soldier fly larva diet exhibit enhanced growth performance.

Keywords: Tilapia- food - zootechnical performance - weight gain

Summary

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Introduction

In a world where more than 800 million people continue to suffer from chronic malnourishment, and with the global population expected to grow by another 2 billion to reach 9.6 billion by 2050 — with a concentration in coastal urban areas , we face the immense challenge of feeding our planet while preserving its natural resources for future generations (FAO, 2014).

The critical role of aquatic food products in food security and nutrition is increasingly recognized, not only as sources of proteins but also as unparalleled providers of essential omega-3 fatty acids and bioavailable micronutrients. A crucial aspect of transforming our agricultural and food systems should be prioritizing and better integrating fish and fisheries products into global, regional, and national food system strategies and policies (FAO, 2022).

Tilapia, belonging to the family Cichlidae, are African freshwater fish distributed throughout Africa, except in the northern Atlas Mountains and Southwest Africa. About 700 species of Cichlids have been reported in Africa (B. J. McAndrew, 2000), with Tilapia being the most economically important fish in aquaculture across various countries in the Americas. This species exhibits morphological adaptability under different environmental conditions (Andrés Montoya-L, et al., 2019).

It is noteworthy that Algeria is a significant importer of soybeans and corn, which imposes a considerable cost on the Algerian economy. Increasing the use of locally sourced feeds for Nile Tilapia aquaculture could potentially reduce the country's dependence on imports while supporting local farmers.

The object of This study aims to explore the growth and health responses of Tilapia to diets enriched with locally sourced food by products..

Chapter 01
General view

1 Aquaculture in the world

Aquaculture is one of the fastest-growing sectors in the global food industry. Over the past 20–30 years, it has experienced consistent and significant growth in commercial and industrial production worldwide **(Marc .V, 2023).** Aquaculture currently provides more than 50 percent of the fish consumed by humans **(FAO, 2022),** underscoring its crucial role in meeting global food needs.

There is a growing recognition of the need to integrate aquaculture into local food systems across all continents (Bartley, D. M. 2022). As of 2018, aquaculturists were reported to farm approximately 622 species or species items, including finfishes, mollusks, crustaceans, amphibians, reptiles, aquatic invertebrates, and aquatic plants (Bartley, D. M. 2022). From 2000 to 2018, global aquaculture production increased from 43.0 to 120.1 million metric tons (Mt), marking a nearly 180% increase **(FAO, 2023).**

In 2022, global aquatic animal production was estimated at 178 million tons (FAO, 2022), highlighting its impressive growth trajectory in recent decades. By seizing this opportunity, countries can generate employment, meet global demand for seafood, and enhance their food security goals **(Kobayashi, M., and al. 2015).**

Aquaculture encompasses several sectors, including fish farming for breeding fish, shellfish farming for cultivating shellfish, crustacean farming for rearing crustaceans, and algae culture **(BARNABE, 1991).**

2 Africa aquaculture

Aquaculture in Africa has experienced slower growth compared to other regions, largely due to various challenges. These include conflicts over resources, limited access to credit, difficulties in obtaining quality seed and feed, and inadequate access to information (**Finegold, C. 2009).** Meeting the increasing demand for fish will require enhancements in postharvest processing to minimize fish losses.

3 Aquaculture in algeria

In Algeria, aquaculture production has shown substantial growth, increasing from 351 tonnes in 2000 to 5,436 tonnes in 2020. This represents an annual growth rate of 14.68%, surpassing sub-regional, regional, and global averages, and is the highest among neighboring countries.

The share of aquaculture in Algeria's total fisheries production rose from less than half a percent before 2005 to over 6 percent by 2020 **(FAO, 2022).**

In terms of consumption, Algeria recorded a total fish and seafood consumption of 159,662 tonnes (live weight equivalent) in 2017. Of this, 95,806 tonnes were supplied from domestic sources, while 63,856 tonnes (live weight equivalent) were imported (FAO, 2020). Algeria's imports of aquatic products increased significantly from USD 13 million in 2000 to USD 120 million in 2020, with an annual growth rate of 12%, surpassing world, regional, and sub-regional averages. Tunas, bonitos, and billfishes accounted for approximately half of the country's aquatic product imports in 2020 (**FAO, 2022**).

Looking ahead, Algeria's aquaculture sector would need to grow by 18.84% annually from 2020 to 2030 to meet an additional demand of 25,112 tonnes driven solely by population growth. To cover the additional demand of 833,020 tonnes resulting from both population growth and increased preference, the growth rate would need to reach 65.51% annually (**Cai, J. and Leung, P., 2022).**

4 General view of the Tilapia culture

Tilapia, native to Africa, originated from the Nile Valley and spread to central and western Africa **(Alex B, 1990).** The species was artificially introduced to many Asian and some Pacific Island countries starting in the 1950s (Nandlal, S., 2014). Over the last half-century, Tilapia farming has expanded across tropical and semi-tropical regions worldwide **(Popma, T., &Masser, M. 1999)**. It is the second most cultivated fish globally, reaching 6.67 million tonnes annually, following carp, and consumes approximately 3% of the world's fishmeal supply **(Sarr, SerigneModou, and al., 2019).**

Tilapia is highly valued in aquaculture due to its rapid growth, prolific breeding in captivity, and tolerance to diverse environmental and farming conditions. Cultivating this fish requires minimal inputs, and the technology can be straightforward and adaptable for small-scale fish farmers **(Mills, R., Rautemaaand al, 2020).**

5 Geographies of Tilapia production in the word :

The primary Tilapia producers include China, Indonesia, Egypt, Brazil, the Philippines, and Thailand (FAO, 2014). As for major importers, the United States, Mexico, Côte d'Ivoire, and Iran are notable (Abed &Beloufa, 2019).

Global Tilapia production has significantly increased from approximately 1 million tonnes in 2000 to 5.97 million tonnes in 2018, with a total value of nearly US$11.2 billion. Among the 120+ nations reporting Tilapia production, China alone contributed 27% of the global volume in 2018. The top three producers—China, Indonesia, and Egypt—accounted for 64% of the global production that year **(FAO,2020).**

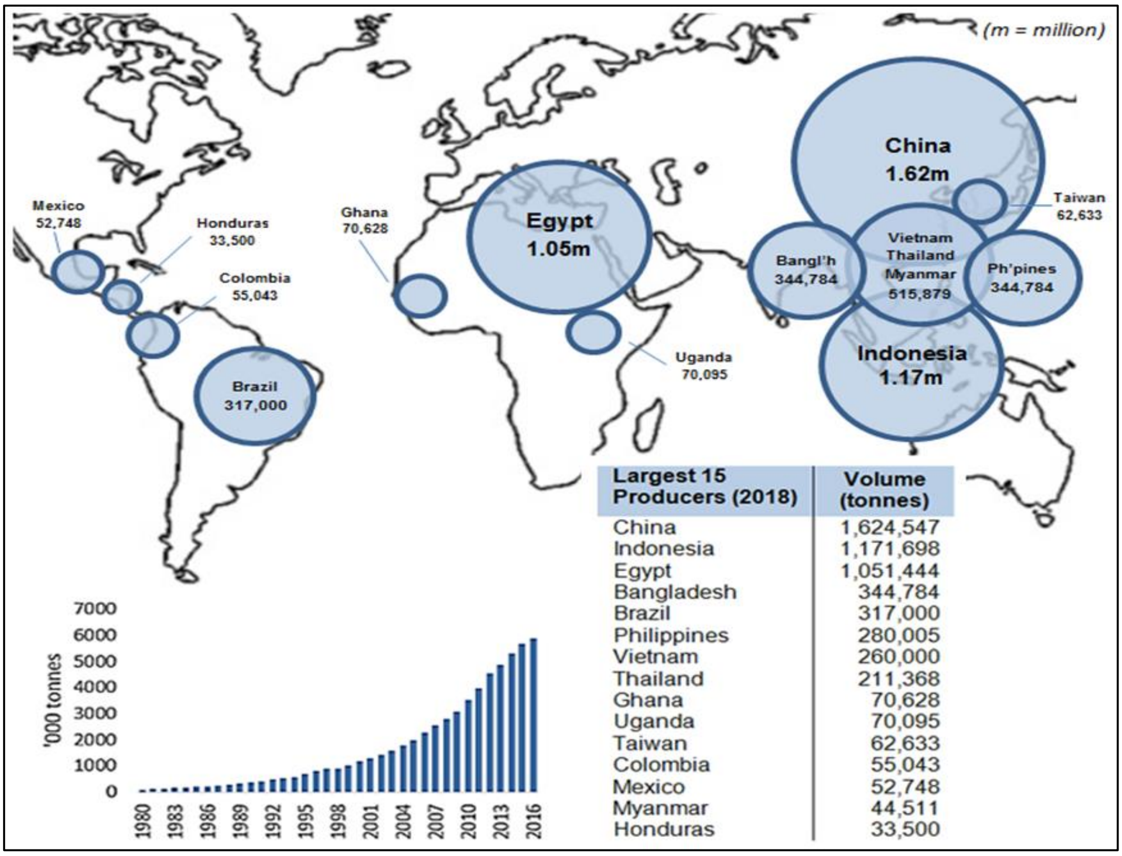

Figure 1 : Global Tilapia Production (FAO, 2020).

6 Types of the Tilapia

Tilapia aquaculture primarily revolves around three species from the genus Oreochromis (O. niloticus, O. aureus, and O. mossambicus) and two species from the genus Tilapia (T. zillii and T. rendalli) (Siddiyui and Al-Hurbi, 1995). These species are typically distinguished by distinct banding patterns on their caudal fins..

6.1 Nile Tilapia (OREOCHROMIS NILOTICUS)

The Nile Tilapia is the most widely farmed Tilapia species globally **(Romana-Eguia, M., and al., 2020).** It is highly valued for its rapid growth, resilience, and adaptation to breeding in tropical regions .

6.2 Mozambique Tilapia (*Oreochromis mossambicus*)

Also known as the Mozambique mouth brooder, Kuyper, or mud bream (South Africa), and Ikun mu-jair or Miracle fish (Indonesia), the Mozambique Tilapia exists in two forms in northern Queensland. The "pure form" is found in the Townsville-Thuringowa region, while a hybrid form is present in the Cairns region, Atherton Tablelands, and the Burdekin River system. Both forms are deep-bodied with nearly symmetrical, tapered extensions at the rear edge of their single dorsal and anal fins. These extensions are longer in males than in females. Sexually mature males of both forms have enlarged jaws, often with a concave upper profile of the head (Webb, A., Maughan, M., & Knott, M., 2007).

6.3 Red Tilapia (*Oreochromis sp.*)

Tilapia (*Oreochromis sp.*) is a fish of significant economic importance, ranking fourth among global fishery commodities. In 2016, it accounted for 8% of the total world fish production (FAO, 2018)

7 Environmental requirements of the Tilapia

Tilapia can thrive under a wide range of environmental conditions, including salinity, dissolved oxygen levels, temperature, pH, and ammonia levels . Compared to most freshwater fish species, Tilapia exhibit remarkable tolerance to varying conditions. Salinity tolerance varies among species, with Nile Tilapia being the least adaptable to significant changes (e.g., direct transfer to 18 parts per thousand salinity). Conversely, Mozambique Tilapia, blue Tilapia, and redbelly Tilapia (T. zilli) are known for their high salt tolerance, capable of thriving in salinities up to 36 parts per thousand, though optimal growth and reproduction occur at salinities up to 19 parts per thousand **(El-Sayed, A. F. M. (2006) .**

In terms of dissolved oxygen, Tilapia are highly tolerant, capable of surviving in conditions as low as 0.1 mg/L, although optimal growth typically occurs at levels above 3 mg/L **(Mjoun, K., and al . (2010).**

Temperature significantly influences their metabolism, with optimal growth occurring between 22°C (72°F) and 29°C (84°F), and spawning usually taking place above 22°C (72°F). While most Tilapia species cannot survive temperatures below 10°C (50°F), blue Tilapia demonstrate exceptional cold tolerance, surviving temperatures as low as 8°C (46°F). Some species can withstand temperatures as high as 42°C (108°F) **(Sarig, 1969; Morgan, 1972; Caulton, 1982; Mires, 1995).**

Table 1: environment conditional of the Tilapia (Sarig, 1969; Morgan, 1972; Caulton, 1982; Mires, 1995).

parameter	range	optimum for growth
Salinity, parts per thousand	**Up to 36**	**Up 19**
Dissolved oxygen, mg/L	**Down to 0.1**	**> 3**
Temperature, C°	**8–42**	**22–29**
pH	**3.7–11**	**7–9**
Ammonia, mg/L	**Up to 7.1**	**< 0.05**

8 Tilapia in Algeria

The Tilapia Fish Is very little present in Algerian market; In Algeria, the Tilapia species is farmed because of its hardiness to climatic conditions, especially in the Saharan zone, where water temperature and salinity stimulate its growth and reproduction **(TOUAHRIA, N, 2020)**

The Ouargla wilaya has large quantities of fresh and brackish water from boreholes used to irrigate palm groves and underlying crops. The availability of water and the numerous irrigation basins and canals have made it possible to plan the development of a Saharan aquaculture cluster integrated with agriculture, based on the extensive breeding of freshwater fish (mainly Nile Tilapia and its hybrids such as red Tilapia) in synergy with the development of the palm groves **(FAO.,2018)**

Chapter 02
Presentation of the RED Tilapia (OREOCHROMIS SP)

1 Definition of the red Tilapia :

Tilapia culture then flourished through the 1980's with the introduction of a hybrid species called the red Tilapia (*Oreochromis spp*.). This species was known for its red-orange to pale red (pink) color which was more appealing to the local Filipino-Chinese market**(Romana-Eguia, M. R. R., Eguia, R. V, 2020)**, One of the main factors that affect the success of this industry is the selection of species with high productive potential, which are rich in proteins and a variety of unsaturated fatty acids and organoleptic conditions , Such is the case of red Tilapia due to its features such as the absence of intramuscular spines, mild flavour, and easy preparation **(Mendez-Martinez, Yuniel, et al.2023)** , One of which is the red Tilapia which has an appealing colour and taste. It has many economical characteristics such as being omnivorous, reproductive in captivity, highly resistant to diseases and ability to grow in brackish and salt waters **(Apino, R. M., Emplonuevo, R. M., & Vera Cruz, E. M. (2022) .**

Figure 2 : red Tilapia (Apino, R. M, (2022)

2 Life history:

The "red" Tilapia has become increasingly popular because its similar appearance to the marine red snapper gives it higher market value. The original red Tilapias were genetic mutants. The first red Tilapia, produced in Taiwan in the late 1960s, was a cross between a mutant reddish orange female Mozambique Tilapia and a normal male Nile Tilapia. It was called the Taiwanese red Tilapia. Another red strain of Tilapia was developed in Florida in the 1970s by crossing a normal colored female Zanzibar Tilapia with a red-gold Mozambique Tilapia. A third strain of red Tilapia was developed from a mutant pink Nile Tilapia crossed with wild Blue Tilapia. All three original strains have been crossed with other red Tilapia of unreported origin or with wild Oreochromis species. Consequently, most red Tilapia in the Americas are mosaics of uncertain origin. The confused and rapidly changing genetic composition of red Tilapia, as well as the lack of (head-to-head) growth comparisons between the different lines, make it difficult for a producer to identify a (best) red strain **(Popma, T., &Masser, M. (1999)).**

3 Morphologic of the Tilapia:

The morphological plasticity of Tilapia has been characterized previously by GM. For example, **(Lorenz, O., Smith, P., & Coghill, L. (2014).**determined that after an eradication attempt with rotenone, Tilapia were deeper in body and head shape than pre-management individuals. Similarly, (**Ndiwa, T. C., Nyingi, D. W., Claude, J., &Agnèse, J. F. (2016).**found variations in the head, caudal peduncle and anal fin base of Nile Tilapia from extreme environmental conditions compared to populations experiencing less extreme conditions. These authors also registered morphological differences between populations with similar genetic background. Also, **(Firmat, C., Schliewen, U. K., Losseau, M., &Alibert, P. (2012))** described that invasive populations of Mozambique Tilapia exhibited a more elongated body shape, a shorter caudal peduncle and a more expanded anterior region relative to native populations. Concerning shape changes during growth, **(Fujimura, K., & Okada, N. (2008))**assessed the developmental trajectory that leads to the adult lower jaw shape in Nile Tilapia and concluded that differences in adult shapes might be due to differences arising early in development. Differences in shape between lines, Therefore, we hypothesized that a phenotypic variable species as Tilapia would show differences in shape between separate rearing sites.

4 Black solidary fly :

The black soldier fly (*Hermetia illucens*), hereinafter referred to as "Hermetia," belongs to the family Stratiomyidae. In English specialized literature, it is known as the "Black Soldier Fly" (BSF). It is part of the order Diptera (Diptera). The fly and the pupa measure about two centimeters, with males slightly smaller than females**. (Wohlfahrt, J., &Sandrock, C. (2023).**

The protein content of larvae fattened on brewer's grains and pasta was higher, while the fat content was lower compared to larvae fattened on fruits and vegetables. However, these levels can vary significantly depending on the individual components. (**Wohlfahrt, J., &Sandrock, C. (2023).**

5 Reproduction

In all *Oreochromis* species the male excavates a nest in the pond bottom (generally in water shallower than 3 feet) and mates with several females. After a short mating ritual the female spawns in the nest (about two to four eggs per gram of brood female), the male fertilizes the eggs, and she then holds and incubates the eggs in her mouth (buccal cavity) until they hatch. Fry remain in the females mouth through yolk sac absorption and often seek refuge in her mouth for several days after they begin to feed.(**Popma, T., &Masser, M. (1999)**.

5.1 Male and female Tilapia

Male Tilapia are usually larger than females of the same age. To tell the difference between male and female fish, compare the illustrations in which show the differences between the external appearances of the sex organs of a mature fish.

The male has two body openings situated just forward of the anal fins, of which one is the anus. The other is the opening of the urethra, at the end of the genital papilla (an oval-shaped lobe just rearward of the anus), from which milt (sperm) and urine are discharged.

The female has three body openings, of which one is the anus. The genital papilla of the female has two openings. They are the urethra, which is hardly visible to the naked eye, and the opening of the oviduct (a crescent-shaped slit), from which eggs are released.

These features are more visible and identifiable when the fish have grown to 10–20cm in length and 100–150g in weight. Mature Nile Tilapia can also be distinguished by their coloration under the jaw — reddish in males and greyish in females.**(Bhatta, Set (2012).**

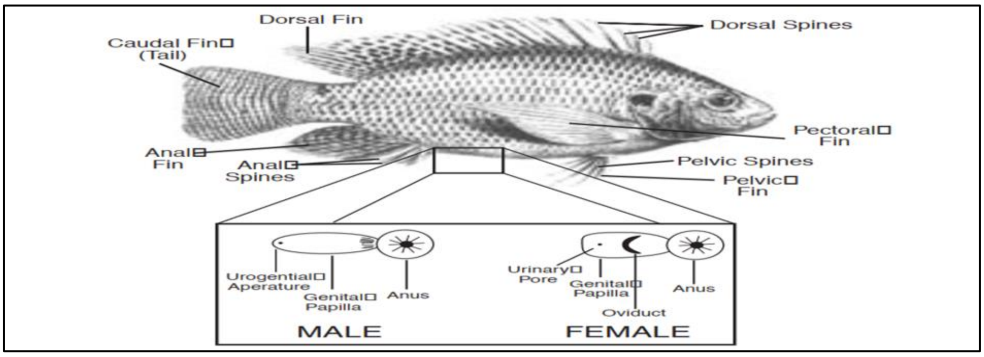

Figure 3 : presentation of the different between the male and female of the Tilapia (Fins and genital papilla of the Nile Tilapia) (Bhatta, Set (2012).

6 World production of the red Tilapia:

The Food and Agriculture Organization (FAO) is a reliable source for fisheries and aquaculture statistics. Their most recent global Tilapia production figures are from 2018, at around 5.5 million metric tons (**FAO, 2022)**, we have to mention that the Red Tilapia Isn't a Single Species: Red Tilapia is often a name for genetically modified or hybridized Nile

Tilapia or Mozambique Tilapia bred for a reddish hue. Total Tilapia production statistics typically group all Tilapia varieties together.

7 Hematological of the red Tilapia:

The blood system directly or indirectly reacts to changes in the environment, objectively reflects the physiological state and allows predicting the direction of adaptive response in the body Changes in hemoglobin, hematocrit, fluctuations in the number of red blood cells and white blood cells clearly show the physiological reactions of the blood under the toxic effects from the environment , The blood system is one of the major organ systems in which heavy metals impact (**Pharm. and Tech , 2019**)

Table 2 : hematological of the res Tilapia (Pharm. and Tech , 2019)

Composition	Control
Hematocrit (%)	39.29 ± 6.04^{a}
Hemoglobin (g%)	8.180 ± 0.535^{a}
Red blood cells (*$10^6/mm^3$)	2.554 ± 0.267^{a}
White blood cells (*$10^3/mm^3$)	60.27 ± 3.59^{a}

8 Natural food and feeding habits:

Early juveniles and young fish are omnivorous, feeding mainly on zooplankton and zoobenthos but also ingest detritus and feed on aufwuchs and phytoplankton. At around 6 cm TL the species becomes almost entirely herbivorous feeding mainly on phytoplankton, using the mucus trap mechanism and its pharyngeal teeth (**Moriarty, D. J. W. (1973**). The pH of the stomach varies with the degree of fullness and when full can be as low as 1.4, such that lysis of blue-green and green algae and diatoms is facilitated (**Moriarty, D. J. W. (1973)).** Enzymatic digestion occurs in the intestine where pH increases progressively from 5.5 at the exit of the stomach to 8 near the anus. Nile Tilapia exhibit a diel feeding pattern. Ingestion occurs during the day and digestion occurs mainly at night (**Trewavas, 1983**). The digestive tract of Nile Tilapia is at least six times the total length of the fish, providing abundant surface area for digestion and absorption of nutrients from its mainly plant-based food sources (**Opuszynski and Shireman, 1995).**

Chapter 03 Methodology

1 Breeding system

The object in our experiment focused on creating a nutritious and affordable a nutritional diet made with local ingredients. so in order to achieve our goal, we try to make a feed formulation at least contains 30% protein ,6% crude fat , also 18% glucid.

1.1 Installation of the tank

First of all , before the experiment begin we start installed the breeding system from putting the tank each one in there place.

Figure 4 : Breeding system , a: laboratoire facilite ,b,c: two different tank

1.1.1 Filtration system

After that , We creating a simple filtration system from Double-layered plastic crate: bottom layer holds a ceramic cylinder, top layer filled with cotton wo

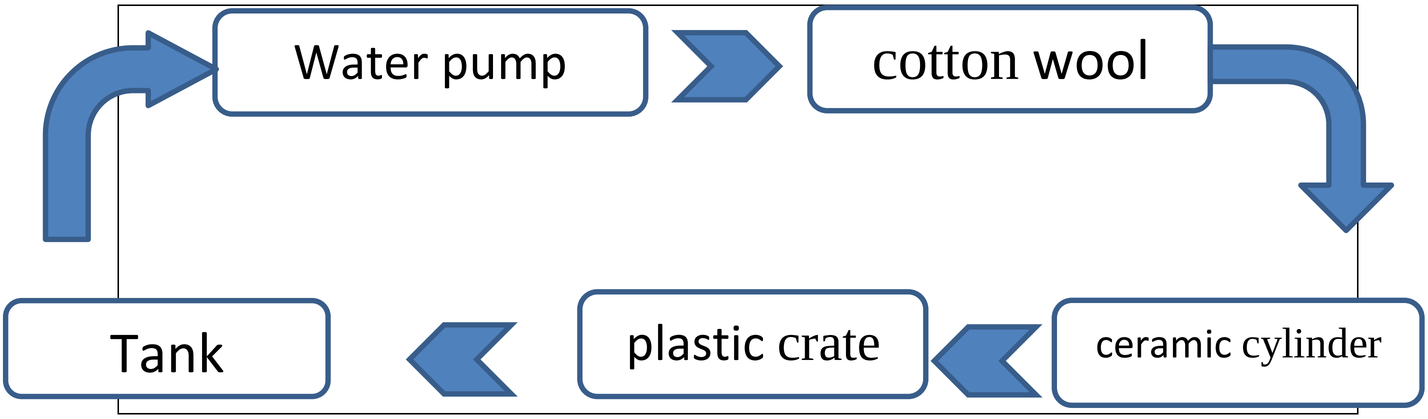

Figure 5 : creation of the filtration

1.1.2 Temperature system

Temperature plays a crucial role in aquaculture, affecting various aspects of the growth, health, and productivity of aquatic organisms. Temperature management is essential in aquaculture to optimize the growth, reproduction, health, and survival of aquatic organisms. Therefore, rigorous monitoring and control of temperatures in farming systems are indispensable to ensure sustainable and efficient production. Because temperature is the main factor affecting the fish survive , so For the temperature regulation , We use Fish tank heating rod (a simple one)

1.1.3 water pump

the quality of the water effect the result in our experiment and have a disease effect for the fish.so to avoid water gets dirty we need a water pump connected to a plastic tube.

1.1.4 Oxygen system

To provide all the environment conditional for the fish to give us the best result , We use a simple mechanical system of the dissolved oxygen in our tank from pump connect with plastic tube

1.2 Food preparation

in this experiment we focus on the result more than the steps so we didn`t follow a specifique experiment protocol to prepare the different diet we made it by the traditional technique

we have to mention that we have three different diets

first one basically in animal source protein (black solidary fly)

second one is vegetables protein source (peas + bean)

the last one is the control diet which e is the ONAB formulation

Table 3 : chemical l composition of the three diets

composition	aliment 01	aliment 02	onab
protien	30	34	28
lipides	5,44	10	6
glucides	25	24,7	14

1.2.1 Preparation

Red Tilapia thrive on a balanced diet, and creating homemade feed pellets can ensure they receive the essential nutrients they need for optimal growth and health. Here's a comprehensive guide to crafting nutritious red Tilapia feed pellets using a combination of traditional and modern techniques:

Begin by grinding all the dry ingredients, including corn, soybean meal, peas, and wheat flour, beans into a fine powder using a hammer mill or grinder , Follow a specific recipe tailored to the age and nutritional needs of your red Tilapia. Precisely measure each ingredient using a weighing scale to ensure consistent nutrient content.

In a large mixing bowl, combine all the dry ingredients from formulas 1 (the same think for the rest formulation) , add the olive oil and the eggs after that Slowly add sterile water to the dry ingredient mixture , mixing continuously until a dough-like consistency is achieved. The dough should be easily formed but not sticky. Consider a brief conditioning step (15-30 minutes) after adding moisture to allow ingredients to absorb moisture and facilitate pellet formation. While optional, steam conditioning can further improve pellet quality. Briefly expose the moistened mixture to steam (5-10 minutes) to soften it and enhance binding , Utilize a manual or electric pellet mill to transform the mixture into thin, long strands. Adjust the die size to achieve a pellet diameter of around 3mm, suitable for red Tilapia, Spread the formed pellets on a clean, dry surface in a well-ventilated area protected from direct sunlight. Allow the pellets to dry for at least 3 days, turning them occasionally to ensure even drying.

The last part is the storage , Store the dried pellets in airtight containers in a cool, dry place to maintain freshness and prevent spoilage.

Therefore, the reference feed used in this study is the one produced by the National Office of Animal Feed (ONAB), with the following composition:

- 55% Soybean

- 8.5% Corn

- 30% Wheat bran

- 1.5% Limestone

- 0.8% Phosphate

- 3.7% Olive oil

- 0.5% Mineral-vitamin complex

1.2.2 Feeding

Each tank contains fish with an average weight of 15 grams. They are fed a daily amount equal to 5% of the average fish weight, divided into three separate meals:

1/ in the morning

2/ in the noon

3/ in the evening

2.4.The food distribution occurred as a result of:

In the first day : 25% food tested , 75% control

Three days after that : 50%food tested , 50% control

Three days after that : 75%food tested , 25% control

Participants will continue to receive only thoroughly tested food for the remainder of the experience.

1.3 The parameters studied

1.3.1 The weight and the size

An electric scale is used to measure weight after the tanks are cleaned, which is done by emptying them completely within 07 days. There is an intermediate tank that is used to evacuate fish during the emptying process.

Results and discussion

1 Average Initial Weight

The histogram represents the initial weights (in grams) for three different diet groups. At first glance, it's noticeable that the control group has weights clustered between 200g and 300g, while the BSF (Black Soldier Fly) tank shows a cluster between 400g and 500g. This difference in initial weights could potentially influence the final results of the experiment.

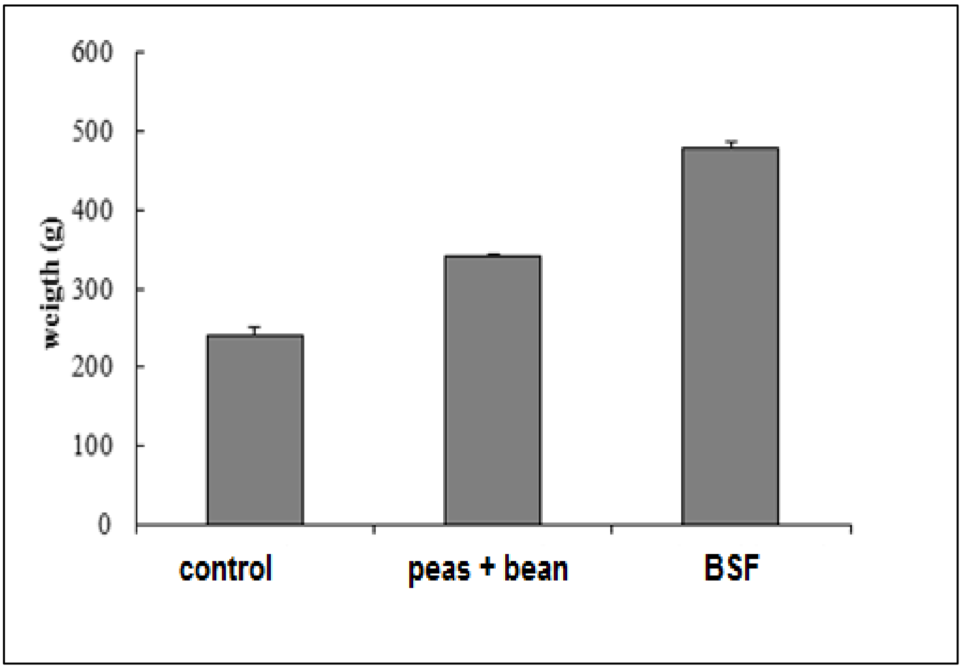

Figure 6 : Average Initial Weight

2 Average Initial Length

This graph represents the initial length (in cm) for different diets. It shows that the (peas + bean) diet exhibits the highest initial length for each fish (12cm / 12.5 cm). Following this is the BSF diet at 11.7 cm per fish, and the control diet at 11.5 cm per fish.

Additionally, it is evident that these lengths are expected to increase throughout the experiment period. For instance, the control diet is projected to reach 13.5 cm per fish, the (peas + bean) diet to 13 cm to 13.5 cm per fish, and the BSF diet to 13 cm per fish**.**

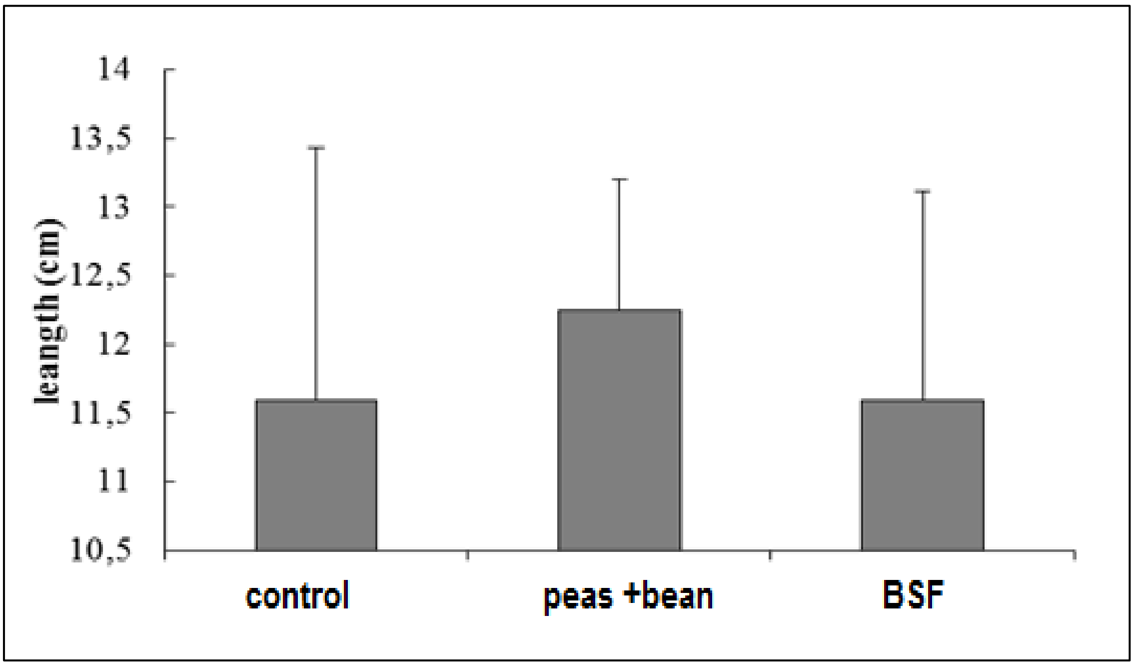

Figure 7 : Average Initial Length

3 Initial Average Width

This graph represents the initial width (in cm) for three different nutritional diets. Similar to the average length observations, the second diet (peas + bean) shows the highest width levels (3.5 cm/fish to 4 cm/fish), followed by the BSF diet at 3.5 cm/fish, and the control diet ranging between 2.5 cm/fish to 3 cm/fish

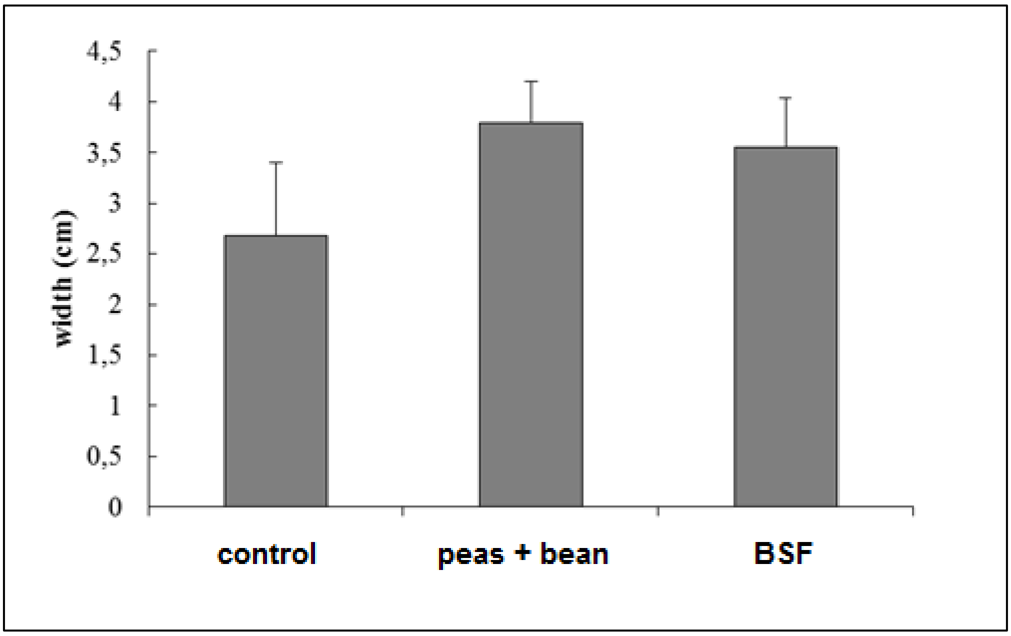

Figure 8: Initial Average Width

4 Average Weight Gain

The graph shows the weight improvement over a 4-week experiment period. In the first week, all three diets showed slight development, with the BSF diet exhibiting the most noticeable improvement. The control and peas + bean diets remained stable.

By the second week, both the control and peas + bean diets showed minimal development, while the BSF diet displayed a decrease in weight.

Based on the graph, it suggests that a diet rich in animal protein (BSF) may lead to faster weight gain in red Tilapia fry compared to diets high in vegetable protein (peas + bean) or a standard diet (control).

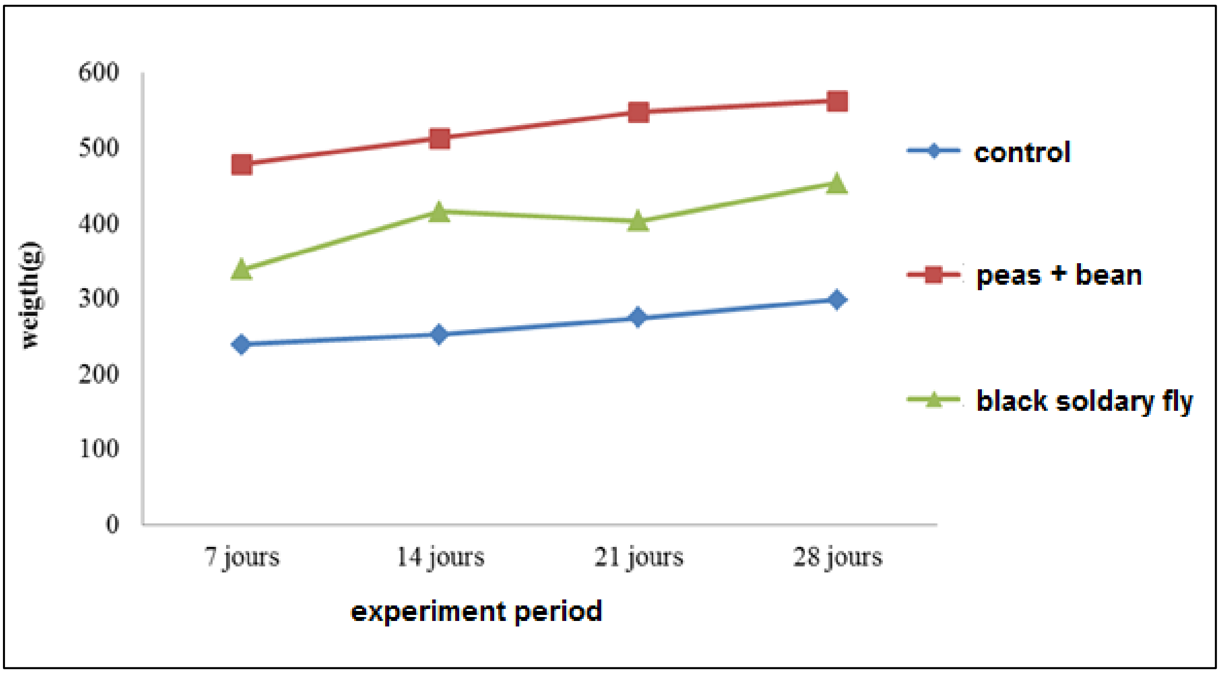

Figure 9 : Average Weight Gain

5 Average Daily Gain

The histogram illustrates the daily evolution in the average weight of each food diet. It is evident that the diet containing the highest evolution in this experiment is the one with animal protein, which provides all essential amino acids crucial for fish growth.

The second diet, consisting of peas + beans, also yielded significant results. Vegetative protein sources contain all essential amino acids but require more energy for breakdown, making it harder for fish to utilize efficiently.

Comparing these results with the control diet, it is clear that our new food diet can achieve superior outcomes with minimal resource investment.

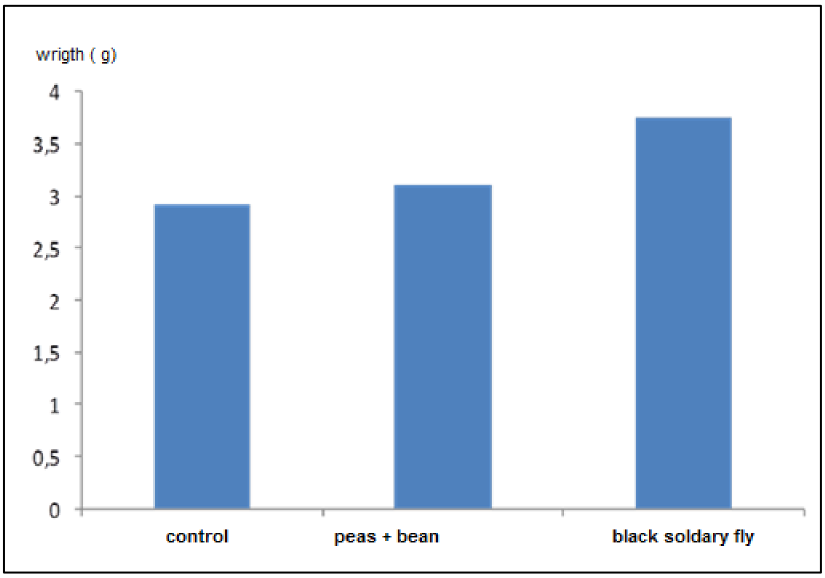

Figure 10 : Average Daily Gain

6 Length evolution

From 7 days to 14 days: All three lines show consistent development.

From 14 days to 21 days: The red line (peas + bean) and the blue line remain at the same level (100cm to 160cm), while the green line (BSF) shows slight development (20cm).

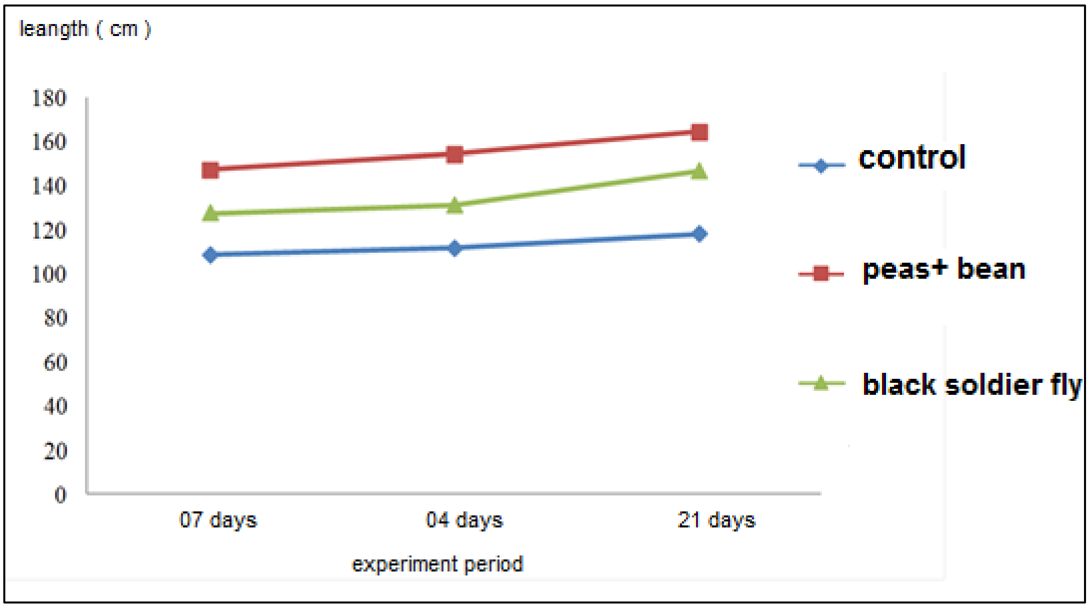

Figure 11: length evolution during the 30 days

7 Width evolution

This graph represent the evolution of the width in the experiment period of 21 days so

As we explain the evolution in length we can say the same think about the width

First week show a stable improvement

Second week registry a little development in the three lines

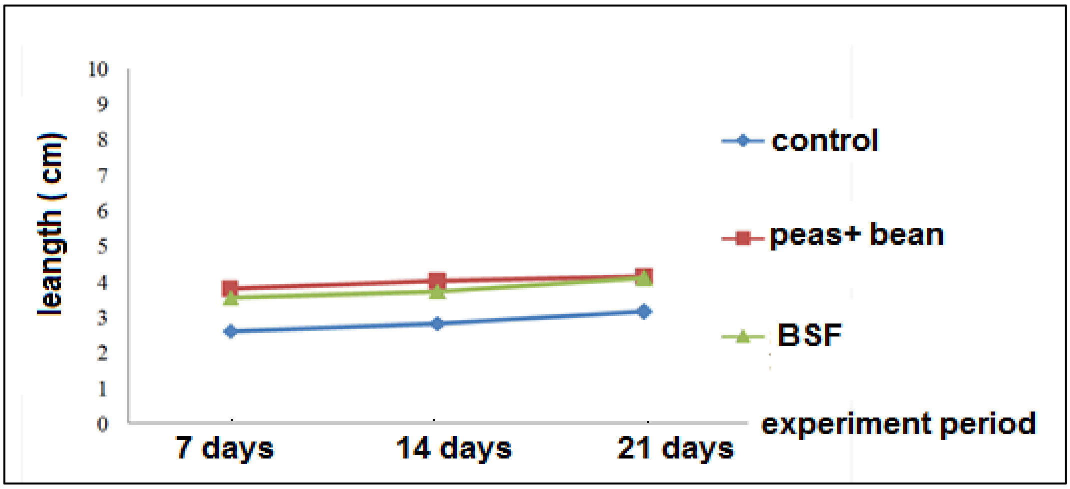

Figure 12 : Width evolution entier experiment period

Table 4: the growth parameters and body indices of red hybrid Tilapia fed with formulated diets for 4 weeks .

Growth parameter	**bsf**	**peas + bean**	**control**
GMM	12,2	12,7	16,16666667
ADG	0,406666667	0,423333333	0,538888889
GMH	3,05	3,175	4,041666667

The expansion of aquaculture has significantly boosted total fish output year after year. This growth is primarily attributed to the transformation of aquaculture from an artisanal practice to a scientific endeavor (De Silva). In 2018, global fish production peaked at 179 million tonnes, with nearly 90% of this output directly contributing to human consumption **(FAO, 2020).**

Several studies suggest that numerous leguminous or cereal plants and their by-products can serve as valuable partial protein sources for Tilapia. Examples include leucaena leaf meal (with 30% crude protein content), brewery wastes, various corn products such as gluten, gluten feed, distiller's grain, and co-products, as well as cassava leaf meal, green gram legume, lima bean, and leaf protein concentrates, all recognized for their significance (Lim and Dominy, 1991).

The exclusive use of agri-food by-products to feed farmed fish could be explained by the high availability of these by-products in rural areas, and therefore their greater accessibility in terms of cost ((Mendez del Villar and Bauer, 2013; PRESOA, 2011). On this matter, Ouattara (2004) observes a 29.49% increase in mass gain and a 60.53% survival rate among juvenile Sarotherodon Melanotheron fed with feed containing 30% protein compared to a diet based on wheat bran, rice, and corn.

The inclusion of black soldier fly larvae meal consistently improves feed conversion ratios (FCR) across various fish species, such as Atlantic salmon post-smolt (Lock et al., 2016) and Siberian sturgeon (Rawski et al., 2020). Studies suggest that defatting insect meals enhances their digestibility and nutrient utilization, thereby optimizing feed efficiency (Basto et al., 2020). Specifically in Nile Tilapia, replacing soybean meal with 100% black soldier fly larvae meal has been associated with enhanced growth performance (Shati et al., 2022). The observed high survival rates in experimental Tilapia can be attributed to rigorous experimental conditions and the efficient utilization of defatted black soldier fly larvae meal (Munguti et al., 2024). Recent studies by Abdel-Tawwab et al. (2020), Wachira et al. (2021), Limbu et al. (2022), and Shati et al. (2022) have also corroborated these positive outcomes for Nile Tilapia..

This study aimed to assess the impact of experimental feeds composed of locally sourced animal and plant ingredients on the growth of red Tilapia "Oreo-chromis Sp." compared to a standard reference feed. The overall weight and average size of the red Tilapia fish were monitored every seven days in two experimental tanks. Observations of weight and morphometric measurements indicated fluctuations in both parameters across various batches.

The physico-chemical parameters of the water generally fell within the recommended optimal range. The recorded temperature of 28°C during the experiment aligns with European regulations for fish water (2006/44/EEC and 2006/113/EC), which specify a range of 8 to 30°C. Mélard (1999) identified the optimal temperature for the growth of *Oreochromis spp*. to be between 26-30°C.

Regarding the feeding regimes, the batch receiving the reference feed showed an average weight increase from 17.72 g to 27 g. In contrast, the batch fed with an alternative feed made from black soldier fly larvae saw its average weight rise from 30.9 g to 40.81 g over a thirtyday period. This outcome can be attributed to the efficiency of insects as food converters, as they do not require energy to maintain a high body temperature (Nijdam et al., 2012).

The plant-based feed composed of peas and beans resulted in an average weight variation in the batch from 36.83 g to 45.58 g during the same period. These findings are consistent with various research studies, such as those conducted by Falaye&Jauncey (1999) using cocoa husk meal for Nile Tilapia.

Morphometric measurements revealed that fish receiving the reference feed exhibited an increase in average width, from 3.13 cm to 3.25 cm over a 30-day period. In contrast, fish fed with feed made from black soldier fly larvae showed an increase in average width from 3.58 cm to 4.09 cm during the same period. The feed containing peas and beans resulted in an increase in average width from 3.62 cm to 4.12 cm.

Similar patterns were observed for the lengths of the experimental subjects. The reference feed led to an average length increase from 9.67 cm to 10.92 cm over 30 days. Fish fed with black soldier fly larvae saw their average length increase from 11.75 cm to 12.96 cm. Conversely, the third feed option (peas and beans) resulted in a length increase from 11.91 cm to 13.62 cm.

In terms of daily biomass gain, Tilapia fed the control diet exhibited the highest rate (0.53 g), followed by those fed a diet comprising peas and beans (0.42 g), and then those fed black soldier fly larvae, which recorded a gain of approximately 0.40 g. However, the formulated diets did not enhance daily biomass gain compared to the control diet. This pattern was consistent for weekly and monthly biomass gains as well (table 4).

Conclusion

Conclusion

This study examined the impact of incorporating local products and by-products into Tilapia diets on zoo technical performance. The results indicated varied effects of the different diets tested. Specifically, average daily gains (ADGs) were 2.90 g, 3.20 g, 3.6 g, 1.55 g, and 0.33 g for Food 1 (ONAB), Food (Formula BSF), and Formula with peas and beans, respectively.

Morphometric measurements revealed that fish fed the reference diet increased their average width from 3.13 cm to 3.25 cm over 30 days. In contrast, those fed a diet based on black soldier fly larvae saw their average width increase from 3.58 cm to 4.09 cm during the same period. Similarly, fish fed a diet containing peas and beans increased their average width from 3.62 cm to 4.12 cm.

Overall, the study demonstrates that the tested feeds exert varying effects on zootechnical performance, with the black soldier fly larvae-derived feed yielding the most favorable outcomes, followed by the peas and beans diet compared to the ONAB diet.

In conclusion, despite existing constraints and limited resources, our formulated diet consistently delivered superior results, suggesting potential for advancing sustainable and efficient practices in animal production.

Figure 13 : creation of the filtration

Figure 14 : Temperature regulation

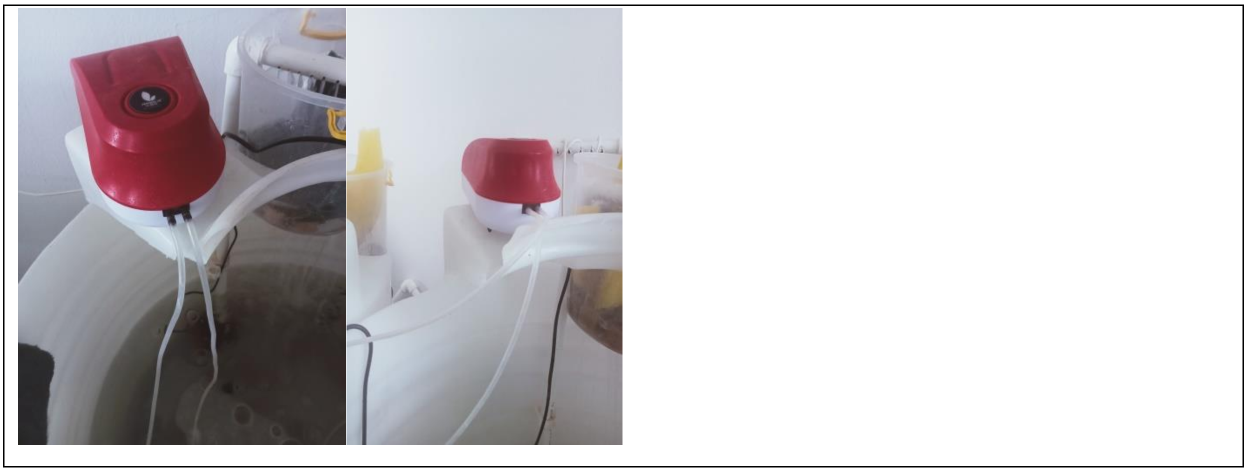

Figure 15 : water pump

Figure 16 : Aliment A : peas + bean

Figure 17: aliment B / bsf

Figure 18: control diet (ONAB)

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