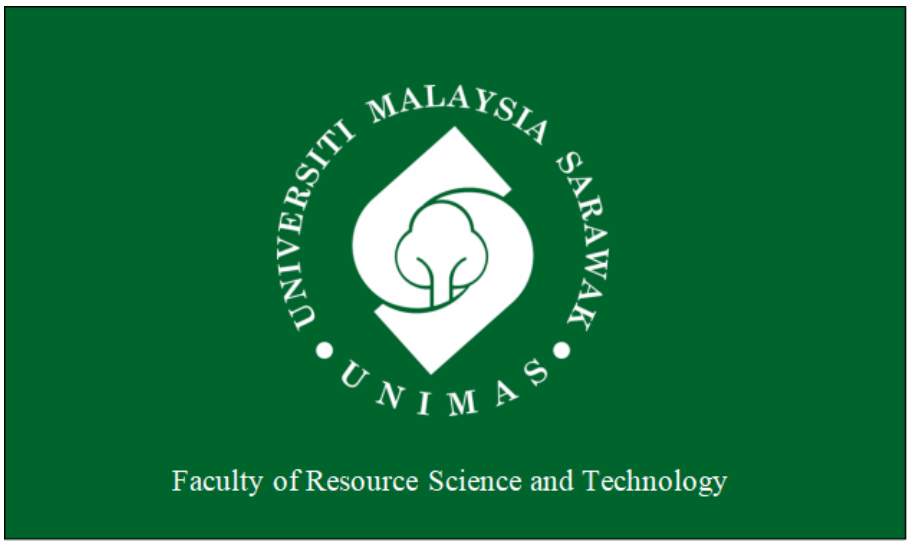

The Relationship Between Operational Feed and Fish Growth in Tilapia Fish Industries of Sarawak

Ayu Nabila Binti Khairul Anuar (72138)

Bachelor of Science with Honours
(Aquatic Resource Science amd Management)
2022

The Relationship Between Operational Feed and Fish Growth in Tilapia and Empurau Fish Industries of Sarawak

Ayu Nabila Binti Khairul Anuar (72138)

A final year project is submitted in partial fulfilment for the degree Bachelor Science with Honours

Supervisor: Dr Mohammad Bodrul Munir

WS49 Aquatic Resource Science and Management

Faculty of Resource Science and Technology

Universiti Malaysia Sarawak

2022

ACKNOWLEDGEMENT

First and foremost, all praises to God, the Almighty, for his showers of blessings throughout my research study to complete this research successfully.

I'd want to convey my gratitude to Dr. Mohammad Bodrul Munir, my research supervisor, for allowing me to conduct this study and provide me with complete supervision throughout. His motivation, vision, and sincerity have greatly influenced me.

Next, thank you to Mr Thian Hai Chung for his contribution for my research study and result regarding empurau and tilapia fishes in his farm. His sincere cooperation are very appreciated in order to provide me the best result for my study.

I also would like to thank to Borneo Empurau Sdn Bhd and Borneo Aquaculture Enteprise staffs for giving me the opportunity in order to complete my research study in every way.

Finally, I want to dedicate this report to my deeply cherished pals as well. I wish to express my loving thanks to my family and friends for their endless love, support and understanding during my studies in UNIMAS.

The Relationship Between Operational Feed and Fish Growth in Tilapia and Empurau Fish Industries of Sarawak

Ayu Nabila Binti Khairul Anuar

Aquatic Resource Science and Management Programme
Faculty of Resource Science and Technology
University of Malaysia Sarawak

ABSTRACT

This study focused on the growth performance and the diets intake by *Oreochromis niloticus* and *Tor tombroides* in the aquaculture farm. 80 tilapia fishes per acre were measured in the farm. The proximate analysis of the Uni-President feed and dead Black Soldier Fly Larvae (BSFL) raw feed used in the Borneo Aquaculture Enteprise. The protein content in BSFL raw were (459.2± 0.02 g) higher than in the Uni-Presidential feed (332 ± 0.22 g) . In terms of moisture and fiber content, BSFL feed also contain higher amount which were 101.2 ± 0.26 g and 123.9± 0.11 g meanwhile for Uni-Presidential feed, it contains 97.5 ± 0.19 g and 39.0 ± 0.09 g respectively. Apart from that, lipid, ash, NFE content and GE in the BSFL raw (11.3± 0.09 g, 7.7± 0.33 g, 201.2± 0.06 g, and 296.6± 0.35 MJ/kg) much lower than Uni-Presidential feed (61.5 ± 1.01 g, 98.5 ± 0.88 g, 371.5 ± 0.56 g, and 188.9 ± 0.22 MJ/kg). Survival rate of fish consumed BSFL raw was 100% and Uni- Presidential feed was 96.5%. There was significant difference (P=0.02107) between the tilapia's (*Oreochromic niloticus)* weight gain of BSFL raw feed diet and Uni-Presidential feed. The growth rates and survival rate of Red Tilapia (*Oreochromic niloticus*) was studied and proven to be higher when consumed dead BSFL raw feed.

Key words: Tilapia, BSFL raw feed, Uni-Presidential feed, Growth Performance, Nutrient Content

ABSTRAK

Kajian ini memberi tumpuan kepada prestasi pertumbuhan dan pengambilan diet oleh Oreochromis niloticus dan Tor tombroides di ladang akuakultur. 80 ekor ikan tilapia setiap ekar telah diukur. Analisis proksimat makanan Uni-President dan makanan mentah BSFL yang mati yang digunakan dalam Borneo Empurau Sdn Bhd dan Borneo Aquaculture Enteprise. Kandungan protein dalam BSFL mentah adalah (459.2± 0.02 g) lebih tinggi daripada makanan Uni-Presidential (332 ± 0.22 g). Dari segi kandungan lembapan dan serat, suapan BSFL juga mengandungi jumlah yang lebih tinggi iaitu 101.2 ± 0.26 g dan 123.9± 0.11 g manakala untuk makanan Uni-Presidential, ia mengandungi 97.5 ± 0.19 g dan 39.0 ± 0.09 g masing-masing. Selain itu, kandungan lipid, abu, NFE dan GE dalam BSFL mentah (11.3± 0.09 g, 7.7± 0.33 g, 201.2± 0.06 g, dan 296.6± 0.35 MJ/kg) jauh lebih rendah daripada makanan Uni-Presidential (61.5 ± 1.01 g, 98.5 ± 0.88 g, 371.5 ± 0.56 g dan 188.9 ± 0.22 MJ/kg). Kadar kemandirian ikan yang memakan Black Soldier Fly (BSFL) mentah adalah 100% dan makanan Uni-Presiden adalah 96.5%. Terdapat perbezaan yang ketara antara pertambahan berat ikan tilapia (Oreochromic niloticus) diet makanan mentah BSFL dan makanan Uni-Presidential. Kadar pertumbuhan dan kadar kemandirian Tilapia Merah (Oreochromic niloticus) telah dikaji dan terbukti lebih tinggi apabila mengambil makanan mentah BSFL yang mati.

Kata kunci* : *Tilapia, BSFL mentah, Uni-Presidential, Prestasi pertumbuhan, Kandungan nutrien

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AOAC	-	Association of Official Analytical Chemists
BSF	-	Black Soldier Fly
BSFL	-	Black Soldier Fly Larvae
FDA	-	Food and Drug Administration
FAO	-	Food and Agriculture Organization
FBD	-	Fisheries Biosecurity Division
FCR	-	Food Conversion Ratio
FM	-	Fish Meal
HACCP	-	Hazard Analysis and Critical Control Point
GAqP	-	Good Aquaculture Practices
GE	-	Gross Energy

NFE	-	Nitrogen Free Extract
RG	-	Relative Growth
SR	-	Survival Rate
UN	-	United Nations
UPM	-	University Putra Malaysia

1.0 INTRODUCTION

Tilapia species is very common and relative known in aquaculture industry. Aquaculture plays an important role in the seafood industry as it is one of an alternative way for the supply of seafood to the consumers in a shorter period without harming nature. It is a rapidly expanding landscape for aquatic foods, with production reaching an all-time high of 114.5 million tones in 2018 (FAO, 2010). Because of that, the aquaculture farm management is very important in order to provide the best quality of seafood sources to everyone because people will only choose the best food especially for those who lives in the city where they have limited stocks of fishes, prawns, crabs, clams and all kind of seafoods. UN Nutrition (2021) stated although the current food systems produce enough food for the global populations, the cost of a healthy diet is unfavorable for many people.

Thus, this is a very serious matter because as this COVID -19 happened, it is expected to exacerbate food insecurity and undernourishment through disruptions to food supplies. There are estimated about 83 - 132 million people becoming malnourished because of this Covid-19 (FAO *et al*., 2020). Thus, to provide the best products, the farmers need to be aware about the fish nutrition in their daily food and the whole farm management. Farmers must take the needed quantities of each nutrient for each species cultured. The nutritional requirements of most species are relatively extensive and complex and the nutrients they require includes carbohydrates, lipids, nucleic acids, proteins, minerals, and vitamins (Jessica *et al.,* 2015).

Supported by the (FAO, 2007) food safety is very important especially for analyzing and managing relevant risks to human, animal and plant life and health and associated risks to the environment. Other than ensuring the fish diet, aquaculture farm management in the terms of water quality, farm systems, and disease control are very

serious matters with the purpose to achieve the best products. In this respect, Fisheries Biosecurity Division (FBD) had developed biosecurity to strengthen the biosecurity control within the country. FBD had developed the Biosecurity Measures Plan as guide for fish farmers, ornamental fish producers and exporters, along with Good Aquaculture Practices (GAqP) to promote sustainable production (Sekaran, 2014).

Expensive cost of fish feeds either floating or extrusive feeds, it becomes a serious matter to all the aquaculture farmers. To provide the best for their species, they must invest in that expensive feed but still have other commitments towards their farm. This is the main problem that sometimes they choose to buy the cheaper one or make it by themselves having not enough macro and micronutrients in the fish diets. Blood meal is a low-cost feed where it is used as a protein source in the diets of livestock (Mulik, 2014) for the purpose to replace fish meal, but they have insufficient nutrients content. When an unbalanced diet happened in the farm, they must face other problems too which can affect the growth performance of the fish.

This problem is also related with the aquaculture management on how the farmers handle their farm by the water quality, farm systems, disease outbreak and many other aspects. When these problems are faced in the farm, they will have problems with the seafood production whenever they want to provide the best one to be sold at the market. With the high demand of the seafood supplies, sometimes they just provide the stocks for the consumers without ensuring the products quality. Although the seafood industry itself has been slow to promote seafood's healthfulness, most consumers are aware of its nutritional value (Anderson *et al.,* 1991). To overcome those problems, the knowledge about the fish diet and farm management must be taken more seriously as they are the main problems that arise before the others. (FAO, 2000)

declared that there are additional recommendations for improving nutrition and feeding procedures in support of long- term aquaculture development in the third millennium.

The objectives of this research are to:

1) To identify the nutrients content of the operational feeds for the tilapia species in the commercial fish farm.

2) To observe the diets and growth performance of red tilapia (*Oreochromis niloticus*).

2.0 LITERATURE REVIEW

2.1 Red Tilapia (*Oreochromis niloticus*)

Red Tilapia is one of the most popular cultured species among aquaculturist and countries. Nile tilapias were cultured about 3,000 years ago by Egyptian and mostly being cultured in Africa. Towers (2005) stated that tilapia is the generic name for a group of African cichlids. Oreochromis, Sarotherodon, and Tilapia are the three genera that are important in aquaculture. Plankton, some aquatic macrophytes, planktonic and benthic aquatic invertebrates, larval fish, detritus, and decaying organic matter are among the natural foods consumed by tilapia. It can be fed with anything hence having high growth rate making them easier and low cost to be cultured. Tilapias are more resistant to high salinity, high water temperature, low dissolved oxygen, and high ammonia concentrations than most regularly farmed freshwater fish (Towers, 2005). In Malaysia, tilapia has traditionally been a popular and favourite fish among locals (Ismail & Jumatli, 2021).

2.3 Nutrients Required in The Fish Diet

Stefanie (2014) stated that macronutrients (carbohydrate, lipid and protein), amino acids, vitamins, and minerals are the essential nutrients for the fish. These nutrients must be included in the fish diets in an effort to achieve a healthy and quality cultured species. Different species require different contents of each nutrient along with their life stages where feed typically represents approximately 50 percent of the variable production cost. The nutritional content of the feed depends on what species of fish is being cultured and at what life stage (Steven, 2017). These nutrients must be sufficient and complete in the fish diet either prepared or artificial feeds.

Based on the guidelines that can be used by the farmers for fish diet, the food must be included with proteins, carbohydrates, lipids, vitamins, and minerals which have different functions for their growth. First and foremost, needed essential nutrient is protein and it is also known as the most expensive component of fish feed (Steven *et al.,* 2017) which functions to promote optimal growth and health. In general protein requirements are typically lower for herbivorous fish and omnivorous fish than the carnivorous fish. Protein requirements also vary with rearing environment, water temperature and water quality, as well as the genetic composition and feeding rates of the fish (Steven *et al.,* 2017).

The second most important nutrient is lipids as it is a substitute for protein in aquaculture feeds. Lipids typically make up about 7 - 15 percent of fish diets, supply essential fatty acids, and serve as transporters for fat-soluble vitamins (Davide *et al*.,2017). Lipids can be gotten from many sources including marine fish and algal oils which are high in omega-3 highly unsaturated fatty acids. They supply the lipid sources for manufacture of fish diets. For optimal growth and health, marine fish require omega-3 fatty acids in amounts ranging from 0.5 to 2.0 percent of their dry diet (Steven *et al.*, 2017). This kind of nutrients in the fish sources could give benefits to people who consume the fillets where it could reduce symptoms of depression and improve cardiovascular health. Thus, it will directly contribute to the characteristics of quality seafood sold in the market.

The next required nutrient is carbohydrates, it is the cheapest source of energy in the fish diets, so it is the energy source in the fish diet that the farmers used to reduce feed costs. David D. Kuhn, an assistant professor from Virginia State University stated that carbohydrates are stored as glycogen that can be mobilized to satisfy energy demands. However, fish do not require carbohydrates as much as mammals where they

can only extract about 1.6 calories from 1 gram of carbohydrate and mammals can extract about 4 calories of energy from 1 gram of carbohydrate.

Another required nutrient is vitamins which an organic compound necessary are vitamins and minerals. Vitamins are good supplements for fish growth and health which are also the same for humans. Vitamin C is the best and most powerful antioxidant that could improve and enhance the immune system of fish. Therefore, the fish with good growth and health is the best seafood quality to be supplied for the consumers. For minerals, it is necessary in the fish diet which functions for the fish's body. There are macrominerals (calcium, sodium, potassium, chlorine, chloride, sulphur and phosphorus) which function to regulate osmotic balance and bone formation of the species) and microminerals (chromium, copper, iron, manganese, iodine, zinc, and manganese) are required for their enzyme and hormone systems.

2.3.1 Nutrients Required for The Red Tilapia (*Oreochromis niloticus)*

Table 1: Protein requirement for red tilapia species according to different life stages (FAO, 2012)

Protein requirement in freshwater		
Life stage	Weight (g)	Requirement (%)
First feeding larvae		45-50
Fry	0.02-1.0	40
Fingerlings	1.0-10.0	35-40
Juveniles	10.0-25.0	30-35
Adults	25-200	30-32
	>200	28-30
Broodstock		40-45

The major nutritional needs which are proteins of cultivated tilapia are well understood and summarized in table 1 above provided by FAO. It stated that different stages of life require different amounts of proteins this also applies to other nutrients like carbohydrates, lipids, vitamins and minerals. The minimal requirement for dietary

lipids in tilapia diets is 5%, while diets containing 10-15% lipids have been shown to boost growth and protein consumption efficiency (FAO, 2012). Following with other nutrients required, carbohydrate is needed for tilapia sp about 35-40 % carbohydrate in their daily feeds.

2.4 Aquaculture Farm Management

Farm management is not only related with the installed system and the management itself defines a lot of things and in the aquaculture field. Farm management is an economic institution such as leasing and credit to farm management (Bliss, 2021). The more efficient the farm management, the more profits will be gained by the owner hence it needs more costs to organize it. As technology progresses, the most efficient farms in the future will most likely be larger than the most efficient farms now (Bliss, 2021). However, the farmers can reduce costs by purchasing in bulk and claiming volume discounts like fertilizer, seed, crop chemicals, petroleum goods, machinery, and repair services can all be negotiated (Bliss, 2021). Farm management covered all aspects including the feeds management by managing their daily intake, feeding time and nutrients content in the feeds itself. It is important for Malaysia's aquaculture development to make sure the farms practice sustainable aquaculture development due to its strategic location in the Southeast Asia. Hence, at the farm level, all areas of an aquaculture farm management have a direct impact on the sector's current and future sustainability. Ismail and Jumatli (2021) reported excellent and efficient aquaculture farm management methods will affect the sector's potential growth and reduce farm production risks and vulnerabilities.

2.5 Common Methodology Used

From the previous research study which was done by (Lily *et al.,* 2017) on macro and micronutrients contents on selected marine fishes located in the area of Tuticorin, Southeast coast of India that involved about nine fish species samples. The macronutrients in the fish samples were assessed using the Association of Official Analytical Chemists' standard techniques (AOAC). The study is the study of the contents of nutrients inside the fish body by using flesh by following different procedures based on the nutrient's studies. Result of the findings defined the nutrients of the samples did not exceed the World Health Organization's recommended safety limits for seafood (WHO, 2013).

Recent research studies based on feed types and its nutrition discover that the nutritional content of the feed depends on what species of fish is being cultured and at what life stage (Steven, 2017). When fish are raised in high density indoor systems or cages and are unable to forage for natural food for example algae, aquatic plants and small invertebrates, they are a complete diet that should be provided. For supplemental diets, on the other hand, are only meant to complement the natural food available to fish in ponds or outside raceways. Supplemental diets do not offer a complete set of vitamins and minerals, but they are commonly used to supplement a natural diet with additional protein, carbohydrate and fats (David *et al.,* 2017).

3.1 MATERIALS AND METHODS

3.1 Study Areas Selection

The study was undergone at Borneo Aquaculture Enteprise which is exclusively for red tilapia production respectively. The data of proximate analysis of the nutrients content of the feed used for their cultured species and fish growth performance were collected from them.

3.1.1 Borneo Aquaculture Enteprise

Borneo Aquaculture Enteprise is the sister farm to Borneo Empurau Fish Farm Sdn Bhd where it specialized and exclusive for red tilapia production. It was established in 2009 and has been producing Red Tilapia since 2017. Their speciality was producing and supplying to the customers nutritious and economical Red Fish Tilapia. The farms cover 247 hectares (about 600 acres) of lake space in the pristine waters of the Batang Ai Hydroelectricity Dam in Lubok Antu district, with a total area of 10,000 hectares. They are currently Sarawak's largest producer of Tilapia fish, with 5,000 cages.

3.2 Proximate Analysis of The Feed

The proximate analysis of the fish feed used have been collected from the aquaculture farm, Borneo Aquaculture Enteprise. For tilapia fries rearing, the farm usually uses the normal Vietnam fish feed which is Uni-President. However, the farm informed that the study that UNIMAS conducted research from 2018-2020 with their own formulated feed. The [b]GE =Gross Energy Measured using Bomb Calorimeter, Parr 1356 Bomb Calori. Then, the proximate analysis of Uni-President is given in Table 2 and proximate analysis of BSFL raw is stated in Table 3.

3.3 Growth Performance Estimation

Total of tilapia fish (*Orecochromis niloticus*) involved in the study is about 80 fishes per acre. The measurement of weight of each fish were measured once in every week for along 16 weeks total. Meanwhile, for the length measurements of the fish, the farm do not have the data as they are more specialized in the industrial works and not for research work. Growth performance of the fish was related with the feed consumed mainly about the the nutrients content and studied their relationships with the fish growth performance.

3.4 Statistical Analysis

For analyzing the growth performance of fishes, few formulas were used to estimate the survival rate and weight gain of the population cultured. (Munir *et al*., 2016) stated the survival rate (SR) was determined in order to determine the efficiency of the test feeds in terms of fish development. The proximate analysis of the feeds used were recorded and determination of their nutrient contents needed were done for each species. Thus, the growth performance data and proximate analysis of dead BSFL raw feed and Uni-Presidential diet feed were identified by using Microsoft Excel 2021. Growth performance of the tilapia fish were determined by calculating its weight every four weeks of the months and were compared between the data collected.

i) The survival rate was determined by the following formula:

$$\text{Survival rate (\%)} = = \frac{No\ of\ harvested\ fishes}{Initial\ no\ of\ fishes} \cdot 100$$

The data were analyzed by using t-test by comparing their significance level between two treatments of each weight means by using a computer using Microsoft Excel Version 16.61.1.

4.0 RESULTS

There were two different diets used from this farm as the feeds to the cultured tilapia species. Dead BSFL raw diet is the main feed used to feed the tilapia species. The usual Uni-Presidential feed also been used when they do not need to boost the growth of the fish and also during fries' stage. In this farm, dead black soldier fly larvae (BSFL) along with Uni-presidential commercial fish feed have been given directly to the fish.

The proximate analysis of Uni-President is given in Table 2:

Table 2: Proximate analysis of Uni-Presidential tilapia feed (mean ± Sd; n=3)

Proximate composition g / kg	Uni-Presidential fish diet
Moisture	97.5 ± 0.19
Protein	332 ± 0.22
Lipid	61.5 ± 1.01
Ash	98.5 ± 0.88
Fiber	39.0 ± 0.09
NFE[a]	371.5 ± 0.56
GE[b] (MJ/kg)	188.9 ± 0.22

[a]NFE = Nitrogen Free Extract (1000-{Moisture+Protein+Lipid+Ash+Fiber})

[b]GE =Gross Energy Measured using Bomb Calorimeter, Parr 1356 Bomb Calori

The proximate composition of BSFL used in the farm is in table 3:

Table 3: Proximate analysis of BSFL raw (mean ± Sd; n=3)

Proximate composition g / kg	Dead BSFL dead raw fish diet
Moisture	101.2 ± 0.26
Protein	459.2± 0.02
Lipid	11.3± 0.09
Ash	7.7± 0.33
Fiber	123.9± 0.11
NFE[a]	201.2± 0.06
GE[b] (MJ/kg)	296.6± 0.35

[a]NFE = Nitrogen Free Extract (1000-{Moisture+Protein+Lipid+Ash+Fiber})

[b]GE =Gross Energy Measured using Bomb Calorimeter, Parr 1356 Bomb Calori

Dead BSFL raw contains higher amount of moisture (101.2 ± 0.26 g), protein (459.2± 0.02 g), and GE (296.6± 0.35 kg) meanwhile for Uni-Presidential fish diet contains lower values of moisture (97.5 ± 0.19 g), protein (332 ± 0.22 g) and GE (188.9 ± 0.22 kg). However as for lipids, ash, fiber and NFE, BSFL accommodate lesser than Uni-Presidential diet which were 11.3± 0.09 g, 7.7± 0.33 g, 123.9± 0.11 g, 201.2± 0.06 g and 61.5 ± 1.01 g, 98.5 ± 0.88 g, 39.0 ± 0.09 g, 371.5 ± 0.56 g respectively. Both diets have different nutrients content which makes the farm change from using Uni-Presidential feed into the dead BSFL feed to gain profits for the industrial purposes as the fishes grow into an adult stage.

Tilapia growth performance using dead BSFL raw feed and Uni-President (From fingerlings to grower) were presented in the table 4 as shown below:

Table 4: Tilapia growth performance by using BSFL raw feeds and Uni-Presidential tilapia fish diets.

Parameter/ Sampling Time		Comparison growth between two feeds	
		Dead BSFL raw	Uni-Presidential
Initial Growth in g	Initial	17.22 ± 0.12	17.09 ± 0.14
Growth gain in g	After_4W	86.47 ± 0.37	55.08 ± 0.12
	After 8W	195.25 ± 0.17	99.67 ± 0.14
	After 12W	312.61 ± 0.66	202.54 ± 0.09
	After 16W	401.02 ± 0.66	330.95 ± 0.11
Survival rate (%)	End of 1 cycle	100	96.5

All the values are means (mean ± Sd; n=3). Means of these two treatments are significantly different ($p<0.05$)

In the nursery stage, the tilapia fries have been given commercial starter feed. Fish fed with dead BSFL raw it has the earlier sell which sometimes three months crop but for Uni-Presidential, it takes time at least four months meaning 16 weeks. Initial weight for tilapia fishes fed with BSFL raw showed at 17.22 ± 0.12 g and for Uni-Presidential they weighted at 17.09 ± 0.14 g which was slightly lighter. The trends of their weight gain increased thus showed that fishes consumed dead BSFL raw diet has better growth gain compared to Uni-Presidential feeds fishes. Mean of tilapia fishes who consumed BSFL raw diets had heavier weight (401.02 ± 0.66 g) than fishes consumed Uni-Presidential feeds (330.95 ± 0.11 g). The survival rates

(%) of fish were different in two different treatments. The survival rates in treatment I was 100% and treatment-II was 96.5%. Statistical analysis shows that there was significant difference ($P<0.05$) in the mean of the fish's weight gain between two different diets which indicates that there were difference in two different treatments. The survival rates in the treatment I was 100% and treatment-II was 96.5%. The survival rate in treatment I is significantly higher than those in treatment II (Table 4).

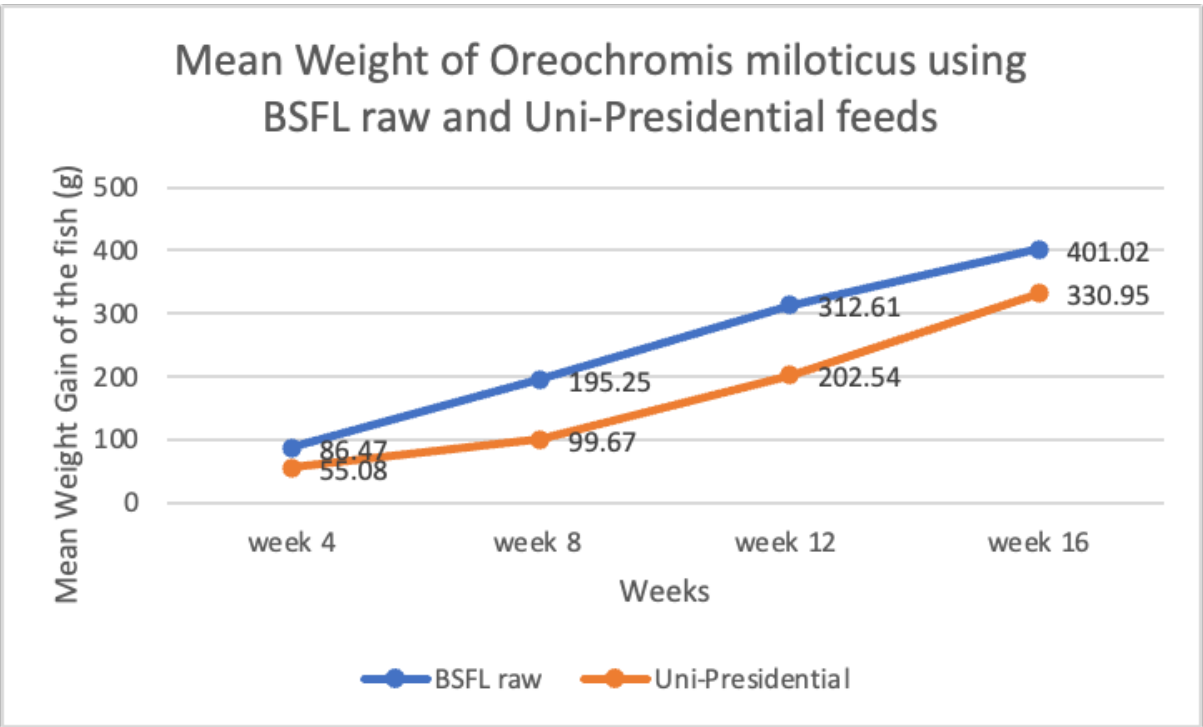

Figure 1: The graph of Mean Weight of Tilapia (*Oreochromis niloticus)* between the two feeds

From the graph shown above, the mean weight of tilapia showing that both feeds have positive impact and result to the fish's growth performance. The pattern of the graph were uniformly increased from week until week 16.

5.0 DISCUSSION

From this study, the industry managed to rear their products by having healthy fishes. Fish meal (FM) is the finest ingredient for a primary source of protein in fish feed since it meets the protein requirements of fish (Alam *et al.,* 1996). There were two types of meal used to produce tilapia which were Uni-Presidential feed and dead BSFL raw feed. The black soldier fly (BSFL) is a non-pest insect that may colonise a wide variety of rotting plants and animal debris in tropical and warm-temperate regions (Muir *et al.,* 2017). These pre -pupae contain 42% crude protein and 35 % fat, making them a viable replacement for fishmeal in industrial fish feed production (Newton *et al.,* 1977). This is an alternative way of the farm itself to increase the tilapia fish products by providing high proteins feeds to achieve maximal growth performance.

5.1 Protein

In the present study, BSFL contains higher amount of proteins which were 459.2± 0.02 g and Uni-Presidential feed contains 332 ± 0.22 g of proteins. For fry and fingerling, the best protein digestibility occurs at 25 °C (Stickney, 1997), and the optimum dietary protein to energy ratio was determined to be in the range of 110 to 120 mg per kcal digestible energy (FAO, 2022). At the farm it was set and maintained the temperature between 24°C to 27 °C. Protein is very important for their growth development and (Wang *et al.,* 2017) stated to maintain the optimal mix of other components to meet their energy requirements while meeting the minimal protein required for maximal development. Nairuti *et al.,* (2021) showed in their previous study that with the exception of lysine and methionine, BSFLM values were found to be higher than FM when the amount of essential amino acid (EAA) in the protein (g/kg crude protein) was calculated. However, it was different from other study when compared to other fish meal (FM), BSFLM exhibited reduced amino acid (AA) content (g/kg feed). Thus, this

proved that BSFLM is a good source of protein for the growth performance of the cultured species.

5.2 Moisture

In terms of BSFLM, it contains extra moisture 101.2 ± 0.26 g compared to Uni-Presidential feed 97.5 ± 0.19 g which determined the texture of the feeds hence makes the fish prefer BSFL raw more compared to the pellet feeds. According to Ojewola et al., (2005), the nutrient content of samples can be affected by factors such as the source, harvesting stage, processing procedures, and drying. Previous research has revealed that the moisture content in fish feed should be between 10% and 2% and this range contributes in the proper balance of other soluble elements such as minerals and vitamins (Muteti *et al.,* 2020).

5.3 Lipids and Gross Energy

Next, for lipid content BSFL contains less amount of lipid which were 11.3± 0.09 g compared to lipid in the commercial feed used that contain about 61.5 ± 1.01 g as shown in the table 7 above. Lipid is one of the vital contents as it serves a key physiological function in fish growth and development by providing the energy, required fatty acids, and fat-soluble minerals for the fish. Dead BSFL raw diet recorded higher amount of Gross Energy (296.6± 0.35 MJ/kg) meanwhile Uni-Presidential diet have (188.9 ± 0.22 MJ/kg) which referring back to the protein contents in each feed. High lipid levels in feeds may cause fat accumulation in fish muscle, inhibiting growth and ultimately resulting in low-quality fish fillets with a shorter shelf life. As for the fiber contents in the feeds, they were observed Uni-Presidential feed have lower amount compared to dead BSFL raw which were 39.0 ± 0.09 g and 123.9± 0.11 respectively. Fiber is necessary for both facilitating binding and improving digestive efficiency (Holland, 2014).