Dried acetes as growth promoter for guppy (Poecilia reticulata) nutrition

C F Komilus* and N M M Mufit
Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin Besut Campus, 22200, Besut, Terengganu, Malaysia

*Corresponding author e-mail: conniekomilus@unisza.edu.my

Abstract. Acetes is a marine shrimp that is still an under-studied source as feed ingredient for tropical ornamental fish. Ornamental fish is regarded as pet fish due to its mystic attractiveness for pet fish enthusiasts and requires good protein source to attain good growth and skin colour enhancement. The prevailing feed industry due to continuous pandemic has resulted many enthusiasts to look for alternative growth promoter as feed for guppy. The aims of this study were to determine the nutritional composition in dried Acetes and to investigate the effects of dietary dried Acetes meal on growth performance of Guppy (Poecilia reticulata). Five dietary isocaloric feeds namely Tcontrol (commercial feed only), T0 (100% commercial feed and 0% of dried Acetes), T1 (75% commercial diet and 25% of dried Acetes spp.), T2 (50% commercial diet and 50% of dried Acetes), T3 (25% commercial diet and 75% of dried Acetes) and T4 (0% commercial diet and 100% of dried Acetes) were formulated as feed for juveniles of Guppy (Poecilia reticulata) reared in triplicates for 30 days. Growth indices like Body Weight Gain, Feed Conversion Rate, Feed Intake and Survival Rate were observed in every 10 days. Results indicated that T4 with 100% dried Acetes attained a significantly high BWG of 222.6% with low feed intake and FCR of less than 3.5. It can be concluded that inclusion of 50 to 100% dried Acetes in feed has contributed to optimal growth performance of guppy. It is also recommended that further studies on dietary Acetes could be done to examine other properties that could be further developed as superfeed for ornamental fish and thereby enhance growth and productivity of the ornamental fish industry as well as economic efficiency.

Keywords: Acetes, Guppy, growth promoter, protein source

1. Introduction

According to [1], more than 90 percent of the freshwater ornamental fish are captive bred, compared to only about 25 of a total of 8000, in the case of marine fish and ornamental fish industry relies heavily on the export and import of introduced species. The ornamental fish industry in Malaysia has some 259 ornamental fish exporters who were involved in collection, breeding and marketing in 2014 [2]. The continuous growth of this industry has also raised concerns over the economic viability and ecological sustainability of the industry especially on increasing feed price for fish.

Nutrient requirements of ornamental fishes vary from species to species. Optimum nutritional support is essential for the fish to mature in confined waters [3]. Nutrient requirements describe the basic nutrients and quantities to be included in a full and balanced diet for healthy animals. Fish need nutrients...
to maintain health and reduce the risk of diseases. However, nutrition and good quality water are probably two major aspects that require special attention in maintaining a successful ornamental aquarium ([4];[5]). Diets including dietary supplements for aquarium fish should focus on improving growth performance with better feed utilization ([6][7][8]).

Dietary aspects of ornamental fish play crucial roles in ensuring good growth in fish. Several studies found that diets for ornamental fish can be either supplemented or replaced with other natural local products like squid meal, prawn meal, lobster meal, chicken liver, mussel meal and many others can provide good growth performance to fish. These feed ingredients are protein sources that can replace costly commercial fish meal ([6], [9],[10]). According to [10], it is crucial to know both quantitative and qualitative nutrient requirements of ornamental fish as these can determine good growth, survivability and degree of coloration for fish. The basic requirements for ornamental fish are protein, carbohydrates, and lipid.

Maintaining live ornamental fish in aquarium is expensive. Besides managing good water quality, it is also need to ensure that feeds given meet the nutritional requirement of fish. Imported ornamental fish feeds fetch high price in Malaysia’s marketplace that range from USD16 per unit to more than USD143 in online Shoppe. The prices quoted online are rather high as prices of these goods included importation levy. In most cases, preferences of many enthusiasts are more to quality feed as explained by [11] that approximately 80% of fishkeeping hobbyists feed their fish exclusively prepared foods that most commonly are produced in flake, pellet or tablet form. The report also notes that major players in the ornamental fish feed market include Alltech, Coppens International BV, Cargill, Growel Products, Tetra, Canadian Aquatic Feed, Ocean Star International (OSI), Land O’Lakes, SPAROS, Tetra Aquarium, Tzong Yang, Sera, Huey Hung, Grand Sumo Original, Qian Hu Corporation Limited, Hikari, and Haifeng Feeds, among others, which are regarded as international brand for ornamental fish feeds.

As ornamental species command a much higher price per organism than food species, they justify the higher costs of specialty feeds. As ornamental industry is fast developing today, it is therefore anticipated that ornamental hatcheries shall look into feed with minimal feed costs that requires further research in developing more economical ways of providing these specialty feeds. It is [12] suggested that such innovations will benefit food fish aquaculture as an increasing diversity of species with more specialized feed requirements are brought into aquacultural production. Therefore, this research is timely to be conducted up gaps in the ornamental fish feed manufacturing industry for Malaysia.

### 2. Methodology

#### 2.1. Research Location

The study was carried out at the Faculty Bioresources and Food Industry (FBIM), University Sultan Zainal Abidin, Besut Campus, Kuala Besut, Terengganu, Malaysia, located at longitude 102.6075 and latitude 5.7415. The temperature was moderate with minimum of 30°C to a maximum of 36°C.

#### 2.2. Acetes Selection and Processing

Dried *Acetes spp.* were purchased from a supermarket in Besut, Terengganu. The amount purchased was approximately 600g in dried form. Dried *Acetes spp.* were blended using commercial blender (Hamilton Beach 990 Food Blender) into small particles or powder. Powder of dried *Acetes spp.* were then sieved completely to eliminate bigger particles. 10g of dried *Acetes spp.* was put aside for proximate analysis. Experimental diets were formulated according to Table 1 below.
Table 1. Ingredients of Five Fish Feed Treatments

| Ingredients                          | Percentage of Dried Acetes sp. powder in treatments, % |
|--------------------------------------|--------------------------------------------------------|
|                                      | 0           | 25          | 50          | 75           | 100          |
| Dried Acetes sp. powder, g (61 CP)   | 0           | 5           | 10          | 15           | 20           |
| Fish meal, g (55 CP)                 | 20          | 15          | 10          | 5            | 0            |
| Oil palm, g                         | 5           | 5           | 5           | 5            | 5            |
| Mineral mix, g                      | 8.5         | 8.5         | 8.5         | 8.5          | 8.5          |
| Multivitamin mineral, g             | 8.5         | 8.5         | 8.5         | 8.5          | 8.5          |
| Wheat flour, g                      | 4           | 4           | 4           | 4            | 4            |
| Sago powder, g                      | 4           | 4           | 4           | 4            | 4            |
| Total for 50g                        | 50          | 50          | 50          | 50           | 50           |

2.3. Experimental Design
75 tails of Guppy (Poecilia reticulata) with average weight of 0.1g were selected for a 30days feeding trial were divided randomly into triplicates for each of 5 treatments including control with fifteen tails per treatment into groups in plastic containers with 500ml capacity. Treatments were T0 (100% commercial feed and 0% of dried Acetes sp); T1 (75% commercial diet and 25% of dried Acetes spp); T2 (50% commercial diet and 50% of dried Acetes spp); T3 (25% commercial diet and 75% of dried Acetes spp) and T4 (0% commercial diet and 100% of dried Acetes spp). A 24hours light photoperiod was provided throughout the trial. Fish were fed twice per day (8.00 am in the morning and 6.00pm in the evening. Water quality was measured every 10 days using YSI Multi-parameter for dissolved oxygen, water temperature, pH and ammonia respectively. Fish samplings were done at every 10 days on body weight, amount of feed given and survival rate. Growth performance index ([13] like Body Weight Gain (BWG), Feed Conversion Ratio (FCR), survival rate and Feed Intake (FI)) were taken every 10 days respectively to monitor growth performance. The calculations were calculated according to the formula below:

\[
\text{BWG} : \text{Final weight of fish} - \text{initial weight of fish} \quad \text{(1)}
\]
\[
\text{FCR} : \frac{\text{Feed intake}}{\text{ADG}} \quad \text{(2)}
\]
\[
\text{FI} : \text{amount of feed given} - \text{amount of feed leftover} \quad \text{(3)}
\]
\[
\text{Survivality} : \frac{\text{(live fish ÷ total fish)}}{100\%} \quad \text{(4)}
\]

2.4 Proximate Composition
Analysis of Dry matter (DM), crude protein (CP), crude fiber (CF), crude lipid, ash, and NFE in experimental diets were conducted according to [14]. Proximate composition of the samples was analyzed in accordance with the official standard methods of analysis. The Kjeldahl method was adopted
for the determination of crude protein while Soxhlet method was adopted for the determination of crude lipid. The samples were subjected to 550°C overnight for determination of ash while samples were placed at 105°C in an oven until a constant weight is achieved for moisture content.

2.5 Statistical Analysis
All data were analyzed by Minitab 17 procedures for One-way Analysis of Variance (ANOVA). Significant differences among treatment means were analyzed using multiple range tests with a 5% probability.

3. Result

3.1. Proximate Composition
Figure 1 demonstrated that dried Acetes spp. has high composition of crude protein at approximately 60.17%. Lipid is considerably low at 2.50% while moisture, ash and crude fibre were 12.11%, 11.91% and 3.29% respectively.

Figure 1: Nutritional composition in Acetes spp

During 30 days of treatments, there has 5 different treatments of diet that fed to the fishes which T0, T1, T2, T3 and T4. Table 2 shows that CF values of feeds were 40.69±1.22, 26.49±0.20, 26.70±0.43, 34.78±0.76 and 26.695±2.17 respectively. This result shows that there is significant difference (p>0.05). The highest fiber content is T0 (40.69%) where it can convert excess needed into fat in fish body.

Table 2. Proximate Composition of Feeds

| Composition     | T0         | T1         | T2         | T3         | T4         |
|-----------------|------------|------------|------------|------------|------------|
| Crude protein   | 26.40±0.13 | 31.78±1.00 | 29.86±0.09 | 32.32±0.14 | 26.57±7.62 |
| Crude fiber     | 40.69±1.22 | 26.49±0.20 | 26.70±0.43 | 34.78±0.76 | 26.70±2.17 |
| Lipid           | 14.88±1.73 | 11.43±0.14 | 10.97±3.55 | 13.07±3.17 | 9.58±0.77  |
| Ash             | 30.42±0.42 | 27.67±0.23 | 29.13±0.43 | 22.44±4.18 | 27.73±1.31 |
| Moisture        | 13.14±0.11 | 12.24±8.49 | 10.35±0.23 | 11.33±0.32 | 8.22±0.12  |

60.17 3.29 2.50 12.11 11.91

10.00 20.00 30.00 40.00 50.00 60.00 70.00

Crude protein Crude fibre Lipid Moisture Ash

Value of percentage (%) Nutritional Composition
Values are mean ± SE of duplicates measurements. Treatments samples followed by a, b, and c in row were significantly different (p < 0.05)

3.2. Growth performance

3.2.1 Body weight gain (BWG)

The body weight gain of Guppy (P. reticulata) is shown in figure 2. Result shows in first 10 days has slightly significance differences (p > 0.05) in body weight gain of Guppy (P. reticulata). However, in 20 days and 30 days does not has significance differences for all treatments. Body weight gain of Guppy (P. reticulata) is shown in figure 2. Result shows that positive growth among all treatments with time. After 10 days of feeding trial, all treatment show that there are increase of body weight gain from day-0. Control has lowest BWG at 27.5% while other treatments containing dried Acetes spp. show incremental growth with higher inclusion dried Acetes spp. in diet. The highest BWG during 10 days is T4 (0% of fish meal and 100% of dried Acetes sp.) at 222.6%. Other treatments like T1, T2 and T3 recorded 75.7%, 142.3% and 177.5% respectively.

![Figure 2. Body weight gain (BWG) in all treatments on 10, 20 and 30 days.](image)

3.2.2 Feed Intake (FI)

There were no significant differences among treatments throughout the feeding trial. Figure 3 clearly shows a decrease of feed intake among all treatments as fish grow. In day 10, treatment 1 and treatment 2 with 0.8267% and 0.8665% respectively showed slightly higher feed intake compared to control. T3 and T4 also demonstrate good growth, similar to control.
3.2.3 Feed Conversion Ratio (FCR)

Figure 4 shows that the average of food conversion ratio between five treatments along 30 days. The significance differences was not present between all five treatments. There are no significant differences of FCR among treatments after 30 days feeding trial. Although there were no differences, there is a decreasing trend of FCR with the higher inclusion of Acetes spp. in diets as shown in figure 4. Results from BWG of fish show that fish in treatment T0 and T1 have slower growth as compared to other treatments. This may be due to the differences of protein content in both fish meal and Acetes spp, in which dried Acetes spp. meal has higher protein at 60% than fish meal (55%) as indicated in figure 4. Inclusion of higher level of Acetes spp. induced good growth performances in T2, T3 and T4 with inclusion 50%, 75% and 100% of dried Acetes spp. meal respectively. Higher BWG at 269.5%, 293.8% and 322.9% for T2, T3 and T4 respectively showed slightly lowest feed conversion ratio at 3.03, 2.93 and 3.33.

3.2.4 Survival Rate

Figure 5 shows the percentage of survival rate Guppy (Poecilia reticulata) during 30 days feeding trial. In day 10, survival rate of fish was the highest among all treatments that ranged from 93.33% to 100%.
This show that the diets gave good impact to fish condition as fish remain healthy and active. This is also most probably due to availability of dried *Acetes* spp. that provided good nutrients for immune systems in fish.

In general, survival rate of fish had slowly deteriorated and decreased to 66.70% to 86.70% after 10 days. This indicates that survival of fish were still high although some died during treatments days. Survival rate continued to decrease at day 30 in which percentage of survival rate fish decreased to 53.30% to 80%. At day 30, T3 showed the best survival rate that ranged from 80% to 100% as compared to treatment T1 with 47% from 100%. Survival rate for treatments T0, T2 and T4 also slightly decreased from 100% to 60%. This could be due to poor water condition due to uneaten diets that could disturb water quality in containers.

![Figure 5. Percentage of survival rate Guppy (*Poecilia reticulata*) during 30 days of treatments.](image)

### 3.2.5 (*In-Situ*) Water Quality Analysis

Table 3 shows the *in-situ* water quality analysis of five treatments within 30 days. There were no significance differences of water quality for all parameters level among treatments during 30 days. Water quality condition in all containers were under control except DO and ammonia and met the standards of suitable water quality in culturing tropical ornamental fish like water temperature, DO, pH and ammonia that range from 20-28 °C, 4-10 mg/L, 6-8 and low 0.03 [15] respectively.

| Parameters              | T0 (Control) | T1        | T2        | T3        | T4        |
|-------------------------|--------------|-----------|-----------|-----------|-----------|
| Water Temperature, °C   | 27.32±1.14   | 27.30±1.11| 27.37±1.20| 27.29±1.17| 27.38±1.13|
| pH                      | 7.43±0.28    | 7.49±0.25 | 7.52±0.25 | 7.54±0.27 | 7.58±0.23 |
| Dissolved Oxygen, mg/L  | 0.83±0.20    | 0.99±0.47 | 1.11±0.54 | 1.01±0.39 | 1.71±0.82 |
| Ammonia, NH₄⁺           | 0.27±0.10    | 0.24±0.08 | 0.26±0.09 | 0.24±0.08 | 0.24±0.07 |

Values are mean ± SE of duplicates measurements. Treatments samples has no significantly different (p > 0.05)
4. Discussion

Dried Acetes spp. meal contains high protein that can improve fish growth. Fish meal (FM) is currently the main protein source in snapper feeds due to its high protein content, excellent of essential amino acids (EAA), and provides high nutrient digestibility. The expensive price of fish meal today with an estimated USD1.48K per Metric Ton is forcing feed manufacturers to find substitute for fish meal or use low fish meal protein diet. Several studies on replacing dietary fish meal protein with other protein source like krill oil or soy lecithin ([16] [17] [18] [19]) show positive growth performances without effect on fish health.

Dried Acetes, a small shrimp that resembles krill is native to the western and central Indo-Pacific and can be easily found in the coastal waters of Malaysia. This species with an estimated 61.07% crude protein content or even higher as reported by [20] is a suitable substitute to replace fishmeal used in fish feed. The high protein content provides energy for fish to maintain its productivity such as movement, reproductive performance, survival and more. In addition, dried Acetes spp. can be a good source of health beneficial nutrients. However, Table 2 indicates no significant differences of protein content between 100% inclusion of fish meal and 100% inclusion of Acetes spp. This is due to similar protein content in both ingredients. There is also possibility of no protein-sparing as there is no increase of lipids with incremental Acetes in diets. Therefore, no interaction is observed on the increase of protein content with higher inclusion of Acetes in diets. Dried Acetes spp. contains low mineral at approximately 11.91%. As mineral contents in Acetes are lower than ash content in good quality fishmeal that averages between 17% to 25% ([21], additional minerals must be added in diets for good mineral balance.

Lipids typically make up about 7% to 15% of fish diets. Lipid content found in dried Acetes spp. meal is still within the required lipid for fish. Lipid provides essential polyunsaturated fatty acids (PUFA) in both omega-3 and omega-6 families of fatty acids [21]. In general, the proximate compositions of dried Acetes spp. as shown in the results indicate that Acetes is suitable protein source for ornamental fish feed due to its high protein composition that improves growth while lipid and minerals are useful in maintaining fish good health. Acetes is able to provide most of the nutritional requirements for ornamental fish species to improve the productive development [22].

Result shows that control has lowest BWG at 27.5% while other treatments containing dried Acetes spp. show incremental growth with higher inclusion dried Acetes spp. in diet. The highest BWG during 10 days is T4 (0% of fish meal and 100% of dried Acetes spp.) at 222.6%. Other treatments like T1, T2 and T3 recorded 75.7%, 142.3% and 177.5% respectively. Similar pattern is shown in Day 20 of feeding trial. BWG in control show tremendous growth to nearly 200% from 129.12%. This may indicate good digestibility of feed in fish. According to [23], as fish grow larger, their protein requirements usually decreased due to rearing environment conditions such as water temperature, and water quality and genetic composition. All these factors are expected to contribute to low feeding rates. However, it is observed that all the treatments using dried Acetes spp. did not show any poor feeding rate; instead BWG of fish fed with Acetes ranged from 193.4% to 268.5% that indicate positive incremental growth with incremental dried Acetes feed.

In day 10, treatment 1 and treatment 2 with 0.8267% and 0.8665% respectively showed slightly higher feed intake compared to control. T3 and T4 also demonstrate good growth, similar to control. The good feed intake may be due to palatability of the diets. According to [24], a high palatability minimizes the time feed remains uneaten and thereby minimizes nutrient losses through leaching. Feed intake seems to decrease in Day 20 as well as Day 30 for all treatments. This could be due to full satiation is attained by fish [23] stated that diets with excessive energy levels may result in decreased feed intake and reduced weight gain. However, in this experiment proves that formulated diets have well balanced that nutrient require in fish with high protein can give them better growth.

Inclusion of higher level of Acetes spp. induced good growth performances in T2, T3 and T4 with inclusion 50%, 75% and 100% of dried Acetes spp. meal respectively. Higher BWG at 269.5%, 293.8% and 322.9% for T2, T3 and T4 respectively showed slightly lowest feed conversion ratio at 3.03, 2.93 and 3.33. This indicates that dried Acetes spp. is a good diet for fish and may have enhanced better
growth for guppy. A good dietary nutrient is when percentage of crude protein is high in diets. It can increase the BWG of fish while consuming low feed.

Survival rate of fish had slowly deteriorated and decreased from 66.70% to 86.70% after 10 days. This indicates that survival of fish are still high although some died during the feeding trial. Survival rate continued to decrease to day-30 in which percentage of survival rate fish decreased between 53.30% to 80%. At day-30, T3 showed the best survival rate that ranged from 80% to 100% as compared to treatment T1 with only 47% survival rate. Survival rate for treatments T0, T2 and T4 had also slightly decreased from 100% to 60%. This could be due to health condition of some fish which had deteriorated during the feeding trial. However, the study did not include any health study on the fish throughout the research.

Water quality condition in all containers were under control except diluted oxygen (DO) and ammonia were within the standards of suitable water quality in culturing for ornamental tropical fish culture. Suitable water quality characteristics as suggested by [15] were water temperature, DO, pH and ammonia that range from 20-28 °C, 4-10 mg/L, 6-8 and low 0.03 respectively. The water quality management are focused on the main parameters which are dissolved oxygen, pH, temperature and ammonia. Water change is the method where water in small environment is been exchanged with new water. Water change need to be done to maintain good water quality in enclosed culture system. Water management in accordance to aquaponic recirculation system [25] or application of biofloc technology according to [26] and [27] could be employed as a potential water management system for ornamental fish culture in future.

5. Conclusion

Crude protein, crude fiber, lipid, moisture and ash of dried Acetes spp for were 60.17%, 3.29%, 2.50%, 12.11% and 11.91% respectively. The composition shows that dried Acetes spp. meal is a good source as protein source for fish. The growth performances of fish indicated positive growth along the 30-days feeding trial. Inclusion of 100% of dried Acetes spp. meal in dietary T4 that contains 26.57±7.62 of crude protein demonstrated highest BWG of 322.9% and low feed intake of 0.57% that indicated that the feed is high palatable to fish. In conclusion, the best dietary treatment that can be as an alternative or replacement of protein source in ornamental fish diet is diet that contains 100% dried Acetes spp.

Acknowledgements

This research was supported by Ministry of Higher Education (MOHE) through Fundamental Research Grant Scheme (FRGS/1/2021/WAB04/UNISZA/02/2). We also want to thank Akuajaya Enterprise Sabah who partially supported this work by sharing knowledge related to freshwater aquaculture management.

Contributor statement: Connie Fay Komilus and Nur Mazni Mohd Mufit are respectively the main contributors of this research.

Statement of conflict of interest: The author declares that there are no conflicts of interest in this scientific paper.

References

[1] FAO 2015 World Review of Fisheries and Aquaculture. Food and Agriculture Organization (FAO).

[2] Ng C 2016 The ornamental freshwater fish trade in Malaysia. Downloaded from eprints.utar.edu.my/2437/1/The_ornamental_freshwater_fish_trade_in_Malaysia.pdf. Accessed on 8 June 2021.

[3] Gowsalya T S S 2018 Maturation Diets for Ornamental Fishes - An Analysis. Oceanography & Fisheries, 6(3) pp 1-3
[4] Swain S K, Ail S.K.S. Jena S K. Bairwa M K and Sahoo S.N 2021 Preference of breeding substratum, embryonic development and seed production of honey gourami, *Trichogaster chuna* (Hamilton, 1822)-An indigenous ornamental fish in demand, *Aquaculture*, 542 (736874)

[5] de Oliveira L C C, Costa L G B, Eiras B J C F, Brabo M F, Veras G C, de Moura L B, Salaro A L and Campelo D AV 2020 Feeding strategy induces compensatory growth in Heros severus fingerlings, an Amazonian ornamental fish, *Aquaculture Reports*, 18, 100436

[6] Pattanaik S S, Sawant P B, Martin Xavier, K A, Srivastava P P, Dube K, Sawant B T and Chadha, N K 2021 Dietary carotenoprotein extracted from shrimp shell waste augments growth, feed utilization, physio-metabolic responses and colouration in Oscar, *Astronotus ocellatus* (Agassiz, 1831), *Aquaculture*, 534, 736303.

[7] Haque R.Sawant, Sardar P B, P., Martin Xavier K A, Varghes T, Chadha N K, Pattanaik S D. Jana P and Naik V A 2021 Synergistic utilization of shrimp shell waste-derived natural astaxanthin with its commercial variant boosts physio metabolic responses and enhances colouration in discus (*Symphysodon aequfasciatus*), *Environmental Nanotechnology, Monitoring & Management*, 15, 100405.

[8] Wen B, Chen Z, Qu H and Gao J 2018 Growth and fatty acid composition of discus fish *Symphysodon haraldi* given varying feed ratios of beef heart, duck heart, and shrimp meat, *Aquaculture and Fisheries*, 3(2) pp 84-89

[9] Bell N A, Jeffrey S, Maclusca J L and Colombo S M 2019 The effect of lobster meal on the growth performance and pigmentation of the common goldfish (*Carassius auratus*), *Aquaculture Reports*, 13, 100187

[10] Pai I K, Altaf M S and Mohanta K N 2016 Development of Cost Effective Nutritionally Balanced Food for Freshwater Ornamental Fish Black Molly (*Poecilia latipinna*). *Journal of Aquaculture Research & Development*, 7(2)

[11] Brooks M 2017 Market trends in aquarium fish keeping and ornamental fish feeds. In: Hatchery Feed. *Aquafeed Horizons*. p38

[12] Henry E C 2017 Feeds for Ornamental Hatcheries. In: Hatchery Feed. *Aquafeed Horizons*. 38p.

[13] Zuanon J A S, Morais J A, Carneiro A P S, Campelo D A V, Pontes M D and Salaro A. L 2016 Dietary crude protein levels for juvenile beta. *Boletim Do Instituto de Pesca*, 42(3), pp 590–597

[14] AOAC 2006 Official Methods of Analysis of the Association of Official Chemist (AOAC).

[15] Cline, D. (2019). Water Quality in Aquaculture. *Freshwater-Aquaculture*. Retrieved from freshwater-aquaculture.extension.org/water-quality-in-aquaculture/

[16] Kokou F, Vasilaki A, Nikoloudaki C, Sari A B, Karalazos V and Fountoulaki E 2021. Growth performance and fatty acid tissue profile in gilthead seabream juveniles fed with different phospholipid sources supplemented in low-fish meal diets, *Aquaculture*, Volume 544, 737052

[17] Torrecillas S, Montero D, Carvalho M, Benitez-Santana T and Izquierdo M 2021 Replacement of fish meal by Antarctic krill meal in diets for European sea bass Dicentrarchus labrax: Growth performance, feed utilization and liver lipid metabolism, *Aquaculture*, Volume 545,737166

[18] Choi J, Lee K W, Han G S, Byun S, Lim, H J and Kim H S 2020 Dietary inclusion effect of krill meal and various fish meal sources on growth performance, feed utilization, and plasma chemistry of grower walleye pollock (Gadus chalcogrammus, Pallas 1811) *Aquaculture Reports* Volume 17 100331

[19] Wei Y, Chen H, Jia M, Zhou H, Zhang Y, Xu W, Zhang W and Mai K 2019 Effects of dietary Antarctic krill Euphausia superba meal on growth performance and muscle quality of triploid rainbow trout Oncorhynchus mykiss farmed in sea water, *Aquaculture*, Volume 509 pp72-84,

[20] Balange A K, Xavier M A K, Kumar S, Nayak B B, Venkateshwarlu G and Shitole S S 2017 Nutrient profiling of traditionally dried *Acetes. Indian Journal of Fisheries*, 64(special issue), pp 264-267

[21] Miles R. and Chapman F 2021he Benefits of Fish Meal in Aquaculture Diets. *IFAS Extension Univeristy of Florida.*
[22] Velasco Y and Corredor W 2011 Nutritional requirements of freshwater ornamental fish: review. Revista MVZ Cordoba, 16(2).
[23] Craig S (2017 Understanding Fish Nutrition, Feeds, and Feeding. Virgina Cooperative Extension, pp 256-420.
[24] Malli G P, Reddy D R and Ranjan R 2017 Evaluation of Acetes Indicus Meal as Replacement To Fish Meal in Litopenaeus Vannamei Diets Reared Under Varying Water Salinities. Journal Exp. Zool. India, 20(1), pp 617-622.
[25] Endut A, Lananan F, Jusoh A, Wan Cik W N and Ali N 2016 Aquaponics Recirculation System: A Sustainable Food Source for the Future Water Conserves and Resources. Malaysian Journal of Applied Science, 1(1), pp 1-12
[26] Lananan F, Hamid S H A, Din W N S, Khatoon H and Endut A 2014 Aquaponics Symbiotic Bioremediation of Aquaculture Wastewater in Reducing Ammonia and Phosphorus utilizing Effective Microorganism (EM), International Biodeterioration & Biodegradation, 95, pp 127-134
[27] Hamid S H A, Lananan F, Din W N S, Lam S S, Khatoon H, Endut A and Jusoh A 2014 Harvesting Microalgae Chlorella sp nby bio-flocculation of Moringa oleifera seed derivatives from aquaculture wastewater phyto remediation, International Biodeterioration & Biodegradation, 95, pp 270-275