Agricultural Development
Vol. 10, No. 4, 31-37, 2025
ISSN(E) 2576-683X
DOI: 10.55220/25766740.v10i4.377

Comparative Analysis of Australian Red Claw Crayfish Growth, Protein Content Nad Meat Characteristics Across Diverse Natural Feeds

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Abstract

This study aimed to evaluate the growth performance, feed conversion ratio (FCR), mortality rates, protein content, meat characteristics, and profitability of ARC crayfish fed with different natural feeds. Results showed that crayfish fed with commercial feeds had the highest weight gain and a better feed conversion ratio (28.2) compared to natural feeds. Crayfish fed with trash fish and eggshell had the highest mean mortality (4.33). The highest crude protein was recorded from crayfish fed with a combination of vegetables, trash fish, and eggshell. For sensory evaluation, it showed that crayfish fed with vegetables and eggshell had the best meat taste, texture, and aroma. Lastly, the highest ROI was observed in crayfish fed with trash fish and eggshell. Overall, these findings focused on the potential of other natural feeds as alternatives to commercial crayfish feeds.

Keywords: Crayfish, Feed conversion ratio, Growth performance, Meat characteristics, Natural feeds, Protein content.

1. Introduction

Australian red claw crayfish or also known as Cherax quadricarinatus is an endemic, tropical freshwater crustacean belonging to the infraorder Astacidea, which also contains lobsters, native to Northern Queensland, Australia. Physically robust, tolerant of low dissolved oxygen concentrations (Joyce, and Pirozzi, 2015). Australian Redclaw crayfish belongs to the family Parastacidae, which is only found in Australia, New Zealand, New Guinea, Madagascar, and parts of South America (Ackefors, 2000). This potentially broad geographic range, coupled with physical robusticity, straightforward life cycle, and production technology as well as a low protein food requirement, means that they are economical to produce (FAO, 2017).

Red claw crayfish are omnivorous and extremely opportunistic eaters; it means that they can eat about anything edible they come across. In captivity, for the best growth, red claw crayfish need a good mix of meats and vegetation, the lifespan of the red claw crayfish is about 4-5 years long. However, under optimal conditions, they can live up to 6 years in the tank (Michel, 2023).

Nowadays, Australian red claw crayfish has become popular as one of the food sources of people due to its uniqueness and being new to the Philippines. In the Philippines there are still not as many breeders as there are available, resulting in a higher price. Although ARC crayfish are still not sold to the public, there are a few individuals who are trying to become breeders of ARC crayfish (Mabulak Jr 2023). As stated above, the ARC crayfish is not a picky eater, they eat anything edible such as leaves, vegetables, crushed snails, earthworms, brine shrimp, dead fish, or shrimp, and there are also commercialized feeds that can be bought online such as shrimp pellets, shrimp granules, frozen blood worms, and fish foods (Michel, 2023).

This study aims to determine the best feed for Australian red claw crayfish which can sustain its growth and enhance the protein content and meat characteristics. Vegetable waste can be found anywhere, and it has the nutrients that can sustain the survival of ARC such as carotenoids, polyphenols, dietary fibers, vitamins, enzymes, and oils, among others. Vegetables are essential for providing additional nutrients and fiber to the crayfish, giving blanched veggies to the crayfish; this will cause them to soften and facilitate digestion more easily. For protein-based feeds, Red Claw Crayfish get their necessary proteins and lipids from eating fish, shrimp, and tiny insects. With this well-balanced and nourishing diet is essential for their health, growth, and vibrant coloration (Wanderer Snail, 2023).

2. Materials and Methods

2.1. Research Method

This is experimental research that aims to make comparisons across different natural feeds to determine the effect in growth, protein content and meat characteristics of crayfish.

2.2. Species of Crayfish

Australian Red Claw Crayfish is the subject to be used in this study. The variety of this crayfish is known for their relatively docile temperament compared to other crayfish species, which make them easier to handle and breed. It is also known as for its vibrant red coloration and native to freshwater habitats in Australia. It is prized for its large size, vibrant coloration, and delicious taste that makes it popular in aquaculture.

2.3. Research Locale

This study was conducted in a rural Purok Pag-asa, Brgy. Hondagua Lopez, Quezon. Known for its richness in fresh water supply. The research site is situated approximately 500 meters away from the local market. The site is surrounded by river, rice field and small vegetables yard. It offers good environmental conditions that is ideal for investigating the growth of crayfish and it have a clean water source that can be used in the study.

2.4. Treatments and Layout

There were 4 treatments and replicated 3 times. The crayfish will be fed using commercial feeds, vegetable with eggshell, trash fish with eggshell, and combination of vegetable, trash fish and eggshell. The treatments are as follows: Treatment One consists of commercial feeds; Treatment Two includes vegetables and eggshells; Treatment Three comprises trash fish and eggshells; and Treatment Four combines vegetables, trash fish, and eggshells.

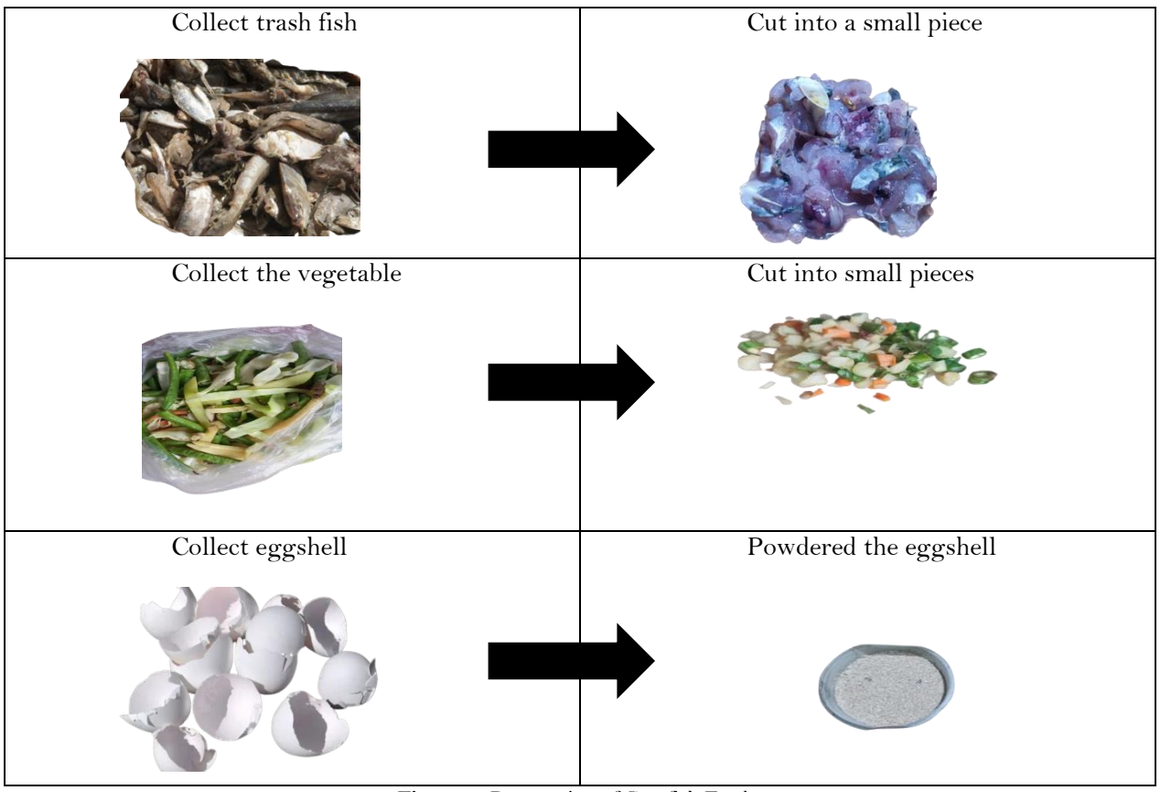

Figure 1. Preparation of Crayfish Feeds.

2.5. Cage Design

The researchers used a ref tub cage with a measurement of 21 inches' width, 37 inches' length and 16 inches height. It was composed of 12 cages that can accommodate 7 crayfish per cage. To provide oxygen in the crayfish, the researcher used aerator. Also, by the use of water lily in the cage it can also provide oxygen. Then each cage, the researchers provided hides that made from PVC.

2.6. Water Quality

Table 1. Water Quality Requirements.

Temperature	**18°C to 25°C**
pH	7 to 8.5
Water Level	12cm to 15 cm

Researcher adhering to these water temperature and pH requirements, 18°C to 25°C for temperature, 7 to 8.5 for pH, and 12 cm to 15 cm water level.

2.7. Maintenance of Cage

To ensure the cleanliness of water, the researcher replaced 1/4 of the water in the cage every 3 days, and it replaced by fresh water that have talisay leaves to improve the growth and health of crayfish.

2.8. Stocking and Feeding in Cages

Seven crayfish were put in one ref tub cage. Commercial feeds, vegetable and eggshell trash fish and eggshell, and combination of vegetable, trash fish and eggshell are given to the crayfish twice a day at a rate of 2% to 5% of

its body weight. Then the feed was submerged in the water, so that the crayfish can grab it easily. Vegetables such as carrots and potatoes are boiled first for easier digestion when fed.

2.9. The Subject / Sampling / Sampling Technique

Incidental sampling was used in the sensory evaluation of crayfish meat characteristics. There were 30 respondents who served as the panel of evaluators.

2.10. Research Instrument

The researcher used rating and free tasting technique to identify the acceptability of crayfish meat. The rating provided blank space for respondent profile such as name, age, and gender. Then next part is the perception of the respondent on the meat characteristics of crayfish such as taste, texture and acceptability. After answering, the perception of the respondent was tallied to identify the results. The perception of the respondent on the meat characteristics of crayfish such as taste, texture and acceptability were identified using the rating scale below.

Table 2. Criteria to be Used on the Evaluation of Meat Characteristics of Crayfish.

Scale	Verbal Interpretation			
	Taste	**Texture**	**Acceptability**	**Aroma**
9	Extremely flavorful	Extremely tender	Extremely acceptable	Extremely strong aroma
8	Very flavorful	Very tender	Very acceptable	Intense aroma
7	Moderate flavorful	Moderate tender	Moderate acceptable	Very strong aroma
6	Slightly flavorful	Slightly tender	Slightly acceptable	Strong aroma
5	Neither flavorful nor tasteless	Neither tender nor firm	Neither acceptable nor unacceptable	Moderate aroma
4	Slightly tasteless	Slightly firm	Slightly unacceptable	Weak aroma
3	Moderate tasteless	Moderate firm	Moderate unacceptable	Faint aroma
2	Very tasteless	Very firm	Very unacceptable	Very faint aroma
1	Extremely tasteless	Extremely firm	Extremely unacceptable	Very weak or no aroma

2.11. Data to be Gathered

In terms of growth, the weight of crayfish was gathered every 15 days after stocking in cage at Purok Pag-asa, Brgy. Hondagua Lopez, Quezon. The data was recorded until it became 3 months old. Then the protein content of crayfish was analyzed at Lipa Quality Control Center Inc (LQCCI) in Lipa, Batangas. While the meat characteristics of crayfish was determined using 9-points Hedonic scale by Peryam and Pilgrim (1957) by using the free taste techniques.

2.12. Statistical Analysis

Analysis of variance (ANOVA) is a tool used in analyzing the difference of two or more groups to identify if there are any significant differences in growth, protein content and meat characteristics of crayfish fed with different natural feeds. From the perception of respondent about the meat characteristics of crayfish fed with different natural feeds, the data to be gathered was interpreted using mean and ANOVA. To identify the comparison between different natural feeds in terms of meat characteristics of crayfish, the researchers used the Statistical Analysis for Agricultural Research (STAR) software.

3. Results and Discussions

3.1. ARC Crayfish Growth Weight Fed with Different Natural Feeds

The growth of crayfish significantly influenced by different type of feeds they intake. Some of the agricultural product used as alternative feeds for crayfish such as vegetable and trash fish. Those natural feeds can affect the growth rate of crayfish by gaining some nutrient needed like protein and amino acids. On this study, it shown the difference between those natural feeds in terms of growth of the crayfish depending on the nutrient content of the chosen feeds.

Table 3 shows the weight of ARC Crayfish fed with different natural feeds for 3 months. Every 15 days of data gathering, ARC crayfish fed with commercial feeds had the highest weight and have a significant difference to other natural feeds. But during the first 15 days of experiment, those crayfish fed with vegetable and eggshell, trash fish and eggshell, and combination of vegetable, trash fish and eggshell don't have a significant difference to each other.

Table 3. Weight Gain of ARC Crayfish Fed with Different Natural Feeds.

Treatment	15 days (g)	30 days (g)	45 days (g)	60 days (g)	75day (g)	Final weight gain (g)
T1 (Commercial feeds)	0.9067 a	1.22	2.00	2.50	3.00	4.00
T2 (Vegetable and eggshell)	0.5567 b	1.11	1.56	2.28	2.78	3.61
T3 (Trash fish and eggshell)	0.5000 b	0.67	0.94	1.50	2.11	2.67
T4 (Combination of vegetable, trash fish and eggshell)	0.5567 b	1.11	1.56	2.22	3.06	3.78
CV %	21.28%	36.27%	39.68%	41.775	45.81%	41.40%

Commercial feeds resulted to highest growth rate because of the following reasons: high protein content, have a balance nutrition, easy digestion and it include a growth enhancer. According to the study of Ende et al., (2021) crayfish fed with the pelleted fish feed exhibited significantly ($P < 0.05$) higher mean final body weight ± SD (FBW,

13.84 g ± 1.24) compared to animals fed fish faeces (11.14 g ± 0.47) and those fed the combination of fish faeces/watercress roots (12.91 g ± 1.99).

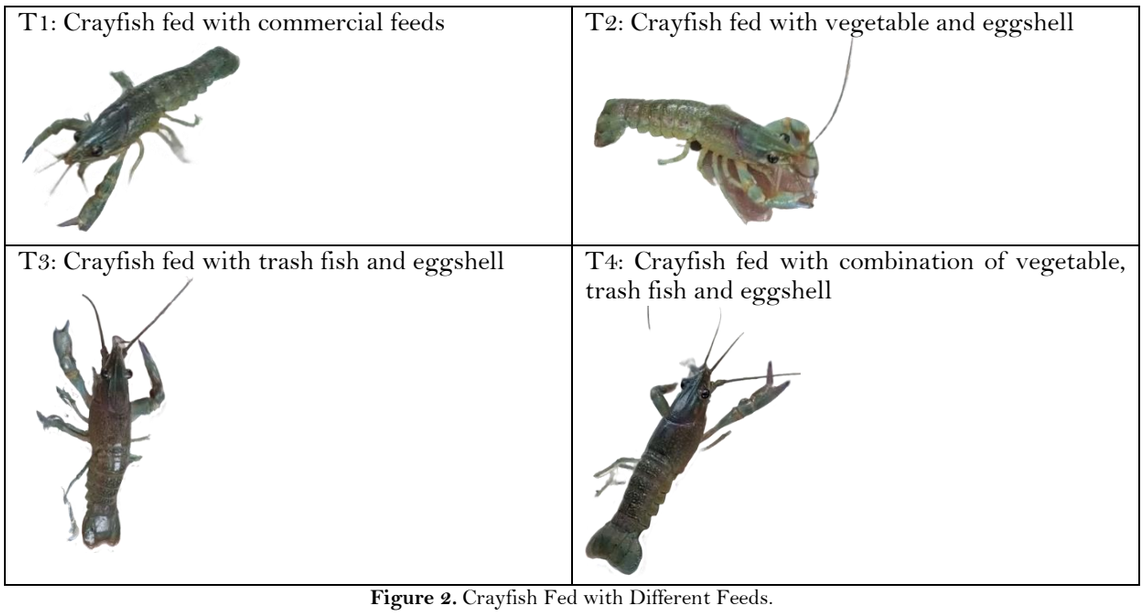

Figure 2. Crayfish Fed with Different Feeds.

3.2. Feed Conversion Ratio of ARC Crayfish

Feed conversion ratio (FCR) is a measurement tool used in aquaculture to identify the efficiency of feeds intake for ARC crayfish farming. In this measurement tool, it shows the total amount of feeds that crayfish intake in whole experiment. Using FCR on production or farming can help to identify the profitability and can help to choose the better alternative feeds.

Table 4 show the feed conversion ratio (FCR) of ARC crayfish, where the weight of feeds intake divided by the weight of the crayfish gain. The feed conversion ratio (FCR) was evident in crayfish fed with commercial feeds (28.2); followed by those fed with vegetable, trash fish and eggshell (29.7); trash fish and eggshell (31.57); and vegetable and eggshell (35.25).

ARC crayfish fed with commercial feeds had a lowest feed conversion ratio (FCR) means it had a better efficiency because commercial feeds are completes in nutrient which are efficiently utilized by that crayfish. According to the study of Towers (2014) the 6.18 feed-conversion ratio (FCR) for red claws fed the supplemental diet was lower than or similar to previous reports, but higher than values reported by others. The higher FCR values in this study were probably due to several factors.

Table 4. Feed Conversion Ratio.

Treatment	T1: Commercial feeds	T2: Vegetable and eggshell	T3: Trash fish and eggshell	T4: Combination of vegetable, trash fish and eggshell
Total Feeds intake	705g	705g	726g	742.5g
Product type	Meat	Meat	Meat	Meat
Initial weight	68g	70g	71g	72g
Final weight	93g	90g	94g	97g
Total gain weight	25g	20g	23g	25g
Feed Conversion Ratio	28.2	35.25	31.57	29.7

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3.3. Mortality of Crayfish

Mortality of crayfish is one of the major problems in crayfish farming, there are different factor that results to mortality such as; cannibalism, and poor water quality. To avoid this problem having a proper management is helpful. Having a high mortality rate can affect the profitability of crayfish farming. Then molting stage of crayfish is also one of the factors that caused of mortality, since that crayfish shells was too soft after molting, that's why other crayfish can easily eat other crayfish.

As shown in Table 5, crayfish fed with trash fish and eggshell had the highest mean mortality with 4.33. Followed by crayfish fed with combination of vegetable, trash fish and egg shell composed of 4.00, then those crayfish fed with vegetable and eggshell had 3.33, while those crayfish fed with commercial feeds had 3.00 of mortality mean

The mortality rate of ARC crayfish fed with trash fish and eggshell had the highest rate because of the reason that, when is decomposed in the water it released toxin like ammonia that can pollute the water in the cage. Those ammonias that decomposed in the water can possibly harm the ARC crayfish. According to the study of Lin et al., (2023) ammonia is one of the primary water pollutants in aquaculture, has been shown to induce a wide range of

eco-toxicological effect on aquatic animals. Under the intensive aquaculture model, *P. clarki* tend to be overfed and the excessive remnant feed could result in high ammonia levels which are deadly to crustaceans (Lou et al., 2021).

Table 5. Mortality.

Treatment	Mean Mortality
T1: Commercial feeds	3.00
T2: Vegetable and eggshell	3.33
T3: Trash fish and eggshell	4.33
T4: Combination of vegetable, trash fish and eggshell	4.00

3.4. Protein Content of ARC Crayfish

Different natural feeds can help enhance the protein content of ARC crayfish. Providing a natural feed for crayfish like trash fish and other vegetable which contains protein on their nutrients can help crayfish to enhance its protein content. Also, a protein rich diet can help enhance the crayfish molting process and its health. Crayfish is known for its high valued protein content which make them a good source of food, especially for health-conscious individual.

Table 6 shows that among different feeds, combination of vegetable, trash fish and eggshell resulted to highest crude protein content (16.47%), followed by commercial feeds (15.39%), trash fish and eggshell (15.19%) and vegetable and eggshell feeds which contain 15.18% crude protein.

Table 6. Protein Content of Australian Red Claw Crayfish Fed with different Natural Feeds.

Treatment	Result for Crude protein Analysis (%)
T1: Commercial feeds	15.39
T2: Vegetable and eggshell	15.18
T3: Trash fish and eggshell	15.19
T4: Combination of vegetable, trash fish and eggshell	16.47

Trash fish are rich in protein that helps enhance the growth and protein content of ARC crayfish. Fish meal (FM) is used as a major animal protein source within most aquatic animal formula due to its high digestibility, balanced essential amino acid composition, vitamins, minerals and good palatability. There are some anti-nutritional factors present in plant protein sources, such as protease inhibitors and lectins contained on SM and gossypols involve in CM, which could affect the growth of aquatic animals (Jiang et al., 2023). According to the study of Mettis et al., (2009) the result of the present study indicates that red claw grown in ponds can be fed a practical diet in which fish meal is completely replace with a combination of plant proteins, such as soybean meal and distillers dried grains with soluble with a protein level of 28 percent.

3.5. Sensory Evaluation of ARC Crayfish

Sensory evaluation on meat characteristics of ARC crayfish can help to identify the market value and acceptance of the consumer. By doing this, it helps to identify the best alternative natural feeds that help to enhance the meat characteristics of ARC crayfish. Providing a different natural feed for ARC crayfish can cause of different meat quality.

Table 7 shows the result on the sensory evaluation of crayfish meat. In terms of taste, crayfish fed with vegetable and eggshell was rated as very flavorful, followed by commercial feeds which was rated as moderately flavorful, trash fish and eggshell rated as slightly flavorful, and combination of vegetable, trash fish and eggshell which was rated slightly flavorful. In terms of texture, crayfish fed with vegetable and eggshell; commercial feeds; trash fish and eggshell were rated as moderately tender. While crayfish fed with combination of vegetable, trash fish and eggshell have been rated as slightly tender. In terms of Aroma, crayfish fed with vegetable and eggshell and commercial feeds was perceived to have a very strong aroma. The remaining crayfish fed with other feed combination were rated with strong aroma. In terms of overall acceptability, crayfish fed with vegetable and eggshell, it was rates as very acceptable. Those fed with trash fish and eggshell and commercial feeds was rated as moderately acceptable. While crayfish fed with combination of vegetable, trash fish and eggshell were rated as slightly acceptable.

Table 7. Sensory Evaluation of ARC Crayfish Meat.

Treatment	T1: Commercial feeds	T2: Vegetable and eggshell	T3: Trash fish and eggshell	T4: Combination of vegetable, trash fish and eggshell
Taste	7.33	8.27	6.87	6.17
Descriptive Interpretation	Moderate flavorful	Very flavorful	Slightly flavorful	Slightly flavorful
Texture	7.43	7.63	7.43	6.56
Descriptive Interpretation	Moderate tender	Moderate tender	Moderate tender	Slightly tender
Aroma	7.3	7.8	6.9	6.2
Descriptive Interpretation	Very strong aroma	Very strong aroma	Strong aroma	Strong aroma
Overall Acceptability	7.63	8.33	7.67	6.6
Descriptive Interpretation	Moderate acceptable	Very acceptable	Moderate acceptable	Slightly acceptable

Using natural feeds like vegetable can help to improve the meat quality of crayfish because it had antioxidants that help to improve the taste and texture of crayfish meat. Also, vegetables provide fiber that help for easy

digestion that make crayfish to absorb more nutrient from the alternative feeds. In contrast with the study of Xu et al., (2022) the results showed that dietary protein sources had no significant growth performance. Nevertheless, significantly higher richness taste was observed in animal protein group. The inosine-5′-monophosphate content in animal protein group was significantly higher than that in plant protein group.

3.6. Cost of Production of ARC Crayfish

Crayfish farming now growing here in the Philippines, this type of farming is profitable if they have efficient management to minimize the cost on production. Nowadays crayfish farming start to grow rapidly because there's a lot of breeder and grower here in the Philippines. Also, crayfish is one of the dishes served in the fancy restaurant.

Table 8 shows the cost of production in rearing crayfish. Highest ROI was obtained from T3 (Trash fish and eggshell), followed by T4 (Combination of vegetable, trash fish and eggshell). While the rest of the treatment had negative ROI.

ARC crayfish fed with trash fish and eggshell had the highest return on investment (ROI) because the cost of the trash fish in the market is cheap. According to the study of Bunlipatanon et al., (2012) stated that in spite of the variations observed in each of the farm sites, the results indicate that the overall growth performances and fish survival rates between the two feed types were similar, for both species. However, better cost-benefit and resource use were recorded for fish reared on trash fish/low valued fish.

Table 8. Cost of Production.

Cost of Materials	Treatment			
	T1: Commercial feeds	**T2: Vegetable and eggshell**	**T3: Trash fish and eggshell**	**T4: Combination of vegetable, trash fish and eggshell**
Crayfish	Php500	Php500	Php500	Php500
Electricity	Php 8.6	Php 8.6	Php 8.6	Php 8.6
Labor cost	Php 186.22	Php 175.87	Php 165.61	Php 171.43
Cage	Php 7.14	Php 7.14	Php 7.14	Php 7.14
Feeds	Php 105.75	Php 70.5	Php 36.3	Php 55.68
Total expense	Php 806.96	Php 762.11	Php 717.65	Php 742.85
Total harvest	93g	90g	94g	97g
Income (Php 6000/kg)	Php 558	Php 540	Php 564	Php 582
Profit	Php -248.96	Php -222.11	Php 153.65	Php 160.85
ROI	-31%	-29%	-21%	-22%

4. Conclusions and Recommendations

4.1. Conclusion

Feeding crayfish with commercial feeds resulted to highest growth rate as compared to other natural feeds. ARC crayfish fed with commercial feeds had a lowest feed conversion ratio (FCR) means it had a better efficiency because commercial feeds are completing in nutrient which are efficiently utilized by that crayfish. The mortality rate of ARC crayfish fed with trash fish and eggshell had the highest rate because when it decomposed in the water it released toxin like ammonia that can pollute the water in the cage. Those ammonias that decomposed in the water can possibly harm the ARC crayfish. Then ARC crayfish fed with the combination of vegetable, trash fish and eggshell resulted to highest protein content. While vegetable and eggshell feeds resulted to highest rate in sensory evaluation due to its characteristics. Then, feeding with trash fish and eggshell resulted to highest return on investment (ROI). In general, all of the feeds used in the study could be utilized.

4.2. Recommendations

Using commercial feeds is recommended for the crayfish farmer if the intention is for breeding because it can help to grow the crayfish quickly. Then combination of vegetable, trash fish and eggshell is recommended if the target market are prioritizing nutritional value because it provide a high protein content. While using vegetable and eggshell as substitute feeds is highly recommended if the purpose is for human consumption because it provides a good quality meat. Then for cost effectiveness it is recommended to use trash fish and vegetable as substitute feeds because it has a lower cost but high in profitability without compromising the quality of crayfish. During rainy days it is recommended to change 50% of water using the conditioned water that stored for several days, also fed crayfish with small amount of feeds during rainy days because crayfish are less active when the temperature drops.

Based on the findings and limitations of this study, the recommendations provided as a guide for future researcher to continue the advancement of the study. The researcher should study the water temperature, quality, and nutrients present in water which can affect the growth and reproduction of the Crayfish. For economic purposes, the future researchers may study the consumer preferences on the acceptable characteristics of crayfish and the potential exports markets for it. By addressing these recommendations, the future researcher can contribute knowledge in caring ARC crayfish and help to expand the industry of aquaculture.

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