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Effects of the Partial Replacing of Fish Meal with Marine Polychaetes (*Nereis* sp.) on the Nutritional Value of *Macrobrachium rosenbergii* Shrimp

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ABSTRACT

Background and Objective: Fish meal is a high-cost in the production of shrimp feed so, partial replacement of fish meal with polychaete meal (*Nereis* sp.) is one of the successful solutions for aquaculture. This study examined marine worms as a high-value protein source and low-cost components of freshwater shrimp diets. **Materials and Methods:** Two types of diets were prepared, replacing 25 and 50% of the fish meal with polychaetes meal, in addition to the control diet (without adding polychaetes meal). The moisture, protein, fat, ash, and carbohydrates were estimated. The significance of the differences in average nutritional contents was studied by using one way-ANOVA test ($p<0.05$). **Results:** The results of this study showed a significant difference ($p<0.05$) in the fat content between the prepared diets (50 and 25% of polychaetes meal compared to control (70% fish meal). The highest percentages were 16.20 and 12.77% in 50 and 25% polychaetes meal, respectively compared to the control (10.55%). In contrast, statistical analysis did not find any significant differences ($p>0.05$) in protein, carbohydrate, ash, moisture content, and total energy content between the experimental diets and the control. **Conclusion:** The nutritional value of shrimp diets was improved by substituting polychaetes meal (*Nereis* sp.) for fish meal. This was achieved by raising the amount of fats rich in super-unsaturated fatty acids in the diet.

KEYWORDS

Aquaculture, fish meal, nutrition, reproduction, polychaetes, *Nereis* sp., *Macrobrachium rosenbergii*

INTRODUCTION

The steady increase in population numbers and the growing demand for fish products pose a major challenge to the aquaculture sector. This encourages the identification of sustainable practices to meet food demand. Fish meal is a high-quality source of protein in the diets of aquaculture fish, and the high reliance on these feeds as the main source of protein in aquafeeds has led to overexploitation of marine resources and caused intolerable fluctuations in feed production costs[1]. The amount of feed produced in marine shrimp breeding reached 10.1% of the total global feed production of 29.031 million ton, while the amount of feed produced to rear freshwater crustaceans reached 4.5% of the total global feed

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production[2]. The costs of the production of shrimp feed range from 40-60% of the total production costs[3]. In contrast, a previous study by Suarez *et al*.[4] also confirmed that the cost of fish meal in fish and shrimp feeding is high, which is a basic requirement in shrimp feed because it contains a balanced percentage of protein, fat, minerals, and vitamins[5]. There are also huge quantities of *Macrobrachium rosenbergii* freshwater shrimp in the Wadi Hajar area, which is characterized by the population's demand for eating it due to the taste and quality of its delicious meat. To contribute to supporting the aquaculture sector in Yemen and achieving the principle of sustainability, the available ingredients must be exploited and the appropriate conditions must be created for their success, and research has shown that most of the costs of farming are the cost of preparing feed, and the idea of studying the provision of components of feasibility of freshwater shrimp are cheap price. As an alternative to the expensive fish meal, some of them are marine worms meal as rich in quality protein and high nutritional value. This study aimed to evaluate the nutritional value of partial replacement of fish meal with polychaetes meal (*Nereis* sp.) which could be one of the successful solutions for freshwater shrimp culture.

MATERIALS AND METHODS

Marine polychaetes collection: This study was carried out from May to December, 2022. Marine polychaetes were collected from the flat area of the intertidal zone of the Shihr and Al-Ais Regions. It is classified into species. *Nereis* sp., used a field classification guide[6], and then transferred to the laboratory and kept in the refrigerator until the experiments began.

Preparation of diet: Three types of local diets were prepared in the laboratory of the Faculty of Environmental Sciences and Marine Biology, Hadhramout University, Yemen. Diet number 1 was used as a control 70% fish meal (FM 70%) (without polychaetes meal) and the other was replaced by a percentage of fish meal with marine polychaetes meal (PM) with different rates as 25 and 50% (Table 1). The percentage of fish meal and polychaetes in the control diet was determined by 70 and 0%, respectively, while the percentage of fish and polychaetes meals (PM 25%) in diet number 2 (the replacement rate is 25%) reached 52.5% of fish meal and 17.5% of polychaetes meal, whereas, in the diet number 3 (the replacement rate is 50%), the percentage of fish and polychaetes meals reached 35% for each of them (Table 1). The residue of the components involved in the formation of freshwater shrimp diet was in fixed percentages according to D'Abramo *et al*.[7]. In all diets, fish liver oil is 2%, fish liver meal 3%, chicken eggs 10%, wheat meal 10%, and sesban pods 5% (Table 1).

Determination of chemical composition: The estimation of the chemical composition of the diet including moisture, protein, fat, ash, and carbohydrates of control and experimental diets was carried out using oven-dried samples, this method was described by AOAC[8]. So that the protein was estimated using the Kjeldahl method[8], while the Soxhlet Method is used known as the intermittent method for estimating the raw fat percentage in the sample. The moisture content was estimated by drying a known weight of the moist sample by using a drying oven (Model number: SD-DO42L-China) at 105°C until the stability of the weight.

Table 1: Percentages and quantities of feed components manufactured locally at the college of environmental sciences and marine biology

Ingredients	A control diet (70% FM)	PM 25 (25% PM)	PM 50 (50% PM)
Fish meal	700	525	350
Polychaetes meal	0	175	350
Fish liver oil	20	20	20
Fish liver meal	30	30	30
Chicken eggs	100	100	100
Wheat	100	100	100

FM: Fish meal and PM: Polychaetes meal

Carbohydrates were estimated by knowing the difference between the percentages of all the nutrients (protein, fat, ash, and moisture content). On the other hand, the ash content was estimated by taking a known weight from the sample in a ceramic crucible and placed in the muffle furnace oven (Model number: B-T 1200-China) at 550°C for 4 hrs[9].

Statistical analysis: Complete Randomized Design (CRD) was used with two replications. Excel program was used to calculate the mean and standard deviation of treatment (different diets) and control to explain the differences between them. The significance of the differences in average nutritional contents (protein, fat, carbohydrates, moisture, and ash) was studied by using a one-way ANOVA test, The Bonferroni test also was chosen to find the *post hoc* between treatments. All statistical tests were performed at the level of statistical significance ($p<0.05$) by using Statistical Package for the Social Sciences (SPSS), software version 26.

RESULTS AND DISCUSSION

It is known that the percentage of nutrients in a feed is determined by the percentage of those elements in the crude materials composition. The sources of feed components consist of animal and plant sources, and marine animal sources such as fish meal and marine invertebrates are important in the formation of fish and crustacean diets, due to their high content of proteins and fats with high nutritional value. In addition, it is complete in its content of amino acids and fatty acids necessary for growth, rapid sexual maturity, and increased survival of fish[9-11]. The results of the current study showed that the average protein content ranges between 32.30-35.90% in all experimental diets and controls (Table 2). These percentages are low, especially the ingredients in the formation of the diet, most of them with marine animal sources, such as marine fish and polychaetes meals, these meals were highly protein. The high percentage of ash in the studied samples may be due to the increased bone content in the fish meal more than in the tissues, which led to a higher percentage of ash. In addition, the use of the sesban plant in the diet led to a relative increase in the percentage of fiber and a reduced percentage of protein. The study conducted by Bayissa *et al.*[12] showed that whole fish meal contains a higher percentage of fat and ash than its tissues, and this study showed that fish tissues contain a much higher concentration of protein than whole fish. The study carried out by Bayissa *et al.*[12], confirmed that whole fish meal contains a higher percentage of fat and ash than fillets (tissues), and this study also showed that fillets contain a much higher percentage of protein than whole fish. The results of this study also indicate that there are no significant differences ($p>0.05$) in the protein rate between the experimental diets (50% PM and 25% PM) and control (70% FM) (Table 2). Despite the high protein rate in the control (without replacement, 70% FM) it reached 35.9%, while its ratio in 25% PM and 50% PM decreased to 35.05 and 32.37%, respectively.

The low percentage of protein in diets does not indicate a lack of quality diets, as the efficiency and quality of protein are not determined by its quantity, but rather by its quality, the extent of the balance of amino acids, and its digestibility coefficient. The study conducted by Farhat and Khan[13] showed that the diet used with a protein level of 35% to feed catfish fingerlings gave the best growth rates compared to diets with higher protein levels that reached 40 and 45%. This study also confirmed that levels of protein in the diet ranging from 34.4-39.6% are very suitable for the growth of catfish.

Table 2: Proximate composition (dry weight basis (%)) analysis of control and experimental diet

Composition	Control diet (70% FM)	PM25 (25% PM)	PM50 (50% PM)
Protein	35.9±2.2^{a}	35.05±1.25^{a}	32.30±2.7^{a}
Fat	10.55±0.01^{a}	12.77±0.17^{b}	16.2±0.20c
Ash	42.75±1.00^{a}	40.5±1.5^{a}	36±0.75^{a}
Moisture	5.25±0.6^{a}	6.25±0.25^{a}	8.5±1.75^{a}
Carbohydrate	5.55±1.18^{a}	5.43±4.00^{a}	7±6.00^{a}
Total energy	13.60±1.00	14.26±1.70	13.60±2.00

Different letters are significantly different ($p<0.05$), FM: Fish meal and PM: Polychaetes meal

The results of this study revealed that the percentages of the fat ranged between 10.50-16.20%, carbohydrates (5.55-7.00%), moisture (5.25-8.50%), and ash (36.0-4 2.75%). All were within reasonable limits, except for ash, which was high, and this may be due to the high percentage of bones in the fish meal and the increase in the ratio of fiber in the sesbania pods, which led to a decrease in the ratio of protein in the diets. In contrast, the results of the One-way Analysis of Variance (ANOVA) did not show a significant difference ($p>0.05$) in the percentage of carbohydrates, moisture, and ash between the different experimental diets (25% PM) and (50% PM) also when compared these experimental diets with control (70% FM), while the results of statistical analysis showed that there were significant variations ($p<0.05$) in the percentage of fats between (50% PM) was recorded the highest fat content, reached 16.2% compared to (25% PM) and control, where the fat content decreased to 12.77 and 10.55%, respectively. This may be due to the partial replacement of fish meal with marine polychaetes meal (Table 2).

Many studies have confirmed that marine polychaetes are rich in fats and contain most of the highly unsaturated fatty acids that are important for the growth of fish larvae, fish fingerlings, and marine organisms. On the other hand, a study conducted by Wang *et al.*[14], confirmed that the percentage of fat in marine polychaetes ranges between 12.0-16.0%, and the percentage of protein ranges between 54.0-58.0%, which is considered a balanced protein in amino acid content. Another study conducted by Laining *et al.*[15] which used marine polychaetes meal in broodstock diets, confirmed that feeding marine polychaetes to mother fish and shrimp led to faster sexual maturation. The same study by Leelatanawit *et al.*[16] showed that feeding tiger shrimp (*Penaeus monodon*) with marine polychaetes meal (*Perinereis nuntia*) improved growth and survival rates and increased the efficiency of their sperm compared to feeding them with other commercial diets. the results of the one-way ANOVA (analysis of variance) did not show a significant difference ($p>0.05$) in the total energy between the different experimental diets (25% PM) and (50% PM) compared with control. The results of this study showed an increase in the percentage of total energy in a diet containing 50% PM reaching 15.23 MJ/kg compared to 25% PM and the control, whose values decreased to 14.26 and 13.60 MJ/kg, respectively. Future studies are required to evaluate the extent of the effect of the diets prepared in this research on the growth rates and survival rate of freshwater shrimp and fish larvae and to test the extent of their effect on the stimulation of sexual maturation, the release of eggs, and the increase in fertility in mothers.

CONCLUSION

Replacing 50% of the fish meal with the polychaetes meal (*Nereis* sp.) in freshwater shrimp diets led to improving their nutritional value by increasing the content of fats rich in super-unsaturated fatty acids in the diet. Since the use of polychaetes meal (*Nereis* sp.) improves the nutritional value of the diet, therefore, when applied to fish and shrimp diets, it will lead to improving the growth rate and survival rate. The high-fat content in the diet, especially super-unsaturated fatty acids, will lead to faster sexual maturation in shrimp mothers and increase fertility and larval survival rates.

SIGNIFICANCE STATEMENT

This study identified to evaluate the nutritional value of partial replacement of fish meal with polychaetes meal (*Nereis* sp.), which could be beneficial for the improved growth and survival of larval stage shrimp. This study will assist researchers in uncovering critical areas in freshwater shrimp culture. The results of this study showed a significant difference ($p<0.05$) in the fat content between the prepared diets (50% polychaetes meal, 25% polychaetes meal compared to control (70% Fish meal). The highest percentages were investigated in 50% polychaetes meal and 25% polychaetes meal, reaching 16.2 and 12.77%, respectively compared to control (10.55%). Statistical analysis did not show any significant differences ($p>0.05$) in protein, carbohydrate, ash, moisture, and total energy content between experimental diets and control. Future studies are required to evaluate the extent of the effect of the diets prepared in this research on the growth rates, and survival rates of freshwater shrimp.

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