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Effect of Dietary Replacement of Fishmeal with Rejected Chicken Meat on Growth Performances of *Cyprinus carpio* var. *Koi (Linnaeus, 1758)* Juveniles

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Abstract

A 42-day feeding trial was conducted to evaluate the effect of diets formulated using fishmeal and chicken meat meal on the growth of ornamental koi (*Cyprinus carpio*) juveniles. Two isonitrogenous (CP 42%) experimental diets were prepared using imported chicken meat meal (T_1) prepared from rejected chicken and imported fishmeal (T_2). A commercial fish feed was used as control (T_3). Ninety 28-days old mixed-sex koi juveniles were randomly allocated to nine glass tanks (45×30×30 cm^3 each) at a stocking density of 10 fish per tank. Each treatment had three replicates. The results showed that fat content of T_3 were lower ($P<0.05$) than that of T_1 and T_2 while ash content of T_1 was lower ($P<0.05$) than T_2. There was no differences ($P>0.05$) in weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR) and survival of fish fed with control and experimental diets. The chicken meat meal could be used as a protein supplement in koi feeds to replace high cost fishmeal. Hence, ornamental *Cyprinus carpio* could be raised with lowest cost on T_1 than that of from commercial koi diet.

Keywords: *Cyprinus carpio*; koi carps; chicken meat meal; specific growth rate

1. Introduction

Fishmeal is an important protein source used in aquafeed to supply essential amino acids which are closely similar to the composition required by the cultured fish to support better growth, and increase the palatability of feeds (Lall and Dumas, 2015; FAO, 2016). Expanding feed-based global aquaculture causes increasing global demand for the fishmeal production. However, their consistent supply became questionable due to overfishing of small, pelagic fish species (Boyd, 2015) which are mainly used for non-food purposes such as fishmeal and fish oil. According to FAO (2016), around 16 million tonnes of fish produced in the world in 2014 were converted for fishmeal production. Because of prevailing limitations for fishmeal production and their coincided high prices, alternative sources are being researched to replace the fishmeal in aquafeeds. Plant protein sources, except soybean meal limits their inclusion level in aquafeed due to unbalanced essential amino acid composition (Lall and Dumas, 2015) which directly influences the growth of cultured fish (Chakrabarty *et al.*, 2010).

Meat meal, which is a rendered product made from mammalian tissues such as tendons, ligaments, skeletal muscles, gastrointestinal tract, and lungs (Lall and Dumas, 2015), considered to be an alternative for fishmeal. They have been incorporated in aquafeeds as a replacement of fishmeal in the diet of food-fish species (Kureshy *et al.*, 2000; Wei *et al.*, 2004; Qinghui *et al.*, 2006; Wei *et al.*, 2006; Hernández *et al.*, 2016). However, there are only few feed trials have been conducted on ornamental fish species (Mahfui *et al* 2012). In this context ornamental fish are often fed with diets of food-fish species (Knop and Moorhead, 2012). However, use of suitable aquafeed may increase the profit margin of any aquaculture enterprises. Therefore, there is a need to identify less expensive and sustainable ingredients to utilize in ornamental fish diets with better nutritional quality comparable to fishmeal based diets.

Cyprinus carpio (koi) is a popular freshwater ornamental fish raised throughout the world mainly on commercial aquafeed (Yesilayer, *et al.*, 2011; Weerasingha *et al.*, 2017). Major production cost in an aquaculture industry is attributed by feed cost. Hence, formulation of a suitable ration for *Cyprinus carpio* using cheap and locally available ingredients would be a promising avenue for the development of this sector. In this context an experiment was conducted to analyze the effect of a diet prepared using rejected chicken meat at slaughter house on growth performance of *Cyprinus carpio*.

2. Materials & methods

2.1 Experimental diets

Two isonitrogenous feeds (Table 1) were prepared using chicken meat meal (T_1) and imported fishmeal (T_2) in the Nutrition Laboratory of the Department of Animal Science, Faculty of Agriculture, Eastern University, Sri Lanka (EUSL). Commercial koi fish feed (T_3) was used as a control.

Feed ingredients (Table 1) were purchased from the local market. Meat meal was prepared from the rejected fresh chicken in Crysbro meat processing unit, Gampola, Sri Lanka. The carcass was chopped in to small pieces and oven-dried at 80 ^{o}C until constant weight is obtained.

The dried meat was ground by a hammer mill to prepare meat meal. Proximate composition of the ingredients were analysed by AOAC (1990) methods prior to form feed formulae. All the ingredients were sifted separately using 0.5 mm sieve. Then they were weighed according to the formula and mixed together for 20-30 minutes by adding soya oil gradually. The mixture was blended with lukewarm water and homogenized until a dough-like paste is formed. The dough was squeezed through a string hopper mold and steamed. The pellets were air dried first and oven dried at 50 ºC for overnight and crushed and sieved to get 2 mm pellets as described by Weerasingha *et al.* (2017). The dried pellets were packed separately in airtight polythene bags with clear labels and stored at - 20 ºC.

Table 1. Feed formulae of the experimental diets

Ingredients (% of feed basis)	Diets		
	T_1	T_2	T_3
Fishmeal (imported)	0.0	50.0	-
Soya oil	0.3	5.0	-
Probiotic	1.0	1.0	-
Vitamin mineral pre-mixture	1.1	1.0	-
Rice bran	10.0	10.0	-
Soybean meal	12.6	6.0	-
Wheat flour	14.0	14.0	-
Corn	16.0	13.0	-
Chicken meat meal	45.0	0.0	-
Proximate composition (% of dry matter basis)			
Moisture	11.0	9.0	12.0
Lipid	12.1	11.9	6.0
Ash	9.0	13.0	11.0
Protein	42.2	42.2	42.0

2.2 Experimental fish and feeding trial

Ninety mixed-sex koi juveniles of 28-day old were purchased from Oasis Ornamental Fish Farm, Polonnaruwa, Sri Lanka. Feeding trials were conducted in 9 indoor freshwater glass tanks (45×30×30 cm^3 each) for 42 days at the Department of Animal Science, EUSL. The fish with a mean initial weight of 0.79±0.01 g was randomly distributed into nine tanks (experimental units) at a stocking density of 10 fish per tank. All three types of feeds (treatments *viz.* T_1, T_2 and T_3) were randomly assigned to three replicate groups so that each experimental unit had three replicates. Fish was fed three times a day (09:00, 12:00 and 15:00 h) at the rate of 10% of total body weight. Feeding rate was adjusted according to the body weight during the experimental period. Uneaten feed was collected from the bottom of the tank with a siphon 30 minutes after the feeding and dried in an oven at 60 °C to calculate feed intake. One third of the water in each experimental unit was exchanged twice a week and inner walls of each tank were scrubbed daily to remove algae and other organisms. Fish mortality was recorded during feeding times. Continuous aeration was provided by aerators. The mean values for the respective water quality parameters maintained in the tanks were: water temperature, 26.5 ± 0.1 ºC; pH, 7.6 ± 0.1; total ammonium nitrogen, 0.13 ± 0.02 mgL^{-1} and dissolved oxygen, 3.8 ± 0.1 mgL^{-1}.

2.3 Analysis of samples

Weight of the fish was measured weekly and length was measured fortnightly. Two samples (5 fish per sample) from each tank were taken separately and measurements were recorded. Fish were starved for 12 hrs before weighing. Weight gain, specific growth rate, feed conversion ratio, profit index and survival were calculated as described by Hernández *et al.* (2016). Proximate composition of experimental diets was determined by standard methods of AOAC (1990). All the measured and calculated data were analysed in SAS software package (Version 9.1) using PROC UNIVARIATE and PROC GLM procedures. Means of different treatments were compared by Duncan's Multiple Range Test at $P<0.05$ level of significance.

3. Results

There were no significant differences in growth performance and feed efficiency of *Cyprinus carpio* juveniles fed on the control and experimental diets (Table 2). Body weight of koi juveniles at 70-days of growth for the respective dietary treatments ranged as: T_1, 2.38 to 3.30 g; T_2, 2.87 to 3.39 g and T_3, 2.95 to 3.58 g.

Table 2. Growth and feed performance indices of juvenile *Cyprinus carpio* fed with three types of experimental diets for 42 days. WG: weight gain, SGR: specific growth rate, LG: length gain, FCR: feed conversion ratio, SUR: survival.

	Diets		
	T_1	T_2	T_3
WG (%)	289.2 ± 36.9	317.4 ± 41.9	247.5 ± 53.4
SGR (% day^{-1})	5.5 ± 0.7	6.1 ± 0.8	4.7 ± 1.1
LG (%)	187.9 ± 7.0	191.4 ± 26.6	199.2 ± 3.0
FCR	2.0 ± 0.1	2.1 ± 0.2	2.3 ± 0.4
SUR (%)	80.0 ± 0.0	83.3 ± 5.8	93.3 ± 11.5

Means in the same row with different superscript letters are significantly different (P<0.05)

Complete replacement of commercial koi diet with the diets prepared from chicken meat meal and fishmeal did not affect the growth (Figure 1), survival, and FCR of *Cyprinus carpio* from 28-days old to 70-days old.

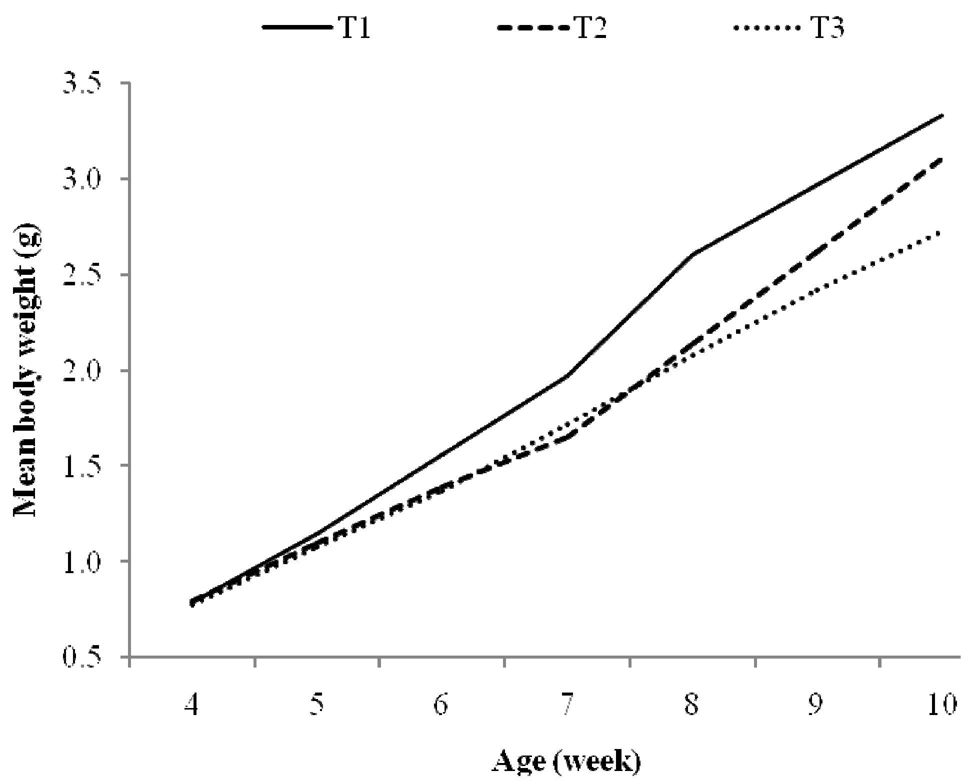

Figure 1. Growth of *Cyprinus carpio* juveniles fed with three types of experimental diets over a 42-day trial

4. Discussion

Compared to commercial koi feed (T_3), experimental diets are rich in lipid due to supplementation of chicken meat meal (T_1) and fishmeal (T_2) which contain more lipids than plant-based protein supplements (Lall and Dumas, 2015). As *Cyprinus carpio* is an omnivore (Strange, 2010) their ration could be supplemented with comparatively high amount of plant based feed ingredients to minimize feed cost. In this context T_3 comprises low levels of lipids than the experimental diets. According to Choi *et al*. (2015) optimal dietary lipid allowance for cyprinids is below 12%.

Because of bone portions of fishmeal (Herath and Satoh, 2015; National Research Council, 1993), T_2 has high amount of ash than T_1 which was prepared with carcass of broiler chicken. In general meat meal has less bone which yield lower ash content (Tangendjaja, 2015). This result agrees with the review of Chr. Jensen (1990) that ash content of a commercial fishmeal can vary from 11% to 18%. Weerasingha *et al.* (2017) reported that two isonitrogenous feeds (35% crude protein) prepared for ornamental koi using fishmeal made out of *Dawkinsia singhala* and *Puntius chola* consisted of 14.5% and 15.1% ash and 8.67% and 9.25% lipid respectively. Thus the variation in proximate composition is due to species of fish used to prepare fishmeal as feed ingredient. Kwikiriza *et al.* (2016) reported that high ash content in fishmeal is due to contamination with inorganic particles such as sand.

Supply of required amount of high quality protein to meet amino acid requirements of fish is important for maximum growth (De Silva *et al*., 2012) and wellbeing of fish. Current study shows that feeding ornamental *Cyprinus carpio* with the experimental diets does not have any significant effects on their WG, SGR, LG, FCR, and survival. This may be attributed that the prepared diets are isonitrogenous to commercial diet which will be formulated to supply appropriate quantity and quality of protein and other nutrients. Though the fat content of the experimental diets are rich in lipid, efficiency of their utilization is comparatively low by omnivorous fish, such as koi than carnivorous fish. This was in agreement with the study of Choi *et al*. (2015) that feeding juveniles of red and white fancy carp (*Cyprinus carpio*) with the diets, prepared using fishmeal (protein source), and fish oil and mixture of soybean and linseed oil (lipid source) to have 40% crude protein and 7% lipid resulted optimal growth and efficient feed utilization. Furthermore, the study reported 312 % day^{-1} of WG and 2.5% of SGR for the periods of 56 days.

Past studies revealed insignificant treatment effects on growth parameters of koi carp juveniles fed with diet made out of minor cyprinid powder as protein supplement (Weerasingha *et al.*, 2017), final body weight, relative growth rate and protein efficiency of koi fed with diet containing fishmeal, hazelnut meal and soybean meal in different ratios (Yesilayer, *et al.*, 2011), and SGR, WG, FCR, protein efficiency, survival juveniles of spotted rose snapper (*Lutjanus guttatus*) fed by partially replaced fishmeal with meat and bone meal and tuna byproducts meal (Hernández *et al*., 2016). Studies showed that WG and feed efficiency of Red Drum juveniles did not differ when they were fed with diets prepared using fishmeal and poultry by-product meal (Kureshy *et al*., 2000). In contrast, Emre *et al.* (2003) reported that SGR, WG and protein efficiency of mirror carp (*Cyprinus carpio*) fingerlings significantly decreased and FCR was significantly increased when the fishmeal was replaced by poultry by-product meal in their diet. Mahfuj *et al*. (2012) suggested feeding koi carp larvae with mixture of chopped tubificid worms (50%) and commercial diet (50%) significantly increased LG, WG, and SGR.

Current study shows that commercial koi feed can be completely replaced with the prepared feed without any harmful impact on fish growth. Yesilayer *et al.* (2011) reported that koi carp juveniles can be raised with the feed prepared from replacing fishmeal by 50 to 100% soybean meal and hazelnut meal without any harm on growth parameters.

5. Conclusions

In conclusion, a balanced diet for ornamental *Cyprinus carpio* (koi carp) could be prepared with cheapest cost than commercial koi feed using rejected broiler chicken meat for human consumption obtained from meat processing plants. Feeding ornamental koi with the prepared diet does not affect the growth parameters and feed efficiency, ornamental *Cyprinus carpio* could be raised with lowest cost than that of from commercial koi diet and profit could be increased.

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