WWJMRD 2024; 10(09): 19-21
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor SJIF 2017: 5.182 2018: 5.51, (ISI) 2020-2021: 1.361
E-ISSN: 2454-6615

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Impact of Silkworm Pupae as Supplementary Feed for Feeding to Fingerlings of Common Carp

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Abstract
Studies were conducted to evaluate the impact of silkworm pupae in the practical diets for *common carp* fingerlings growth and survival. Four experimental diets using silkworm pupae with 25%, 30%, 35%, and 40% protein levels incorporate with rice bran, mustard oil cake-based control diet (25% protein) were formulated. Fish seed was feed @ 4% of the body weight of the fish. In term of growth (SGR), feed conversion (FCR), protein efficiency ratio (PER) and protein and lipid deposition in the muscle, silkworm pupae incorporated (43.75%) diet having 40% protein level showed the best performance of the fish in comparison to those with the control diet. The results indicate that silkworm pupae could be the possible low-cost animal protein rich alternative source and may be successfully used as supplementary feed for Common carp fingerlings.

Keywords: Silkworm pupae, Supplementary feed, Fingerling, Common Carp.

Introduction
In aquaculture, the feeds are the most expensive inputs and account for 57-87% of total recurring expenditure. A wide variety of locally available ingredients are used as feed for exotic carps. Due to the rapid expansion of sericulture in several parts of India, particularly in the southern states there is ample scope for the utilization of silkworm pupae, a major byproduct of this industry, as a feed ingredient. Studies on the usefulness of silkworm pupae as feed for Indian Major Carp fingerlings have shown that it is more suitable than mustard oil cake and rice bran as supplementary feed. In an earlier study conducted by Nandeesha, *et al.* [1], it was shown that feeding common carp with diets containing upto 30% silkworm pupae resulted in progressive increase in growth with increasing level of pupae as compared to a fishmeal based 30% protein diet and the highest weight was recorded at 30% of pupae incorporation. The most economic source of protein is from natural food stuffs plant and animal origins particularly animal wastes and non-conventional feed sources. Animal proteins in general are superior over the plant protein because these are rich in all essential amino acids and are more digestible. Addition of animal protein improves the nutritional status and biological value of formulated diets. For economic and practical reasons these diets must be prepared from locally available protein sources which are preferably unsuitable for human consumption. These exists a high demand for formulation of low-cost animal protein rich feed for growing stages of fishes. An attempt was made in the present study to formulate complete feed for fingerlings of Common carp, replacing conventional feed ingredients with animal protein silkworm pupae and fortifying it with micronutrients and also to see how far it is cost effective and useful to the farmers. Silkworm pupae and mustard oil cake was preferred as animal and plant protein ingredient respectively. Therefore, this investigation was carried out using silkworm pupae as animal protein sources and to find out the relationship between different dietary protein levels and fish growth.

Materials and Methods
The acclimatized fingerlings of *Cyprinus carpio* (average length 5.9 cm. and weight 2.96 g) were stocked in aquaria (60 x 30 x 30) randomly. Care was taken to select healthy fishes of almost uniform size. The fingerlings were stocked at the rate of 10 fingerlings/ aquarium.

Feed formulation was done by 'Pearson square' method using determined values of protein and energy content of the ingredients. Various ingredient combinations used in different composition ($g100g^{-1}$ of dry matter basis) for control and experimental diets are given in Table No.-1. The experimental feed- T_2, T_3, T_4 and T_5 were prepared by finely powdered, mustard oil cake, rice bran, silkworm pupae, multivitamin tablets and soybean oil with Carboxy methyl cellulose as a binder, while feed T_1 was prepared by mixing all the above except silkworm pupae.

Table-1: Formulation of experimental diets.

Ingredients ($g100g^{-1}$)	Diets				
	T_1 (Control)	T_2 (25%)	T_3 (30%)	T_4 (35%)	T_5 (40%)
Rice bran	50	59.37	43.75	28.12	12.50
Mustard oil cake	50	20.31	28.12	35.95	43.75
Silkworm pupae	-	20.31	28.12	35.95	43.75
Vitamin-Mineral mixture	1.0	1.0	1.0	1.0	1.0
Starch	3.0	3.0	3.0	3.0	3.0

The weighed rice bran, mustard oil cake, silkworm pupae and soybean oil, were thoroughly mixed and then multivitamin tablets added to each diet. For pelletization, 6% water was added to the mixture for control and experimental diets and then it was continuously agitated and mixed thoroughly by hands. Mixture was pressure cooked for about 25 minutes for the purpose of sterilization. Mixture was then cooled and pellets were prepared by a hand pelletizer. The pellets (2 mm. diameter and 2.5 cm. length) were then spread on a paper at room temperature under the fan for complete drying. The fingerlings of Common carp were provided with experimental feeds-T_2, T_3, T_4, T_5 in aquarium no.5-20, while feed T_1 (control) in aquarium no.1-4 @ 4% of the body weight of the fishes /day, divided into two equal parts and offered to the fish twice daily at 8.00-8.30 a.m. and 4.00-4.30 p.m., except on days when weekly measurements were taken. Feeding rate was adjusted on weekly basis based on the weight of fish recorded. Each dietary treatment was carried out in four replications. Standard methods were followed for analysis of physico-chemical parameters of water.

Results and Discussions

The experiment was conducted in 20 aquaria. The stocking density was 10 fingerlings / 60 litre water. During the experimental period silkworm pupae was used as major protein supplement. All the experimental diets except control diet were prepared by finely powdered mustard oil cake, rice bran, silkworm pupae and vitamin mineral premix using starch as a binder. Control diet was prepared by all above ingredients used to prepare experimental feed except silkworm pupae. Feed was given @ 4% body weight of the fish's day^{-1}, divided into two equal installments. Five treatments were set up to carry out the experiment with four replications. Control diet (T_1) was with 25% protein, while test diet T_2 was with 25%, T_3 with 30%, T_4 having 35% and T_5 diet with 40% protein level. Weekly observations on growth and physico-chemical parameters were taken. Proximate analysis of feeds and fish tissue was done following the standard method from AOAC. PER, FCR, FCE, ADG, SGR and total weight gain in fish was calculated for control as well as test diets and statistical analysis for all these parameters was done by C.R.D. test. This test of significance was applied to achieve major results. Fish meal is important ingredient in aquaculture diets because of its high protein quality and palatability, however, among all diet ingredients fish meal is most expensive. Significance of silkworm pupae as a non-conventional low-cost source of animal protein ingredient was assessed in present work. In the present investigation, silkworm pupae appeared to be a suitable animal protein supplement as evident from specific growth rate (SGR), which was found to be 1.95, 2.45, 2.73 and 3.45% day^{-1} in the test diets T_2, T_3, T_4 and T_5 as compared to 1.82% day^{-1} in the control diet (T_1). Similarly, food conversion ratio (FCR) was 2.64, 2.42, 1.92, 1.89 and 1.81 respectively in control diet and diets having silkworm pupae respectively. Little work has been done pertaining to the inclusion of silkworm pupae in fish feed for optimum growth of fishes. Earlier workers, Rangacharyulu *et al* (2003) found that optimum inclusion of fermented silkworm pupae silage 30.2-30.9% protein levels gave good result in Carps fishes. Nandeesha *et al* (2002) found that inclusion of non-defatted silkworm pupae upto 50% gives good result in terms of growth in common carp. Singh and Gaur (2005) found optimum inclusion up to 30% of slaughterhouse waste is optimum for fish feed. Nandeesha *et al* (1989) studied the inclusion of sericulture waste and found better growth and conversion with the diet containing de oiled silkworm pupae, as compared to conventional feed mixture of rice bran and the mustared oil cake (1:3). Das (2006) found that inclusion of chicken viscera upto 35% gave good result in *Labeo rohita* fingerlings. In the present investigation 43.75% de-oiled silkworm pupae gave best result. This combination gave best specific growth rate (3.45% day^{-1}) and protein efficiency ratio (2.77%) among al the experimental diets. Diet with 35.95% inclusion of silkworm pupae resulted in moderate growth and SGR being 2.73 % day^{-1}. PER was found to be low being 2.40 for 35.95% silkworm pupae. The diet with 28.12% silkworm pupae gave, SGR of 2.43% day^{-1} giving the third best performance, but its PER was lowest among all diets being only 2.04. In the diet having 25% protein level only 20.31% silkworm pupae was included which gave third best PER (1.60) among all the diet group but SGR was 1.95% day^{-1} which showed the lowest level among all the diets containing silkworm pupae. The results indicate that optimum level of silkworm pupae inclusion in carp diet of *Cyprinus carpio* was 43.75% as far as their growth, feed utilization and survival is concerned. The total cost of feed for T_1, T_2, T_3, T_4 and T_5 was Rs. 61.56, 67.95, 80.03, 85.25 and 90.49 respectively. The net increase in fish body weight for T_1, T_2, T_3, T_4 and T_5 was 2.36, 2.65, 3.45, 3.63 and 3.82 g $fish^{-1}$ respectively. However, the cost of production per kg fish for T_1, T_2, T_3, T_4 and T_5 was Rs. 26.08, 25.64, 22.60, 23.48 and 18.56 respectively. The cost of production was lowest in T_5 (40% with silkworm pupae)

and highest in T_1 (25% without silkworm pupae, i.e. control).

In aquaculture, supplementary feed costs more than 60% in input costs, therefore, silkworm pupae may be utilized as one of the cheapest protein source of supplementary feed for increasing production of fish.

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