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Alternative Source of Protein "Silkworm Pupae" (*Bombyx Mori*) In Coldwater Aquaculture

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Abstract

The main constraint presently is the availability of sufficient/ required quantity of cost effective quality feed. At present one of the main fish feed ingredient (fishmeal) is procured from outside the state due to which the cost of production is very high. In order to make available sufficient quantity of cost effective feed and cater to the demand of various rearing units for feed in the State, it is high time to replace fishmeal with alternate source of protein. Kashmir valley produces good quantities of feed materials derived from crops and other sources. These include a wide variety of oil-seed cakes and meals, pulses, and mill by-products of seeds and grains. Also available are appreciable quantities of by-products from the meat, fish, fruit processing industries and particularly silkworm pupae. Keeping in view the nutritional value of silkworm pupae and its profuse availability in the state, cost effective feed could be formulated and feeding trails in coldwater aquaculture could be conducted. Lot of research has been done on the replacement of fishmeal throughout the world.

Key words: Fishmeal; Silkworm; Aquaculture;

Introduction

Silkworms have a crunchy exterior and reportedly, the taste and texture of mashed potato inside when fresh! A silkworm pupa is the by-product after the silk thread has been wound off from the cocoon and can serve as feedstuff. The most common species for commercial silk production is the mulberry silk worm (Bombyx mori) of the sub-phylum Tracheata (articulated animals). The caterpillar of the moth feed chiefly on the mulberry leaf. The percentages of total protein and lipid contents by dry weight are 55.6 and 32.2% respectively. Silkworm pupae protein had high levels of essential amino acids such as valine, methionine and phenylalanine. The contents of essential amino acids in silkworm pupae protein satisfied the FAO/WHO/UNU suggested requirements (2007).

Sericulture in Kashmir

The history of sericulture in J&K State is traced, and the silk industry was demonopolised in 1988. About 27,000 farming families produce around 829 MT of cocoons worth Rs.5.50 crore. An increase to around 1,500 MT is planned in the next decade. Productivity and quality need to be improved through better packages of mulberry cultivation and silkworm rearing, and high yielding quality silkworm breeds. Majority of cocoon production coming from the spring crop - an autumn crop has been introduced but yield and quality are not yet good.

Major input cost in aquaculture is the running cost expended on feeding the cultured fish.

Protein is the most expensive component in fish feeds. Fish meal is most important feed ingredient as dietary protein source for cultured fish. Shortage and high cost of fish meal make fish feed expensive hence the search for alternative sources of protein in fish feeds. Generally, the feed stuffs of animal origins are considered better alternative protein source in et.al fish diets because of their higher content and other superior indispensable amino acids than the plant origins [23]. Several animal protein sources were evaluated to formulate the diets for fish such as poultry by-product meal, meat and bone meal, snail and other invertebrate meal [10, 13, 21, 25, 33]. Main tendency is to partial replacement of fish meal with alternative protein source [30, 31]. Insects may constitute a significant biomass (Table 1).

Nutritional attributes

Silkworm (Bombyx mori) pupa is a protein-rich feed ingredient with a high nutritional value. Its crude protein content ranges from 50% DM to more than 80% DM (for defatted meal). The lysine (6-7% of the protein) and methionine (2-3% of the protein) contents are particularly high. However, the true protein

Table 1: Cocoon production during last few years (Source: Sericulture Development Department, Jammu and Kashmir, 2016)

Year	Cocoon Production (MT)	Income generation (Lac Rs.)	Avg. Price for "A" grade (Rs.)	Productivity per Oz. (Kg)	Rearers population (Nos.)
2008-09	738	455.67	192.00	31.00	19700
2009-10	810	800.00	300.00	32.00	22800
2010-11	860	1100.00	410.00	32.5	25500
2011-12	917	963.00	350.00	33.00	27000
2012-13	901	1193.00	397.00	32.00	28000
2013-14	1022	2226.00	650.00	34.23	29400
2014-15 (Spring)	1105 (P)	-	750.00 (P)	42.00 (P)	31882

(calculated as the sum of amino acids) in silkworms was found to correspond to only 73% of the crude protein content (Finke, 2002), which was explained by the presence of chitin, since this component contains nitrogen. However, the chitin content of pupae meal is relatively low, about 3-4% DM [6, 28]. The presence of chitin and insoluble protein may also explain the presence of fibre, and values of 6-12% DM of ADF have been reported [6, 11]. Un-defatted pupae meal is rich in fat, typically in the 20-40% DM range. Defatted meal contains less than 10% oil in the DM. Silkworm oil contains a high percentage of polyunsaturated fatty acids, notably linolenic acid (18:3), with reported values ranging from 11 to 45% of the total fatty acids [11,20,32] Compared to other animal by-products, silkworm pupae meal is relatively poor in minerals [3-10% DM]. Silkworm litter appears to have an extremely variable composition, with crude protein values reported to be between 15 and 58% DM [3, 32].

The benefits of silkworm in fish feed

Silkworm pupae in a fish diet are a great way to simulate the type of nutrient dense variety that Koi and other aquarium fishes would experience if they were kept in mud pond. A fish in the wild graze on a wide variety of edible plants, algaes and insects throughout the day. In order to replicate that varied food source in a tank or pond, including some other nutrient sources, like silkworm pupae, is a great idea.

While there are a number of different silkworm pupae options available on the market, Hikari® manufactures a unique product which is processed and packaged to avoid oxidation, a common issue with competitive silkworm pupae type products. This fresher and more potent delivery system of for these nutrients help fish avoid potential health problems from too much of a good thing or rancidity.

Use of silkworm pupae meal in aquaculture

When silkworm meal replaced part, or all, of the fish meal in common carp (*Cyprinus carpio*) diets, similar performance (growth and feed conversion) was observed [22]. Un-defatted silkworm pupae meal was safely used up to 50% without hampering growth and meat quality of the fish (Nandeesha et al., 2000). In a comparison between silkworm pupae meal and plant leaf meals (alfalfa and mulberry), feed conversion efficiency, nutrient digestibility and nutrient retention were better for diets based on silkworm meal than for diets based on plant leaf meals [29].

In silver barb fingerlings (*Barbonymus gonionotus*), highest growth rates were observed in fish fed a diet with about 38% of total dietary protein replaced by silkworm pupae meal [15].

Mahseer fingerlings (*Tor khudree*) fed a diet containing 50% defatted silkworm pupae at 5% body weight had better growth and survival rates than fingerlings fed no or lower amounts of silkworm pupae [24].

Fermented silkworm pupae silage or untreated fresh silkworm pupae paste were incorporated in carp feed formulations, replacing fish meal, in a polyculture system containing the Indian carp (*Catla catla*), mrigal carp (*Cirrhinus mrigala*), rohus (Labeo rohita) and silver carp (*Hypophthalmichthys molitrix*). Survival rate, feed conversion ratio and specific growth rate were better for fermented silkworm pupae silage than for untreated silkworm pupae or fish meal (Rangacharyulu et al., 2003). In rohu, undefatted silkworm pupae and defatted silkworm pupae produced significantly better protein digestibility values than fish meal [8].

Mozambique tilapia (*Oreochromis mossambicus*) were able to utilize the protein of both defatted and undefatted silkworm meal (apparent protein digestibility of 85-86%) [8].

Chum salmon fry (*Onchorhynchus keta*) fed over 6 week diets supplemented with 5% silkworm pupae meal at the expense of fish meal did not show improvement in growth rate and protein content, though silkworm supplementation enhanced feed efficiency [1].

Silkworm pupae meal was used as a substitute for fish meal at up to 75% of the protein in Asian stinging catfish (*Heteropneustes fossilis*) diets without adverse effects on growth [8].

Un-defatted silkworm pupae were found to be a suitable fish meal substitute in diets for walking catfish (*Clarias batrachus*). Digestibility of the crude protein in silkworm meal was found to be similar to that of fish meal [2].

In Japanese sea bass (*Lateolabrax japonicus*), the energy digestibility of un-defatted silkworm pupae meal (73%) was lower than that of poultry by-product meal, feather meal, blood meal and soybean meal, but comparable to that of meat and bone meal. Protein digestibility was also lower (85%) than that of poultry by-product meal, blood meal and soybean meal but it was comparable to that of feather meal and higher than that of meat and bone meal [12].

Shrimp growth trials showed that digestive efficiency was reduced when silkworm meal was used to replace fish meal [26].

In juvenile abalones (*Haliotis discus hannai* Ino.), a combination of soybean meal and silkworm pupae meal replaced fish meal, resulting in slightly higher survival rate and better growth performance (Cho SungHwoan, 2010).

Antioxidant activity of silkworm pupae oil

Supanida Winitchai et al. extracted oil from five native Thai silkworm varieties. The oil extracted by the Soxhlet method from silkworm varieties showed free radical scavenging activity [27]. Deori et al. investigated antioxidant activity of pupae of the muga and Eri silkworm and concluded that, the pupae could be used as natural antioxidants on food products [5].

Conclusion

Silkworm pupae protein had high levels of essential amino acids such as valine, methionine and phenylalanine. The contents of essential amino acids in silkworm pupae protein satisfied the FAO/WHO/UNU suggested requirements (2007). In addition, they also possessed n-3 fatty acids, especially α-linolenic acid (36.3%), as a major component. Keeping in view the above facts, silkworm pupae can be used as an alternative source of protein in fish feed instead of fishmeal.

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