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 trials 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...
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 [15].

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 (*Oncorhynchus 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].

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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.

References

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