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Silkworm Pupae Meal - A Promising Fish Meal Substitute in Aqua Feed

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SUMMARY

Insect meal plays an essential role in the aquafeed sector. Since the demand and price of fish meal have been consistently increasing, the feed formulators search for an alternative protein source to replace fish meal in the aquafeed. Among various insect meal silkworm pupae meal is one promising alternative protein source with a nutritional profile matching with fish meal. The pupae which remains after the reeling of silk fibre becomes a waste in the sericulture industry,which can be utilized as a feedstuff for animals. And Silkworm pupae is readily available, cheaper, and can be a better substitute for the fish meal in the aquafeed.

INTRODUCTION

In the 27th century BC, sericulture originated in China and later spread all over the globe. The major silk-producing countries in the world are China (57.5%), Japan (13.2%), India (10.3%), South Korea (5.4%), and Thailand (2.1%) (Taufel et al., 1993). According to FAO, (2012) the world production of reelable silkworm cocoons stood at 485000 tonnes in 2011. If the amount of the raw silk is 161000 tonnes, then 324000 tonnes of fresh pupae are produced. Presently India is the second-largest silk-producing country in the world and the world's largest silk consumer. Among the various type of silkworm, mulberry silk or *Bombyx mori* is the most common contributing to about 80% of India's silk production (Heuze et al., 2014). Silkworm pupae are a protein-rich waste of the silk industry. This silkworm pupa derived from reeled silk has low cost and high nutritional value. Dried silkworm pupae are a valuable protein (50-71% DM) source and lipid (30%) source (Meicai and Gaoqiang, 2001).Owing to a high protein content, it is a suitable feed for livestock, particularly for the monogastric species such as poultry, piggery, and fishes (Trivedy et al., 2008). Besides a high-quality protein source, silkworm pupae are also rich in essential amino acids (Rumpold and Schluter, 2013).

Silkworm pupae

silkworm cocoon

The Nutritional Profile of Silkworm Pupae:

Silkworm pupae contain 8% ether extract, 3% crude fiber, 20-25% oil, and 5% mineral matter (Nagaraj and Basavanna, 1969). The remaining 20-25% is composed of carbohydrates and other organic matter. According to the Bureau of Indian standards (1971), the proximate composition of the silkworm pupae is 50% crude protein, 25% crude fat, 50% moisture, 3% crude fiber, and 5% ash. However, based upon the treatment process, the nutritional value of the silkworm pupae may vary. Oven-dried silkworm pupae contain 47.9% protein, 27% fat, 3.4% fiber, and 5.6% total ash (Fagoone, 1983). Amino acid composition of the non-defatted silkworm pupae as g/16 g nitrogen is Alanine 5.8, Arginine 5.6, Aspartic acid 10.4, Cystine 1.0, Methionine 3.5, Lysine 7.0, Isoleucine 5.1, Leucine 7.5, Phenylalanine 5.2, Threonine 5.1, Tryptophan 0.9, Glutamic acid 13.9, Histidine 2.6, Proline 5.2, Serine 5.0, Glycine 4.8, Tyrosine 5.9, Valine 5.5 (Longvah et al., 2011). The proximate composition of de-oiled silkworm pupae is: 68.7% protein, 2.5% lipid and 4% crude fibre (Panda 1970). However, according to BIS, (1971) the nutritive composition of the deoiled silkworm pupae is 10% moisture, 65% crude protein, 3%

crude fat, 4% crude fibre, 6.5% total ash and 1.5% acid insoluble ash. Amino acid composition of the defatted silkworm pupae as g/16 g nitrogen is: Alanine 4.4 ± 0.2, Arginine 5.1 ± 0.3, Aspartic acid 7.8 ± 0.7, Cystine 0.8 ± 0.5, Methionine 3.0 ± 0.4, Lysine 6.1 ± 0.4, Isoleucine 3.9 ± 0.2, Leucine 5.8 ± 0.2, Phenylalanine 4.4 ± 0.3, Threonine 4.8 ± 0.3, Tryptophan 1.4 ± 0.2, Glutamic acid 8.3 ± 0.7, Histidine 2.6 ± 0.1, Proline 5.2, Serine 4.5 ± 0.2, Glycine 3.7 ± 0.3, Tyrosine 5.5 ± 0.2, Valine 4.9 ± 0.2 (Lin et al., 1983).

Silkworm pupae as a feed for fishes:

Due to the high demand for fish meal in the market, the silkworm pupae meal can be a suitable alternative protein source to replace fish meal partially or totally in aquafeed. Several studies show that the de-oiled silkworm pupae has higher protein content than the non-deoiled silkworm pupae meal and can also be used as a dietary protein source in the fishes (Blair, 2018).

Silkworm pupae as a feed for carps:

Silkworm pupae are an excellent protein source for fish feed. Common carp fed with silkworm pupae meal as an ingredient in their diet show good growth performance with a better feed conversion ratio (Erechin, 1976). Indian major carps also show a good response when fed with silkworm pupae meal. Catla *(Catla catla)* provided with 30% non-deoiled silkworm pupae in the diet showed a higher growth rate than control diet (Jayaram and Sherry, 1980a). In combination with shrimp waste and clam meat, Mrigal (*Cirrhinus mrigala*) fed with silkworm pupae incorporated pellet feed and clam meat show better growth (Borthakur, 1983). Silkworm pupae can be replaced up to 100% fish meal in the diet of Catla fingerlings with better growth and survival (Hasan, 1991). On the contrary, rohu *(L. rohita)* shows better feed utilization and growth performance, only up to 50% replacement for the fish meal by silkworm pupae (Begum et al., 1994). Grass carp *(Ctenopharyngodon idella)* had better growth when fed with a silkworm pupae-based diet (Hora, 1962).

Silkworm pupae as a feed for marine fishes:

Lee et al., (2012) studied the effect of the dietary replacement of fish meal with silkworm pupae meal, and bone meal on the growth performance of juvenile olive flounder (*Paralichthys olivaceus*). The experiment results imply that 10% silkworm pupae and 10% silkworm pupae + 20% promote meal revealed good growth and without any adverse effects on the feed utilization. Energy production and crude protein digestibility of Japanese seabass (*Lateolabrax japonicas*) improved by 73% and 85%, respectively, when fed with non-deoiled silkworm pupae. This improvement was more or less equivalent to meat and bone meal diets, but lower than that of poultry meal, feather meal, blood meal, and soya meal (Ji et al., 2010).

Silkworm pupae as a feed for shellfishes:

In giant freshwater prawn (*Macrobrachium rosenbergii*) silkworm pupae as a replacement for fish meal in the diet did effect growth performance when the inclusion level was maintained at 8.6% by weight (Jintasataporn et al., 2011). A combination of soya meal (29%) and silkworm pupae meal (16.9%, DM basis) can replace 100% fish meal in the diet of Abalone juveniles (*Haliotis discus*). Further, it is better to use a combination of silkworm and soya meal for better survival and growth in abalone (Cho, 2010).

CONCLUSION

Thus silkworm pupae are one of the promising insect meals for use as a feed ingredient in aquaculture. They are rich in protein, lipid, vitamins, and minerals with a nutritional profile matching fish meal. Hence, it can replace the fish meal partially or totally without causing any adverse effects to fish. Economically cost of silkworm pupae being lower than fish meal can also reduce the feed cost, which is the need of the day in the long-term sustainability of the aquaculture sector.

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