INSECT MEAL AS AN ALTERNATIVE FOR PROTEIN SOURCE IN ANIMAL NUTRITION

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INTRODUCTION

The shortage of feed and fodder for livestock is a pressing issue in many parts of the world, including India. Traditional feed ingredients such as soy, maize, and fishmeal are facing supply constraints due to factors like climate change, rising prices, and competition with human food production. This has led to increased costs for animal agriculture and reduced availability of high-quality nutrition for livestock. In this context, insect meal is emerging as a promising alternative. Rich in protein, essential amino acids, and fats, insect meal offers a sustainable and cost-effective solution to address the growing demand for animal feed. By utilizing organic waste and reducing dependency on conventional feed sources, insect meal not only helps alleviate feed shortages but also contributes to a more circular and eco-friendly agricultural system. They grow and reproduce easily, have high feed conversion efficiency (since they are cold blooded) and can be reared on bio-waste streams. One kg of insect biomass can be produced from on average 2 kg of feed biomass. Insects can feed on waste biomass and can transform this into high value food and feed resource. Studies have demonstrated that it is technically feasible to produce insects on a large scale and to use them as alternative sustainable protein rich ingredient in pig and poultry diets.

THE NUTRITIONAL BENEFITS OF INSECT MEAL

Insect meal is produced from various edible insect species, such as crickets, mealworms, and black soldier fly larvae, etc. These insects boast a high protein content, ranging from 30% to 80% by dry weight, depending on the species. They provide essential amino acids, vitamins, and minerals, making them an excellent protein source for livestock. The protein quality of insect meal is comparable to that of traditional animal protein sources, as it contains all essential amino acids required for animal health and is easily digestible. The nutritive composition of insect meal can be variable depending on diet, climate conditions and phase of development. Some of the common insects utilised and studied as insect meal are given below along with their nutritional composition:

1. **Black soldier fly larvae (*Hermetia illucens*):** Fresh larvae have a DM content of 35-45% which is quite high making them easier and less costly to dehydrate. BSF larvae have been reported to have as high as 41.1–43.6% crude protein (CP), 14.6–28.4% ash and 5278.49 kcal/kg gross energy (GE) on DM basis. The larvae are also rich in minerals like calcium, phosphorus, potassium, sodium, magnesium, iron, manganese, zinc and copper ,and essential amino acids like valine and leucine.
2. **Housefly (*Musca domestica*):** There are two types of meal available from housefly, i.e., the housefly larvae meal (which contains about 60.38% CP and GE value of 4800.80 kcal/kg on DM basis) and the housefly pupae meal (with about 76.23% CP, and GE value of 4877.23 kcal/kg on DM basis). The maggots showed higher Calcium, Phosphorus and metabolizable energy (ME) content (4140 kcal/kg) than soyabean meal (2250 kcal/kg). Essential

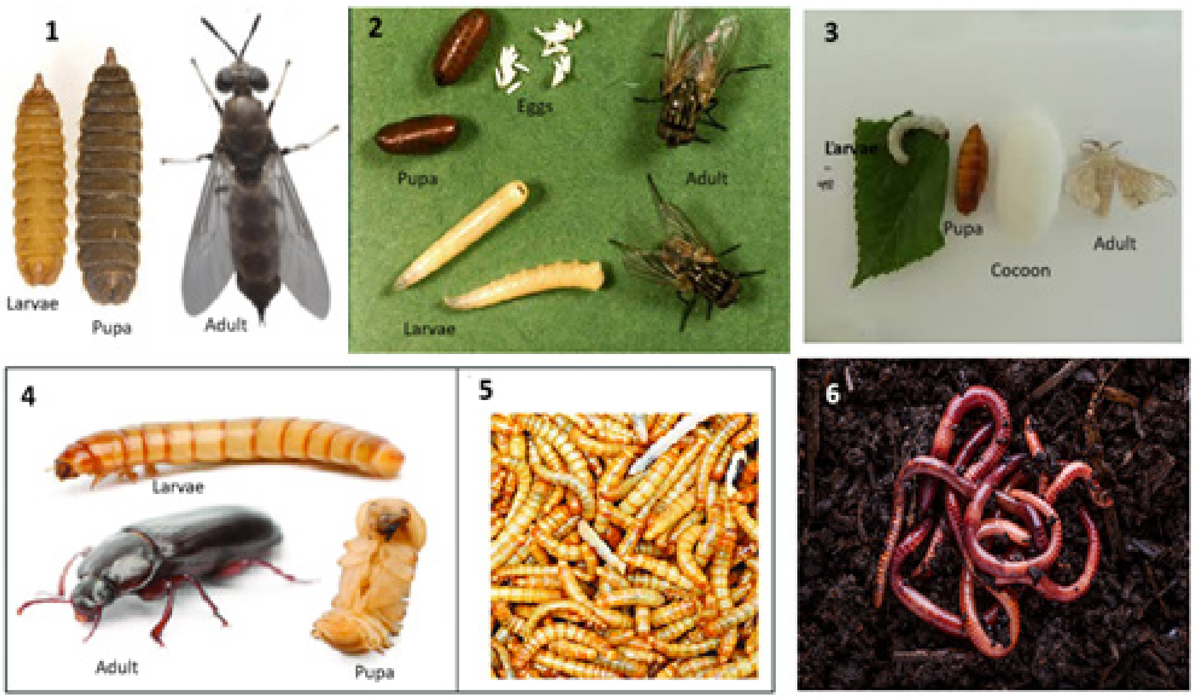

Fig A: Different developmental stages of 1. Black soldier fly; 2. Housefly; 3. Silkworm; 4. Mealworm (*Tenebrio molitor*), 5. Larvae meal of T. molitor, 6. Earthworm.

fatty acid (EFA) like linoleic acid is also found in good amount in the larvae as well as pupae meal. The maggots have higher amino acid content than the soyabean meal. Specifically a higher quantity of the essential amino acids like lysine, arginine, phenylalanine, tryptophan and valine, but a lower level of methionine and cystine.

3. **Mealworm larvae (*Tenebrio molitor*):** The crude protein and ash in mealworm larvae were reported as 45–60% and 3.0–4.5% DM, respectively. The Calcium content and the Ca:P ratio is not adequate for poultry production (particularly for hens), but such problems can be solved by feeding mealworm with a Ca fortified diet. Mealworm contained considerable quantities of most of the B vitamins and choline, although lower levels of both vitamins B1 and B12 were found.
4. **Earthworm:** The CP content of earthworm meal ranges from 38.87% to 65.68% DM with ME of 3525.36 kcal/kg. This wide range in protein content is due to different species of earthworm used and also probably due to stage of growth. They are rich source of iron, calcium, phosph[1]orus, potassium, sodium and fatty acids, along with notable amounts of other important elements.
5. **Silkworm:** The Silkworm pupae is a waste product of silk industry that can become an excellent unconventional protein and energy source for poultry and livestock diets after proper processing. The dried pupae powder contained 71.9% CP and 4.0% ash on a DM basis. The mineral analysis indicated high potassium content with a low Na/K ratio and low heavy metal content. It contains 18 known amino acids, including all of the essential amino acids and sulphur-containing acid acids.

6. **Crickets (*Gryllus testaceus walker*):** crickets can survive and grow well on a variety of organic materials including forage diets, agricultural and food industry by-products and plants considered as weeds are potential cheap and sustainable feed sources. Crickets were reported to have a high CP level

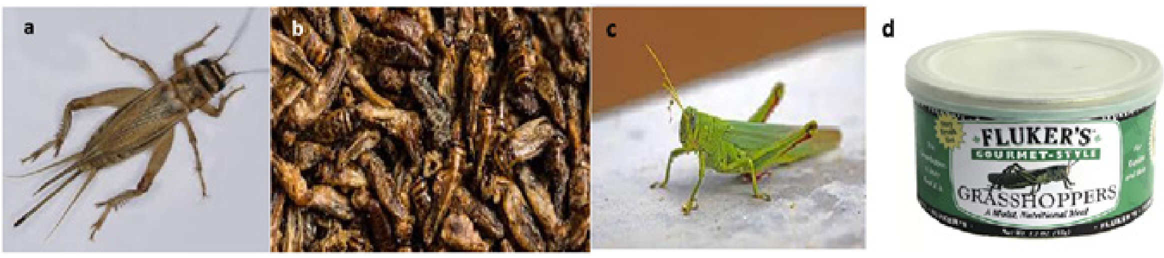

Fig B: a. A cricket; b. Processed cricket meal; c. A grasshopper; d. Can of grasshopper meal for pets.

ranging from 55 to 73% and sufficient EAAs, except for methionine and lysine, which can be supplied directly in the feed.

7. **Grasshoppers:** The crude protein content varies from 29 to 77.1% due to various species, developmental stages and different processing methods. A Gross energy of 1917 kcal/kg on DM basis has been reported. Among vitamins vitamin-B3 was found to be highest, followed by vitamin C, vitamin B2 and vitamin A. The grasshopper meal is also a rich source of PUFAs and essential amino acids.

Constituents % in DM)	Housefly maggot meal	Silkworm pupae meal	Fishmeal	Soy meal
Crude protein	50.4 - 62.1	60.7 -81.7	70.6	51.8
Lipid	18.9	25.7	9.9	2.0
Calcium	0.47	0.38	4.34	0.39
Phosphorus	1.60	0.60	2.79	0.69

Source FAO, 2011 and 2013

Fig C: Comparison of some insect's meal with soy meal and fish meal

SUSTAINABILITY OF INSECT MEAL

Insect meal stands out for its sustainability advantages. Insect farming requires significantly fewer resources than conventional crop farming:

- ✓ Environmental Sustainability: Insect farming has a smaller carbon footprint compared to traditional feed production and requires less land and water.
- ✓ Feed Conversion Efficiency: Insects have demonstrated remarkably high FCEs compared to traditional livestock, making them a promising alternative for sustainable protein production. Example, Crickets have a feed conversion ratio of 1.7:1, making them much more efficient than cattle, which have a ratio of 8:1and Black soldier fly larvae have been shown to have an FCE of 2:1.
- ✓ Waste reduction: Insect farming can help reduce food waste by converting organic by-products into valuable protein.
- ✓ Lower Feed Costs: Insect meal provides a cost-effective alternative to expensive traditional feed ingredients like fishmeal and soy.

PRODUCTION METHODS

Insect farming is versatile and adaptable to various scales. These insects are reared in controlled environment and are fed organic waste materials, such as food scraps or agricultural by-products, to promote rapid growth. Once the insects reach the desired size, they are harvested, cleaned, and pre-processed to remove contaminants. After harvesting, insects are processed into meal through drying, grinding, and defatting, creating a fine powder suitable for animal consumption.

APPLICATIONS OF INSECT MEAL

✓ **Poultry:** Insect meal can be incorporated into poultry diets to improve growth rates, egg production, and meat quality. The fatty acid composition of Black soldier fly larvae, which is rich in lauric acid, can improve egg yolk quality and enhance flavor. For example, black soldier fly larvae meal has been shown to be an excellent source of protein for broilers and layers.

✓ **Swine:** Insect meal can be fed to pigs, improving their growth performance. In piglets, insect meal can be a highly digestible protein source, especially in weaning diets. Research shows that pigs fed insect-based diets may experience similar or slightly better growth rates compared to those fed conventional protein sources.

✓ **Ruminants (Cattle, Sheep, Goats):** While ruminants have more complex digestive systems, certain insect meals (like those from black soldier flies) can be used in small amounts without affecting rumen health. Insects are rich in fats, which can help improve the energy density of ruminant feeds. For dairy cows, insect meal is a potential source of protein that supports milk production.

✓ **Aquaculture:** In aquaculture, insect meal has been tested as a replacement for fishmeal, which is a significant component of fish feeds. Black soldier fly meal, for example, has shown to be an excellent alternative to fishmeal in diets for tilapia and trout.

CURRENT WORK AND FUTURE OUTLOOK

Globally, insect meal has gained significant attention for its sustainability and nutritional benefits. Companies like AgriProtein and Ynsect are pioneering large-scale insect farming, particularly using black soldier fly larvae (BSFL), to produce protein-rich meal for livestock and aquaculture feeds. Research by organizations such as the FAO and universities worldwide has demonstrated the potential of insect meal as a cost-effective and eco-friendly alternative to traditional feed ingredients like fishmeal and soy. In India, institutions like ICAR and NIANP have been exploring insect meal's use in poultry, aquaculture, and livestock, with studies showing its potential to improve feed efficiency. Private companies in India like AgriProtein India and Insectta are establishing insect farming operations, focusing on converting organic waste into high-quality protein. Government support for sustainable agriculture through initiatives like Atmanirbhar Bharat is further accelerating the adoption of insect meal in India, with a growing emphasis on its role in waste management and circular economies.

CONCLUSION:

The growing shortage of traditional feed and fodder for livestock underscores the urgent need for innovative solutions in animal agriculture. Insect meal, with its rich nutritional profile and sustainability benefits, offers a promising alternative to conventional feed ingredients. By leveraging organic waste and reducing dependence on resource-intensive feed sources like fishmeal and soy, insect meal can help alleviate feed shortages, lower costs, and enhance food security. As the technology advances and regulatory frameworks evolve, insect meal has the potential to become a key component in creating more sustainable and resilient livestock farming systems worldwide.