

Insect based bioconversion:

Future need of growing population

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*Organic waste from houses, restaurants, food processing plants etc is enormous. The waste is often disposed in the open ground which pollutes the environment. Insect-based bioconversion of such waste can be a solution for diverting the pressure of meat production on agricultural lands. Enterprises like aquaculture and poultry are highly dependent on agricultural lands for nutrition. Hence, insect-based food can also be an option to meet their feedstuff demand. Black soldier fly (*Hermetia illucens*) which is widely present in India can be utilized for bioconversion of waste. Adoption of such enterprise will not only produce valuable animal feed, biodiesel, fertilizers, drugs etc but also provide employment.*

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WITH growing world population, the demand for food is also increasing. The demand for the meat is expected to rise up to 58% by 2050, putting a greater pressure on agricultural land. To satisfy the demands of the growing population, the forests are being slashed to expand the agriculture. Enterprises like aquaculture and poultry need vast agricultural fields for nutrition but these agricultural outputs are highly prone to fluctuating price and the unavailability of the feedstuff at industrial level. Their diets are mostly based on cereals and oilseeds and alternate to these can be insect-based food.

The waste from agriculture-based industry, houses, hotels etc is dumped into the environment untreated, which serves as a major source of pollution. A wide diversity of herbivorous and detritivorous insects are specialized to convert this organic waste to products of human interest. This process of conversion is termed as insect based bioconversion. The output from the bioconversion can be used as feed for animals, food for humans, and industrial

compound such as biodiesel, lubricant, pharmaceuticals, dyes etc. The process also produces organic manure of high quality. Such enterprises will generate employment on a vast scale.

The insects are abundantly available on earth and are more diverse than any group of animal. It is estimated that there are between 5–10 million species of insects, of which only 10–20% are known and only a million of them have been catalogued. More than 1500 species of insects are used as food for about 3000 ethnic groups in more than 120 countries. Hence, there is immense opportunity to use insects as an alternative for feedstuff.

Bioconversion

The following points need to be considered for the immediate adoption of such innovative approach for waste management by the public and private sector:

- Approximately 1.3 billion tonnes of global food gets wasted and it is increasing annually.
- Requirement of more agricultural land for animal meat production, fertilizer, biofuel, pharmaceuticals etc.

- Environmental pollution caused by waste.
- Increasing unemployment.

Processing

Agricultural and food waste may be considered a problem, but insect-based bioconversion thrives on organic waste from such sources. On an industrial level, there should be constant supply of feedstock, and that preferred feedstock is waste from agriculture and food waste coupled with farm, houses, restaurants and food processing plants. Given below is the basic processing of the insects in the rearing facility:

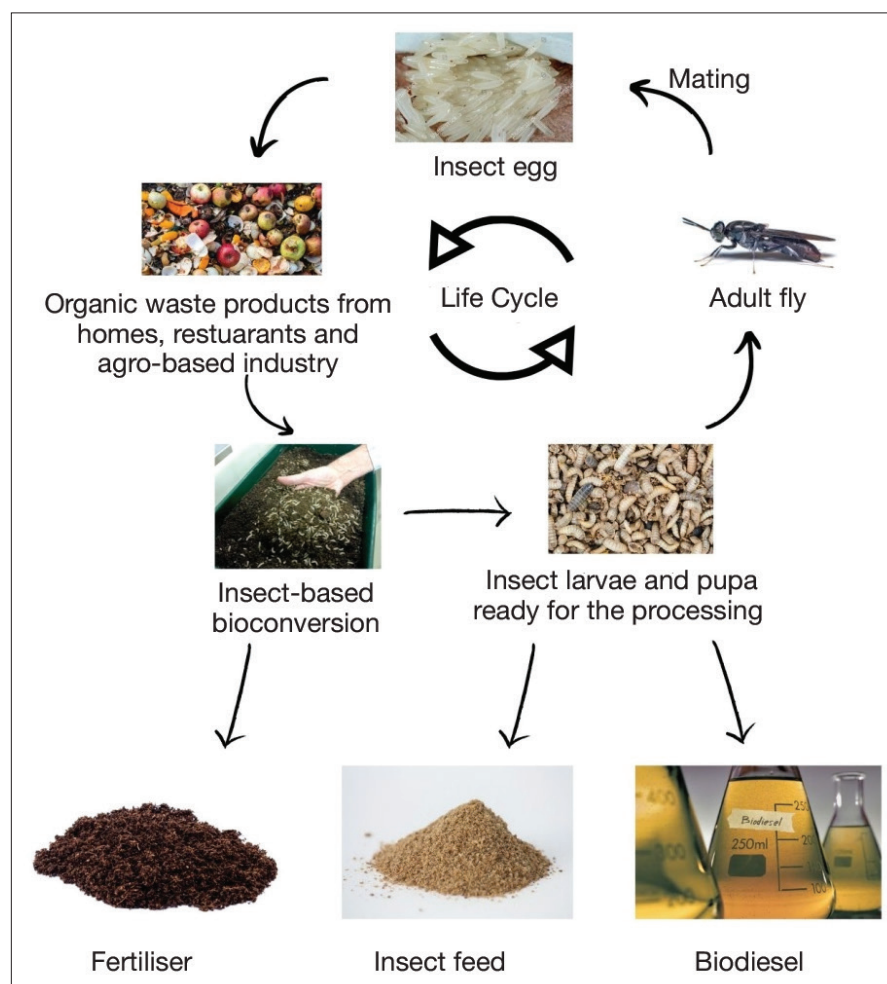
- The waste feedstock may require pre-processing before it can be used as feedstock for the given insects.
- Some pre-consumer food wastes like juice pulps are already processed and can therefore go directly into the bioconversion process. After the feedstock is ready, the insect inoculum is added in the form of egg or larvae.
- For all the species of insects, most of the bioconversion takes place in larval stage only and late instar or when the insects undergo pupation is suitable for

harvesting.

- Harvesting or extraction may be done mechanically, or some of the insect have self-extractable behaviour i.e. they choose to pupate elsewhere, in such cases the routes may be clearly made. The leftover frass by the insect can be further broken down by the microbial action which then yields a very good quality of manure.
- The harvested insects may be processed for selling or refined into valuable commodities such as biodiesel, defatted insect meal, pharmaceuticals, etc.

Insect as animal feed

Meat production requires high protein-based diet, such as soybean meal, wheat, corn, and animal meal. Many studies have been carried out to check better and viable alternative to these agro-based products. Researchers have come up with microorganisms, and diverse animal by-products as feed but these are still under intense investigation to address some constraints including anti-nutritional factors and unbalanced nutrient profile. On the other hand, insects act as complete food for the fishes and birds. In this regard, insect breeding is a viable option to be accepted as a profitable enterprise by the farmers. The insects provide a wide option of substrate to be used as their diet. They can be reared on simple plant-based diet, with some insects even utilizing the industrial waste, organic waste and even inorganic waste.



Insect based bioconversion

The most well studied and commonly used species for the animal feed are Black soldier fly larvae (BSFL), House fly, Mealworms and Crickets. When ground into insect meal they may be used as a replacement for soya and fish meals in many animal feed. The suitability of these insects has been proven for the monogastric animals like pigs,

poultry, freshwater prawns, and some fish species. The larvae have high protein content and a good nutrient profile. It has been observed that larvae feed from waste of food processing plant contains 30% lipid, of which 3% is omega-3 fatty acid.

In animal production, comparison of input feed to output meat is referred to as the Feed



Black soldier fly adult

Source: https://en.wikipedia.org/wiki/Hermetia_illucens



Black soldier fly larvae



Black soldier fly as chicken feed

Source: <https://kimmyfarm.com/en/black-soldier-fly/larvae>

Conversion Ratio (FCR). A lower FCR indicates high efficiency of conversion of the food waste into animal biomass. Study shows the following FCR of various insects: Black soldier fly larvae (BSFL) (1.4–2.6), Mealworms (4.1–19.1), and Crickets (2.3–10.0). Hence, from the data we can confirm that BSFL are very much suitable for the bioconversion of waste food products. In comparison, conventional livestock FCRs are: poultry (2.3) and pork (4.0). This suggests, it takes a larger quantity of feed to produce a kg of beef or pork than it takes to produce a kg of insects. For example, if we consider the average FCR of Black soldier fly to be 1.7 then, for every 100 kg of restaurant waste we can produce 58 kg of BSFL. Now, if the FCR for the poultry is to be taken as 2.3, then 58 kg of insect meal will generate around 25 kg of poultry meat. Insect-based bioconversion of food waste therefore is an appealing opportunity for producing marketable proteins, while simultaneously mitigating the negative impacts of food waste.

Production of biodiesel

Biodiesel is a promising alternative of conventional fossil fuel. The production of biodiesel from the agriculture is debatable,

larvae feed decaying vegetables and dry leaves, producing 34.2 g of biodiesel from 234.8 g of dried mealworm larval biomass.

Production of fertilizer

The leftover frass when treated with suitable microbes and earthworms can yield a very high-grade fertilizer. These fertilisers can be used directly for conditioning of the manure. Studies have shown that growth rate and chemical composition of cabbages grown using Black soldier fly frass were identical to commercial fertilizers. Similarly, onion production was identical for both insect frass and compost amendments. This may be due to the added ammonia (NH_4^+) from nitrogen in insect frass, which has been shown to increase 5-fold relative to the non-fertilized plants. Additionally, insect frass compost helps in reduction of pathogenic microbes and pesticides.

Case study

The fact that BSFL can grow on any organic source is utilised by many industries around the globe. Many companies are successfully converting organic waste into manures, proteins, lipids and other valuable products.

An example of a successful industry is Agri Protein. It is a British agricultural and biotechnology company which carries insect-



Black soldier fly manure

Source: <https://kimmyfarm.com/en/black-soldier-fly/larvae>

based bioconversion. The company is mainly dependent on the BSFL, it breeds BSFL on food waste from a variety of sources including restaurants and supermarkets. The company has products like MagMeal™ (high protein rich meal for chicken, fish, pigs and pets), MagOil™ (for aquaculture and pet food as an alternative of palm oil) and MagSoil™ (organic soil conditioning product). A unit in South Africa converts 72 tonnes of food waste each day, in turn generating 16 tonnes of insect meal (dried powder from ground insect biomass), 9 tonnes of insect oil, and 88 tonnes of fertilizer. In 2018, they raised a fund of 105 million dollar from bioconversion.

Future prospects

Attributing to such an immense capability to breakdown the organic matter into simpler form, these flies still are underexploited for harnessing their true capability in managing waste. These flies can be released on organic waste matter such as farm waste, food waste etc. In India, management of farm waste is difficult, because of small land holding and less mechanisation. In such cases, these flies can be released on the waste material where they will breakdown the farm waste into manure. Similarly, the flies could be released in the dump yards located on the outskirts of the cities to reduce the amount of organic waste. These flies will accelerate the process of decomposition of the waste material

hence the offensive smell from such pile of waste could be reduced.

In India, BSFL is utilised to a micro level only. Individual farmers of families have taken up such initiative to utilise these flies for organic waste management and use the larvae for poultry or fish farming. On a larger scale, we have not adopted this technique and both private and government sectors should come up with the projects to implement such ideas on industrial level. Not only protein source, biodiesel, manure and other products of pharmaceutical importance could be generated from the industry. Here, government has important role in supporting such industry by providing subsidy and reducing taxes on such products. Further, the government agencies such as ATMA and other organisations can take up responsibilities to advertise and transfer the technology to the farmers and public. Adoption of such innovation on community level would help bring changes in society and help change the perception about waste.

SUMMARY

Insect based bioconversion can be seen as a very promising approach to provide protein source to the growing population and at the same time organic waste management can be effectively done. The BSFL promises many value added products. BSFL farming is easy and can be adopted on a community level, also it has potential to support big

industries. The enormous amount of agricultural waste produced in India, which currently is simply thrown in landfills situated on the outskirts of the cities can be utilized to produce valuable products. Thus, the major source of pollution can be stopped and the negative consequences on environment may be eliminated. Thus, insect-based bioconversion possesses an enormous source of capitalization. If the waste of the farm and household is utilized properly, it will add up to the income of the farm by monetizing the waste products to valuable products such as protein meal, manure, lipids and other valuable products of pharmaceutical importance. Insect-based food is currently not accepted by majority of Indians but the growing fish and poultry sector can utilize waste derived insect protein as a feed for meat production. High quality manure obtained from the BSFL can effectively reduce the need for the fertilizer in the farm. These little efforts by the farmers can add to the farm income. Further, the lipids extracted from mature larvae could be used to produce biodiesel and some pharmaceutical products. As we are continuously looking for the alternate source of fossil fuel, biodiesel produced from such waste can be an alternative.

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Pusa Decomposer A microbial consortium for in situ paddy straw management

Pusa Decomposer is a microbial consortium of fungi developed by IARI for accelerated degradation of paddy straw into manure in 20–25 days. This technology is an effective eco-friendly solution for agri-residue management and an alternative to burning, thereby decreasing air pollution and improving soil health. A standard operating protocol (SOP) has also been developed for *in situ* management of agri-residue. The protocol involves application of the Pusa Decomposer spray, followed by rotavator for proper mixing of the spray with the straw and light irrigation to ensure moisture in the field. During 2020, Pusa Decomposer was demonstrated in an area of about 13,420 ha in different states of the country including Delhi. In 2021, the Pusa Decomposer shall be applied to > 15 lakh acres in the four states of Punjab, Haryana, Uttar Pradesh and Delhi.



Pusa Decomposer



Spraying



Mixing and incorporation



Irrigation



Germination of wheat