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Insect farming potential in India and hurdles associated

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Abstract
Insects are used as a natural food and other useful products in many parts of the world from time immemorial. Insect as protein has several benefits over conventional protein source. They produce protein sustainably, using less food, water, and land. The production of edible insects can help meet the world's expanding population's need for a steady and balanced supply of food. Although insect farming is a comparatively new concept; requires knowledge and expertise but it has potential to grow as an industry in a developing country like India considering the opportunities.

Keywords: India, insect farming, opportunities, potential, protein source

Introduction

Since about 7,000 years ago, people have been eating edible insects, which have several nutritional and environmental benefits. With more than 2,300 species known to exist, especially in Africa and Asia, insects are an important source of protein, vitamins, and minerals. They are also known for its therapeutic qualities, which have been connected to a number of health advantages in many cultures. These include nutritional supplements and remedies for ailments like asthma and pregnancy-related problems. Compared to conventional cattle, insects have remarkable feed conversion efficiency and require a lot less food, water, and land, making them a sustainable choice for protein production. With a rich tradition of silkworm cultivation in the North-East region, particularly among tribal communities, edible insects provide not only a vital food source but also a variety of by-products like silk and organic fertilizers. It also underscores the comparatively easier rearing processes of eri and mulberry silkworms compared to muga, which faces environmental challenges. Additionally, the utilization of silkworm farming by-products in animal feed and compost production indicates a sustainable approach to resource management. Despite the extensive cultivation of mulberry silkworms across India, the resistance to consuming them due to cultural beliefs presents a challenge that must be navigated to fully realize the potential of edible insect farming in enhancing food security and promoting sustainable livelihoods in the region. The practice of consuming insects, remains largely stigmatized among high-class populations in India, often perceived as a primitive lifestyle. This perception is compounded by concerns over allergic reactions, potential microbial contamination, and the accumulation of heavy metals and pesticides in insect-derived foods. The need for stringent identification and prevention strategies regarding these risks is paramount for safe insect production. Additionally, challenges such as counterfeit products and the requirement for high-quality, stable insect supplies necessitate the development of industrial automated rearing facilities. The absence of regulatory frameworks further hinders entrepreneurship in the edible insect sector. Despite these challenges, India has significant potential to emerge as a key player in the insect farming market, addressing the increasing protein demand for its growing population. Promoting educational interventions and creating awareness are essential for establishing sustainable practices in insect farming, ultimately contributing to economic empowerment and food security.

Diversity of insects and their uses

Insects are the diverse group of invertebrates under the phylum Arthropoda originated in the Early Devonian chert of Rhynie, Scotland long been utilized by human being for food and variety of other products. It is evident from the early literature, paintings and fossils that human were able to hunt products from ferocious insects like honey, consumed wild insects and gradually able to domesticate some insect species of their use. It is evident from the painting discovered in the Cave of the Spider located in Cazunta river that honey was used by human being more than 10,000 years ago. Honey was used as food and medicine in many civilizations. *Apis indica* (the Indian bee), *Apis mellifera* (the European bee) and *Apis florea* (the little bee), these species are domesticated by human being and raised to produce honey. Use of lac is also traced back to prehistoric time. Lac insects are raised for commercial production of resin, dyes and wax. Indian lac insect, *Kerria lacca* is the most important lac insect; *K. chinensis* and *K. sharda* are also exploited for lac production. India is the highest producer of the lac in the world. Though several species of organisms produce silk, but rearing of six species of silkworms *viz*., mulberry silkworm (*Bombyx mori)*, muga silkworm (*Antheraea assamensis*), eri silkworm (*Samia ricini*), tropical tasar silkworm (*A. mylitta*) and temperate tasar silkworm (*A. proylei* and *A. pernyi*) are done commercially to get the silk. The origin of sericulture dates back to 2640 B.C and now cultivation is spread in more than 50 countries of the world. India is privileged in being the 2nd largest producer of silk, China being the first. Now-a-days silkworms are cultivated not only for textile material but also for using as bioreactor**,** food, in cosmetics and pharmaceutical industry.

Insect farming, though not widely known and less-discussed topic, but in recent times, is a rapidly growing business around the globe as well as in India particularly to meet the demand of rich protein at low cost. There are various uses of insect protein, *viz*., animal feed (fish, poultry, pig etc.), foods and beverages, pharmaceutical, cosmetics etc. Some insect species like *Trichogramma* sp. are raised to control pest population. This type of natural enemy farming is also gaining popularity in India in organic farming system as well natural farming system. As the global population projected to reach 9.7 billion by 2050 (Gallo and Federico, 2018) [7], there is high need for alternative protein sources to meet the rising demand for protein (Tang *et al*., 2019) [17]. Moreover, it is indispensable to handle the nutritional requirement of developing countries that face food insecurity and malnutrition. The size of the insect protein market was valued at US$ 517.70 Mn. in 2022 and revenue of 25.2% is predicted to grow from 2023 to 2029, reaching nearly US$ 2496.39 Mn. But this type of study or statistics is not readily available in Indian context. In 2023, the top exporters of insects were China ($5.93M), Spain ($2.06M), United Kingdom ($934k), Australia ($840k), and Vietnam ($810k) whereas leading importers were Thailand ($5.08M), France ($1.63M), Australia ($1.42M), South Korea ($1.27M), and United States ($1.14M). The top funding companies for insect farming startups are Netherlands-based company black soldier fly startup Protix and Deli Bugs, South Africa's AgriProtein, and France's Ynsect, USA's Enviro Flight, United States LLC, Thailand Unique, UK-based company Eat Grub Ltd. etc. However, Exo protein, an American insect food company is leading in production of insect food for human consumption.

The practice of consuming edible insects dates back approximately 7,000 years (Ramos-Elorduy, 2009) [15]. Over 2,300 species belonging to 18 orders have been identified as edible, with five orders featuring at least 100 documented species (Jongema, 2017) [8]. Edible insects are viewed as a significant source of highly nutritious food. Consumption of insects is an extensive practice of many tribal and ethnic groups residing in Africa, Asia, Australia, Oceania, and Latin America, where they serve as a crucial nutrient source in diets and are also recognized for their medicinal benefits (Ordonez-Araque and Egas-Montenegro, 2021). In Africa, around 500 species are consumed (Kelemu *et al.*, 2015) [10], while India recognizes about 255 species as edible (Chakravorty, 2014) [6]. Commonly eaten insects include grasshoppers, termites, large moth caterpillars, beetles, bees, wasps, ants, locusts, crickets, cicadas, leafhoppers, planthoppers, true bugs, dragonflies, and various flies (Van Huis *et al*., 2013) [18]. In some countries and areas, insects are utilized as nutraceutical food. In Nigeria, crickets (*Brachytrupes membranaceus*) are consumed to support mental development and care during pregnancy and after childbirth. Similarly, in Asia, the Chinese beetle (*Ulomoides dermestoides*) is often used to treat asthma, arthritis, and tuberculosis. In Assam, disappeared matured eri larva from the cocoon spinning frame and thereafter forming the cocoon elsewhere is used to cure asthma of children.

Nutrient content and health benefit of insects are rich in proteins with a balanced containing healthy unsaturated amino acid profile, fatty acid and also a good source of micronutrients such as vitamins and minerals. It also contained immune stimulants such as chitin and antimicrobial peptids; protein serves muscle repairing, immunity and hormone production.

Nutritional content of different species is although different but insects possess significantly high amount of protein and fat. Adults require 0.8 gm of protein per kg of body weight, as such a 70 kg adult requires 56 gm of protein per day. Let us see Indian's consumption compared to world (Table 1).

Table 1: Average protein supply (gm) / day/ person in 2021 (UNFAO)

Country	gm of protein/ day/ person
Iceland	145.62
China	124.61
US	124.33
Indonesia	79.75
Pakistan	70.77
India	70.52
Nigeria	59.08
Congo	28.59

Source: Anon., 2025a [1]

This shows disparity leading to a critical gap for public health and economic productivity. People are concerned with balance diet and healthy lifestyle and are attempting to increase protein in their daily diets. In one hand, those acquainted with traditional food habits preferring vegetarian protein sources and on the other, rising middle classes are hankering for more protein rich diets. At a compound growth rate (CARG) of 6.8%, Indian market will grow to $1.88 to 2.08 billion by 2029-30 from that of $1.4 billion to 1.528 billion in 2024-25. Joining global giants like Areher Daniels Midland Co. and four other sharing 8.02% of the protein market in 2023, domestic player Paraf Milk Foods Limited is providing dairy protein like whey protein supplement with USD 92.03 million in 2023 is projected to 125.2 million by 2030 growing at CAGR of 5.08%. Table 2 exhibits the global protein requirement projected in 2032:

Table 2: Global protein requirement projected in 2032

Protein source	Market price
Marine- derived protein	USD 17.53
Microbial protein market	USD 15
Dairy protein	USD 900
Duckweed protein	USD 185.5
Organic rice protein market	USD 155.6

Anon., 2025c [3], 2025d [4] & 2025e [5]

Edible insects require less food, water, and land. Livestock is the world's highest user of agricultural land (68%). The chief advantage of edible insect farming is that possibility of raising them by using organic food waste like compost, manure or vegetable waste which is not used by human being for consumption and thereby reduces environmental contamination and pressure on land use. However, there is possibility in reduction in growth, development and deficiency of nutrients and increase of mortality rate after consumption of this type of wastes by the insects. Insects, being cold blooded organism have high feed conversion efficiency requires less water and whatever the water is required accumulate from their food only. Insects are found to be 12 to 25 times more efficient in conversion of low protein feed to high quality protein compared to animals. Following table shows the use of land and water for different protein production practices:

Table 3: Land and water used by different protein production practices

Protein production practice	Land use (m^2) / kg of protein	Water use (m^3) / kg of protein
Insects	4	5
Rapeseed	50	16
Soyabean meal	73	21
Nuts	79	139
Eggs	57	20
Chicken	71	34
Beef	1636	112

Source: Mekonnen and Hoekstra, 2012 [11]; Poore and Nemecek, 2018 [14]; Ritchie and Roser, 2020 [16]

Edible insect farming helps in emitting lower greenhouse gases. In India farming of large number of cattle and livestock are done not only for milk and other purposes but also as a source of protein which are responsible for emitting huge amount of greenhouse gases. If farming of insects can be popularized in India then it will reduce the quantity of livestock production and reduce the pollution in the environment. The majority of commercially raised edible insect species, such as the house cricket (*Acheta domesticus*), the migratory locust (*Locusta migratoria*), the yellow mealworm (*Tenebrio molitor*), and the silkworms perform better than traditional cattle in terms of both direct emissions of GHG and ammonia generation (Oonincx *et al*., 2010) [12]. Literature available in terms of green house gas emissions in the process of protein production is compiled in the following table -

Table 4: Greenhouse gas emissions per 100 g of protein production

Protein	GHG emissions (kg CO_2eq./100 g of protein)
Beef	35.5
Lamb	19.9
Shellfish	18.2
Cheese	10.8
Fruit	10.4
Milk	9.5
Pork	7.6
Vegetables	6.8
Fish	6
Poultry	5.7
Rice and grains	4.8
Eggs	4.2
Tofu	2
Breads and pastas	1.3
Legumes	0.9
Nuts	0.3
Insects	0.9 -1.2

Source: Anon., 2025b [2]

Again, rapid increase in India's population also leads to food insecurity limiting the available resources. Therefore, there is tremendous scope of edible insect farming in India. Along with other insects, silkworm farming has vast scope as it is a traditional practice, less skill oriented industry, and people are raising it from time immemorial. Another important thing is that it may give several other products including silk, fertilizer, raw material for cosmetic industry, medicinal industry etc.

In North-East Region of India and other tribal dominated areas of India eating of edible insects including silkworm larva, pre-pupa and pupa is a delicacy and it has remarkable endowment towards sustainable livelihood. They collect wild edible insects and cultivate silkworms for both human consumption and silk. Assam, the leading producer of muga and eri silk of India, produces eri silk as a by-product only where pupa is the main product. The tribal people and other ethnic communities of Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram and Nagaland used to consume larva, pre-pupa and pupa of eri silkworm either as raw or as boiled pupa, fried pupa, chilli pupa, pupa masala *etc*. Muga growers of Assam used to eat muga pupa during the time of reeling muga cocoon. Proximate composition of mulberry, eri and muga silkworm pupa is mentioned in Table 5. Rearing of eri and mulberry silkworm is comparatively easier than muga silkworm as it is reared inside the house by supplying mainly castor and kesseru leaves; and mulberry leaves respectively. Like tasar, muga silkworm is reared outside the house on its primary host plants *som* and *soalu*. Because of outdoor rearing it has to face harsh environmental condition and pest and predator attack etc. Eri, mulberry, tasar and muga pupa can be used as feed for fish, poultry, piggery etc. Pupa oil can be used in soap making industry. During silkworm rearing, irregular, rejected, injured and dead larvae are discarded which can be fed to poultry because of higher protein content. Compost and vermi-compost can also be prepared from the uneaten leaves and excreta. There is tremendous scope of eri and muga farming in NE India due to congenial climate, naturally available food and age old tradition. Although mulberry silkworm is extensively cultivated compared to non mulberry silkworms and almost in every state of India but it is not consumed in the traditional or the leading states because of their traditional belief, customs, religion and unwillingness towards the concept of eating insects.

Table 5: Proximate composition of silkworm pupae (g/100 g dry weight)

Components	Mulberry pupa	Eri pupa	Muga pupa
Moisture%	7.62 ± 0.458	8.43 ± 0.614	7.80 ± 0.386
Crude protein%	46.06 ± 0.458	54.56 ± 0.392	61.63 ± 0.836
Crude fat%	27.33 ± 0.541	19.50 ± 0.624	17.00 ± 1.185
Crude fibre%	3.05 ± 0.167	3.50 ± 0.031	3.30 ± 0.235
Ash%	4.20 ± 0.303	4.76 ± 0.130	4.56 ± 0.018

Source: Kashyap *et al*., 2023 [9]

Except tribal dominated areas of India, most of the high class people consider entomophagy as a primitive lifestyle. Another problem associated with entomophagy is possible allergic reactions due to consumption of insects. Presence of microorganisms and parasites in the insect protein is a risk for using insect as a food. Identification of microorganisms and parasites, their prevention and reducing the severity is very important for a fruitful and safe insect production. Insect can accumulate heavy metal and pesticides in their food which may lead to residual effect to consumer. Another challenge associated with insect farming is counterfeit products. When insects are sold as food item, the companies involved in the production process require huge, authentic supply of high level and stable quality product. This can be possible only through industrial automated rearing facilities. Educational interventions are required not only to promote entomophagy but also to grow the edible insects in proper environmental conditions maintaining balanced nutrition. Extensive knowledge is also mandatory in harvesting, processing, packaging and marketing of insect protein. The cost or price of insect protein is still high due to limited production, high feed costs and less technological intervention. In near future, it is expected that high market demand, technological advancement like automation will help to reduce the price. Absence of regulatory frameworks or laws for edible insect farming in India is a key issue which prevents the companies or private parities to come forward for start-ups to grab the global insect market.

Conclusion

India has significant potential to emerge as a key participant in the insect farming business, addressing the rising protein need for its expanding population at a reduced cost, despite the challenges inherent in insect farming. Creating awareness among people and developing proper methodology for specific insect farming will help to grow this industry to become sustainable and contribute towards livelihood.

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