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## Insects as an alternate source of nutrition: A review

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#### Abstract

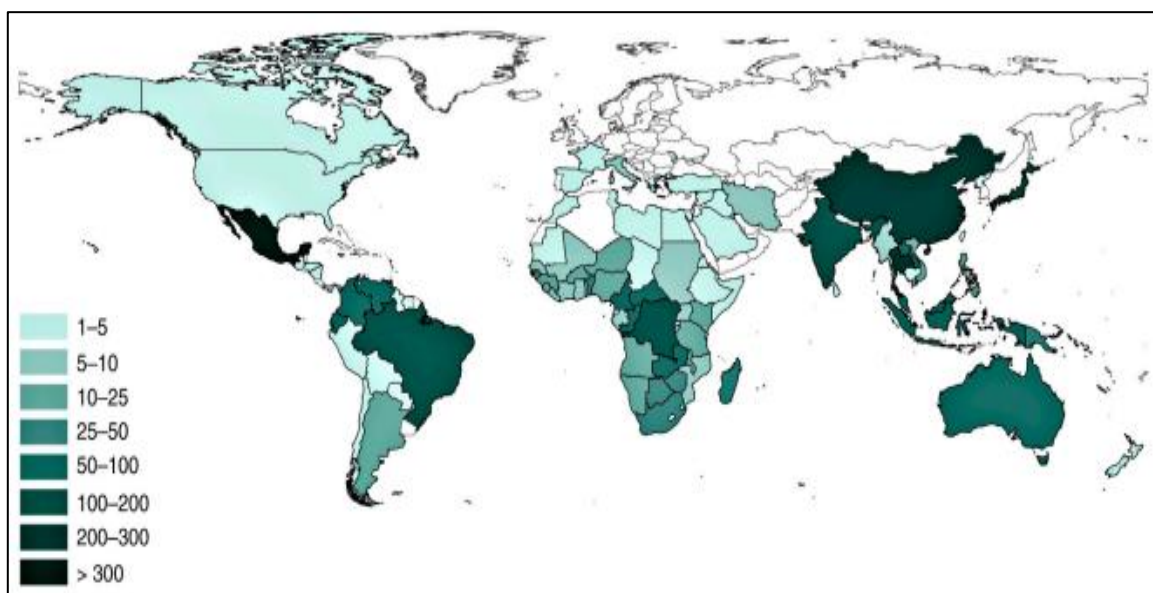
Global increase in population and insufficient access to land and food is leading to the search for alternative sources of food. Edible insect has obvious economic and environmental benefits and they have been in the limelight recently because of their huge potential in many industries. Edible insects' consumption is not only limited to India but is consumed by people all around the world, as these edible insects are extremely nutritious consisting rich content of fat, protein and micronutrient content varying species to species. Therefore, they represent a valuable alternative food for future generation. The global demand for alternative foods rich in proteins is increasing rapidly; the possibility to explore insects as an innovative kind of feed and quality protein source besides other useful nutrients such as fats, minerals and vitamins. This paper primarily focuses on the various types of insects that are edible and the nutritional value of those insects.

**Keywords:** Edible insects, entomophagy, nutritional value, sensory characteristics

#### Introduction

As the population is increasing globally, the demand for space is also increasing rapidly. But due to the limited access to land, the food available is also limited and this lead to the search for alternate food sources. According to the study, it is expected that by the year 2050, the inhabitants will increase to 8.2-10.5 billion (Ventura *et al.*, 2013) <sup>[1]</sup>. The threat to global food security is also growing due to the drastic change in the climatic condition and lessening of natural resources, and that is why the insects are now being considered as a sustainable alternate for humans. The consumption of insects is not only limited to India only, insects are consumed by people all around the globe and these insects are not only highly nutritious with high protein but also consist fat and micronutrients which varies from species to species. According to the sources it is estimated that there are more than 2300 species of the insects that are considered fit to be consumed all over the globe and these species provide more nutritional value and energy as compared to the other traditional source for protein. (Tang *et al.*, 2019) <sup>[2]</sup> It is expected that there are around 6-10 million insect species around the globe, out of which there are more than 2300 species of insects of 18 various orders have been confirmed as fit for eating. As an alternate protein, edible insects for the intake are very good in as it is environmentally sustainable and healthy for humans. Around 2 billion people consumes insect in their daily diet as they are they are very rich in proteins, easily affordable, environmental-friendly, taste good (Mishan, 2018) <sup>[3]</sup>.

In the 21<sup>st</sup> century rising demand for food and protein of animals, lack of food, ecological pressure, growth in population, and the increase in demand for protein between the functioning classes, insects as alternatively feed and food seems to be a significant business. This is the reason why entomophagy is ordinarily known as utilization of insects for eating and it is well-known in subtropical and tropical areas because of warm and moist type of weather. It positively contributes to the environment as well as human wellbeing. The idea of eating insects and their commercial production is getting better and increasing gradually and in a little while the insect eating sector will be the most important leading sector in food industry. The paper mainly focuses on the all the nutritional benefits of the insects that can be as an alternate source for food for the future generation.



**Fig 1:** Number of insect species consumed in various countries worldwide

**History**

For around 400 million years insects are present, which surely makes them amongst the most primitive land animals that have been present on the earth (Bernard *et al.*, 2017) [4]. Around 7000 years ago, natives began eating insects. The paleontological study shows that the insects were the major part of the early human diet (Huis, 2016) [5]. Nowadays insects species are being consumed commonly and are very well-liked due to their availability and size. For catching and to be located easily, insect needs to be large enough to make the effort and should also be preferably in large quantity. Insects can be eaten up at various stages of life and has plenty of methods for preparation like eating them uncooked, fried, boiled, roasted. During early time gatherers and hunters ate bugs to survive as bug has numerous nutritional benefits which include plenty of fat, protein and adequate amount of micronutrients. Insects were generally consumed and processed as human food (Fenenga, *et al.*, 1978) [6]. But, sometimes the insects were not identified correctly due to lack of proper information and knowledge. For example, word

"locust" was incorrectly used to describe crickets, grasshoppers, and cicadas, as well as other insects and caterpillars. As a result, the insects in the publication were not properly identified and classified, and ethnographers were even less specific. A number of insect archaeological records are questionable and misleading.

**Common edible insects**

Generally, insects have clear number of benefits in terms of nutrition value. The nutritional value and composition of insects are quite a lot similar to that of foods that are of animals (Raubenheimer, *et al.*, 2013) [7]. Not only for humans insects are the source of nutrients and active substances, but also for the poultry. It is estimated that worldwide there are around 6-10 million total number of insects, with over 2,300 species and 18 various orders are identified as edible insects. Some of the insects that can be consumed are: butterfly, grasshoppers, ants, bees, spiders, termites, cockroaches etc. below mentioned table 1 includes all the insects that are consumed globally.

**Table 1:** Various insects that are consumed in different countries

Consumption of insect	Country
Giant water beetle.	Thailand
Butterfly, Grasshoppers, crickets, Cicadas, Ants Flies, Bees and Wasps,	South America
Caterpillars, Mopane worm, Termites and Locusts	Africa
Giant queen ants, Palm grubs and Caterpillars	Colombia
Papua, Palm grubs, Grasshoppers, Crickets, Stick insects, Mantids and Locust	Pacific Islands
Grasshoppers, Crickets, Silk worm pupapa, Dragonflies, Termites, and Beetles.	Asia
Honey ants, Grubs, Moth, Bardi grubs and Cerambycid beetle	Australia
Termite, Dragonfly, Grasshopper, Ants and Mulberry silkworm, Honey bee, Cricket.	India
Silkworm pupa, Fly larvae, Cricket, Termites and Locusts	China

Source: Insects Cambridge World History of Food

**Insects: Nutritional Value**

Amidst rising global population, the demand for food is also increasing, insects that are edible seems to offer a substitute and a sustainable means for fulfilling the nutritional demand for growing global population. Edible insects consists the sufficient source of various nutrients that are typically required by human body. As compared to traditional high protein animals, insects have a good supply of nutrition and

protein. Human body can easily assimilate the nutrients (Huis, *et al.*, 2013) (Finke, *et al.*, 2014) [9, 10]. Dietary value of insects that are edible is highly variable, which depends on the basis of level of the origin, metamorphosis or the diet of the insects (Bukkens, 1997) [11]. Overall, there are clear advantages of the edible insects to be considered as a source of nutrition. The nutritional value of edible insects is sometimes equal and sometimes it is superior as compared to birds and mammal

foods. Eating insects significantly improves and increase the protein intake in human body (Rumpold, *et al.*, 2013) <sup>[13]</sup>. Protein content in insect dry matter ranges from 35% (termites) to 61% (crickets, grasshoppers, and locusts) and can reach 77%.in some of the latter species (Verkerk, *et al.*, 2007) <sup>[13]</sup>. Most edible insects meet up the optional amino acid

content for tyrosine, phenylalanine, threonine, lysine and tryptophan. The nutritional value of some very general species that are eaten globally is presented in Table 2. The information provided below includes the protein, carbohydrate, fat mineral composition, and energy value of the insect species per 100 grams of dry weight.

**Table 2:** Common nutritional value of edible insect g/100g dry weight

S. No.	Species (order)	Protein	Fat	Mineral	Carbohydrate	Energy Kcal
1	Caterpillar (Lepidoptera)	15-60	7-77	3-8	2-29	323-450
2	Beetles (Coleoptera)	21-54	18-52	1-7	6-23	138-447
3	Cockroach (Blattodea)	20-23	6-8	1-2	5-7	200-220
4	Bees (Hymenoptera)	1-81	4-62	0-6	1-6	416-655
5	Cricket (Orthoptera)	8-25	34	2-17	4-11	120-323
6	Spider (Arachnida)	63	9-10	0.5-1	0	320-390

(Belluco, *et al.*, 2013), (Finke *et al.*, 2014), (Finke, 2007) <sup>[14, 10, 15]</sup>

### Benefits

Because edible insects appear to be more adaptable than other animals, they may provide economic benefits. A significant increase in production is required to sustain a growing global population as the world's population grows (Finke, 2007) <sup>[15]</sup>. This expansion will eventually be a very heavy burden on the restricted natural resources, which includes water, energy, oceans and land. Current production cycles will lead to forest destruction, climate instability and enhanced greenhouse gas emissions. Livestock production, in particular, will eventually be a contributing factor to environmental issues, as it accounts for roughly two thirds of global land use for agricultural purpose. In insects Chitin content is typically around 10% of dried weight and varies according to insect species and developmental stage (Maezaki, *et al.*, 1993) <sup>[16]</sup>. Roughly there is about 90% of dietary fibre in purified chitin (Paoletti, *et al.*, 2007) <sup>[17]</sup> that are capable to be digested by humans (Steinfeld, *et al.*, 2006) <sup>[18]</sup>. Chitin, a principle component of insects and its deacylated form, chitosan, both have the potential to improve cardiovascular and colonic health, as well as inborn and immune responses, reduction in cholesterol, and wound healing. Edible insects benefit from the ability to be raised on natural byproducts such as manure, human waste, and compost, which can help to reduce pollution in the environment. Insect farming becomes more profitable when insect feed is replaced with organic byproducts.

### Insects in the mini livestock sector

The livestock sector contributes significantly to global income and livelihoods, accounting for roughly half of total agricultural GDP (Oonincx, *et al.* 2012) <sup>[19]</sup>. Even with rising demand for animal products, livestock other than traditional species such as pigs, goats, and chickens are often overlooked. Mini livestock, such as insects, can, on the other hand, be useful for economic diversification. Insect farming is a well-organized use of space that can be done in urban, peri-urban, and rural areas (Tuorila, 2007) <sup>[20]</sup>. Despite the fact that some insects have been domesticated, most species, such as tarantulas, must be collected in their natural environment. Mini livestock businesses are beneficial because:  
Need very less space

No competition for food meant for human consumption

Their demand exceeds supply

Generate cash inflows quickly because of high reproductive rates

High to very high financial returns

Part of human nutrition

Efficiently change feed to protein

Somewhat simple to manage

Can be transportable easily

Do not require in-depth training and are often easy to raise

### Food security

The Food and Agriculture Organization (FAO) of the United Nations predicts that the world population will exceed 9 billion by 2050, necessitating an increase of 100% in food production (Finke, 2007) <sup>[15]</sup>. There will eventually be an increase in food demand, but there will be a rising shortfall in cultivable land required to produce this food. Climate change will eventually reduce agricultural land availability, exacerbating food insecurity, impacting mostly the low-income countries, including elevated malnutrition and poverty. Because insects can be consumed, they have been proposed as a valuable source of food in geographical areas where people suffer from malnutrition and food insecurity can provide protein, vitamins, and minerals required for human health and well-being. Sectors dealing with insect production could eventually provide a solution to the food shortage (Paoletti, *et al.*, 2007) <sup>[17]</sup>.

### Palatable attributes of insects

In some parts of India, insect are eaten alive as soon as they are captured. If they are to be processed further, the most humane method of killing them is scalding with hot water and starvation for 1-3 days. Roasting, boiling, baking, frying, or drying are examples of subsequent culinary processing.

### Taste

Taste must be prioritized in food selection because it is governed by sensory characteristics. Taste is the main control that determines whether the food is allowed into the gut or not. Although some evidence suggests that all humans have the same types of taste receptors (Chakravorty, *et al.* 2011) <sup>[21]</sup>, this does not mean that all substances taste the same to everyone.

**Table 3:** The flavor and taste of some edible insect species

Taste and flavor	Edible insect
Fried potatoes	Mealy bug
Caviar	Eggs of water boatman
Herring	Caterpillars of erebid moths
Sweet, almost nutty	Ants, termites
Whole meal bread	Larvae of darkling beetles
Fatty brisket with skin	Larvae of wood-destroying beetles
Fish	Dragonfly larvae and other aquatic insects
Mushrooms	Cockroaches
Apples	Striped shield bugs
Pine seeds	Wasps
Raw corn	Caterpillars of smoky wainscots

### Odour

The olfactory nerve is the first cranial nerve in humans, and it is far more sensitive than taste (and other vertebrates). As a result, odor of food is important not only for detecting it from a distance, even if it is not visible; it also allows a person to pre-judge the food's acceptability as edible or not. Stinkbugs are a good example of this: pungent and stinky, these pentatomids are a favorite food of many insectivorous people in Asia (Teffo, *et al.*, 2007) and Africa (Reineke, *et al.*, 2012) [22, 23].

### Visual appearance

Coloration, for animals and humans with colour vision, can do too much than just indicate whether or not a food is hazardous to one's wellbeing. On the developmental stage it can provide major information of a food, as well as the amount of sugar or fat in it, indicating whether the food is worth the effort of collecting. Because insects can have different developmental stages, shapes, and colours, it is easier to distinguish highly valued stages or individuals from less valuable ones in this manner.

### Textural aspects

In order to consider an item as edible and acceptable as food, a closer inspection and texture assessment are also important. Items with a smoother, softer surface draw more attention than those with a bristly, rough surface. Spiny appendages, for example, are carefully removed from insects before they are further prepared for consumption.

### Future of edible insects

Global meat demand is increasing and a lack of available land is prompting a search for alternative protein sources. Utilization of edible insects is rising as people are becoming more involved in a new resource as it has enormous amount of nutrition. However, some insects are still unavailable on a regular basis because they can only be harvested in the wild. Despite the fact that some species have been successfully reared on a large scale, insect farming for food is still in its infancy (Waterhouse, *et al.*, 2016) [24]. The edible insect industry is expected to grow due to the introduction of new insect products, improved cultivation, and production optimization. In India and other developing countries where malnutrition is prevalent, consumers may consume insects on a regular basis. They could also be used as a nutritional supplement in the development of special diets for athletes, who are at risk of protein energy malnutrition. Insect farming appears to be more environmentally friendly than livestock farming when it comes to greenhouse gas emissions, water

consumption, and land requirements. In order to meet the nutritional needs of the world's growing human population, suitable for eating insects appear to be a viable and sustainable option. (Erens, *et al.*, 2012) [25]. However, several issues must be addressed before the potential of fit for human consumption insects to increase food security can be realized. As a healthy food source, more research should be done on the nutritional value and health benefits of various insects in order to offer a foundation for their encouragement. The long-term viability and environmental impacts of insect breeding, collection, and production must be studied in comparison to traditional agriculture and livestock farming, which are thought to be more environmentally damaging. The socioeconomic benefits of collecting and rearing insects to improve food security in low-income areas should be researched further. Insects appear unconcerned about animal welfare issues, though it is unknown how much discomfort and pain they endure (Elias, *et al.*, 2010) [26].

### Risk associated with an insect meal

The presence of a large number of insects in the wild may have a significant impact on the landscape ecosystem and agricultural production. As a result, eating insects raised on farms under controlled and defined conditions is advised. The use of appropriate and safe feed protects the health of edible insects. Allergies can also be caused by eating insects. Some insects have chitin-based external body coverings that humans find difficult to digest.

### Conclusion

As the global human population grows, so does the demand for animal protein. However, due to food shortages in some parts of the world and increased environmental pressure, the consumption of edible insects as a human food source has emerged as a worldwide concern. Obtaining ecologically sustainable food security is one of the world's most pressing issues today. According to the evidence, entomophagy is extremely important in addressing food insecurity. High-quality protein, micronutrients, bioactive substances, and fibre can be obtained from edible insects. Edible insects are naturally rich in protein, fat, and micronutrients, and they may be able to meet the nutritional needs of the body. When compared to other protein sources, edible insects have an estimated energy content of 400-500 kcal per 100 g of dry matter and edible insects also have a higher economic value. However, there is still concern that eating edible insects could endanger one's wellbeing and security. To improve one's wellbeing and safety, food safety and development should work together. Suitable rules and regulations should be

developed to address food safety concerns. Edible insects can supply high-quality protein, micronutrients, bioactive substances, and fibre. Edible insects are high in protein, fat, and micronutrients, and they may be able to meet the nutritional needs of the body. When compared to other protein sources, edible insects have a higher energy content of 400-500 kcal per 100 g of dry matter, and they also have a higher economic value. However, there is still concern that using edible insects may pose health and safety risks. To improve health and safety, development and food safety should work together. To address food safety concerns, proper rules and regulations should be developed.

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