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Edible insect : a food for future generation

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Abstract

The practice of eating insects has been recorded for a long time. With obvious economic and environmental benefits, edible insects have recently been in the limelight due to their great potential in multiple industries. The consumption of insects, is practiced by indigenous communities in different parts of the world. Entomophagy is considered one of the best ways to deal with the tremendous global pressure on animal protein. Entomophagy is believed to be able to quickly provide large numbers of multiple nutrients and provide solutions for combating famine. Great attention has been paid to the use and production of edible insects. Large-scale production and use of edible insects helps improve the environment, health, and livelihoods of those who consume them. However, legal approaches to culturing and producing edible insects.

Keywords: Edible insect, Entomophagy, consumption, Nutritional value, Food safety.

1. Introduction:

Nutrient requirements can be defined as the number of balanced nutrients an organism needs to perform repairs and important functions. People need many different nutrients like carbohydrates, fats, vitamins, minerals, proteins, fibers from different diets. Lack of important nutrients, especially proteins and important elements, weakens the structure of the body and makes it impossible to carry out daily tasks.

Malnutrition is even more prevalent in developed countries with poverty, social isolation and substance abuse. However, malnutrition in most adults is associated with illness and can occur due to the following causes: reduced food intake of macronutrients and micronutrients Increased loss or changed requirements increased energy expenditure (in certain illness processes). The nutritional value of edible insect varies greatly due to the large number of edible species, and also depends on the metamorphosis stage, habitat, and diet of insects. The amount of each nutrient required is called the nutrient requirement and varies from population to population.

Insects not only play an important role in the ecological processes of nature, but have also been part of human nutrition since ancient times. As populations continue to grow and demographics are distorted in most societies around the world, their role as nutritious foods is increasingly being advocated by researchers and policy makers around the world Insects are used in many parts of the world as potential sources of proteins, lipids, carbohydrates, and Consuming insects wisely and healthily has become a trendy solution to poverty. Edible insects are playing an important role in various food systems. In fact, they have been a vital source of essential nutrients in many developing regions. Many people are still under economic pressure and are therefore malnourished.

Insects are healthy, nutritious alternatives to mainstream staples such as chicken, pork, beef and even fish from ocean catch. Many insects are rich in protein and good fats and high in calcium, iron and zinc. Insects already form a traditional part of many regional

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and national diets. Insects promoted as food emit considerably fewer greenhouse gases than most livestock (methane, for instance, is produced by only a few insect groups, such as termites and cockroaches). Insect rearing is not necessarily a land-based activity and does not require land clearing to expand production. Feed is the major requirement for land.

The ammonia emissions associated with insect rearing are also far lower than those linked to conventional livestock, such as pigs. Because they are cold-blooded, insects are very efficient at converting feed into protein (crickets, for example, need 12 times less feed than cattle, four times less feed than sheep, and half as much feed as pigs and broiler chickens to produce the same amount of protein). Insects can be fed on organic waste streams. Insect harvesting/rearing is a low-tech, low-capital investment option that offers entry even to the poorest sections of society, such as women and the landless. Livelihood opportunities for both urban and rural people. Insect rearing can be low-tech or very sophisticated, depending on the level of investment. During the course of evolution, after the complex interplay of culture and religion took place, the omnivorous diet got sorted into the different current modern diets. Humans are taught to think about food beyond the nutritional quality it possesses. Accordingly, some food items are high protein content and quality superior to many protein sources, fatty acid. Besides, they are rich in dietary fiber in the form of chitin, which presents a host of other health. Primarily, insects are taken as foods because of the low cost. For wild resource-rich species, harvesting is almost free. For farming species, they usually feed on a wide range of cheap fodders with efficient energy transmission. Studies also states that eating insects would reduce the consumption of pesticides, especially the chemicals. Beyond being eaten to allay the hunger or just for pleasure, insect extracts can be used as a source of medicine, healthcare and industrial products (Liu & Wei 2002).

Evidence points to at least 113 countries where insects form or formed a part of human diets in one way or the other. This practice of consuming insects as part of the human diet is referred to as entomophagy (Evans et al., 2015). Over 3000 ethnic groups in mainly African, Asian, and Latin American countries eat insects as part of their normal diet (van Huis et al., 2013). They can be eaten at various life stages including eggs, nymphs, and adults, depending on the species and processing method (Ramos-Elorduy, 2009). Even though over two billion people eat insects, it is still met with great resistance by many Western consumers. Most have grown up viewing all insects as 'bugs', initiating feelings of disgust or fear (Looy et al., 2014; Tan et al., 2015; Yen, 2009). However, there has been an increasing interest in edible insects' due to the nutritional and sustainable benefits. In 2013, United Nations' Agriculture and Food Organisation released a detailed report (van Huis et al., 2013) on the potential of insects as food and feed. The commercial production and distribution of insects and insect products such as cricket flours, protein bars, and chips has increased over recent years in Western societies.

More than 2300 species of 18 orders have been reported as edible insects, of which 5 orders are with at least 100 records. These insects inhabit in both aquatic and terrestrial environments (Jongema 2017). The majority of them are harvested from nature though some species are farmed in a large scale. Insects are highly nutritious and healthy food source with high fat, protein, vitamin, fibre and mineral content. al. 2013).In India, a total of 255 species of edible insects are recorded so far and it is mostly practiced in North Eastern State of India however few tribes from Tamil Nadu, Karnataka, Kerala, Odisha, Madhya Pradesh and Indian Andaman Islands use termites, locusts, ants and bees as food. Many scientists and researchers have collected and documented more than 200 edible insects from North Eastern India and from Assam around 67 species of edible insects under 8 orders and 27 families are reported to be consumed (Thangjam et al, 2020). Study also concludes that Entomophagy is also a common practice among the ethnic peoples of Assam especially among the tribes of Dhemaji, Morigaon, Udalguri, Baksa and Karbi Anglong districts and are closely associated with their culture (Thangjam et al, 2020).In China, silk moth pupae have been edible for a long time and have been approved as a new food source by the Ministry of Health of the Republic of China (Zhu, 2004). This semi-domesticated silk moth pupa has been used by the indigenous peoples of India to prepare a variety of traditional tasty foods (Barman, 2011). Eating silk moth pupae can supplement your intake of vitamin B2. This may be important to prevent the serious effects of vitamin B2 deficiency (Kwon et al., 2012).

The insects traditionally consumed in Assam, India, the silk moth pupae, can supplement the nutritional needs of the population. This prevents the development of various malnutrition-related disorders (Mishra et al. 2003). Antherarea assamensis is a silk-producing moth belonging to the order Lepidoptera and

Saturniidae. The Muga culture, which originated in Assam, naturally produced gold threads, and the tribesmen used silk moth cocoons for their livelihoods. (Tikader et al.2013).

2. Why insects to be consumed

Consuming insects wisely and healthily has become a trendy solution to poverty. Edible insects are playing an important role in various food systems. In fact, they have been a vital source of essential nutrients in many developing regions. Many people are still under economic pressure and are therefore malnourished.

Insects are healthy, nutritious alternatives to mainstream staples such as chicken, pork, beef and even fish (from ocean catch).Many insects are rich in protein and good fats and high in calcium, iron and zinc. Insects already form a traditional part of many regional and national diets. Insects promoted as food emit considerably fewer greenhouse gases than most livestock (methane, for instance, is produced by only a few insect groups, such as termites and cockroaches). Insect rearing is not necessarily a land-based activity and does not require land clearing to expand production. Feed is the major requirement for land.

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Edible insects can diversify diets, improve livelihoods, contribute to food and nutrition security and have a lower ecological footprint as compared to other sources of protein. These potential benefits combined with a heightened interest in exploring alternative sources of food that are both nutritious and environmentally sustainable are spurring commercial production of insects as food and animal feed. Safety risks of eating insects highly depend on the insect species, the environment they are reared in or collected from, what they eat, and the production and processing methods used. A thorough assessment of food safety hazards will help to establish appropriate hygiene and manufacturing practices, which remain a challenges for the sector. Developing appropriate regulatory frameworks and encouraging close collaboration among stakeholders will facilitate establishing a multidisciplinary pathway for the sector to promote food safety.

The numerous advantages of insect consumption, the future of insect industry is unfavourable in Western societies (Sogari, 2015; van Huis, 2016), given that existing cultural distaste cannot be changed rapidly (De Foliart, 1999). Fortunately, the increased consumer knowledge about edible insects also increases the willingness to pay for insect food (Piha et al., 2018). Continuous promotional efforts to increase exposure, coupled with development to enhance taste and appearance (Looy et al., 2014; van Huis et al., 2013), has successfully improved the negative perceptions in some Western countries. For example, consumers in Belgium increasingly accept insects as an excellent food source (van Thielen et al., 2019). Furthermore, the insect industry in the Netherlands has been successfully marketed, and the freeze-dried insect powder is sold as a meat replacement (Raheem et al., 2018). To increase acceptance, social, practical, and contextual factors affecting food consumption must be emphasized to consumers (House, 2016). Such efforts involve continuous education and promotion regarding the potential for edible insects to solve environmental, population, and land-availability problems today and in the future.

3. Nutritional value of insects

Overall, insects have obvious advantages in nutritional value. Their nutritional compositions are actually quite similar to those of the traditional animal foods (Raubenheimer & Rothman 2013). They have enormous potential as a source of nutrients and active substances not only for human, but also for poultry. The nutritional value of edible insects is very diverse mainly because of the large number and variability of species. Nutritional values can vary considerably even within a group of insects depending on the stage of metamorphosis, origin of the insect and its diet (Morales-Ramos, 2014). Similarly the nutritional value changes according to the preparation and processing before consumption (drying, cooking, frying etc. (Van Huis et al 2013).According to Payne et al 2016, insect nutritional composition showed high diversity between species. The Nutrient Value Score of crickets, palm weevil larvae and mealworm was significantly healthier than in the case of beef and chicken and none of six tested insects were statistically less healthy than meat. Most edible insects provide sufficient energy and proteins intake in the human diet, as well as meeting the amino acid requirements. Insects also have a high content of mono- and polyunsaturated fatty acids .

Insects at all life stages are rich sources of animal protein. The body of some insects can reach almost 70% of protein content. The proportion of crude protein is generally from 40 to 75% based on dry weight basis, with the average values per order from 33 to 60%. Edible insects usually contain more crude protein compared with the conventional meat, though their amino acid compositions are usually analogous. As food, they can provide essential amino acids at an ideal level, which are generally 76 to 96% digestible (Ramos-Elorduy et a,1997). Apart from diverse amino acids contents, the fat content of insects in immature stages varies from 8 to 70% based on dry weight. The fatty acid compositions are similar in different sources of meat, including all groups of insects (Bukkens 1997). The fat contents of Lepidopteran and Heteropteran larvae are higher than that of other edible insects. Larvae are the best source of fatty acids or oil compared with insects at other stages. The adults are overall slim with a fat content less than 20%. The fat in insects is mainly triacylglycerol (Arrese & Soulages 2010).

Insects are great resources of vitamins and micronutrients though some studies pointed out these contents can be affected by feeding. They could provide biochemical substances such as vitamins A, B1–12, C, D, E, K, which are needed for normal growth and health (Kouøimská & Adámková 2016). For example, caterpillars are especially rich in B1, B2 and B6 (Rumpold & Schluter 2013). Bee brood (pupae) is rich in vitamins A and D (Finke 2005). Red palm weevil (Rhynchophorus ferrugineus) is a good source of vitamin E (Bukkens & Paoletti 2005). The contents of mineral elements in different insects all differ significantly. Most insects only contain a low amount of Calcium (less than 100 mg/g based on dry matter), but larvae of house flies and adults of melon bugs are typically abundant with it (Bukkens & Paoletti 2005).It is also found that most edible insects are however, particularly abundant with iron. The account that iron takes in insects is usually higher than that in fresh beef (Rumpold & Schluter 2013).

According to different experts, the consumption of insects could be a good solution to relieve children's undernourishment due to their high content on fatty acids. Moreover, according to the Entomological Society of the United States, termites, caterpillars, grasshoppers, flies, spiders and weevils are richer protein sources than other domestic animals.

About 1 of 2 pregnant women and almost 40% of preschool children in develop countries are believed to suffer from anaemia (lack of iron) as a consequence of a poor diet, which can drive them to develop problems in physical and cognitive development, to have an increased risk of morbidity in children and a reduced work productivity in adults. Insects contain a great amount of different micronutrients, such as iron, copper, magnesium, phosphorus, manganese, selenium and zinc. Moreover, they are a great source of fiber as they have a lot of chitin, the main structural component of arthropods' cuticle. Chitin has a molecular structure similar to plants' cellulose and also has an important role on intestinal health.

Some insects (e.g., grasshoppers, crickets, termites, and mealworms) are rich in iron, zinc, calcium, copper, phosphorus, magnesium, and manganese. Invertebrates without a mineralized skeleton have very little calcium content (de Castro et al., 2018; Mlcek et al., 2014). Most edible insects have similar iron content to beef (Bukkens, 1997), but we currently know little about mineral bioavailability of insects (de Castro et al., 2018). A rare study found that consuming insects can provide the high proportions of daily mineral recommendations for humans, particularly in terms of iron (Latunde-Dada et al., 2016). The investigations of vitamin content are also insufficient, but available data indicate that edible insects contain carotene, vitamin B_1, B_2, B_6, C, D, E, and K (Mlcek et al., 2014).

Silkworm (*Antheraea assamensis)* rich in protein, is a promising edible insect species for food application with extra benefits to the environment. The need to consumption globally is paramount, as there is high demand on the already scarce protein sources available worldwide. Approximate nutritional content of edible insects have been summarized in Table1.

Table 1: Nutritional composition of edible insect.

species	Protein (%)	Fat (%)	Fiber (%)	Calcium(mg/kg)	Phosphorus(mg/kg)
silkworm	9.3	1.1	1.1	177	2370
cricket	15.4	3.3	2.2	275	2520
Mealworm	18.7	13.4	2.5	169	2950
Fruit flies	21.0	5.9	2.2	526	4080
waxworm	14.1	24.9	1.4	243	1950

Information about silkworm. Silkworm pupae can be eaten raw or in processed form (roasted, toasted, fried, boiled, etc). Their nutritional composition normally depends on silkworm types. Typically silkworm pupae are regarded as highly nutritious foods that are an excellent source of energy, fats, proteins and amino acids. Mishra *et al.* (2003) reported that, overall consumption was highest for Eri (87.7%) followed by Muga (57.4%) and mulberry silkworm pupae (24.6%) irrespective of age group and gender. Amongst the three major communities predominant in the villages,the highest consumption was in the Ahom community (Eri 91% and Muga 63%). In conclusion these unconventional food items with high cultural acceptability and nutritive value may be utilized in formulating potential alternate recipe for malnourished population as well as nutritious delicacy for others.

The proximate compositions (%) for non-mulberry and mulberry silkworm pupae were in the range of: total protein (12 to 16%), total fat (11 to 20%), carbohydrate (1.2 to1.8%), moisture (65 to 70%) and ash (0.8 to 1.4%) (Mishra *et al.* 2003). The silkworm pupae protein is boosted with high level of essential amino acids, namely methionine, valine, and phenylalanine. Silkworm pupae also contain diverse mineral compositions (mg/100 g) such as 102.31 mg calcium, 1826.59 mg potassium, 287.96 mg magnesium, 1369.94 mg phosphorus, 274.57 mg sodium, 9.54 mg iron, 17.75 mg zinc, 2.08 mg manganese and copper, and 0.08 mg selenium to c

4. Nutritional Status of muga silkworm Pupa

Muga pupa is a delicacy and dietary staple for many North-eastern tribes who eat muga silkworm in its pupal stage after formation of cocoons. Muga pupae are naked and suitable for human and animal consumption, either directly as a raw staple food or after processing such as roasting, fried food, baking and cooking with spices. In these cases, the pupae are used fresh and the cooked foods are perishable.

Silk cocoons are composed of fiber proteins (fibroins) and adhesive glue proteins (sericins),which provide physical barrier to protect the inside pupa. Moreover, other proteins were identified in the cocoon silk, many of which are immune related proteins. A total of 129 proteins were identified, 30 of which were annotated as protease inhibitors. Protease inhibitors accounted for 89.1% in abundance among extracted proteins. These protease inhibitors have many intramolecular disulfide bonds to maintain their stable structure, and remained active after being boiled (Guo et al., 2016)

The silkworm pupa would be a good source of the functional fatty acid, á-linolenic acid and the functional pigments, lutein and neoxanthin (Tomotake *et al.*2010). The silkworm pupae possessed n-3 fatty acids, especially á-linolenic acid (36.3%), as a major component (Longvah *et al.*, 2011). Winitchai *et al.* (2011) studied that, the pupae oil obtained from Soxhlet extraction had unsaturated fatty acid content in the range 72-79% and alpha-linolenic acid content in the range 32-44%, whereas that obtained from the maceration extraction.

The pupal protein contained 18 known amino acids, including all of the essential amino acids and sulphur-containing amino acids (Jun Zhou et al., 2006). The pupal protein was of high quality due to its high content of essential amino acids. Longvah *et al.,(*2011) reported that, the amino acid scores of Eri pre pupae and pupae protein were 99 and 100 respectively, with leucine as the limiting amino acid in both cases. Net protein utilization (NPU) of pre pupae and pupae was 41 as compared to 62 in casein. Protein digestibility corrected amino acid score (PDCAAS) was 86.Suresh *et al.* (2012) reported that, the pupae of silkworm are an alternative source of chitin which consequently yields chitosan. Among the different races of mulberry silkworm, multivoltine pure races contain higher chitin of 3.225 percent in male pupae and 3.078 per cent in female pupae. Similarly higher chitosan per cent was observed in male 2.449 per cent and 2.354 per cent in female pupae. Priyadarshini and Revanasiddaiah (2013) estimated the crude and purified protein percentage from de-oiled pupae powder at the different hours (0 hours, 72 hours, 144 hours, and 216 hours) of pupae development of Eri silkworm. It was found that crude protein and protein concentrate was gradually increased from 0 hours to 216 hours both in male and female pupae. However, female pupae exhibited 45.1g of protein concentrate at 216 hours of development when compared to male pupae .

5. Conflict of interest

The author declares that there is no conflict of interest.

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