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A review on entomophagy: Natural food insects for ethnic and tribal communities of North-East India

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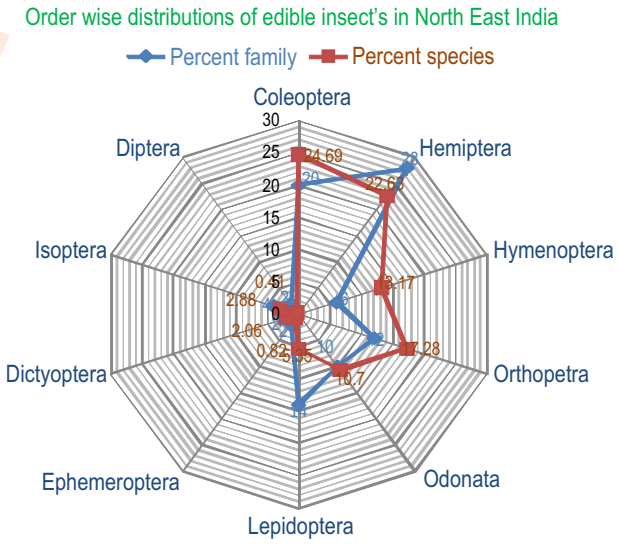
Abstract

Entomophagy insects are local food/ feed in most parts of the North Malay Archipelago. These insects are a standard natural resource that provides food and economical safety to most ethnic groups of Eastern Himalayas. Entomophagy not only supports the nutritional food security, but also provides the family livelihood to the tribal populations during difficult times of the year. Since, edible insects are great source of supplemental food item that would meet the people's present and future need, they're preferred by tribal communities as eggs, nymphs, larvae, pupa and adults insects, and eaten as fried, cooked, roasted or are even consumed as raw repeatedly.

In India, a complete of 245 species, 50 families and 10 orders of edible insects have been recorded so far as food and it's mostly practiced in eight North Eastern States of India. Among the edible species of insects, biggest consumption is of coleopteran species with 24.69%, followed by Hemiptera (22.63%), Orthoptera (17.28%), Hymanoptera (13.17%), Odonata (10.70%), Lepidoptera (5.35%), Isoptera (2.88%), Dictyoptera (2.06%) and therefore the least were Diptera (0.41%) and Ephimeroptera (0.82%). Study of edible insect in India evolved the uncharted natural resources of north-east region and medicinal, traditional beliefs of tribal people. This review paper discuss about the common edible insects consumed by different ethnic and tribal communities in North-east India.



Key words: Edible insects, Entomophagy, North Malay Archipelago, Tribal communities

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Introduction

The existence of insect ways back to 400 million years which makes them among the oldest land animals. They diverged members of largest phylum Arthropoda that are 390 million years ago a rapid evolution and radiation that's considered faster than the other organisms. Silk worm (*Bombyx mori*) larvae consumed by the Chinese are one among the historic evidences of edible insects. But edible insects scientifically gained attention only after Holt (1885) attempted to contradict the western chauvinism against consuming insects. Berensberg (1907) augmented the contribution of edible insect as food for human being in past as well as future time. In 1942, Bodenheimer reported the benefits of consuming insects for the environment also as well as human. Meyer-Rochow (1973) studied the edible insects utilized in Papua New Guinea and utilization of those edible insect species for food purpose. In 1997, Ramos Elorduy started the work to spot and make record of the edible insects consumed in Mexico. Wilsanand *et al.* (2007) reported detailed description of six insect species utilized in traditional therapeutics and their products for treating over 15 kinds of ailments in Kerala state.

Correspondingly in North-east India a study on entomophagy by indigenous tribe of Dhemaji district in Assam identified fourteen species of edible insects that were used as food and among them four species were consumed as medicine. Chakravorty *et al.* (2013) analyzed the nutritional and anti-nutritional compositions of two species *Oecophylla smaragdina* and *Odontotermes* sp. consumed in Arunachal Pradesh. Recently, off 30 edible insects consumed by the tribals of Assam has been reported consumed maximum number of species (10) falls under the order Orthoptera, followed by Hymenoptera (6), Coleoptera (5) then Hemipterans (3), Lepidoptera (2) species (1) species each of Odonota, Mantodea, Blattollidea and Isopteran, respectively (Das, 2019; Thangjam *et al.,* 2020). The aim of this review is to emphasis on work to seem at the status of entomophagy in North-east India, diversity of edible insects and nutritive value with their cultural values along indigenous knowledge. The edible insects have potential source of income generation for poor rural peoples of North-east India and it's besides that major role in nutrition and therapeutic values. Increased emphasis of edible insects would also contribute towards conservation of threatened biodiversity of insects.

Definition of Entomophagy: Entomophagy is defined as the practice of eating edible insects by human as a food and springs from two Greek words "entomon" means "insect" and "phagein" means "to eat". The people of North-east India consider edible insects as delicious and nutritious food rich in protein, fat, vitamins and minerals. They are also used for therapeutic purposes for example; the formic acid of red tree ants (*Oecophylla smargdina*) is utilized in for treating scabies, malaria, tooth aches, stomach disorders, sign anomalies etc. (Doley and Kalita, 2012).

Why eating insects is useful?: Insects are nutritious, delicious and easily available within the wild. They are as well as easy to collect or harvest, manageable. Some edible insects are often domesticated and require small area for rearing. They are often reared in urban environments and not necessity of land-basedactivity for production. They often produce at organic kitchen waste. They require less water for survival of life. They emit less greenhouse gases (GHGs) than the foremost livestock.

Status of Entomophagy: North-east region of India comprise of eight states: namely, Assam, Manipur, Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim. The North-east region is bordered Myanmar, Bhutan, Tibet-China and Bangladesh on the north-south and east side except the west side area which is connected to West Bengal and remaining parts of India. North-east region of India is hot spot for insect biodiversity covering 262,179 sq km area of other countries. This area comprise largely of hills and accents 7 per cent land of India. Only river valley of Brahmaputra in Assam and a little part of Manipur are the plains area in NEH region. This region is homeland for many tribal population.

The region has about 220 ethnic tribal communities where 78 communities have a population of 5000. It constitutes around 12 per cent of the total tribal population of India and 25.81 per cent population of North-east India. According to FAO (2020), by 2050 the world's population will reach 9.1 billion, 34 percent higher than today. Urbanization will continue and reached about 70 percent of the world's population will be urban (compared to 49 percent today). In order to feed this larger, more urban and richer population, food production must increase by 70 percent. Annual cereal production will need to rise to about 3 billion tonnes from 2.1 billion today and annual meat production will need to rise by over 200 million tonnes to reach 470 million tonnes. Since India is assured under the Food Security Act (2013), it clearly states that everybody should get good nutritious food in sufficient quantity and quality for the entire year. However, it's jeopardized by the ever-increasing human population which causes imbalance between food production and nutrition (Paul *et al.,* 2018). Consistent with Swaminathan and Bhavani (2013), the present population of India, 1.2 billion would reach 1.8 billion by 2050 India. To feed the increasing population of India, there should be an increase in land, water, inputs and other natural resources. But it's seems to be impossible as evident from various reports the food production is fluctuating every year due to global climate change, unusual seasonal distribution and sometimes due to scanty rains.

Despite this fact, India stands atop within the production of fruits, vegetables and milk, but per capita availability of those products is below the family need. Under such circumstances, proteinaceous and nutritive food through alternative sources of food is being searched. Hence, an urgent requirement to research on protein sources like insects which have great potential for contribute the global food security has arisen. During this connection, edible insects appear as promising and a possible option because they are an upscale source of antioxidant, rich protein, minerals and vitamins (Van Huis, 2013;

Singh *et al.,* 2013). In many countries, except for Europe and North America, insects forms a major part of the diet and also considered a delicacy (FAO, 2013) and is in practice since ages. FAO (2013) estimated that 1900 insect species are approximately by 2 billion people globally. The mostly consumed edible insects worldwide belong to order Coleoptera 31%, Lepidoptera 18%, Hymenoptera 14%, Orthoptera 13%, Hemiptera 10% and three percent each of Isoptera, Odonata and Diptera. Entomophagy is predominantly practiced in Asia, Africa, Australia and Latin America. India is a tropical country that has more diversity and abundance of edible insect species. Varshney (1997) reported that 589 families and 51450 insect species are found in India. In another estimate by Alfred *et al.* (1998), 59353 species belonging to 619 family's have been reported from India. Therefore, India has potential insect bio-resource to be utilized for future food consumption, thus, helping the still existing entomophagy in our country and to revive some entomophagic practices need to be seen as actions benefiting the state as an entire (Chakravorty *et al.,* 2013).

In all 255 edible insects species have been recorded so far and entomophagy is practiced in North-eastern state of India, while few tribes from Tamil Nadu, Karnataka, Kerala, Odisha, Madhya Pradesh and Indian Andaman Islands consume termites, locusts, ants and bees as food (Yesadharan *et al.,* 2011; Thangjam and Kadam, 2020; Loganathan and Haldhar, 2020). The North Malay Archipelago is native to several traditionally living indigenous tribes and communities are in close proximity with nature. Consumption of edible insects as food/ feed is common among tribal people of North-east India. The food prepared traditionally by tribal people is connected to their social culture for all times and health. The region generally practices consumption of edible insects and it's also a neighbourhood of their culture since time immemorial. For instance, the Mishings and Ahom tribe communities of Assam consume red ants (*Oecophylla smargdina*) as food items during Assamese Festival "Bohag Bihu" in April month (Doley and Kalita, 2012). The farmers of Majuli Island on the Brahmaputra River of Assam have managed the beetles, *Lepidiota mausuet* by using as edible food. Majuli area has been severely infested by beetle; *Lepidiota mausuet* locally referred to as the hati-puk, since 2005 and it has taken a severe toll on agriculture. *Lepidiota mausuet* is found in such large numbers only in Majuli area could also be due to soil structure and availability of water (Bhattacharyya *et al*. 2015). However, now people don't need to control beetle, as they have developed delicious beetle dishes, which had gained immense popularity among the people. Bhattacharyya *et al.* () are popularizing the beetle dish with the slogan "Eat it before it eats your crops". It was found that beetle is rich in protein and carbohydrates and has no toxic content and might be nutritious food for humans and poultry.

Diversity of Entomophagy: Out of all the species on earth, 73.5% are invertebrates and most of these, are arthropods organisms. Insects are the most dominant of all the arthropods in terms of survival and adapting to their environmental and Insects exist upto 80% of all living organism. More than 7000 species are described as new species per annum. Dominance of insects in the animal world owes to their survival survive and adaption to different habitats, high reproductive potential, quality to consume different sorts of food and thus the power to defence their enemies (Kumar, 2001). North-east India eight sister states namely Assam, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Nagaland, Tripura and Sikkim. The geographical area of this region lies between 20o50'-29o30' N latitude and 89o49'–97o30' E longitude. The use of edible insects as food is common to all or any ethnic people of North-east India mainly by tribes of Arunachal Pradesh, Assam, Manipur and Nagaland. Studies have revealed that almost 245 insect species, 50 families and 10 orders are used as food by different tribes of North-east India (Fig. 1). Among these, the massive per cent consumption of edible insect families belong to Hemiptera (28%) followed by Coleoptera (20%), Lepidoptera (14%), Orthoptera (12%), Odonata (10%), Hymenoptera (06 %), Isoptera (4%), Ephemeroptera (02%), Dictyoptera (02%) and Diptera (02%). The highest percent consumption of edible insect species belong to order Coleoptera (24.69%) followed by Hemiptera (22.63%), Orthoptera (17.28%), Hymenoptera (13.17 %), Odonata (10.70%), Lepidoptera (5.35%), Isoptera (2.88%), Dictyoptera (2.06%), Ephemeroptera (0.82%), and Diptera (0.41%).

The utmost highest biodiversity were found of Coleoptera (60 species) and Hemiptera (55 species) and lowest biodiversity of species was found so as Diptera (01 species) and Ephemeroptera (02 species) (Thangjam and Kadam, 2020; Loganathan and Haldhar, 2020). Pentatomid bug (*O. montana*) was first identified as edible food species by Sachan *et al.* (1987) as a delicious food for inhabitant Mizo Hills in North-east India. Meyer-Rochow and Chakarvorty (2013) studied and identified vernacular names of a minimum of 42 species of insects used as edible food by Ao-Nagas in Nagaland which include Orthoptera (11 species), each of Coleoptera and Lepidoptera (9 species), Hemiptera (8 species) and remaining insect orders Mantodea and Odonata. He also studied 60 edible species and identified some food insects Meiteis of Manipur and Khasi of Meghalaya tribes and reported that Arunachal tribes consume large number of Orthopterans insects as compared to other insect-consuming tribes of India.

Nyishi and Galo tribes of Arunachal consume about 102 species of insects (Chakravorty *et al.,* 2013). Out of 102 species, 40 belonged to the order Coleoptera; 26 Orthoptera; 12 Hymenoptera; 8 Hemiptera; 5 Homoptera; 3 Ephemeroptera; 4 Odonata; 2 Plecoptera; 3 Dictyoptera; 2 Isoptera; `and 3 Diptera. Thakur and Firake (2012) reported that the cinnamon bug, *Ochrophora (Udanga) montona* is fried in oil and consumed in Assam, Mizoram Manipur and Tripura. Forty different species of insects are consumed by ethnic tribes of Karbi, Anglong and Dhemaji district of Assam and the most common among them are 5 different sorts of silkworms pupae and thus the tribe, Karbis, Rengma and Nagas are found to be the absolute best number of insect (32 insect species) consumers (Doley and Kalita, 2012).

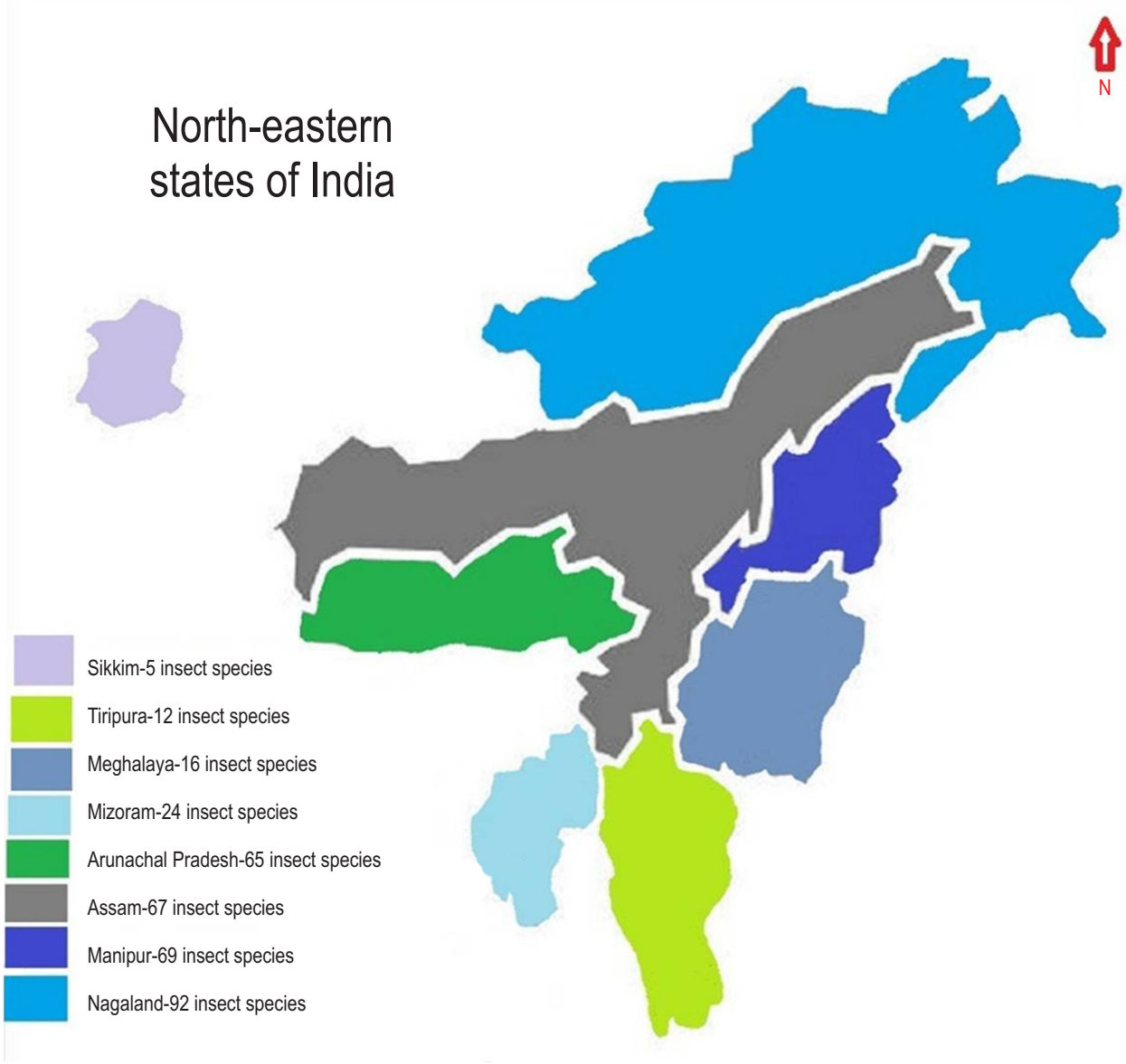

Fig. 1: Consumption of edible insect species in different states of North-east India.

In Manipur, 41 edible insect species belonging to eight orders under 24 families and 36 genera have been identified as edible by humans. Hemiptera has the highest number of edible species (10) and and lowest one species of each Dictyoptera and Isoptera order. Meitei, Tarao, Tangkhul, Chothe and Thadou tribes consume a far better number of insect species (28-30) as compared to other ethnic groups in Manipur (Shantibala *et al.,* 2012; Singh *et al.,* 2013). In another worked of consolidated edible insects utilized eastern part of Arunachal Pradesh by Wancho and Nocte tribes of the Tirap district and Shingpo, Tangsa, Deori and Chakma of Changlang district were reported.. A minimum of 51 insect species belonging to 9 orders were considered as edible food for people.

The very best number of edible species belonging to Coleoptera (14), followed by each of 10 species of Orthoptera and Hymenoptera, 9 of the Hemiptera, 3 Lepidoptera, 2 Isoptera and one each of Ephemeroptera, Odonata and Mantodea (Meyer-Rokhow and Chakarvorty, 2013). In North-east states, various tribes Angami, Ao, Chakhesang, Khiamnuingan, Konyak, Lotha and Sumi of Nagaland have been reported to consume of 92 different species of edible insect belonging to nine orders and 29 families (Pongener *et al.,* 2019; Loganathan and Haldhar, 2020). In Manipur, the tribes Meitei, Tarao, Tangkhul, Chothe and Thadou consume higher number of edible insect species about 69 species belong to 29 families and 9 orders (Shantibala *et al.,* 2012; Singh *et al.,* 2013). In Assam, the tribes of Dhemaji,

Morigaon, Udalguri, Baksa and Karbi Anglong districts consumed around 67 species of edible insects that comes under 8 orders and 27 families (Doley and Kalita, 2012; Rahman *et al.,* 2018; Thangjam and Kadam, 2020). In Arunachal Pradesh, the ethnic tribes of Nyishi of East Kameng, the Galo of West Siang, Adi tribe of East Siang, Wangcho (Wancho) and Nocte of Tirap district, and therefore tribes of Shingpo, Tangsa, Deori and Chakma of Changlang district consume about 65 species of edible insects belonging to 9 orders and 24 families (Chakravorty *et al.,* 2013; Singh *et al.,* 2013). However, due to the influence of Western culture in new generations, consuming edible insects are considered disgust and primitive nature. The practice of entomophagy is fading day by day in NEH region and thus there's need to conserve the practice of entomophagy and also popularize insect farming, their conservation and marketing facilities during this region for future food security.

Entomophagy as Food Industries: The value of edible insects has increased rapidly because the Food and Agriculture Organization (FAO) has started promoting insects as viable dietary alternative (Van Huis, 2013). Globally by 2023, the edible insect as foodstuff market is predicted to exceed up to USD 522 million (Han *et al.,* 2017). Since 2012, the edible insect as food market has made major progress with government support and successful research endeavors in Korea. However, lingering negative perceptions of edible insects hamper global market expansion and limit insects as a mainstream dining option, which may be related to the actual fact that people are skeptical to novel foods due to general neophobic tendencies (Dobermann *et al.,* 2017). Such attitude is one of the challenges faced by edible insect food industry. Fortunately, the positive sign of social perception of novel foods may cause its consumption as consumer attitudes are driven multiple factors (food-choice motives) beyond neophobia (Van Thielen *et al.,* 2019). Thus, promoting edible insects as food should emphasize their practical value, which can create consumer demand in future. Adding edible insects as food in already human foods may more acceptable for an insect phobic culture than providing insects directly as food option and benefited to formation of more sustainable business models (Han *et al*., 2017).

The main hurdle in edible insect as food industry is shortage of systematic research on the supply quality, safety and shelf-life of insects. (Van Huis, 2013). Insect farming also requires good standardization method and control that needs government legislation involved and final product regulations (Han *et al.,* 2017). Another advantage of these edible insect is that they are used as part of natural neighbourhood animal feed diets. Insect mixed with animal feeds are particularly for worth of feeds and reduced the about 70% of livestock production expenses through insect feed (Van Huis, 2013). The foremost promising and widely studied insects for industrial feed production are black soldier flies, larvae, pupae, adults, yellow mealworms, silkworms, grasshoppers and termites (Dobermann *et al.,* 2017). In comparison to commercial corn or soyabean based diets, the housefly larvae based diet significantly increases the carcass weight, total feed intake and also daily gain weight of broiler chickens. However, study found that replacing soybean oil with black soldier fly larvae meals has no effect on the expansion performance of broilers. Many smallholder farms in Asia and Africa use insects as fish feed for continues year (Dobermann *et al.,* 2017). Replacing fish meal with black soldier fly meal in diets doesn't affect the odor, flavor, or texture of fish. Likewise, mealworms can successfully replace 40 to 80 percent of the standard catfish diet without adversity growth development (Roncarati *et al.,* 2015). Edible insects are consumed curry, roasted, fried, raw and chutney. Depending on the type of insects and form of consumption; these are made with or without ingredients like spices and oil. Hard body edible insects are eaten roasted or as fried food but soft covering body edible insects are eaten raw or as curry.

The art preparing insects cuisine is typically tradition which are passed on from generation to generation. Honeybees, pentatomid bugs, ants and termites consumed both in raw and roasted form by trible people. Interviews and feedback from tribals reveal that they have various ways to enhance the taste of edible insect dishes. Many spices and herbs like garlic, pepper, chili and salt are added to increase the taste and flavour of insect food stuff. After removing the wings of Acridids grasshoppers are fried in oil and are simply eaten with salt. The edible insects can also be stuffed in a bamboo pipe and smoked dry for 3-4 days mixed with pepper and salt and eventually added to rice meals. Longhorned grasshoppers (Tettigonidae) are collected in less numbers due to their solitary habits and are roasted in oil after removing their wings. It is usually fed to children or old people as they have more antioxidant and nutritive values. Crickets and mole crickets are harvested during summer at night from May to July. Yet, the foremost value of Orthopteran grasshoppers as edible food insects in the Galo area are grasshopper, *Schizodactylus monstrosus* (Schizodactylidae). Freshly harvested *S. monstrosus* are put inside a bamboo pipe and dried and smoked for about one week. The dried material is then crushed into a fine powder and mixed with pepper, salt, turmeric and bamboo shoots to form a special kind of chutney.

This chutney is eaten with rice or with a local drink (a fermented rice beer) referred to as Apung and is most delicious by all the members of tribe considered, regardless of age and sex. Pentatomid bug, *Aspongopus nepalensis* and other species of bug collected from river banks are highly utilized as chutney. After discarding wings of adult termites, they're consumed either roasted or dry fried by the local tribes (Chakravorty *et al.,* 2013). Rajan (1987) reported that in Tamil Nadu, the winged termites are harvested and sold to the merchants in the market by many forest tribes. Termites are fried along with groundnut and Bengal gram (pulse), puffed rice and salt are added to it. The fried pulses, spices and salt enhance the taste of food and are eaten in rural villages of Southern India. Most of Odonates are eaten nymph stage but Lepidoptera are eaten at larval and pupal stages. In Hymenoptera order, the eggs also are eaten along with other stages of insects (Shantibala *et al.,* 2012).

Nutritive and medicative features of entomophagy: Insects as biological resources has not yet bean utilized all around the world. Edible insects as an appropriate source of nutrition for humans has already been proved through various studies in most of the continents. 'Medicine Is Food and Food Is Medicine' likewise edible insects are natural inexhaustible resource of food with nutritional, economical, medicinal and ecological benefits to tribal people. Edible insects have higher protein content with digestibility and a couple of minerals, vitamins, fats and carbohydrates to make a superb food. Insects are the foremost cost effective source of protein as compared to animal meat and fish (De Foliart, 1997). Insects used in traditional medicine to treat many diseases of citizenry and animals like common fever, hemorrhage, epilepsy, scabies, violent headaches, bronchitis and bite. Insects also are used for treating wound to prevent gangrene and to extend milk flow in lactating women (Tango, 1994). On dry weight basis, the crude protein contents of varied edible insects from Mexico and Central African Republic, exceeded 80 per cent and ranged high upto 82 percent with digestible protein higher upto 64 per cent. Insects are rich source of minerals as most of the edible insects have high proportion of Ca, K, Fe and Mg (Ramos-Elorduy, 2008).

The chemicals evoked from edible insects are important for self-defence and are also being exploited by many scientists for preparing anticancer drugs and antibacterial diseases. For instance, pierisin protein purified from pupa of pierid butterfly and its cytotoxic effects against human gastric cancer disease. Cecropin is reported to have cytotoxic effect against mammalian lymphoma and leukemia cells. The nutritive value offered by insects is an attraction for nutritionists doctors and physicians (Xiaoming *et al.,* 2010). Carboxylic acid composition of some edible dung beetles in Thailand was analyzed by Bophimai and Siri (2010). The fat, fibre, sodium and potassium content was high in stink bug, *A. nepalensis* and calcium and magnesium content were comparatively high in *C. servilla* larvae. Eri silkworm pupae contained 16% protein, 8% fat, 24 mg Ca, 175 mg P, 54 g Mg, 2.1 g Zn, 7 g Fe, 0.69 mg Mn and 0.45 ug per 100 grams Cu. In case of termites, the sexual forms were found to have 87.3% protein, 2.7% carbohydrates and 6.7% aminoalkanoic acids, whereas the workers had 81.6% protein, 1.2% carbohydrates and 4.6%, aminoalkanoic acids, respectively (Paul and Dey, 2011).

Further, high content of protein (75%) and total essential amino acids (44%) in defatted Eri silkworm meal is used for preparing protein concentrates. Complete nutritional analysis of four species of edible insects was described by Thakur and Firake (2012). The nutritive value of five insects were studied that the highest protein content was noted in dragon fly, *Crocothermis servilla* larva 70.48 followed by acridid, *Oxyahyla hyla* adult having 64.67%, surface grasshopper, *Oedaleus abruptus* adult content 60 percent and eri silkworm, *Samia ricini* pupa content 71.9 percent (Longvah *et al.,* 2011; Shantibala *et al.,* 2012). In India, the eggs, larvae, nymphs, pupae and adult insects are consumed at different level because its vast difference within the content of nutrients as per insect development period. Tom *et al.* (2013) reported the nutritional constituents of untamed silk moth in Sudan. The insect, *Cirina forda* was nutritionally studied for proximate, amino acid, carboxylic acid and mineral compositions and its determine the protein and lipid contents of 31.40 ± 0.3 and 16.12 ± 1.1 (% dry weight), respectively. Nutritional value of *Rhynchophorus palmarum* larva was analyzed by Gbogouri *et al.* (2013). The composition of unsaturated omega-3 and 6 fatty acids in mealworms is comparable to fish (higher than cattle and pigs) and thus the protein, vitamin and mineral content of mealworms is analogous to fish and meat. Insects have high feed conversion ratios (FCRs) and emit low concentration of green-house gases. Insects are often used rather than fish meal and fish oil in animal diet. Insects have better calorific value than meats, maize, soybeans, lentils, or other legumes.

The data show that insects have 50% higher caloric value than soybeans, 87% higher than corn, 70% above fish, lentils and beans and 95% higher values than wheat and rye, respectively. Proteins content is varied in different insects like caterpillars contain 50-60g $100g^{-1}$ dry weight, the palm weevil grubs contain 23-36g, Orthopterans contain 41-91g and ants contain 7-25g. Proteins were found to rich in essential amino acids with a high protein score ranging between 90% to 172% and 52.4% of unsaturated fatty acids with linoleic and linolenic acids. The nutritional value of edible insects of North-east India was reported to posses high level of protein (Shantibala *et al.,* 2012). Chakravorty *et al.* (2013) recommended edible insects as human food in North-east India and reported that *B. orientalis* adults contained palmitoleic acid (20–26%), linoleic acid (36–40%), stearic acid (9–32%), palmitic acid (50%), vitamin B12 and minerals (Fe, Zn, Cu). Consumption of crickets, termites, grasshoppers and caterpillars showed high energy value. Protein content was significantly higher than animal foods like, chicken, pork, eggs, beef or lamb (Gahukar, 2016). Sangavi and Sarath (2017) found low fat (2%) but amino acids (57%) and protein (72%) content in mulberry silkworm, *B. mori* pupa powder and unsaturated fatty acids (75%), essential linoleic acid (33%) and alpha-linoleic acid (35%) in oil extracted from pupae. *B. mori* pupae contained protein (55.6%), fat (32.2%) and high levels of essential amino acids like valine, methionine and phenylalanine.

Healthy nutrition for human being are increasing the cost of animal proteins-rich food and demand is increasing in future for protein-rich food in developing country as India so that alternate sources of protein rich food are highly needed like edible insects. Research data has shown that edible insects are excellent source of proteins, antioxident and other nutrients. Hence, insects as food could be help to revolutionaries' food and feed security and this might be replacing the normal animal food sources. This review paper may help in assessing the potential of edible insects as food for humans and gather existing information and research on edible insects. Globally, 2000 species of insects are consumed by local people on daily basis. It was important to generate awareness about insect food to rural people. In future we may get some more new insects which may be used as food and also used as

medicine for various diseases. Molecular work about insect nutrition and medicinal properties of insects also enhance the Entomophagy culture in future.

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Add-on Information

Authors' contribution: S.M. Haldhar: Conceptualization, Data curation, Formal analysis, Writing - original draft; **R. Thangjam, V. Kadam, K. Rolania, S. Singh, S.R. Dhaka:** Writing - review and editing; **B.L. Jakhar:** Made the figures; **R. Loganathan:** Data curation; **K.I. Singh, K.M. Singh:** Supervision, Writing - review and editing.

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