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Nutritional and Therapeutic Benefits of Edible Insects and Molluscs as an Alternative Food Source among Major Tribes in Assam: Review

Sangeeta Gogoi[1] & Gitalee Bhuyan[1]
Department of Zoology, Madhabdev University, Narayanpur, Lakhimpur, 784164, Assam

Corresponding Author: **Sangeeta Gogoi**

Abstract: After the population growth rate increases tremendously, alternative food sources are receiving much attention in this regard. Edible insects and edible freshwater mollusca species are accepted to be the best alternative food among the different tribal communities since time immemorial. They are revealed to be rich in different nutrient composition which can benefited the mankind to get nutritious food to a great extent in India. They also plays significant role in treating different deadly diseases like cancer, stroke, myocardial infarction, inflammation and many other. Edible insects of northeastern region have been reported to be rich in different bioactive compounds and are having antioxidants properties because of which they play an essential role in preventing deadly diseases. Several species of Mollusca are considered as highly nutritive and a good alternative source of proteins, vitamins and minerals. Thus, it can be represented that the edible insect species and molluscs present in this region to be the most preferred and the cheapest source of nutrients i.e carbohydrate, lipid and minerals. It is pretty clear that these two cheapest alternative food sources are available in northeastern region and have the ability to combat against malnutrition and under nourishment to a great extent.

Keywords: edible insects, freshwater molluscs, nutritional, tribal communities

Introduction

In the 19th century the world population has crossed the threshold limit by entering into the billions house for the species Homo sapiens sapiens (Linnaeus, 1758). After that the population growth rate increases tremendously and reached upto 8.2 billion in the mid 2024 (World population prospects, 2024) and it has been suggested by several projections that it will reach upto 9 billion by 2050 (Grafton et al., 2015). The rapidly increasing global population is escalating the demand for food, but the productivity is severely hampered by the impacts of climate change, industrialization, urbanization and diminishes the areas for food production. Therefore, alternative food sources are receiving much attention in this regard. Edible insects and different species of Molluscs are accepted to be

the best alternative food since time immemorial (Patel et al., 2019 and Das, 2020). They are revealed to be rich in different nutrient composition which can be benefited the mankind to get nutritious food to a great extent (Zelinska et al., 2018). Varied insects species belonging to different families, used as a food source worldwide for having high nutritive values. This dietary consumption of insects is termed as Entomophagy. A study revealed that 2205 species of insects are consumed globally by 128 countries where Asia is regarded to be one of the edible insects rich continent having 932 species and India to be the third edible insect rich country for having 262 species (Omuse et al., 2024). In today's world, the term zootherapy is regarded to be the best alternative therapies known to be practiced worldwide in which animals or their derived products are used for the treatment of different human ailments (Wilsanand et al., 2007).

People from different communities of North-east India accept insects to be the part of their diet and considered as delicacy. It is regarded to be a part of their culture since early days. Different tribal communities of Assam majorly Mising, Bodo, Rabha uses wide variety of insects as part of their nutrition and depicted as a viable dietary option. Edible insects were depicted to have the ability to compensate nutrient deficiencies in animal such as proteins, carbohydrates, fats and minerals (Li et al., 2023). Edible insects also play a significant role in treating different deadly diseases like cancer, stroke, myocardial infarction, inflammation and many others ailments as they have been repoted to be rich in antioxidants because of which they plays an essential role in preventing these diseases (Dhar et al., 2024). The eri silkworm is reported to have highest antioxidant properties as compared to red weaver ant, honey bee, muga silkworm and termites (Sailo et al., 2020).

In addition to entomophagy, malacophagy is also popular among the different tribal communities of Assam. Several species of Mollusca are considered as highly nutritive and a good alternative source of proteins, vitamins and minerals. Gastropods and Bivalve are regarded as the important food source for human which have abundant amount of proteins, fats, carbohydrates, when measured on a dry basis. Historically, mollusca have been used for consumption by different tribal communities of North-east India (Jadhav et al., 2020). Jadhav et al, 2023 reported that a total of 23 markets in Assam, Meghalaya, Mizoram, Manipur, Nagaland Tripura and West Bengal found to sold large quantities of Molluscs. Among the Northeastern states, Mizoram (7 species) and Meghalaya (6 species) found to sold highest number of Molluscs. The study also yielded 18 species of freshwater mollusca (16 gastropods and two bivalves) belonging to 5 families and 8 genera. Assam being a part of northeastern states is no doubt of having a great diversity of freshwater molluscs. Among the major tribal communities of Assam such as Bodo, Mising, Rabha, snail is one of the common meal. In the Goalpara region, snail meat is considered a traditional delicacy believed to possess healing properties that can cure numerous ailments, specifically around 18 health issues (Rabha et al., 2014a). Traditionally molluscs have been also used as an

ethnomedicine for treating different aspects like inflammatory conditions, can act as immune-modulator, anticoagulant anti-microbial agent, to treat cardiac disease, controlling blood pressure, rheumatism, to cure conjunctivitis (Ahmad et al., 2018; Jadav et al., 2023; Sonowal et al., 2021). Thus, the different variety of edible insect species belonging to the phylum Arthropoda (class-insecta) and some species of phylum Mollusca specifically freshwater playing a great role among different communities of Assam, India in terms of its nutritional as well as medicinal value. They have the potentiality to be as major global future food for human. Therefore, proper investigation about its distribution patterns, identification of sites, future conservation planning should be done. This review aims to study about the different species of edible insects and molluscs used by the three major communities of Assam as its alternative food.

Materials and methods

This review was conducted on different sources such as PubMed, Google Scholar, Science Direct etc. Different research papers were studied on edible insects and molluscs used by major tribes of Assam, India such as Mising, Bodo and Rabha, as an alternate food source. Papers with originality along with the depicted time restrictions i.e between 2000-2024 were chosen. Keywords such as edible insects, molluscs, therapeutic properties, tribes of Assam and nutritional analysis were used for the literature search. Studies were excluded if they were duplicates or lacked relevant data whereas regional as well as national and international level research and review papers were selected based on their relevance to the title. The articles were first thoroughly studied for duration of several weeks to ensure comprehensive understanding and to extract data and insights. Data were extracted from the included studies based on the pre-designed tables capturing details such as scientific names of edible insects and molluscs, family, their nutritional content, therapeutic properties and other key attributes. Thus, the data were extracted and synthesized to summarize the current evidence on nutritional and therapeutic properties of edible insects and molluscs.

Result and Discussion

Insects as food among Mising folk

Mising also called Miri is one of the major community of Assam and it is regarded as the second largest group of scheduled tribe (plain) of northeast India (Chungkrang et al., 2016). Mising community are known to be the riverine tribe of Assam (Pegu and Gogoi, 2021) and are found in riverine areas of different districts of Assam like Lakhimpur, Dhemaji, Sonitpur, Sibsagar, Jorhat and Dibrugarh. As per the 2011 census, Assam is home to a substantial Mising-speaking population with approximately 680,424 individuals identifying as Mising speakers (Payung, 2021). The Mising people are primarily agrarian, with wet rice cultivation being a significant part of their economy. They also engage in

fishing and weaving, which are essential to their way of life. The mising villages are typically located near rivers, with traditional houses called 'Chang ghar' made of bamboo, wood and thatch. Healthcare and education is the main area of concern as the mising childrens are facing challenges for quality education and healthcare facilities are also limited, with some communities relying on traditional medicinal practices. This tribal community have the uniqueness to maintain the cultural and social relationships with the nature and used a wide diversity of resources to meet their demand to lead a healthy and disease-free life. One such example is their food habits, they utilize a great diversity of edible insects to get better nutrition and used as alternative food source and as medicine to aid in treatment of different diseases. Basically they consume the immature stages of the insects such as eggs, larva, nymph, pupa and also the adult insects (Dutta et al., 2016). The rearing product of the insects like honey are also consumed for various therapeutic purposes (Doley and Kalita, 2011). Different mode of preparation is adopted by the people of community like baking, frying, steaming, boiled, curry, chutney etc. and the gathering techniques adopted by them are also quite simple. A study by Doley and Kalita, 2012 reported that in dhemaji district a total 15 species belonging to 12 families and 15 genera are consumed by the people of Mising community as food and for different therapeutic purposes. Moreover, it has been reported that the Giant water bugs, eri silkworm, muga silkworm and house cricket are most popular insects among them. They uses red ant (Oecophylla smaragdina) as food to get a healthy disease free life which aid in treating different diseases like malaria, scabies, tooth aches, stomach disorders, blood pressure etc (Chakraborty et al., 2011). A survey reported 11 species of edible insects are found to be consumed by the missing tribe of Majuli and Mirza (Dhar et al., 2024). Eri silkworm and red weaver ant are extremely popular among them in which the nest of the red ant are collected from the trees which then submerged in water to get the eggs and larva abundantly. The consumption of the edible insects is in the peak during the summer season among the people of this tribe and remains minimum during the winter season.

Insects as food among Bodo folk

The Bodos are another ethnic community and are the early immigrants of Assam confined to the North bank area of the river Brahmaputra, Assam. They are scattered in different parts of Northeast India, primarily residing in Assam's Bodoland Territorial Region (BTR), in different districts like Kokrajhar, Baksa, Udalguri and Chirang of Assam. Agriculture is the primary source of livelihood for the Bodo community, though many are also engaged in traditional practices like fishing, weaving and animal husbandry. The Bodo tribe has a significant number of speakers with 1.45 miliion people, constituting 4.53% of the state (Assam) population, with a majority concentrated in BTR (Census of India, 2011). The knowledge of entomophagy among the people of Bodo community is very

much rich and consider edible insects as their traditional diet. A study revealed that a total 25 species of insects belonging to eight orders and fourteen families are consumed as food by the people of Bodo present in Assam (Narzari and Sarmah, 2015). In a study in some remote village of Udalguri district, BTAD, Assam reported altogether 23 species of edible insects belonging to 21 genera and 16 families. Among the villagers, giant water bugs and eri silkworms larvae are more preferable species of edible insects. They depend on this insects in terms of different therapeutic purposes and regarded as one of the major component of folk medicine (Hazarika and Goyari, 2017). No doubt, NE- India as home to the great diversity of edible insects. The Bodo people residing in Rani area of Kamrup district, Assam has been reported to consume different species of edible insects. A study revealed that the people consume 8 species belonging to 6 orders and are found to be readily available in the market on a daily basis (Ghosh et al., 2017). The rural areas of Kokrajhar are also inhabited by great numbers of Bodo community where zootherapy is an integral part of their life. A survey was conducted which reported that the people of that area greatly depend on 23 species of arthropods belonging to 17 families and 11 orders for food and for treating different ailments like rheumatoid arthritis, stomach ache, wound healing, allergy and many more (Basumatary et al., 2023). The practice of eating insects can help the people to overcome the problem of malnutrition globally. In a recent survey in the four districts of Bodoland Terrotorial Region (BTR), an autonomous division in Assam, India reported to have 32 species of insects belonging to 19 families and 8 orders, which are consumed by the Bodos residing there (Muchahary et al., 2023).

Insects as food among Rabha folk

Rabha tribe is belonging to the great Bodo family and is dispersed into different districts of Assam. Basically this tribe is scattered in the lower Assam region, Kamrup, Goalpara, part of West Bengal and Meghalaya. The Rabha community is primarily agragrian, both men and women work in fields, with women also skilled in weaving and play significant role in family and social matters. According to 2011 census, the total Rabha population of Assam is 298,189, constituting 0.95% of Assam's total population and and 7.63% of state's total Scheduled Tribe population (Das et al., 2023). The edible insects are not a choice among the people of rabha community at the time of scarcity of food, but it has been regarded as the planned diet throughout the year. Among the rabha people insects like cricket, grasshoppers, termites, red ants, beetle larva, silkworm, water giant bug (japripoka), water scavangers (karaipoka), snail (hamka), honeybee etc are mostly preferred. In Medaghat, a place in Baksa district, telpoka khunda (coackroach paste with chilli and other ingredients) is a common insect delicacy among the Rabha folk. It is also used as a traditional medicine to cure jaundice (Rabha, 2016). Moreover, an entomological study in the Goalpara district have reported that altogether 13 species belonging to 12 families and 13

genera are perefered by the Rabha people residing in that district. It has been also reported that in order to get edible insects, local people use different fishing gears like jakoi, dip net, hand net (Das et al., 2015).

Sl. No	Common english name/ Local name	Scientific name	Family	Mode of preparation	Consumption stage	Therapeutic value
1	Red weaver ant (Amroliporua)	Oecophylla smaragdina (Fabricius, 1775)	Formicidae	Eggs are fried with onion and chilly, roasted, raw or smoked	Eggs, larva	Common cold, jaundice, cough
2	Ant	Atta spp. (Fabricius 1804)		Fried, raw	Adult	Asthma, mumps, cold, arthritis
3	Bi-coloured arboreal ant	Tetraponera rufonigra (Jerdon, 1851)		Inserted inside eri coccon and worn around the neck hanging in the chest	Whole adult	Epilepsy (mirgi)
4	Grasshopper (short horned)	Eupreponotus inflatus (Uvarov, 1921), Choroedocus robustus (Serville, 1838), Chondracris rosea (De Geer, 1773), Phlaeoba infumata (Wattenwyl,1893), Oxya		Fried or smoked	Adult	Headache, arthritis, Cure liver disorder

		fuscovittate (Marschall, 1836)	Acrididae			
5	Grasshopper (long horned)	Megapoda elongate elongate (Linnaeus, 1758)		Fried in oil or smoked	Adult	Headache, arthritis
6	Locust	Schistocerca gregaria (Stal, 1873)		Fried	Adult	Body oil is used to treat lip cracking
7	Potter wasp	Vespa affinis (Linnaeus, 1764)	Vespidae	Fried in oil, roasted, raw	Adult	Headache, stomach problems and burn
8	Paper wasp	Polistis olivaceus (De Geer, 1773),		Raw roasted or smoked	Adult	Headache and burn
9	Yellow jacket wasp	Vespa orientalis (Linnaeus, 1771)		Fried	Adult	Cough, cold, stomach problem
10	Lesser paper wasp	Parapolybia varia (Fabricius, 1787)		Fried, roasted or taken raw	Adult	Cough, sore throat
11	Honeybee	Apis dorsata (Fabricius, 1798) Apis mellifera (Linnaeus, 1758) Apis florae (Fabricius, 1787)	Apidae	Baked powder of body mixed with honey	Adult	Cure boil, snakebite and cough
12	Honeybee (Mou)	Apis indica (Fabricius, 1798)		Eggs are fried with onion and	Eggs	Cough, cold, fever, back pain, chest

				chilli , honey, beehive		pain, mouth ulcer, burns, cold asthma, throat pain
13	Ricksecker's water scavenger beetle	Hydrochara rickseckeri (Horn, 1895)	Hydrophilidae	Roasted, fried or smoked	Larva and adult	Cold, cough, fever, small pox, stomach aches, dysentery and even paralysis
15	Water scavangers (Karaipoka)	Hydrophilus olivaceus (Fabricius, 1781)		Roasted and paste or chutney is prepared with hot chilli, ginger, garlic, coriander and salt	Adult	Cold, cough, fever, dysentery
16	Water scavenger beetle	Hydrophilus piceus (Linnaeus, 1758)		Fried	Adult	Cold, cough, fever
17	Nepa (water scorpion)	Lacotrephes griseus (Meneville, 1835)	Nepidae	Fried	Adult	Stomach problem
18	Red water scorpion	Laccotrephes ruber (Linnaeus, 1764)		Wings and legs removed, fried or roasted	Adult	Gastric, stomach problem
19	House crickets	Acheta domesticus (Linnaeus, 1758)	Gryllidae	Fried	Adult	Protein supplement
20	Cricket	Tarbinskiellus portentosus (Lichtenstein		Roasted or fried	Adult	Good vision, Protein supplement

		, 1796)				
21	Water giant bug (jhapripoka)	Lethocerus indicus (Lepeletier & Serville, 1825)	Belastomatidae	Chutney and being fried in mustard oil after wings are removed	Adult	Health tonic and protein supplement, dry cough
22	Water bug	Diplonychus rusticus (Fabricius, 1874)		Fried or rosted	Adult	Asthma
23	Muga silkworm	Antherea assamensis (Helfer, 1837)	Saturniidae	Larvae and pupa are roasted, fried with onion and chilli	Larva and pupa	Constant itching and soreness of throat
24	Eri silkworm	Samia ricini (Jones,1791)		Pupa and larva are fried in oil	Pupa and larva	Protect the liver, cocoon and cocoon ash use to protect children from evil spirit
25	Stink bugs (Jumiles)	Euschistus taxcoensis (Ancona, 1932)	Pentatomidae	Raw, fried or smoked	Adult	Anti-bacterial, anti-inflammatory and antioxidant
26	Predacious diving beetle	Dysticus marginalis (Linnaeus, 1758)	Dystiscidae	Wings removed and fried	Adult	Asthma, protein supplement
27	Potter wasp	Eumenes petiolatus (Olivier, 1791)	Eumenidae	Fried	Adult	Headache, burn
28	Cicada	Pomponia imperatorial	Cicadidae	Fried	Adult	Protein supplement

		(Westwood, 1842)				
29	Termite	Odontotermes obesus (Rambur, 1832)	Termitidae	Wings removed and fried	Adult	Ulcer
30	Termite (Wuri)	Microtermes obesi (Holmgren, 1912)		Wings removed and fried	Adult	Ulcer
31	Mulberry silkworm	Bombyx mori (Linnaeus, 1758)	Bombycidae	Larvae and pupa are roasted, fried with onion and chilli	Larva and pupa	Constant itching and soreness of throat
32	Cockroach	Periplanata Americana (Burmeister, 1838)	Blattidae	Roasted and fried	Adult and nymph	Asthma, tuberculosis
33	Mole cricket	Gryllotalpa africana (Beauvois, 1805)	Gryllotalpidae	Wings are removed, fried or smoked, adult insects are grinded with Lasia spinosa root the heated with mustard oil and paste is applied	Eggs, nymph and adult	foot infection, Anti-allergic use,
34	Nsenene	Ruspolia baileyi (Kirby, 1909)	Tettigoniidae	Fried or smoked	Adult	Protein supplement
35	Praying mantis	Manis inornate	Mantidae	Fried or smoked	Adult	Frequent urination,

		(Werner, 1930)				bed wetting
36	Giant wood spider	Nephila sp. (Leach, 1815)	Nephilidae	Fried or smoked	Adult	Anti-bacterial, wound healing
37	Dragonfly nymph	Neurothemis tullia (Drury, 1773)	Libellulidae	Nymph roasted or fried	Nymph	Curing urinary disorder in children
38	Dragonfly	Crocothemis servilia (Drury, 1770)		Fried or roasted	Nymph and adult	cure urinary disorder
39	June beetle	Phyllophaga spp. (Thomas, 1827)	Scarabaeidae	Wings discarded, fried or roasted	Adult	Heal wounds
40	Rhinoceros beetle	Orycetes rhinoceros (Linnaeus, 1758)	Scarabaeidae	Fried	Adult	Heal wounds
41	Dune cricket	Schizodactylus monstrosus (Drury, 1770)	Schizodactylidae	Wings and legs discarded, fried, smoked, roasted and make chutney	adult	Chitin of dune cricket act as prebiotic promoting growth of beneficial gut bacteria
42	Mayfly	Ephemera danica (Linnaeus, 1761)	Ephemeroptera	Boiling of nymphs	Nymph	Stomach disturbance
43	Common house spider	Parasteatoda tepidariorum (Koch, 1841)	Theridiidae	Spider web to be applied on affected areas	Spider web	Cracked skin, chapped lips
44	Daddy long-legs spider	Pholcus phalangioides (Fussli, 1775)	Pholcidae	Inserted inside eri coccon and worn	Adult	Shortness of breath

				around the neck hanging in the chest		
45	Jujai mala	Unidentified	Unidentified	Nymph roasted or fried	Nymph	Protein supplement
46	Burbila gadget	Unidentified	Unidentified	Fried or smoked	Adult	Normalize blood pressure, protein supplement
47	Burbila pisa	Unidentified	Unidentified	Fried or smoked	Adult	Normalize blood pressure, protein supplement
48	Wasps	Unidentified	Pompilidae	Larvae roasted fried, raw or smoked	Larva and adult	Stomach problems
49	Ant lion	Myrmeleon sp. (Linnaeus, 1767)	Myermeleonitidae	Inserted inside eri coccon and worn around the neck hanging in the chest	Larva	Shortness of breath
50	Scorpion	Unidentified	Unidentified	Whole species boiled in mustard oil and applied	Adult	Joint pain

Table:1- List of edible insects used by Mising, Bodo and Rabha communities of Assam that provides therapeutic benefits. (Doley and Kalita, 2012 ; Narzari and Sharmah, 2015; Dutta et al., 2016; Rabha, 2016; Ghosh et al., 2017; Thangjam et al., 2020; Hazarika and Goyari, 2022; Pradhan et al., 2022; Muchahary et al., 2023; Basumatary and Choudhury, 2023; Dhar et al., 2024)

The data presented in table-1 reveals a remarkable diversity of edible insects consumed by the Mising, Bodo and Rabha tribes of Assam, India, highlighting the rich entomophagy practices among these communities.

Molluscs as food among different tribes of Assam

Mollusca is the second largest phylum after Arthropoda of the kingdom Animalia. Body consists of external spicules or shell, foot and mantle. Moreover, it can be characterized by the presence of radula and coelom. They are majorly adapted to live in aquatic environmenrt but some are adapted to the terrestrial region. They are regarded as the important part of the ecosystem and act as bio-indicators of environment pollution as they have the capability to store impurities in their bodies and can monitor the degree of pollution in water as well as in land (Borkakati et al., 2009). About 80,000 species of mollusca are found to be gastropods and 33700 are bivalves. In India, there are 5050 molluscan species are found (Saikia et al., 2023). Northeast India is one such region in the world where different variety of freshwater molluscs are reported. It has been established that Assam to have 29 species of snails, all of them are revealed to be present in different aquatic habitats like shallow stagnant water body, slow moving shallow water, beel, rice field, river in the Goalpara district of Assam (Rabha et al., 2014b). A field survey was conducted in the upper Brahmaputra basin to assess the diversity of freshwater mollusks (gastropods and bivalves) and it has been reported that altogether there are 18 gastropods and 27 bivalve species belonging to nine families. It was revealed that most of the species reported from that region are either in the least concern or data deficient category of IUCN Red List (Sonowal et al., 2021).

Assam being the diversified state of Northeast India where different tribal communities inhabits, zootherapy is found to be very common among the tribal communities of Assam (Betlu., 2013). Different varieties of freshwater molluscs are consumed by the tribal communities of Assam for food and medicinal purposes (Table-2). It was documented that the tribal people residing in the dhemeji district of Assam prefers a great variety of non-conventional food delicacy to meet the demand of food as well as for therapeutic purposes, where mollusca is one of their choice. They usually prefer the Pila globosa (Apple snail), which is consumed by boiling the fleshy part and taken for good vision (Gogoi and Chakraborty, 2023). The shell of Pila globosa is rich in minerals especially calcium and it has been traditionally used to treat different ailments like blood pressure, heart disease, asthma, rickets, rheumatoid arthritis, osteoporosis, calcium metabolism, bleeding piles, constipation (Patel and Kurhe, 2023). A survey was done to document the aquatic faunas of Ranganadi river, Assam and was reported that the tribal communities especially Bodo and Mising residing in the river basin prefer to have mollusca as their food. Four mollusca species namely Brotia costula, Bellamya benghelensis, Parreysia corbis and Lamellidens marginalis were reported first time from the Ranganadi river basin (Chetia et al.,

2020) . Moreover a field study was done to assessed the diversity distribution and conservation status of freshwater pond mussel Lamelidens species from upper Brahmaputra basin of Assam. Altogether 2135 live specimens belonging to four species of Lamellidens were reported during the study period. It is about 832 specimen of Lamellidans corrianus, 741 specimen of Lamellidens marginalis, 437 of Lamelldens phenchooganjensis and 125 specimen of Lamellidens jekinsianus (Sonowal and Kardong, 2020). A major discovery is also made from the Brahmaputra river basin in Assam from where two new freshwater mussel genera- Pseudoscabies and Assamnaia are found and making a huge rediscovery of the genus Assamnaia which was considered as an extinct genus for about 168 years (Botolov et al., 2024). This rediscovery affirms the richness of biodiversity in Assam where endemic molluscan species are found.

Mollusca of Assam and other regions exhibit remarkable diversity, reflecting the complex geographical and climate history of these regions. Understanding and conserving the rich diversity of Assam is essential for maintaining ecosystem health and promoting biodiversity, serving as a reminder to protect and conserve this natural resource for future generations.

Sl. No	Scientific name	Family	Mode of consumption	Therapeutic value
1	Brotia costula (Rafinesque, 1833)	Pachychilidae	Soup	Pain, antioxidant and antimicrobial agent
2	Pila globosa (Swainson, 1822)	Ampullariidae	Soup	Asthma, pain, tuberculosis, stomach disorder, joint swelling, rheumatism, quick healing of wounds, snail immersed water is used to cure conjunctivitis, good vision
3	Pila theobaldi (Hanley, 1875)		Soup prepared from the eggs	Cure Rickets
4	Pila virens (Lamarck, 1822)		Soup	Rickets, night blindness
5	Pila scutata (Mousson, 1848)		Soup	Rickets, night blindness
6	Pila olea (Reeve, 1856)		Soup	Rickets
7	Lamellidens marginalis (Lamarck, 1819)	Unionidae	Soup	Control blood pressure and cure cardiac ailments
8	Parreysia spp.		Soup	Control blood pressure and cure cardiac ailments, wound healing
9	Filopaludina bengalensis (Lamarck, 1822)		Soup	Cardiac disease, controlling blood pressure, rheumatism
10	Idiopoma dissimilis (Muller, 1774)		Soup	_____

11	Bellamya bengalensis f. typical ((Lamarck, 1822)	Viviparidae	Soup	Asthma , conjunctivitis, night blindness, arthritis
12	Bellamya bengalensis f. balteata (Benson, 1836)		Soup	Asthma , conjunctivitis, night blindness, arthritis
13	Angulyara oxytropis (Benson, 1836)		Cooked in oil or pork fat along with some chillies	Anaemia
14	Cipangopaludina lecythis (Benson, 1836)			———
15	Paludomus pustulosa (Annandale, 1921)	Poludomidae	Soup	Protein supplement
16	Paludomus crasa (Busch, 1842)		Soup	Wound healing
17	Paludomas blanfordiana (Nevill, 1877)		Soup	Kidney function, eyesight, joint pain
18	Lymnaea sp. (Lamarck, 1799)	Lymnaeidae	Soup	Jaundice

Table: 2 List of freshwater mollusca species having food and therapeutic value (Jadav et al., 2020; Jadav et al., 2023; Chetia and Das, 2020; Sonowal et al., 2021; Prabhankar and Roy, 2009; Chutia and Pegu, 2017; Gogoi et al., 2023; Patel and Kurhe, 2023; Tripathy and Mukhopadhayay, 2015; Betlu 2013)

Nutritional composition of edible insects

From nutritional point of view, insects have a significant amount of nutrient components present in edible insects. Among the essential amino acids, phenylalanine and tyrosine are notably abundant in edible insects, contribute significantly to their nutritional profile. Apart from phenylalanine and tyrosine ,

edible insects also contain other essential amino acids like lysine, tryptophan and threonine (Kourimska and Adamkova, 2016)). From the various elemental studies macroelements such as sodium, potassium, magnesium, phosphorus, sulphur, calcium and various microelements such as iron, zinc, manganese, copper are also depicted to be found variedly among different species of edible insects (Sarmah et al., 2022). The nutritional values of different component varies from one species to another and even varies in individuals belonging to same species depending upon its diet, stage of metamorphosis, habitat and sex (Finke and Oonincx, 2014). Insects like grasshoppers, locusts, crickets belonging to the orthopteran order are revealed to have high protein content in it as compared to insects belonging to other orders (Zhou et al., 2022). Apart from nutritional component edible insects are reported to possess some secondary metabolites such as phenol and flavonoid having antioxidant properties (Shantibala et al., 2014). Northeast India region being the biodiversity hotspot have a wide variety of insects inhabited in both aquatic and terrestrial environment. Different investigation has been done to demonstrate the proximate composition, elemental composition, antioxidant properties of commonly available edible insects of Assam. The following table 3 and 4 illustrates the nutritional profile of edible insects including proximate analysis and mineral composition respectively.

Insect species	**Moisture content %**	**Crude protein %**	**Crude fat%**	**Crude fibre %**	**Carbohydrate %**	**Ash content %**
Weaver ant	___	55.28	14.99	19.84	7.30	2.59
Eri silkworm	7.89	49.74	22.23	8.24	7.8	4.10
Predacious diving beetle	5.46	56.37	15.04	14.28	5.45	3.40
Termite	___	33.7	50.9	6.3	6.1	3.0
Dragonfly	___	55.2	19.8	11.8	4.6	8.5
Rhinoceros beetle	___	52.0	10.8	17.9	2.0	11.8
House cricket	___	62.6	12.2	8.0	12.3	5.0
Grasshopper	___	68.9	7.9	12.4	6.7	4.2
Cockroach	___	65.6	28.2	3.0	0.8	2.5
Atta spp.	___	43.0	31.0	10.0	14.0	2.0
Honey bee (larva)	___	42.0	19.0	1.0	35.0	3.0
Praying mantis	___	69.65	12.5	1.50	12.81	3.54

Table:3- Proximate analysis of some of the commonly available edible insects of Assam (Chakraborty et al., 2016; Choudhury et al., 2020; Rumpold.and Schluter, 2013; Omotoso, 2015; Bbosa et al., 2019; Chakraborty , 2014; Ramos et al., 2012; Akintunde et al., 2019)

Insect species	Sodium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Iron (mg/100g)	Zinc (mg/100g)
Red ant	149.10	710.49	74.47	15.27	18.39
Muga silkworm	10.67	20.65	20.65	5.70	35.18
Honeybee	75.59	222.83	222.83	25.18	13.49
Winged termite	118.56	58.70	58.70	18.50	5.40
Eri silkworm	11.50	72.83	72.83	24.47	7.67

Table: 4 Mineral composition of some edible insects (Sailo et al., 2020)

Nutritional composition of edible freshwater molluscs

Mollusca is regarded to be a popular food source among different tribes of Northeast India. It has got several beneficial aspects to be used as an alternative food source in terms of its high nutritional value as well as high therapeutic value. Mollusca species are known for their high nutritional value (rich in protein, fats, minerals and vitamins). Das, 2020 reported that the protein composition of snails and mussels contain all the essential amino acids required by the humans and it has been also revealed that 100 g of mollusc meat have the capability to supply 30% of the daily amino acid to a 75 kg body weight person. It has a higher amount of protein content as compared to cereals and low amount of fat (Table-5). Freshwater mollusks are also reported to have excellent amount of minerals. Both macro and micro elements are reported to be present such as calcium, phosphorus, potassium, manganese and magnesium and are also rich in iron, copper and zinc contents (Table-6). Thus, it can be represented as the most preferred and the cheapest source of crude proteins, carbohydrates, lipids and minerals. Though it is required more exploration and analytical studies, but from the extensive literature review it would be suggested that edible freshwater molluscs available in northeastern region have the ability to combat malnutrition and undernourishment to a great extent as it have a proper amount of different nutrients (Jadhav et al., 2023) .

Mollusca	Ash	Moistur	Protein	Fat %	Carbohyd	Crude

species	%	e%	%		rate %	fibre%
Pila globosa	2.59±0.02	85.5±0.02	8.27±0.05	0.72±0.03	2.90±0.03	0.02±0.01
Bellamya bengalensis	3.64±0.04	82.1±0.04	8.96±0.26	0.98±0.02	4.30±0.17	0.03±0.01
Lamellidans marginalis	2.18±0.02	85.9±0.68	6.46±0.24	0.50±0.10	4.94±0.29	0.002±0.01
Brotia costula	7.28±2.15	69.86±3.68	12.91±2.52	0.82±0.16	9.12±2.81	___
Bellamya dissimilis	67.73±5.48	11.18±2.17	0.99±0.20	8.15±2.36	11.46±6.42	___

*Mean values are not significantly different (P<0.05). The data are reported on a wet basis.

Table: 5 Proximate analysis of flesh of different mollusca species (Baby et al., 2010; Chutia et al., 2020; Debnath et al.,2016)

Mollusca species	Calcium	phosphorus	Iron	Sodium	Potassium
Pila globosa	304.42	133.35	99.14	43.48	31.89
Bellamya bengalensis	166.40	128.84	100.71	53.69	39.37
Lamellidans marginalis	210.21	62.03	94.33	39.47	32.42

Table: 6 Minerals in dried flesh of different mollusca species in mg/100g (Baby et al., 2010)

Conclusion

From the study it can be concluded that among the major tribes of Assam (Mising, Bodo and Rabha), species of the Acrididae family, comprising various grasshopper species, are among the edible insects commonly consumed by the tribal people of Assam, often by fried in oil or smoked. Moreover, species belonging to the Viviparidae family are found to be abundantly consumed as edible molluscs, particularly in the form of soup whereas the species belonging to Pachychilidae family is least consumed among the major freshwater snail families. Thus, edible insects and molluscs offer a promising alternative food source among tribal communities of Assam, providing rich source of nutrients (such as high level of proteins, fats, vitamins and minerals) and also traditionally use for therapeutic purposes to minimize or cure certain common and deadly diseases. Some commonly treated ailments includes joint pain, respiratory issues,

digestive issues, inflammatory conditions and skin problems. Therefore, the present study suggests to further study the complete profiling of nutrients and also to search the molecular pathway through which it can fight against the diseases.

Author's contribution

Conceptualization, Dr. Gitalee Bhuyan; investigation and the main text are written by Sangeeta Gogoi.

Conflict of interest

There is no conflict of interest to disclose.

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