INSECT DELICACIES AMONG THE MISHING AND THE TIWA COMMUNITIES
AND THEIR IMPLICATIONS FOR DISEASES AND FOOD SECURITY

RIMPI DHAR¹, BHANITA BORA¹, SANGEETA CHOUDHURY¹ AND ARUP KUMAR HAZARIKA¹*

¹Department of Zoology, Cotton University, Guwahati, Kamrup Metro 781001, Assam, India
*Email: arup.hazarika@cottonuniversity.ac.in (corresponding author): ORCID ID 0000-0001-6206-3195

ABSTRACT

The Mishings and the Tiwas, along with various global communities, have traditionally consumed insects for their palatability since ancient times. This study reveals the remarkable nutritional and anti-inflammatory properties of these edible insects, making them viable dietary options. *Eupreponotus inflatus* was observed to have the highest protein content at 65.81%, *Vespa affinis* with the highest carbohydrate content at 19.18%, and *Anaciaeschna donaldi* exhibiting the highest fat content at 27.31%. *Apis indica* and *Gryllotalpa africana* demonstrated superior anti-inflammatory activity at 3.48 mg/ml and 3.45 mg/ml, respectively. Given that inflammation is implicated in numerous chronic diseases, the observed nutrient profiles and anti-inflammatory characteristics of these edible insects position them as suitable dietary supplements globally. The presented insect species could serve as beneficial additions or alternatives to existing diets. The study underscores the need for broader recognition of the nutritional and anti-inflammatory benefits offered by these edible insects. By aligning with contemporary nutritional needs and global food challenges, integrating these insects into diets could contribute significantly to public health.

Key words: Edible insects, entomophagy, food security, diets, nutrient value, anti-inflammatory activity, Mishing tribe, Tiwa tribe, trends in consumption, chronic diseases, proteins, carbohydrates

The practice of consuming insects as food is popular and long-standing in certain parts of the world. Approximately 2,000 insect species are consumed in at least 113 countries (Yen, 2009). It has been proven that edible insect species such as *Gryllus* sp. (cricket) contain significant amount of protein, essential amino acids, and other micronutrients (Rumpold and Schlüter, 2013; Oibiokpa et al., 2018; Ojha et al., 2021). Despite this, the eating of insects—which is mainly done in Asia, Africa, and Latin America—is often looked at with disgust in west (Hazarika and Kalita, 2023). Insect foods have more potential nutrients than other conventional foods. Insects can compensate for the general deficiency in animal proteins, fats, and calories that occurs among marginal societies (De Foliart, 1975; DeFoliart, 1992). A study by Zielińska et al. (2015) revealed that protein content in adult cricket (*Gryllodes sigillatus*), larvae of mealworm (*Tenebrio molitor*), and adult locust (*Schistocerca gregaria*) ranged from 52.35% to 76% and fat content ranged from 12.97% to 24.7%. Edible insects may have superior health benefits as they contain high levels of vitamin B12, iron, selenium, folic acid, biotin, phosphorus, manganese, zinc, fiber, essential amino acids, omega-3 and omega-6 fatty acids, and antioxidants, albeit variation in quantity is seen based on different factors (Rumpold and Schlüter, 2013; Nowakowski et al., 2022).

The generation of free radicals is a part of normal body metabolism. It is the imbalance between the generation of reactive oxygen species (ROS) and the ability of cells to neutralise them that leads to oxidative stress. Several studies have shown that antioxidant and anti-inflammatory peptides have protective effects against ROS and may contribute to a significant reduction of the level of oxidative stress (Carrasco-Castilla et al., 2012; Karaś et al., 2015; Torres-Fuentes et al., 2011; Zielińska et al., 2017). Oxidative stress is associated with the development of so-called “civilization diseases”, such as cancer, stroke, myocardial infarction, or inflammation, as well as the degenerative process associated with aging, including Parkinson’s and Alzheimer’s diseases (Ali et al., 2008; Stadtman, 2006). Consumption of foods rich in antioxidants such as insects plays an essential role in the prevention of these diseases. In recent times, insects have come under the limelight and increased scrutiny due to their perceived importance as a part of multifaceted strategies for achieving global food security (Van Huis, 2015). This investigation aims at studying different aspects of entomophagy prevailing among the Mishing and Tiwa tribal communities of Assam. Mishings, also known as Miris, are a mongoloid ethnic indigenous community in the north-east India. They belong to the Tibeto-Burman family of Indo-
Chinese group. They are a riverine tribe in Assam (Pegu, 2021). Tiwas are one of the scheduled tribes in Assam. Their origin is believed to be in the Tibet region (Sarma Thakur, 1985). This investigation also evaluates the anti-inflammatory activity and nutritional benefits of several edible insect species consumed by these communities.

**MATERIALS AND METHODS**

The study area comprises of three districts and 1 town of Assam viz., Majuli (27.0016°N, 94.2213°E); Nagaon (26.3480°N, 92.6838°E); Morigaon (26.2529°N, 92.3370°E); Mirza town (26.3002°N, 91.6931°E). The sample survey population consisted of 3,572 people from 28 villages and 4 towns in the study area. The population of Majuli largely belongs to the Mishing and Deori community while Mirza town is inhabited by Mishings, Rabhas and Bodos. We surveyed the Mishings of Majuli and Mirza for their practice of insect consumption. On the other hand, Tiwas largely reside in the districts of Morigaon and Nagaon. Hence, we surveyed these two districts for the practice of insect consumption among the Tiwas. To collect data on different aspects of this unique practice, a questionnaire was designed. It had questions on the local name of the insects, period of availability and consumption, edible parts, mode of eating, method of collection or rearing, reason for consumption, along with basic information about the interviewee. The survey was conducted from January 2022 to December 2022. A line-sampling method was used to select the households described by Bostoen and Chalabi (2006). Interviewees were classified into four age groups: (1) above 60 years; (2) between 40 to 60 years; (3) between 20 to 40 years; and (4) below 20 years. The age group above 60 years included community leaders and elderly person and were considered as key informant, due to their prolonged stay with the targeted community.

Insect collection, preservation and identification: Terrestrial edible insects were caught using entomological nets, beating tray, water traps, digging and handpicked. Large insects were handpicked following the method described by Musundire et al. (2014). The soil dwelling edible insects were collected by digging with the help of spades. The flying insects were collected using entomological nets. Insects hide in herb dominated or small shrub dominated vegetation were collected using Sweep nets. The red weaver ants were first harvested by plucking the nest from the tree and then putting them in a bucket of water before being processed for consumption. Light trap method was used to collect nocturnal insects in the evening (18:00-20:00 PM), where a CFL of 50 W was arranged in front of a white cloth and a bowl filled with water was placed under the light sources, so that the light attracted the insects which were then collected by hand or insects were fallen into the water which prevented them to escape. For collection of most of the aquatic edible insects long handled aquatic hand nets along with traditional equipment like Jakoi, Chaloni, etc. were used. The kick net method was used for collection of some aquatic insects, where the insects were first removed from its substrate, and then collected with the help of a net. For preservation of specimens, both dry and wet preservation methods were followed (Krogmann and Holstein, 2010). The carbohydrate and protein contents of the samples were estimated following the Anthrone method (Ludwig and Goldberg, 1956) and the method of Lowry et al. (1951), respectively. The lipid content was estimated as crude petroleum ether extract of the dry material and was calculated as per AOAC (1970) guidelines. The analysis of crude lipid was carried out following AOAC (1970) guidelines. Vitamin B1 (thiamine) and vitamin B3 (niacin) were estimated following the method of Okwu and Josiah (2006), while vitamin C (ascorbic acid) estimation followed the method described by Ismail et al. (2003). For anti-inflammatory potential study, preparation of samples was done according to Zelińska et al. (2017). Protein isolation was performed according to a method described by Girón-Calle et al. (2010). In vitro digestion and absorption was performed according to a method described by Gawlik-Dziki (2012). Lipoxygenase (LOX) inhibitory activity was determined by Lipoxygenase (LOX) inhibitory activity assay (Axelroad et al., 1981). Statistical analysis was performed using Microsoft Excel.

**RESULTS AND DISCUSSION**

The conducted survey found that 11 species of edible insects were consumed by the Mishing tribe of Majuli and Mirza whereas 12 species were consumed by the Tiwa tribe of Morigaon and Nagaon (Fig. 1; Table 1). A few of the edible insects were seen to be common in both the communities. They were *Philosamia ricini* (eri silkworm), *Hieroglyphus banian* (grasshopper), *Vespa affinis* (potter wasp) and *Oecophylla smaragdina* (red weaver ant). These edible insects fall under 14 families and 7 orders; 7 of these fed by the Mishing community were also reported by Doley and Kalita (2012). The present reported same six species with the...
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Table 1. Edible insects consumed by the Mishing and Tiwa community

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Common local name</th>
<th>Common English name</th>
<th>Scientific name</th>
<th>Order</th>
<th>Family</th>
<th>Stage of consumption</th>
<th>Period of consumption</th>
<th>Mode of consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mishing community</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Amroliporua</td>
<td>Red ant</td>
<td>Oecophylla smaragdina</td>
<td>Hymenoptera</td>
<td>Formicidae</td>
<td>Egg</td>
<td>All year</td>
<td>Raw, oil fried</td>
</tr>
<tr>
<td>2</td>
<td>Uisiringa</td>
<td>House cricket</td>
<td>Acheta domesticus</td>
<td>Orthoptera</td>
<td>Gryllidae</td>
<td>Adult</td>
<td>May-Sep</td>
<td>Oil fried, smoked</td>
</tr>
<tr>
<td>3</td>
<td>Giwalani</td>
<td>Dragon fly</td>
<td>Ichneumonopsis rapax</td>
<td>Odonata</td>
<td>Gomphidae</td>
<td>Nymph</td>
<td>Mar-Aug</td>
<td>Fried</td>
</tr>
<tr>
<td>4</td>
<td>Foring</td>
<td>Short horned grasshopper</td>
<td>Oxya multidentata</td>
<td>Orthoptera</td>
<td>Acridae</td>
<td>Adult</td>
<td>Harvesting periods</td>
<td>Roasted, oil fried, smoked</td>
</tr>
<tr>
<td>5</td>
<td>Foring</td>
<td>Short horned grasshopper</td>
<td>Heiroglipsis banian</td>
<td>Orthoptera</td>
<td>Acridae</td>
<td>Adult</td>
<td>Harvesting periods</td>
<td>Roasted, oil fried, smoked</td>
</tr>
<tr>
<td>6</td>
<td>Foring</td>
<td>Long-horned grasshopper</td>
<td>Mecopoda elongata</td>
<td>Orthoptera</td>
<td>Tettigoniidae</td>
<td>Adult</td>
<td>Harvesting periods</td>
<td>Roasted, oil fried, smoked</td>
</tr>
<tr>
<td>7</td>
<td>Borol</td>
<td>Potter wasp</td>
<td>Vespa affinis</td>
<td>Hymenoptera</td>
<td>Vespidae</td>
<td>Egg, larva</td>
<td>Apr-Oct</td>
<td>Raw, roasted, oil fried</td>
</tr>
<tr>
<td>8</td>
<td>Borol</td>
<td>Paper wasp</td>
<td>Polistis olivaceus</td>
<td>Hymenoptera</td>
<td>Vespidae</td>
<td>Egg, larva</td>
<td>Apr-Oct</td>
<td>Raw, roasted, smoked</td>
</tr>
<tr>
<td>9</td>
<td>Eri polu</td>
<td>Eri Silkworm</td>
<td>Philosamia ricini</td>
<td>Lepidoptera</td>
<td>Saturniidae</td>
<td>Larva, pupa</td>
<td>Mar-Oct</td>
<td>Oil fried</td>
</tr>
<tr>
<td>10</td>
<td>Lingkar</td>
<td>Ricksecker’s Water Scavenger Beetle</td>
<td>Hydrochara rickseckeri</td>
<td>Coleoptera</td>
<td>Hydrophilidae</td>
<td>Adult</td>
<td>May-August</td>
<td>Roasted, Smoked, Fried</td>
</tr>
<tr>
<td>11</td>
<td>Lingkar</td>
<td>Diving Beetle</td>
<td>Agabites acudactus</td>
<td>Coleoptera</td>
<td>Dytiscidae</td>
<td>Adult</td>
<td>May-August</td>
<td>Roasted, Smoked, Fried</td>
</tr>
<tr>
<td>2. Tiwa community</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Eri puka</td>
<td>Eri Silkworm</td>
<td>Philosamia ricini</td>
<td>Lepidoptera</td>
<td>Saturniidae</td>
<td>Larva, pupa</td>
<td>Mar-Oct</td>
<td>Oil fried</td>
</tr>
<tr>
<td>2</td>
<td>Mou</td>
<td>Honey bee</td>
<td>Apis indica</td>
<td>Hymenoptera</td>
<td>Apidae</td>
<td>Larva</td>
<td>Whole year</td>
<td>Raw, roasted, oil fried</td>
</tr>
<tr>
<td>3</td>
<td>Khokolap</td>
<td>Giant water bug</td>
<td>Lethocerus indicus</td>
<td>Hemiptera</td>
<td>Belostomatidae</td>
<td>Adult</td>
<td>May-Oct</td>
<td>Oil fried</td>
</tr>
<tr>
<td>4</td>
<td>Khoi puk</td>
<td>Diving beetle</td>
<td>Dytiscus marginalis</td>
<td>Coleoptera</td>
<td>Dytiscidae</td>
<td>Adult</td>
<td>Whole year</td>
<td>Oil fried, roasted</td>
</tr>
<tr>
<td>5</td>
<td>KakotiForing</td>
<td>Short horned grasshopper</td>
<td>Chondracris rosea</td>
<td>Orthoptera</td>
<td>Acridae</td>
<td>Adult</td>
<td>May-Sept</td>
<td>Oil fried, smoked, roasted</td>
</tr>
<tr>
<td>6</td>
<td>Tel foring</td>
<td>Short horned grasshopper</td>
<td>Eupreponotus inflatus</td>
<td>Orthoptera</td>
<td>Acridae</td>
<td>Adult</td>
<td>May-Sept</td>
<td>Oil fried, smoked, roasted</td>
</tr>
<tr>
<td>7</td>
<td>Foring</td>
<td>Grasshopper</td>
<td>Hieroglyphus banian</td>
<td>Orthoptera</td>
<td>Acridae</td>
<td>Adult</td>
<td>June-Oct</td>
<td>Oil fried, smoked, roasted</td>
</tr>
<tr>
<td>8</td>
<td>Uisiringa</td>
<td>Mole cricket</td>
<td>Gryllotalpa africana</td>
<td>Orthoptera</td>
<td>Gryllotalpidae</td>
<td>Adult</td>
<td>Whole year</td>
<td>Oil fried, roasted, smoked</td>
</tr>
<tr>
<td>9</td>
<td>Borol</td>
<td>Potter wasp</td>
<td>Vespa affinis</td>
<td>Hymenoptera</td>
<td>Vespidae</td>
<td>Egg, larva</td>
<td>Apr-Oct</td>
<td>Raw, roasted, oil fried</td>
</tr>
<tr>
<td>10</td>
<td>Amroliporua</td>
<td>Red ant</td>
<td>Oecophylla smaragdina</td>
<td>Hymenoptera</td>
<td>Formicidae</td>
<td>Egg</td>
<td>March-Aug</td>
<td>Oil fried</td>
</tr>
<tr>
<td>11</td>
<td>Ui puka</td>
<td>Termite</td>
<td>Macrotermes</td>
<td>Isoptera</td>
<td>Termitidae</td>
<td>Larva, adult</td>
<td>March-July</td>
<td>Oil fried</td>
</tr>
<tr>
<td>12</td>
<td>Hatapuk</td>
<td>Dragonfly</td>
<td>Anaciaeschna donaldi</td>
<td>Odonata</td>
<td>Aeshnidae</td>
<td>Nymph</td>
<td>March-Oct</td>
<td>Oil fried</td>
</tr>
</tbody>
</table>
Tiwa community as shown by Rahman et al. (2017). The consumption of the other 4 species by the Mishings and 6 species by the Tiwas are new and has not been reported up until now. The orders reported in the present study are consistent with those by Doley and Kalita (2012), and Rahman et al. (2017). In both the communities, eri silkworm and red weaver ant were seen to be extremely popular and were claimed to be a favourite by a considerable number of interviewees. It was found that eggs and larvae were the preferred edible part of the red weaver ant. The Mishings submerge the ant nest in water and the eggs and larvae start to rise to the top of the water and float. These are then collected and processed for consumption. The survey also revealed that wasp eggs are eaten after removing the exoskeleton. Edible insects, along with Pat Pura and Sai Mod, are an indispensable part of Alì Aai Lrigang, the traditional festival of the Mishings.

Period of consumption of edible insects is decided by seasonal availability. So trends in consumption follow trends in availability of edible insects. As temperatures start rising, insect consumption sees a rise in both communities. Among the Mishings, insect consumption shows an upward trend from February to April and peaks during the hot and humid months of May to August. After this, it declines from August to November leading to the winter months of December till February showing decreased but uniform consumption. Among the Tiwas, increasing from February till June, insect consumption peaks during the summer months of June, July and August; thereafter follows a declining trend till November. Similar to the Mishings, consumption decreased but uniform in the winter months of December till February. The trends of consumption in these two communities show similarity in that both peak during summers and remain minimum during winters. This finding echoes the trends of edible insect availability and hence consumption by different tribes in the Bodoland Territorial Region of Assam, which is shown in a study by Kalita et al. (2022).

It was observed that 96.5% of the Mishing interviewees said that they consume insects regularly or occasionally, whereas 71.7% of the Tiwa interviewees said so (Fig. 1). A study by Kalita et al. (2022) shows similar observations in other insect consuming communities. Interestingly, in the Tiwa community, it was observed that members of the same family had opposing attitudes on entomophagy; while some members considered edible insects a tasty treat, others do not eat them at all due to several reasons ranging from simply unappealing to repelling appearance and adverse reactions. In both communities, the most popular reason for entomophagy remained superior taste followed by inexpensiveness and tradition (Fig. 2, 3). This is concurrent with the findings of Kalita et al. (2022). Nutritional benefits were neither a popular nor a hugely known reason for consumption in both communities. Medicinal importance was found to be comparatively minute in both communities (0.5%).

Nutrient profiling of 14 species was performed and protein content was the highest in all of them followed by fat and carbohydrates except in Vespa affinis carbohydrate content was higher in this (Fig. 4). Eupreponotus inflatus was found to contain the highest...
quantity of protein among all 14 species; *V. affinis* the highest quantity of carbohydrate; and *Anaciaeschna donaldi* the highest quantity of fat. In a study by Anankware et al. (2021), interspecific difference in nutrients content was appreciable similar to present study. Miankeba et al. (2022) from the Democratic Republic of Congo analyzed the protein content of ten edible insect species (using the Dumas method). This study focused on the amino acid (AA) profiles of the six major commercially relevant species using HPLC (high-pressure (or performance) liquid chromatography). The protein contents varied significantly from 46.1 to 52.9% (dry matter). Edible insects contain a reasonable amounts of vitamins B1, B3, and C (Fig. 5). Vitamin B3 was found to be considerably higher than vitamins B1 and C. *P. ricini* contained the highest quantity of vitamin B3 closely followed by *C. rosea* and *Gryllotalpa africana*. Vitamins B1 and C content were comparable in the studied species. Kouřimská and Adámková (2016) noted that insects contain a variety of water soluble and lipophilic vitamins as B group vitamins, vitamins A, D, E, K, and C. However their content is seasonal and dependent on the feed. Vitamin C is a well-known powerful antioxidant with the ability to mop up free radicals thereby reducing inflammation (Sinbad et al., 2019).

The present study showed that lipoxygenase (LOX) activity was successfully curbed by hydrolysates and peptide fraction extracted from the edible insects. Calculations illustrate high anti-inflammatory activity in all the five studied species. Highest anti-inflammatory activity was seen in *Apis indica* very closely followed by *G. africana*. Others also showed commendable anti-inflammatory activity (Fig. 6). LOX activity is an inflammatory marker and has been used to elucidate anti-inflammatory activity in edible insects in a previous study by Zielinska et al. (2017). LOX Inhibitory Assay was also employed to observe the anti-inflammatory activity in Purple basil seeds (*Ocimum basilicum* L. cv. Dark Opal) in a study by Szymanowska et al. (2015). Although radical scavenging activity of a few edible insects from Assam has been studied by Kalita et al. (2022) in a recent study, LOX Inhibitory Assay or any other assay to observe reduction in inflammation by
edible insects of this region has not been performed until our study. The Mishings and the Tiwas have been eating insects as tradition, and an inexpensive delicacy. Both communities stated superior taste as the major reason for consumption of edible insects. However, in the west, the “yuck” factor associated with insect consumption is a major hindrance to overcome (Hazarika and Kalita, 2023). Good taste, an excellent nutrient profile and sustainability are compelling factors for wide acceptance of edible insects.

AUTHOR CONTRIBUTION STATEMENT

RD conceived and designed the research and performed statistical analysis. RD and BB collected samples and performed experiments. AKH and SC contributed to writing and editing the manuscript. All authors read and approved the manuscript.

CONFLICT OF INTEREST

No conflict of interest.

REFERENCES


