Eco. Env. & Cons. 30 (1) : 2024; pp. (92-98)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i01.017

Edible Insects: A Sustainable Solution for Nutrition, Medicine, and Economic Development of Manipur, India

Rahul Sanjenbam[1], Yumnam Laxmi Chanu[1], Bijayalakshmi Devi Nongmaithem[1], Ajit Kumar Ngangbam[1]* and Oinam Lukhoi Singh[2]

[1]Manipur International University (MIU), Ghari Awang Leikai, Imphal, Manipur 795140, India
[2]Nambol L. Sanoi College, Nambol, Manipur 795 134, India

(Received 8 August, 2023; Accepted 23 September, 2023)

ABSTRACT

Edible insects have been gaining recognition as a sustainable and alternative food source worldwide. In Manipur, a northeastern state of India, the consumption of insects has been a part of traditional diets for centuries. This review paper examines the potential of edible insects in Manipur, with a focus on their nutritional and medicinal value and commercial production. A comprehensive review of the existing literature on edible insects in Manipur, as well as related studies from other regions was conducted. The findings indicate that insects are a rich source of protein, essential fatty acids, and micronutrients. They also possess medicinal properties and can contribute to the treatment of various ailments. The review also highlights the challenges and opportunities in commercial insect production in Manipur. Overall, this review paper provides valuable insights into the potential of edible insects in Manipur, and their role in promoting food security and sustainable development in the region.

Key words: *Nutritional value, Entomophagy, Traditional medicine, Food value, Edible insects*

Introduction

The practice of eating insects is widespread across the world. Such consuming of insects have been habituated in many countries of Africa, South America, and Southeast Asian countries (Baiano, 2020). The natives of these countries have consume edible insects as the delicious food items and a good source of proteins in many restaurants and markets. So far relevant literature are concerned, around 1900 insect species have been identified as edible species (Huis *et al.*, 2013). These edible insects are coming under the insect orders Orthoptera, Heteroptera, Hemiptera, Coleoptera, Hymenoptera, and Lepidoptera. Since time immemorial, people of various ethnic backgrounds residing in Manipur have been capturing and consuming a wide range of insect species. These insects are also sold in some local markets in Manipur, and serve as a source of income for many local communities (Lokeshwari and Singh, 2019). Insects such as *Belostoma* sp., *Lethocerous* sp., *Hydrophilus* sp., *Locust* sp., larvae and pupa of silkworm, bees and cricket species have been commonly sold in the popular market as delicious and costly items. Various researchers predicted that the sustainable source of protein for the enormous increase of human population in future would be the insect proteins (Tang *et al.*, 2019; Zhao *et al.*, 2021). In addition to their nutritional value, edible insects are also used for their medicinal properties. For example, termites are believed to have anti-inflammatory and anti-microbial properties while *Locust migratoria* are used to treat coughs and asthma (Singh, 2014). In Manipur, insects such as silkworm pupae and grasshoppers are used in traditional medicine to treat various ailments (Singh, 2014). According to United Nation, the global population is projected to reach 9 billion by 2050, and the demand for food will increase accordingly. The use of edible insects as a food source has gained maximum attention as a potential solution to meet the increasing demand for food, while reducing the environmental impact (Premalatha *et al.*, 2011).

Why Entomophagy?

Studies have shown that insects such as beetles, caterpillars, and termites contain high levels of essential amino acids, vitamins and minerals (Kouøimská and Adámková, 2016). For instance, the larvae of the bamboo borer (*Omphisa fuscidentalis*) have been found to contain high protein (30 %) and lipid (43 %) (Sheileja *et al*., 2022.). Some edible insects have higher food value in terms of protein, fat and minerals than meat of slaughtered animals(Orkusz, 2021).In addition to their nutritional value, edible insects have several other advantages as a food source. Several edible insects are known to have antimicrobial and anti-inflammatory properties (Mlcek *et al.,* 2014; Mozhui *et al.*, 2021; Jena *et al*., 2020; Aiello *et al.*, 2023). Insectsare efficient in converting feed to body weight, they have low greenhouse gas emissions and can thrive in diverse environments, making them a sustainable food source (Huis *et al.*, 2013). With the increasing in global population, the demand for food is also increasing considerably, and insects could play a key role in meeting this requirement (Oonincx, 2015).

Entomophagy in Manipur

Edible insects have been a traditional source of protein in many cultures around the world, including in the Indian state of Manipur and other states of Northeast India. Studieson the consumption of insects as food have identified numerous edible species in India, with approximately 255 species consumed by various tribes. Among these, the coleopteran species were found to be the most commonly consumed, followed by Orthoptera, Hemiptera, Hymenoptera, Odonata, Lepidoptera, Isoptera and Ephimeroptera (Chakravorty, 2014). In Manipur, 73 edible insect species belonging to 9 orders, under 29 families have been identified. The order Hemiptera has the highest representation with up to 21 species, while the orders Odonata and Hymenoptera have 17 and 10 species, respectively. The orders Orthoptera and Lepidoptera each have 4 species, while the orders Isoptera and Dictyoptera, as well as the order Ephemeroptera, are represented by only 1 species each (Table 1) (Babu and Singh, 2021; Thangjam *et a*l., 2020.).

Nutritional Value

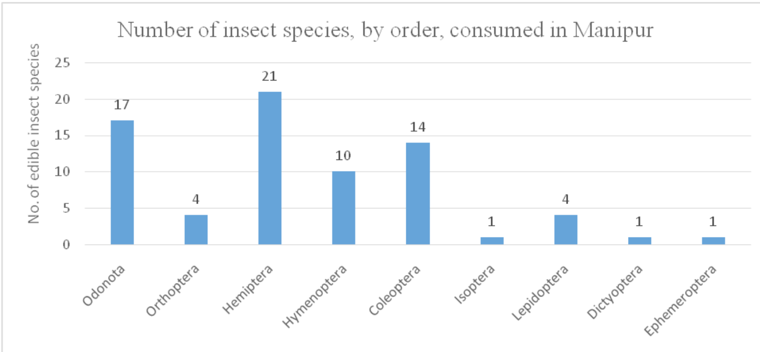
Throughout many cultures around the world, people have been consuming insects as a food source for centuries. Recently, there has been a resurgence of interest in the nutritional value of edible insects as they are considered a sustainable and protein-rich food source. Edible insects contain a range of important nutrients including protein, healthy fats, vitamins, minerals, and fibre (Tang *et al.*, 2019). The precise nutritional composition of edible insects can vary depending on factors such as species, developmental stage, and preparation method (Meyer-Rochow *et al.,* 2021). Insects also have a good source of essential amino acids needed for muscle growth and repair, healthy fats such as omega-3,vitamins, and minerals like iron, calcium, and zinc (Nowakowski *et al.*, 2021; Zhao *et al*., 2021). Table 2 and 3 represent the proximate composition and mineral contents of some edible insects from several northeastern states of India.

Medicinal Value

Manipur is recognized for its diverse ecosystem, encompassing a wide range of insects that have been conventionally employed for their medicinal properties. Among these, some of the*Apis* sp.has garnered significant attention due to its available documented therapeutic studies. Research has shown that honey, larvae, and pupae of *Apis* sp. possesses substantial antibacterial properties that can be utilized for treating respiratory tract diseases, easing mental stress, alleviating gastric troubles, and thereby aiding in the healing of external wounds (Singh, 2014). Further research has demonstrated that the honey produced by *Apis* sp. can also serve as a natural remedy for regulating blood pressure. Additionally, cooked larvae and pupae of *Apis dorsata* have been traditionally used to provide relief from heart ailments (Mozhui *et al.,* 2021). Certain compounds found in termites and their nests have been found to have antimicrobial properties and are

Table 1. Edible Insects of Manipur

A)



B)

Sl.No	Order	Family	Species
1.	Coleoptera	Hydrophilidae	*Hydrous olivaceous* (True water beetle), *Hydrous indicus* (Water scavenger beetle), *Tropistemus sp.*(Water beetle)
		Dytiscidae	*Cybister sugillatus*, *C. tripunctatus*, *C. ventralis*, *Rhantus sp.*, *Hydaticus sp.* *Hydrophilus olivaceous* (Water beetle), *Hydrophilus triangularis* (Giant water scavenger), *Cybister fimbriatus* (Cybister beetle)
		Curculionidae	*Cyrtotrachelus dux* (Bamboo beetle)
		Dynastidae	*Oryctesrhinoceros* (Rhino beetle)
		Cerambycidae	*Anoplophora glabripennis* (Long horn beetle)
2.	Hemiptera	Belostomatidae	*Lethocerus indicus* (Giant water bug), *Diplonychus rusticus* (water bug)
		Nepidae	*Ranatra sp*, *Laccotrephes maculatus*, *L. ruber*, *L. variepes* (Water scorpion), *Cercometus* sp. (Water bug),
		Dinidoridae	*Coridius* sp. (Bug)
		Pentatomidae	*Udonga Montana* (Stink Bug)
		Cicadidae	*Pomponia sp.*(Cicada)
		Corixidae	*Micronecta* sp. (Lesser water boatmen), *Micronecta haploides* (Water Boatmen)
		Notonectidae	*Notonecta* sp, *Paranisops* sp., *Enithares ciliate*, *Enithares mandalayensis* (Backswimmer)
		Hydrometridae	*Hydrometridae greeni* (Marsh treaders), *Hydrometra* sp. (Water measurer)
		Garridae	*Geris sp*, *Aquarius* sp., *Limnogonus* sp.(Water strider)
3.	Hymenoptera	Apidae	*Apis cerana*, *A. mellifera*, *A dorsata* (Honey bee)
		Vespidae	*Vespa affinis* (Lesser banded hornet), *Vespa mandarinia* (Japanese giant hornet), *Vespa cincta* (Common oriental hornets), *Vespa vulgaris*(Common yellow jacket), *Polistes* sp., *Polistes* sp.(Paper wasp)
		Formicidae	*Solenopsis geminate* (Ant)
4.	Orthoptera	Acrididae	*Oxy hyla hyla* (Rice Grasshopper), *Acridium melanocorne* (Short horn Grasshopper), *Gryllus* sp.(Field cricket)
		Gryllotalpidae	*Gryllotalpa orientalis* (Mole cricket)
5.	Odonata	Libellulidae	*Pantala flavescens*, *Acisoma panorpoides*, *Crocothemis servilia*, *Orthetrum triangulare*, *Orthetrum Sabina*, *Sympatrum* sp., *Rhyothemis variegate*, *Diplacodes trivialis*, *Libulla sp.*,*Leucorrhina sp.*, *Palpopleura sexmaculata*, *Tramea basilaris*, *Urothemis signata* (Dragonfly)
		Corduliidae	*Corduliidae* sp. (Dragonfly)
		Coenagrionidae	*Pseudagrion microcephalum*, *Ischnura sp.*(Dragonfly)
		Lestidae	*Lestes sp.*(Stalked wing damsel flies)
6.	Ephemeroptera	Baetidae	*Baetid* sp.(Mayfly)
7.		Dictyoptera	Mantidae *Heirodula* sp.(Preying mantid)
8.	Isoptera	Termitidae	*Odontotermes* sp.(Termite)
9.	Lepidoptera	Bombycidae	*Bombyx mori* (Mulberry silkworm)
		Saturniidae	*Samia Cynthia ricini* (Eri silkworm), *Antheraea proylei* (Tasar silkworm)
		Crambidae	*Omphisa fuscidentalis* (Bamboo worm)

Table 2. Proximate composition of edible insect species

Insect Species	Locality	Protein	Lipid	Carbohydrate	Moisture	Ash	Energy (kcal/100g)	References
Coridius sp.	Manipur	36.5[a]	38.7[a]	0.06[a]	9.5%	2.9[a]	494.4	(Thounaojam *et al.*, 2022)
Omphisa fuscidentalis	Manipur	30.5[a]	43.1[a]	4.18[a]	12.7%	2.4[a]	526.6	(Sheileja *et al.*, 2022.)
Crocothemis servilia	Manipur	70.4%	4.93%	1.18%	13.46%	1.34%	496.8	(Shantibala *et al.*, 2014)
Hydrophilus olivaceous	Manipur	25.08%	6.94%	2.39%	49.05%	1.90%	584.9	(Shantibala *et al.*, 2014)
Diplonychus rusticus	Assam	57.67[b]	27.87[b]	3.18[b]	9.06[c]	4.74[b]	498.8	(Sarmah *et al.*, 2022)
Cybister sp.	Assam	51.42[b]	28.95[b]	3.68[b]	4.71[c]	3.25[b]	505	(Sarmah *et al.*, 2022)
Lethocerus indicus	Assam	50.03[b]	26.63[b]	2.92[b]	3.38[c]	2.39[b]	474.6	(Sarmah *et al.*, 2022)
Laccotrephes sp	Assam	54.75[b]	8.90[b]	2.74[b]	9.19[c]	3.71[b]	331.9	(Sarmah *et al.*, 2022)
Ranatra sp.	Assam	56.56[b]	8.67[b]	3.52[b]	7.07[c]	3.72[b]	337.7	(Sarmah *et al.*, 2022)
Oecophylla smaragdina	Arunachal Pradesh	55.28[a]	14.99[a]	NA	NA	2.58[a]	385.2	(Chakravorty *et al.*, 2016)
Odontotermes sp	Arunachal Pradesh	33.67[a]	50.93[a]	NA	NA	3.01[a]	617.4	(Chakravorty *et al.*, 2016)

[a]: % dry weight, [b]: g/100 g dry weight, [c]: g/100g, fresh weight, NA: not available.

used in traditional medicine for treating respiratory and enteric infections (Jena *et al.,* 2020). Similarly, different communities in Manipur use *Notobitus* sp., *Rhynchophorus* sp., and pink oak borer to relieve cough (Devi *et al.*, 2022). The larvae of *Rhynchophorus palmarum* have been found to contain linoleic and linolenic acids, which possess properties that can combat microbes and inflammation (Delgado *et al.,* 2019).

The larvae and pupae of silkworm species have been reported to have beneficial properties such as anticancer activity, antigen-toxicity, and the regulation of blood glucose and lipids (Kumar *et al.*, 2015). Additionally, they are also utilized by farmers and tribal natives of Manipur as a natural remedy to relieve symptoms associated with bronchitis and pneumonia. While these insects have been traditionally used for medicinal purposes, further scientific research is required to determine their effectiveness and safety for use in modern medicine. However, these traditional remedies highlight the potential for insects to be used as a source of natural medicines.

Commercial Production

The commercial production of edible insects is gaining importance due to its potential inaddressing numerous global food challenges. United Nations predicted thatthe world population is expectedto reach 9 billion by 2050, which will significantly increase the demand for food. Insects are known to have a rich source of protein, vitamins, and minerals, and their consumption can help address protein deficiency and malnutrition in various parts of the world (Huis *et al.*, 2013). It was suggested that adding edible insects to biscuits and cookies could be a promising approach to enhance the nutritional, biofunctional, and health-promoting benefits of baked goods, potentially helping to prevent diseases related to nutrient deficiencies (Ogunlade *et al.*, 2023). Likewise there are several approaches taken up to promote consumption of edible insects even in Europe and other part of the world (Caparros Megido *et al.*, 2016; Orsi *et al.*, 2019). Insects require less land, water, and feed when compared totraditional livestock, making them a more sustainable and ecofriendly source of food (Guiné *et al.*, 2021). Commercial production of insects also generates less greenhouse gas emissions and contributes to the preservation of biodiversity (Huis *et al.*, 2013). Commercial production of some edible insects could potentially help alleviate the problem of overexploitation of cer-

Table 3. Mineral Content of some edible insects (mg/100gm, dry weight)

Insect Species	Locality	Ca	K	Fe	Zn	Mg	P	Na	Mn	Cu	References
*Coridius sp***.**	Manipur	232.7	200.1	373.6	13.3	42.8	48.4	142.5	25.9	2.3	(Thounaojam *et al.*, 2022)
Omphisa fuscidentalis	Manipur	1339.1	568.6	84.7	28.1	21.9	55.5	279.1	21.9	1.5	(Sheileja *et al.*, 2022.)
Crocothemis servilia	Manipur	86.5	268	11.3	9.3	37	NA	1410	NA	1.9	(Shantibala *et al.*, 2014)
Hydrophilus olivaceous	Manipur	24.3	390	461	11.8	99	NA	816	NA	1.7	(Shantibala *et al.*, 2014)
Diplonychus rusticus	Assam	40.13	27.78	99.02	7.22	45.20	147.16	28.62	4.22	2.50	(Sarmah *et al.*, 2022)
Cybister sp.	Assam	32.09	34.60	25.30	4.98	38.40	153.32	22.49	3.70	2.78	(Sarmah *et al.*, 2022)
Lethocerus indicus	Assam	48.30	23.86	49.90	6.58	38.40	120.42	26.22	1.98	2.22	(Sarmah *et al.*, 2022)
Laccotrephes sp.	Assam	56.15	23.86	90.40	5.76	43.20	76.34	20.94	2.22	3.80	(Sarmah *et al.*, 2022)
Ranatra sp.	Assam	32.15	22.00	112.10	6.20	33.60	114.52	19.74	2.62	4.20	(Sarmah *et al.*, 2022)
Oecophylla smaragdina	Arunachal Pradesh	74.67	710.00	NA	18.9	93.14	NA	150	10.35	0.85	(Chakravorty *et al.*, 2016)
Odontotermes sp.	Arunachal Pradesh	68.34	507.27	NA	12.23	47.7	NA	92.73	1.686	1.72	(Chakravorty *et al.*, 2016

NA: not available

tain species as insects such as *Lethocerus indicus* have been negatively impacted and overexploited (Macadam and Stockan, 2017; Ramos-Elorduy, 2006). Moreover, the production of edible insects has the potential to provide a new source of income for farmers and contribute to the development of local economies (Durst and Hanboonsong, 2015). In many parts of the world, edible insects are already a significant part of traditional cuisine, and commercial production can support the preservation and promotion of cultural heritage. Furthermore, the edible insect industry can provide job opportunities in various stages of production, including farming, processing, and marketing (Durst and Hanboonsong, 2015; Guiné *et al.*, 2021).

The consumption of insects in Manipur is deeply rooted in the cultural traditions of many indigenous communities in the state, and considered an important source of protein and other essential nutrients. In recent years, there has been a renewed interest in promoting entomophagy in Manipur as a sustainable and healthy food source, both for local communities and as a means of addressing global food security for sustainable food supply (Thangjam *et al*., 2020). However, there are some concerns about the safety of eating insects (Tang *et al*., 2019). Some insects may contain toxins or heavy metals if they are collected from polluted areas. There are also challenges to overcome these before insects can be widely adopted as a food source, such as developing efficient and sustainable insect farming systems (Tang *et al*., 2019), and overcoming social and cultural barriers to consumption. Therefore, proper scientific studies are required before considering insects as edible food sources.

Conclusion

This review paper has thoroughly examined the edible insects of Manipur, with focus on their nutritional and medicinal values, as well as possibility for commercial production. Several studies have revealed that insects possess remarkable nutritional value, being abundant in protein, vitamins, and minerals. Furthermore, they have long been a goodsource of traditional medicine and have been recognized to effectively treat numerous human ailments. Moreover, the commercial production of insects can offer a dependable source of income for local farmers, while also enhancing food security in the region. Based on several studies, it is evident that the edible insect industry in Manipur has significant potential for further development, and can greatly benefit the local economy and promote the well-being of the population.

References

Aiello, D., Barbera, M., Bongiorno, D., Cammarata, M., Censi, V., Indelicato, S. and Saiano, F. 2023. Edible

Insects an Alternative Nutritional Source of Bioactive Compounds: A Review. *Molecules.* 28(2): 699.

Babu, S. and Singh, M.O.K. 2021. Cultural entomology and edible insect diversity in a wetland ecosystem: A case study from the Loushi pat basin, Manipur. *Indian Journal of Traditional Knowledge (IJTK).* 20(1): 180-190.

Baiano, A. 2020. Edible insects: An overview on nutritional characteristics, safety, farming, production technologies, regulatory framework, and socio-economic and ethical implications. *Trends in Food Science & Technology*. 100: 35–50. https://doi.org/10.1016/j.tifs.2020.03.040

Boué, G., Federighi, M., Laurent, S., Jury, V. and Yan, X. 2023. Processing edible insects into powders: A review of available processes and potential microbial inactivation methods. *Journal of Insects as Food and Feed*. 9. https://doi.org/10.3920/jiff2021.0203

Caparros Megido, R., Gierts, C., Blecker, C. and Brostaux, Y. 2016. Consumer acceptance of insect-based alternative meat products in Western countries. *Food Quality and Preference*. 52: 237–243. https://doi.org/10.1016/j.foodqual.2016.05.004

Chakravorty, J. 2014. Diversity of Edible Insects and Practices of Entomophagy in India: An Overview. *Journal of Biodiversity, Bioprospecting and Development.* 01(03). https://doi.org/10.4172/2376-0214.1000124

Chakravorty, J., Ghosh, S., Megu, K., Jung, C. and Meyer-Rochow, V. 2016. Nutritional and anti-nutritional composition of *Oecophylla smaragdina* (Hymenoptera: Formicidae) and *Odontotermes sp.* (Isoptera: Termitidae): Two preferred edible insects of Arunachal Pradesh, India. *Journal of Asia-Pacific Entomology*. 19. https://doi.org/10.1016/j.aspen.2016.07.001

Delgado, C., Romero, R., Espinoza, R.V., Trigozo, M. and Correa, R. 2019. Rhynchophorus palmarum used in Traditional Medicine in the Peruvian Amazon. *Ethnobiology Letters.* 10(1): 120–128.

Devi, M.B., Sandhyarani Devi, O. and Dineshwor Singh, S. 2014. Aquatic edible insects of Loktak lake of Manipur, North East, India. *Journal of the Entomological Research.* 38(1): 67-70.

Devi, W.D., Bonysana, R.K., Kapesa, K., Mukherjee, P.K. and Rajashekar, Y. 2022. Ethnotherapeutic practice of entomophagy species by the ethnic community of Tangkhul, Mao and Poumai community of Manipur, NER India. *Journal of Ethnic Foods.* 9(1): 17. https://doi.org/10.1186/s42779-022-00132-9

Durst, P.B. and Hanboonsong, Y. 2015. Small-scale production of edible insects for enhanced food security and rural livelihoods: Experience from Thailand and Lao People's Democratic Republic. *Journal of Insects as Food and Feed*. 1(1): 25–31. https://doi.org/10.3920/JIFF2014.0019

Guiné, R. P. F., Correia, P., Coelho, C. and Costa, C.A. 2021. The role of edible insects to mitigate challenges for sustainability. *Open Agriculture.* 6(1): 24–36. https://doi.org/10.1515/opag-2020-0206

Huis, A. van, Itterbeeck, J. van, Klunder, H. and Mertens, E. 2013. Edible insects: Future prospects for food and feed security. *FAO Forestry Paper.* No. 171. https://www.cabdirect.org/cabdirect/abstract/20133217074

Jena, S., Das, S. and Sahu, H. 2020. Traditional value and antibacterial activity of microtermite (*odontotermes obesus*) of Mayurbhanj district, Odisha, India. https://doi.org/10.13140/RG.2.2.33557.24809

Kim, S.K., Weaver, C.M. and Choi, M.K. 2017. Proximate composition and mineral content of five edible insects consumed in Korea. *CyTA - Journal of Food.* 15(1): 143–146. https://doi.org/10.1080/19476337.2016.1223172

Kouøimská, L. and Adámková, A. 2016. Nutritional and sensory quality of edible insects. *NFS Journal*. 4: 22–26. https://doi.org/10.1016/j.nfs.2016.07.001

Kumar, D., Dev, P. and Kumar, R.V. 2015. Biomedical Applications of Silkworm Pupae Proteins. In D. Kumar & R. R. Kundapur (Eds.), *Biomedical Applications of Natural Proteins: An Emerging Era in Biomedical Sciences* (pp. 41–49). Springer India. https://doi.org/10.1007/978-81-322-2491-4_3

Lokeshwari, R.K. and Singh, O.L. 2019. *Vespa Basalis*: An edible insect in Ukhrul District, Manipur. *Indian Journal of Entomology.* 81(3): 495. https://doi.org/10.5958/0974-8172.2019.00106.8

Macadam, C.R. and Stockan, J.A. 2017. The diversity of aquatic insects used as human food. *Journal of Insects as Food and Feed.* 3(3): 203–209. https://doi.org/10.3920/JIFF2016.0046

Meyer-Rochow, V.B., Gahukar, R.T., Ghosh, S. and Jung, C. 2021. Chemical Composition, Nutrient Quality and Acceptability of Edible Insects Are Affected by Species, Developmental Stage, Gender, Diet, and Processing *Method Foods*. 10(5): Article 5. https://doi.org/10.3390/foods10051036

Mlcek, J., Borkovcova, M., Rop, O. and Bednarova, M. 2014. Biologically active substances of edible insects and their use in agriculture, veterinary and human medicine – a review. *Journal of Central European Agriculture.* 15(4): 225–237. https://doi.org/10.5513/JCEA01/15.4.1533

Mozhui, L., Kakati, L. N. and Meyer-Rochow, V.B. 2021. Entomotherapy: A study of medicinal insects of seven ethnic groups in Nagaland, North-East India. *Journal of Ethnobiology and Ethnomedicine.* 17(1): 17. https://doi.org/10.1186/s13002-021-00444-1

Nowakowski, C., Miller, A., Miller, M.E., Xiao, H. and Wu, X. 2021. Potential health benefits of edible insects. *Critical Reviews in Food Science and Nutrition.* 62: 1–10. https://doi.org/10.1080/10408398. 2020. 1867053

Ogunlade, A.O., Ogidi, C.O., Aladejana, O.M. and Bodunde, R.S. 2023. Evaluation of Nutrient Contents and Antioxidant Activity of Wheat Cookies Fortified with Mushroom (*Termitomyces robustus*) and Edible Insects. *Journal of Culinary Science & Technology*, ahead-of-print. https://doi.org/10.1080/15428052.2023.2181253

Oonincx, D.G. 2015. Insects as food and feed: nutrient composition and environmental impact. Wageningen University and Research

Orkusz, A. 2021. Edible Insects versus Meat-Nutritional Comparison: Knowledge of Their Composition Is the Key to Good Health. *Nutrients.* 13(4): Article 4. https://doi.org/10.3390/nu13041207

Orsi, L., Voege, L.L. and Stranieri, S. 2019. Eating edible insects as sustainable food? Exploring the determinants of consumer acceptance in Germany. *Food Research International*. 125: 108573. https://doi.org/10.1016/j.foodres.2019.108573

Payne, C. L. R. 2015. Wild harvesting declines as pesticides and imports rise: The collection and consumption of insects in contemporary rural Japan. *Journal of Insects as Food and Feed*. 1(1): 57–65. https://doi.org/10.3920/JIFF2014.0004

Premalatha, M., Abbasi, T., Abbasi, T. and Abbasi, S.A. 2011. Energy-efficient food production to reduce global warming and ecodegradation: The use of edible insects. *Renewable and Sustainable Energy Reviews.* 15(9): 4357–4360. https://doi.org/10.1016/j.rser.2011.07.115

Ramos-Elorduy, J. 2006. Threatened edible insects in Hidalgo, Mexico and some measures to preserve them. *Journal of Ethnobiology and Ethnomedicine.* 2(1): 51. https://doi.org/10.1186/1746-4269-2-51

Sarmah, M., Bhattacharyya, B., Bhagawati, S. and Sarmah, K. 2022. Nutritional Composition of Some Commonly Available Aquatic Edible Insects of Assam, India. *Insects.* 13(11): Article 11. https://doi.org/10.3390/insects13110976

Shantibala, T., Lokeshwari, R.K., Debaraj Sharma, H. 2012. Entomophagy practices among the ethnic communities of Manipur, North-East India. *International Journal of Integrative sciences, Innovation and Technology.* 1(5): 13-20.

Shantibala, T., Lokeshwari, R.K. and Debaraj, H. 2014. Nutritional and antinutritional composition of the five species of aquatic edible insects consumed in Manipur, India. *Journal of Insect Science*. 14(1): 14. https://doi.org/10.1093/jis/14.1.14

Sheileja, T., Shantibala, T. and Singh, K. M. 2022. Nutritive value of bamboo worm *Omphisa fuscidentalis (Lepidoptera: Crambidae)*: An edible insect as protein rich food.

Singh, K.M., Singh, M.P., Kumawat, M.M. and Riba, T. 2013. Entomophagy by the tribal communities of North East India. *Indian Journal of Entomology.* 75(2): 132136.

Singh, O.L. 2014. Medicinal insects of Manipur. *Int J Res Methodol Soc Sci*. 66: 100.

Tang, C., Yang, D., Liao, H. and Sun, H. 2019. Edible insects as a food source: *A review. Food Production, Processing and Nutrition.* 1(1): 8. https://doi.org/10.1186/s43014-019-0008-1

Thangjam, R., Kadam, V., Ningthoujam, K. and Sorokhaibam, M. 2020. A review on edible insects and their utilization in Northeastern Himalaya. *Journal of Entomology and Zoology Studies.* 8(3): 1309-1318.

Thounaojam, S., Singh, K.M., Shantibala, T., Haldhar, S.M. and Singh, K.I. 2022. Nutritional aspects of an edible insect, *Coridius sp.* (Hemiptera: Dinidoridae) of Manipur. *Journal of Agriculture and Ecology.* 14: 158–163. https://doi.org/10.53911/JAE.2022.14223

Twining, C.W., Shipley, J.R. and Winkler, D.W. 2018. Aquatic insects rich in omega3 fatty acids drive breeding success in a widespread bird. *Ecology Letters*. 21(12): 1812-1820.

Tzompa Sosa. 2016. Insects are a sustainable source of omega-3. ScienceDaily.Retrieved

March 30, 2023 fromwww.sciencedaily.com/releases/2016/01/160111122520.htm

Zhao, M., Wang, C.-Y., Sun, L. and He, Z. 2021. Edible Aquatic Insects: Diversities, Nutrition and Safety. *Foods*. 10: 3033. https://doi.org/10.3390/foods10123033