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ENTOMOPHAGY, A WAY OF FOOD SUSTAINABILITY AMONGST THE TRIBAL PEOPLE IN BAKSA DISTRICT, ASSAM, INDIA.

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ABSTRCT: Entomophagy is the habit of human consumption of insects as food. It is a habit of eating food without hampering environmental sustainability. The eggs, larvae, pupae, and adults of certain insect species have been eaten by humans from prehistoric times to the present day. Because of their high nutritive value, insects present a potential sustainable food source for humans. Insects not only provide a reliable and sustainable source of high-quality animal protein, but, they are efficient recyclers of organic matter and provide a source of economic gain for the poor. A total of 31 species of edible insect belonging to 9 orders were recorded from the different habitat types in the study area. It has already been found that insect-based food is environmentally friendlier alternative to conventional high protein products. The present paper also deals with the importance of entomophagy as a sustainable source of animal protein as well as mineral content. The present study indicates that edible insects are nutritious in terms of protein (2.5–24.6 g/100g fresh wet weight), also rich in mineral contents such as Ca, Mg, Fe etc. Considering the rising global population and environmental degradation, entomophagy fits in as a renewable source of food security for the future.

Key-words: Alternative, Conventional, Entomophagy, Renewable, Sustainability

1. Introduction:

Entomophagy means the habit of consumption of insects by human as their food. Insects are known to be eaten in 80% of the world's nations. Entomophagy is an age-old tradition amongst the indigenous communities in Assam as food supplement. Insects have been an important wild source of protein and micronutrients for millennia. Insects provide food at low environmental cost, contribute positively to rural livelihoods, and play a fundamental role in nature. Besides, insects are efficient recyclers of organic matter and provide a source of economic gain for the poor through their commercialization.. According to Smetana et al. (2016) insect-based food can be an environmentally friendlier alternative to conventional high protein products. Entomophagy depends upon insect availability, palatability and nutritional value as food. Edible insects are a rich source of protein, essential minerals and vitamins (Van Huis, 2013).

Studies point out that insect population is likely to increase with the changing climate (Saunders, 2008). Saunders (2008) suggested that commercialization and marketing of edible insects could create money-making opportunities and add key nutrients to the diet of many vulnerable populations. Global warming will increase both insects' population growth and their metabolic rates. Higher temperatures from global warming, mainly due to elevated CO_2, will increase numbers of pests. The Intergovernmental Panel on Climate Change IPCC (Team *et al*., 2007) predicted an increase of the air temperature at the order of 1.1 to 6.4ºC by the year of 2100. Due to their ectothermic nature, insects are very likely to respond quickly to increased temperatures (Robinet & Roques 2010), and rising temperatures have the potential to affect most of terrestrial insects, altering their ecological roles, as well as intra- and inter-specific interactions. Insects are among the groups of organism most likely to be affected by climate change because climate has a strong direct influence on their development, reproduction and survival. Moreover, insects have short generations' times and high reproductive rates, so they can more like to respond quicker to climate change than long-lived organisms, such as plants and vertebrates (Menendez, 2007). About 2,100 insect species consumed by humans are harvested from nature. Insects contribute significantly to the food security and livelihoods of the poor, especially women and children, who sell insects on the market or use them for personal consumption (Kalaba et al., 2013; Lindsey et al. 2013; Vantomme et al. 2004). According to the Food and Agriculture Organization, "crickets need six times less feed than cattle, four times less than sheep, and twice less than pigs and broiler chickens to produce the same amount of protein". They also produce significantly less greenhouse gasses than animals and it takes less land to raise them.

The ethnic tribal people in and around the study region consume many insects as food and also use these edible insects as a source of income for their livelihood. Eating insects are efficient, good for the environment, improve animal welfare and reduce the risk of diseases in humans. Insects play important roles in ecosystem services, and changes in their abundance and diversity have the potential to alter the services they provide (Hillstrom & Lindroth 2008).The use of edible insects as food plays a major role in food security, health, and environment protection. It is, therefore, necessary to cultivate or grow edible insect species to maintain a good human nutrition and environmental condition. The significance of the study is that entomophagy is not only good for nutritional point of view but far better from the ecological point of view for sustainable environment.

Objectives: The main objectives of the present study are

I.To find out the diversity of edible insects and health and safety impact of the insect eaters in the study area.

ii. To estimate the protein as well as mineral contents of commonly consumed insects in the study area

2. Material and Methods:

2.1 Study Area: The study area of the present study is 'Baksa Distrct', Assam, India. The latitude and longitude of the study area is 26.6935° N, 91.5984° E. The total geographical area of the study area is 2400 square kms. The district is bounded by Bhutan Hill in the North, Udalguri district in the East, Barpeta, Nalbari and Kamrup districts in the South and Chirang district in the West. The climate of the district is sub-tropical in nature with warm and humid summer and also followed by cool and dry winter. The winter temperature drops to 10^0C and summer temperature goes up to 35^0C. South west monsoon activates from June and continues up to September or October. The Baksa district represents three types of vegetation: sub-Himalayan alluvial semi-evergreen forest, east Himalayan mixed moist deciduous forest, the commonest type of grasslands and semi-evergreen alluvial grasslands Shrubs, climbers, herbs, Shrubs etc. (Champion and Seth, 1968).

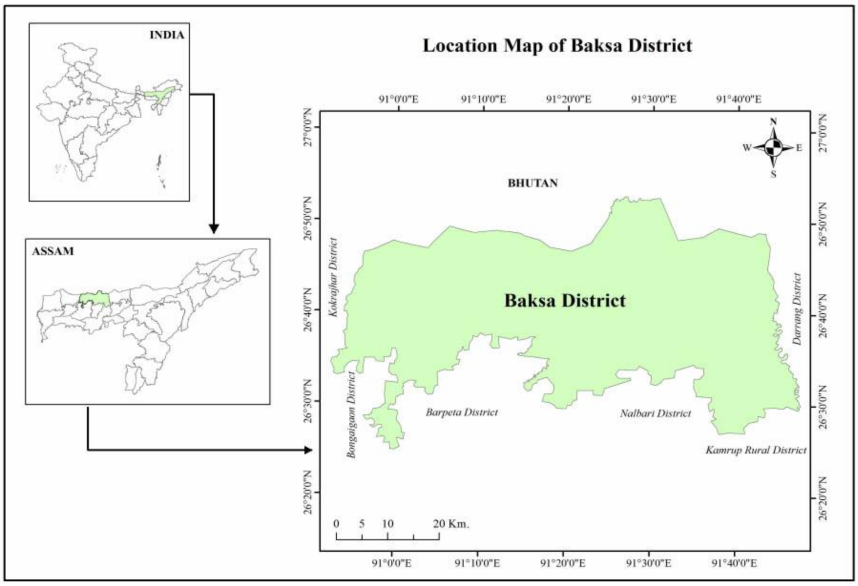

Fig.-1: The map of Baksa, Assam, India

2.2: Field survey: Extensive field survey was conducted from October 2017 to February 2018 by performing interviews using questionnaire format. About 26 villages were taken as sampling sites to conduct field survey in the study area.

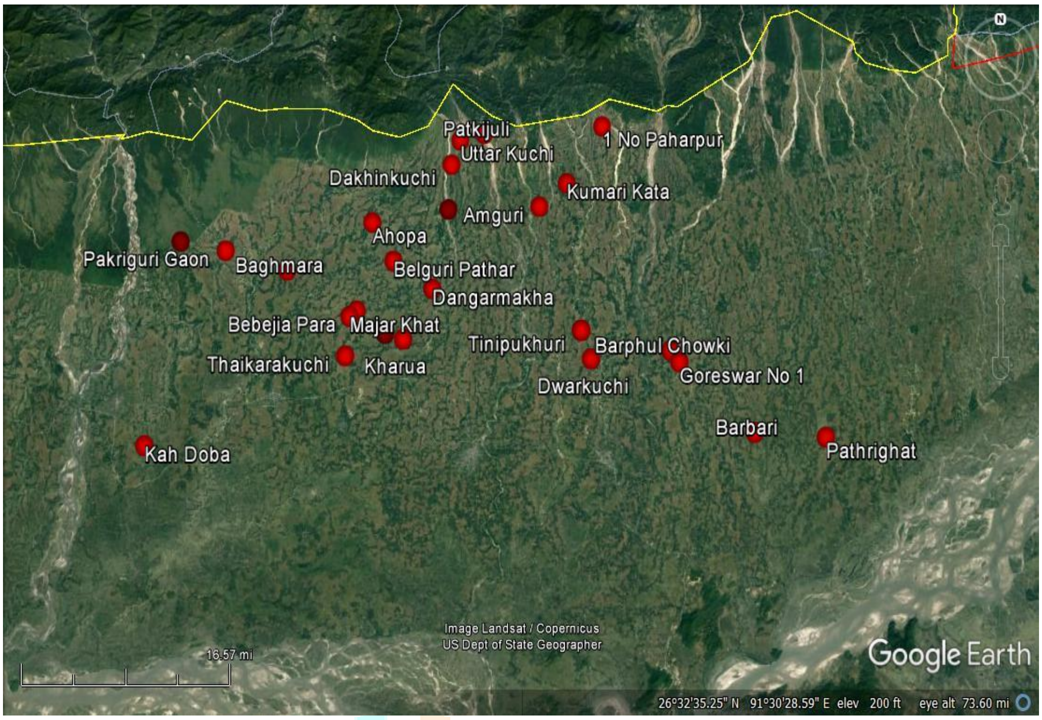

Fig-2: Map in GPS Coordinates of sampling villages of insect collection in Baksa District, Assam

2.3: Biochemical Analysis: About 16 no. of matured specimens of the seasonally available edible insects was selected for bio-chemical analysis of protein and mineral contents. The protein content of the edible insects is estimated following the method of Lowry *et al*., (1951) using bovine serum albumin as a standard protein. The soluble protein content of edible insects is expressed in mg per gm in fresh weight (Values are represented as ± standard deviation).Each parameter of biochemical analysis is determined five (5) times and result reported as mean ± SD. The mineral contents of edible insects were determined by atomic absorption spectroscopy (AAS). All the value of the micronutrients of the sample was recorded in ppm (parts per million) and calculated. The calculated values in AAS were converted into mg/100 g sample using the following formula.

µg/gm of sample= (AAS reading x volume taken)/wt. of sample

(i.e. 1 ppm = 0.001 mg/g)

3. Result: During survey, a total of 31 species of edible insect belonging to 18 families and 9 orders were recorded from the different habitat types in Baksa District, Assam. Out of these 31species, Orthopterans order shared with maximum number of 10 species followed by Hymenoptera of 6 species and Coleoptera of 5, Hemiptera of 4, Lepidoptera by 2 species and then 1 species each from Odonota, Mantodea, Blattodea and Isopteran respectively.

Table 1: Taxonomy with seasonal availability of edible insects in Baksa District

Sl. No.	Scientific name	Order	Family	English name	Edible part	Mode of eating
1	*Vespa affinis*	Hymenoptera	Vespidae	Potter wasp	Eggs &Larvae	Raw, Roasted, fried,
2	*Polistis olivaceus*	Hymenoptera	Vespidae	Paper wasp	Eggs &Larvae	Raw, Fried, smoked
3	*Parapolybia varia*	Hymenoptera	Vespidae	Lesser paper wasp	Larvae	Fried, raw
4	*Oecophylla smaragdina*	Hymenoptera	Formicidae	Weaver ant	Eggs	Raw,Fried,
5	*Lethocerus indicus*	Hemiptera	Belostomatidae	Giant Water bug	Adult	Fried or Smoked
6	*Laccotrephes ruber*	Hemiptera	Nepidae	Water scorpion	Adult	Fried or Smoked
7	*Hydrophilus olivaceus*	Coleoptera	Hydrophilidae	Water Scavenger	Larvae and Adult	Fried or Curry
8	*Gryllotalpa africana*	Orthoptera	Gryllotalpidae	Mole cricket	Adult	Fried or smoked
9	*Eupreponotus inflatus*	Orthoptera	Acrididae	Short-Horned Grasshopper	Adult	Fried or smoke
10	*Choroedocus robustus*	Orthoptera	Acrididae	Short-Horned Grasshopper	Adult	Fried
11	*Chondracris rosea*	Orthoptera	Acrididae	Short hornedGrasshopper	Adult	Fried
12	*Heiroglyphus banian*	Orthoptera	Acrididae	Grasshopper	Adult	Fried, smoked
13	*Gryllus bimculatus*	Orthoptera	Gryllidae	Field Cricket	Adult	Fried, smoked
14	*Oxya hyla hyla*	Orthoptera	Acrididae	Short horned	Adult	Fried, smoked

				Grasshopper		
15	*Mantis religiosa*	Mantodea	Mantidae	Praying mantis	Adult	Fried, smoked
16	*Periplaneta americana*	Blattodea	Blattellidae	Cockroach	Adult	Fried
17	*Acheta domestica*	Orthoptera	Gryllidae	House Cricket	Adult	Fried, smoked
18	*Eretes stictus*	Coleoptera	Dytiscidae	Larva of diving beetle	larvae	fried
19	*Phyllophaga spp.*	Coleoptera	Scarabaeidae	June beetle	Adult	fried
20	*Ictinogomphus rapax*	Odonota	Gomphidae	Dragon fly	Nymph	Fried
21	*Mecopoda elongate*	Orthoptera	Tettigoniidae	Long horned grasshopper	Adult	Roasted orfried
22	*Ruspolia baileyi*	Orthoptera	Tettigoniidae	Nsenene	Adult	Fried, smoked
23	*Orycetes rhinoceros*	Coleoptera	Scarabaeidae	Rhinoceros beetle	Larvae(Grubs)	fried
24	*Philosamia ricini*	Lepidoptera	Saturnidae		Larvae, pupae	fried
25	*Anthera assama*	Lepidoptera	Saturnidae	Muga silkworm	Larvae, pupae	Fried
26	*Apis cerena indica*	Hymenoptera	Apidae	Indian honey bee	Egg& larvae	Raw
27	*Apis dorsata*	Hymenoptera	Apidae	Rock bee	Egg& larvae	Raw
28	*Plectroderma scalator*	Coleoptera	Cerambycidae	Wood borer	Larvae	Fried
29	*Diplonychus rusticus*	Hemiptera	Belostomatidae	Water beetle	Adult	Fried or curry
30	*Microtermes obesi*	Isoptera	Termitidae	Termite	Larvae,Adult	Fried
31	*Pomponia imperatorial*	Hemiptera	Cicadidae	Cicada	Adult	fried

A total of 16 numbers of insects consumed by tribal people are chemically analysed their protein amount which is shown in the table-2. Among these 16 numbers of species, 9 species were common insects' pests (table-3) which usually invade agricultural crops as well as vegetables in the study area.

Table -2: the soluble Protein content in 16 edible insects in mg/gm. Fresh wet weight (values are mean±SD of three replicates). Means having different superscripts (a,b,c…) differ significantly (P<0.05).

Common Name	Protein content (mg)	
	Mean	**SD**
Lethocerus indicus	216.33^{hi}	± 2.52
Microtermes obesi	145.67^{cd}	± 7.09
Gryllotalpa africana	169.00^{e}	± 7.94
Acheta domestica	198.00^{fg}	± 8.54
Eupreponotusinflatus	152.67^{d}	± 6.66
Choroedocusrobustus	220.33^{i}	± 8.50
Ruspoliabaileyi	192.00^{f}	± 8.54
Vespa affinis(*larvae*)	145.00^{cd}	± 7.21
Oecophylla smaragdina	82.00^{b}	± 5.57
Hydrophillus olivaceus	246.00^{j}	± 8.72
Philosamia ricini (pupae)	194.00^{f}	± 6.56
Laccotrephes ruber	208.00^{gh}	± 8.19
Philosamia ricini(larvae)	136.00^{c}	± 6.08
PeriplanetaameriP P Periplaneta americana	136.00^{c}	± 6.08
Phyllophaga spp.	244.33^{j}	± 6.66
Eretis sticticus (larvae)	25.36^{a}	± 1.49

As these nine insect pests (Table-3) are consumed in the ethnic tribal people in the study area and so such insect eating habit reduces the use of pesticides and subsequently entomophagy helps in environmental sustainability in the study area.

Table-3: The soluble Protein content in some common insects' pest consumed by ethnic tribal people

Common Name of some insect pest	**Protein content (mg)**			
	Mean			**SD**
Winged Termites	145.67	cd	±	7.09
Mole Crickets	169.00	e	±	7.94
House Crickets	198.00	fg	±	8.54
Grasshopper (big sized)	152.67	d	±	6.66
Grasshopper (brown colour)	220.33	i	±	8.50
Grasshopper (small sized)	192.00	f	±	8.54
Wasp (larvae)	145.00	cd	±	7.21
Cockroach	136.00	c	±	6.08
June beetle	244.33	j	±	6.66

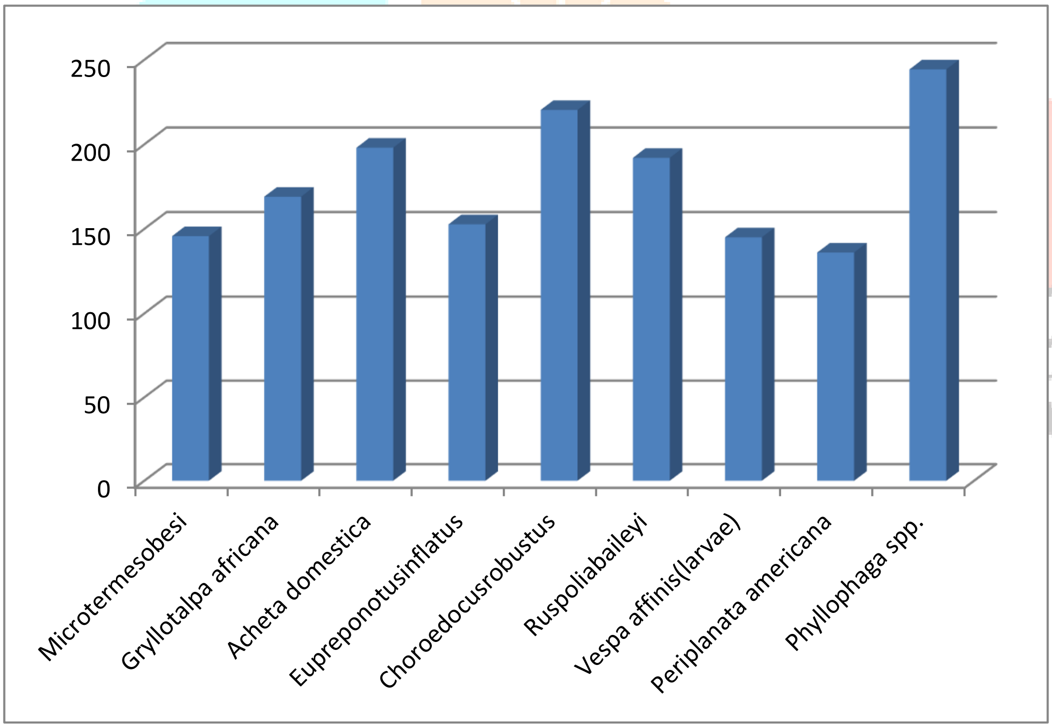

Fig-3: Graphical representation of protein contents in edible insect pests in study area

The mineral contents of edible insects show high diversity among the species. Each species has a specific amount of mineral. Insects also have a high content of mineral elements such as copper, iron, magnesium, manganese, phosphorus, calcium and zinc. From the biochemical study of mineral content of some edible insect pests it is found that no heavy metals lead (Pb) or cadmium (Cd) is found in the experimental insects.

Table-4: Mineral content of some edible insects pests

Name of insects	Cu mg/100g	Fe mg/100g	Ni mg/100g	Cr mg/100g	Zn mg/100g	Mn mg/100g	Ca mg/100g	Mg mg/100g
Acheta domestica	0.217	9.582	0.100	0.106	14.113	0.304	69.520	5.905
Ruspolia baileyi	0.837	12.935	0.022	0.028	12.675	1.428	28.337	16.505
Gryllotalpa africana	0.023	6.468	.0056	0.978	7.211	2.342	19.900	29.800
Eupreponotus inflatus	0.987	18.451	0.5422	0.432	11.132	3.110	38.994	15.405
Choroedocus robustus	0.782	19.060	0.0544	2.004	10.982	1.980	39.866	19.478
Vespa affinis(*larvae*)	01.711	33.682	0.305	0.998	33.986	2.325	18.349	22.764
Periplaneta americana	0.056	2.753	0.066	0.860	1.22	4.445	5.832	5.206
Phyllophaga spp.	0.452	6.078	0.087	1.220	3.811	9.090	16.221	23.402
Microtermes obesi	0.870	16.924	0.009	1.228	14.568	1.922	22.223	13.432

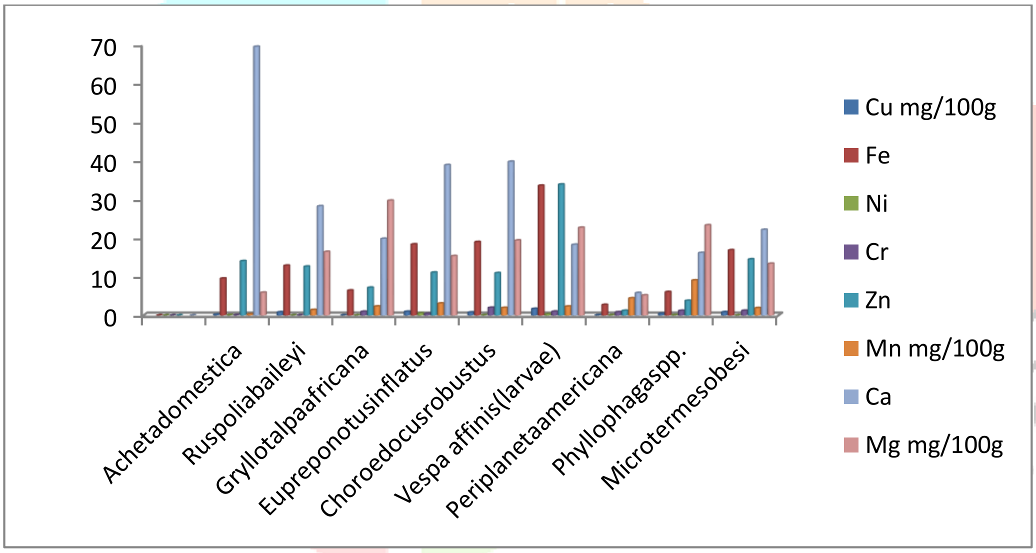

Fig-4: Graphical representation of mineral contents in some edible insects' pest

4. Discussion: Insect nutritional composition is highly diverse in comparison with commonly consumed meats. The present biochemical analysis shows that insects vary widely between species in terms of protein as well as mineral elements. Insects rich in protein and high in mineral contents. Insects can be an even more efficient source of protein than animals. A study published in the European Journal of Clinical Nutrition shows that "insects contain values of between 9.96 and 35.2 grams of protein per 100 grams, compared with 16.8-20.6 grams for meat"(Payne et.al,2016). According to Chen *et al.*, (2009) edible insects are rich in are protein and fat but not so rich in carbohydrate. On chemical analysis, it is observed that edible insects are rich in macronutrient content in terms of protein ranges from 2.54g/100g to 24.6 g/100g fresh wet weight. Thus, the present study revealed that there was a significant variation in the protein content among the commonly consumed insects. A recent study on edible insects by Payne *et al., (*2016) revealed that the value of protein content exposed with insects containing median values of between 9.96 g and 35.2 g of protein per

100 g, compared with 16.8–20.6 g for meat. Similar results were observed in the study of Finke (2002); Oonincx *et al.*, (2010); Oonincx *et al.*,(2011); Oonincx *et al.*, (2012),who revealed that the protein content of insects was highly variable and ranged between 75% and 91% with many species containing around 60% protein on a dry matter basis. Ramos-Elorduy *et al.,* (2012) observed the protein content in Orthopteran insects ranging from 43.9 to 77.1% of dry matter. Other works support the presence of rich protein contents in these insects (Haldar *et al.*, 1999 and Ganguly *et al.*, 2013). The present investigation reveals that the protein content of some insect pests belong to order Orthoptera ranges from 15.26g/100g to 22.03g/100g fresh weight.

The present study discloses that edible insects are high in calcium, zinc, iron and in magnesium. Talwar *et al.*, 1989 reported that minerals are known to play important metabolic and physiologic roles in the living system. Iron, zinc, copper and manganese strengthen the immune system as antioxidant enzyme cofactors. The study conducted by Rumpold & Schulter (2013) and Makore *et al.*, (2015) had the similarity with the present study. They found that insects have significant amounts of minerals such as phosphorus, magnesium, calcium, iron, zinc and potassium. In the present study, *Acheta domestica*, a terrestrial insect pest, contains the highest amount of calcium (69.520mg/100g) and other terrestrial edible insects are in between the range of 5.832mg/100g to 39.866mg/100g.

Smetana et al. (2015) concluded that insect-based and soy meal-based products were associated with the lowest environmental impact. It is reported that poultry production in Thailand is associated with 89% higher greenhouse gas emissions, on an edible protein basis, than cricket, an edible insects (Halloran et al. 2017). Moreover, many species of herbivorous insects will meet less nutritious host plants under elevated CO2, which may bring about both prolonged larval developmental times and greater larval mortality (Coviella and Trumble 1999). Increased levels of CO2 will enhance plant growth, but may also increase the damage caused by some phytophagous insects (Gregory et al. 2009). Edible insects, either as a source of food or feed, have an impact on the environment. According to Smetana et al. (2016), insect-based food can be an environmentally friendlier alternative to conventional high protein products. The emission of NH_3 in the case of insects is very less in comparison to other livestock animals ranging from 1.57 to 4.29 mg/kg BM/day. But, pigs emit 4.8–75 mg/kg BM/day (, cattle 14–170 mg/kg BM/day and poultry 72–436 mg/kg BM/day (Koerkamp et al., 1998, Nicks et al., 2003, Cabaraux et al., 2009) Demmers et al., 1999). It is found that edible insects are rich in protein and minerals. Moreover, insects eaters were found to be healthier compared to insect non-eaters.

5. Conclusion: The present study indicates that edible insects are nutritious in terms of protein (2.5–24.6 g/100g fresh wet weight), also in mineral contents. Protein is necessary in building and repairing body tissues besides the growth and maintenance of tissues. Global climate change and the increasing food insecurity in many parts of the developing world may put insects on the menu for many families in many communities. The production of edible insects has great potential not only in terms of supply of protein and nutrient for humans but also as an economic aspect in the food sector. So, rearing of insects has been suggested as a good substitute to conventional livestock production.

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