International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Macronutrient Content of Some Edible Insects with Reference to the Baksa District of Assam, India

Dr. Jayanta Kr. Das

Assistant Professor, Dept. of Zoology, Barama College, Barama

Abstract: ***Insects are very tasty food used in India as well as other countries in the world. Insects play an important role in the creation of a sustainable food security. The habit of eating insects has been being a part of daily life for a number of ethnic tribal people in North east India. Insects not only provide nutritional protection but also give a livelihood to poor ethnic people of society. This paper has focussed on the quantitative analysis of macronutrient contents in insects commonly consumed in Baksa district Assam. The survey results show that entomophgy is most common in villages of Assam in comparison to urban areas. On chemical analysis it is observed that edible insects are nutritious in terms of protein (2.5–24.6 gm/100g fresh weight), lipid (1.6-18.6 gm. /100g fresh wt.), and carbohydrate (0.2- 5.8 gm/100 g fresh wt.). In the present study, Phylophaga spp., a terrestrial insect, contains the highest amount of protein (24.4 g/100g fresh wet.) in comparison to other terrestrial edible insects studied. The Hydrophilusolivaceus, an aquatic edible insect, has maximum amount of protein in comparison to other studied insects Most of the insects consumed in the study area are rich in proteins compared to other macronutrients and thus it suggests that insects can be used as substitute protein supplements instead of other meat or fish proteins in our normal diet.***

Keywords: Ethnic, Livelihood, Nutritional, Supplements, Sustainable

1. Introduction

Insects are specialized group of animals belonging to the largest animal phylum Arthropoda in Animal kingdom. Most of the insects found in the Study area are edible that provide food and livelihood to the ethnic people in the study area. Insects are one of most successful diverse groups in the animal kingdom because they are able to live in and adapt to diverse habitats of air, water and land, possess the high reproductive capacity and can live on different kinds and qualities of food. Insects have the wide range of adaptation and they can adjust in any environmental conditions. Food and Agriculture Organization of the United Nations (2013) states that insects have a high nutritional value and their farming is environmentally friendlier compared to other animal protein sources.

Most of the vertebrates viz fishes, toads, frogs, turtles, snakes and lizards, birds and some mammals including man also consume insects as a major part of their diet. A recent data reveals that 2141 different species are consumed by the people of all over the world (Mitsuhashi, 2016). It was found that a total of 81 species are eaten in Arunachal Pradesh by two ethnic tribes namely Galo and Nyishi (Chakravorty *et al.*, 2011).

In many developing countries in the world, insects remain a vital and preferred food amongst variou cultures and an essential source of protein, fat, minerals and vitamins (Durst and Shono, 2010). The growth of the fish was also reported to be fast if fed with insects (Ronghang and Ahmed, 2010).The ethnic people in the study area consume crickets, mole crickets, grasshoppers, water giant bug (Bellostoma), water scavengers, termites, June beetle, eggs of red ants, beetle, larvae and pupae of Eri, and Muga, larvae of wasps etc. No negative impacts were found among the insect consumers in the study area, rather the insect-eaters are seen to be well-fed. Therefore, there lies the significance of the present study in the Baksa, Assam. Moreover, there are claims by the consumers that the insects are good for healthy growth and various illnesses of human beings. Considering these facts, the present study was conducted to know nutritional status of common edible insects consumed by some group of people in the district of Baksa, Assam. As far as Baksa District, Assam is concerned, no work has been carried out on nutritional composition of edible insects till now, and so the present investigation is significant with the aim to evaluate the macro-nutrients composition of selected insects commonly consumed by certain groups of people in the study area.

2. Experimental Section

The study area of the present study is 'BaksaDistrct', Assam, India (Fig-1). The latitude and longitude of the study area is 26.6935° N, 91.5984° E. The Baksa district, Assam is one of the 27 districts in Assam of the north- eastern India. Baksa District is located in the foothills of Bhutan Himalayas and northern part of Brahmaputra flood plain (26º 32' -26º 40' N, 90º 56'- 91º 43'E).

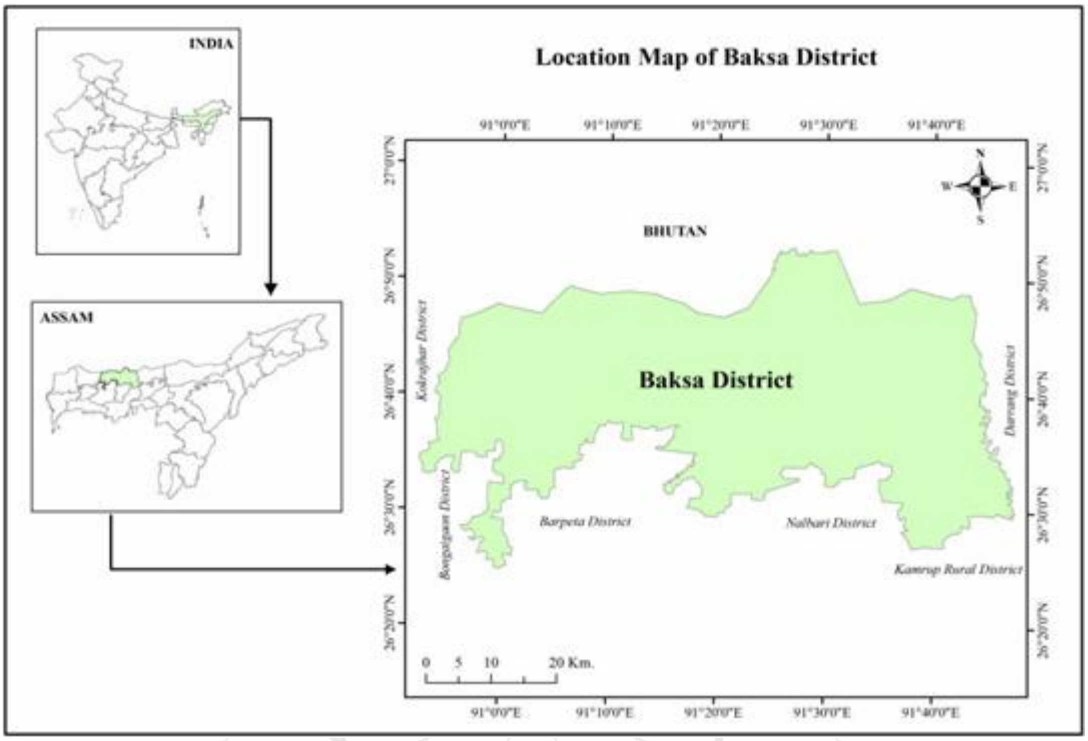

Figure 1: Map of the Study Area

Edible insects were collected using entomological nets, beating tray, water traps, digging and handpicked. The insect specimen were identified and classified with valid taxonomic key. Few were preserved with standard methods (Ghosh and Sengupta, 1982) and identified later on comparing with the other specimens. Some insects were identified in the ZSI, Shillong, N.E, India.

For chemical analysis, adult and healthy insects were selected. 10% tissue homogenate was prepared by mixing 1 gram of insect in 10 ml of phosphate buffered saline (PBS, pH 7.4) using a tissue homogenizer. The homogenate was centrifuged at 6,000 rpm for 10 min using a centrifuge machine. The supernatant was collected and used as tissue source for biochemical analysis.

Estimation of protein

The protein content of the edible insects were estimated following the method of Lowry *et al*., (1951) method using bovine serum albumin as a standard protein.

Estimation of carbohydrate

Estimation of carbohydrate was done by following anthrone method (Sadasivam and Manickam, 2008).

Estimation of lipid

The total lipid was estimated using chloroform methanol method described by Folch*et al.*,(1957).

3. Result and Discussion

During survey, a total of 30 species of edible insect belonging to 18 families and 9 orders were recorded from the different habitat types in Baksa District.

3.1 Diversity of edible insects in Baksa, Assam

Table 1shows the diversity of edible insects consumed by the ethnic people in Baksa district found during questionnaire survey.

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

Sl. No.	Scientific name	Order	Family	English name	Seasonal availability	Edible part	Mode of eating
1	*Vespa affinis*	Hymenoptera	Vespidae	Potter wasp	April- September	Eggs &Larvae	Raw, Roasted, fried,
2	*Polistisolivaceus*	Hymenoptera	Vespidae	Paper wasp	April-Oct	Eggs &Larvae	Raw, Fried, smoked
3	*Parapolybiavaria*	Hymenoptera	Vespidae	Lesser paper wasp	April-Oct	Larvae	Fried, raw
4	*Oecophylla smaragdina*	Hymenoptera	Formicidae	Weaver ant	March-Aug	Eggs	Raw,Fried,
5	*Lethocerusindicus*	Hemiptera	Belostomatidae	Giant Water bug	Whole Year	Adult	Fried or Smoked
6	*Laccotrephesruber*	Hemiptera	Nepidae	Waterscorpion	Jun-Oct	Adult	Fried or Smoked
7	*Hydrophilusolivaceus*	Coleoptera	Hydrophilidae	Water Scavenger	Whole Year	Larvae and Adult	Fried or Curry
8	*Gryllotalpaafricana*	Orthoptera	Gryllotalpidae	Mole cricket	Whole Year	Adult	Fried or smoked
9	*Eupreponotusinflatus*	Orthoptera	Acrididae	Short-HornedGrasshopper	May-Sep	Adult	Fried or smoke
10	*Choroedocusrobustus*	Orthoptera	Acrididae	Short-Horned Grasshopper	June-Oct	Adult	Fried

11	*Chondracrisrosea*	Orthoptera	Acrididae	Short hornedGrasshopper	June-August	Adult	Fried
12	*Heiroglyphusbanian*	Orthoptera	Acrididae	Grasshopper	June-Oct	Adult	Fried, smoked
13	*Gryllusbimculatus*	Orthoptera	Gryllidae	Field Cricket	May-Sept.	Adult	Fried, smoked
14	*Oxyahyla*	Orthoptera	Acrididae	Short hornedGrasshopper	April-September	Adult	Fried, smoked
15	*Mantis religiosa*	Mantodea	Mantidae	Praying mantis	June-November	Adult	Fried, smoked
16	*Periplanetaamericana*	Blattodea	Blattellidae	Cockroach	Whole year	Adult	Fried
17	*Achetadomestica*	Orthoptera	Gryllidae	House Cricket	May-Sept	Adult	Fried, smoked
18	*Eretesstictus*	Coleoptera	Dytiscidae	Larva of diving bettle	Whole year	larvae	fried
19	*Phyllophaga spp.*	Coleoptera	Scarabaeidae	June beetle	April- June	Adult	fried
20	*Ictinogomphusrapax*	Odonota	Gomphidae	Dragon fly	March- August	Nymph	Fried
21	*Mecopoda elongate*	Orthoptera	Tettigoniidae	Long horned grasshopper	May-Sept	Adult	Roasted orfried
22	*Ruspoliabaileyi*	Orthoptera	Tettigoniidae	Nsenene	June-Oct	Adult	Fried, smoked
23	*Orycetesrhinoceros*	Coleoptera	Scarabaeidae	Rhinoceros beetle	Sept-Feb	Larvae(Grubs)	fried
24	*Philosamiaricini*	Lepidoptera	Saturnidae	Erisilkworm	April-Sept	Larvae, pupae	fried
25	*Antheraassama*	Lepidoptera	Saturnidae	Muga silkworm	April-Sept	Larvae, pupae	Fried
26	*Apisindica*	Hymenoptera	Apidae	Indian honey bee	May-Sept	Egg& larvae	Raw
27	*Apisdorsata*	Hymenoptera	Apidae	Rock bee	May-Sept	Egg& larvae	Raw
28	*Plectrodermascalator*	Coleoptera	Cerambycidae	Wood borer	May- August	Larvae	Fried
29	*Diplonychusrusticus*	Hemiptera	Belostomatidae	Water beetle	May-Sep	Adult	Fried or curry
30	*Microtermesobesi*	Isoptera	Termitidae	Termite	March- July	Larvae,Adult	Fried

3.2 Biochemical Analysis of edible insects:

Out of these 30 edible insects species, 16 adult healthy insect species were selected for bio-chemical analysis.The soluble protein, lipid and carbohydrate contents present inedible insects are expressed in mg per gm in fresh weight as shown in the following table (Values are represented as ± standard deviation):

Table 2 (A): Protein, lipid and carbohydrate content in different 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)		Lipid content (mg)		Carbohydrate content (mg)	
	Mean	SD	Mean	SD	Mean	SD
Bellostoma	216.33 ^{hi}	± 2.52	133.00 ^{f}	± 7.21	29.00 ^{c}	± 3.61
Winged Termites	145.67 ^{cd}	± 7.09	186.33 ^{g}	± 7.64	45.35 ^{fg}	± 5.78
Mole Crickets	169.00 ^{e}	± 7.94	65.00 ^{de}	± 4.36	58.00 ^{ij}	± 3.46
House Crickets	198.00 ^{fg}	± 8.54	69.00 ^{de}	± 4.36	53.00 ^{hi}	± 2.65
Grasshopper (big sized)	152.67 ^{d}	± 6.66	72.01 ^{e}	± 6.25	32.02 ^{cd}	± 3.44
Grasshopper (brown colour)	220.33 ^{i}	± 8.50	69.00 ^{de}	± 3.61	48.00 ^{gh}	± 2.65
Grasshopper (small sized)	192.00 ^{f}	± 8.54	70.33 ^{de}	± 6.81	41.05 ^{ef}	± 2.73
Wasp (larvae)	145.00 ^{cd}	± 7.21	68.33 ^{de}	± 4.04	61.00 ^{j}	± 6.56
Weaver ant (egg)	82.00 ^{b}	± 5.57	35.00 ^{b}	± 4.58	2.90 ^{a}	± 0.17
Water scavenger	246.00 ^{j}	± 8.72	62.00 ^{d}	± 3.61	38.00 ^{de}	± 2.65
Eri (Pupae)	194.00 ^{f}	± 6.56	73.00 ^{e}	± 3.61	18.03 ^{b}	± 1.62
True water beetle	208.00 ^{gh}	± 8.19	72.00 ^{e}	± 3.61	35.00 ^{cde}	± 4.58
Eri (4th instar larvae)	136.00 ^{c}	± 6.08	46.10 ^{c}	± 2.85	32.17 ^{cd}	± 2.25
Cockroach	136.00 ^{c}	± 6.08	192.04 ^{g}	± 8.49	2.10 ^{a}	± 0.10
June beetle	244.33 ^{j}	± 6.66	22.28 ^{a}	± 2.41	35.67 ^{de}	± 2.52
Eretissticticus (larvae)	25.36 ^{a}	± 1.49	16.30 ^{a}	± 0.97	45.35 ^{fg}	± 3.75

Table 2 (B): Analysis of variance (ANOVA) of protein, lipid and carbohydrate content among different insects

Concentration	Variation	Sum of Squares	df	Mean Square	F	Significance
Protein	Between Groups	155278.615	15	10351.908	214.576	P<0.001
	Within Groups	1543.791	32	48.243		
	Total	156822.406	47			
Lipid	Between Groups	115136.776	15	7675.785	299.551	P<0.001
	Within Groups	819.977	32	25.624		
	Total	115956.753	47			
Carbohydrate	Between Groups	13183.601	15	878.907	73.709	P<0.001
	Within Groups	381.566	32	11.924		
	Total	13565.167	47			

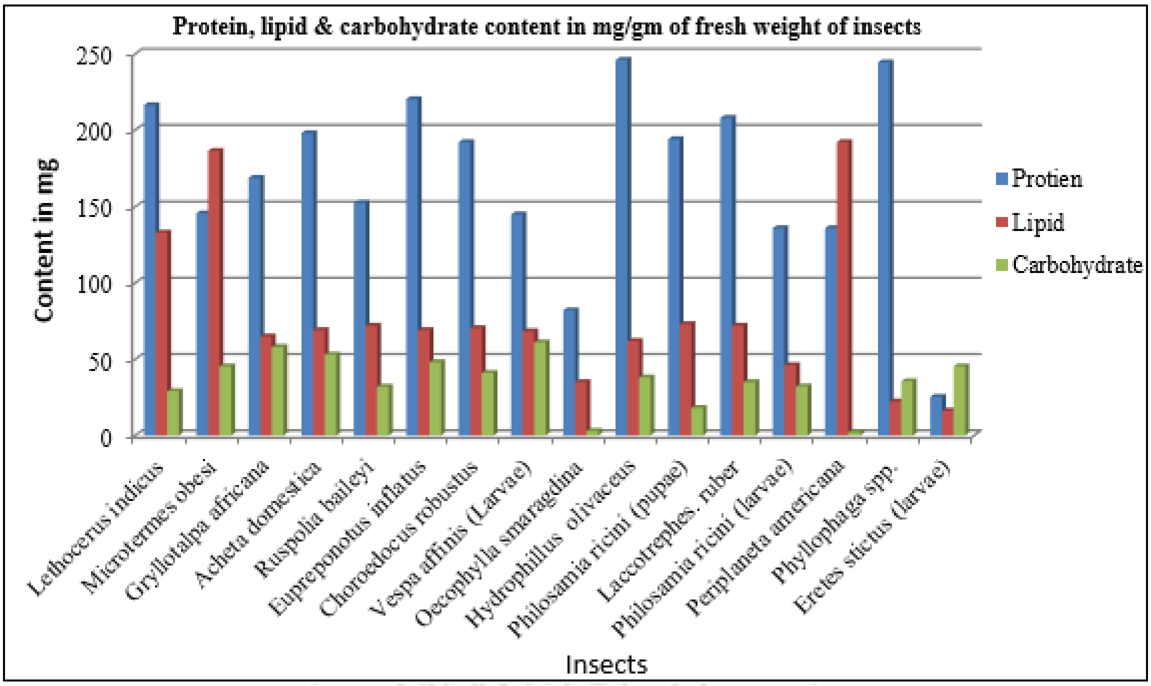

Figure 2: Multiple bar diagram ofmacronutrients composition of commonly consumed edible insects (mg/gm fresh weight)

From the above multiple bar diagram the following observation were found :

(i) The protein contents are more in larve followed by water scvenger, june beetle and grasshopper (brown colour).
(ii) The protein content is less in weaver ant or red ant.
(iii) The lipid contents are more in winged termites followed by bellostoma.
(iv) The lipid contents are found to be more or less same in other insects.
(v) The content of carbohydrate is not found in much amount in any of the insects.

Again while calculatingpairwise correlation between the protein, lipid and carbohydrate contents available in the edible insects, the following correlation matrix can be obtained(Table:3).

Table3: Correlation amongmacro nutrient contents of the edible insects

Correlation matrix

	Protein	Lipid	Carbohydrate
Protein	1	0.0451	0.3556
Lipid	X	1	-0.3652
Carbohydrate	X	X	1

From the correlation it can be concludedby followingfindings :

(i) There is less positive correlation between conetent of protein and lipid content in insects.It can be inferred here that when the protein content in any insect incerases then the lipid content in it also increases in a very small amount.
(ii) There is positive correlation between conetent of protein and carbohydrate content in insects.It can be inferred here that when the protein content in any insect incerases then the carbohydrate content in it increases i.e when the content of protein in any insect is more it implies that the content of carbohydrate will also be more. We can infer that insects are rich in protein and carbohydrate contents together.
(iii) There is negative correlation between conetent of carbohydrate and lipid content in insects.Itis foundhere that when the carbohydrate content in any insect incerases then the lipid content in it decreases i.e. we can infer that insects are not rich in lipid and carbohydrate contents together.

The present biochemical analysis shows that insects vary widely between species in terms of macro-nutrient. Insects are rich in protein and lipid with reasonable amount of carbohydrate. On chemical analysis, it is observed that edible insects are rich in macronutrientcontent in terms of proteinranges from 2.54g/100g to 24.6 g/100g fresh wet weight. Similar results were found by Chen *et al.*, (2009) that edible insects were rich in protein and fat but not so rich in carbohydrate. 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. According to Payne *et al.*, (2016) insect nutritional composition showed high diversity between species which has conformity with the present result of biochemical estimations. Similar biochemical results on edible insects were recorded by Bozdoğan*et al.*, (2016) who indicated that proteins, lipids and carbohydrates were important constituents of insects and there was no relationship between the wet weight and the amount of protein, lipid and carbohydrate.The present study revealed that lipid content of studied edible insects varies from1.6g/100g–19.2 g /100g fresh wet weight, carbohydrate content varies from 0.2 g/100g - 5.8 g/100 g fresh wet weight. Thus, during bio-chemical estimation, the protein content of edible insects was found to be the highest amount followed by lipid content. The lipid content of *Hydrophilusolivaceus*, *Lethocerusindicus* and

Laccotrephesruber is 6.2g/100g, 7.2 g/100g and 13.3g/100g respectively. A considerable amount of carbohydrate in the studied aquatic insects is found ranging from 2.9g/100g (*L. indicus*), 3.5g/100g (*L. ruber*) to 3.8g/100g (*H. olivaceus*). Amongst the terrestrial insects *Phyllophaga species* has highest amount of protein 24.4g/100g but it has found less amount of lipid i.e. 2.2g/100g and carbohydratecontent with3.5 g/100g. Out of all studied terrestrial insects, *Periplanetaamericana* has the highest lipid contentwith 19.2g/100g with moderate amount of lipid with 13.5 g/100g and least amount of carbohydrate i.e. 0.21 g/100g.Insects suggest a high fat content in the human diet.

The biochemical estimation of three different species of grasshopper showed a variation in terms of macronutrients contents. The present investigation reveals that the protein content of grasshoppers belong to order Orthoptera ranges from 15.26g/100g to 22.03g/100g fresh weight and the lipid content of edible Orthopteran species ranges from 6.9 g/100g to 7.2 g/100g fresh insects. These findings have the similarity with the result of Xiaoming*et al.*,(2010) who recorded that the protein content Locust and grasshoppers (Adults) belong to order Orthoptera ranged from 13 g/100g t0 28g/100g fresh weight. From the macronutrient point of view, grasshoppers are good source of protein and these insects were collected from agricultural field habitats during crop harvesting time.

The study on Oecophyllas *maragdina*, Fabricius conducted byBorgohain*et al.*, (2014) statedthat highest amount of total lipid was observed in larva of *Oecophyllasmaragdina* with a mean value of 24.92 g/ 100g. This result contradicts with the result of the present study that egg of *Oecophyllasmaragdina* which mean value of total lipid is only 3.5g/100 g. Of course, the sample of the biochemical study is different. Borgohain *et al.*, (2014) studied on larva of *Oecophyllasmaragdina* whereas the present study is made on eggs of *Oecophyllasmaragdina*. This can be interpreted that nutrient composition of edible insects may vary on the basis of different life stages of the insects.

The present study also reveals that 100 grams fresh weight of house cricket (*Achetadomestica*) contains 19.8 grams of protein, 6.9 grams of lipid and 5.3 grams of carbohydrate. These findings have congruity with the results of Lukiwati (2010) who revealed that 100 grams of cricket contain 121 calories, 12.9 grams of protein, 5.5 grams of fat, 5.1 grams of carbohydrates. Even Cockroach, a house hold pest, is also rich protein i.e. 13.6g/100g with sufficient amount of lipid content i.e. 19.2g/100g. This result is in agreement with the report of Bozdoğan *et al.*(2016) who indicated that, proteins, lipids and carbohydrates are importantto selection of an effective biological control agent.

4. Conclusion

It is already established that insects can be used as pollinators, biological control agents, and vehicles for education. The high cost of animal protein, which is beyond the reach of the poor, has greatly encouraged entomophagy. It is also found that the use of pesticides has been reduced in areas where insects are used as a food resource. Protection of food is a vital issue for low income group of people who need to fight to meet their nutritional needs. Thus edible insects can play vital role to meet the nutritional need for the poor people of the society.

5. Acknowledgements

The author like to express my sincere acknowledgement to **Director,** IASST, Boragaon, Guwahati, Assam for giving me permission of doing all the bio-chemical tests there. I also like to thank and grateful to **Dr.Dipali Devi**, Professor, Sericulture Branch, IASST, Boragaon, Guwahati for her valuable and full support in completion of biochemical experiments.

References

[1] Bozdoğan, H., Erbey, M., &Aksoy, H. A. (2016). Total amount of protein, lipid and carbohydrate of some adult species belong to curculionidae family (Coleoptera: Curculionidae).
[2] Borgohain, M., Borkotoki, A., &Mahanta, R. (2014). Total Lipid, Triglyceride and Cholesterol Contents in OecophyllaSmaragdina, Fabricius Consumed in Upper Assam of North East India. *International Journal of Scientific and Research Publications*, pp 455.
[3] Chakravorty, J., Ghosh, S., & Meyer-Rochow, V. B. (2011). Practices of entomophagy and entomotherapy by members of the Nyishi and Galo tribes, two ethnic groups of the state of Arunachal Pradesh (North-East India). *Journal of ethnobiology and ethnomedicine*, *7*(1), 5.
[4] Chen, X., Feng, Y., & Chen, Z. (2009). Common edible insects and their utilization in China. Entomological research, 39(5), 299-303.
[5] FAO (2013). Edible insects: Future prospects for food and feed security. Forestry paper, 171: -154.
[6] Folch, J., Lees, M., & Sloane-Stanley, G. H. (1957). A simple method for the isolation and purification of total lipids from animal tissues. *J biolChem*, *226*(1), 497-509.
[7] Ghosh, A. K., &Sengupta, T. (1982). Handbook on insect collection, preservation and study.
[8] Lowry, O., Rosebrough, N., Farr, A., & Randall, R. (1951). Protein determination by a modified Folin phenol method. *J. biol. Chem*, *193*, 265-275.
[9] Lukiwati, D. R. (2010). Teak caterpillars and other edible insects in Java. Forest insects as food: humans bite back, 99.
[10] Mitsuhashi, J.(2016) Edible Insects of the World, 1st ed.; CRC Press: Boca Raton, FL, USA, 2016; p. 296.
[11] Payne, C. L. R., Scarborough, P., Rayner, M., &Nonaka, K. (2016). Are edible insects more or less 'healthy'than commonly consumed meats? A comparison using two nutrient profiling models developed to combat over-and undernutrition. *European journal of clinical nutrition*, *70*(3), 285-291.
[12] Ronghang, R, Ahmed, R. (2010) Edible insects and their conservation strategy in Karbianglong district of Assam, North East India. The Bioscan 2: 515-521
[13] Sadasivam, S., &Manickam, A. (2008). Biochemical Methods New Age International (P) Limited. *New Delhi*, 4-10.
[14] Xiaoming, C., Ying, F., Hong, Z., &Zhiyong, C. (2010). Review of the nutritive value of edible insects. Forest insects as food: humans bite back, 85.