International Journal of Food Science and Nutrition
ISSN: 2455-4898, Impact Factor: RJIF 5.14
www.foodsciencejournal.com
Volume 2; Issue 4; July 2017; Page No. 38-42

Nutritional aspects of an aquatic edible insect *Sympetrum* sp. (Odonata:Libellulidae) of Assam, northeast India

Silistina Narzari, Jatin Sarmah

Department of Biotechnology, Bodoland University, Kokrajhar, Assam, India

Abstract
Insects are popularly consumed in different parts of the globe. The aquatic edible nymphs of *Sympetrum* sp. (Odonata: Libellulidae) of Assam, Northeast India is little known to science but is a delicacy among certain tribal communities in the region. This study reports the nutritional compositions of the edible nymph of *Sympetrum* sp. The proximate composition analysis revealed that it contains 76.75 g/100g of protein. Mineral analysis by Atomic Absorption Spectrophotometer showed that this food can supplement rich amount of phosphorus, iron and copper to human nutrition. Amino acids analysed by High Performance liquid Chromatography presented all essential amino acids excluding leucine. Fatty acid analysis by Gas Chromatography Mass Spectrometry revealed that it contains 50.62% of Saturated Fatty Acids, 49.36% of Unsaturated Fatty Acids. This study first reports the rich nutritional aspects of the nymphs of *Sympetrum* sp. The results of this work would possibly be a nutritional reference for local consumers.

Keywords: amino acids; fatty acids; minerals; nutritional compositions; tribal communities

1. Introduction
Consumption of edible insects is an ancient practice among many tribal communities of Northeast India. In rural northeast India particularly, edible insects are not only valuable sources of protein but also a highly appreciated delicacy. Protein and fats are, however, not the only benefit gained from insect consumption. With an energy, protein and fat constituent comparable to or superior to that of beef and pork, there are additionally other good reasons to promote entomophagy [1, 2]. Significant levels of other essential nutrients are also contributed by insects, for example, the weaver ant (*O. smaragdina*), harvested in Arunachal Pradesh, India possesses significantly higher levels of iron and zinc than does beef or pork [3]. Amino acid contents in edible insects are higher than the adult requirements specified in the WHO/FAO pattern [4]. Moreover, Ramos-Elorduy (2008) [5], DeFoliart (1992) [6] and Krause and Mahan (2003) [7] found that the fats in insect larvae, are mostly polyunsaturated and consequently is a healthier alternative to fats found in conventional beef and vegetables. Insects are consumed at different stages of development while most of them are consumed in their immature stages [8, 9]. It is known that in Northeast India, insects are consumed, but the scope of their use, the species utilised and the ecology of the edible insects are indistinct and focused mainly on the eri silkworm (*Samia ricinii*), an edible insect commercially reared in Assam, India. There are at least 25 insect species that are considered edible in Assam, India [10]. Most of these insect species have been documented for their edibility and their proximate nutritional values [11]. However, there are more species eaten in Assam for which less information is available. This paper investigates the nutritional value including minerals, amino acids and fatty acids of edible *Sympetrum* sp. of Assam, Northeast India.

2. Materials and methods
2.1 Sample collection and preparation
Representative samples of *Sympetrum* sp. were collected from their aquatic freshwater habitats using traditional traps called "Jakhai". The specimens were taken to the laboratory of Bodoland University, Kokrajhar, Assam, India, washed thoroughly, sun dried and grinded to dry powder as dry matter (DM) for the nutritional analysis.

2.2 Mineral Analysis
Minerals were determined in an Atomic Absorption Spectrophotometer (AAS) (Graphite furnace Analytikjena AG Vario 6) at specific individual wavelength for each mineral after digesting the samples with concentrated nitric acid (HNO_3) and concentrated perchloric acid ($HClO_4$) (HNO_3: $HClO_4$ = 5:1) [12].

2.3 Amino acid analysis
The sample was hydrolyzed by 6N hydrochloric acid hydrolysis. The hydolysed sample were subjected to pre - column dervitization with Phenyl Iso Thio Cyanate (PITC) reagent and amino acid analysis performed by High Performance liquid Chromatography (HPLC – Agilent 1100 series, Diode Array Detector) by using Agilent TC-C18(2) analytical Octadecylsilane (ODS) 5.0 µm, 4.6 X 250 mm using 32 amino acid standard [13]. The amino acid score was calculated based on the recommended consultation pattern by FAO/WHO/UNU (1985) [14].

2.4 Determination of Fatty Acids
Lipids were extracted from the sample by the method of Bligh and Dyers (1959) [15] and methylated as described in AOAC (2001) [16]. Analysis of fatty acids was carried out in GC-MS QP 2010 Plus – Shimadzu using Helium as carrier gas with a flow rate of 0.75 mL/min. The injector and detector ports temperature was maintained at 225ºC and 285ºC. The fatty acids were expressed as percentages of total methyl esters and the ratio of polyunsaturated fatty acids/saturated fatty acids (PU/SA) calculated.

2.5 Data analysis
Data are reported as mean ± standard deviation for each analysis.

3. Result and Discussion
3.1 Proximate and Mineral Composition
Data provided in Table 1 show the proximate composition of *Sympetrum* sp. Food sample containing low moisture indicate good shelf life characteristics [17]. Moisture content 1.61% of *Sympetrum* sp. was lower compared to the moisture values of all edible insects reported by Banjo *et al*. (2006) [18] which would be advantageous for its storage. On the other hand the ash content was found to be higher than those of edible insects reported by Banjo *et al.* (2006) [18] and Shantibala *et al.* (2014) [19]. The level of protein content 76.75% in *Sympetrum* sp. was higher in comparison to 70.48% of *C. servilia* an aquatic edible odonata consumed in Manipur, India. Moreover, most aquatic insects have shown to be a source of good amount of protein content [19]. Incorporation of processed *Sympetrum* sp. in food can substantially augment the daily protein requirement among the malnourished. Fat content in *Sympetrum* sp. (4.53%) reflects its calorific value which commulatively would contribute 395.77 kcal/100g energy value in a diet supplemented with it.

Table 1: Proximate compositions of *Sympetrum* sp. g/100g dry weight

Moisture	Total solids	Ash	Fat	Protein	Carbohydrate	Calorific value (Kcal/100g)
1.61 ± 0.06	98.39 ± 0.06	5.11 ± 0.04	4.53 ± 0.02	76.75 ± 0.03	12.00 ± 0.05	395.77 ± 0.03

***Source*:** Narzari and Sarmah (2015) [11]. Results are in means of triplicate determinations ± SD.

Mineral components in insects are several times higher than many traditional foods and hence these are remarkable nutrients [20]. Most edible insects contain higher amounts of iron than beef [21]. Mineral deficiency in food specifically iron and zinc represent major public health problems [22]. The mineral composition of *Sympetrum* sp. shown in Table 2 show that insects

Fig 1: Nymph of *Sympetrum* sp.

Sympetrum sp. would supplement good amount of macronutrients as potassium, sodium and phosphorus to human diet whereas the recommended daily intake (RDA) [23] for human suggest that *Sympetrum* sp. would be a better provider of micronutrients which would substantially provide surplus amount of iron (75 – 168.75) and copper (222.22%) to human nutrition. Thus about 100g of *Sympetrum* sp. consumed can provide sizeable amount of recommended daily intake of potassium, sodium, magnesium, calcium, phosphorus and zinc and surplus amount of iron and copper for health and nutrition to the consumers.

Table 2: Recommended intake of essential minerals per day compared with *Sympetrum* sp.

Mineral	DRI (mg per day)		*Sympetrum* sp. (mg per 100 g dry weight)	(%) RDA fulfillment	
	Male	Female		Male	Female
Potassium	4700	4700	1690.05 ± 2.04	35.95	35.95
Sodium	1500	1500	240.80 ± 0.55	16.05	16.05
Calcium	1000	1000	20.50 ± 0.03	2.05	2.05
Magnesium	400	310	22.0 ± 0.08	5.50	7.09
Phosphorus	700	700	626.78 ± 1.43	89.54	89.54
Zinc	11	8	0.50 ± 0.008	4.54	6.25
Iron	8	18	13.50 ± 0.01	168.75	75
Copper	0.9	0.9	2.00 ± 0.007	222.22	222.22

Results are in means of triplicate determinations ± SD. DRI – Dietary Reference Intake

3.2 Amino acid composition
The amino acid compositions of *Sympetrum* sp. is shown in Table 3. All the essential amino acids except leucine were present in this species. Essential amino acids (EAA) can be obtained only from the ingested food [24]. Munro and Crim (1988) [25] specified threonine, histidine, valine, methionine, tryptophan, phenylalanine, isoleucine and lysine as the eight essential amino acids for an adult human nutrition. All these essential amino acids were present in *Sympetrum* sp. with threonine was the most abundant essential amino acids. Of the non essentials amino acids aspartic acid was the most abundant.

Table 3: Amino acid (AA) composition of *Sympetrum* sp. g/100g dry weight.

Non-Essential (A A)	% Total AA	Essential AA	% Total AA
Aspartic acid	14.60 ± 1.44	Threonine	6.53 ± 0.42
Amino adipic acid	11.02 ± 1.53	Histidine	5.54 ± 0.97
Glutamic acid	6.21 ± 0.48	Tyrosine	4.44 ± 0.11
Glycine	2.41 ± 1.36	Valine	5.07 ±0.88
Aspargine	7.69 ± 0.30	Methionine	2.98 ± 1.01
Taurine	3.62 ± 0.53	Tryphtophan	2.29 ± 0.67
Phosphoserine	0.76 ± 0.30	Phenylalanine	3.41 ± 0.55
Proline	9.60 ± 0.23	Isoleucine	3.57 ± 0.26
Arginine	ND	Leucine	ND
Phosphoenolamine	2.87 ± 0.48	Lysine	5.54 ± 0.02
-	-	Cysteine	1.70 ± 0.31
Total non EAA	58.24	Total EAA	41.07

Results are in means of duplicate analysis ± SD.

The "chemical score" of amino acid is an index of its protein quality [26]. Chemical score of all essential amino acids except lysine surpassed the recommended level (score>100). The least amino acid score observed was that of lysine (95%). Leucine remained undetected in the sample. The chemical score of histidine was recorded to be the highest in *Sympetrum* sp. Histidine enhances the growth of infants and young children [27] and the consumption of *Sympetrum* sp. would therefore supplement the protein requirements.

Table 4: Amino acid score of *Sympetrum* sp. based on FAO/WHO/UNU (1985) consultation pattern.

Amino Acids	FAO/WHO/UNU (Mg/G Protein)	Chemical Score (%)
Histidine	15	369
Isoleucine	30	119
Leucine	59	ND
Lysine	45	95
Methionine	16	187
Phenylalanine + Tyrosine	38	124
Threonine	23	192
Tryptophan	11	200
Valine	35	144
Amino Acid Score	-	95
Limiting Amino Acid	-	Lysine

3.3 Fatty acid compositions

The quality and properties of natural fats are portrayed by the chemical structures of fatty acids [5]. In *Sympetrum* sp. the proportion of saturated fatty acids (SFA) was slightly higher than the unsaturated fatty acids (UFA). The presence of both unsaturated (UFA) and saturated fatty acids (SFA) in this insect may be advantageous as they would complement the physiological functions of each other. The SFA: UFA ratio of 1.03 would seem nutritionally undesirable due to the linkage between antherosclerosis and SFAs [28]. However, not all SFAs have the same effect on cholesterol synthesis only saturated fats with chain lengths of 12, 14, and 16 elevate blood cholesterol [29]. On the contrary, unsaturated fatty acid as oleic acid is known to lower cholesterol [30]. Therefore, since saturated fats with chain lengths of 12 (lauric acid), 14 (myristic acid) were present in concentrations of 8.57% and 1.60% respectively considerable concentration of oleic acid (8.65%) may produce balancing effect on the cholesterol elevating fatty acids. Polyunsaturated fatty acids (PUFA) and saturated fatty acid (SFA) that is PUFA/SFA ratio <0.20 has also been associated to high cholesterol and coronary heart disorders [31]. The PUFA/SFA ratio of *Sympetrum* sp. was 0.49 which suggest that this insect is not associated to risk for certain coronary heart diseases. 12.46% of linoleic acid further enhances the nutritional potential of PUFA fraction in *Sympetrum* sp.

Table 5: Fatty acid composition of *Sympetrum* sp.

Fatty acids	% of fatty acids	Fatty acids	% of fatty acids
Valerianic Acid (C5:0)	0.54 ± 0.23	Linderic Acid (C12:1)	1.17 ± 0.07
Caprylic Acid (C8:0)	6.75 ± 0.38	Lauroleic Acid (C12:1)	1.19 ± 0.19
Capric Acid (C10:0)	2.42 ± 0.66	Tsuzuic Acid (C14:1)	2.58 ± 0.20
Undecylic Acid (C11:0)	29.13 ± 0.24	Oleic Acid (C18:1)	8.65 ± 3.09
Lauric Acid (C12:0)	8.57 ± 1.68	Civetic Acid (C17:1)	1.84 ± 0.70
Myristic Acid (C14:0)	1.60 ± 1.21	Other MUFAs	5.92 ± 3.03
Margaric Acid (C17:0)	0.87 ± 0.07	Total MUFAs	24.60
Nonadecylic Acid (C19:0)	0.73 ± 0.516	Linoleic Acid (C18:2)	12.76 ± 0.18
Total SFAs	50.62	Arachidonic Acid (C20:4)	9.34 ± 1.43
Caproleic Acid (C10:1)	1.83 ± 0.02	Other PUFAs	2.66 ± 0.35
Obtusilic Acid (C10:1)	1.42 ± 0.09	Total PUFAs	24.76
PUFA/SFA 0.49			

Results are in means of duplicate analysis ± SD

4. Conclusion

This study provides an overview of the nutrient composition of *Odonata* sp. an aquatic insects consumed among some tribes in Assam, Northeast India. This food species contain significant proportions of proteins, minerals amino acids and fatty acids. The nutritional qualities of this species is unique and can be exploited to provide high-quality diets, especially for regions plagued by iron deficiencies and poor supply of dietary polyunsaturated fatty acid sources.

5. Acknowledgment

This work was supported by the Department of Science and Technology (SoRF-Disha scheme), Government of India. The authors acknowledge Department of Biotechnology, Government of India for allowing us to avail facilities at Bioinformatics Infrastructure Facilities (BIF) and Institutional Biotech-hub (DBT) at Bodoland University.

6. References

1. Gullan PJ, Cranston PS. The Insects, an Outline of Entomology. 2nd Edition. Blackwell Science, Oxford, UK, 2000.
2. Yen AL. Edible insects: traditional knowledge or western phobia? Entomological Research. 2009; 39:289-298.
3. Chakravorty J, Ghosh S, Megu K, Jung C, Meyer-Rochow VB. 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. 2016; 19:711-720.
4. De Guevara L, Padilla P, Garcia L, Pino JM, Ramos Elorduy J. Amino acid determination in some edible Mexican insects. Amino acids. 1995; 9:161-173.
5. Ramos-Elorduy J. Energy supplied by edible insects from Mexico and their nutritional and ecological importance. Ecology of Food and Nutrition. 2008; 47(3):280-297.
6. DeFoliart GR. Insects as human food. Crop Protection. 1992; 11:395-399.
7. Krause M. Mahan LM. Food Nutrition and Diet Therapy. Philadelphia, PA WB. Saunders Co, 2003.
8. Meyer Rochow RVB. Edible insects in the three different ethnic groups of Papua and New Guinea. American Journal of Clinical Nutrition. 1973; 226:663-667.
9. Ramos-Elorduy J. Insects in the diet of tropical forest peoples in Mexico. Food and Nutrition in the Tropical Forest, UNESCO. 1993; 17:1-18.
10. Narzari S. Sarmah JA. study on the prevalence of entomophagy among the Bodos of Assam. Journal of Entomology and Zoology studies. 2015; 3:315-320.
11. Narzari S, Sharmah J. Proximate composition of wild edible insects consumed by the Bodo tribe of Assam, India. International Journal of Bioassays. 2015; 4:4050-4054.
12. Puwastein P, Siong TE, Craven G, Feliciano RR, Judpsrasong. Asean Manual of Food Analysis, 1st ed. Regional Centre of ASEAN network of Food Data System. Institute of Nutrition, Mahidol University. 2011, 41-60.
13. Shi Z, Li H, Li, Z, Hu J, Zhang H. Pre-column Derivatization RP-HPLC Determination of Amino Acids in Asparagi Radix before and after Heating Process. IERI Procedia. 2013; 5:351-356.
14. FAO/WHO/UNU. Expert consultation, Energy & protein requirements. WHO Technical Report Series No. 724. World Health Organization, Geneva, Switzerland, 1985.
15. Bligh EG, Dyer WJ. A rapid method of total lipid extraction and purification. Can J Biochem Physiol. 1959; 37:911-917.
16. Association of Official Analytical Chemists, Fat (Total, Saturated and unsaturated) in Foods. Hydrolytic Extraction gas chromatographic method. AOAC Official Methods 996.06. Revised edition of (1996), Inc, Virginia, USA. 2001, 1-40.
17. Bhulaidok S, Sihamala O, Shen L, Li D. Nutritional and fatty acid profiles of sun-dried edible black ants (*Polyrhachis vicina* Roger). Maejo International Journal Science and Technology. 2010; 4:101-112.
18. Banjo AD, Lawal OA. Songonuga EA. The nutritional value of fourteen species of edible insects in southwestern Nigeria. African Journal of Biotechnology. 2006; 5:298-301.
19. Shantibala T, Lokeshwari RK, Debaraj H. Nutritional and antinutritional composition of the five species of aquatic edible insects consumed in Manipur, India. Journal of Insect Science. 2014; 14:1-10.
20. Siemianowska E, Kosewska, Aljewicz M, Skibniewska KA, Polak-Juszczak L, Jarocki A, *et al*. Larvae of mealworm (*Tenebrio molitor* L.) as European novel food. Agricultural Sciences. 2013; 4:287-291.
21. Bukkens SGF. Insects in the Human diet: Nutritional aspects. In Paoletti M.G. editions: Ecological implications of minilivestocks; role of rodents, frogs, snails and insects for sustainable development. Science Publishers, New Hampshire. 2005, 545-577.
22. Michaelsen KF, Hoppe C, Ross N, Kaestel P, Stougaard M, Lauritzen L, Molgaard C, Girma T, Friis H. Choice of foods and ingredients for moderately malnourished children 6 months to 5 years of age. Food Nutrition Bulletin. 2009; 30:343-404.
23. Dietary Reference Intakes (DRIs). Recommended Intake for Individuals, Elements. Food and Nutriton Board, Institute of Medicine, National Academics, 2004.
24. Sizer F. Whitney E. Nutrition Concept and Controversies. Eighth editions. Division of Thompson Learning Inc., Wadsworth, 2000.
25. Munro HN, Crim MC. The proteins and amino acids. In: Shils, M.E. and Young, V. Editions. Modern nutrition in health and disease. Lea and Febiger, Philadelphia. 1988, 1-37.
26. De Conconi JRE, Moreno JMP, Mayaudon CM. Protein content of some edible insects in Mexico. Journal of Ethnobiology. 1984; 4:61-72.
27. Cameron M. Hofvander Y. Manual on feeding infants and young children. Second editions. FAO of the United Nations, Rome, Italy, 1980.
28. Reiser R. Saturated fat in the diet and serum cholesterol concentration. A critical examination of literature. American Journal of Clinical Nutrition. 1973; 26:524.

29. Mensink RP. Effect of the individual saturated fatty acids on serum lipids and lipoproteins concentrations. American Journal of Clinical Nutition, 53 (Suppl). 1993, 980S-986S.
30. Bonanome A, Grundy SM. Effect of dietary stearic acid on plasma cholesterol and lipoprotein levels. N. Engl. J. Med. 1988; 318:1244-1248.
31. Mann J. Disease of the heart and circulation: the role of dietary factors in aetiology and management. In: Garrow JS, James WPT editions. Human Nutrition and Dietetics. Churchill, Livingstone London. 1993; 619-650.