SUMMARY

Since the recent global food crisis, practices of fuller utilization of surrounding biodiversity around the world are thus becoming the main focus in order to explore alternative food resources.

Eating insects appear to be culturally universal, only varying with location, insect population and ethnic group. Taking into consideration that insects have a high fecundity, can be multivoltine, have a high feed conversion efficiency, low space requirement, and are omnivorous in addition to their nutritive value, edible insects can contribute to world food security and represent an interesting food.

A bewildering variety of insects has found acceptance as food among the indigenous people of the state but there is a stark possibility that indigenous wisdom will disappear due to the trend of westernization unless it is recorded or they are assessed as value added food component. In this regard, hardly any systematic scientific work had been taken up until recent time.

The present work therefore, has been undertaken with an objective to document various insect species taken as food and assessment of nutritional value of the selected edible insect species of Adi tribe of Arunachal Pradesh with a hope to evaluate nutritional benefits to advance the search of alternative source of food.

A consolidated list of edible insects used in the central part of Arunachal Pradesh inhabited by Adi tribe in East Siang District, West Siang District, Upper Siang District, and Lower Dibang Valley District has been prepared. The list is based on thorough, semi-structured field-interviews with 20 informants. The villages were selected on random basis; these villages were the Adi villages in all the four districts of Arunachal Pradesh.
The present study revealed that at least 43 insect species, belonging to 8 orders were considered edible. The largest number of the edible species belonged to the Orthoptera (16) followed by 8 each of the Hemiptera and Hymenoptera, 5 of Odonata, 3 Coleoptera and one each of the Mentoidae, Ephemeroptera and Lepidoptera. The selection of the food insects amongst the Adi tribe is dictated by traditional tribal beliefs as well as the taste and availability of the insects. Depending on the species, only particular or all developmental stages are consumed. Some food insects may be included in the local diet throughout the year, others only when seasonally available. Commonly insects are being prepared for consumption by roasting, frying or boiling.

Based on the above findings eight types of insects of orthopteran species namely Conocephalus sp., Mecopoda sp., Hexacentrus sp., Schistosereca sp., Ducetia japonica, Phyllozelus sp., Oxya fuscovittata, as well as assorted sample (mixture of grasshopper, locust etc. frequently collected by women folk during the work in the field) were selected for nutrient content analysis. These species are most preferred common species of orthoptera used as food by Adi tribe.

Eight insects categories were assessed for proximate nutrient compositions (moisture, crude protein, crude fat, crude fiber and ash were carried out following the standard methods. Calorific values were computed from the values obtained for carbohydrate, protein and fat. Amino acid, fatty acid profile and minerals content were analysed following standard procedure using HPLC, GC-FID and AAS respectively.

Result of proximate analyses revealed that the protein content was predominant among all the macronutrients (protein, fat, fiber, ash and NFE) in all studied insects (53.077% to 67.823%). Compared to conventional food of animal and plant origin, the analyzed samples were superior to some conventional food used as source of protein such as chicken beef, pork egg, bamboo shoot soybean and mung beans etc. Fat content in all the species in this study was much lower than protein content except for Hexacentrus sp. had the highest fat content (30.327%)
and lowest was in *Conocephalus* sp. (6.326%). The fat content of rest of the insects ranged from 7.930% to 14.993%. High fat content is particularly relevant in the developing countries as much of energy is expended in doing works manually in contrast to developed countries where the work is done through machine. Therefore, these insects particularly *Hexacentrus* sp. can serve as a good source of fat.

Similarly, the fiber content was 3.272% to 11.840% in the analyzed insects. It was comparable to the dietary fiber content (g/100g) of rice (4.1), wheat (12.5), whole Bengal gram (28.3), lentil (15.8), cabbage (2.8), green colocasia (6.6), yam (4.2). Relatively high moisture value (41 to 59%) in the insects under study will not assist in keeping quality since they may prone to spoilage on careless keeping. The mean energy values (kcal/100g) was highest for *Hexacentrus* sp. (532.035 kcal/100g) followed by 421.184kcal/100g in *Oxya fuscovittata*, 409.261kcal/100g for *Ducetia japonica* and assorted sample. Comparatively lower values 377.098 kcal/100g to 394 kcal/100g in rest of four species in the present study. The calorific value of the tested insects was higher than that reported calorific values for rice (345 kcal), wheat (345 kcal), whole grams (335 kcal), and egg (173 kcal).

The quality of protein depends largely on its amino acid content. Most of the essential amino acid (EAA) and non essential amino acid (non-EAA) a total of 18 amino acids were present in the analyzed insects. The most predominant ones were Glu, Ala, and Asn as non-essential amino acid and Leu, Lys Val and Ile as essential amino acid. All the studied insects contained considerable amount of Lys, Leu Val. Lys could meet recommended values as proposed by FAO/WHO/UNU (2007) upto 82.4% to 158.9 in all analyzed samples and comparable to some conventional protein sources of plant origin. Lys has received attention as it is a limiting amino acid in cereals, especially wheat, rice, cassava and maize based diets which are prevalent in the developing countries including India. All the amino acid fulfilled more than 100% of
the requirement for human as per FAO/WHO/UNU’s (2007). Amino acid contentment in the analyzed sample was comparable to egg, veal, pork, beef and chicken. The results of the amino acid in these insects indicated that proteins of these insects are of good quality and the analysed insects can be recommended for protein and amino acid source as and when need arises.

A total of 14 SFAs were detected and 3 SFA’s were, 14:0 myristic acid, 16:0 palmitic acid, and 18:0 stearic acid could be detected in all species. The concentration of total SFAs ranged from 12.73 g/100g in Hexacentrus sp. to 2.17g/100g in Schistocerca sp.

A total of 7 monounsaturated fatty acid (MUFA) was detected but they were species specific some they contained all seven and others were having only few. Palmitoleic acid and Olic acid could be detected in all. In addition, low concentrations of eicosenoic acid (20:1) were also detected in all the species, except for Conocephalus sp. and Ducettia japonica where it was below the detection level. Low level of Erucic acid could be detected only in Hexacentrus sp.

The concentration of total Polyunsaturated Fatty acid (PUFA) ranged from 1.62 g/100g in Phylozelsus sp. to 4.0 g/100g in assorted sample, accounted for 19.90 to 43.16 % of total fatty acids. Among detected PUFAs, linoleic acid (C18:2), 18:3 n-3 linolenic acid was detected in all the species and linoleic acid was most abundant in all the species. 18:3 n-6 linolenic acid were detected in all the species except Hexacentrus sp.

The PUFA/SFA ratio is one of the major parameters currently used to assess the nutritional quality of the fat fraction of foods. Nutritional guidelines recommended for PUFA/SFA ratio is above 0.4 (FAO/WHO, 2003). PUFA/SFA was 0.0892 in Conocephalus sp.
0.115 in Hexacentrus sp. 0.327 in Ducetia Japonica. However, rest of the species are having PUFA/SFA ratio: 1.119 in Mecopoda sp.; 0.746 in Schistocerca sp.; 1.357 in Phyllozelus sp.; 1.124 in Oxya fuscovittata and 1.346 in assorted grasshopper sample.

Therefore, fatty acid compositions of analyzed orthopteran insects in general reinforce the utilization of these insects as promising sources of fat from nutritional point of view as well as have their industrial implication too. However, Hexacentrus sp. with comparatively high fat content and having higher SFA, may be compensated by presence of UFA where SFA and UFA % (58.6 : 45.6% of total fatty acid). Therefore, the quality of fat in Hexacentrus sp. may also serve as good source of fat

Furthermore, macro-minerals (mg/100g) i.e. calcium, magnesium, sodium and potassium as well as micro-minerals (mg/100g) i.e. copper, iron zinc and manganese were present in the tested insects. The mineral composition (mg/100g) in the analyzed insects contained moderate amount of sodium, potassium and calcium and magnesium as per recommended daily requirement.

Micro-minerals (Fe, Cu, Zn and Mn) content in the studied insects was better than macro-minerals as per requirement proposed by ICMR 2009. Highest level iron was present both in Conocephalus sp. and Oxya fuscovittata (about 28.664 mg/100g and 25.325 mg/100g could meet the RDA value 168.61% for male 136.5% for female.

Consequently, Conocephalus sp followed by Oxya fuscovittata to Schistocerca sp. can be recommended for iron (Fe), Mecopoda sp. and Ducetia japonica, Hexacentrus sp for zinc (Zn); Mecapoda sp Schistocerca sp. for copper (Cu) and all the species for Manganese (Mn). Most of the analyzed edible insects show high zinc content could function as zinc supplementing food (ingredients). Furthermore, these insects contain in most cases sufficient amount of manganese and copper. Therefore it can be concluded that, although a 100 g of the studied
insects generally lack sufficient amount of calcium, potassium but these insects have the potential to provide with specific microminerals such as iron, zinc, manganese and copper. It is further assumed that the content of microminerals in these can be controlled via feed. In addition, these insects can be utilized in low-sodium diets.

Therefore, continued consumption studied grasshopper species needs to be advocated and encouraged in solving the problem of malnutrition among the less privileged in parts of Arunachal Pradesh and world at large where need arises. Yet in order to make recommendations regarding the use of these species as food enrichments in diets, it is important to look at traditional diets in their entirety, and in particular at staple foods, and to compare their nutritional quality against that of edible insects locally available in the region.