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Nutritive value of bamboo worm *Omphisa fuscidentalis* (Lepidoptera: Crambidae): An edible insect as protein rich food

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Abstract
The bamboo worm, *Omphisa fuscidentalis* is commonly used as delicious food by different ethnic communities of Northeast India, especially in Manipur. The nutritional and ant nutritional aspects of *O. fuscidentalis* revealed high protein (30.5%) and lipid (43.1%) content. A total energy of available carbohydrates, protein, and fat was provided about 526.6 kcal/100 g of energy. Out of the micro-nutrient compositions, potassium and calcium are the most prominent minerals observed in the larva which can be used as supplementary food to human diets. IC_{50} % of 373.17 µg/ml indicate higher than the standard value of ascorbic acid. Low values of ant nutritional elements like phenol (53.0 mg/100g) and tannin (62.0 mg/100g) content showed non-toxic. The insect can be cultured in captive using commonly available bamboo host plant. The edible insects provide economic support, nutritive values, food security and environment management.

Keywords: Nutritive, bamboo worm, protein, rich, *Omphisa fuscidentalis*

Introduction
Insects are the most diversified and abundant form of life that organize a main component of the total faunal biodiversity on earth. Generally, edible insects represent significant biological resources, not only proteins and fats benefit gained but also significant levels of essential nutrients comparable to or superior to that of meat and the high cost of animal protein, which is beyond the reach of the poor, has greatly encouraged entomophagy (Narzari and Sarmah, 2017) [21]. The shortage of food resources due to population explosion and decrease in agricultural production has become an important issue for present human civilization where focused is on searching for alternative sustainable food resources, the insect received as priority food. As a global responsibility, Food and Agricultural Organization (FAO), took an initiative to create policy and proposed the program of feeding the world's still growing human population with alternative sources of food including insects and as well declared insects as the priority alternative with minimum environmental hazards (FAO, 2013). Edible insects are not only regarded as a tasty food commodity of high nutritive value, but also considered to possess health enhancing properties.
Consumption of edible insects is an ancient practice across the globe. In India, North-East region is inhibited by diverse ethnic communities where entomophagy practiced is one of their inseparable food cultures with its highly appreciated delicacy. The region is known for being a distinctive part of the Indo-Burma biodiversity hotspot having a very rich and fascinating diversity of insect fauna. Insects have been using in varied ways such as for edible, medicinal, industrial and cultural purposes (Shantibala, *et al*., 2012) [28]. Within the northeast, the state of Manipur is gifted with more than 33 ethnic communities with distinct identity, culture and food habit ensuring advantage for evolving innumerous knowledge on entomophagy, but there is little information on scope of their scientific nutritional benefits and medicinal properties of potential edible insects for promoting value addition or alternative food sources to avail nourishment to human community as whole. The study was designed to evaluate the nutritive content including minerals, volatile compounds and antioxidant activity of one of the most widely accepted edible insect *Omphisa fuscidentalis* (Lepidoptera: Crambidae) of Manipur, Northeast India.

Material and Methods
Specimens of *Omphisa fuscidentalis* were collected from Local Market, Churachandpur District, Manipur, collected at larval stage which is the ideal stage of consumption (Figure 1).

Specimen was taken to the Laboratory Dept. of Entomology, College of Agriculture, CAU, Imphal. In the laboratory, the sampled insect was washed thoroughly in distilled water, then oven-dried (50°C), ground to a powder and prepared as dry matter (DM) for further analyses. All the solvents and chemicals used in the study were of analytical grade. Using the techniques recommended by the Association of Official Analytical Chemists (AOAC, 1990) [3], the analyses were performed for proximate compositions, i.e., moisture content, crude protein, carbohydrate, crude fat, crude fibre and ash content.

Fig 1: Bamboo worm *Omphisa fuscidentalis* larvae collected from fresh bamboo and women selling at local market, Churachandpur District

The proximate composition (ash, moisture, lipid, protein and carbohydrates) of *Omphisa fuscidentalis* larvae was determined by following standard methods of the Association of Official Analytical Chemists (AOAC). Moisture percentage was calculated by drying the sample in an oven at 100°C for 2 h. The dried sample was put into desiccators and allowed to cool and reweighed. The process was repeated until constant weight was obtained. Crude protein was determined by the Kjeldahl method and total protein content was calculated as the amount of total N determined multiplied by nitrogen-to-protein conversion factor of 6.25. Fat percentage was calculated by drying fats after extraction in a Soxhlet using Diethyl ether. Ash percentage was calculated by combusting the samples in silica crucible placed in a muffle furnace. Crude fibre was determined through double digestions, first with sulphuric acid and then with sodium hydroxide. The percentage of carbohydrate was determined by subtracting all of the components (crude protein, crude lipid and ash) from 100. The percentage of nitrogen free extract (NFE) was determined by subtracting all of the components (crude protein, crude lipid, crude fibre and ash) from 100. The calorific value (kcal/100 g) was computed by multiplying the factors for carbohydrate and protein by 4 each and that of fat by 9 and then taking the sum of the products. All of the analyses were performed in triplicate and expressed as mean ± standard deviation.

Minerals were determined by atomic absorption spectrophotometry after dry-aching the samples and acid dilution (AOAC, 1990) [3]. The ash was digested with HCL made up to 100 mL and filtered before the mineral elements were determined by Atomic Absorption Spectrophotometer (AAS). All the analyses were performed in triplicate and expressed as mean ± standard deviation.

The antioxidant potential of the methanol extract was determined on the basis of their scavenging activity of stable 1, 1-diphenyl-2-picryl Hydrazyl (DPPH) free radicals (Sanchez-Moreno *et al*. 1998) [27]. Ascorbic acid was used as the standard, and the absorbance was measured at 517nm. The IC_{50} value denotes the concentration of the sample required to scavenge 50% of the DPPH free radicals.

The total phenol content (TPC) of methanol extract of the samples was estimated by following Folin-Ciocalteu method (Harborne, 1973) [15], measuring the absorbance spectrophotometrically at 650 nm (Thermo Fisher Scientific, Multiskan Go) after 30 min incubation at room temperature and in dark. TPC of the extract will be estimated by adding 1ml of freshly prepared Folin-Ciocalteu reagent (Sigma-Aldrich, USA) in ratio (1:9), 1ml of 10% sodium carbonate (Merck) and 7ml Millipore water (Elix Technology, Merck), all together in the ratio of 1:1:1:7. The concentration of TPC in the extracts was determined and expressed as mg Gallic acid (Sigma-Aldrich, USA) equivalent (mg GAE/100g DM) using an equation obtained from the standard Gallic acid graph.

Tannin content was determined by the qualitative method using tannic acid as standard solution (Enujiugha and Ayodele-Oni 2003) [10]. A finely-ground sample (0.2 g) was soaked in 10 mL of 70% acetone for 15 minutes in ice water. To the filtrate, 0.5 mL of Lowery reagent and 2.5mL of 20% sodium carbonate was added and incubated for 40 minutes. Absorbance was measured at 700nm.

Statistical Analysis and Expression of Results

All the data obtained for the proximate contents, fatty acids, minerals and the antioxidant activities will be evaluated by using one-way ANOVA (Analyses of Variance. P values < 0.05 will be regarded as “significant” and P values < 0.01 as “very significant”. The experimental result of the insect sample will be performed in triplicate and given as Mean ± Standard deviation (SD).

Results and Discussion

The proximate composition of *Omphisa fuscidentalis* larvae such as moisture, crude protein, carbohydrate, lipid, ash, Fibber, and energy were analysed and the results are presented in Table 1. Moisture content of 12.7% was found in larvae of *O. fuscidentalis* which is lower as compared to the moisture content of all edible insects reported by Banjo *et al*.

(2006) [4] and Shantibala, *et al*. (2014) [29] which would be advantages for its storage as low moisture content indicates good shelf life characteristics. The protein content was found to be 30.5% which is shown to be a good source of protein. The protein content (%) exhibited by the insects was significantly higher than in conventional animal meats, and therefore insects may offer an affordable source of protein to counteract protein malnutrition (Kariuki 1991) [16]. The lipid content was observed to be 43.1% in *O. fuscidentalis* larvae which is lower as compared to the fat content (60.42%) of Bamboo insect, *Chilo fuscidentalis* by Ying and Xiao-Ming, (2000) [32]. The fat content of Bamboo worm larvae is higher than edible insects reported by Ying *et al*. 2001 [33] found between 10 and 50%. The energy available in the carbohydrates, protein, and fat was also analysed. A total of about 526.6 kcal/100 g of calorific value was reflected in *O. fuscidentalis* larvae which contributing high energy value in the diet supplemented with it. The gross energy value given by these edible insects depends on the amount of protein, fat, and carbohydrate contents in the insect. In the study the larval crude fibre and ash content were found to be 4.17% and 2.4% respectively which is lower as compared to edible aquatic insects reported by Shantibala *et al*. (2014) [29]. The crude fibre content of the insect in this study were quite low, compared to other edible insects reported by Adeduntan 2005 [1], Mbah and Elekima 2007 [20]. High crude fibre content in the insects could be due to the chitin normally found in insects (Akinnawo and Ketiku 2000) [2]. Chitin is a structural nitrogen-based carbohydrate found in the exoskeleton of insects, which may have ‘anti-nutrient’ properties due to potential negative effects on protein digestibility (Belluco *et al*., 2013) [5]. A study comparing dried honey bees and honey bee protein concluded that the removal of chitin improved the quality of the insect protein as measured through protein digestibility, amino acid content, protein efficiency ratio and net protein utilisation (Ozimek *et al.* 1985) [22]. On the other hand, chitin is notably high in fibre, and chitin extracts from the exoskeletons of shellfish have been approved by relevant authorities and are readily used in Japan as a source of fibre in cereals (DeFoliart 1992) [9]. Although chitin is usually considered to be indigestible by humans (Bukkens 1997) [6], chitin lytic enzymes, produced by bacteria from human gastrointestinal tracts, have recently been found, suggesting that chitin and chitosan can be digested (Paoletti *et al*. 2007 [23]; Rumpold & Schluter 2013 [26]).

Moreover, the high crude fiber content can be used to complement animal roughages in addition to other uses mentioned earlier (Mbah and Elekima 2007) [20].

Table 1: Proximate composition of *Omphisa fuscidentalis*

Component	Proximate Composition (%)
Moisture	12.7 ±0.06
Protein	30.5 ±0.12
Lipid	43.1 ±0.23
Carbohydrates	4.18± 0.08
Calorific value	526.6 ± 5.76
Fibre	4.17± 0.03
Ash	2.4± 0.03

Data are expressed as Mean ± SD (n=3) on dry weight basis

Mineral profile

Among the micro-nutrient compositions, calcium was the most prominent in *O. fuscidentalis* larvae followed by potassium, sodium, iron, magnesium, phosphorus, *etc*., which is shown in Table 2. Mineral content are well as remarkable nutrient values in insects are several times higher than most of the traditional foods we consumed. (Narzari and Sarmah, 2017) [21]. Mineral deficiency mainly leads to major primary health issues. *O. fuscidentalis* larvae contained highest amount of calcium 1339.1 mg in 100g of dry weight along with potassium (568.6mg), sodium (279.1mg), iron (84.7mg), magnesium (69.1mg), phosphorus (55.5mg), zinc (28.1mg), manganese (21.9mg) and copper (1.5mg). Hence, *Omphisa* larva supplement good amount of micronutrients with surplus amount of Ca, K, Na and Fe for human consumption. The level of minerals present in edible insects indicates that insects are good sources of minerals for the human body (Kinyuru, *et al.* 2010 [17]). Most insects with detritivorous, predaceous, and blood-sucking feeding habits have higher concentrations of sodium than phytophagous insects (Chapman 1998 [8]). Because sodium is both an electrolyte and mineral, it helps to maintain the amount of fluid inside and outside the body’s cells and the electrolyte balance in the body.

Table 2: Major mineral profile of *O. fuscidentalis* larvae (concentration in mg/100g DM)

Mineral	*O. fuscidentalis* (mg/100g dry weight)
Phosphorus	55.5 ±0.05
Sodium	279.1±7.11
Magnesium	69.1 ±0.64
Potassium	568.6± 0.87
Calcium	1339.1± 30.65
Manganese	21.9± 0.50
Iron	84.7± 0.77
Copper	1.5± 0.00
Zinc	28.1± 0.17

Results are in means of triplicate determinations ± SD

Ant nutritional factor: The total phenolic and tannin content of methanol extract of selected insect *O. fuscidentalis* larvae were found to be 53.0 mg/100g DM and 62.0 mg/100g DM respectively which is shown in Table 3. Chakravorty *et al.*, 2016 reported tannin content for *Oecophylla. Smaragdina* and for *Odontotermes* sp. as 615.0 mg/100 g and 496.67 mg/100 g respectively, values much lower than some common foods of plant origin. Polyphenolic compound is considered as one of the most effective antioxidant constituents in plants food and grains (Velioglu *et al.*, 1998 [31]). Tannin forms insoluble complexes with protein, thereby reducing the absorption of protein due to phenolic hydroxyl groups that produce unstable radicals (Feeney, 1969). With the increasing utilization of antioxidant property in food industry for health benefits very less information is reported on phenolic content and its compounds for edible insects. Suh *et al.,* (2010) [30] found many phytochemical constituents from extracts of Coleopteran larva (*Allomyrina Dichotoma*) as well as the adult edible beetle, *Holotrichia parallel* was found with phenolic compounds and proposed that catching with protein synergising their antioxidant activity (Liu *et al*., 2012) [19].

Table 3: Ant nutritional factor of *O. fuscidentalis* larvae

Insect species	Phenol (mg/100g)	Tannin (mg/100g)
Omphisa fuscidentalis larvae	53.0± 0.84	62.0± 5.14

Results are in means of triplicate determinations ± SD

The antioxidant property DPPH free radical scavenging assay of methanol extract compared with standard ascorbic acid was analysed and is presented in Figure 2. The IC_{50} value of the insect was found to be 373.17 µg/ml which is greater than the standard value (122.87 µg/ml) and lesser than *Crocothemis Servilia* (880 µg/mL) showing scavenging activity ranging from 110 to 880 µg/ml, with highest and lowest in *Cybister tripunctatus* (110 µg/mL) and *Crocothemis Servilia* (880 µg/mL) reported by Shantibala *et al.* (2014) [29]. The species with lesser IC50% value had stronger antioxidant properties.

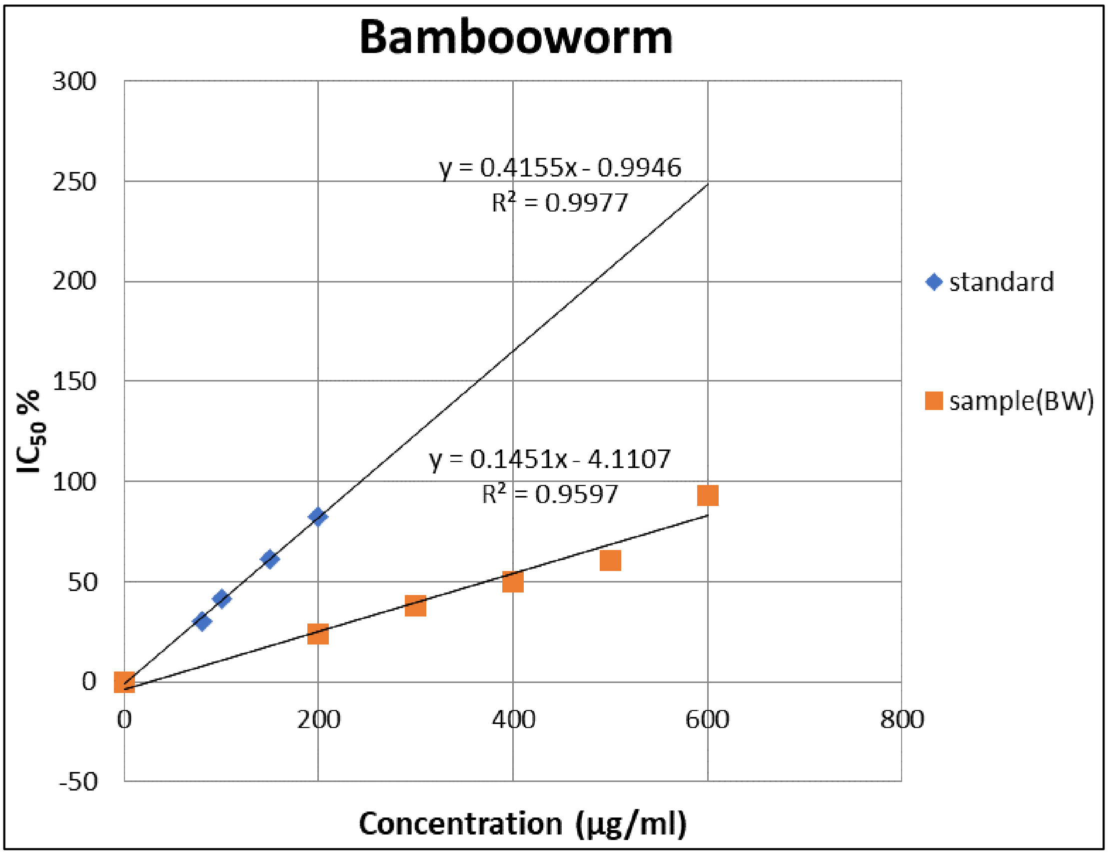

Fig 2: DPPH scavenging assay of *O. fuscidentalis* larvae compared with standard ascorbic acid (IC_{50} % vs. concentration)

Conclusion

The present study investigated the nutritional element analysis of Bamboo worm larvae typically consumed by people in Manipur, India. The practice of entomophagy had also been reported in all seven states of the Northeast region (Pathak and Rao 2000; Chakravorty 2011) [24, 7] and in other countries such as Thailand (Hanboonsong 2008) and Mexico (Ramos Elorduy *et al*. 2009) [25]. Consumption of this insects is very common in state especially by the tribal community because people tend to use insects that are readily available, plentiful, and easy to capture, store, and tasteful while eating. The insect studied showed high amounts of nutritional content and delicious after being fried deeply. As the insect host Bamboo plants are rich in quantity and easy to culture, the resource of Bamboo worm insect can be utilized properly for good prospect of development and human health. The DPPH scavenging assay is considered as one of the simplest methods for evaluation of antioxidant property, where the activity of extract depends on hydrogen-donating ability and structural conformation of compounds (Fukumoto and Mazza, 2000) [13]. With the increasing population in the state as well as worldwide, the practice of Entomophagy (eating insects) need to get more attention, edible insect consumption as a highly poetized alternative food for human diet mostly in developing countries of Asia and Africa with indigenous group of people. Moreover, Manipur and other Northeast states where the tribal community appreciated the acceptance of a wide range of insect species with high delicacy among the ethnic communities of state. However, not much work has done on scientific and nutritional content of edible insects in the state, with this view the present investigation on nutritional aspects of *O. fuscidentalis* larvae is taken up recommending as a good source of nutrients and to combat deficiency problems.

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