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Macronutrient Composition of Giant Water Bug (*Lethocerus* sp.) Edible Insect in Mexico and Thailand

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Abstract: The health benefits of nutrients provided by edible insects are not properly studied, even though insect intake in Latin American and Asia is a cultural tradition since ancient times. Insects from the giant water bug (Belostomidae family) are consumed both in Mexico and Thailand, and are known as "Cucarachon de agua" (*Lethocerus americanus*) and "Mangda" (*Lethocerus indicus*), respectively. Raw samples of these insects were collected on 2014 at Xochimilco channels from Mexico and from Warorot night market in Chiang Mai, Thailand to further analyze nutrient composition of samples according to official methods of analysis (AOAC) techniques. The nutrient compositions were as following: proteins 60.12% and 53.11%; lipids 5.72% and 8.15%; minerals 5.46% and 6.75%; fiber 10.95 % and 12.23%; soluble carbohydrates 17.75% and 19.74%, for insects obtained from Mexico and Thailand, respectively. Giant water bug shows differences in nutrient composition. It may be the consequence of differences in the environment where they acquire the nutrients necessary for growth and reproduction. However, giant water bugs are available all year around and are a good source of proteins that could help people to obtain a cheaper source of this important macronutrient.

Key words: Giant water bug, edible insect, nutrition, health, nutraceutical.

1. Introduction

Macronutrient malnutrition is characterized as a disease of poverty in the midst of plenty. It means that while edible sources rich in macronutrients are readily available, they are not consumed or not in adequate amounts by vulnerable groups due to a lack of awareness. People in rural areas suffer of undernutrition, mainly protein-energy malnutrition (PEM) worldwide, therefore, alternative nutritional food sources are needed [1]. Insect consumption has played an important role as part of human nutrition in many regions around the world, including Latin America and Asia, since ancient times [2-4]. The composition of many edible insects has been published in the literature, and although significant variations were found, many insects provide satisfactory amounts of energy and protein, meet amino acid requirements for humans, are high in monounsaturated and/or polyunsaturated fatty acids, and rich in micronutrients, such as copper, iron, magnesium, manganese, phosphorous, selenium and zinc, as well as riboflavin, pantothenic acid, biotin and in some cases, folic acid [3]. The nutritional values of edible insects are highly variable, not least because of the wide variety of species. Even within the same group of edible insect species, values may differ depending on their habitat and diet. Moreover, where commonly consumed, insects comprise only a part of local diet; nevertheless, because of their nutritional value, they are still a highly significant food source for human population [3]. Mexico and Thailand have a long cultural history of eating insects, and in those countries, there is a large reproduction of edible insects of the giant water bug (Belestomidae family), *Lethoserus americanus* in Mexico and *Lethoserus indicus* in Thailand. Both insect inhabitants from fresh water rivers, streams and ponds can be easily collected,

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either when they are attracted to bright lights or with nets directly from the water [5]. The aim of this study was to assess macronutrient composition of giant water bug from Mexico and Thailand to investigate their feasibility as human food and to determine if there is a difference in chemical composition of insects from two different geographical locations where insects are consumed.

2. Materials and Methods

2.1 Sampling

2.1.1 Mexico

Convenience sampling (sampling method for wild or uncultivated foods) [6] of giant water bug was provided in summer, 2014 at Xochimilco lakeside area, where insects were collected randomly using water nets in the bottom of the canals. After collection, insects were transported in plastic bags with water from their habitat to the laboratory at the Metropolitan Autonomous University to determine taxonomy, moisture and chemical composition of samples in dry basis according with official methods of analysis (AOAC) techniques [7, 8].

2.1.2 Thailand

Material was bought by their common name “Mangda” at Warorot market in Chiang Mai, Thailand [5, 9]. The raw bugs of 3 cm long were washed under running tap, air-dried with sunlight exposition and stored in a can for subsequent air transportation to Mexico for taxonomy determination, moisture and macronutrient analysis according with AOAC [7].

2.2 Nutrients Content Analysis

2.2.1 Moisture

Sample moisture content was determined by using the direct drying method. Homogenized sample by weight of each organism 10 g was dried in an oven Felisa (Felisa S.A. de C.V., Jalisco, Mexico) at 60 °C for 24 h. Dry samples were powdered in a mortar, and then passed through a 30-mesh size. The obtained fine powder was used for further analysis.

2.2.2 Proteins

Sample protein content was determined according to the principle of the Kjeldahl method [7]. Sample of 5 g was digested with 15 mL of concentrated H_2SO_4, using an electrically heated aluminum block digester. The resulting digest was diluted, and then made alkaline with 50 mL 40% NaOH. This was followed by rapid steam distillation of ammonia from the diluted digest into 25 mL of 4% H_3BO_3 for manual titration with 0.2 N HCl. A convention factor of 6.25 was used to convert the measured nitrogen content to protein content. All samples were analyzed in triplicate, and the results were expressed as g/100 g dry basis of sample [8, 10].

2.2.3 Minerals

Ash content was determined using a dry ashing method at 600 °C in a muffle furnace Felisa (Felisa S.A. de C.V., Jalisco, Mexico) for 6 h to constant weight to eliminate the organic matter. Remaining inorganic material was cooled and weighed. All samples were analyzed in triplicate, and the results are expressed as g/100 g dry basis of sample.

2.2.4 Lipids

Lipid content determination was performed by the semi continuous solvent extraction method [7]. The sample of 10 g was extracted with 180 mL petroleum ether on a Soxhlet apparatus (Sigma-Aldrich, Mexico city, Mexico) at 120 °C for 6 h. Petroleum ether was removed by evaporation and the lipid residue was weighed. All samples were analyzed in triplicate and the results are expressed as g/100 g dry basis of sample.

2.2.5 Fiber

Raw fiber determination of the sample (10 g) was performed by acid hydrolysis with H_2SO_4 0.255 N, followed by alkaline hydrolysis with NaOH 0.313 N in a Labconco apparatus (Labconco corporation, Kansas city, USA). Sample was analyzed in triplicate and results expressed as g/100 g dry basis of sample.

2.2.6 Soluble Carbohydrates

Carbohydrate content on dry basis was calculated by difference according to the following Eq. (1):

Soluble carbohydrates =

[100 – (protein + lipids + ash + raw fiber)] (1)

3. Results and Discussion

Insects are underutilized in most countries, even though they may be used for nutritional programs to fight against malnutrition and to improve alimentary security of populations in different countries of the world facing undernutrition.

Giant water bugs are some of the largest insects worldwide, which are known as “Cucarachón de agua” in Mexico (Fig. 1a) and “Mangda” in Thailand (Fig. 1b) [5]. This insect is available all year around, but the best collection periods are on spring and summer time, because on autumn and winter, their availability diminishes (Table 1).

These insects belong to the Belostomidae family (Table 2) and reproduce in streams, ponds and other water environments. Most of insects are consumed in rural areas but not as part of population’s regular diet, which might be due to the lack of knowledge about of nutritional benefits that these insects may provide for human populations.

3.1 Moisture

Moisture is almost half of the insect’s weight in both Mexican and Thai samples, being slightly higher in the insects of Thailand (Table 3). Due to the high content of water, raw samples might suffer a decomposition process, causing for microorganism growth. So, for preservation and further consumption, insect samples must be dried and stored in dried containers or any other appropriate package.

3.2 Proteins

Proteins comprise one of the five classes of complex biomolecules found in cells and tissues, except for DNA, RNA, polysaccharides and lipids. The diet must contain not only enough protein and amino acids, but also enough non-protein energy to permit the optimal utilization of dietary protein [11]. It has been estimated that protein requirements are 0.8 g/kg of weight for adults. This estimation is about 50 g/d for adult women (body weight about 63 kg) and 63 g/d for men (body weight about 79 kg) [12]. Protein content in Mexican and Thai samples showed 60.12 ± 0.5 g/100 g and 53.11 ± 0.8 g/100 g of proteins, respectively (Table 4). Thus, these insects are

(a) “Cucarachón deagua” from Mexico (b) “Mangda” from Thailand

Fig. 1 Insects of the giant water bug (Belostomidae family).

Table 1 The availability of giant water bug.

Season	Availability
Winter	x
Spring	+
Summer	+
Autumn	x

x: low availability; +: high availability.

Table 2 Taxonomical classification of giant water bug.

Category	Mexico	Thailand
Order	Hemiptera	Hemiptera
Family	Belostomidae	Belostomidae
Genus	*Lethocerus*	*Lethocerus*
Specie	Americanus	Indicus
Common name	Cucarachón de agua	Mangda

Table 3 Moisture content (%) in giant water bug (*Lethocerus* sp.) samples from Mexico and Thailand.

Content	Mexico	Thailand
Moisture (%)	52.25	55.09
Dry matter (%)	47.75	44.91

Table 4 Nutrient composition (g/100 g dry sample) of giant water bug (*Lethocerus* sp.).

Nutrient	Mexico	Thailand
Proteins	60.12 ± 0.50	53.11 ± 0.80
Lipids	5.72 ± 0.40	8.15 ± 0.70
Minerals	5.46 ± 0.70	6.75 ± 0.30
Fiber	10.95 ± 0.80	12.23 ± 0.60
Soluble carbohydrates	17.75	19.74

Protein = N (%) × 6.25; soluble carbohydrates obtained by difference; all values are the mean of triplicates.

a valuable source of proteins that may help to fulfill protein requirements for humans. Although the quality of proteins for nutritional purposes, determined by their amino acid composition [13], was not determined in this study, due to the nutritional value that these insects may offer, they represent a cheap source of animal protein [5], and so their consumption should be encouraged to help those people who can not afford other protein sources and contribute to low down protein-energy malnutrition (PEM) which results from an inadequate calorie or protein intake. In addition, a bilateral Student's *t*-test for independent samples was performed to analyze for differences between Mexican and Thai samples. Results showed that protein content is higher in Mexican samples that that in Thai ones ($P < 0.05$), which must be due to environmental differences from the areas where insects were collected [3].

3.3 Minerals

Minerals are simple chemical elements, which presence and roles are important for cellular activities. Their contribution to health maintenance is essential. There are more than 20 necessary minerals for metabolism control and for keeping tissues functions.

Total mineral analysis shown in Table 4 demonstrated that both samples do contain minerals, being found 5.46 ± 0.7 g/100 g and 6.75 ± 0.3 g/100 g for Mexican and Thai samples, respectively. Statistical analysis (bilateral Student's *t*-test) showed no significant difference between samples tested ($P > 0.05$). In fact, most of minerals are distributed widely among every kind of food, so almost every diet will include enough of them [14].

3.4 Lipids

Lipids are important macro-nutrients due to their participation on a wide range of metabolic and regulatory processes, for example, they are essential for the absorption of fat-soluble vitamins. In addition, ω3 and ω6 are essential fatty acids that have beneficial effects for human health, such as, heart support, mental health, immune functions, inflammatory processes, reduction of glucose intolerance, as well as insulin resistance prevention, among others. Recommended fatty acids intake ranges from 20% to 35% of the daily food intake. For a 2,000 calories diet, this represents 56 g to 78 g of fat, and for a 3,000 calories diet, 83 g to 117 g of fat [15]. Lipid content analysis showed that Mexican and Thai samples contain about 5.72 ± 0.4 g/100 g and 8.15 ± 0.7 g/100 g, respectively (Table 4). Statistical analysis demonstrated significant differences in lipids content between Mexican and Thai samples, being higher in Thai samples ($P < 0.05$), which again, just as happened with proteins, may be due to differences in the environment composition where insects grow and reproduce. On the other hand, according to the requirements for an adequate nutritional status in humans, and as happens with other foods, it is not possible to fulfill lipid requirements only with one kind of food, in this case with giant water bug. However, these insects may contribute to health maintenance by means of the enrichment of people's diet. In addition, current dietary recommendations for ω3 fatty acids are 1.6 g/d for men and 1.1 g/d for women, whereas ω6 fatty acids recommendations are 17 g/d for men and 12 g/d for women [16]. In this context, another worth mentioning fact is that the fatty acids profile in giant water bug includes mono-unsaturated fatty acid (MUFA) and poly-unsaturated fatty acid (PUFA), as well as ω3 and ω6 fatty acids, which has been demonstrated in previous analysis on 2011 of giant water bug from Xochimilco, Mexico [17]. Thus, these edible insects may be an important source of lipids for people that can not afford other lipid sources and so contribute to human population's health maintenance.

3.5 Fiber

Insects with a hard body which have high chitin content have high fiber and ash content [18]. Besides, the amount of fiber seems to be associated with that of the ash; the higher the fiber content, the greater the amount of ash. The insects studied here are consumed in their adult stage, so they have a hard exoskeleton made of chitin, a natural source of fiber (N-acetylglucosamine) needed for appropriate food digestive processes. Samples comparison regarding fiber content showed no significant differences between Mexican and Thai samples ($P > 0.05$), being found 10.95 ± 0.8 g/100 g and 12.23 ± 0.6 g/100 g of fiber, respectively. According to the recommendations of Codex Alimentarius, a product qualifies as a source of fiber if it contains 3 g/100 g, and it can be described as high in fiber if it contains 6 g/100 g or more [19]. Furthermore, epidemiologic studies suggested that colon cancer can diminishe by fiber consumption, and so, between 20 g/d and 30 g/d of fiber are recommended. Besides, some kinds of fiber absorb bile acids, the main metabolite of cholesterol, so fiber consumption may be helpful for diminishing cholesterol blood levels [20]. In addition, other studies showed that fiber consumption may be an effective mean of reducing blood pressure, as well as lowering the risks of coronary heart disease. For the aforementioned, the consumption of the insects studied here would not just be an alternative source of nutrients as energy supply, but also would provide this important component that could contribute to people's health.

3.6 Soluble Carbohydrates

Soluble carbohydrates are an important source of energy that is not in high amounts in the insects assessed in this study, being 17.75 g/100 g and 19.74 g/100 g for Mexican and Thai samples, respectively. However, due to the high amounts of proteins found in these insects, it is likely that the excess of proteins can be transformed into carbohydrates by means of gluconeogenesis, so the lack of immediate energy sources may be overcome by metabolic processes.

4. Conclusions

In Mexico and Thailand, giant water bug is an edible insect available all year around and is commonly consumed by people living in rural areas. The analysis performed in this study demonstrated that these insects are a valuable source of nutrients that may contribute to health maintenance of people living in rural areas. In addition, results showed that there are some differences regarding the amounts of nutrients found in samples depending on the area where insects were collected. Mexican samples have higher amounts of proteins than Thai samples, while in contrast, the lipid content found in Thai samples is higher than that in Mexican insects. And there were no differences found for the rest of the nutrients analyzed.

Both samples of insects are not only an alternative source of energy, but also an important source of fiber that may help to prevent cardiovascular diseases. Lastly, differences found may be due to environmental variations of the area where insects reproduce and acquire their nutrients necessary for growth and reproduction.

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