

## Quality proteins from edible indigenous insect food of Latin America and Asia

Virginia Melo<sup>1\*</sup>, Maritza Garcia<sup>1</sup>, Horacio Sandoval<sup>1</sup>, Héctor Daniel Jiménez<sup>1</sup> and Concepción Calvo<sup>2</sup>

<sup>1</sup>Autonomous Metropolitan University, Xochimilco, Mexico City, <sup>2</sup>National Institute of Medical Sciences and Nutrition, Salvador Zubirán, Mexico City

**Abstract:** There is a serious worldwide nutrition problem due to good quality protein deficiency affecting low income people. Insects are a good alternative, their consumption is all over the world, therefore is important, to improve production and preservation techniques, to market them for available to all population. Insect research has been conducted for more than twenty years, with species from Mexico and other countries of Africa, Asia, Australia and America. Species of 107 edible insects have been studied for their nutritional value and bioavailability. Proximal analysis of five land and aquatic species of insects were performed according AOAC (2000) methods. Results were in this order, grasshoppers, *Sphenarium purpurascens* Ch protein 71.50%; fat 5.75%; minerals 2.5%; fibre 3.89%; soluble carbohydrates 16.36%. Chicatana ant, *Atta Mexicana* B protein 66.00%; fat 24.02%; minerals 3.00%; fibre 2.06%; soluble carbohydrates 4.92%. Maguey grub, *Aegiale hesperiaris* K protein 30.88%; fat 58.55%; minerals 2.29%; fibre 0.12%; soluble carbohydrates 8.16%. Escamol ant eggs, *Liometopum apiculatum* H protein 40.90%; fat 33.96%; minerals 7.58%; fibre 1.3%; soluble carbohydrates 16.26%. Ahuahutle mosquito eggs are a mixture of *Krizousacoria azteca* J and other species, protein 53.60%; fat 4.33%; ash 21.00%; fibre 3.00%; soluble carbohydrates 18.07%. Insects have a good nutritional value and are high in protein with all essential amino acids. Promoting cultivation and preservation techniques will be a good source of income for people who grow these insects not only for their consumption but for commercialization at urban cities.

**Key words:** edible insects, essential amino acid, nutrition, proteins

### جودة البروتينات من الحشرات المحلية الصالحة للأكل في أمريكا اللاتينية وآسيا

فيرجينيا ميلو<sup>1\*</sup>، ماريتزا غارسيا<sup>1</sup>، هوراسيو ساندوفال<sup>1</sup>، هيكتور دانيال جيمénez<sup>1</sup> وكونسبسيون كالفو<sup>2</sup>

<sup>1</sup>جامعة متروبوليتان ذاتية الحكم، Xochimilco، مكسيكو سيتي، <sup>2</sup>المعهد الوطني للعلوم الطبية والتغذية، Zubirán، سلفادور، مكسيكو سيتي

**الملخص:** هناك مشكلة غذائية في معظم دول العالم بسبب نقص البروتين عالي القيمة وخاصة الذي يؤثر على ذوي الدخل المحدود وبالتالي تعتبر الحشرات البديل لتحسين الإنتاج وصون التقنيات لنواحي تسويقية لجميع السكان. وقد أجريت البحوث على الحشرات خلال العشرين سنة الماضية لأنواع عديدة من المكسيك وإفريقيا وآسيا وأستراليا وشمال أمريكا. وقد تمت دراسة الأنواع لعدد 106 من الحشرات صالحة للأكل بناء على قيمها الغذائية ومدى غناها الحيوي في البيئة وقد اجري تحليل مبدئي على خمس أنواع أرضية ومائية تم تقييم أدائها وفقاً لتقنيته AOAC (2000). قد أوضحت النتائج بأن نسبة البروتين في حشرة جراد الجندب 71.5% ونسبة الدهون 5.7% والمعادن 2.5% والألياف 3.89% والكربوهيدرات المذابة 16.36% ونسبة البروتين 66.00% ونسبة الدهون 24.02% والمعادن 3.00% والألياف 2.06% والكربوهيدرات المذابة 4.92% وديدو *Aegiale hesperiaris* K 30.88% ونسبة البروتين 58.55% ونسبة الدهون 2.29% والألياف 0.12% والكربوهيدرات المذابة 8.16% ونسبة البروتين 40.90% ونسبة الدهون 33.96% والمعادن 7.58% والألياف 1.3% والكربوهيدرات المذابة 16.26%، يعتبر باعوض *Ahuahutle* mosquito من خليط من *Krizousacoria azteca* J وعدة أنواع وكانت النسب البروتين 53.6% ونسبة الدهون 4.33% والرماد 21% والألياف 3% والكربوهيدرات المذابة 18.07%. وبالتالي تعتبر الحشرات ذو قيمة اقتصادية ومصدر جيد للبروتينات مع جميع الأحماض الأمينية الأساسية مما يشجع إكثارها وصون وحفظ تقنيات الحفاظ عليها. بالنسبة لكثير من الأشخاص الذي يعملون في تربية الحشرات ليس فقط لاستهلاكهم ولكن لتسويقها في المدن الحضرية.

\*Corresponding Author, Email: vmelo@correo.xoc.uam.mx

## Introduction

The adequacy of food supply depends upon productive resources and population grows. More than half the earth inhabitants who find difficult, to get enough to eat have few choice of foods. They must be content with whatever is at hand, which most probably provide a grossly inadequate diet. On the other hand, persons who live in areas of abundance, even in the midst of plenty, ignorance of adequate food habits frequently cause them to select deficient diets. The relation of adequate food to human welfare is a problem of international scope which at the same time is also uniquely personal. Food is whatever an individual eats to maintain his/her normal metabolism and body weight. Several species of Orthoptera order, grasshoppers are part of the diet of some ethnic groups at all five continents. Ants adults of Hymenoptera order, but different species, are eaten with other local names just before rainy season at north, Thailand, Colombia, Brazil and Mexico. Escamoles ant eggs represent the delicate gourmet dish in Mexico, Laos, Cambodia, and at every special restaurants of Europe. Maguey grubs of Lepidoptera order and ahuahutle Hemiptera order are species native from Mexico and much appreciated (Menzel et al., 1998). The development of chemistry has made it possible to define the composition and functions of food in rather precise terms (Fannema, 2008). As the result of chemical analysis it has been found that really all foods as they occur in nature contain proteins, fats, carbohydrates, vitamins, mineral salts and water (Coulter, 2009). Proteins due to its importance as human nutrient have become the main concern of food technologist and nutritionists (FAO/WHO, 1973). Proteins responsible for the nitrogen supply represent 16.5% of an adult body (Hudson, 1991). Insects are widely spread all over the world (Melo et al., 2010), many of them well known and appreciated for their organoleptic characteristics (Dumont, 1987). Some have been eaten in Mexico since prehispanic era (Sahagun, 1830) and still consumed in rural areas and high class restaurants as gourmet dishes. Insects, when are well accepted by

consumers can be intake to improve human nutrition.

The aim of this study is to perform analysis of macronutrients, amino acids and sensory quality of edible insects to promote consumption among population.

## Materials and methods

### Sampling

Five species of insects of different orders were gathered with techniques according to each species at several agro climatic zones of Mexico and in different biological cycles of metamorphosis stages; eggs, larvae and adults, to be classified (Moron and Terron, 1988) and chemical analyzed by AOAC (2000) methods.

Escamol; ant eggs, were manually collected in a dry rocky land from nests under the ground. Maguey grub; larvae stage gathered from inside maguey cactus leaves, both species available from February to May. Ahuahutle; mosquito eggs mixture of four species, got from a bundle of grass, stick in a pond under the water, affordable all year a round. Grasshoppers; adults reproduced from May to January samples were captured with nets among weed land. Chicatana; ant adults, manual pick up from soil right after mate flight before rainy season in June and July (Pastrana, 1985). Nomenclature and name of insects were determined from adult stage of each species (Moron and Terron, 1988).

### Chemical analysis

Chemical analyses of each insect sample were performed. All values are mean of triplicate determinations. Moisture content was measured by drying 100g of each sample, after being washed and chopped, in an oven at 60°C for 24 h. The insects were powdered separately in a Willey Mill to 60 mesh size; fine powder so obtained was used for further proximal analysis (Nielsen, 2009). Crude protein was calculated by multiplying the percent Kjeldahl nitrogen (Humphries, 1956) with the factor 6.25. The remaining proximate composition was estimated by AOAC (2000) methods. Nitrogen free extractives were calculated by difference (Muller and Tobin, 1980). Proteins were acid-hydrolyzed with 6N HCL at 110°C

for 8 h in vacuum. After flask evaporation the dried residue was dissolved in buffer Beckman NaS, pH 2.65. Known aliquots were determined by cation exchange chromatography in a BEKMAN 6300 gold Automated Amino Acid Analyzer, using ninhydrine as color reagent. The determination of the sulphur amino acids methionine and cysteine was carry out by means of oxygenating hydrolysis, using a mixture of formic acid and hydrogen peroxide (9:1) at 110°C for 24 h, after cooling sample was processed as, with acid hydrolysis. Buffers of pH 2.6 and 3.0 were used. Tryptophan was

determined by basic-hydrolyzed with Ba(OH)<sub>2</sub>, dried residue was dissolved in a buffer Beckman NaS, pH 6.8 after that same steps as other amino acids (Osborne, 1986). Acceptance was measured by hedonic scales of nine parameter, sensory evaluation was deemed by a team of 20 panellists not trained selected from using an hedonic scale from one to nine, from 9 like extremely, 5 neither like nor dislike to 1 dislike extremely (Stone and Sidel, 2004). The basic quality characteristics considered were, general appearance, color, taste and consistency.

## Results

**Table 1. Nomenclature of sample species.**

Order	Family	Scientific name	English name	Local name	Consumption stage
Orthoptera	Arcrididae	<i>Sphenarium purpuracens</i> Ch	Grasshopper	Chapulines	Adult
Hymenoptera	Formicidae	<i>Atta mexicana</i> B	Ant	Chicatana, Noku	Adult
Lepidoptera	Megatymidae	<i>Aegiale hesperiaris</i> K	Maguey grub	Gusano blanco de maguey	Larvae
Hymenoptera	Formicidae	<i>Liometopum apiculatum</i> H	Ant egg	Escamol	Egg
Hemiptera	Corixidae	<i>Krizousacorixia azteca</i> J	Mosquito eggs	Ahuahutle*	Egg

\* Ahuahutle is a mixture of *Krizousacorixia azteca* J, *Krizousacorixia femorata* G, *Corisella texcocana* J., *Corisella mercenaria* S. eggs (Moron and Terron, 1988).

Table 1 describes the nomenclature of scientific taxonomy, English and local names as well as consumption of metamorphosis stage of insects considering that some insects like grasshoppers are included in diet of worldwide population, ants are very much appreciated in Thailand, Colombia, Brazil and Mexico,

escamoles ant eggs are popular in Mexico, Laos and Cambodia, maguey grubs and escamoles are a gourmet dish in Mexico, mosquito eggs, a mixture of eggs of several species of insects find on cyperus leaves stick in the water at local lakes of Mexico.

**Table 2. Year round insects availability.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Grasshopper	X	x	x	x	X	X	X	X	X	X	X	X
Chicatana ant	-	-	-	-	-	X	X	-	-	-	-	-
Maguey grub	-	X	X	X	X	-	-	-	-	-	-	-
Escamol eggs	-	X	X	X	X	-	-	-	-	-	-	-
Ahuahutle	X	X	X	X	X	x	x	x	X	X	X	X

X= Abundant, x= Low, - = Not available. Seasonal available depend of biotic and abiotic habitat conditions.

Table 2 shows some species of insects are seasonal as mention above, but availability

may change according to biotic and abiotic conditions of the environment.

**Table 3. Macronutrients of 5 edible species of insects (g/100g dry basis).**

Insect	Protein	Lipids	Minerals	Fibre	NFE
Grasshopper	71.50	5.75	2.50	3.89	16.36
Chicatana ant	66.00	24.02	3.00	2.06	4.92
Maguey grub	30.88	58.55	2.29	0.12	8.16
Escamol eggs	40.90	33.96	7.85	1.30	15.99
Ahuahutle	53.60	4.33	21.00	3.00	18.07

All values are mean of triplicate determinations. NFE= nitrogen free extractives or soluble carbohydrates. Protein= Kjeldahl NX6.25. P<0.05

In Table 3, convenience sampling of insects were performed on the basis of accessibility of

wild or uncultivated ones and analysed for macronutrient composition.

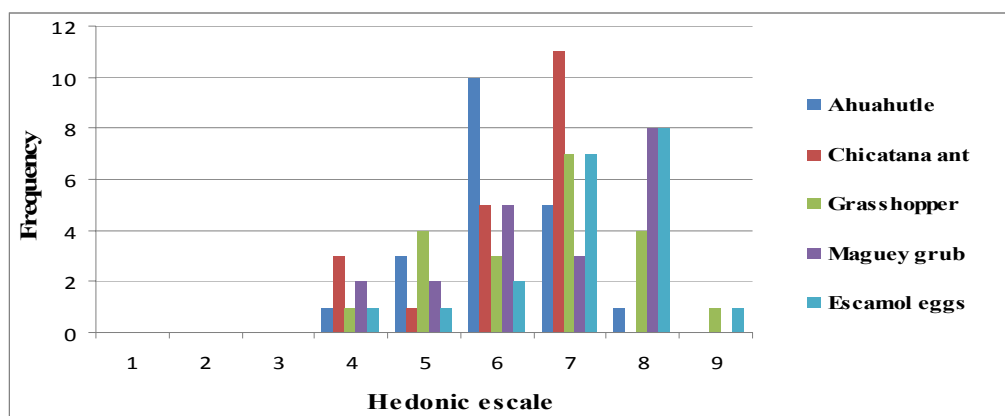
**Table 4. Essential amino acid composition of 5 edible species of insects from Mexico. (g/16g N).**

Insect	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Tryptophan	Valine
Grashopper	4.2	8.5	5.7	4.2	7.7	3.9	0.6	5.6
Chicatana ant	5.1	7.5	5.1	4.0	7.5	4.1	0.6	6.0
Maguey grub	4.5	6.1	5.0	3.1	7.0	4.1	0.8	5.1
Escamol eggs	4.5	7.6	5.5	4.5	6.6	4.3	0.7	6.0
Ahuahutle	5.0	8.0	3.5	2.9	6.2	4.0	1.1	6.0
FAO (1973)	4.5	7.0	5.5	3.5	6.0	4.0	1.0	5.0

Five species have all essential amino acids.

Table 4 shows the amino acid composition of insects. The original amino acid composition data were reported as grams amino acid per 100g of sample for each amino acid. The nitrogen content of the sample was used to

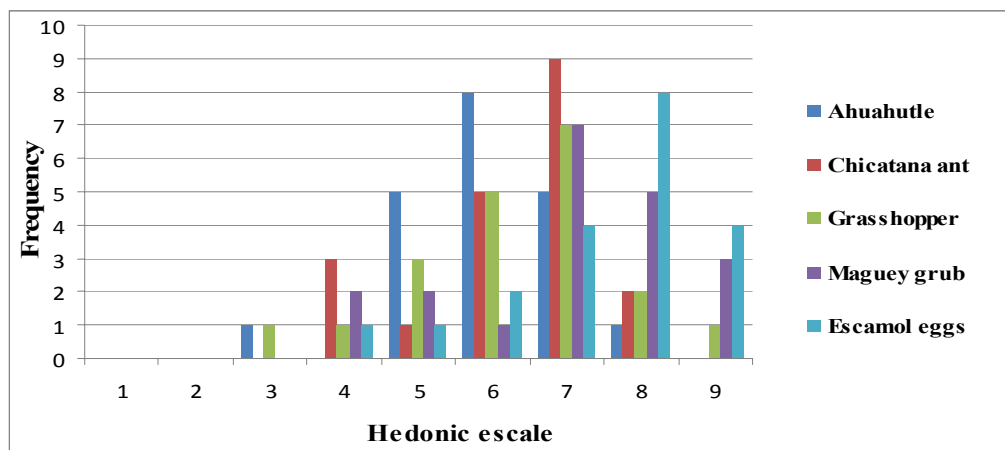
convert the amino acid per 16g nitrogen. The values were expressed in g/16g N because the conversion factors for each fraction from nitrogen to protein were not known.



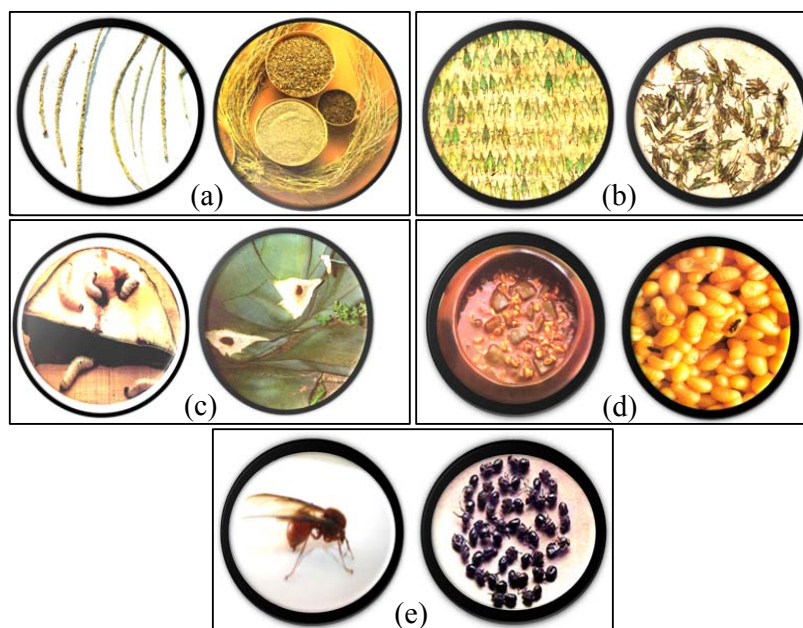
**Figure 1. Acceptance of flavour in 5 selected edible insects in Mexico.**

Tested based on a 9 point hedonic scale, 1=dislike extremely, 5=neither like or dislike, 9=like extremely.

Escamoles, maguey grub and chicatana ant are much better accepted however grasshopper and ahuahutle consumption is higher due to availability and public price.



**Figure 2. Acceptance of texture in 5 selected edible insects in Mexico.**  
Tested based on a 9 point hedonic scale, 1=dislike extremely, 5=neither like or dislike, 9=like extremely.



**Figure 3. Edible species of insects from Mexico (a) Ahuahutle (Mosquito eggs) *Krizousacorixia azteca* J; (b) Chapulines (Grasshopper) *Sphenarium purpuracens* Ch; (c) Gusano blanco de maguey (Maguey grub) *Aegiale hesperiaris* K; (d) Escamol (Ant egg) *Liometopum apiculatum* H; (e) Chicatana, Noku (Ant) *Atta mexicana* B.**

## Discussion

The crude protein content of all five edible insect samples was found in a high amount especially when compared with other protein sources population frequently consume (Table 3). They have all essential amino acids (Table

4). Crude lipids are high in escamol ant eggs, maguey grub larvae and the chicatana ant adult, because of their high content of fatty acids they must be frozen to storage for further consumption to void peroxidation of polyunsaturated fatty acids, in ahuahutle

mosquito eggs, and grasshoppers, fats are low. Most of them are low in non-digestible compounds specially escamol and maguey grub, however chichatana adult ant, ahuahutle mosquito eggs and grasshopper have some. Similarly nitrogen free extractives or soluble carbohydrates are low and mineral contents high mostly in ahuahutle, minerals were not analyzed and quantified individually separately.

In regard the amino acids, tryptophan was the limitant when compared with FAO/WHO (1973) requirement pattern. Regarding the sulfo amino acid methionine, and lysine ahuahutle is distinctly different when compared whit FAO/WHO (1973) recommendations, in other insects are similar.

### Conclusion

Insects are eaten in Mexico and all over the world since ancient times and consumed in rural areas and in urban cities at high class restaurants, with a great demand. They are easy to capture, some species should be dehydrated to preserve, others high in fatty acids must be frozen to storage. All of them have many culinary uses, as in spreads, soups, fillings and in a variety of many stews. Insects analyzed raw represent a high quality food, because of their protein content with all essential amino acids, some species with high amounts of polyunsaturated fatty acids and vitamins, are a good supply of minerals, not individually identity or quantify in this paper. For urban population represent a wide amount of gourmet dishes highly demanded by consumers. Some species of insects are seasonally reproduced but in urban cities are preserved by different techniques to have them available throughout the year.

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