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Macronutrient composition of the Chicatana ant *(Atta mexicana)*, Edible Insect during the rainy season in Mexico

Abstract

Feed security is a current international problem. It has been seen that worldwide population is growing and the constant urbanization and rising middle class have increased the global demand for food, especially for animal-based protein sources. Therefore, it is necessary to evaluate what is eaten and what is produced to find new options of underutilized food to satisfy this demand and meet basic requirements of nutrition. Insects in Africa, Asia, Australia, and Latin America are a regular part of the local diets of different ethnic groups, as a cheap source of food to meet nutrition requirements for human health. Chicatana ant, *(Atta mexicana)* consumed in Mexico, is one of the common edible insects. These ants come out of their nests during the first strong rains of the year and are thus gathered in this period. The adult stage of Hymenoptera order has important macronutrient content, such as protein, lipids, and carbohydrates, essential for human nutrition. The aim of this research was to assess the nutritional content of Chicatana ants, an adult stage of the Formicidae family, and its link with a positive impact in human health. Sample was collected in summer 2017 in Oaxaca city, and analyzed according to AOAC techniques, 1995. Results are the mean of three determinations. Data obtained was: Protein 31.88%, Lipid 34.65%, Fiber 6.13%, Minerals 7.58%, and soluble Carbohydrates 19.76%. Chicatana ant is not only a good source of macronutrients for body maintenance, but also for health improvement of human beings. They provide high quality proteins, essential for the human body and to enhance the immune system. Carbohydrates content in Chicatana ant are low; however, the protein excess by gluconeogenesis process provide glucose, which canbalance the requirements of soluble carbohydrates. Its fiber content helps digestion processes and microbiota maintenance. Minerals were not assessed individually.

Keywords: chicatana ant, edible insects, nutrition, health

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Introduction

According to the FAO, by 2050 the world will host 9billion people that will need to be fed; therefore, in order to meet this need, food production should be almost double. In recent years it is been seen that not only land scarcity, climate change, and polluted overfished oceans are serious problems for food production, and expanding the area devoted to farming is not enough fora viable sustainable option. Therefore, it is necessary to evaluate what is eaten and what is produced to find new options of underused food to satisfy this demand and meet basic requirements of nutrition.[1] On the other hand, it is known that for every 10animal species, 8 are insects, which can be found everywhere, in a wide variety of shapes, sizes, and nutritional content; the magnitude of this renewable natural resource should not be underestimated.

In Mexico, entomophagy (consumption of insects) is a practice which dates back to prehispanic times, later on Sahagun, Fray Bernardino, documented 96 species of edible insects in the Florentine codex. Nowadays, 504 species of edible insects have been reported along the Mexican republic. Chicatana ants (*Atta mexicana*), which are reproductive females or fecundated queens, are one of the most common edible insect in Mexico and they are consumed in a large part or the center and southern area of the country.[2] This adult stage of Hymenoptera order has important macronutrient components such as proteins, lipids, carbohydrates, minerals, and vitamins. In the underground nests of this specie live a queen, workers, eggs, larvae, and pupae. This specie presents a holometabolic development, they are reddish brown, head armored with a 770spine of each occipital lobe, the workers usually lack wings, ocelli, and their ovaries are atrophied. The queen can be easily recognized by its large size, compared to males and workers that are similar in size.[3] Females and queens, which are giant red ants and the size of a quarter, come out of their nests during the early summer rainy periods,[4] intent on mating and form colonies of their own; by the thousands, they take high into the air in a spiral pattern, during the following minutes they copulate with males. It is at that moment when harvesters are able together them using baskets, the chicatana ants are brought to a central roasting tent and stirred with a handful of salt and oil in a mud pot over an open fire. Others are cooked fresh in special stands and sold on the streets or in the city markets.[5]

Objectives

The aim of this research was to assess the nutritional content of macronutrients in ants of the adult stage of a Hymenoptera order and the link with a positive impact in human health.

Methodology

Sample collection

Convenience sampling was performed during early summer 2017, in the country side near by the city of Oaxaca, Oaxaca. Part of the sample was placed in glass containers and labeled with the data of

collection: date, place, time, and common name of the insect and name of the collector. After collection, chicatana ants were identified according to their taxonomy, as it is showed below (Table 1).

Table 1 Taxonomy and name of Chicatana Ant

Chicatana ant	Taxonomy and name
ORDER:	Hymenoptera
FAMILY:	Formicidae
GENUS:	Atta
SPECIE:	mexicana B
Binominal name:	Atta mexicana B
Commonname:	Chicatanaant,

Chemical analysis

The chemical composition of the sample was done in 200g of "Chicatana" collected on the ground, early in the morning. Ants were cleaned from dust and transported in glass containers by land, to the Universidad Autonoma Metropolitana - Xochimilco, Mexico, and were kept refrigerated at 4ºC for further moisture analysis and chemical composition determination. Analysis was performed in triplicate and according to AOAC[6] techniques.

Determination of moisture content

Sample moisture content was determined using the direct drying method. Homogenized sample (10g) was dried in a muffle furnace (Felisa SA de CV, Jalisco Mexico) at 60° for 24h. Dry samples were powdered in a mortar, and then passed through a 30 mesh size. The obtained fine powder was used for further analysis.

Determination of total minerals

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

Determination of protein content

Sample protein was determined according to the principle of the Kjeldahl method (AOAX method 945.01).[6] Sample (5g) was digested with 15mL concentrated H2SO4, using an electrically heated aluminium block digester. The resulting digest was diluted and then made alkaline with 50mL, 40% NaOH. This was followed by rapid steam distillation of ammonia from the diluted digest into 25mL 4% H3BO3 for manual titration with 0.2NHCL. A conversion 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/100g dry basis of sample.[7]

Determination of lipid content

Lipid content determination was performed by the semi continuous solvent extraction method (AOAC method 934.01)[6] as follows: sample (10g) was extracted with 180mL pretrolum ether on a soxhlet apparathus (Sigma-Aldrich, Mexico city, Mexico) at 120°C for 6h. Petroleum ether was removed by evaporation and the lipid residue was weighed. All samples were analyzed by triplicate and the results were expressed as g/100g dry basis of sample.

Determination of fiber

Raw fiber determination of the sample (10g) was performed by acid hydrolysis with H2SO4 0.255 N, followed by alkaline hydrolysis with NaOH 0.313 N in a Labconco apparathus (Labconco Corporation, Kansas, city, USA). Sample was analyzed in triplicate and results were expressed as g/100g dry basis of sample.

Determination of soluble carbohydrates

Carbohydrates content on dry basis was calculated by difference according to the equation: Soluble carbohydrates = [100 – (protein + lipids + ash + raw fiber)].

Results and discussion

Sampling

Chicatana ants (*Atta mexicana B)* (Figure 1), insects belonging to the Hymenoptera order and to the Formicidae family, are highly distributed in the south of Mexico (Figure 2) and can be found during the rainy season. Insect collection was performed in Oaxaca, Oaxaca, during the early summer 2017. Insects were washed and sun-dried; then insects were kept in glass containers and transported by land to the laboratory for further analysis. Oaxaca City is located in Southeastern Mexico. It is bordered by the states of Guerrero to the west, Puebla to the northwest, Veracruz to the north, Chiapas to the east. To the south, Oaxaca has a significant coastline on the Pacific Ocean. Oaxaca is also one of the most biologically diverse states in Mexico, ranking in the top three, along with Chiapas and Veracruz, for the number of reptiles, insects, amphibians, mammals and plants that live there. The state is within the tropical latitude; its climate varies with altitude. There are three principal climate regions in the state. The first one is the hot and subtropical lands. This accounts for about 30% of the state. The next one is the semi hot and semi humid regions, which account for about 18%, and the third is temperate and semi humid for about 16%. All of these climates experience a rainy season in summer and early fall. As most of the state is over 2,000m (6,562ft) above sea level, average temperature is about 18°C (64.4°F), Central Valleys, area of the sample collection, and all other zones are over 2,000m (6,562ft) above sea level and have a temperate climate. The state receives the majority of its rain during summer and early fall (Figure 3).

Figure 1 *Atta mexicana B.*

Availability during the year

Chicatana ants (*Atta mexicana B*) are not available all year around and their seasonal availability depends on biotic an abiotic conditions of the environment. These insects are mainly available during the rainy season in theearly summer (Table 2).

Determination of Moisture content

As it can be seen in Table 3, Chicatana ant moisture content is low, being more that 68% of its weight dry matter.

Figure 2 *Atta mexicana B.* Sell at local market.

Figure 3 Oaxaca state (Pink), Oaxaca city (Red).

Table 2 Availability of Chicatana ant during the year

Jan	Feb	Mar	Apr	May	Jun		Jul	Aug		Sep	Oct	Nov		Dec
-	-	-	x	x	X	X		x	-		-		-	-

X= Abundant; x= Low; - = not available

Table 3 Moisture determination of Chicatana ant

Water content of Chicatana ant	
Moisture	31.88%
Drymatter	68.12%

Macronutrients composition of Chicatana ant

Determination of protein content

Proteins are fundamental components for cellular and organ function, thus the diet must contain not only enough protein and amino acids but also non-protein energy to permit optimal utilization of dietary protein. Protein energy malnutrition is very common in the world and has severe effects on brain functions; in addition, people with protein energy malnutrition have a decreased immune function and, hence, are more susceptible to infectious diseases.[8] Protein requirements are 15% of total diet, so excess proteins can be transformed into carbohydrates (energy source) by gluconeogenesis. As it is shown in Table 4, protein content of Chicatana ant is high (31.88g/100gr dry sample), so it might be a good option to fulfill protein requirements for maintaining appropriate metabolic functions.

Table 4 Proximate Nutritional content

Macronutrients composition of Chicatana ant g/100g dry basis	
Protein	31.88
Lipids	34.65
Rawfiber	6.13
Minerals	7.58
Soluble carbohydrates	19.76

All values are mean of triplicate determination, N kjeldahl x 6.25 = N proteic
*Soluble carbohydrates obtained by difference

Determination of lipid content

Lipids are required for a diverse array of cellular processes, including structure, function, and energy-related roles. In addition, lipids contain more than twice the energy per gram (9kcal/g) as carbohydrates or protein contain (4kcal/g), which explains why humans preferentially store fat as the primary energy reservoir; furthermore dietary lipids are also a source of lipid-soluble vitamins and sterols. It has been recommended that 20-35% of the daily food intake should come from fat.[9] Lipid content of Chicatana ant is 34.65/100g dry sample, so these insects contain a valuable amount of this important macronutrient that might contribute to the health maintenance of people living in rural areas. Additionally, it has been reported that edible insects are a considerable source of lipids, being the importance of these two essential fatty acids well recognized, mainly for the healthy development of children and infants. Fatty acid composition of insects is related by the plants on which they feed.

Determination of fiber

Fiber determination shows that Chicatanaant contains 6.13g/100g of dry sample of fiber. Dietary fiber is generally defined as polysaccharides (chitin N-acetilglucosamine monomers of exoskeletal material of all insects) that cannot be digested by human enzymes. In 1970, Burkitt and Trowel mentioned that the prevalence of heart diseases and some cancers was associated to the lack of consumption of dietary fiber; therefore, the adequate intake of dietary fiber is important for human health.[10] Dietary fiber from a great variety of foods will help to protect from some types of cancers and also to aid to normalize blood lipids, thus reducing cardiovascular disease.[11] In addition, fiber can also slow glucose absorption and reduce insulin secretion, which is important for diabetics and non diabetics as well. Chicatana ant is an alternative source of fiber, which together with their regular diet, might help people to fulfill fiber requirements.

Determination of soluble carbohydrates

The carbohydrate group includes some of the most important molecules with multitude of roles involved in human nutrition, such as energy reserves (brain´s unique energy source) among others. Chicatana ant contains 19.76g/100g dry sample of carbohydrates. In general, it is known that the human diet must be composed of 60% carbohydrates, so these edible insects contain a low amount of this important nutrient; however, due to the high amount of proteins found in Chicatana, the excess of protein can be transformed into carbohydrates by means of gluconeogenesis.[12]

Conclusion

i. Nutritional content of Chicatana ants depends on their habitat and diet.

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ii. Chicatana Ants can be easily collected during rainy season in several states of Mexico. These ants are seasonal, but once dried and salted, they can be stored without spoilage for several months.
iii. Chicatana ants are not only a good source of macronutrients for the body maintenance, but also they can increase health and development of the human being.
iv. Provides proteins of high quality and enough energy from other biomolecules, such as fatty acids and soluble carbohydrates to allow the optimal utilization of dietary proteins.
v. Fiber content for a good digestion and some minerals.
vi. Macronutrients contained in Chicatana ants could help improving health in people who consume them.

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Conflict of interest

Authors declare that there is no conflict of interest.

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