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*Article*

# Analysis of the Nutritional Value of the Glasshead Ant (*Atta laevigata)* Smith 1858

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**ABSTRACT**

Edible insects are important in the diets of some traditional populations and are gaining prominence in haute cuisine due to their eccentricity and palatability. The glasshead leafcutter ant (*Atta laevigata)* Smith 1858, whose indigenous name is **sarai-wengyia**, is commonly consumed by the Sateré-Mawé ethnic group and has a very pleasant aroma and flavor. However, there is no information on its nutritional composition in the scientific literature. This study aimed to analyze the nutritional value of the glasshead leafcutter ant, based on its centesimal composition and mineral content. The insects were collected in the municipality of Maués-AM and stored at -20 °C. The centesimal composition was analyzed according to official analytical methods for food analysis. Proteins were determined by the Kjeldahl method, lipids by the Bligh-Dyer method, ash by incineration in a muffle furnace at 550 °C, and moisture by drying in an oven at 105 °C until constant weight. pH and acidity were also analyzed. The mineral content was analyzed using the energy-dispersive X-ray emission spectrometry (EDX) method. All analyses were performed in triplicate and on a wet weight basis. The moisture content found was high, corresponding to 57.1 ± 5.5%. A high protein content (26.7 ± 0.5%) was also found, higher than that of boiled chicken eggs and equivalent to meat and meat products. The ash content was also high, with an average of 17.3 ± 3.1%, similar to that found in other insects, such as termites. Lipids were found in smaller quantities, corresponding to 3.0 ± 0.6%. The ant showed significant results for macrominerals, such as phosphorus, sodium, and calcium. The average acidity was 5.3 ± 0.80% and the pH was 6.3 ± 0.02. It can be concluded that the glasshead ant, traditionally consumed by indigenous populations, has significant nutritional value, standing out as a potential alternative food source.
**Keywords:** ant, traditional populations, Amazon.

**RESUMO**

Os insetos comestíveis são importantes na alimentação de algumas populações tradicionais e vêm ganhando destaque na alta gastronomia, devido à sua excentricidade e palatabilidade. A saúva-cabeça-de-vidro (*Atta laevigata)* Smith 1858, cujo nome indígena é **sarai-wengyia**, é habitualmente consumida pela etnia Sateré-Mawé e apresenta aroma e sabor muito agradáveis ao paladar. No entanto, não há informações sobre sua composição nutricional na literatura científica. Este estudo teve como objetivo analisar o valor nutricional da saúva-cabeça-de-vidro, com base na sua composição centesimal e conteúdo de minerais. Os insetos foram coletados no município de Maués-AM e armazenados a -20 °C. A composição centesimal foi analisada conforme os métodos analíticos oficiais para análise de alimentos. As proteínas foram determinadas pelo método de Kjeldahl, lipídios pelo método de Bligh-Dyer, cinzas por incineração em mufla a 550 °C e umidade por secagem em estufa a 105 °C, até peso constante. Também foi analisado o pH e a acidez. O conteúdo de minerais foi analisado pelo método de Espectrometria de emissão de raios-X por dispersão de energia (EDX). Todas as análises foram realizadas em triplicata e em peso úmido. O teor de umidade encontrado foi elevado, correspondendo a 57,1 ± 5,5%. Também foi encontrado um alto conteúdo de proteínas (26,7 ± 0,5%), superior ao ovo de galinha cozido e equivalente a alimentos cárneos e seus derivados. O teor de cinzas também foi elevado, com média de 17,3 ± 3,1%, valor semelhante ao encontrado em outros insetos, como os cupins. Em menor quantidade, foram encontrados os lipídios, correspondentes a 3,0 ± 0,6%. A formiga apresentou resultados significativos para macrominerais, como fósforo, sódio e cálcio. A

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média de acidez foi 5,3 ± 0,80% e pH foi 6,3 ± 0,02. Conclui-se que a saúva-cabeça-de-vidro, tradicionalmente consumida por populações indígenas, apresenta valor nutricional relevante, destacando-se como um potencial alternativo alimentar.
**Palavras-chave:** formiga, populações tradicionais, Amazônia.

## Introduction

Unconventional foods, such as edible insects, are important in the diets of some traditional populations and are gaining prominence in haute cuisine due to their eccentricity (Mariutti et al., 2021).

The word "entomophagy" is used to represent the act of eating insects (Gahukar, 2011). Insects are considered a comparable alternative to the main conventional sources of animal-based foods, such as fish, chicken, pork, and beef (EFSA Scientific Committee, 2015).

Entomophagy is becoming increasingly popular among the world's population (Romeiro et al*.,* 2015). Insects such as termites, crickets, larvae, and ants are considered foods with high protein and energy content, and may contain significant amounts of amino acids, fatty acids, and micronutrients such as copper, iron, manganese, magnesium, phosphorus, and selenium, as well as vitamins such as riboflavin, pantothenic acid, biotin, and folic acid (Rumpold; Shlüter, 2013).

The Food and Agriculture Organization (FAO) states that around 80% of countries include insects in their diet, with 23 of these nations located in the Americas. More than a thousand species of insects are already part of the human diet, especially in the eastern part of the globe, where they are most popular in tropical regions, places where insects tend to be larger and easier to capture.

In Brazil, some insects are consumed in traditional dishes. One example is the ant popularly known as Tanajura or Içá, which is highly appreciated in Minas Gerais, Amazonas, and throughout northeastern Brazil, where it is used as an ingredient in farofa. The ant known as saúva (*Atta cephalotes*) is consumed mainly in the North region and has a higher protein content than chicken (23%) and beef (20%), reaching 42.59% (Terramerica, 2013).

*Atta laevigata* Smith, 1858 (Figure 1), known as the glasshead saúva, is considered the second most common species of saúva in Brazil (Anjos et al., 1998). The original description of the species was made in 1858 by Fred Smith, based on an 11.5 mm worker collected in Santarém, Pará (Gonçalves, 1942; Smith, 1858). According to Gonçalves (1942), the main morphological characteristics for identifying *Atta laevigata* are: well-developed head; abundant erect hairs on the pronotum and anterior part of the thorax; rounded cephalic lobes; legs with short hairs.


Figure 1. *Atta laevigata*. Source: The authors, 2024.

*Atta laevigata* inhabits Colombia, Venezuela, Guyana, Bolivia, and Paraguay (Borgmer, 1950; Gonçalves, 1960; Mariconi, 1970) and, in Brazil, is present in all five geographic regions, including the state of Acre, which appears to have been recently colonized (Forti et al., 2003). However, it is not found in the states of Espírito Santo, Santa Catarina, and Rio Grande do Sul, as well as in the southern regions of Bahia, the interior of the Northeast, and the central portion of the Amazon (Amante, 1972; Della Lucia et al., 1993; Mariconi, 1970; Paiva Castro et al*.,* 1961; Troppmair, 1973).

This geographic distribution has been described by many authors based on field observations, confirming that the species occupies extensive areas of South America. However, these studies do not prove its absence in certain areas close to its known locations. Thus, *Atta laevigata* has been recorded in an increasing number of locations, mainly due to the opening of highways and the expansion of livestock farming, which act as vectors for the dispersal of the species (Vinha et al., 2022).

The entrance to their nests is rounded in shape, surrounded by mounds of loose soil (Anjos et al., 1998). In some Brazilian states, the leafcutter workers of this species are considered pests because they defoliate plants in order to cultivate fungi that sustain the colony (Della Lucia et al., 1993). These fungi act as an "external stomach," digesting cellulose and transforming plant allelochemicals into substances that are palatable to ants (Della Lucia et al., 1993).

The glasshead leafcutter ant has an acidic aroma and flavor, which is very pleasant to the palate, and usually generates a great feeling of satiety in those who consume it. Therefore, it is important to know its chemical composition and physical-chemical characteristics in order to provide information about its nutritional value. The objective of this study was to determine the nutritional value of the glasshead leafcutter ant (*Atta laevigata*) Smith 1858, quantifying the content of total carbohydrates, crude protein, total lipids, moisture, ash, calories, minerals, and evaluating the pH and total acidity.

## Materials and methods

### *Samples*

The glasshead leafcutter ants were collected in the Nossa Senhora de Nazaré Indigenous Community, located in the rural area of the municipality of Maués, Amazonas. After collection, they were stored and transported to the Nutrition Laboratory of the Institute of Health and Biotechnology of the Federal University of Amazonas, in the municipality of Coari, Amazonas.

### *Determination of the physical-chemical characteristics of glasshead leafcutter ants*

The physical-chemical analyses were performed on a wet basis. All analyses were performed in triplicate. The results were expressed as mean ± standard deviation for each sample.

#### *Moisture*

The moisture content was determined by direct drying in an oven until constant weight (IAL, 2008). The crucibles were identified in triplicate and dried in an oven with air renewal (DeLeo, model SVN-38) at 105 °C. After 3 h, the crucibles were removed from the oven with metal tweezers and cooled in a desiccator containing silica gel for 20 min. The crucibles were then weighed on an analytical balance (Shimadza, model AUY220).

Approximately 3 g of the sample were weighed in triplicate, spreading the sample to form a thin layer. The set (crucibles containing the samples) remained in the oven at 105 °C for 3 h. They were then transferred to a desiccator containing silica gel. After about 20 min, the set was weighed again. The weighings were repeated every three hours until a constant weight was reached. In total, six weighings were performed.

*Ash*

The ash content was determined by muffle furnace combustion at 550 °C (Cienlab, model SSFM 6) (AOAC, 1995). Three grams of the sample were weighed in previously tared crucibles using an analytical balance. Carbonization was performed on a hot plate at 300 °C (Nova Técnica, model NT 339), and then the samples were incinerated in a muffle furnace at 550 °C, weighing every 3 hours until a constant weight was reached.

*Crude protein*

The protein content was determined by the modified Kjeldhal method (method 991.20, AOAC, 1995), which consisted of three stages: digestion, distillation, and titration. In this analysis, 0.1 g of the sample was used in triplicate.

*Total lipids*

Total lipids were quantified by cold extraction using the Bligh-Dyer method, which employs three solvents in different proportions: chloroform, methanol, and water (Bligh; Dyer, 1959).

*Total carbohydrates by difference*

The total carbohydrate content was calculated by the difference between 100 and the sum of the percentages of moisture, protein, lipids, and ash.

*caloric value*

The caloric value was calculated by adding the calories provided by total carbohydrates, lipids, and proteins, multiplying their values in grams by the Bryant and Atwater factors, in which carbohydrates and proteins represent 4 kcal/g and lipids 9 kcal/g.

*Acidity and pH*

Total acidity was determined by titrating the sample solution with 0.01 N sodium hydroxide until color change. The pH was measured using a digital pH meter (Bel, model PHS3BW), previously calibrated according to the manufacturer's manual instructions. (Figure 12).

*Minerals*

The mineral content was determined by energy dispersive X-ray emission spectrometry (EDX) using a FisherScope* X Ray XAN 250 device with a tungsten tube, an exposure time of 200 s, and a voltage between 0 and 40 keV. This is a qualitative analysis, in which the method consists of scanning the sample with a high-energy X-ray beam. All elements were identified by their Kα and/or Kβ energies (K. Janssens, 2003). Geological reference standards, such as GBW 3125, 7105, and 7113, were used to calibrate the equipment. Using mathematical software, the emission peaks were related to the respective concentrations of each element.

For each element found, quantification was performed using external standards of salts of known purity, diluted in boric acid, also of known purity, in at least six predetermined concentrations. These standards were subjected to the same analysis conditions as the samples. Finally, the quantifications were performed based on the measured intensities (cps/uA).

## Results and Discussion

The results obtained from the analyses of the centesimal composition of the glasshead weevil are presented in Table 1.

Table 1. Centesimal composition of the glasshead leafcutter ant, on a wet basis, and comparison with other insects

| | Glasshead leafcutter ant Atta leavigata | Tanajura[1] Atta sexdens | Leafcutter ant[2] Red-haired carpenter ant | Cockroach[3] Nauphoeta cinerea | Grasshopper[4] Ruspolia differens |
|---|---|---|---|---|---|
| Humidity (%) | 57.10 | 37.22 | 61.31 | 31.60 | - |
| Ash (%) | 17.30 | 0.84 | 1.87 | 3.90 | 2.80 |
| Protein (%) | 26.70 | 13.24 | 26.57 | 40.56 | 43.10 |
| Lipids (%) | 3.00 | 31.51 | 0.87 | 5.41 | 48.20 |
| Total carbohydrates (%) | 1.80 | - | - | 18.48 | 2.00 |
| Calories (kcal/100 g) | 141 | - | 615 | - | - |

Source: The author, 2024; [1] Fontes et al., (2018); [2] Gallo et al., (2020); [3] Miranda et al., (2022); [4] Kinyuru et al., (2018).

### *Moisture*

The moisture content found in the sample in this study was 57.1%. When compared to the moisture values of other insects of the same genus *Atta*, it is lower than that found in the *Atta sexdens rubropilosa* leafcutter ant by Gallo et al. (2020), which was 61.31%, and higher than the value observed by Fontes et al. (2018), who found 37.22% in the *Atta sexdens* leafcutter ant. The difference between the values is due to the way these insects were prepared and analyzed. While Gallo et al. (2020) characterized the dry part of the sample, Fontes et al. (2018) analyzed a wet sample. In this study, the samples were analyzed in a wet state, which partially explains the differences found in the studies, since the moisture content of food is related to the composition, quality, and stability of the analyzed product.

### *Ash*

The fixed mineral residue content found in the sample in this study was 17.3%, on a wet basis. When compared to the ash values of other insects of the same genus *Atta*, it is higher than the value found in *Atta sexdens rubropilosa* by Gallo et al. (2020), which was 1.87% ash, and also higher than the value observed by Fontes et al. (2018), who found 0.84% in the leafcutter ant *Atta* spp. Fixed mineral residue is the inorganic product that remains after burning the organic matter in the sample, and its determination is an indication of the richness of the mineral elements present (IAL, 2008).

### *Crude protein*

The total protein content found in the sample was the most significant, reaching 26.7%. Gallo et al. (2020) obtained 26.53%, a value very close to that of this study. Fontes et al. (2018), in turn, found 13.24%, a value much lower than in other studies. Leaf-cutting ants appear to be in the same protein range as everyday foods such as beef, poultry, fish, and eggs. According to the TACO nutritional table, beef contains 21.60% protein; chicken breast 21.50%; fish, especially peacock bass, 18%; and raw eggs 13%. These results reinforce the relevance of insects as a protein source and their potential inclusion in the human diet.

### *Total lipids*

The amount of this compound found in the present study was 3.0%. Gallo et al. (2020) found 0.89% for *Atta sexdens rubropilosa*, while Fontes et al. (2018) found 31.51% for *Atta sexdens.* Thus, we can affirm that the amount of fat present in the saúva, even though lower than the value found by Fontes et al. (2018), may contribute to its palatability.

### *Carbohydrate*

In the present study, the total carbohydrate content found in saúvas was 1.8%. It was not possible to compare this with the other authors cited, as they did not present results on this nutrient. Therefore, we made a comparison with other insects described in the scientific literature as an alternative for the human diet. Miranda et al. (2022) found 18.48% in the cockroach *Nauphoeta cinérea*. In the study by Silva et al. (2019), the authors found 5.1% carbohydrates in the same species. Thus, it can be observed that saúvas have the lowest carbohydrate content when compared to other edible insects. It is known that carbohydrates are used as raw material by the food industry, and their deficiency in the body can cause health problems such as weakness, irritability, or even depression (FIB, 2012).

### *Calories*

In the present study, the value was 141 Kcal/g, indicating a lower energy content compared to other leaf-cutting ants, as observed by Gallo et al. (2020), who recorded 615 Kcal/g, a very high value when compared to the average of other insect species, such as butterflies (508.89 Kcal/100 g) and beetles (478.99 Kcal/100 g) (Rumpold; Schluter, 2012).

### *Minerals*

In this analysis, the levels of chromium, chlorine, and sulfur minerals are important for interpreting the data, especially when compared to the other insects presented in Table 2.

In the present study, a relatively high sodium content of 9.7% was found, although much lower than that observed in another leafcutter ant (*Atta sexdens*), in which Kinyuru et al. (2018) obtained a value of 26.2%. For the grasshopper (*Ruspolia differens*), an even higher content of 358.7% was recorded. In the organism, sodium performs the function of maintaining osmotic pressure (pressure exerted on a solution to prevent the passage of solvent through a semipermeable membrane) (Pereira, 2005).

For phosphorus, a value of 3.5% was obtained when compared to the tanajura leafcutter ant (*Atta sexdens*), in which Kinyuru et al. (2018) found a value of 106%. For the grasshopper (*Ruspolia differens*), a value of 140.6% was found. Phosphorus deficiency in metabolism causes symptoms similar to those of vitamin D deficiency. The first sign of a deficiency of this macronutrient is loss of appetite, followed by a reduction in the energy available for metabolism, which can lead to weight loss (Mcdowell, 1992).

For calcium, the glasshead leafcutter ant had a content of 0.3% when compared to the tanajura leafcutter ant (*Atta sexdens*), in which Kinyuru et al. (2018) found a value of 22.2%. For *Ruspolia differens*, a content of 27.40% was recorded.

Table 2. Minerals present in glasshead leafcutter ants compared to other edible insects.

| Minerals | Atta Laeviagata | Atta sexdens | Ruspolia Differens |
|---|---|---|---|
| **Calcium (%)** | 0.3 ± 0.35 | 22.20 | 27.40 |
| **Sodium (%)** | 9.7 ± 2.43 | 26.20 | 358.70 |
| **Chromium (%)** | 4.3 ± 2.55 | - | - |
| **Phosphorus (%)** | 3.5 ± 1.07 | 106.00 | 140.60 |
| **Chlorine (%)** | 8.8 ± 4.49 | - | - |
| **Sulfur (%)** | 4.6 ± 3.73 | - | - |
| **Iron (%)** | 0.0 ± 24.93 | 10.70 | 16.60 |
| **Potassium (%)** | - | 51.70 | 370.60 |

Source: *Atta laeviagata*: glasshead ant (The author, 2024); *Atta sexdens*: tanajura; *Ruspolia differens*: grasshopper (Kinyuru, 2018).

The chlorine content presented in this study was 8.8%. Other authors did not obtain results for this mineral. According to Pinheiro (2005), chlorine is important for maintaining osmotic pressure and water balance, acting in conjunction with sodium and potassium.

For sulfur, the present study found a content of 4.6%. The other authors did not present results for this analysis. Sulfur has several functions in the body: it is a constituent of cellular proteins, melanin, cocarboxylase, vitreous humor, synovial fluid, connective tissues, mucopolysaccharides, heparin, insulin, and cartilage; it acts in the metabolism of nervous tissue; participates in detoxification mechanisms; and integrates, as an SH group, coenzyme A, glutathione, and cystathionine (Pereira, 2005). Sulfur is found in protein molecules in foods such as meat, poultry, fish, eggs, milk, legumes, and nuts (Souza, 2016).

The chromium content found in this study was 4.3%. In studies by other authors, no results were reported for this mineral. According to Ferreira et al. (2002), chromium is essential for human health, as it acts in the metabolism of carbohydrates and lipids, performing a function related to the mechanism of action of insulin. A deficiency of this micromineral in the diet can cause serious health complications, such as diabetes and cardiovascular problems (Ferreira et al., 2002).

In this study, no potassium levels were identified in ants, indicating the need for a more specific analysis to quantify this mineral. After all, potassium plays several important roles in the body, mainly in muscle function and nerve impulse transmission. It is also essential for normal cell function. When imbalanced, its intra- and extracellular concentrations can affect neural transmission, muscle contraction, and vascular tone (Fereira et al., 2002).

Micronutrients play an important role in the nutritional value of food. Their deficiencies, common in many countries, can have adverse health consequences, contributing to impaired growth, immune function, and mental and physical development (Dary; Hurrell, 2006). Thus, with the promising results obtained, we can see that the glasshead leafcutter ant can contribute minerals necessary for the diet, as well as other foods present on the population's table. Although present in small amounts, these micronutrients are essential for the proper functioning of the body.

***pH and Acidity***

In this study, the result for acidity by titration at a temperature of 20 °C was 5.3 ± 0.80%. For pH, a value of 6.3 ± 0.02 was obtained, which, when compared to other foods, shows that the saúva has a value close to that of fresh milk, whose pH varies from 6.6 to 6.8 at 20 °C. It is also close to the pH of beef, which varies between 5.8 and 6.2, a range considered suitable for consumption.

The determination of acidity using a 0.01 mol/L sodium hydroxide solution allows for more accurate results for food preservation purposes, since the decomposition process almost always alters the concentration of hydrogen ions (AOAC, 1995).

**Final considerations**

The nutritional values obtained for the glasshead ant show that it has the potential to be included as an alternative food in the human diet. This reinforces the cultural and social importance of eating according to the customs of a particular ethnic group, pointing to the need to encourage research and development of preparations that value traditional ingredients and the indigenous heritage still present today.

The results revealed that this species of ant has an excellent nutritional profile, with a high content of proteins and essential minerals, such as phosphorus, sodium, and calcium, highlighting its potential as a relevant source of nutrients. The high protein content found indicates that eating this insect may be a viable alternative for enriching the human diet, especially in regions where access to conventional sources of protein is limited. In addition, the presence of important minerals suggests that the glasshead ant may play a relevant role in combating the deficiency of certain minerals in vulnerable populations.

Despite the high moisture and ash content, which may reflect the composition of these insects' natural habitat, the data obtained indicate that the glasshead leafcutter ant not only preserves its cultural importance for traditional populations, but can also be valued in haute cuisine and the food industry, acting as an exotic and nutritious ingredient.

Finally, this study presents unprecedented data and paves the way for future research exploring other nutritional, chemical, and functional aspects of this species, as well as its potential applications in different food contexts. This contributes to the valorization of the Amazon's biological resources and the promotion of sustainable food practices.

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