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Communication

[*Comunicação*]

Nutritional composition of larvae of mealworm (*Tenebrio molitor* L.) and crickets (*Gryllus assimilis*) with potential usage in feed

[*Composição nutricional de larvas de* Tenebrio molitor *e de grilos (*Gryllus assimilis*) com potencial de uso na alimentação animal*]

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The use of insects in animal feed currently presents itself as an alternative to soybean meal since it requires low land and water for its production. The *Tenebrio molitor* is reported as an easy breeding and maintenance insect due to the low production cost. In addition, these insects have been evaluated both in human food (Costa, 2017) and animal feed (Belforti *et al.*, 2015). Another interesting species is the cricket of the genus *Gryllus assimilis*, since it has a high rate of reproduction and development at certain time of the year, mainly due to heat, humidity, and the presence of crops such as corn and soybean. Semi-arid Regions, such as the Northeast of Brazil, present low soy production and may, eventually, present a shortage of protein sources for use in animal feed.

Thus, the use of insects can be an alternative to solve this problem. However, there is little information about the chemical composition of different types of insects. In addition, the nutritional composition of insects can be changed depending on their diet (Siemianowska *et al.*, 2013). The aim of the present study was to determine the nutritional composition of *Tenebrio molitor* larvae and crickets of the genus *Gryllus assimilis* for usage in animal feed.

MATERIAL AND METHODS

The study was approved by the Ethics Committee in Research with Production Animals (CEPAP) of the Federal University of Sergipe, under protocol number 03/2019. Chemical analyses of insects followed the protocols described by AOAC (Official…, 1990). Samples of Tenebrio larvae and crickets were placed in plastic containers, weighed, and euthanized in a freezer at -6 ° C. Then, the samples were dried in forced circulation ovens at 55 ° C and ground in a ball mill. The dry matter content of the samples was determined according to protocol 934.01. The crude protein (CP) content was determined by the Kjeldahl method (protocol 954.01). The gross energy (GE) was determined using a calorimetric combustion pump (IKAC200).

The content of ether extract (EE) was determined using the Soxhlet method (protocol 955.04). The ash content (Ash) was determined according to the 942.05 protocol. The levels of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to protocol 937.18. The content of phosphorus (P) was determined by a colorimetric test (Fiske and Subbarow, 1925). Acid molybdate and reducing solution were added to wet-ash samples to make a phosphorus-molybdenum complex. The color intensity was proportional to the P concentration and was determined with a spectrophotometer using absorbance at 620 nm (SpectraCount, Model # AS1000, Packard, Meridian, CT). The other macrominerals and trace minerals were obtained from dry digestion.

Potassium (K) was determined by the method of flame photometry, while sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), manganese

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(Mn), zinc (Zn) and copper (Cu) were determined by the atomic absorption spectrophotometric method (protocol 968.08) using an atomic absorption spectrometer (AAnalyst 300, Perkin Elmer, Norwalk, CT).

RESULTS AND DISCUSSION

Proximal composition and mineral content of *Tenebrio molitor* larvae and crickets of the genus *Gryllus assimilis* are shown in Table 1.

Table 1. Proximal composition and mineral content of *Tenebrio molitor* larvae and crickets of the genus *Gryllus assimilis* (dry matter-basis)

Item[1]	Values	
	Tenebrio molitor larvae	*Crickets* (*Gryllus assimilis*)
Crude Protein, g/kg	490.2	541.3
Ether extract, g/kg	335.4	75.2
Gross Energy, kcal/kg	7,188.6	5,942.6
NDF, g/kg	71.8	277.8
ADF, g/kg	64.0	193.0
Ash, g/kg	36.8	49.1
Macrominerals		
Total phosphorus, g/kg	8.56	8.3
Potassium, g/kg	8.39	11.6
Sodium, g/kg	1.39	1.10
Total calcium, g/kg	0.44	3.88
Magnesium, g/kg	2.30	0.82
Trace minerals		
Iron, mg/kg	48.4	96.8
Manganese, mg/kg	15.0	23.7
Zinc, mg/kg	189	18.3
Copper, mg/kg	18.0	21.7

[1]Chemical analyses followed the protocols described in AOAC (Official…, 1990).

The CP content in *Tenebrio molitor* larvae was 490.2 g/kg. Past studies reported similar results (Costa, 2017; Fontes *et al.*, 2019). The observed CP in crickets was 541.3 g/kg. In addition to the high content of CP, insects have high digestibility since they are products from animal origin (De Marco *et al.*, 2015).

Larvae of mealworm (*Tenebrio molitor* L.) and crickets showed EE contents of 335.4 g/kg and 75.2 g/kg, respectively. Barroso *et al.* (2014) observed EE content in larvae of mealworm varying from 294.0 to 308.0 g/kg. The edible insects have been stated to have more nutritional contents than other conventional food, such as soybean and meat (Ravzanaadii *et al.*, 2012). Siemianowska *et al.* (2013) reported larvae of mealworm (*Tenebrio molitor* L.) contains more total protein, total fat, and ash than traditional meats i.e. chicken, pork, beef, fish, and eggs. However, the authors cited the chemical content of insect body depends on species, climate, habitation, and feed.

Tenebrio molitor larvae and crickets showed a high GE content of 7,188.6 kcal/kg and 5,942.6 kcal/kg respectively, when compared to other feedstuffs, such as grain corn with an average of GE of 4,432.95 kcal/kg (Rostagno *et al.*, 2017). The contents of NDF and ADF found in larvae of mealworm (*Tenebrio molitor* L.) were 71.8 g/kg and 64.0 g/kg, respectively. The NDF observed in crickets of the genus *Gryllus assimilis* was 277.8 g/kg and the ADF was 193.0 g/kg. Finke (2007) stated differences between NDF and ADF are generally associated with hemicellulose content, but in insects, these analyses may be associated with chitin content. The author reported the ADF may contain up to 68.8% of the total amino acids present in insects, resulting in high levels of NDF and ADF in the samples. Chitin is a structural polysaccharide composed of β-(1-4) bonds linking N-acetylglucosamine residues which acts improving immune responses (Muzzarelli, 2010). Veldkamp *et al.* (2012) stated the usage of insects in the diet of birds would have immunological effects due to chitin.

The determined amounts of Ash, P, K, Na, Ca, mg, Fe, Mn, Zn, and Cu in the *Tenebrio molitor* L. were 36.8 g/kg, 8.56 g/kg, 8.39 g/kg, 1.39 g/kg, 0.44 g/kg, 2.3 g/kg, 48.4 mg/kg, 15 mg/kg, 189 mg/kg, and 18 mg/kg of feed, respectively. In the crickets, the quantified contents were 49.1 g/kg (Ash), 8.30 g/kg (P), 11.6 g/kg (K), 1.10 g/kg (Na), 3.88 g/kg (Ca), 0.82 g/kg (Mg), 96.8 mg/kg (Fe), 23.7 mg/kg (Mn), 18.3 mg/kg (Zn) and 21.7 mg/kg (Cu). Siemianowska *et al*. (2013) stated that fresh and powdered larvae of mealworm are characterized by high content of minerals containing more phosphorus, magnesium, zinc, iron, cupper, and manganese than Polish conventional meats of animals and eggs. Larvae of mealworm (*Tenebrio molitor* L.) and crickets of the genus *Gryllus assimilis* may be alternatives for reducing the use of vegetable protein sources in animal feed.

Keywords: poultry farming, insects, protein

RESUMO

Atualmente, tem-se discutido a utilização de insetos na alimentação animal devido ao seu potencial para substituir as fontes tradicionais de proteína utilizadas. O objetivo deste trabalho foi determinar a composição nutricional de larvas de Tenebrio molitor *e de grilos do gênero* Gryllus assimilis*. Os teores de energia bruta (kcal/kg), proteína bruta (g/kg), extrato etéreo (g/kg), cinza (g/kg), FDN (g/kg) e FDA (g/kg) encontrados nas larvas de* Tenebrio molitor *foram de 7.188,6, 490,2, 335,4, 36,8, 71,8, e 64,0 respectivamente; nos grilos* (Gryllus assimilis*), os valores foram de 5.942,6, 541,3, 75,2, 49,1, 277,8, e 193,0 respectivamente. Os macros e microminerais quantificados foram fósforo, potássio, sódio, cálcio, magnésio, ferro, manganês, zinco e cobre. Nas larvas de* Tenebrio molitor*, os valores encontrados foram de 8,56 g/kg, 8,39 g/kg, 1,39 g/kg, 0,44 g/kg, 2,3 g/kg, 48,4 mg/kg, 15 mg/kg, 189 mg/kg e 18 mg/kg respectivamente. Para os grilos* (Gryllus assimilis*), os teores encontrados foram respectivamente de 8,30 g/kg, 11,6 g/kg, 1,10 g/kg, 3,88 g/kg, 0,82 g/kg, 96,8 mg/kg, 23,7 mg/kg, 18,3 mg/kg e 21,7 mg/kg. Larvas de* Tenebrio molitor *e grilos do gênero* Gryllus assimilis *podem ser alternativas para reduzir o uso de fontes de proteína vegetal na alimentação animal.*

Palavras-chave: avicultura, insetos, proteína

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