



AGRARIAN SCIENCES

Chemical composition and nutrient digestibility of insect meal for broiler

LEILANE R.B. DOURADO, PATRÍCIA M. LOPES, VANESSA KARLA SILVA,
FRANCISCA LUANA A. CARVALHO, FRANCINETE A.S. MOURA, LUCIANA B. SILVA,
LUIZ GUSTAVO GIANNECCHINI, SANDRA REGINA F. PINHEIRO, DANIEL BIAGIOTTI
& JANAINA M. KIMPARA

Abstract: To determine the chemical composition and digestibility of insect meal for poultry made from the larvae of *Tenebrio molitor* (TL) and nymphs of *Gryllus assimilis* (GAN) a total excreta collection test was carried out, substituting 20% of the reference diet with each type of meal. The meals presented 6074 and 5975 kcal/Kg of gross energy, with 49.34% and 52.66% protein for TL and GAN respectively. The most nutrient digestibility was less than 65%, except for energy and ether-extract digestibility in the meal from *Tenebrio molitor* larvae, which were over 70%. The meals under analysis can be used as a source of nutrients in poultry diets.

Key words: *gallus gallus*, alternative feed, *Tenebrio molitor*, *Gryllus assimilis*.

INTRODUCTION

The search for ingredients for animal feed has always been based on reducing costs, however, in recent years there has also been concern about the impact of animal feed on the environment.

As such, alternative sources of protein, of comparable value and high digestibility, are essential for sustainable poultry production in the future. Especially as the demand for protein for animal and human consumption is constantly increasing, i.e. production presents an important global challenge (Bovera et al. 2015).

An alternative to traditional sources of protein for animal feed is the use of insects in the diet. Arguments can be made for their use, since insects grow and reproduce easily, have a high feed conversion efficiency and can feed on organic residue (Veldkamp et al. 2012).

The aim of the present study was to determine the chemical composition and digestibility of nutrients in insect meal from the larvae of *Tenebrio molitor* (TL) and nymphs of *Gryllus assimilis* (GAN), in broilers.

MATERIALS AND METHODS

The experiment was approved by the animal ethics committee of the Federal University of Piauí, registration no. 283/17. The research was developed in the Poultry Sector of the Bom Jesus Technical College in the State of Piauí (PI), associated with the Federal University of Piauí (UFPI). The chemical analysis the composition of the food and excreta was carried out at the Animal Nutrition Laboratory of UFPI and at LAVINESP, UNESP in Jaboticabal, São Paulo.

To produce the meal, larvae were collected from a commercial poultry farm in Parnaíba, PI,

where they were cleaned with water and kept in 1000L boxes containing a substrate of wheat bran to be bred at Embrapa Meio Norte until it was time to produce the meal. Upon reaching the pre-pupal stage, the larvae were collected and stored in a freezer, dried in a forced ventilation oven at 55°C for 72 hours and then ground twice in a mill having a 4 mm mesh. The meal was stored in a freezer for later analysis of the chemical composition and for use in the digestibility test.

A total of 63 male Ross broilers, with eight days of age, were distributed in a completely randomised design consisting of three diets, with seven replications of three birds each. A reference diet was formulated to meet the nutritional demands of the birds, and the other diets were obtained by replacing 20% of the reference diet with each type of insect meal at the following substitution levels: Reference Diet, Reference Diet (80%) + 20% *Tenebrio molitor* larvae, Reference Diet (80%) + 20% *Gryllus assimilis* nymphs. The reference diet was formulated to contain maize (55.845%), soybean 45 meal (33.668%), soybean oil (4.109%), dicalcium phosphate (1.738%), limestone (0.867%), common salt (0.197%), vitamin-mineral supplement (1.0%), Methionine (0.197%), L-threonine (0.153%), L-arginine (0.126%), Biolys L-lysine (0.581%) and washed sand (1.193%), to meet energy, amino-acid and mineral requirements, as per the recommendations of Rostagno et al. (2017) for regular to medium-performance male broilers of 8-21 days.

The birds were housed in 1 x 1 x 0.5m metabolic cages. The total excreta collection method was used as per Sakomura & Rostagno (2016). The experimental period was four days for adaptation and four days for total excreta collection. At the end of the experimental period, the amount of consumed feed and the total excreta produced were evaluated.

For each sample, the dry matter, gross energy and nitrogen content was determined following methodologies established earlier in the laboratory. The ether extract was analysed with the Soxhlet method using an Ankon analyser. Values for apparent metabolisable energy corrected for nitrogen (AMEn), the digestibility coefficient of the protein and fat, and mineral matter retention were determined from the laboratory results as per Sakomura & Rostagno (2016).

RESULTS

The values for dry matter composition, crude protein, crude energy, ether extract, mineral matter and apparent metabolisable energy, and the digestibility coefficients for dry matter, crude protein, ether extract, mineral matter and crude energy of the *Tenebrio molitor* larvae and *Gryllus assimilis* nymphs based on the dry matter, are shown in Table I.

From the data presented in Table I, it can be seen that the *Tenebrio molitor* larvae (TL) and *Gryllus assimilis* nymphs (GAN) have a chemical composition compatible with other ingredients previously used and described by Rostagno et al. (2017). The high values for crude protein and fat (EE) of the two insect meals should be noted; these may be compared and are superior to the principal protein and oil ingredients used in poultry diets.

DISCUSSION

The results of the chemical composition found for the two meals (*Tenebrio m.* larvae and *Gryllus a.* nymphs) are close to those reviewed by Makkar et al. (2014), except for the fat value of the *Gryllus assimilis* nymphs, since in this study the value found was far greater than the

Table I. Chemical composition and digestibility/retention coefficients for dry matter (DM), crude protein (CP), ether extract (EE), mineral matter (MM) and gross energy (GE), and apparent metabolisable energy (AMEn) of the insect meals, *Tenebrio m. larvae* (TL) and *Gryllus a. nymphs* (GAN).

	DM	MM	CP	EE	GE	AMEn
	Chemical composition of the NM/DM (%)				(Kcal/Kg of NM/DM)	
TL	94.56	3.16/3.34	49.34/52.18*	30.44/32.19	6074/6423	
GAN	90.15	3.69/4.10	52.66/58.41	26.61/29.52	5975/6628	
	Digestibility/retention coefficient \pm standard error (%)				(Kcal/Kg of NM)	
TL	64.9 \pm 8.3	56.6 \pm 12.0	49.3 \pm 7.7	76.2 \pm 20.9	76.9 \pm 3.6	4847 \pm 450
GAN	52.5 \pm 5.0	49.4 \pm 7.3	31.3 \pm 2.8	64.0 \pm 8.6	58.7 \pm 2.6	4412 \pm 307

DM: dry matter; NM: natural matter. *37.5/39.7% according to the nitrogen conversion factor established by Janssen et al. (2017).

mean value described for the domestic cricket by Makkar et al. (2014); whereas Adámková et al. (2017) determined values for ether extract greater than 30% for the two meals, where the fatty acids with the highest percentage were palmitic, oleic and linoleic.

The variation in the chemical composition of the meals may be related to the substrates used to breed the insects (Oonincx et al. 2015), as well as to their stage of development (Makkar et al. 2014).

In Table I, it can be seen that the digestibility coefficients for dry matter, crude protein, ether extract and mineral matter were less than 65%, except for the digestibility of the crude energy and ether extract from the meal of *Tenebrio molitor* larvae, of 76.9 and 76.2% respectively. It can be said that the meal from the *Tenebrio molitor* larvae (TL) has a high nutrient concentration with a high apparent digestibility for fat and energy, as well as for the remaining data, in relation to the *Gryllus assimilis* nymphs (GAN).

One of the possible explanations for the low nutrient digestibility is the presence of chitin, since most insects have this carbohydrate

in their structure. Chitin is a polysaccharide composed of a long-chain polymer of N-acetylglucosamine, whose use by production poultry is still poorly established (Hossain & Blair 2007). Khempaka et al. (2011) state that the increased addition of chitin to broiler diets reduces protein digestibility; however, nutrient digestibility is not impaired by the addition of up to 0.9%.

It is known that birds are able to digest chitin, as they produce the enzyme chitinase in different parts of the gastrointestinal tract, with a greater proportion produced in the proventriculus (Koh & Iwamae 2013); such chitin digestibility is generally around 30% (Khempaka et al. 2011), but may vary depending on the source.

In spite of the of the birds' low ability for digesting chitin, this may not be the only factor to influence the digestibility of insect meal, since from the values shown in Table I, the meal from the *Gryllus a. nymphs* has a lower protein digestibility than that of the meal from the *Tenebrio m. larvae* (31.3% x 49.3%); however, according to Adámková et al. (2017), the amount of chitin in the two types of meal is 7% and 13%

respectively, which would theoretically indicate that the meal from the *Tenebrio* larvae must be less digestible, since it contains more chitin than the meal from the *Gryllus* nymphs. Various factors, such as structural characterisation, function, chitin synthesis and the endogenous production of chitinases by insects might explain this difference, since in different insects, they present different characteristics (Merzendorfer & Zimoch 2003).

Another aspect that has generated discussion in recent years is that some insect meals contain non-protein nitrogen. A nitrogen conversion factor of 6.25 to estimate the protein content might therefore be overestimating such values for the insect meal. However, this factor may be different in plants, grain and insects, and may be wrongly estimating not only the values for crude protein, but also the digestibility of the protein by different species (Jonas-Levi & Martinez 2017, Nery et al. 2018). Janssen et al. (2017) found a conversion factor of 4.75 for the protein of *Tenebrio molitor*, and if this conversion factor were to be considered, this study would show the protein value for the *Tenebrio m.* meal to be 37.5% instead of 49.3%, giving rise to a difference of 11.8%. No conversion factors were found to estimate the corrected protein value for the *Gryllus a.* meal.

Knowledge of the chemical composition and digestibility of the meal from *Tenebrio molitor* larvae and *Gryllus assimilis* nymphs, shows that they can be a substitute source of energy and protein in diets for broilers.

Acknowledgments

The authors wish to thank FAPEPI for the Scientific and Technological Development scholarship and bench fee granted to the third author. Further thanks are due to EMBRAPA, GENPAS, LAVINESP and Evonik.

REFERENCES

- ADÁMKOVÁ A, MLCEK J, KOURIMSKÁ L, BORKOVCOVÁ M, BUŠINA T, ADÁMEK M, BEDNÁROVÁ M & KRAJSA J. 2017. Nutritional Potential of Selected Insect Species Reared on the Island of Sumatra. *Int J Environ Res Public Health* 14: 521.
- BOVERA F, PICCOLO G, GASCO L, MARONO S, LOPONTE R, VASSALOTTI G, MASTELLONE V, LOMBARDI P, ATTIA YA & NIZZA A. 2015. Yellow mealworms larvae (*Tenebrio molitor* L.) as protein source for broilers: Effects on growth performance and blood profiles. *Br Poult Sci* 56: 569-575.
- HOSSAIN SM & BLAIR R. 2007. Chitin utilisation by broilers and its effect on body composition and blood metabolites. *Br Poult Sci* 48: 33-38.
- JANSSEN RH, VINCKEN JP, VAN DEN BROEK LAM, FOGLIANO V & LAKEMOND CMM. 2017. Nitrogen-to-Protein Conversion Factors for Three Edible Insects: *Tenebrio molitor*, *Alphitobius diaperinus*, and *Hermetia illucens*. *J Agric Food Chem* 65: 2275-2278.
- JONAS-LEVI A & MARTINEZ JJI. 2017. The high level of protein content reported in insects for food and feed is overestimated. *J Food Compost Anal* 62: 184-188.
- KHEMPAKA S, CHITSATCHAPONG C & MOLEE W. 2011. Effect of chitin and protein constituents in shrimp head meal on growth performance, nutriente digestibility, intestinal microbial populations, volatile fatty acids, and ammonia production in broilers. *J Appl Poult Res* 20: 1-11.
- KOH K & IWAMAE S. 2013. Chitinolytic Activity of Mucosal Enzymes in the Different Parts of the Digestive Tract in Broilers. *J Poult Sci* 50: 65-67.
- MAKKAR HPS, TRAN G, HEUZÉ V & ANKERS P. 2014. State-of-the-art on use of insects as animal feed. *Anim Feed Sci Techno* 197: 1-33.
- MERZENDORFER H & ZIMOCH L. 2003. Chitin metabolism in insects: structure, function and regulation of chitin synthases and chitinases. *J Exp Biol* 206: 4393-4412.
- NERY J, GASCO L, DABBOU S & SCHIAVONE A. 2018. Protein composition and digestibility of black soldier fly larvae in broiler chickens revisited according to the recent nitrogen-protein conversion ratio. *J Insects Food Feed* 4: 171-177.
- OONINCX DGAB, VAN BROEKHOVEN S, VAN HUISA & VAN LOON JJA. 2015. Feed Conversion, Survival and Development, and Composition of Four Insect Species on Diets Composed of Food By-Products. *Plos One* 10(12): e0144601.
- ROSTAGNO HS ET AL. 2017. Tabelas Brasileiras para Aves e Suínos – Composição de Alimentos e Exigências nutricionais. 4ª ed., Viçosa: UFV, 488 p.

SAKOMURA NK & ROSTAGNO HS. 2016. Métodos de pesquisa em nutrição de monogástricos. Jaboticabal: FUNEP, 262 p.

VELDKAMP T, VAN DUINKERKEN G, VAN HUIS A, LAKEMOND CMM, OTTEVANGER E, BOSCH G & VAN BOEKEL MAJS. 2012. Insects as a sustainable feed ingredient in pig and poultry diets- a feasibility study. In: Report 638. Wageningen Livestock Research, Lelystad, The Netherlands. p. 3-10.

How to cite

DOURADO LRB, LOPES PM, SILVA VK, CARVALHO FLA, MOURA FAS, SILVA LB, GIANNECCHINI LG, PINHEIRO SRF, BIAGIOTTI D & KIMPARA JM. 2020. Chemical composition and nutrient digestibility of insect meal for broiler. *An Acad Bras Cienc* 92: e20200764. DOI 10.1590/0001-3765202020200764.

*Manuscript received on June 17, 2020;
accepted for publication on September 21, 2020*

LEILANE R.B. DOURADO¹

<https://orcid.org/0000-0001-7141-6677>

PATRÍCIA M. LOPES²

<https://orcid.org/0000-0002-4125-7772>

VANESSA KARLA SILVA³

<https://orcid.org/0000-0002-8095-2647>

FRANCISCA LUANA A. CARVALHO²

<https://orcid.org/0000-0001-6132-412X>

FRANCINETE A.S. MOURA¹

<https://orcid.org/0000-0003-1569-719X>

LUCIANA B. SILVA¹

<https://orcid.org/0000-0002-7127-600X>

LUIZ GUSTAVO GIANNECCHINI³

<https://orcid.org/0000-0002-2263-5256>

SANDRA REGINA F. PINHEIRO⁴

<https://orcid.org/0000-0001-8509-8497>

DANIEL BIAGIOTTI⁵

<https://orcid.org/0000-0001-7828-1955>

JANAINA M. KIMPARA³

<https://orcid.org/0000-0003-2872-7650>

¹Universidade Federal do Piauí, Campus Professora Cinobelina Elvas, BR 135, Km 3, Planalto Horizonte, 64900-000 Bom Jesus, PI, Brazil

²Universidade Federal do Piauí, Centro de Ciências Agrárias, Pós-Graduação em Ciência Animal, Campus Ministro Petrônio Portella, s/n, Ininga, 64049-550 Teresina, PI, Brazil

³Embrapa-Meio Norte, BR 343, Km 35, Zona Rural, 64210-970 Parnaíba, PI, Brazil

⁴Universidade Federal dos Vales do Jequitinhonha e Mucuri/UFVJM, Campus JK, MGT 367, Km 583, nº 5000 Alto da Jacuba, 39100-000 Diamantina, MG, Brazil

⁵Universidade Federal do Piauí, Colégio Técnico de Bom Jesus, BR 135, Km 3, Planalto Horizonte, 64900-000 Bom Jesus, PI, Brazil

Correspondence to: **Leilane Rocha Barros Dourado**
E-mail: leilane@ufpi.edu.br

Author contributions

Conceived and designed the experiments: JMK, VKS and LRBD; Performed the experiment with insect breeding and flour production: VKS, LBS and LGG; Performed the experiment with broiler chicks: PML, FLAC and FASM; data collection, processing samples and Chemical analysis: PML, FLAC, FASM and SRF; Analyzed the data: LRBD and DB; Drafted the manuscript: LRBD and PML; Reviewed the manuscript and performed the final check: LRBD.

