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SHORT NOTE

Nutritional value of four pest animals to be used in feeding monogastric organisms

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Palabras clave adicionales

Achatina fúlica.
Amino ácidos.
Composición bromatológica.
Phyllophaga spp..
Pieris brassica.
Spodoptera frugiperda.

RESUMEN

Las muestras de animales plagas fueron colectadas, secadas y molidas. Estas fueron analizadas para determinar su contenido en proteína, cenizas y aminoácidos. Los análisis bromatológicos mostraron que *Achatina fulica* y *Pieris brassica*, contienen más proteína bruta, (PB) (779.2 y 812.2 g/kg) en comparación a *Phyllophaga* spp. y *Spodoptera frugierda* (432. 5 y 445.7 g/kg). Comparando el perfil de aminoácidos, *A. fulica* y *P. brassica* obtuvieron los niveles más altos en la mayoría de los amino ácidos esenciales (AAE) que la torta de soya y en el caso de *A. fulica*, éste exhibió valores más altos que la harina de pescado en arginina, cisteina, glicina, serina y tirosina. Observando la relación de AAE/AANE (amino ácidos no esenciales) en las harinas, sólo *S. frugiperda* presentó valores similares a la harina de pescado (0.85). Todas las harinas de animales plagas presentaron una reducción en la cuantificación de amino ácidos en relación con los valores de PB obtenidos por el método de Kjeldahl, esta reducción se encontraba entre 28.6 y 38.0%. Esta disminución podría deberse a la combinación entre la proteína y la quitina que se encuentran en el cuerpo de los insectos. A pesar de esta reducción la cuantificación de amino ácidos de los animales plagas podría ser una buena alternativa para su uso en la alimentación de monogástricos, especialmente para peces y crustáceos.

Valor nutricional de cuatro plagas para ser empleadas en la alimentación de monogástricos

Additional keywords

Achatina fulica.
Amino acids.
Bromatological composition.
Phyllophaga spp.
Pieris brassica.
Spodoptera frugiperda.

SUMMARY

The pest samples were collected, dried, and grounded. They were analysed to determinate contain of protein, energy, ashes and amino acids. The bromatological analysis showed that Achatina fulica and Pieris brassica, obtained a higher amount of crude protein (CP) (779.2 and 812.2 g/kg) in comparison to *Phyllophaga* spp. and *Spodoptera frugiperda* (432.5 and 455.7 g/kg). Comparing the amino acids profile, *A. fulica* and *P. brassica* obtained higher values in most of the essential amino acids (EAA) than soybean meal, and *A. fulica* exhibited even higher values than fish meal (FM) in Arginine, Cysteine, Glycine, Serine, and Tyrosine. Observing the relation of EAA/NEEA (no essential amino acids) in all the meals only *S. frugiperda* presented a similar value to fish meal (0.85). All the pest meals presented a reduction in the amino acids quantification in comparison to the CP values obtained by the Kjeldahl method, with reduction between 28.6 through 38.0%. This diminution could be due to the linkage of the protein to the chitin content of the insect body. In spite of the reduction of the amino acids quantification, the pest meals could be an alternative in feeding monogastric organisms, especially fish and crustaceans.

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INTRODUCTION

Pest animals are one of the main problems in agriculture. They not only cause economic loss, but they can also transmit diseases to humans and animals. This is the case of the African snail (*Achatina fulica*), which is widespread in South America, it is an aggressive omnivore with a diet that includes plants, mushrooms, organic matter in decomposition, paper, and even stuccoed walls (Avendaño and Linares, 2015). It is known to be a carrier of helminths, protozoa, and bacteria that are a health concern to the human population (Morocoima et al., 2014). In some regions of Africa, they are part of the people`s diet and are also used to feed poultry (Diarra et al., 2015).

As well as snails, insects are the natural base food of many omnivorous and carnivorous animals. Their protein and fat content are similar to beef or fish meat, and they have a higher energy value than soybeans, maize, fish, lentils, or other beans (Tran et al., 2015). For controlling pest insects, farmers use indiscriminate and unwise chemical pesticides that can result in control failure, while also polluting the environment and upsetting the ecological balance (Karuppuchamy and Venogopal, 2016). Eradicating insect is an impossible task that causes not only pollution, but also human and animal health problems due to the use of contaminants.

In Ecuador, *A. fulica* is a serious threat, because it has spread much faster than predicted, affecting 86.2% of the country. This species most often affects cocoa, plantain and banana plantations, but it also disturbs 56 other species of cultivated plants (Goldyn et al., 2016). The larva of *Phyllophaga* sp., the cabbage butterfly (*Pieris brassica*), and the larva of *Spodoptera frugiperda* are pests that affect wide varieties of crops such as sugarcane, cabbage, potato, maize, rye, rice, bean, and sweet potato, among others of economic importance (Weppler, 2008). They are widespread, and for this reason, some farmers use these pests as food for their farm animals (poultry and dogs) as a protein source. Animals eat them without problems, and have even been observed searching for these pests as food.

Considering all these facts, the pests could be used in fish nutrition, replacing partial or total fish meal (FM) and/or soybean meal (SBM), which are expected to undergo continuous price increases due to the demands of protein sources for farm animals. According to Makkar et al. (2014), the consumption of animal product will increase a 60 – 70% by 2050 and for that to increase animal production will be necessary to have alternative meals with high protein content and similar amino acids (AA) profile than soybean meal (SBM) and fish meal (FM), that is the case of some insect meals which have similar AA to FM and much better profile than SBM (Tran et al., 2015). The objective of this research was to determinate the bromatological composition including the amino acids profile of four pest animals as alternative meals to be used in animal nutrition.

MATERIALS AND METHODS

Prior to the collect of the insects, the project was approved by the Agriculture Faculty Committee that belongs to the Technical University of the North to collect the samples for the composition analysis. These insects do not require special permission because they are plague for the crops, especially potatoes, Cruciferaceae family, corn and in the case of the African snail is a plague for the Amazon regions. There is no requirement for a National approval.

All the insects were collected in the Imbabura region. The larva of *Phyllophaga* spp. were collected from potato crops and nearby fields; they were transported alive in a plastic bottle. *S. frugiperda* larva were collected from corn cobs, which they usually plague. Adults of *P. brassica* were collected from the fields nearby white cabbage because it was not cabbage white season at that moment. All the insects collected were frozen, then lyophilized and grounded.

The African snails were collected near the city of Esmeraldas, because they are widespread in this province. They were frozen and sealed in plastic sacks, then boiled as a measure to prevent disease transmission. After boiling, the pedal and visceral mass was mechanically separated from the shell of the snails. Later, the pedal and visceral mass was lyophilized and ground. Fish meal and soybean meal samples were collected and ground before the analysis.

Whole insects were chemical analysed according to AOAC (1990) procedures: dry matter (105 ºC to constant weight), ash (incinerated at 550 ºC to constant weight), and crude protein (CP) (N x 6.25) by the Kjeldahl method after an acid digestion (Kjeltec 2300 Auto Analyser, Tecator Höganas, Sweden) and Crude Lipid (CL) were extracted with methyl ether (Soxtec 1043 extraction unit, Tecator).

Following the method previously described by Bosch et al. (2006), amino acids of raw materials were analysed in a Waters HPLC system (Waters 474, Waters, Milford, MA, USA) consisting of two pumps (Model 515, Waters), an autosampler (Model 717, Waters), a fluorescence detector (Model 474, Waters), and a temperature control module. Aminobutyric acid was added as an internal standard patron before hydrolyzation. The amino acids were derivatized with AQC (6-aminoquinolyl-N-hydroxysuccinimidyl carbamate). Methionine and cysteine were determined separately as methionine sulphone and cysteic acid after oxidation with performic acid. Amino acids were separated on a C-18 reverse-phase column Waters Acc. Tag (150 mm x 3.9 mm).

Once the AA of each meal is determinated and quantified, the protein reduction or real protein is determinated using the following formulation:

Protein Reduction (%) = $100 - [(\Sigma_{AA} * 100)] / CP$

RESULTS

The bromatological analysis **(Table I)** showed a protein value fluctuation among the species, the lowest values were observed in *Phyllophaga* sp. (432.5 g/kg), and the highest in *P. brassica* (812.2 g/kg) and *A. fulica* (779.2 g/kg). *Spodoptera* sp. obtained the highest value in crude fat content (342.8 g/kg) as well as energy (5528.99 Kcal/kg).The other pest animals presented crude fat values between 46.8 and 74.7 g/kg. *Phyllophaga* sp. presented the lowest dry matter (56.41 %) and the highest ash content (172 g/kg).

The amino acids quantification, *A. fulica* presented the highest values in Arginine, Cysteine, Glycine, Proline, and Tyrosine compared to the other pest animals and even FM reference values. At the same time, African snail and *P. brassica* exhibited higher values than SBM in most of the EAA, except Leucine **(Table II)**. In the case of *S. frugiperda*, this meal presented the better

Table I. The bromatological composition of pest meals, fish meal and soybean meal (g/kg) (La composición bromatológica de la harina de parásito, harina de pescado y la harina de soja (g/kg)..

	Dry Matter (%)	Crude Protein (g/ kg)	Crude Lipid (g/kg)	Ash (g/kg)	Crude Fiber (g/kg)	Energy (Mj/ kg)	NFE¥ (g/kg)
A. fulica	94.94	779.2	46.8	68.1	Nd	16.59	105.9
Phyllophaga sp.	56.41	432.5	74.7	172.0	Nd	13.73	320.8
S. frugiperda	84.37	450.7	342.8	43.5	Nd	23.15	158.0
P. brassica	92.22	812.2	55.6	69.1	Nd	16.78	63.0
Soybean meal*	88.58	592.8	20.2	85.3	4.11	15.05	260.6
Fish meal*	92.28	678.8	112.3	181.5	1	16.06	28.2

¥ NFE= calculated: 100- (Crude Protein + Crude Lipid + Ash + Crude Fiber)
Energy = calculated: {(CL x 9) + (CP x 4) + (NFE x 4)}
Nd = Not determinated
*These data proceeded from previous analysis done at the Animal Science Department that belongs to the Polytechnic University of Valencia. They are used for comparing with the values obtained in this study (three samples).

EEA/NEEA relation, and this was similar to the FM reference (0.85). *Phyllophaga* spp. exhibited the lowest values in all the amino acids quantifications and the lowest EEA/NEEA relation. Considering the most limiting amino acids (Lysine and Methionine), African snail and *P. brassica* were deficient in comparison to FM, but higher than SBM.

Furthermore, the amino acids profile showed a marked reduction of real protein contains in contrast to values obtained by the Kjeldahl method. The *Phyllophaga* sp is the insect meal that presented the highest reduction (38.3%) followed by *P. brassica* (36.53%), *S. frugiperda* (30.64%) and *A. fulica* (24.61%) was pest meals with the lowest reduction value, but much higher than SBM (11.91%) and FM (0%).

Tabla II. Amino acids quantification of pest meals, soybean meal and fish meal expressed in dry matter. (Cuantificación de aminoácidos de las comidas de plagas, harina de soja y harina de pescado expresados en materia seca).

Amino acids	*Achatina fulica*	*Phyllophaga* spp.	*S. frugiperda*	*Pieris brassica*	Soybean meal*	Fish meal*
Essential Amino Acids (EAA) (g/ kg)						
Arginine	49.96	6.03	20.75	34.60	37.48	40.49
Histidine	6.95	6.79	8.53	16.37	13.33	17.06
Isoleucine	27.82	15.86	15.36	25.81	25.55	31.79
Leucine	49.41	18.79	24.40	39.72	41.56	56.40
Lysine	33.66	13.55	21.87	32.29	30.08	66.26
Methionine	7.44	3.47	5.46	8.56	6.61	17.58
Phenylalanine	22.65	11.15	13.87	15.82	27.78	24.56
Threonine	25.14	12.16	14.53	19.12	20.3	25.43
Valine	32.38	21.92	20.79	39.26	26.41	39.52
Non Essential Amino acids (NEAA) (g/ kg)						
Alanine	36.72	19.45	24.58	48.05	23.31	42.51
Aspartic Acid	60.85	23.00	31.08	49.84	64.54	84.77
Cysteine	7.36	2.88	3.06	4.37	07.19	7.28
Glutamic Acid	90.08	36.96	47.14	65.11	107.60	116.94
Glycine	44.54	20.37	17.56	34.49	23.82	36.91
Proline	33.00	25.46	17.03	35.08	26.45	23.24
Serine	35.94	13.80	14.80	22.68	26.20	40.60
Tyrosine	23.53	16.41	15.27	24.47	14.16	21.68
Relation EEA/NEEA	0,77	*0,69*	*0,85*	*0,81*	0,78	0.85

*These data proceeded from 10 previous analysis done at the Animal Science Department that belongs to the Polytechnic University of Valencia. They are used for comparing with the values obtained in this study.

DISCUSSION

The protein and amino acids content of *A. fulica* meal showed that this could be an adequate raw material to totally replace SBM and partially replace FM in animal nutrition in comparison to the other three pest meals. Moreover, trials were performed in laying hens with good results (Diarra et al. (2015), proving its potential as an alternative meal. The use of the African snail as a protein source is an option to control this pest, because it is hard to eradicate due to its rapid growth rates, voracity, and high propagative capacity, becoming an excellent alternative in feeding farm animals, especially omnivorous and carnivorous fish in the rural areas where it has invaded the forest small farms.

In the case of *P. brassica,* this species exhibited the highest CP value, and its AA content was also higher than the SBM used in this research, except in Arginine, Leucine, Phenilalanine, and Threonine. There is no report of this moth used as food for farm animals or humans in the Andean regions of Ecuador, but considering the nutritive values, this meal could also be an alternative protein source in animal nutrition, especially in fish and crustacean nutrition, due to its good CP and AA content as Riddick (2016) proposed. There are no work references using adult moths in animal nutrition, but rather only the larva of some species such as *Bombix mori, Antheraea assamensis, A. mylitta,* among others species. Those larva meals were used in feeding pigs, poultry, fish, and crustaceans (Makkar et al., 2014).

Studying *Phyllophaga* spp. larva meal, the protein value was a bit higher than those reported by Sánchez-Muros et al. (2014) (42.6%) of the same species. This protein value is also higher than corn, cottonseed, canola meal, lupins, peas, wheat, sorghum, barley, rye, and oats, common meals used in animal nutrition (Zhou et al., 2008). Moreover, this insect meal presented the highest CL and NFE content, converting this species also into a good energy source. Farmers in the Andean regions commonly use this larva to feed poultry and dogs, and they do not report health problems in their animals due to the insect feeding. They also use it to cure the flu. According to them, it is a savory larva and it is easy to collect, for this reason, it could also be an alternative, being used in farm animals. In Mexico, this species was part of common meals for some Indian communities (Ratcliffe, 2006 p. 95).

Examining *S. frugiperda*, its protein content was similar to protein meals such as bone and meat meal and soybean meal (Troni et al., 2016). The AA content of this meal was higher than the SBM and in Ile and Val AA of FM reported by Sánchez-Muros et al. (2015). In addition, this meal exhibited the most equilibrated relation between EAA/NEAA (0.85) in comparison to the other pests and even the SBM reference in this study and Sánchez-Muros et al. (2015). This relation was similar to the FM reference. Farmers of the Andean regions of Ecuador who cultivate corn, collect the larvae to feed their chickens.

Until now, other pests such as common housefly larvae, black soldier flies, termites, silkworms, mealworms, and grasshoppers (Van Huis et al., 2013) were used for feeding farm animals with good results. Their protein values ranged from 40, 9 to 69%, and the EAA values were in some cases a bit higher and others very similar to those obtained in *Phyllophaga* spp., *S. frugiperda,* and *P. brassica*.

Comparing between the total amino acids and the values of the crude protein obtained, there was between 24 and 38% diminishment and this lacking "protein" could be part of cuticular protein or protein bounded to chitin, known as the fiber component in insects that are not nutritionally available according to Finke, (2007). Moreover, chitin is a non-toxic, biodegradable linear polymer and it has an immune-system stimulating property, being part of insoluble insect fraction, so chitin could improve the immune status of the animals (Veldkamp et al., 2012).

As Veldkamp et al. (2012) affirmed proteins are present all over the insect body, and there are different types of proteins; the muscle protein; hemolymph protein, and protein incorporated in the exoskeleton, when protein and amino acids composition are determined, those data are obtained from whole insects, not for isolated proteins (Finke as cited in Makkar et al. 2014), which was the case in this study.

The bromatological results and the cultural use that farmers give to them, show that these alternative meals could represent income in rural areas, as well as good protein sources for farm animals such as poultry, pigs, and fish, reducing the use of SBM and FM, prices for which are rising constantly. Another beneficial aspect of using pests as protein sources is that farmers could eliminate the use of pesticides in their crops, in this way reducing the contamination in the soil and offering agricultural products free of pesticides.

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