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CHEMICAL CHARACTERIZATION OF THE AGROINDUSTRIAL BY-PRODUCTS DESTINED FOR PIG FEEDING.

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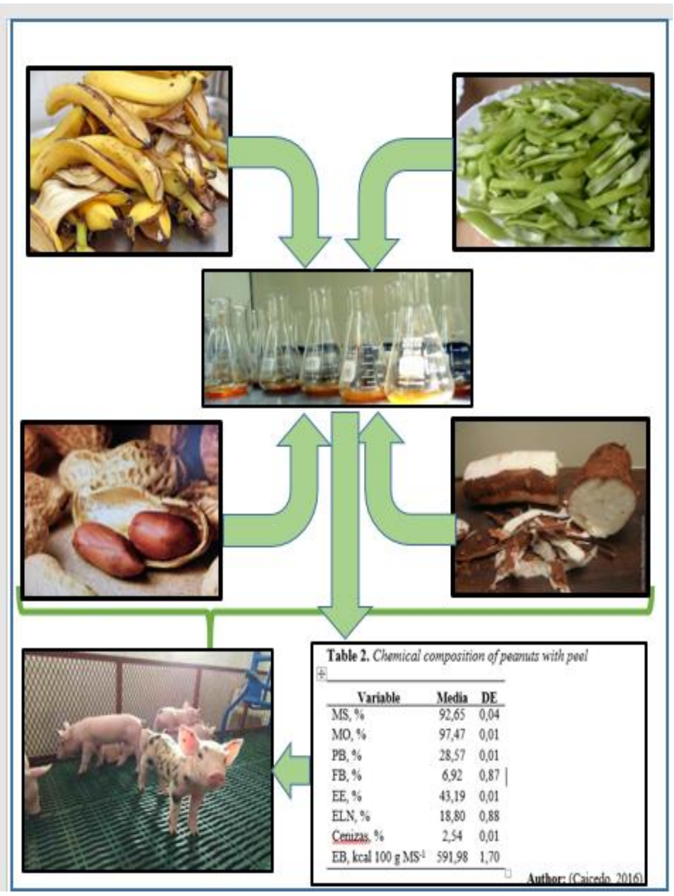
Graphical Abstract



Abstract.

The increase in the volume of agroindustrial, agricultural and domestic solid wastes entails a series of implications related to health and environmental aspects. The objective of this research was to determine the chemical composition of agroindustrial residues of shelled peanuts, peanuts in shell, banana peels, cassava peels, shelled beans and beans peas for use in pig feeding. The contents of matter (DM), organic matter (OM), crude protein (PB), crude fiber (FB), ashes, ethereal extract (EE), nitrogen free extracts, ELN and gross energy EB, were determined in agroindustrial residues by the use of descriptive statistics, and mean and standard deviation were determined. Peanut and shelled peanut residues showed the highest content of MS (91.65, 92.65%), PB (28.22, 28.27%), EE (40.49, 43.19%), and EB (577.68, 591.98 kcal kg MS^{-1}). Shelled beans had an acceptable ELN content (62.66%). In relation to the FB, the bean peel had the highest content (49.03 %). The banana peel and cassava presented the highest ash content (8.82 and 8.49 %) respectively. The agroindustrial by-products of shelled peanuts, peanuts, banana peels, cassava peels, peas and shelled beans presented a significant content of MS, MO, PB, ELN, EE, Ashes and EB, all suitable for use in pig feeding.

Key words: *pig feed, proximal analysis, agroindustrial residues.*

Introduction

According to GADPPz (2011), there are about 5.000 hectares of papa china in Pastaza province. It is considered as a traditional crop essential for small farmers survival. This fields reach a maximum yield of 38 tons per hectare. 60 % of this production is destined for export market and domestic consumption, while the other 40 % becomes by-products of tubers that are discarded in the countryside and turns into waste, consequently it becomes a problem for the environment and the crop.

The great growth of the population and the increase by the demand of food has caused a competition between humans and animals for the transcendental raw materials use for elaboration of feed, causing a rapid increase in its cost. This situation forces nutritionists to search for cheaper alternative foods for animal feed (Abdulrashid and Nnabuenyi, 2009).

The use of alternative raw materials in swine feeding, with the aim of replacing imports and reducing competition for human food to protect the environment, is a challenge for nutritionists, as well as for small and medium producers in the search for sustainable and efficient solutions in animal production systems (Agbédé *et al.*, 2002).

In Ecuador, there are viable agro-industrial byproducts for swine feeding that are not used due to lack of knowledge about their nutritional characteristics (Caicedo, 2013). Its nutrients can be raw material to generate products of interest, as food for pigs (Domínguez et al., 2012). In this regard, the use of rice husk (Martin, 2009), coffee pulp (Noriega *et al.*, 2008), apple waste (Díaz *et al.*, 2010), mangos (Rego *et al.*, 2010) taro tubers (Caicedo *et al.*, 2013) among others, has been reported with satisfactory results in the productive performance of the animals.

As reported by the GADPPz (2011), in the province of Pastaza there are approximately 5,000 hectares of Chinese potatoes, considered a traditional crop of importance for the survival of small farmers, this farm reaches yields of up to 38 tons per hectare, of which 60% is used for the export market and domestic consumption, while the remaining 40% are by-products of tubers that are discarded in the field and do not receive any use, so it becomes more of a problem for the environment and the cultivation

The objective of this research was to determine the chemical composition of the agro-industrial residues of peanuts without peel, peanuts with peel, banana peel, cassava peel, beans without peel and husk of beans for use in swine feeding.

Materials and Methods

Origin of agroindustrials waste. - The research was conducted in the city of Puyo, province of Pastaza, Ecuador. This area has a semi-warm or humid subtropical climate, with rainfall ranging between 4000 and 4500 mm per year. It is located at an altitude of 900 meters above sea level, with an average relative humidity of 87% and minimum and maximum average temperature of 20 to 28 ºC (IGM, 2016).
The by-products were obtained from the Artisanal Association (CONFERIB). Randomly, 2 kg of sample of each type of agro-industrial by-products were collected, these residues were treated and conditioned separately in the bromatology laboratory of the Amazon State University, in the later samples were dehydrated at a temperature of 60 ° C for a 5 hours to perform the grinding and subsequent analysis.

Chemical characterization of agroindustrial waste. - The content of dry matter (MS), ash, crude protein (PB), ether extract (EE), nitrogen-free extracts (ELN) and crude fiber (FB) was determined according to the procedures of the AOAC (2005). Organic matter (OM) was obtained by subtracting (100 -% ash). The gross energy (EB) was evaluated using a Parr brand adiabatic calorimetric pump, model 1241.

The data on the chemical composition of the byproducts were analyzed using the descriptive statistical module and the mean and standard deviation (SD) were determined, using the statistical program Infostat Version 1.0 for Windows (Di Rienzo et al., 2012).

Results and Discussion

Table 1. *Chemical composition of peanuts without shell.*

Variable	Media	DE
MS, %	91,65	0,16
MO, %	96,74	0,21
PB, %	28,22	0,12
FB, %	5,85	0,02
EE, %	40,49	0,76
ELN, %	22,19	0,65
Cenizas, %	3,27	0,21
EB, kcal 100 g MS^{-1}	577,68	4,65

Author: (Caicedo, 2016)

The peanut without peel, **Table 1,** presented high contents of MS (91.65%), MO (96.74%), PB (28.22%), EE (40.49%), EB (577.68 kcal 100 g MS-1) and low levels of FB (5.85%), ELN (22.19%) and ashes (3.27%).

Table 2. *Chemical composition of peanuts with peel*

Variable	Media	DE
MS, %	92,65	0,04
MO, %	97,47	0,01
PB, %	28,57	0,01
FB, %	6,92	0,87
EE, %	43,19	0,01
ELN, %	18,80	0,88
Cenizas, %	2,54	0,01
EB, kcal 100 g MS^{-1}	591,98	1,70

Author: (Caicedo, 2016)

As well as shelled peanuts, peanuts in shell have excellent nutritional qualities for its use in pig feeding as a protein supplement (Pozza *et al.*, 2005). However, we must take into consideration the high level of fat in this food and there is no way to prevent or eliminate the presence of mycotoxins and aflatoxins in the process of manufacturing balanced meals, even if a "sequestrant" of mycotoxins and aflatoxins, which may have adverse effects on the performance of animals (Etienne and Dourma, 1994; Schwarzer, 2002), the product should be stored in a clean and dry place to minimize the entry of these pathogens into the food (Jouany, 2007).

Table 3. *Chemical composition of the banana peel*

Variable	Media	DE
MS, %	14,06	0,11
MO, %	91,19	0,01
PB, %	7,93	0,70
FB, %	5,85	0,02
EE, %	5,02	0,07
ELN, %	72,40	0,76
Cenizas, %	8,82	0,01
EB, kcal 100 g MS^{-1}	378,15	0,37

Author: (Caicedo, 2016)

In **Table 3**, the chemical composition of the banana peel is observed, this by-product presented a good content of PB (7.93%), MO (91.19%), EE (5%), ELN (72.40) %), ash (8.82%), EB (378.15 kcal 100 g MS-1) and low levels of FB (5.85%) and MS (14.06%).

The banana peel presented high content of OM, ELN, ash, EB and low levels of MS and FB. In this regard, Campabadal *et al.*, (1988) and Valdivié (2008) showed that it is feasible to use banana peel flour in a 10% inclusion limit in the diet of pigs from 10 to 20 kg without affecting the productive behavior of the animals.

Table 4. *Chemical composition of cassava peel*

Variable	Media	DE
MS, %	23,77	0,59
MO, %	91,52	0,26
PB, %	5,92	0,12
FB, %	8,23	0,08
EE, %	1,21	0,08
ELN, %	76,16	0,31
Cenizas, %	8,49	0,26
EB, kcal 100 g MS^{-1}	355,65	0,79

Author: (Aguiar, 2016)

In relation to cassava peel, Table 4, it presented a high content of MO (91.52%), ELN (76.16%), ash (8.49%), EB (355.65 kcal 100 g MS- 1) and low levels of MS (23.77%), FB (8.23%), PB (5.92%) and EE (1.21%).

Cassava peel is a good source of MO, ELN and EB. To use these residues in the diet of monogastric animals, it is necessary to apply physical, chemical and biological methods to improve nutritional conditions such as increased protein and digestibility (Caicedo *et al.*, 2015), agroindustrial waste is an important source of sugars, starch and structural carbohydrates (Gómez *et al.*, 2013). In research on pigs, Buitrago (1990) established that the flour of these byproducts can be used with an inclusion of up to 30% in the diet without affecting the weight gain of the animals.

Table 5. *Chemical composition of the bean peel*

Variable	Media	DE
MS, %	32,74	0,01
MO, %	97,64	0,04
PB, %	5,03	0,11
FB, %	49,03	0,42
EE, %	0,16	0,01
ELN, %	43,43	0,26
Cenizas, %	2,36	0,04
EB, kcal 100 g MS^{-1}	293,28	0,71

Author: (Caicedo, 2016)

In **Table 5**, the chemical composition of the bean rind is observed, this by-product showed high MO content (97.64%), appreciable MS content (32.74%), FB (49.03%), ELN (43.43%), EB (293.28 kcal 100 g MS-1) and low PB (5.03%), EE (0.16%) and ashes (2.36%).

In correspondence to the tenor of MS, MO, PB, EE, ELN and EB from the nutritional point of view it is probable that there is no detrimental effect on the performance of pigs in the fattening stage (Almaguel *et al.*, 2008; Almaguel *et. al.*, 2013). However, a high content of FB was found in the swine species. The higher its concentration is, the lower its utilization becomes (Ly *et al.*, 1998).

Table 6. *Chemical composition of the shellless bean*

Variable	Media	DE
MS, %	32,74	0,13
MO, %	96,85	0,24
PB, %	31,48	0,13
FB, %	0,93	0,23
EE, %	1,79	0,23
ELN, %	62,66	0,83
Cenizas, %	3,15	0,24
EB, kcal 100 g MS^{-1}	394,47	0,25

Author: (Aguiar, 2016)

The peeled bean is a good source of MO, PB and ELN. Among the factors that must be taken into consideration for the use of this by-product is the content of secondary metabolites that these foods possess (Buntha *et al.*, 2008). In monogastric animals, the inclusion limit of these raw materials must be taken into account so as not to affect consumption and thus the normal performance of the animals (Lezcano *et al.*, 2014).

Conclusions

Peanut byproducts without shell showed a high level of PB, EE and EB. In pig feeding, it is recommended not to include more than 25% of peanuts in the diet because of the high EE content of this resource, it can have a laxative effect in pigs (Rostagno *et al.*, 2011). Among protein supplements, it is perhaps the most palatable.

Agroindustrial byproducts of peanuts without peel, peanuts with peel, banana peel, cassava peel, rind of beans and shelled beans presented good content of DM, MO, PB, ELN, EE, Ash and EB, all suitable for use in the swine feeding.

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Author Contributions

All authors have the same contribution**.**

Conflicts of Interest

There is no conflict of interest of the authors.

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