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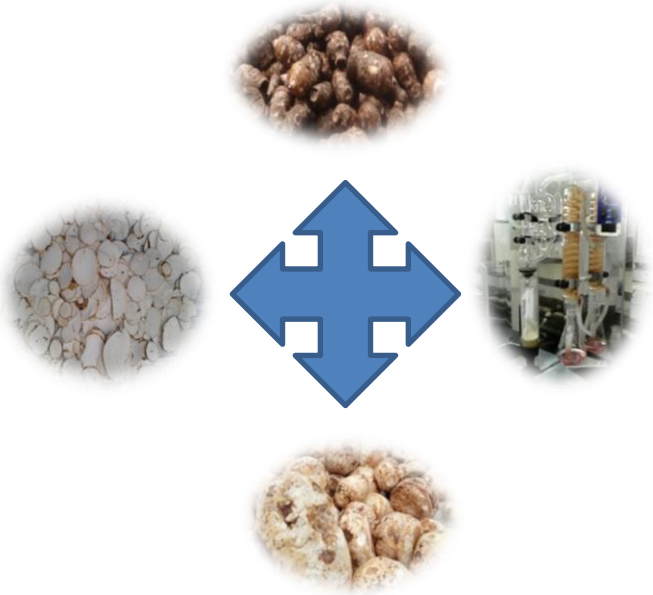
Chemical composition of the taro tuber (*Colocasia esculenta* L. Schott) of waste with and without processing for use in pigs

Willan Caicedo (orlando.caicedo@yahoo.es)[a,d], Felipe Norberto Alves Ferreira (felipe.alves@agroceres.com)[b], Derwin Viáfara (dviafara@uea.edu.ec)[c], Jessica Olivares (agi2015198@uea.edu.ec)[a], Alexander Arias (agr2015184@uea.edu.ec)[a], Jonathan Barrionuevo (agr2015122@uea.edu.ec)[a], Luis Oña (agr2015145@uea.edu.ec)[a], David Naula (agr2015194@uea.edu.ec)[a]

[a] *Departamento de Ciencias de la Tierra, Universidad Estatal Amazónica, Puyo, Pastaza, Ecuador*
[b] *Department of Swine Nutrition, Agroceres Multimix, Rio Claro, São Paulo, Brazil*
[c] *Laboratorio de Bomatologia, Universidad Estatal Amazónica, Puyo, Pastaza, Ecuador*
[d] *Granja Agropecuaria Caicedo, Puyo, Pastaza, Ecuador*

Graphical Abstract



Abstract

To evaluate the chemical composition of the taro tuber (*Colocasia esculenta* (L) Schott) of waste with and without processing for use in pig diets. In samples of natural tubers, solid state fermentation (SEF) and flour, it was determined: dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ash, extract ethereal (EE), nitrogen-free extracts (NFE), gross energy (GE), digestible energy (DE) and metabolizable energy (ME). The experiment was conducted according to a completely randomized design, in the necessary cases the means were contrasted with the Duncan test with ($p<0.05$). The major ($p<0.05$) content in DM presented the flour. In relation to the OM, the highest contents were evidenced in the natural tuber and in flour. As for CP and ashes, the SEF had the best ($p<0.05$) contents. As for the CF and NFE, there were no differences ($p>0.05$) between the unprocessed and processed tuber. Regarding EE, GE, DE and ME, the natural tuber had the highest ($p<0.05$) concentrations, respectively. In conclusion, processed waste taro tubers constitute a good source of nutrients, guaranteeing a local alternative food of adequate nutritional characteristics for use in pigs.

Key words: *flour, SEF, taro by-products, pigs*

Introduction

The feeding in the improved pig represents 70% of the cost of production and is based on the use of cereals and soybeans generating a direct competition for food with the human (Méndez et al 2016). Recently, Ecuadorian pig production experiences great challenges caused by the increase in the cost of traditional raw materials due to climate change and biofuel production (Lezcano et al 2014; Ren et al 2014), and being a dollarized country this situation It worsens every day for the producer, reaching the point that medium and small producers do not make a profit from the raising of pigs (Caicedo et al 2012).

Given this situation, nutritionists have been forced to assess the use of agricultural by-products and agro-industry waste in order to minimize the cost of food. Due to its climatic zones Ecuador has a wide range of resources that need to be valued for the formulation of diets for pigs in their different stages (Sánchez et al 2018). In the province of Pastaza, there is the taro cultivation (*Colocasia esculenta* (L) Schott) which is produced year-round, the cormels are marketed for human consumption in their fresh form, while the main corm or breast tuber is considered as rejection, and its nutritional potential needs to be evaluated.

Several reports indicate that taro tubers have an appreciable nutrient content, and have a lower cost with respect to corn, wheat, sorghum, etc. However, in the natural state they have secondary metabolites that can affect the absorption of nutrients and compromise the health of animals (Agwunobi et al 2002). This situation makes it possible to evaluate several techniques such as solid state fermentation (SEF) and flour production to obtain an efficient use of these resources in the animals diet (Olajide et al 2011). The objective of this study was to evaluate the chemical composition of the taro tuber (*Colocasia esculenta* (L) Schott) of waste with and without processing for use in pig diets.

Materials and Methods

Location

The field work was done at the facilities of the Postgraduate Research and Amazon Conservation Center belonging to the Amazon State University. The nutrient testing of the tuber in its different forms was done at the Bromatology Laboratory of the Amazon State University. The study site has a humid semi-warm or subtropical climate, with rainfall ranging between 4000 and 5000 mm annually. It is located from an altitude of 584 to 900 meters above sea level, with relative humidity of 87% and average minimum and maximum temperature of 18 to 36 ºC (INAMHI 2014; Uvidia et al 2014).

Preparation of the waste taro tuber in natural state, SEF and flour

The preparation of the natural material, SEF and flour was made with the main tuber of the plant known by the producers as breast or waste trunk, 100 kg of fresh three-day post-harvest tubers were purchased at the Teniente Hugo Ortiz rural parish collection center and moved for 20 minutes to the Postgraduate Research and Amazon Conservation Center facilities. Immediately, they were washed, and cut into slices with all husks. Subsequently, three 1 kg samples of chopped fresh material were mixed and collected and taken to the laboratory for chemical analysis. The remaining material was placed on a plastic under greenhouse for 72 hours to reduce the moisture content. Subsequently, the pre-dried material was homogenized and 5 samples of 1 kg each were obtained and inoculated with 2% sugar cane molasses, 1% natural yogurt, 0.5% calcium carbonate and 0.5% vitaminized pecutrin and put to fermentation Ziploc plastic bags of 1 kg sealed non-hermetic for 96 hours under shade at room temperature, after the fermentation time was completed, 3 samples of 1 kg were collected for the respective laboratory study. Finally, with the remaining pre-dried material, drying was completed with the use of an industrial rotary dryer (Burmester brand) at 70 °C for two hours and the flour was obtained 3 samples of 1 kg were collected and taken to the laboratory for determination of chemical components.

Chemical determinations

The chemical analyzes of the natural tuber, SEF and flour were carried out in the Bromatology Laboratory of the Amazon State University. Dry matter (DM), crude fiber (CF), ash, crude protein (CP), ethereal extract (EE) and nitrogen-free extracts (NFE) were tested, according to the procedures of AOAC (2005). The energy calculation for pigs was done using pre-established equations: gross energy (GE) according to Ewan (1989), digestible energy (DE) according to Noblet and Perez (1993), and metabolizable energy (ME) by May and Bell (1971).

Experimental design and statistical analysis

To study the chemical composition data, a completely randomized design was used. The statistical package InfoStat version 2012 (Di Rienzo et al 2012) was used to analyze the results. The mean values were compared with the Duncan test (1955) with ($p<0,05$).

Results and Discussion

Table 1 shows the proximal composition of the waste taro tubers in the natural state, SEF and flour. The flour presented ($p<0.05$) the highest DM content. In relation to the OM, the natural tuber and the flour were higher ($p<0.05$) than the SEF. With respect to the CP, the SEF exhibited the best ($p<0.05$) value. Regarding the content of EE, the natural tuber showed the highest ($p<0.05$) value. As for the ashes, the SEF had a higher content ($p<0.05$). On the other hand, the contents of CF and NFE did not show differences ($p>0.05$) between the forms of tuber preparation.

Table 1. Proximal composition of the waste taro tuber with and without processing

Nutrients	Ways of preparation			SEM	*p*
	Natural	SEF	Flour		
DM, %	25.67[c]	64.41[b]	91.43[a]	0.39	0.0001
OM,%	94.93[a]	91.11[b]	94.52[a]	0.27	0.0001
CP, %	6.72[c]	7.46[a]	7.17[b]	0.07	0.0011
CF, %	4.79	4.70	5.43	0.38	0.3992
EE, %	4.11[a]	2.48[c]	3.81[b]	0.01	0.0001
Ash, %	5.07[b]	8.89[a]	5.48[b]	0.27	0.0001
NFE,%	72.52	71.77	72.68	0.59	0.5427

[ab] *Different letters indicate significant differences for $p<0.05$*

The content of DM and OM that possesses a food is an indicator of vital importance to achieve a good preservation of the raw material for a long time (Tomich et al 2003; Blanco et al 2016). Under tropical conditions, the raw material with a content higher than 89% DM can be efficiently conserved for three months (Blanco et al 2016), while well protected SEF can be used for more than 6 months without health risk to the animals (Borreani et al 2018). However, the tuber in its natural state is rapidly attacked by fungi and bacteria that affect the shelf life of the food and at the same time can cause diseases to consumers and the crop itself (Tournas 2005; Frey-Klett et al 2011).

The highest CP content recorded in the SEF is due to the unicellular protein (UP) that is developed in this process (Chacón 2004; Borras et al 2015). In this regard, UP has a high content of lysine, threonine, glutamic acid and methionine (Páez et al 2008). In this sense, unicellular microorganisms constitute a recurring alternative to convert waste organic matter into UP for human and animal nutrition (Gutiérrez and Gómez 2008).

On the other hand, the EE content of the natural tuber is within the range of taro varieties reported by other researchers (Amon et al 2011; Rodríguez-Miranda et al 2011).

The highest ash content recorded in the SEF is due to the inclusion of calcium carbonate that was made in the food (Borras-Sandoval et al 2017; Fonseca-López et al 2018).

The CF content of this food is within the recommended range for pigs (Bertechini 2013). In relation to the high NFE content of the waste taro tuber with and without processing, this is due to the carbohydrate content of the tuber, which is why it is considered an excellent energy source for use in human and animal diets (Caicedo 2013 ; Adejumo and Oladeji 2012; Madrigal-Ambriz et al 2018).

Table 2 shows the results of the energy content of the waste taro tuber in the natural state, SEF and flour. The best ($p<0.05$) contents of GE, DE and ME presented the tuber in its natural state, followed by flour and SEF, respectively.

Although the tuber in its natural state had the best values of GE, DE and ME Ly et al (2010) indicate that alternative resources of plant origin must have a processing before use in pigs to improve the digestibility coefficients of energy. In fact, if these foods receive some processing such as silage or

flour, the energy use may exceed 80% (Caicedo et al 2018). On the other hand, when alternative foods are used in their natural state, energy use is low (Ly y Delgado 2005).

Table 2. Energy content of the waste taro tuber with and without processing

Nutrients	Ways of preparation			SEM	*p*
	Natural	SEF	Flour		
GE, %	4363.11[a]	4002.77[c]	4223.10[b]	11.95	0.0001
DE,%	3612.92[a]	3031.52[c]	3445.18[b]	23.82	0.0001
ME, %	3610.15[a]	3024.94[c]	3439.57[b]	23.76	0.0001

[ab] *Different letters indicate significant differences for p<0.05*

Conclusions

Processed waste taro tubers constitute a good source of nutrients, guaranteeing a local alternative food of adequate nutritional characteristics for use in pigs.

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