Utilization of the fruit meal from the breadfruit tree (*Artocarpus altilis*) in diets for pre-fattening pigs

Odelín Brea[1], A. Ortiz[1] and A. Elías[2]
[1]*Centro de Estudio de Especies Menores, Universidad de Guantánamo, Carretera a Santiago de Cuba, km 1½. Guantánamo, Cuba*
[2]*Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba*
Email: odelin@fam.cug.co.cu

Fruits from the breadfruit tree (*Artocarpus altilis*) were collected in the municipality of Yateras, Guantánamo province, Cuba for determining their chemical composition and inclusion levels in diets for pre-fattening pigs. Forty eight recently weaned pigs of the Yorkland x Duroc hybrid of 33 d of age and an average live weight of 9.4 kg were used, according to a completely randomized design with four treatments and three replications. It was confirmed that the fruit meal from the breadfruit tree (BFM) has energy, protein, NDF and ADF qualities that instigates its inclusion in pig diets in the pre-fattening stage. Therefore, it was added at dosages of 0, 10, 15 and 20 % as maize substitute according to the design selected. At the end of the experiment equal viability values (100 %) were obtained in all treatments, while that including 20 % of fruit meal from the breadfruit tree differed significantly regarding the control, attaining lower final live weight and average daily gain. Also, a worsening in DM and CP feed conversions (1.77 to 2.11 kg DM/LW, respectively) was found at $P \leq 0.05$. On decreasing the level of conventional concentrate (0 %) with the inclusion of increasing levels of BFM in the diets, concentrates saving was attained. It is recommended the inclusion, as maximum limit, of 15 % of fruit meal from the breadfruit tree in the diets for pre-fattening pigs without affecting feed and protein conversion regarding the control.

Key words: *breadfruit tree fruits, pre-fattening pigs*

In non-ruminant nutrition (pigs and poultry), feeding schemes involving intensive technological conditions obtain the protein and energy from oil cakes and cereal grains, with great dependence on non-renewable fossil energy sources and a high competition degree regarding some human consumption feeding sources (Anon 2009).

This harsh reality propitiates the search for more adequate feeding alternatives to Cuban conditions that encourage a sustainable production in time, with positive effects on the social, economic and ecological fields. These new options must reduce the production costs with environmental benefits and propitiate for the consumer a cheaper product of good quality (Mederos *et al*. 2007).

In the municipality of Yateras, Guantánamo province, Cuba, the benefits of the fruits of the breadfruit tree (*Artocarpus altilis*), can be exploited since this species generate each year 9000 t of dry fruits, approximately. Also, it is possible to find this plant in some municipalities of Santiago de Cuba and Holguín, as well as in domestic orchards of Sierra del Rosario, Pinar del Río province and Island of Youth (Rodríguez and Sánchez 2001). Its fruits are partially used in human and animal feeding. An important part of them is lost since there is overproduction and ignorance on the conservation and utilization ways as energy source (Leyva and Valdivié 2007).

This paper has as objective determining the chemical composition of the fruit meal of the breadfruit tree and its inclusion in pre-fattening pigs.

Materials and Methods

The experiment was developed at the Pig Center "Granadillo", in Guantánamo province. Forty eight pigs of the Yorshire-Landrace x Duroc hybrid of 33 d of age and an average live weight of 9.4 kg. A completely randomized design with three replications was applied. Each replication was formed by four animals for a total of 12 per treatment. The experiment lasted 42 d.

Treatments consisted of the inclusion of 10, 15 and 20 % of fruit meal of the breadfruit tree (BFM) in the concentrate as maize substitute and a control based on conventional feeds.

Table 1 shows the inclusion level of each raw matter per treatment and their nutritive contribution.

For the chemical analysis, samples of the fruits of the breadfruit tree were taken in areas of Yateras municipality. Fruits weighed, as average, 1.5 kg (Leyva 2010) and were developed on brown with carbonate soils (Leyva and Ortiz 2008). For obtaining BFM, it was followed the procedure according to the technology described by Leyva and Valdivié (2007). DM, CP, EE, P and Ca were determined according to AOAC (1995). The metabolizable energy (ME) was taken from Valdivié and Biscudo (2011), NDF and ADF were established according to van Soest *et al*. (1991). The chemical analyses were conducted at the Animal Nutrition Laboratory of the Department of Zootechnics of the Veterinary Medicine Faculty of the Federal University of Minas Gerais, Brazil.

At the end of the experiment, the viability, final live weight, average daily gain, total live weight gain, consumption and feed conversion, were evaluated. Duncan's (1955) multiple range test was applied to all

Table 1. Raw materials per treatment, nutrient contribution

Raw materia, %	Inclusion level of BFM, %			
	0	10	15	20
Maize meal	57.48	46.97	41.45	36.45
Soybean meal	39.49	40.00	40.52	40.52
Fruit meal from the breadfruit tree	0.00	10.00	15.00	20.00
Dicalcium phosphate	1.13	1.13	1.13	1.13
Calcium carbonate	0.50	0.50	0.50	0.50
Common salt	0.35	0.35	0.35	0.35
Choline chloride	0.10	0.10	0.10	0.10
Mineral-vitamin premix[1]	0.45	0.45	0.45	0.45
Soybean oil	0.50	0.50	0.50	0.50
Total (%)	100.00	100.00	100.00	100.00
Calculated contribution				
CP (%)	20.00	20.00	20.00	20.00
ME (MJ/kg DM)	12.59	12.69	12.74	12.79
Ca (%)	0.60	0.60	0.70	0.70
P (%)	0.60	0.60	0.60	0.60

Diets were formulated according to the requirements for the category (NRC 1998)
[1]Contribution of vitamins and minerals (NRC 1998)

variables for finding the differences between means, in the necessary cases.

Results and Discussion

The utilization of any product as human or animal feed requires the knowledge of its nutritive qualities that will allow adopting decisions regarding the ways and consumption limits.

The chemical composition of the BF meal is set out in table 2. This meal contains, approximately, 86 % of DM. It has low CP levels, coinciding with Leyva and Valdivié (2007) in studies with maize, wheat, sorghum and other cereals and pseudo-cereals (FAO 2007). However, they are higher to those of yucca root meal (Buitrago *et al*. 2001), and close to those of sweet potato root meal (Rostagno 2005).

The ether extract content is low. The ADF and NDF content is higher than that of the maize, sorghum, wheat, barley, triticale, rice bran, yucca meal, sweet potato meal and plantain meal (Dale 2006), and slightly lower to oat and paddy rice. The CF content must not create difficulties in pig feeding, when the CF level in the diet does not exceed 10 % according to NRC (1998). In contrast BFM contains 7.74 % of this fraction (Leyva and Ortiz 2008).

Table 2. Chemical composition of the fruit meal from the breadfruit tree, dry basis

Nutrients	Concentration
Dry matter, %	86.00
Crude protein, %	5.20
Ether extract, %	2.02
NDF, %	14.90
ADF, %	8.55
Ca, %	0.98
P, %	0.10

The BFM showed Ca and P concentrations (0.98 and 0.10 %, respectively) considered as acceptable, if compared to the results obtained by Dale (2006) who reported for yellow maize values of Ca lower to those of the fruit of the breadfruit tree. In the case of pigs, they require in the pre-fattening stage 0.7 and 0.6 % of calcium and phosphorus (NRC 1988) for covering the nutritive requirements. These concentrations are fulfilled in diets including 10, 15 and 20 % BFM.

Weaning is a period characterized by a sudden change for the piglet, undergoing from nutritional and social dependency of the sow to a total independency from her. Animals are submitted to a new diet, environment and social relationships which trigger varied reactions. As a consequence of this, a great part experiment the called period “delay in post-weaning growth”. At this stage there is fast, weight loss, diarrhea and even death which normally can be produced at the beginning of the pre-fattening period.

Table 3 shows the productive indicators evaluated in pigs in the pre-fattening period. It was confirmed that for viability and feed consumption there were no significant differences between the evaluated treatments. However, regarding final live weight, ADG and conversion there were significant differences between the control and 20 % fruit meal of the breadfruit tree. This did not occur between the rest of the treatments (10 and 15 %) which did not show significant differences regarding the control.

It is interesting to highlight that although the productive results attained with the control treatment surpassed statistically that including 20 % BFM, this latter presented productive indicators according to the Cuban technical manual for this category.

Table 3. Productive indicators in the pre-fattening stage

Indicators	Fruit meal from the breadfruit tree, %				SE ±
	0	10	15	20	
Initial live weight, kg	9.40	9.40	9.40	9.50	0.11
Final live weight, kg	29.00[a]	27.98[ab]	27.26[ab]	26.05[b]	0.77*
Viability, %	100.00	100.00	100.00	100.00	-
ADG, g/d	465.00[a]	440.00[a]	425[ab]	399.00[b]	15.00*
TWG/kg	19.54[a]	18.48[a]	17.87[ab]	16.50[b]	0.63*
Total consumption, kg DM	34.18	34.25	34.39	34.27	6.70
Consumption, kg DM/d	0.813	0.815	0.818	0.815	0.001
Conversion, kg DM /kg LW	1.77[a]	1.88[a]	1.95[ab]	2.11[b]	0.08*

[ab]Different letters indicate significant differences according to Duncan (1955) *$P < 0.05$

With 15 % inclusion of this alternative feed, gains of 425.68 g/d were obtained coinciding this value with that recommended by the National Pig Group (GRUPOR) for intensive rearing systems in specialized units with the utilization of conventional feeds (concentrates). These gains are similar to those reported by the NRC (1988) for the pre-fattening category and final live weight, although the DM consumption was lower.

Considering results obtained by Leyva (2010) in the quantification of tannin (4.24 g/100 g of DM) and saponin (0.33 g/100 g of DM) concentrations in the BFM, as the inclusion level of BFM increased, the concentration of anti-nutritional factors (ANF) augmented. The presence of these in the diet reduces feed consumption and growth rate of pigs when they are included at levels surpassing 20 % of the diet (De Blas *et al*. 2003).

In this study the presence of tannins and saponins in the BFM were not determined. However, according to Leyva and Valdivié (2007) it is possible that they influenced on the results obtained when included at increasing dosages from 0 – 20 % in the pig diet, increasing the consumption of these anti-nutritional factors. This could account for the poorer productive results obtained in the treatment with 20 % of BFM.

On considering the concentrations of tannins and saponins reported by Leyva (2010) and the inclusion levels of BFM, the ANF concentration (total condensed tannins and saponins) present in the BFM consumed was determined. Results obtained were: total condensed tannins (0.27; 0.40; 0.54 g/100 g of DM), saponins (3.47; 5.21 and 6.95) for the inclusion levels of 10, 15 and 20 %, respectively.

Saponins, the same as the tannins present in this plant, could limit the use of these fruits, since their effects can be manifested on a growth delay of the animals and on protein digestibility. Also, alterations in sugar absorption and inhibition of the digestive enzymes can be provoked, due to the ability they possess to form cell wall complexes with protein, carbohydrates and starches (Stewart 2000).

Martí (2009) utilized up to 30 % of BFM in the feeding of piglets of 33 d of age. This author concluded that it is feasible to replace up to 10 % maize in the diet, with final weight of 24.3 kg, ADG of 436 g and feed conversion of 2.21 kg DM/kg. However, in this experiment it is demonstrated that up to 15 % of the maize in the diet can be replaced and similar performances to the control were attained.

Among non-conventional feeds, sweet potato meal is an energetic substitute widely used (*Ipomoea batata*), capable of replacing up to 50 % of the sorghum in the diet (Alvarado *et al*. 1981).

Morgan (2003) determined a substitution level with enriched coffee pulp of up to 6 and 20 % of the cereal component in formulas used during the first and second pre-fattening stage, respectively.

Mederos *et al*. (2007) on feeding piglets from weaning until 96 d of age with high-test molasses and torula yeast (restricted diet), attained a final weight of 29.9 kg, ADG of 391 g and feed conversion of 2.48 kg DM/kg. Figueroa *et al*. (1988), with the inclusion of the same feeds, fed pigs from 7 to 30 kg live weight and obtained ADG and conversion of 450 g and 3.0 kg DM/kg, respectively.

González and Lara (1991), cited by Pedraza (2000), utilized Bagarip (protein-rich bagasse) at levels of 10 and 20 % of the diet destined to pre-fattening pigs. These authors achieved live weight gains between 333-436 g/d, values lower to those attained in this experiment, and feed conversions between 2.59 and 3.56 kg DM/kg increase.

García and Ly (1994) employed foliar plantain wastes meal, at levels of 5, 10 and 15 % of the diet destined to pre-fattening pigs, and obtained live weight gains between 483-506 g/d, and feed conversions between 2.63 and 3.0 kg DM/kg increase.

In table 4 are set out the conversion indicators of DM, ME and CP in pigs fed with BTM. As the BTM inclusion levels were increased, conversion augmented, although it only worsened with 20 % inclusion. There were no differences between 20 and 15 %, not differing regarding the rest of the treatments. Taking into consideration the difference between concentrate (0%) and the different percentages of BTM inclusion, there were 1.57, 2.58 and 4.74 MJ, regarding the control. In protein, the differences were 22, 36 and 68 g in favor of BTM. In both indicators there was only significant difference between the control and 20 % of BTM inclusion.

With 15 and 20 % inclusion a similar DM conversion was obtained, regarding what was reported by NRC (1988) for this category and live weight. For the efficiency values of 0.474 and 0.368 (NRC 1988) are indicated, while in this experiment 0.489 and 0.519 for 15 and 20 % inclusion, respectively, were attained. This justifies the inclusion of 20 % BFM in diets for pre-fattening pigs. Although results obtained are acceptable, the difference at the highest inclusion levels regarding DM, ME and CP conversions requires to be explained which could be associated to the condensed tannin toxicity produced. This is due to the changes in protein and carbohydrate digestion that are not absorbed in the digestive system, but causing damages in the mucosa, which decreases nutrient absorption. Also, they reduce essential amino acid absorption.

According to Valdivié and Biscudo (2011), BTM has condensed tannin (4.24 g) and saponin (0.33 g/100 g DM) concentrations, which could justify the above mentioned. Frandrejewski *et al*. (2003) reported higher LW gains regarding those of this study, on feeding pigs (Landrace x Duroc) during the period of 13-30 kg LW with a cereal and soybean diet containing 153 g of crude protein, 7.8 g of lysine and 16.2 MJ MS of BE/kg. This could validate the inclusion of lysine in diets with high BTM percentages and could improve live weight gain and feed conversion.

Table 5 shows DM, ME and CP consumption on adding the traditional concentrate components and considering the inclusion of 0, 10, 15 and 20 % BTM, according to what was set out in table 1. Relating to the DM and CP consumed, there were no significant differences between treatments and the control. The same did not occur with ME consumption, where the control and the 10 % differed regarding the remaining treatments. Among these latter there were no differences. As the inclusion levels increased, energy consumption augmented.

Table 6 shows the efficiency in concentrate conversion (0 %) on decreasing its contribution (90, 85 and 80 %) in the different diets, with the inclusion of 10, 15 and 20 % of BTM. It was demonstrated that the consumption of traditional raw material at inclusion levels of 10 and 20 % of BTM is of 1.68-1.69 kg, and in the case of 15 % is lower (1.65 kg). For obtaining 1 kg of ADG/kg LW, it was found the need of increasing the inclusion of traditional raw material to 0.19, 0.3 and 0.43 kg/ADG LW, corresponding to their inclusion levels (10, 15 and 20 %). This brings about 0.08-0-09 of concentrate saving for 10 and 20 % inclusion of BTM and 0.12 kg/ADG LW for 15 %. In addition to the relationship between the inclusion of traditional raw material, BTM and the savings, it was demonstrated that for each unit of conventional concentrate saved, 2.37,

Table 4. Conversion indicators of DM, ME and CP in pigs in the pre-fattening stage consuming fruit meal from the breadfruit tree

Indicators	Fruit meal from the breadfruit tree, %				SE±
	0	10	15	20	
Conversion, kg DM/kg LW	1.77.00[a]	1.88[a]	1.95[ab]	2.11[b]	0.07*
ME conversion/animal, MJ/kg LW	22.30[a]	23.87[a]	24.79[ab]	27.04[b]	0.27*
Difference, MJ/kg LW	-	1.57	2.58	4.74	-
CP conversion, g/ kg LW	354.00[a]	376.00[a]	390.00[ab]	422.00[b]	15.20*
Difference, g/kg LW	-	22.00	36.00	68.00	-

[ab]Different letters indicate significant differences according to Duncan (1955) *$P \leq 0.05$

Table 5. DM, ME and CP consumptions per treatment in pre-fattening pigs fed BFM

Indicators	Fruit meal from the breadfruit tree, %				SE±
	0	10	15	20	
DM consumed, kg	0.82	0.82	0.82	0.82	0.001
ME consumed, MJ/ME	10.24[a]	10.34[b]	10.43[c]	10.44[c]	0.004*
CP consumed, g	163.00	163.00	163.00	163.00	0.32

[abc]Different letters indicate significant differences according to Duncan (1955) *$P \leq 0.05$

Table 6. Efficiency in concentrate conversion

Indicators	Fruit meal from the breadfruit tree, %			
	0 (control)	10	15	20
Traditional raw material consumption, kg	1.77	1.69	1.65	1.68
BTM inclusion, kg/ADG/LW	-	0.19	0.30	0.43
Concentrate saving, kg/ADG/LW	-	0.08	0.12	0.09
Relationship between traditional raw material inclusion and saving	-	2.37	2.50	4.70

2.5 and 4.7 times are required of fruit meal inclusion of the breadfruit tree.

The nutritional characteristics of the fruit meal of the breadfruit tree (CP, minerals, NDF and ADF) make it feasible to be used in animal feeding.

It is concluded that diets for pre-fattening pigs including fruit meal from the breadfruit tree as partial substitute of maize, do not create significant changes in the bio-productive indicators. Inclusion level up to 15 % of fruit meal from the breadfruit tree is recommended in the feeds for pre-fattening pigs.

References

Alvarado, L., Álvarez, R. & Acuero, G. 1981. Utilización de la batata (*Ipomea batatas*) en la alimentación del cerdo. Ciencias. Vet. 3:955

Anon 2009. El enriquecimiento de los alimentos básicos con vitamina A. Available: http://www.paraqueestesbien.com.mx. [Consulted: 02/05/09]

AOAC 1995.Oficial Methods of Analysis 15th. Ed. Assoc. Off, Agric. Anal. Chem. Washington, DC. p.2000.

Buitrago, J., Gil, L. & Ospina, B. 2001. La yuca en la alimentación avícola. Cuadernos Avícolas. p. 25

Dale, N. 2006. Feedstuffs ingredient analysis table. University of Georgia. Athens. p. 67

De Blas, C., Mateos, G.G. & Rebollar, P.G. 2003. Alfalfa y mezcla animal. FEDNA. Madrid, España. 423 pp.

Duncan, D. B. 1955. Multiple range and multiple F test. Biometric.11: 1.

FAO. 2007. *Artocarpus altilis* Fosb. Árbol del pan. Available: http://www.fao.org/aga/agap/frg/afris/es/Data/4.HTM. [Consulted: 15/01/2011]

Figueroa, V., Ly, J. & Pérez, A. 1988. A new approch to the interpretation of total and ileal digestibility date of diet based on different types of sugar cane molasses for growing pigs. IV International Seminar on Digestive Physiology in the Pig. Jablonna. p. 35

Frandrejewski, H., Raj, S., Weremko, D. & Skiba, G. 2003. Progress in research on energy and protein metabolism. Energy metabolism in Landrce x Duroc crosbreed pigs and their parent breeds. EAAP Publication. N0. 109. Rostock-Warnemunde. Germany, p. 13-18

García, A. & Ly, J. 1994. Uso de diferentes niveles de residuos foliares del plátano en la alimentación del cerdo. Comportamiento de cerdos en ceba. Revista Computarizada de Producción Porcina 1: 90

Leyva, C. 2010. Caracterización química de harinas de frutos y hojas del árbol del pan (*Artocarpus altilis*) y su empleo en la alimentación de pollos, conejos y ovinos de ceba. PhD Thesis. Instituto de Ciencia Animal. Cuba

Leyva, C. & Ortiz, A. 2008. Reproducción, reforestación y usos del árbol de la fruta del pan en la provincia de Guantánamo. Technical report. CITMA. Delegación Guantánamo. 46 p.

Leyva, C. & Valdivié, M. 2007. Fruta del pan y alimentación alternativa en animales de traspatio. Revista Asociación Cubana de Producción Animal 1:48

Martí, O. 2009. Utilización de la harina de frutos del árbol del pan en la alimentación de cerdos en crecimiento-ceba. Master Thesis. Universidad de Granma, Cuba. 65 p.

Mederos, C.M., Figueroa, M., García, V. & Cruz, D. 2007. Utilización de diferentes sistemas de alimentación en cerdos al destete con dietas basadas en maíz o miel rica. Revista Computarizada Porcina 2:7

Morgan, F. 2003. La pulpa de café enriquecida. Un aporte al desarrollo sostenible en la zona montañosa de Guantánamo. PhD Thesis. 97 pp.

NRC 1988. National Research Council. Nutrient Requirements of Swine. 9th Revise Ed. Washington, D.C. National Academy Press.

NRC1998. National Research Council. Nutrients Requirements of Pigs, 10th Ed. National Academy Press, Washington DC. p. 96

Pedraza, R. M. 2000. Bagazo rico en proteínas (Bagarip). Alimento animal obtenido por fermentación en estado sólido. Revista de Producción Animal 12:8

Rodríguez, A. & Sánchez, P. 2001. Frutos en Cuba. In: Especies de frutales cultivadas en Cuba en la agricultura urbana. Ed. AGRINFOR-MINAGRI. Cuba. p. 17

Rostagno, S. H. 2005. Tablas brasileñas para aves y cerdos. Composición de alimentos y requerimientos nutricionales. 2da Ed. Reunión de Sociedades Brasileras de Zootecnia. Ed. Vicosa. Departamento de Zootecnia. p. 51

Stewart, J. 2000. Variación genética en árboles forrajeros. In: Agroforestería para la producción animal en América Latina. Ed. M. Rosales. Roma. No. 143. p.327

Valdivié, M. & Biscudo, S. 2011. Alimentacao de animais monogástricos. Mandioca e outros alimentos nao-convencionais. As frutas da árvore de pao (*Artocarpus altilis*). Ed. FEPAF. p. 279

Van Soest, P. J., Robertson, J. B. & Lewis, B. A.1991. Methods for dietary fiber, neutral detergent fiber and no starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583

Received: May 25, 2013