Scientific Paper

Evaluation of the productive performance in growing pigs fed a non-conventional diet

Yuván Contino-Esquijerosa, Rafael Herrera-González, Félix Ojeda-García, Jesús Manuel Iglesias-Gómez and Giraldo Jesús Martín-Martín

Estación Experimental de Pastos y Forrajes Indio Hatuey, Universidad de Matanzas, Ministerio de Educación Superior. Central España Republicana, CP 44280, Matanzas, Cuba
E-mail: yuvan.contino@ihatuey.cu

Abstract

The objective of the research was to evaluate the productive and health performance in fattening pigs, fed a non-conventional diet. Twenty-four female and castrated male pigs were used, with average initial live weight of 23,96 kg and 11 weeks of age, randomly distributed at a rate of 12 animals in two treatments: A) conventional diet, based on commercial concentrate feed; and B) creole diet, elaborated with soybean and mulberry meal as protein sources, and sorghum and cassava meal as protein sources. The pigs were weighed at the beginning of the evaluation and every 14 days. The feed intake (kg day^{-1}), daily weight gain (kg day^{-1}) and feed conversion (kg DM kg LW^{-1}), as well as some hematological indicators, were determined. There were no significant differences regarding live weight at 75 days of age (23,33 and 24,58 kg) and at slaughter (96,91 and 96,64 kg). The mean daily gain was 0,667 and 0,654 kg day^{-1} for the control and the experimental treatment, respectively, with only a numerical difference of 13 g. The hematological indicators (hemoglobin and hematocrit) did not differ between treatments either. It is concluded that the use of a non-conventional concentrate feed elaborated from sorghum, cassava, soybean and mulberry meals did not affect pig production and allowed to save 2 244,4 kg of corn and 237,4 kg of soybean, for which its use is recommended to feed fattening pigs.

Keywords: feed intake, weight gain, meals

Introduction

Pig feeding based on food and agricultural residues has been practiced since long ago in an artisanal way, at small and medium scale, in many places of the world and in Cuba; nevertheless, there are no defined agrarian policies that stimulate the production of non-traditional feedstuffs and promote the use of harvest residues in animal feeding. In this sense, Savón (2014) indicated the importance that the utilization of meals from tropical forages in the feeding and production of monogastric species could have for developing countries.

The search for low-cost protein sources for the elaboration of meals includes testing tree foliage, due to its high availability and nutritional value, which can facilitate its inclusion in pig diets, particularly as a nitrogen source. In this sense, the meal from mulberry (*Morus alba*) leaves, cut in short periods of 60 days, has produced very good results in digestibility experiments and in performance tests with pigs; however, little is known about the nutritional value of this feedstuff when the forage is cut at longer intervals and the fresh stems are also included in the drying process.

There is also experience in the use of the cassava (*Manihot esculenta* Crantz) root as energy source, ensiled as well as in the form of meal (Lezcano *et al*., 2014).

In recent times, sorghum (*Sorghum bicolor* L. Moench) began to be used as substitute grain of corn in pig diets (Rodríguez *et al*., 2015). This cereal shows higher availability and similar nutritional value, as well as acceptable grain yields in areas where the climate is not very favorable; and represents a good energy and protein source for pigs (Moreira *et al*., 2014). The digestible energy content of the grain is comparable to that of corn distillery byproducts (14,2-16,0 MJ DE/kg DM), for which it is recommended as an energy source for growing-fattening pigs, particularly in low-resource regions. With regards to the mineral and vitamin values, sorghum and corn can be considered equivalent (Brestenský *et al*., 2012).

Based on such antecedents, the objective of this research was to evaluate the impact of a non-conventional diet formed by soybean (*Glycine max*), mulberry (*M. alba*), cassava (*M. esculenta*) and sorghum (*S. bicolor*) meals on the productive and health results of fattening pigs.

Materials and Methods

Location. The study was conducted between December and April, 2015, (109 days), in the pig

production area of the Pastures and Forages Research Station Indio Hatuey (EEPFIH) –Matanzas, Cuba–, geographically located at 22º 48' 7" North latitude and 81 º 2' West longitude, at 19,01 masl.

Characteristics of the animals. A total of 24 commercial cross female and castrated male pigs were used, in equal proportion, with 75 days of age at the beginning of the experiment and with an average live weight of 23,95 ± 0,88 kg.

Treatments and design. A completely randomized design was used with two treatments, which had 12 animals each: treatment I (control), 100 % commercial concentrate feed B; and treatment II (creole or non-conventional diet), concentrate feed based on soybean, mulberry, cassava and sorghum meals.

Experimental procedure. The conventional concentrate feed was supplied by the Concentrate Feed Factory Rómulo Padrón, of Jaruco –Mayabeque, Cuba– and the soybean came from the National Flora and Fauna Enterprise, belonging to the Cuban Ministry of Agriculture. The mulberry, cassava and sorghum meals were elaborated at the station. The rations were formulated so that they were isoproteic and isoenergetic and that they fulfilled the recommendations made by the National Research Council (1998); they were completed with minerals and vitamins, according to the established requirements.

The mulberry used for elaborating the meal was not fertilized or irrigated; it was cut in the dry season, with an age of 75 days. The cassava root was from the ecological farm of the station, with an age of 180 days. This farm does not have irrigation and the cassava was fertilized with organic matter directly on the soil. The sorghum grain was obtained from the seed and grain farm of the station, it was harvested at 120 days and its management did not include irrigation or fertilization.

All the components of the diets were dried under direct sunlight in a period between four and five days, on a cement floor, with turning up every 3 h. The mulberry, soybean and sorghum were ground so that the particle size was 1,5 mm, while cassava was ground to 3 mm.

The bromatological composition of the two concentrate feeds is shown in table 1, and the inclusion percentages of the creole diet components appear in table 2.

The animals were individually identified (tattoo), which allowed separation in two groups, and were dewormed at the beginning of the experiment. They were confined in two pens with cement floors, respecting the vital space and the feeding trough front of each category, and they were supplied water at will. A restricted feeding system was applied, by fractioning the diet in two portions per day during the entire rearing time. The adaptation period of the pigs to the diet was 16 days.

Measurements

The pigs were weighed at the beginning and every 14 days, until the end of the trial. Every day feed intake was calculated from the weighing of the supply and the reject. The following productive indicators were quantified: initial live weight (kg), final live weight (kg), live weight increase (kg), intake (kg day^{-1}) and mean daily gain (kg $animal^{-1}day^{-1}$).

The hematological measurements were made at the end of the evaluation, before slaughter, when the animals had an average of 96,77 kg LW and 109 days in the experiment. For such purpose a representative sample was taken of 50 % of the pigs from each treatment (three females and three males), and from the 4 mL of blood sample were extracted by puncture of the femoral artery, with 21 GX38 mm (0,8 × 38 mm) needles, after immobilizing the animal. The samples were collected in Vacutainer™ tubes with ethylenediaminetetraacetic acid (EDTA) and were stored at 4 ºC for their later analysis in the laboratory, which was made in a period not longer than five hours since they were obtained. The hematic profile consisted in the determination of the red line, which included hemoglobin by the cyanmethemoglobin method and the hematocrit by microcentrifugation. For the white cell line, total count of white blood cells was made, as well as differential count of eosinophils, lymphocytes, monocytes and neutrophils through blood smear.

Statistical analysis

The data were processed by using the SPSS program for Windows®, version 15.0. The effect of the treatments on each one of the analyzed variables was evaluated through the difference among means by the Student's t-test for two means.

Results and Discussion

The performance of the productive indicators during the evaluation stage is shown in table 3.

No significant differences were found between treatments for any of the studied indicators. The daily gains are within the range reported by literature for the growth-fattening stage (Contino, 2008;

Table 1. Bromatological composition (%)

	DM (%)	CP (%)	CF (%)	ME (MJ kg^{-1} DM)	Ca (%)	P (%)
			Commercial concentrate feed			
	90,00	16,00	1,40	3,06	1,01	1,99
			Non-conventional diet			
Sorghum meal	88,00	9,00	1,19	3,30	2,01	12,08
Soybean meal	90,00	45,00	1,44	2,90	1,08	6,86
Mulberry meal	90,00	19,00	7,44	2,40	2,29	12,51
Cassava meal	89,00	2.50	1,52	3,40	1,08	2,55
Phosphate	90,00					
Common salt	90,00					
Mineralized salts	90,00					

Table 2. Composition of the non-conventional diet.

Feedstuff	% of inclusion	DM (%)	CP (%)	ME (Kcal kg^{-1} DM)
Soybean meal	15,00	13,50	6,75	0,42
Mulberry meal	14,00	12,60	2,66	0,33
Sorghum meal	64,44	56,71	6,44	2,13
Cassava meal	5,71	5,10	0,10	0,19
Mineralized salt	0,15	0,14		
Di-calcium phosphate	0,40	0,36		
Common salt	0,30	0,27		
Total	100,00	88,68	15,95	3,07

Table 3. Productive indicators of fattening pigs, with the use of commercial and non-conventional concentrate feed.

Indicator	Conventional concentrate feed	Non-conventional concentrate feed	SE (±)
Initial live weight (kg)	23,33	24,58	0,26
Final live weight (kg)	96,91	96,64	0,06
MDG (g/animal/day)	0,669	0,656	0,01
Concentrate feed intake (kg animal^{-1} stage^{-1})	262,3	266,8	0,98
Conversion (kg of concentrate feed kg^{-1} of live weight)	3,56	3,70	0,03

Ly and Pok, 2014), just like the feed conversion, which did not exceed 3,5 kg of concentrate feed and proved that the voluntary intake of the diets was similar, although the crude fiber content was higher in treatment II, which included mulberry forage meal in 14 % of the ration.

In this regard, Ly *et al*. (2001) reported that the inclusion of mulberry meal in the diet of growing pigs does not affect the productive variables, probably due to the high digestibility of the neutral detergent fiber and nitrogen (79,6 and 83,6 %, respectively) in this plant.

Another interesting aspect was the inclusion of sorghum meal in almost 65 %, to substitute corn and wheat bran (which are the habitual energetic

grains of concentrate feeds in Cuba, according to Almaguel *et al*., 2010), without decreases occurring in the intake. In this regard, Etuk *et al*. (2012) stated that the grain of some sorghum cultivars has antinutritional factors (mainly tannins) which reduce its acceptance by monogastric animals and decrease animal yield. Thus, Arias *et al*. (2009) reported a reduction of live weight in 8,3 % when they substituted wheat meal (main energy source) by sorghum silage, which did not occur in this study.

This is supported by the results of Fialho *et al*. (2004), who proved that between 33 and 100 % of corn can be replaced by sorghum low in tannins for piglets, without affecting intake, weight gain and conversion rate. These authors observed that the nitrogen retention was not different among the animals that received the different experimental diets, while the crude protein digestibility (85 % for the diet with 100 % of corn and 85,8 % with 100 % of sorghum) was not affected by the cereal source, and neither was the digestible energy (3 821 *vs.* 3 793 kcal kg^{-1}) or the metabolizable energy (3 619 *vs.* 3 670 kcal kg^{-1}). Moreira *et al*. (2014) also showed that the partial substitution of corn by grain sorghum up to 50 % did not alter the indicators of animal performance. In that study, the sorghum used showed similar values of CF and CP, 1,76 and 9,80 %, respectively, to the ones reported in this research.

Regarding the health status of the animals, no statistical differences were detected in the hematological indicators between treatments, although a trend to the increase of hemoglobin and hematocrit was observed in the experimental group (creole concentrate feed) with regards to the control (table 4).

The hematocrit percentage in both treatments was close to the maximum values (32-50 %) reported in literature (Corredor-Barrios, 2012); while the hemoglobin concentration, considered one of the most important elements present in the blood and which indicates to a certain extent the nutritional level of the animals, had a similar performance to the one found by Contino (2007), and was also within the normal value range for this species. This indicates that during the fattening period the animals did not have hemodynamic alterations, caused by dehydration processes, intense exercise or stress, and no anemic cases appeared either. In general, the pigs did not show at any moment clinical signs to be considered sick.

Leukocytes had a relatively low concentration (the minimum range is 7 000) and this could be associated to the presence of flavonoids in the mulberry and cassava meals, which exert a phytochemical action on the immunological system, improving the organism defenses (Cevallos *et al*., 2007). The percentages of eosinophils and monocytes were within the normal range for the species and the growth stage, just like the lymphocytes and segmented neutrophils, which constitute the first line of defense of the organism.

The total concentrate feed intake (table 3) was 3 147,5 and 3 201,3 kg for treatments I and II, respectively. Considering that in treatment II the sorghum meal was included in 64,44 % and the cassava meal in 5,8 %, this meant an intake of more than 2,2 t of these meals, which are produced with inputs imported in the country. If the soybean inclusion

Table 4. Studied hematological indicators

Indicator \ Treatment	Conventional	Non-conventional	SE (±) Significance
Hemoglobin g dL^{-1}	12,98	13,73	0,43 $p = 0,2858$
Hematocrit (%)	43,25	45,75	1,44 $p = 0,2858$
Monocytes (%)	8,02	7,01	2,53 $p = 0,7919$
Lymphocytes (%)	27,75	25,00	2,51 $p = 0,4811$
Eosinophils (%)	11,25	11,75	1,30 $p = 0,7990$
Segmented (%)	53,25	55,00	1,59 $p = 0,4801$
Leukocytes (mm^3)	10 001	10 026	0,73 $p = 0,8220$

percentage, which was only 15 % (representing an intake of 480,2 kg), is added to this, the saving of corn, wheat bran and soybean (all imported and with prices of 155,91; 190,24 and 350,25 USD t^{-1}, respectively) achieved in this treatment can be inferred. A commercial concentrate feed B, used in the national pig fattening system, includes 42,2 % of corn; 22,8 % of soybean and 30,0 % of wheat bran (Almaguel *et al*., 2010), for which with the concentrate feed based on the meals referred in this study 2 244,4 kg of the energy components (98,7 %) and 237,4 kg of soybean (33,1 %), were saved, which in exchangeable currency means 470,6 USD.

The use of pig feeding variants constitutes one of the higher priority needs, due to the high costs and instability of the raw material for the elaboration of concentrate feeds (Herrera, 2012).

In this sense, the elaboration of a creole concentrate feed based on meals from local feedstuffs propitiated large savings of commercial concentrate feed, mainly of its two main elements, corn and soybean, which are commonly imported grains and show high prices in the international market (Indexmundi, 2016).

It is concluded that the utilization of a creole concentrate feed based on meals from local feedstuffs (cassava, sorghum, mulberry) and soybean is feasible, because the productive and health performances of the animals were similar to those obtained with conventional concentrate feeds. In addition, the use of these feedstuffs propitiates saving imported feedstuffs and, thus, the use of foreign currency for their purchase.

Acknowledgements

The authors thank the work team of the department of biomathematics research of the Animal Science Institute (ICA, for its initials in Spanish) –Mayabeque, Cuba–, for the data organization and processing. They also thank the research and animal husbandry vice-directions of the EEPFIH and the provincial laboratory of the Veterinary Medicine Institute, Jovellanos, Matanzas, for the coordinated work to achieve the results; as well as the project PY P131-LH002-038 «Studies with *Morus* sp. for the development of sustainable technologies of human and animal feeding and health in Cuba», of the Animal Feeding Program.

Bibliographic References

Almaguel, R. E.; Piloto, J. L.; Mederos, Carmen M.; Cruz, Elizabeth & Ly, J. Sustitución de la fuente energética tradicional (maíz) por miel B de caña de azúcar en dietas para cerdos en crecimiento-ceba. *Zootecnia Trop*. 28 (1):57-64, 2010.

Arias, R.; Marrero, L. & Castro, A. Rasgos de comportamiento de cerdos en crecimiento-ceba alimentados con dietas basadas en granos y panícula de sorgos ensilados. *Rev. Comp. Prod. Porcina*. 16 (3):191-193. http://www.iip.co.cu/RCPP/163/163_07artAArias.pdf. [05/06/2016], 2009.

Brestenský, M.; Nitrayová, Soňa; Patráš, P. & Heger, J. The quality of sorghum grain in aspect of utilization amino acids in pigs. *JMBF*. 1 (special):1032-1039, 2012.

Cevallos, J. D.; Villavicencio, M. A. & Giacometti, J. C. Influencia de *Morinda citrifolia* en el perfil hematológico de *Sus scrofa*. *Boletín técnico 7. Serie Zoológica*. *Ecuador*. 3:62-71, 2007.

Contino-Esquijerosa, Y. *Estudio de la inclusión del follaje fresco de Morus alba Linn. var. Acorazonada en dietas porcinas*. Tesis presentada en opción al título académico de Master en Pastos y Forrajes. Matanzas, Cuba: EEPF Indio Hatuey, 2007.

Contino-Esquijerosa, Y.; Ojeda-González, F.; Herrera-González., R.; Altunaga-Pérez, Nancy & Pérez-Rubalcaba, María G. Comportamiento productivo de cerdos mestizos en ceba alimentados con follaje fresco de *Morus alba* como sustituto parcial del concentrado comercial. *Zootecnia Trop*. 26 (3):391-394, 2008.

Corredor-Barrios, R. Perfil hemático de cerdos alimentados con follaje de morera, *Morus alba*. *Revista CITECSA*. 2 (3):27-35, 2012.

Etuk, E. B.; Ifeduba, A. V.; Okata, U. E.; Chiaka, I.; Okoli, Ifeanyi C.; Okeudo, N. J. *et al*. Nutrient composition and feeding value of sorghum for livestock and poultry: a review. *J. Anim. Sci. Adv*. 2 (6):510-524, 2012.

Fialho, E. T.; Rodrigues, P. B.; Lima, J. A. F.; Silva, H. O. & Oliveira, V. Performance and nutrient digestibility of low tannin sorghum fed to pigs from 10 to 30 kg. *Abstracts of the Joint Annual Meeting of the ADSA, PSA, AMPA, ASAS*. St. Louis, USA. p. 22, 2004. http://www.jtmtg.org/JAM/2004/abstracts/22.PDF. [06/06/2016], 2016

Herrera, R. *Sustitución parcial del concentrado comercial por harina de sorgo y forraje fresco de arbustivas proteicas en cerdos mestizos en ceba*. Tesis presentada en opción al título de Master en Pastos y Forrajes. Matanzas, Cuba: EEPF Indio Hatuey, 2012.

Indexmundi. *Índice de precios. Cereales*. http://www.indexmundi.com/es/precios-de-mercado/? mercancia=soja&meses=120. [05/09/2016], 2016.

Lezcano, P.; Berto, D. A.; Bicudo, S. J.; Curcelli, F.; González, Priscila & Valdivié, M. I. Yuca ensilada como fuente de energía para cerdos en crecimiento. *AIA*. 18 (3):41-48, 2014.

Ly, J.; Chhay, T.; Phiny, C. & Preston, T. R. Some aspects of the nutritive value of leaf meals of *Trichanthera gigantea* and *Morus alba* for Mong Cai pigs. *LRRD*. 13 (3). http://www.lrrd.org/ lrrd13/3/ly133.htm. [05/06/2016], 2001.

Ly, J. & Pok, S. Utilización del follaje de morera en la alimentación del ganado porcino en sistemas integrados tropicales. *Rev. cubana Cienc. agríc*. 48 (1):63-66, 2014.

Moreira, F. R. da C. e; Costa, A. N.; Martins, Terezinha D. D.; Silva, J. H. V. da; Medeiros, H. R. de & Cruz, G. R. B. da. Substituição parcial do milho por sorgo granífero na alimentação de suínos nas fases de creche, crescimento e terminação. *Rev. Bras. Saúde Prod. Anim*. 15 (1):94-107, 2014.

National Research Council. *Nutrient requirements of swine*. 10th rev. ed. Washington, D.C.: The National Academy Press, 1998.

Rodríguez, J. L.; Lima, R.; Marrero, L. I. & Castro, A. Consumo a corto plazo en cerdos enfrentados a dietas con harina de granos de una nueva variedad cultivada de sorgo. *Rev. Comp. Prod. Porcina*. 22 (3):153-157. http://www.iip.co.cu/RCPP/223/223_JRodriguez.pdf, [05/06/2016], 2015.

Savón, Lourdes. Harinas de forrajes tropicales. Efectos en ciertos indicadores fisiológicos de cerdos. *Rev. Comp. Prod. Porcina*. 21 (3):99-108. http://www.iip.co.cu/RCPP/213/213_ artresenaLSavon.pdf, [05/06/2016], 2014.

Received: September 20, 2016
Accepted: May 30, 2017