Pastos y Forrajes, Vol. 36, No. 1, January-March, 64-71, 2013

Utilization of sorghum grain and forage from ligneous plants in pig fattening

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ABSTRACT

The objective of this work was to evaluate the productive indicators in fattening pigs substituting 30 % of the crude protein contributed by the commercial concentrate feed, through feeding variants which included sorghum (*Sorghum bicolor*) meal and protein forage plants (*Morus alba* and *Tithonia diversifolia*). The study was conducted in production areas of the Experimental Station of Pastures and Forages "Indio Hatuey" and 44 pigs were used; they were randomly distributed in 4 experimental treatments –with 11 pigs each- and had an initial average weight of 26 kg. The control group (C) received only commercial concentrate; the concentrate feed-sorghum group (C-S) was fed 70 % concentrate feed and 30 % sorghum meal; the concentrate feed-sorghum-tree marigold group (C-S-T) had 70 % concentrate feed, 20 % sorghum meal and 10 % fresh tree marigold forage; and the concentrate feed-sorghum-mulberry group (C-S-M) received 70 % concentrate feed plus 20 % sorghum meal and 10 % fresh mulberry forage. The live weight gains, feed intake and feed conversion were determined every 15 days. The trial stopped 108 days after the beginning, when the animals reached slaughter weight. The average cumulative weight gains (g/animal/day) of groups C (623) and C-S (625) showed significant differences (P<0,01) with regards to C-S-T (570) and C-S-M (524). The global feed conversion (kg DM/kg LW) was 3,56 for C; 4,21 for C-S; 5,39 for C-S-T and 5,18 for C-S-M. It is concluded that the inclusion of sorghum meal as energy resource and its combination with forage from protein forage plants constitutes a viable alternative for Cuban pig production.

Key words: *Morus alba*, pigs, *Sorghum bicolor*, *Tithonia diversifolia*

INTRODUCTION

In the Latin American tropic the low productivity of livestock is related to the low availability of feedstuffs and their poor nutritional value, with which productivity increases when enough quantity of inputs is available with adequate nutritional value, so that they allow to satisfy the animal requirements (Sánchez, 2002).

As a result of the current economic situation, developing countries are forced to generate alternatives in the field of animal feeding in order to guarantee the increasing needs of the population. That is why in these countries agricultural models are emerging based on the increase of production, reducing the dependence on external inputs, not only to decrease costs and increase the economic benefits per area unit, but also to be in harmony with the environment.

In current pig production the exclusive use of concentrate feed prevails, elaborated with cereal grains and oil seed cakes; this causes the production costs to increase considerably and make them compete with human food. Concentrate feed represents 70 to 80 % of the production costs, whose reduction –through an adequate supply of this input- will allow to obtain higher profitability for producers, and cost-effective and optimum production levels.

The use of non traditional roughage sources in pig feeding is a viable alternative to partly substitute commercial feeds. These raw materials may substitute imports and reduce competition with human feeding; nevertheless, their use constitutes a challenge –for nutritionists as well as for small and medium farmers- in the search for solutions to achieve economically sustainable and efficient poultry, pig and rabbit productions (Nieves, 2005).

The inclusion of forage ligneous species in the diets of pigs has constituted one of the most important challenges in the last 25 years. At present there is a large number of options and more zootechnical knowledge which allow to design the best way to use them (Savón, Gutiérrez, Ojeda and Scull, 2005). Ly (2005), when reviewing the advances achieved in this topic, stated that most interest has been focused on substituting with the forage ligneous plants, at least, part of the protein required for the good development of pigs, in order to lower the costs and achieve independence in the supply sources.

On the other hand, sorghum could be a viable alternative for the substitution of the traditional grains used in pig feeding; its bromatological composition turns it into an energy and protein source of high nutritional quality in pig rearing and fattening (Pérez *et al*., 2010). In this sense, Saucedo *et al*. (2008) stated that the total or partial substitution of corn by sorghum may increase live weight gains.

Taking into account the above-mentioned antecedents, the objective of this study was to evaluate the productive indicators in fattening pigs, with the substitution of 30 % of the ration of commercial concentrate feed by mixtures of sorghum meal with fresh mulberry and tree marigold forage.

MATERIALS AND METHODS

Location and climate. The trial was conducted at the pig production unit, belonging to the small livestock production facility of the Experimental Station of Pastures and Forages "Indio Hatuey", located at 22º48'7" latitude North and 81º1' longitude West, at an altitude of 19,01 masl. The experiment began on March 23, 2009, and ended on July 9, 2009. During the study (108 days) the prevailing climate was warm, with mean temperature of 22,5ºC and accumulated rainfall of 63 mm.

Facilities. Cubicles 4 m wide and 4 m long were used, with tile floor, lineal feeding troughs and nipple drinkers for water supply, which guaranteed a vital space of 1,36 m^2/animal. These cubicles had walls and roof in order to protect the animals against the weather inclemency and sunrays.

Feedstuffs. During the experimental stage two concentrate feed formulations were supplied (table 1), which differed in the percentages of inclusion of the raw materials, with the subsequent decrease of the crude protein content. Formulation B was supplied only for two weeks, which corresponded to the third weighing of the animals.

The forages, from forage areas of the institution destined for animal feeding in the small animal module, were harvested in the morning, with a regrowth age of 70-90 days. In the case of tree marigold, planting density was 40 000 plants per hectare. This species was 12 months old at the beginning of the trial, was fertilized once with Fitomas® (leaf fertilization in dose of 100 mL/16 L of water) and was maintained without irrigation.

The mulberry was seven years old and had a density of 25 000 plants per hectare. It received organic fertilization (mature cattle dung), 4 t/ha/year in only one application, during the rainy season. No irrigation was applied in the experimental stage.

Sorghum, variety UDC-110 was planted at a rate of 10-12 plants per lineal meter and received neither irrigation nor fertilization. It was harvested at the age of 110-120 days, and it was dried and cleaned before being stored in sacs. Afterwards, it was ground in a hammer mill with a 2 mm sieve.

Table 1. Composition of the formulations of commercial concentrate feed (A and B).

Element	Inclusion (%)		CP (%)		ME (Mcal/kg DM)		Ca (%)		P (%)	
	A	B	A	B	A	B	A	B	A	B
Bran	60,84	19,2	8,82	2,78	1,89	0,60	0,09	0,02	0,06	0,02
Corn	16,2	60,84	1,13	4,26	0,57	2,15	0,36	1,18	0,49	1,61
Soybean	18,0	15,0	6,80	6,3	0,59	0,55	0,04	0,04	0,02	0,08
Phosphate	2,0	2,0	-	-	-	-	0,05	0,05	0,03	0,03
Calcium	2,0	2,0	-	-	-	-	0,08	0,08	-	-
Common salt	0,5	0,5	-	-	-	-	-	-	-	-
Pre-mixture	0,4	0,4	-	-	-	-	-	-	-	-
Choline	0,06	0,06	-	-	-	-	-	-	-	-
Total			16,76	13,34	3,29	3,29	0,61	1,36	1,74	1,74

The feedstuffs were supplied in collective tubular feeding troughs, which guaranteed a trough space of 0,30 m/animal.

Animals. In the trial 44 animals of both sexes were used, with good health conditions and an average age of 90 days at the beginning of the trial. They were randomly divided to form four experimental groups. The initial live weight per group is shown in table 2.

Design and treatments. A completely randomized design and four treatments were used (table 3), with 11 repetitions which corresponded to each animal. The feeding variants were established based on covering the protein requirements of the pigs, according to their weight (NRC, 1998).

Experimental procedure and measurements. Before starting the experiment the pigs were dewormed and the efficacy of the antiparasitic drug used (Levamisol® 10 %, in doses of 7,5 mg/kg LW) was verified.

Before starting the measurements, all the groups received an adaptation to the experimental diets during 10 days. The forage was supplied fresh and without being chopped, in the morning (8:30 a.m.), with 5 % over the needs calculated to facilitate feed selection. In the time between 10:30 a.m. and 11:00 a.m. the mixture of concentrate and sorghum was fed, according to the experimental treatment.

In the groups which received forage, before the daily supply, the residues of the previous day were weighed with a Canon digital scale (15 kg ± 10 g) to estimate the intake. Likewise, before supplying the feedstuffs mechanical cleaning was daily performed, with pressurized water.

Individual weighing was conducted every 15 days and for such purpose a hook scale (150 kg ± 100 g) was used. Afterwards the feeding balances were made, from the average weight of each group, the expected daily gains and the bromatological quality of the feedstuffs. The feed conversion (kilogram of live weight per kilogram of feedstuff) was calculated for the concentrate feed and the total, regarding the quantity of concentrate and the whole ration (Andrial, 2002).

Statistical analysis. The data were recorded in a calculation sheet of Microsoft Excel® and were processed through the statistical pack SPSS® version 15.0 for Windows®.

In the case of the mean daily gain (MDG) a variance analysis was applied; previously, the normal data distribution was tested through the Kolmogorov-Smirnov test and the variance homogeneity was tested with the Levene test (Guerra, Menéndez, Barrero and Egaña, 1990). The differences among means were determined through Duncan's multiple range test (Steel and Torrie, 1992). A regression analysis was also made to determine the best adjustment regression equation, with a value of P<0,05 in the cumulative live weight gains.

RESULTS AND DISCUSSION

The use of pig feeding variants constitutes one of the higher priority needs, due to the high costs and the instability of raw materials for the elaboration of concentrate feeds. This acquires higher importance in the local context in which the modalities of "pig production agreements" are elaborated, where individual producers must contribute 30 % of the feed

Table 2. Average live weight and variation coefficient of the animals in each experimental group.

Group	Weight (kg)	VC (%)
Concentrate (C)	26,30	13,44
Concentrate-sorghum (C-S)	26,60	10,72
Concentrate-sorghum-tree marigold (C-S-T)	26,40	12,55
Concentrate-sorghum-mulberry (C-S-M)	26,20	12,76

Table 3. Experimental treatments and CP contribution of the feedstuffs used.

Treatment	CP contribution, according to the requirements (%)			
	Concentrate	Sorghum	Tree marigold	Mulberry
Control	100	30	-	-
C-S	70	20	-	-
C-S-T	70	20	10	-
C-S-M	70	20	-	10

that will be received by the animals in the fattening cycle and the entities of the Ministry of Agriculture guarantee 70 %. This study was conducted under these premises.

Figure 1 shows the average live weight (LW) in each experimental group. The animals ended fattening without significant differences in the final weight, with 103,3; 104,0; 96,9 and 96,0 kg for the groups: concentrate feed, concentrate feed-sorghum, concentrate feed-sorghum-tree marigold and concentrate feed-sorghum-mulberry, respectively. Fattening was finished when the pigs reached a higher average weight than 90 kg, which was achieved 108 days after the beginning of the trial.

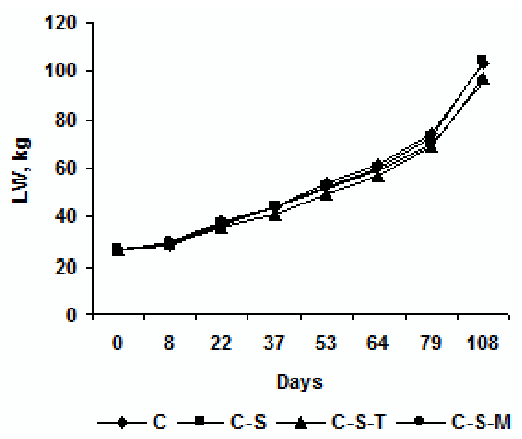

Figure 1. Live weight of the animals in the experimental treatments.

The growth curves were adjusted to a quadratic equation (table 4), with determination coefficients (R^2) between 0,84 and 0,89, and showed significant adjustments in each of the treatments (P<0,001). Under similar conditions, Contino (2007) found a growth rate with adjustment to linear models in crossbred pigs fed with concentrate feed and mulberry forage.

Figure 2 shows the variations of the MDG in the experimental groups in each weighing.

The values of the MDG in the first weighing were similar in three of the experimental groups and did not exceed 350 g/animal/day, while the group that received the mixed diets with mulberry forage showed the highest weight gains (520 g/animal/day, P<0,05). These low results of the MDG could have been related to the interaction of diverse factors, among which the stress of transferring, as well as regrouping and adaptation to new diets, stands out.

Weight gain showed recovery in all the treatments after the first 14 days of adaptation; however, in the third weighing an unforeseen inflexion was observed, which required making an evaluation in this regard. In this period a feed formulation with three less protein percentage units was received, which influenced the productive performance of the animals. When analyzing the protein requirements it was observed that the quantity of this nutrient could not be satisfied, because the feeding balance was carried out from the initial formulation received; this deficiency was corrected during the remaining time of the experiment.

This productive indicator tended to increase as the animals grew and adapted to the different feeding variants. From the second weighing the pigs of the feeding system with 100 % of concentrate feed and the mixture with sorghum were observed to have the highest MDGs, situation which was maintained until the end of the trial.

Osorto *et al*. (2007) supplied *ad libitum* fresh mulberry leaves to fattening pigs, with a conventional diet restricted to 2,5 % of their live weight (control), and obtained a higher weight gain (P<0,01) than the control group (782 *vs*. 633 g/animal/day, respectively). The conversion values were similar (3,15 *vs*. 3,01, for mulberry and the control, respectively), due to an increase (P<0,01) of the occupation days of the animals (14 days) to reach slaughter weight.

These differences in weight gain among the groups are ascribed, partly, to the fact that the energy efficiecy

Table 4. Regression equations of the live weight of the animals in each treatment.

Treatment	Equation	SE±		R^2	Sign.
		b_1	b_2		
C	$Y = 27,84 – 1,84X + 1,37X^2$	1,81	0,19	0,89	***
C-S	$Y = 29,32 – 2,76X + 1,42X^2$	2,03	2,19	0,87	***
C-S-T	$Y = 30,35 – 3,16X + 1,35X^2$	1,97	0,21	0,84	***
C-S-M	$Y = 27,76 – 0,83X + 1,09X^2$	1,97	0,21	0,85	***

R^2: determination coefficient *** P<0,001

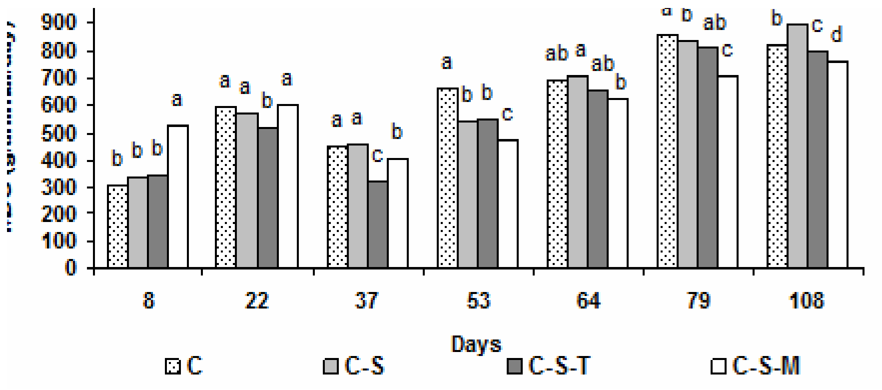

Figure 2. Weight gain of the animals in each treatment.

of roughages is lower than that of concentrate feeds (Ruíz, 1992; Ly and Macías, 1995). This occurs, mainly, because due to the microbial degradation short chain volatile fatty acids are formed (acetic, propionic and butyric), whose efficiency in energy production is lower than that of monosaccharides absorbed at small intestine level and, in addition, because a certain part of the energy is lost as fermentation heat and methane (Ly, 1995). On the other hand, fiber has been proven to induce unfavorable effects on the digestive utilization of nutrients in the diet (Just *et al.*, cited by Dierick, Vervaeke, Demeyer and Decuypere, 1989).

In the fattening pig, and even in piglets of 15-20 kg, a relatively fast adaptation process occurs –only 15 days– when they are fed a more fibrous diet (Santoma, 1997). This process consists in an increase of the size of the stomach and the cecum, which attempts to increase the ingestion capacity of the animal; but in non-isoenergetic diets the lower nutritional density of fibrous diets is not compensated, especially at early ages (Kyriazakis and Emmans, 1995).

The value of productive energy of sorghum has been proven to be similar to corn (3,44 *vs.* 3,53 Mcal/kg); likewise, the values of proteins, lipids, fiber, ashes, vitamins and minerals are similar in both grains (Quisenberry and Tanksley, 1975). That is why sorghum has gained space in the elaboration of concentrates, along with the fact that it does not compete with human feeding as corn does (Acurero *et al.*, 1983).

Figures 3 and 4 show the intakes of dry matter (DM) and metabolizable energy (ME). In both there was a similar trend, because the group which received concentrate showed the lowest intakes, as compared with the one in which 30 % of the ration based on sorghum was supplied. This occurred due to the fact that the diets only received balance by protein and not by these two nutrients, which could have influenced the results obtained in the study.

In this study the intakes could have been influenced by the high DM fecal digestibility of the forage species, which exceeds 80 % (Phiny *et al.*, 2003; González, Tepper and Ly, 2006), as well as their high palatability. This is probably related to the absence of secondary metabolites (tannins, phenols, saponins, among others) which affect voluntary intake (García, Ojeda and Montejo, 2003).

From the plants used in this research, *M. alba* is the most studied in pig feeding. Ly, Ty, Phiny and Preston (2001) found that mulberry did not affect the productive variables in Mong Cai pigs, due to the high digestibility of NDF and nitrogen (79,6 and 83,6 %, respectively). On the other hand, Phiny *et al.* (2003) found that nitrogen retention can be improved with the increase of the inclusion rates of mulberry in pigs, although attention should be paid to the fecal expulsion of water, which increases as the quantity of this plant increases in the diet of the animals.

In an analysis of the use of forage as protein source to substitute the protein nucleus, Sarría (1999) observed that the animals fed forage gained less weight than the ones fed protein nucleus. This difference could have occurred because the fiber contained in the forages caused the animals to defecate more rapidly, which limited the time for the utilization of nutrients in the digestive tract.

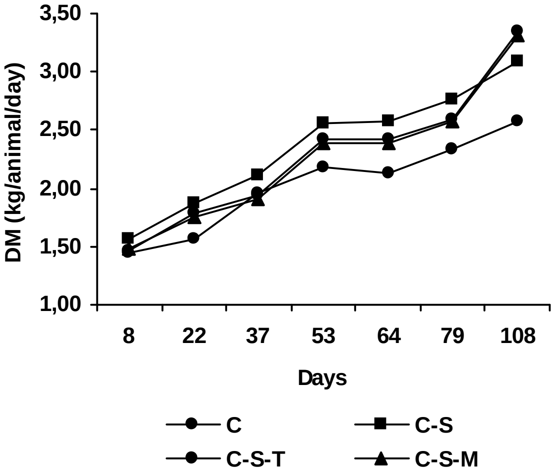

Figure 3. Dry matter (DM) intake of the pigs during the experimental period.

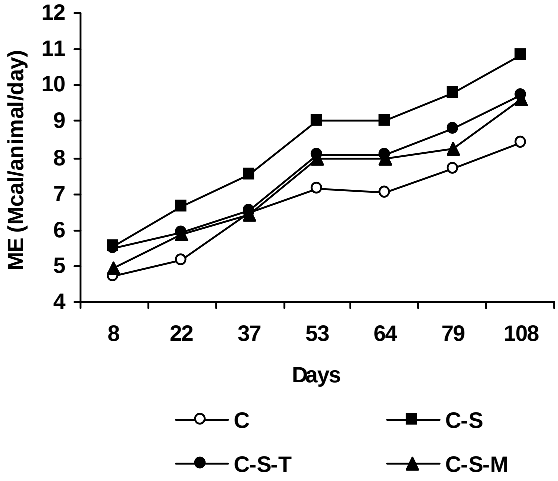

Figure 4. Metabolizable energy (ME) intake of the pigs during the experimental period.

Generally, in conventional diets fiber inclusion is related to an increase in the weight of the gastrointestinal tract; this depends on the inclusion rate and the characteristics of the fibrous material, especially the physical-chemical ones (Savón *et al*., 2008).

In Cuba, when including tree marigold meal to substitute concentrate feed, Savón *et al*. (2008) did not find negative influence on the morphometry of the gastrointestinal organs, for which they considered that it is possible the inclusion of this meal up to 20 %, without interfering in the productive performance of pigs; such response suggests that this plant has excellent characteristics in the diet fiber which make it promising for feeding monogastric animals.

Table 5 shows the main productive indicators of the animals. The lowest feed conversion was that of the concentrate feed, while the other groups had similar values.

In a study in which the main energy source of the concentrate feed (corn) was substituted by sorghum grain at 50 %, the weight gain of the pigs did not show significant differences with regards to the animals that received the diet of 100 % concentrate; although the higher substitutions decreased the weight gain and increased conversion (Acurero *et al*., 1983).

If the diet based on commercial concentrate is considered as reference criterion for the feed conversion, the sorghum inclusion increased such conversion in 18,8 %; its combination with tree marigold, in 12,8 %; and mulberry, in 15,6 %. From these results it is inferred that feed efficiency decreased with the substitution of concentrate by alternative diets; and that it increased, as compared with the sorghum meal, when the protein plants were incorporated –particularly marigold tree.

These changes occurred when a feedstuff different from concentrate or a tree plant was included

Table 5. Productive indicators in the experimental period for each treatment.

Indicator	Treatment			
	C	C-S	C-S-T	C-S-M
Initial live weight (kg)	26,30	26,60	26,40	26,20
Final live weight (kg)	103,30	104,0	96,60	96,00
MDG (g/animal/day)	0,623[a]	0,625[a]	0,570[bc]	0,524[c]
Intake (kg of feedstuff/animal/day)	2,54	3,02	3,51	3,34
Concentrate feed intake (kg/animal/day)	2,54	1,74	1,74	1,74
Feed conversion (kg of total feed/kg of live weight)	3,20	3,80	3,61	3,70
Duration of fattening (days)	108	108	108	108

in pig feeding. Nevertheless, when a total balance of the concentrate during the experimental period was made, the results indicated the advantages of including non conventional feedstuffs in the diets, which constitutes an advantage for our production conditions. In spite of this situation, according to Alonso *et al*. (2001), in Cuba the conversion ranges obtained are considered good, because they are close to 3,5 kg of concentrate per kilogram of live weight.

In this study it is concluded that it was feasible to substitute up to 30 % of the crude protein contribution for fattening pigs by sorghum meal and forage from tree marigold and mulberry, without appreciating deterioration in the productive performance of the animals.

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Received: October 5, 2012
Accepted: December 25, 2012

IV Congreso Producción Animal Tropical 2013

XXIII REUNIÓN DE ALPA

IV CONGRESO INTERNACIONAL DE PRODUCCIÓN ANIMAL

IV CONGRESO INTERNACIONAL DE MEJORAMIENTO ANIMAL

18 AL 22 DE NOVIEMBRE DE 2013

PALACIO DE CONVENCIONES, LA HABANA, CUBA

La Asociación Latinoamericana de Producción Animal (ALPA) y la Asociación Cubana de Producción Animal (ACPA) tienen el placer de invitarle a participar en la XXIII Reunión de ALPA y al IV Congreso Internacional de Producción Animal Tropical. El escenario será propicio para el desarrollo del IV Congreso Internacional de Mejoramiento Animal, el VI Simposio Internacional de Ganadería Agroecológica (SIGA) y el II Simposio de la Federación de Ovejeros y Cabreros en América Latina (Focal).

Se contará con la asistencia de especialistas, investigadores, profesores, empresarios y productores de diversas latitudes. El evento tiene como objetivo motivar el intercambio de experiencias y resultados alcanzados por profesionales, productores y técnicos en los sistemas de producción animal latinoamericanos, atendiendo a su sostenibilidad técnica, económica, ecológica y social, y a las estrategias para el mejoramiento, conservación, utilización y caracterización de los recursos naturales.

La ACPA y los centros de investigación involucrados en el Congreso brindarán su hospitalidad a todos los participantes. El programa combinará armónicamente los aspectos técnicos y productivos con el conocimiento de las riquezas naturales, culturales y humanas que atesora el archipiélago cubano.

INFORMACIONES

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