Silage of alternative feeds of Cuban origin, a technical, economical and environmental option for the production of pork meat

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For evaluating maize substitution by liquid silage from a mixture of sugar cane molasses B, saccharomyces cream, sweet potato tubercle and concentrated vinasse (0, 33, 66 and 100 % dry basis), 144 Yorkshire/Duroc x Landrace pigs, males and females, in equal proportion with a live weight of 30 kg were used. Animals were distributed in four treatments, according to a completely randomized design. They were housed in collective corrals at a rate of six animals/corral and six replications/treatment. There were no significant differences between treatments for 0, 33 and 66 % substitution but the opposite occurred between these and 100 % maize substitution ($P \leq 0.05$) for average daily gain (532, 565, 544 and 495, and 758, 779, 753 and 687g) in the phases of 0-56 and 0-98 d of stay, respectively. The same took place with total feed conversion (3.22, 3.16, 3.38 and 4.16 kg DM/kg increase and 3.63, 3.54, 3.76 and 4.48 kg DM /kg increase) in both stages, respectively. It was demonstrated that the silage of alternative feeds of Cuban origin (AEC) substituted efficiently the imported maize for pig fattening when used up to 66 % with economical and environmental advantages.

Key words: *maize, silage, pigs*

Factors such as globalization, the world's population growth, the climatic change and the biofuel production have presently contributed notably to the reduction of the availability of the majority of the foods, both for human or animal consumption (FAO 2013).

Tropical countries, apart from some exceptions, are not efficient producers of energetic and protein grains for animal feeding. In some cases, the competition for feeds between animals and humans inclines the balance, as logical, to these latter. However, in the tropics, sugar cane production and its derivatives, by-products, tubercles, roots and protein forage of different origins, is important, since can attenuate, to a large extent the deficit of traditional feeds, as well as to reduce the feeding costs for producing meat and eggs destined to the population of these regions (Figueroa y Ly 1990).

The above mentioned feeds have been widely studied by diverse authors with good results. For example, enriched molasses and cassava meal are capable of substituting efficiently all the energy contributed by maize in food production of animal origin (Buitrago 1990, Figueroa and Ly 1990, Hermida 2012 and Zacarías 2012).

A procedure named yoghurt of cassava was produced by the farmers of the central region of Cuba. It consists of grinding the cassava root with the peel, adding water until covering it and, for each 50 kg of root, a liter of natural yogurt must be used. This technology was rapidly extended due to its easy preparation, preservation capacity, possibility of using any type of cassava, even that non fit for human consumption and good acceptance by pigs at levels higher than 50 %. At the same time, producers essayed and attained the substitution of cassava by sweet potato, obtaining similar results and the same advantages.

With this background, a multidisciplinary group of researchers of the Institute of Animal Science (ICA) designed the industrialization of this technology, which was materialized by the Sugar Business Group (AZCUBA), at the Base Business Unit (UEB) "Héctor Molina ", of Mayabeque province. For that, the team of researchers proposed the formulations evaluated with good results at research scale, at the Institute as part of the producers of the zone. The objective of this research was to evaluate the industrial ensiled feed in the feeding of growing-fattening pigs.

Materials and Methods

One hundred forty four crossbred (Yorkshire x Yorkshire/Duroc) pigs, castrated males and females, in equal proportions, with 30 kg live weight were used. Animals were distributed in four treatments, according to a completely randomized design for studying maize substitution (0, 33, 66 and 100 % in dry basis (DB) by the silage obtained industrially at the UEB "Héctor Molina" from a mixture of sugar cane molasses B, saccharomyces cream, grinded sweet potato and concentrated vinasse (wasteof the alcoholic fermentation of final molasses).

Animals were housed in collective corrals at a rate of six animals/corral and six replications/treatment. They were fed daily from the first hours of the morning. Table 1 shows the composition of the experimental diets.

First of all, the standard of dry feed (DF) was

Table 1. Composition of the experimental diets[1]

Ingredients, %	Maize substitution by ensiled feed (% in DB)			
	0	33	66	100
Maize meal	62.0	41.5	21.0	-
Wheat bran	10.0	10.0	10.0	10.0
Soybean meal	24.0	24.0	24.0	24.0
AEC	-	20.5	41.0	62.0
Mono calcic phosphate	2.4	2.7	2.7	2.7
Calcium carbonate	0.5	-	-	-
Sodium chloride	0.5	0.7	0.7	0.7
Premix2	0.45	0.45	0.45	0.45
Choline chloride	0.15	0.15	0.15	0.15
Total	100.0	100.0	100.0	100.0

[1]Isoproteic diets (16 % CP); calcium 0.8 and P, 0.6 %
[2]Vitamins and minerals according to the standards recommended by NRC (1998)

supplied which was moistened by the AEC according the mentioned treatments. After consuming the greatest part of the moistened dry feed (approximately 1 h), the silage was supplied according to the scale established for the weight range, which varied weekly (table 2). Water was given through suction nipples. Animals were weighed at the beginning and every 28 d until the end of the trial at 98 d.

The bromatological composition (table 3) of the ensiled material and the dry feed (DF) was determined by the methodology described in AOAC (2006) (DM, Ash, CP (N x 6.25) and CF). Calcium (Ca) and phosphorus (P) were determined according Silva and de Queiroz (2004).

The microbiological analyses were carried out for establishing the hygienic-health care quality of the ensilage produced. Coliform count was realized according to the pattern NC-120 4832:2002, total bacteria count according to the pattern NC-120 4833:2002, fungi count by NC-120 7954:2002 and the determination of Salmonella according to NC-120 7954:2002. pH was measured by a digital potentiometer with glass electrode, buffering solutions of pH 4 and 7, and an electromagnetic stirring rod for sample homogenization.

The economic analysis considered the maize

Table 2. Feeding technology for the different diets (kg/animal/d)

Weight range, kg	Control	Maize substitution by AEC, %					
		33		66		100	
		AS	AEC	AS	AEC	AS	AEC
30-40	1.90	1.51	1.30	1.12	2.60	0.72	3.94
41-50	2.15	1.71	1.47	1.27	2.94	0.82	4.43
51-60	2.35	1.87	1.57	1.39	3.21	0.90	4.88
61-70	2.55	2.03	1.74	1.51	3.49	0.97	5.30
71-80	2.82	2.25	1.94	1.66	3.86	1.07	5.86
81-90	3.12	2.49	2.24	1.94	4.28	1.19	6.48
91-105	3.42	2.73	2.34	2.02	4.69	1.30	7.10

Table 3. Bromatological composition of the feeds used (%)[1]

Indicators	DM	N	CP	Ash	CF	Ca	P	pH
AEC (n=20)	26.81	1.12	7.0	11.79	2.92	1.58	0.25	3.76
SD	0.99	0.20	1.25	0.83	1.36	0.25	0.03	0.06
AS (n=8)	88.21	3.19	19.93	6.09	3.10	-	-	-
SD	0.50	0.47	2.94	1.69	0.40	-	-	-

[1]Analysis carried out at Instituto de Ciencia Animal (ICA) and Instituto de Investigaciones Porcina (IIP)

cost (90 % DM) of 350 USD t^{-1} and of the AEC (at 90 % DM) of 97.7 USD t^{-1}. Feeding cost per fattened pig was determined.

Results were processed using the statistical program INFOSTAT of Balzarini *et al.* (2001) Version 1. Differences between means were established as per Duncan (1955).

Results and Discussion

Results from the microbiological analysis were in the range of the indicators established in the regulations (NC-120 4833:2002, NC-120 7954:2002, NC-120 7954:2002) issued by the Institute of Veterinary Medicine of the Republic of Cuba (2002) for total bacteria count, coliforms, total fungi count and salmonella (table 4). The growth of these pathogens is limited by the acid pH (3.76) characteristic of the product (Lechevestrier 2005). This is associated with the fact that there were no infectious diarrheas or deaths of animals in the treatments with AEC which in part is due to the acid pH that also creates a favorable environment in the gastrointestinal tract of the animals. Also it is possible to predict an effect of the *Saccharomyces cerevisiae* yeast included in the feed. It is known that the active elements of its wall known as oligosaccharides from glucanes and mananes, selectively activate the growth of microorganisms in the gastrointestinal tract (Pérez 2000 and Galindo *et al.* 2010) and of the lactobacilli excluding pathogen bacteria (Blonmdeau 2001), either by a reduction of its possibilities of adhesion to the wall or directly by an antagonist effect against them (Rodríguez 2010). This implies an important saving of medicines as the antibiotics frequently used for attacking some enteric situations during the rearing.

In table 5 is shown that there were no significant differences for final live weight and average daily gain (ADG) at 56 and 98 d of experimental stay but there were between these and 100 % maize substitution ($P \leq 0.05$), although the value reported did not result insignificant to current situations, related to the prices or the cereal crisis. A similar tendency was observed with total conversion in dry basis for the stages analyzed. It must be highlighted that conversion is reduced significantly ($P \leq 0.01$) as maize is substituted by the silage. This offers a pattern for the saving of this cereal destined to growing-fattening of pigs, according to the feeding technology used.

Traditional silages, of grass forages and legumes, are known and prepared since ancient times, mainly in temperate countries. They are the feeding base of ruminant animals in the coldest months, in which bovine cattle have to be stabulated (Cañete and Sancha 1998). Other biological and chemical silages are produced and used efficiently in animal feeding from fishing wastes (Díaz 2004 and Marrero *et al.* 2009). In addition, the silage of the enriched cassava root is known for fattening pigs (Almaguel *et al.* 2010). Lezcano *et al.* (2014) reported high live weight gains in growing-fattening pigs, on substituting the energy from maize by cassava root ensiled with water and yogurt or vinasse from alcohol distilleries.

Hidalgo (2011) carried out other important studies with concentrated vinasse as additive in poultry and attained important responses in replacement chicks and layers. Similarly, Mora *et al.* (2013) referred to the utilization of concentrated vinasse as feed in pig fattening.

It is important to underline the study of Piloto *et al.* (1990) substituting soybean by Saccharomyces

Table 4. Microbiological analysis of the ensiled feed

Total bacterial count, CFU/g	Coliforms, CFU/g	Total fungi count	Salmonella
2.0-5.0 x 10^4	< 10^2	1.4-2.5 x 10^3	Negative in 25 g

Table 5. Productive performance of pigs (30-105) fed ensiled feed

Indicators	Maize substitution by AEC (% in DB)					
	0	33	66	100	EE (±)	Sig.
Peso inicial, kg	30.50	30.50	30.83	31.17	0.58	
Peso 56 d, kg	60.20^a	62.30^a	61.30^a	57.81^b	0.50	*
Peso 98 d, kg	107.3^a	107.3^a	104.7^a	97.5^b	0.49	*
GMD 0-56 d, g	532^a	565^a	544^a	495^b	16.0	*
GMD 0-98 d, g	758.0^a	779.0^a	753.0^a	687.0^b	22.0	*
Total DM conversion 0-56 d, kg kg^{-1}	3.28^a	3.21^a	3.38^a	4.18^b	0.03	*
Total DM conversion 0-98 kg kg^{-1}	3.56^a	3.42^a	3.76^a	4.48^b	0.03	*
Conversion AS 0-98 d, kg kg^{-1}	3.26^a	2.22^b	1.51^c	1.13^d	0.02	***

abMeans with different letters per row differ at P<0.05 (Duncan 1955)
* P > 0.05
**P < 0.01

yeast in pig fattening with diets of intermediate A and B molasses. These authors obtained ADG higher than 700 g with marked reduction in the cost per ton of pork meat.

Productive results showed in this study confirm those previously mentioned. However, they differ from these because alternative feeds are mixed, industrially processed and turn into an energy feed capable of substituting up to 66 % of the maize of the diet for growth-fattening pigs. Also, they are the first ones reported for AEC in diets for growing-fattening pigs.

With the plant for processing AEC 60 t d-1 are obtained. The silage can be preserved for six months, without loosing its nutritional and organoleptic characteristics. On using vinasse from distilleries, an industrial waste of high polluting effect, a contribution to environment care is made. In addition, the Saccharomyces cream and molasses B are by-products of the sugar agroindustry that do not compete directly with human feeding. On the other hand, the sweet potato that lost commercial value by diverse causes is reutilized making good use of it, avoiding in this ways its putrefaction and consequent contamination.

The economic analysis was carried out taking into account the maize substitution as energy source of high price in the international market that continues increasing. Table 6 shows the notable reduction of the cost of the diets by the substitution of this source of energy for growing-fattening pigs.

Results of this study evidence that the feeding costs with the inclusion of 66 % AEC per fattened piglet are considerably reduced regarding the control with a 39.6 % saving. The economical viability of this technology is high, besides representing the reduction of environmental pollution, since industrial wastes and tropical roots not used for human consumption are utilized.

The proposed ensiled feed is an alternative for the majority of tropical countries, since it is easy to obtain at any scale and allows that small and medium producers not giving up the production of pork meat due to the high cereal prices in the last years as animal feed (FAO 2008).

From results obtained the substitution of 66 % maize by AEC is possible for growing-fattening pigs. With its utilization important economic and environmental advantages are attained.

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Table 6. Economic evaluation of the diets under study

Determined indicators	Maize substitution by AEC (% in DB)			
	0	33	66	100
Maize consumed/pig, t	158.8	126.6	32.3	0.0
Maize cost, USD	55.6	44.3	11.3	0.0
AEC consumed, t	0.0	176.6	351.9	536.0
AEC cost, USD	0.0	5.2	10.4	15.9
[1]Total cost, USD	55.6	49.5	21.7	15.9

[1]Feed cost/fattened pig/average maize price 230 USD/t (FAO 2013)

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