Sugarcane for Beef and Pork Production

Carlos Hernan Molina C., Carlos Hernando Molina D., Enrique Jose Molina D. and Juan Pablo Molina D.
"El Hatico", El Cerrito, Valle del Cauca, Colombia.

Abstract

Tropical countries have a great comparative advantage due to the intensity and regular availability of solar energy which may be exploited through plant photosynthesis. Sugarcane is a C4 plant which has a greater capacity to utilize high light intensities with reduced water requirement and hence produce as much as 3.8 times more biomass per hectare than cereals. Total biomass yields of 255-480 T/ha are reported.

Sugarcane has been used as the basis for meat production systems in the tropics, with the aim of maximizing output per hectare. Fractionation of cane, using traditional artisanal mills (50% extraction) yields juice for fattening pigs, and pressed cane stalk and tops for feeding cattle. Trials were carried out on the farm.

In this study, sugarcane juice, with or without palm oil, and 500 g protein supplement was fed to pigs from 20-80 kg and achieved average daily gains (ADG) of 633 and 666 g/day respectively. A second trial (30-80 kg) showed gains of 565 g/day, with or without palm oil.

Bull calves fed on pressed cane stalk and tops, with *Gliricidia sepium*, multinutritional blocks (20% urea), rice bran and poultry manure grew at 526 g per day, compared to cattle on a similar diet but with integral sugar cane replacing the pressed cane stalk and tops which had an average daily gain of 767 g per day.

Comparison of beef production alone with an integrated pig and beef system favoured the integrated system. Direct production from cane was

3,458 kg beef per hectare compared to 5,870 kg per hectare from pigs and bull-calves together.

These figures compare to a maximum potential production of 1500-2000 kg meat per hectare from one hectare of star grass (*Cynodon nlemfluensis*) with fertilizer and irrigation, under the same climatic conditions. The integrated systems also provided more employment.

KEY WORDS: Livestock, sugarcane, integration, meat production

Introduction

Farming production systems in tropical countries must take as much advantage as possible of the use of the soil, the water, the air and the solar energy. The integration between different animal and vegetal species must ensure production on the long term that warrants the improvement of the soil, the water and the air purity as well as protecting biodiversity that prevails in tropical areas.

From all the energy sources, the most renewable and under-used is the solar one. This is a great comparative advantage for the tropics (Preston, 1992) where it is widely available. Its most logical use is by plants through photosynthesis (Preston and Murgueitio, 1993). The biodiversity and high productivity of tropical ecosystems is due to the major and more regular flow of energy throughout the year (Preston and Murgueitio, 1993). Classical data show that in the tropics, net productivity of energy is twice the one obtained in temperate areas in all ecosystems.

But it is necessary to select the comparative advantages of the same genetic potential taking into account that some plants have an exceptional capacity to use the solar energy when luminosity and temperature are high (Preston and Murgueitio, 1993). These are the C4 plants which can produce more biomass with minor water requirements. Sugarcane is a C4 plant and for this reason, it produces several times more biomass than other grasses as pangola (*Digitaria decumbens*) even without irrigation or added nitrogen (Rodriguez and Ruiz, 1983).

The yields of various varieties of sugarcane are shown in Table 1.

Table 1: Production of biomass from 6 sugarcane varieties (first harvest at 15 months)

Variety	Tops Ton/ha	Canes Ton/ha	Total biomass Ton/ha
MZC-74275	70	235	305
V-7151	45	210	255
RD-7511	90	310	400
Co-421	130	350	480
POJ-2878	60	245	305
CC-8475	90	310	400
Average	81	277	358

Sugarcane yields per year and per hectare are much higher than those of any other traditional crop. From sugarcane juice or A molasses, 3.8 times more energy is obtained than with a secondary cereal (Figueroa and Ly, 1990).

The farming systems should include the production of food, fuel and organic fertilizers, integrating different animal and crop species. They should be more efficient through the optimized use of the components of the tropical wealth: the people, the earth, the water and the solar energy (Preston, 1988).

This paper intends to demonstrate the advantages obtained from meat production systems based on sugarcane, using different animal species and aiming at an increased meat production per hectare in tropical regions without depending on cereals. To reach this objective, it was chosen to feed pigs with the liquid component (sugarcane juice) and cattle with the fibrous component (bagasse and tops) of the sugarcane as the basis of their diet.

The study was conducted in the farm "El Hatico", located in the municipality of El Cerrito in the department of Valle del Cauca in Colombia. The climate and soil conditions are:

Average temperature: 24 C
Relative humidity: 75%
Annual rainfall: 750 mm
Altitude above sea level: 1000 m

Soil:
pH: 6.5 to 7.5
Texture: largely clayey
Organic matter content: 2.5 to 3 %
Phosphorus content: 30 p.p.b.

Since 1988, this farm has been conducting research on the integral use of sugarcane (chopped canes and tops) for feeding cattle while increasing the carrying capacity of the land (Molina *et al*., 1992). The results have been satisfactory from the biological point of view, with Average Daily Gains (ADG) reaching 800 g. Nevertheless, the analysis of the profitability shows that the cost of supplementation is rather high, as sources of by-pass proteins and energy and non protein nitrogen are needed (Molina, 1994).

Therefore, research was re-oriented in the farm in order to integrate cattle and pig production with the aim of optimizing the sugarcane for meat production per hectare.

Background

It is necessary to take advantage of the specific physico-chemical characteristics of sugarcane in a proper way in order to optimize its use for animal feeding. This plant has been genetically selected and industrially processed for many decades with the only aim of producing sugar. Sugarcane is basically composed of two fractions, one of soluble simple sugars, essentially sucrose, and other insoluble fractions made of structural components as cellulosis, hemicellulosis and lignin. The protein content is very low. Furthermore, lignification, crystallization index of cellulosis and its level of polymerization are responsible for the cane rigidity. Taking into account these physical and chemical factors, it is necessary to process sugarcane in order to optimize its use for different animal species (Figueroa, 1990).

The soluble fraction of sugarcane is easy to extract through crushing which permits to reach extraction rates as high as 97% in the sugarcane industry and about the half through the traditional artisanal sugarcane mills. This fraction, the sugarcane juice (16-20% DM) is composed of sucrose and reduced sugars. It is a liquid feed which is rich in energy but difficult to preserve because of its tendency to rapidly ferment (Figueroa and Ly, 1990).

Mena (1981) started research in this field in Mexico on station and on farm. Fermín (1983) and Fernández (1984), in the Dominican Republic, carried out several experiments with the use of sugarcane juice and obtained similar results to those of this work and other works done in Colombia (Table 2) published by Sarria (1994).

Table 2: Results from fattening pigs with a diet based on sugarcane juice and soya cake in different locations in Colombia

Weight (kg)	Nx6,25 (g)	ADG (g/day)	Con-version	Reference
25-91	200	640	3.8	Quiroga and Preston, 1987
20-77	200*	580	3.1	Solano, 1989
21-90	200	730	3.2	Solano, 1989
19-92	300	755	3.2	Solano, 1989
27-98	200	625	3.0	Sarria *et al.*, 1992
27-78	200**	590	3.7	Sarria and Preston, 1992
28-81	200	631	4.0	Sarria *et al.*, 1992a
23-80	200**	455	3.7	Sarria *et al.*, 1992b
24-91	200	681	3.3	Ngoan, 1994
25-90	200	482	4.7	Becerra *et al.*, 1990
	200	720		Fernández CIPAV, 1990
13-90	200	790		Muñoz, 1989

Materials And Methods

Pigs

Two independent experiments were carried out in order to assess the potential of sugarcane juice, in association with small quantities of palm oil (from African oil palm, *Elaeis guineensis*) as the source of energy in the diets of pigs growing from 20 to 80 kg.

The aim was to study the alternative energy sources in order to increase the flexibility of the use of sugarcane juice. Nevertheless, the results are not sufficiently comprehensive to reach any conclusions with reference to the oil in the diet.

So far, it was considered very hard to reach the same levels or higher level of production in the tropics such as those in temperate countries where diets are based on cereals. The experiments carried out by Ocampo (1992) proved that it was not only possible to reach these levels, but even to exceed them with palm oil as source of energy.

The quantities of palm oil used were:

Pigs (kg)	Palm oil (g)
20 to 40	90
41 to 60	120
61 to 90	180

The oil was given twice a day in association with the source of protein.

The sugarcane used for the extraction of the juice was from the variety Mayaguez Colombia 74275, 12 months old, yielding 180 tonnes per hectare (135 tonnes of canes and 45 of tops) and producing a juice of 20 degrees Brix.

The trials were conducted in 4 barns (11 pigs in each) with a cement ground (15 m2) and fences of bamboo.

The results showed in Table 3 concern pigs 'berracos' originated from paternal lineage (Pietrain, Hampshire, Duroc) whereas the results showed in Table 4 concern pigs originated from boars from maternal lineage (Large white, Landrace, Yorkshire). This is important in order to interpret the differences in ADG between the two groups.

The initial weight of the animals were between 17 and 22 kg and they were weighed every 30 days before feeding them. Every treatment was repeated twice with 11 pigs in each.

Protein supplementation consisted in 500 g of a mixture of soya cake, vitamins and minerals (40% protein) per pig per day, given in two meals.

Cattle

Cattle was included in the trial in order to assess its capacity to use the fibrous residue left after crushing the sugarcane to get the juice. A trial was also conducted on bull-calves in order to compare the use of the integral sugarcane (chopped canes and tops) with the use of bagasse and tops.

Two corals were used: each included 200 m^2 of earth with 3 trees for shadow and 20 m^2 of cement grounds near a trough 4 m long (0.8 m per animal). In order to ease the management of the animals, and to keep the natural immunity given to them by grazing on the pastures, they were released during the week ends in pastures of star grass (*Cynodon nlemfuensis*).

The two groups (integral sugarcane; bagasse and tops) were identically supplemented:

- *Gliricidia sepium* (3% of the live weight on fresh matter basis) as the source of protein (Preston and Leng, 1987).
- Multinutrient blocks given *ad libitum* and including 20% urea as a source of non protein nitrogen, 15% cotton husks, 40 % molasses C, 10% rice bran, 5% salt and 10% lime.
- Rice bran as a source of by-pass energy, rich in long chain fatty acids: 500 g per animal per day.
- Poultry manure as a source of non protein nitrogen, minerals and protein: 500 g per animal per day.

The bagasse was obtained from the sugarcane crushed to get the juice for the pigs through an artisanal mill powered with animal draught and with an extraction capacity of 50% of the cane weight as juice. Therefore this bagasse is still rather rich in sugars. It was daily chopped with a Brazilian chopper (Nogueira 12 A) powered by a tractor Fordson Mayor of 65 HP (capacity of chopping 1 ton per hour). The thoroughly chopped bagasse (fragments 1 to 2 cm long) were transported to the trough on carts draught by mules.

The cane tops, which represents 25% of the biomass of the sugarcane, were chopped on the spot with the same equipment and were also transported by mules.

The diet of the control group of Table 5 consisted in integral sugarcane (chopped canes and tops) processed and transported as the tops above mentioned.

The animals used for these trials were from the Lucerna breed (Colombian breed) originating from a triple crossbreeding between the European breeds Holstein, Dairy Shorthorn and the Colombian creole breed Harton del Valle which has inhabited the region for more than four centuries.

Results

Pigs

In the first trial with pigs (Table 3), ADG are 33 g higher with the treatment including African oil palm and sugarcane juice (666 vs 633); taking into account the lower juice consumption (0.7 litres per pig per day), and the intake of 117 g of oil per pig per day, the difference amounts to 1,000 pesos (US$ 1.17) per pig after fattening is completed.

Table 3: Fattening pigs with sugarcane juice and African oil palm

Parameter	Unit	Juice and oil	Juice
Groups	-	2	2
Pigs/group	-	11	11
Duration	days	90	90
Initial weight	kg	21	21
Final weight	kg	81	78
ADG	g	666	633
Standard deviation		0.104	0.112
Intake			
Sugarcane juice	litres	7.7	8.4
African oil palm	g	117	0
Protein Supplement	g	0.500	0.500

In the second trial with pigs (Table 4), there was no difference in ADG between the group fed with sugarcane juice and oil and the group fed with only juice (565 vs 565). It was also observed that in this assessment, the difference between juice intake was maintained: 0.7 litres less per pig per day for the animals receiving an average of 134 g of palm oil per day per pig. In this case, the pigs that received juice and oil had an additional cost of 4,256 pesos (US$ 5) to complete fattening with comparison to the pigs that received only sugarcane juice.

Table 4: Fattening pigs with sugarcane juice and African oil palm

Parameter	Unit	Juice and oil	Juice
Groups	-	2	2
Pigs/group	-	11	11
Duration	days	92	92
Initial weight	kg	30	30
Final weight	kg	82	82
ADG	g	565	565
Standard deviation		0.170	0.118
Intake			
Sugarcane juice	litres	6.8	7.5
African oil palm	g	134	0
Protein Supplement	g	0.500	0.500

The minor ADG found in Table 4 with reference to Table 3, are due to the genetical difference between the animals. The average intake of sugarcane juice for the assessments of Table 3 and 4 are between 7.5 and 8.4 litres per pig per day.

Cattle

As shown in Table 5, the bull-calves used had an average initial weight of 276 kg. The trial lasted for 133 days. The ADG of the group receiving integral sugarcane, Gliricidia sepium, supplemented with multinutrient blocks (20% urea), rice bran and poultry manure were 250 g higher than those of the group receiving bagasse, tops and the same supplementation. The ADG were 767 g and 526 g respectively.

Table 5: Rairing/fattening Lucerna bull-calves with bagasse/sugar-cane tops vs integral sugarcane

Parameter	Unit	Bagasse and tops	Integral sugarcane
Animals	-	5	5
Duration	days	133	133
Initial weight	kg	276	277
Final weight	kg	346	379
ADG	g	526	767
Standard deviation		0.071	0.057
Intake			
Integral sugarcane	kg	0	23
Bagasse	kg	10	0
Tops	kg	6	0
Blocks 20% urea	kg	0.682	1.080
Gliricidia sepium	%LW	3	0
Rice bran & poultry manure	kg	1	1

Multinutrient block intake was 400 g higher for the animals receiving integral sugarcane compared to the animals receiving bagasse: 1080 and 682 g respectively. This might be interpreted by the higher requirements for ammonia concentration in the rumen for the animals receiving more fermentable sugars in their diet (Preston, personal communication, 1994).

Indeed, the low nitrogen content of the sugarcane and its by-products clearly indicates the need to provide supplements in order to increase the levels of ammonia in the rumen. This is done by the urea but this might also be achieved through other sources of fermentable ammonia as poultry manure or fodders with high contents of soluble protein. The requirements are between 20 and 30 g of nitrogen per kg of fermentable carbohydrate in the diet.

Because of the rapid degradation of a high proportion of the fermentable carbohydrates, it is necessary to thoroughly mix the urea with them in order to ensure the proper availability of ammonia from urea while the sugars are fermenting. In diets rich in fibers and sugars, the strategic use of the urea consists in maintaining high levels of ammonia in the rumen, when the fermentation of sugars ends, and the degradation of fibre starts (Leng, 1988).

It was also shown in Table 5 that the standard deviation for the two treatments was very low, 0.071 and 0.057 for the treatment with bagasse and the treatment with integral sugarcane respectively. This shows the confidence in the results that are expected with these two diets.

Conclusions

As shown in Tables 3 and 4, pigs that are fed sugarcane juice *ad libitum* during rairing-fattening and supplemented with 200 g of net protein per pig per day have an ADG of 600 g.

The potential of integral sugarcane (chopped canes and tops), in the fattening of bull-calves supplemented with *Gliricidia sepium* (3% of liveweight on fresh matter basis), multinutrient blocks (20% urea), 0.5 kg of rice bran and 0.5 kg of poultry manure is to produce ADG of 750 to 800 g per animal per day.

The integration of the cattle to take benefit of the crushed sugarcane (bagasse) from which only 50% of the sugar has been obtained, permits to reach ADG of 500 g with a supplementation including protein, non protein nitrogen and a source of by-pass energy (large chain fatty acids).

The present work shows the advantage of the integration of the pigs and cattle for using more efficiently the sugarcane in order to increase meat production per hectare. In Table 6, there is a comparison between the exclusive use of sugarcane for cattle (chopped canes and tops) and the integration between the pigs fed with the juice and the cattle fed with the bagasse and tops.

Table 6: Two alternatives for using sugarcane

Parameter	28 kg integral sugarcane Bull-calf	28 kg fractionated sugarcane Bull-calf	Pig
Integral sugarcane	28 kg		
Bagasse		10 kg	
Tops		8 kg	
Juice			10 l
Gliricidia	9 kg	9 kg	
Multinutrient block	1.1 kg	0.7 kg	
Rice bran & Poultry man.	1 kg	1 kg	
Prot. suppl.			0.5 kg
ADG	765 g	500 g	600 g

To analyze this trial, it is considered that the voluntary intake of sugarcane for a bull-calf of 350 kg in total confinement, amounts to 80 g of fresh sugarcane (canes and tops) per kg of liveweight, which means an offer of 28 kg per animal per day. The fractionation of these 28 kg gives 7 kgs of tops and 21 kg of canes. The crushing of these 21 kg of canes in an artisanal mill extracting 50% of juice, will give 10.5 kg of sugarcane juice and 10.5 kg of bagasse.

Taking into account what was mentioned previously, it is concluded that with the quantity of integral sugarcane needed to feed a bull-calf of 350 kg and to obtain ADG of nearly 800 g, it is possible to feed the same bull-calf with only the bagasse and the tops with ADG of 500 g and with their respective protein supplementation.

In Table 7, the economical analysis shows that the alternative of feeding only the cattle avoids a loss of 281 pesos (US$ 0.33) of lost per animal per day, whereas the association with pig production produces a benefit of 366 pesos (US$ 0.44) per day.

Table 7: Economic analysis of the two alternatives for using sugarcane

System	Integral sugarcane for fattening bull-calves		Fractionated sugarcane (Juice and bagasse)			
Species	Cattle		Cattle		Pig	
ADG (g)	765		500		600	
Value/kg	Pesos	US$	Pesos	US$	Pesos	US$
live weight	900	1.12	900	1.12	1700	2.0
Gross income	689	0.73	450	0.53	1020	1.2
Gross income/ system	689	0.73	1470 Pesos 1.73 US$			
Costs	970	1.14	649	0.76	455	0.5
Net income	-281	-0.33	-199	-0.23	565	0.7
Net income/ system	-281	-0.33	366 Pesos 0.43 US$			

The benefits from the production of organic fertilizer from the pig and cattle excreta should be added to these figures. In the case of the cattle, it is estimated that 17 bull-calves of 350 kg of liveweight (carrying capacity per hectare) can produce 21 tonnes of fresh matter of manure per year, which represents an additional income of about 100,000 pesos (US$ 118) per hectare. In the case of the production system using fractionated sugarcane, pig manure is obtained with its specific properties in relation with the production of energy (methane production) and as a fertilizer.

The potential of production of meat per hectare of sugarcane (yielding 180 tonnes of biomass per hectare) is 4,940 kg in the case of the use of integral sugarcane for bull- calves. When pig and cattle production are associated, it is possible to obtain 2,900 kg of beef and 4,800 kg of pork, which means a total of 7,700 kg of meat per hectare. This meat production is not entirely related to the effect of the sugarcane, as the animals receive a supplementation. Considering the percentage of sugarcane on dry matter basis in the diet, the productions would be:

Bull-calves fed with integral sugarcane:		3,458 kg
Integrated production system:	Bull-calves:	2,030 kg
	Pigs:	3,840 kg
	Total:	5,870 kg

The previous figures are more striking if we take into account that one hectare sown with star grass (*Cynodon nlemfluensis*) with a high level of fertilization and irrigation in the same conditions of climate and soils as mentioned at the beginning of this paper, has a maximum potential of production of 1,500 to 2,000 kg of meat per hectare per year.

Furthermore, from the social point of view with reference to the employment opportunities, this production system of cattle fed integral sugarcane and the integrated system of cattle and pig production based on fractionated sugarcane, generates respectively 4 to 6.5 times more employment than the intensive pasture production system. This is particularly crucial in developing countries often densely populated and with insufficient sources of employment.

References

Figueroa, V. and Ly, J. 1990. Alimentación Porcina No Convencional. GEPLACEA, publicación del grupo de paises Latinoamericanos y del Caribe. 215 p.

Leng, R.A. 1988. Limitaciones Metabólicas en la utilización de la caña de azúcar y sus derivados para el crecimiento y producción de leche en rumiantes. Memorias del Seminario Taller Sistemas Intensivos para la Producción animal y de energía renovable con recursos tropicales, CIPAV. p 1 a 23. Cali, julio 26 al 30 de 1988.

Mena A., 1988. La producción de cerdos con base en la caña de azúcar. Memorias del Seminario Taller Sistemas Intensivos para la producción animal y de energía renovable con recursos tropicales. CIPAV. p l28-135. Cali Valle, Colombia.

Molina, C. H., Molina, C. H., Molina, E. J., Molina, J. P., Gomez, M. E., Murgueitio, E., Rodriguez, L. and Sarria, P. 1994. Pruebas de campo en los trópicos en el uso de biomasa para sistemas integrados y sostenibles de producción animal. Documento presentado a la Organización de las Naciones Unidas para la Agricultura y la Alimentación FAO por la Fundación Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria. Cali, Colombia.

Molina, C. H., Molina, C. H., Molina, E. J. and Molina J. P. 1994. Evaluación sobre Bloques Multinutricionales, realizadas en la Granja El Hatico, Valle del Cauca Colombia. Memorias del Seminario Internacional sobre utilización de bloques Multinutricionales. Guanare, Venezuela. Agosto 1994.

Molina, C.H., Molina, C.H., Molina, E.J. and Molina, J.P. 1992. Integración de agricultura y ganadería doble propósito en el Valle del Cauca. Estudio de caso de la Granja El Hatico en: International Foundation for Science y Universidad Autónoma de Yucatán; seminario Internacional sobre sistemas de producción Doble Propósito. Mérida, Yucatán.

Murgueitio, E. and Preston, T.R. Los sistemas sostenibles de producción como repuesta a la crisis de la producción pecuaria tropical. Convenio Interinstitucional para la producción Agropecuaria del Valle del rio Cauca, 19p.

Murgueitio, E. and Preston, T.R. 1992. Strategy for Sustainable livestock production in the tropics. Centro para la Investigación en Sistemas Sostenibles de Producción Agropecuaria (CIPAV). Cali, Colombia.

Ocampo, A. 1994. El sistema Palma Africana, una Alternativa Sostenible para el Trópico. Memorias del 3 Seminario Internacional Desarrollo Sostenible de Sistemas Agrarios. Maestría en Sistemas Sostenibles de Producción Animal en los Trópicos. p 91-118. Cali, Colombia.

Preston, T.R. 1988. El ajuste de sistemas de producción pecuaria a los recursos disponibles. Memorias del Seminario Taller Sistemas Intensivos para la producción animal y de energía renovable con recursos tropicales. CIPAV. p 1-15. Cali Valle Colombia.

Sarria, P. 1994. Análisis Comparativo de la Sostenibilidad de Sistemas para la Producción de Cerdos basados en Recursos Tropicales. Memorias del 3 Seminario Internacional Desarrollo Sostenible de Sistemas Agrarios. Maestría en Desarrollo Sostenible de Sistemas Agrarios, Maestría en Sistemas Sostenibles de Producción Animal en los Trópicos. p 195-211. Cali, Colombia.