New Research and Development Strategy for a Better Integration of Pig Production in the Farming System in Cuba

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Abstract

In Cuba, emphasis has been placed on a research and development strategy for pig production based on unconventional feeds. The collection of processed food waste from institutions (hospitals, schools and hotels), slaughter-houses, fish-processing plants and agriculture is systematically carried out. The total DM digestibility (77%) and precaecal digestibility (69%) of processed waste in pigs are slightly lower than those of cereals. However, for growing/ finishing pigs, processed waste can be used to substitute up to 50% of the dry matter of cereals with no effect on feed conversion. For pigs from 25 to 90 kg, a diet of 37% organic wastes, 33% sugarcane molasses and 30% concentrates gave acceptable results (ADG: 620 to 710 g/d; and feed conversion: 4.50 to 4.14) and the nutrient balance can be further improved by mineral-vitamin and essential amino-acid supplementation (live weight gains may be increased by more than 100 g/d).

Systems for the preservation of animal slaughter and fish processing wastes, based on the use of inorganic acids or molasses, have been designed to produce protein paste. Protein digestibility is similar to that of soya bean meal and superior to that of meat meal and torula yeast, while N retention was higher than in other protein sources studied. When protein paste contributed some 26.5% of dietary protein, the results (ADG: 780 g/d; Feed conversion: 2.95) were satisfactory. However, when the level was increased to more than 50% of the protein in the diet,

a decrease in average daily gain of pigs was observed (ADG: 700 g/d; Feed conversion: 3.33).

Fish silage has been preserved with 30 ml/kg of sulphuric acid solution and could be satisfactorily used to supply up to 50 percent of the protein in this type of diet. A mixture of 10 per cent molasses and 10 per cent wheat bran, with 80 per cent ground inland fish, placed in a polyethylene bag with a water seal in order to obtain anaerobic conditions, has also been used. The pH was 3.9 with no pathogenic microorganisms in the fish silage. Animal performance was better (ADG: 740 g/d; FC: 2,94 versus 670g/d and 3.46) when fish silage replaced 40 per cent of the soya bean meal in a molasses diet.

Cooked and mashed sweet potato has been used to totally replace maize for fattening pigs with a supplement of soya bean meal (ADG: 770 g/d and FC: 3.51 versus 770 g/d and 3.01). Substituting 0, 25 and 50% of soya bean meal with fresh foliage as the protein source in a sweet potato-soya bean diet showed that the high level of foliage worsened performance (ADG: 770, 690 and 640 g/d; FC: 3.51, 3.55 and 3.81 respectively).

Citrus pulp silage can replace up to 40% of final molasses with better feed conversion (4.08 versus 4.54) and similar live weight gain (600 versus 680 g/d).

Finally, the recycling of piggery waste is used for the production of biogas and the effluent from biodigesters is used to fertilize duckweed (Lemna) which can replace 20 percent of soya bean meal in a diet of sugarcane molasses with no adverse effects on pig performance (ADG: 630 v/s 640 g/d and FC: 4.58 v/s 4.57) .

KEY WORDS: Pig feeding; unconventional feeds; processed food wastes; animal wastes; fish wastes; sweet potato; citrus pulp; duckweed

Introduction

Cuba does not have the climatic conditions or technical development which allow production of valuable cereal crops and protein sources nor the necessary foreign currency to import conventional feedstuffs to support intensive pig production.

In Cuba, emphasis is placed on a research and development strategy for pig production based on unconventional feeding, such as: the recycling of wastes and by-products from restaurants and canteens and from agricultural and industrial activities; and the development of an animal feeding strategy based on perennial tropical crops with a high efficiency of energy yield per unit area, such as sugarcane, bananas and plantains and sweet potato. These systems have been applied to large and medium-sized pig farms. The recycling of excreta, with the production of energy (biogas), fertilizer (humus) and feed (aquatic plants and earthworm biomass), is another component of a sustainable farming system. In addition, the use of wastes and by-products and the recycling of excreta also offers the possibility of reducing environmental pollution.

Processed Food Waste

Wastes or by-products from institutions (hospitals, schools and hotels), slaughter-houses, fish-processing plants and agriculture have been used for pig feeding in Cuba for many years.

The collection of these materials is systematically carried out by tanker trucks following established routes throughout the country. The wastes are sent to industrial plants designed specifically for transforming them into feed for pigs (Del Rio *et al.*, 1980), without sanitary risks. In these plants, the wastes are submitted to selection, grinding, sterilization and mixing with sugarcane molasses, before being conveyed by pipelines to pig fattening units adjacent to the processing plant. Recently, Cuban engineers have designed and developed an autoclave (130 deg C and 2 atmospheres pressure) with mechanical agitation which adequately processes not only kitchen and vegetable wastes but also wastes from slaughter- houses and even dead animals. The advantage of this system compared to dehydration is the savings in fuel oil and the lower investment cost of the equipment.

Analysis of this processed waste shows that it offers a considerable potential as an alternative feed resource for pigs in the tropics. It contains from 14-19% dry matter, 8-16% ash, 18-22% crude protein, 6-12% crude fiber, 6-10% ether extract and a gross energy of 16 to 19 MJ/kg DM (Dominguez, 1985). Processed waste varied in composition and this variation was dependent mainly on the source of the waste material. It differed from conventional swine feeds in its low dry matter content and its relatively high crude protein.

The digestive utilization of the main nutrients of processed swill is slightly lower when compared to cereals (Table 1). Nevertheless, the total and precaecal digestive coefficient of nitrogen and energy, the nitrogen retention and the digestible energy may be considered acceptable and show that processed swill is an important alternative feed resource for pigs.

Table 1. Total and precaecal digestibility in pigs of processed waste.

	Precaecal	Total
Digestibility,%		
Dry matter	68,9	77,1
Nitrogen	65,2	76,0
DE, MJ/kg DM	13,0	14,6
ME, MJ/kg DM	-	13,9
Nitrogen retention, g/day	15,3	16,4

Source: Dominguez *et al.* (1987)

It has been shown (Gonzalez *et al.*, 1984) that for growing/ finishing pigs, processed waste can be used to substitute up to 50% of the dry matter of cereals; there was no effect on feed conversion. However the low dry matter content of processed wastes tends to affect growth due to a reduction in total dry matter intake. Water per se is not believed to reduce efficiency of utilization of the ration components; it does, however, limit consumption when present in excessive amounts in the ration. When processed waste is used as the only source of feed, and the water content is very high (for instance, 80-84%) pigs are forced to consume large quantities of water in the feed, thus limiting the total daily consumption of nutrients. The high water content of processed waste is the most serious problem for young growing pigs up to 50 kg because of the limited capacity of their gastro- intestinal tract. As the pig develops in size, the greater gut capacity tends to minimize the importance of diet concentration. Nevertheless, the use of a dry meal supplement would not appear to be necessary in a processed waste feeding system for pigs when high quality and high dry matter content are available in the processed waste (Table 2).

Table 2. Use of processed waste in growing finishing pigs.

Balanced cereals	100	40	20	-
Processed waste	-	60	80	100
Intake, kg DM/day	2,40	2,21	2,09	1,98
Daily gain, kg	0,86	0,82	0,81	0,75
Feed conversion, kg DM/kg	2,85	2,69	2,59	2,65

Source: Grande *et al.* (1995)

In spite of the variability in the chemical composition of the waste products, the experience in Cuba has been of a relatively stable concentration of dry matter and crude protein in the feed. It has allowed the study of the mixture of processed waste products with other feedstuffs, with the aim of widening the volume of processed waste and increasing the level of dry matter of the diet for pig fattening. Since a great volume of sugarcane molasses is available, it is a common practice in Cuba to mix the processed waste with sugarcane molasses in the plants, at about 10% of the volume of fresh feed produced. The mixture with molasses increases the dry matter of the processed waste by up to 25%, depending on the proportion in the mixture. However, since the sugarcane molasses is essentially a source of carbohydrates, it thus decreases the level of crude protein and energy density of the feed on a

DM basis, and this resulted in poorer feed conversion (Dominguez, 1985). The immediate solution was to add a dry cereal concentrate or a protein source to the mixture. Therefore, the major commercial feeding system used in the last 20 years in Cuba for pigs from 25 to 90 kg consisted of 37% organic wastes, 33% sugarcane molasses and 30% concentrates.

Table 3 shows the results that can be obtained with different mixture of processed wastes which are acceptable in these diets, taking into consideration that the nutrient balance can be improved with adequate mineral-vitamin and essential amino-acid supplementation.

Table 3. Performance of pigs fed different mixtures of processed waste.

	------- per cent of diet --------		
Processed wastes	-	27,8	39,4
Final molasses	-	34,6	49,3
Torula yeast	-	7,9	11,3
Balanced cereals	100	29,7	-
Intake, kg DM/day	2,47	2,92	2,78
Daily gain, kg	0,72	0,71	0,62
Feed conversion kg, DM/kg	3,38	4,14	4,50

Source: Dominguez and Cervantes (1978)

An aspect to take into consideration in these kinds of diets is that the increasing level of final molasses in the ration results in a linear increase in feed conversion without giving any improvement in daily weight gain (Dominguez 1985). These results have led towards studies on the substitution of final molasses by other intermediate or enriched molasses from the sugar industry (Dominguez, 1990), with better results than those obtained with the mixture of final molasses and further justified by differences in the energy density in the molasses.

Nevertheless, Dominguez *et al.* (1988) have reported that, when these foodstuffs are suitably supplemented with minerals (including copper sulphate), vitamins and methionine, live weight gains were increased by more than 100 g daily, irrespective of the type of molasses used (Table 4) and animal behaviour problems with diets of processed waste and final or B molasses decreased notably.

Table 4. Performance of pigs fed processed waste, cereal concentrate and final or B molasses, with or without additives.

	Molasses/Additives			
	Final No	B No	Final Yes	B Yes
Intake, kg DM/day	2,47	2,52	2,71	2,75
Daily gain, kg	0,53	0,62	0,68	0,71
Feed conversion, kg DM/kg	4,78	4,07	4,01	3,89

Source: Dominguez *et al.* (1988)

In fact, the regression analysis of daily gain on the consumption of these types of diets, either supplemented or not, demonstrates that, independently of the level of consumption of the supplement, these diets guarantee between 100 and 150 g more daily gain (Dominguez 1990).

The supplementation of these diets is more important than the kind of molasses used. On the other hand, when molasses are not used at levels higher than 30% of the ration on a dry matter basis, characteristics of behaviour are very similar between processed waste and different sugarcane molasses diets (Table 5).

Table 5. Performance of pigs fed processed waste and different types of molasses.

	Corn	Processed waste + torula yeast		
	Torula yeast	Molasses C	Molasses B	Enriched molasses
Intake, kg DM/day	2,56	2,74	2,61	2,57
Daily gain, kg	0,78	0,74	0,77	0,77
Feed conversion, kg DM/kg gain	3,29	3,67	3,37	3,31

Source: Perez *et al.*(1991)

Slaughterhouse Waste And Dead Animals

The industrialization of animal slaughtering and fish processing for human consumption produces large amounts of wastes that can be used for animal feeding. With regard to the situation in Cuba, processing lines have been designed for these wastes which provide a final product or paste with a high protein content (protein paste).

Systems for the preservation of products for various lengths of time, based on the use of inorganic acids or sugarcane molasses, have been designed. In this connection, the nutritive value of protein paste preserved with inorganic acids has been evaluated by including it as the sole protein source in molasses diets and compared to protein sources of well-known biological value such as soya bean meal, torula yeast and meat meal (Dominguez 1991). Protein digestibility data have revealed it to be similar to that of soya bean meal and superior to that of meat meal and torula yeast, while N retention was higher than in other protein sources studied.

The results with fattening pigs fed protein paste preserved with sugarcane molasses were satisfactory when protein paste contributed some 26.5% of dietary protein. However, when the level of protein paste was increased to more than 50% of the protein in the diet, a decrease in average daily gain of pigs was observed (Table 6). Initially, all this implies the possibility of transforming these organic wastes (which are serious pollutants) into protein sources with a high biological value for pigs.

Table 6. Performance of pigs fed protein paste in cooked sweet potatoes diet.

% crude protein from:			
Torula yeast	62,9	40,9	19,1
Protein paste	-	26,5	52,8
Intake, kg DM/day	2,36	2,30	2,33
Daily gain, kg	0,78	0,78	0,70
Feed conversion, kgDM/kg	3,03	2,95	3,33

Source: Dominguez (1991)

Fish Silage

In a Cuban method for the preparation of fish silage, Alvarez (l972) used a solution of sulphuric acid and water (1:1 by volume) at a rate of 60 ml of acid solution per kg of fresh fish waste. The mixture of fish waste and acid solution was stored in closed plastic tanks and stirred for three minutes, three times a day, for a period of five days. The pH lowered to 1.8, and bacterial putrefaction was avoided, thus allowing the silage to be stored for several months. Cervantes (1979) showed that, if ground fish waste was to be used, it could be preserved by using only 30 ml of acid solution per kg.

Table 7 shows the results of using acid fish waste silage preserved with 30 ml/kg of sulphuric acid solution. The fish silage substituted for fish meal in a diet based on processed swill and final molasses for growing-finishing pigs (Cervantes, 1979). Performance was lower when all the fish meal was replaced by silage and it was concluded that the acid fish silage could be used up to 50 percent of the protein supplied in this type of diet.

Table 7. Substitution of fish meal for acid fish silage in diets based on processed waste.

	Substitution of fish meal, %			
	0	25	50	100
Intake, kg DM/day	2,1	2,1	2,1	1,9
Daily gain, kg	0,54	0,55	0,54	0,44
Feed conversion, kg DM/kg	4,10	4,00	4,00	4,40

Source: Cervantes (1979)

In the case of biological fish silage, some results of pig feeding are presented in Table 8. The silage was prepared using a mixture of 10 per cent of molasses and 10 per cent of wheat bran, with 80 per cent of ground inland fish (mixture of common carp, silver carp, bighead carp and Tilapia sp.) placed in a polyethylene bag with a water seal in order to obtain anaerobic conditions. After three months, the pH was 3.9 with no pathogenic microorganisms in the fish silage. Animal performance was better when fish silage replaced 40 per cent of the soya bean meal in a molasses diet.

Table 8. Use of biological silage as protein replace of soya bean meal in molasses diet.

	Level of soya bean meal substitution, %		
	0	20	40
Intake, kg DM/day	2,07	2,31	2,17
Daily gain, kg	0,63	0,67	0,74
Feed conversion, kgDM/kg	3,34	3,46	2,94

Source: Delgado and Dominguez (1996)

Sweet Potatoes

The starchy roots and tubers harvested in many tropical areas are an important energy source in human and animal feeding. Traditionally, sweet potatoes have been cultivated in tropical countries of Latin America and the Caribbean almost exclusively for tuber production to be used as a staple food, while its foliage has always been considered as a residue. The productive potential of certain varieties of sweet potatoes can reach from 24 to 36 t/ha/crop of roots (Morales, 1980) and the foliage production can vary from 4.3 to 6.0 t dry matter/ha (Ruiz *et al.*, 1980).

The chemical composition of sweet potato roots shows a low protein, fat and fibre content, but high nitrogen free extractives, thus indicating their potential value, mainly as an energy source. Vines are higher in fibre and protein and their principal value is as a source of vitamins and protein. On the other hand, the cooking of sweet potatoes is necessary for two reasons, improvement of starch digestibility and neutralization of trypsin inhibitors.

Taking into account that, in Cuba, intensive and specialized pig production uses liquid feeds for fattening pigs, most of the Cuban experience is with cooked sweet potato tubers offered mashed to pigs (18-20% DM).

Table 9. Utilization of differents sources of protein for pigs fed cooked sweet potato.

	Corn soya bean meal	Sweet potatoes soya bean meal	Sweet potatoes torula yeast
Intake, kg DM/day	2,30	2,71	2,36
Daily gain, kg	0,77	0,77	0,78
Feed conversion, kg DM/kg gain	3,01	3,51	3,03

Source: Dominguez (1992)

Table 9 shows the performance of pigs fed on cooked sweet potato diets compared with a maize/soya bean diet (Dominguez, 1992). These results provide evidence that cooked and mashed sweet potato can totally replace maize for fattening pigs if adequate protein supplementation is given.

The results of partially substituting 25 and 50% of soya bean meal by fresh foliage as the protein source in a sweet potato- soya bean diet show that the high level of foliage worsened some performance traits (Table 10).

Table 10. Sweet potato foliage as a source of protein for pigs fed the tuber.

	Level of soya bean meal substitution, %		
	0	25	50
Intake, kg DM/day	2,71	2,46	2,46
Daily gain, kg	0,77	0,69	0,64
Feed conversion, kg DM/kg	3,51	3,55	3,81

Source: Dominguez (1992)

Citrus Silage

The cannery residue produced by the citrus fruit juice industry is traditionally the raw material for the production of dried citrus pulp. This residue consists of the peel, pulp and seeds of oranges after juice extraction. The pulp thus produced contains a fairly large quantity of highly digestible fibre and nitrogen free extractives.

The silage of citrus pulp has advantages over traditional drying methods because less energy is used and there are improvements in the palatability of the product (Dominguez, 1991). On the other hand, citrus pulp silage can replace final molasses with better feed conversion and the same liveweight gain (Table 11).

Table 11.Performance of pigs fed citrus silage as a replacement for final molasses in processed waste diets.

Citrus silage,%	0.0	12.0	25.0	40.0
Final molasses,%	49.3	37.3	24.3	9.3
Intake, kg DM/day	2,8	2,9	2,6	2,5
Daily gain, kg	0,68	0,62	0,59	0,60
Feed conversion, kg DM/kg	4,54	4,64	4,37	4,08

Source: Dominguez and Cervantes (1980)

Recycling of Piggery Wastes

The modern method of raising animals in confinement has resulted in daily production of large quantities of manure which, when aggravated by a high ambient temperature, serves as the breeding place for flies that spread disease.

The biogas process is an improved anaerobic treatment for animal manure and it is possible to obtain from 80 to 89 per cent recovery of the total solids in the waste (Chao *et al.*, 1996). The solid waste resulting from the biogas process can be turned into useful compost by earthworms. This resulting compost possess a good structure and reasonable quantities of plant nutrients (Garcia *et al.*, 1996).

The liquid effluent from the biodigester can be used to fertilize duckweed or other floating macrophytes in ponds. Some results of feeding fresh duckweed to pigs are presented in Table 12. Duckweed can replace 20 percent of soya bean meal in a diet of sugarcane molasses with no adverse effects on pig performance.

Table 12. Performance of pigs fed fresh duckweed (Lemna spp.) in final molasses diets.

	Level of requirement, %		
Soya bean meal	100	80	80
Fresh lemna	-	20	-
Intake, kg DM/day	2,89	2,89	2,80
Daily gain, kg	0,64	0,63	0,56
Feed conversion, kg DM/kg	4,57	4,58	5,98

Dominguez and Molinet (1996)

Bibliography

Alvarez, R.J. 1972. Estudio comparativo del valor nutricional de la proteina del ensilaje de pescado. Rev. Cubana Cienc. Agric. 6:231.

Cervantes, 1979. Ensilaje y harina de pescado en la ceba de cerdos. Informe de Tema. Ministerio de la Agricultura, Ciudad de La Habana 75 p.

Chao, R, M. Leal, J. del Rio y A. Pineda, 1996. Produccion de biogas a partir de residuales porcinos. Memorias Porcicultura 96. 5to. Congreso de la OIP. La Habana.

Del Rio, J., A. Pineda y R. Chao, 1980. Criterio tecnologico en el diseno de nuevas plantas procesadoras de desperdicios alimenticios. Cienc. Tec. Agric. Ganado Porcino 3(2): 35.

Delgado, E. y P.L. Dominguez, 1996. Elaboracion de ensilaje de pescado y evaluacion de su uso en dietas para cerdos en crecimiento. Memorias Porcicultura 96. 5to. Congreso de la OIP, La Habana.

Dominguez, P.L. 1985. Busqueda y optimizacion de fuentes nacionales que posibiliten el incremento del volumen de desperdicios y subproductos alimenticios disponibles. Informe de Tema. Instituto de Investigaciones Porcinas, La Habana, 29 p.

Dominguez, P.L. 1990. Sistema de alimentacion porcina con desperdicios procesados y otros subproductos agroindustriales. En: Taller Regional sobre "Utilizacion de los recursos alimenticios en la produccion porcina en America Latina y el Caribe" FAO. Roma, Instituto de Investigaciones Porcinas, La Habana.

Dominguez, P.L. 1991. Sistemas de alimentacion de cerdos con desperdicios alimenticios procesados y otros subproductos industriales. Serie de Trabajo y Conferencia No. 1, CIPAV, Cali-Colombia, 41 p.

Dominguez, P.L. 1992. Feeding of sweet potato products to monogastric animals. In Proceedings of the FAO expert consultation on roots, tubers, plantains and bananas in animal feeding, Cali,Colombia. Animal Production and Health Paper No 95, pp 217-233. FAO, Rome.

Dominguez, P.L. y A. Cervantes, 1978. Uso de los desperdicios procesados suplementados con miel final, cereales y levadura torula en la ceba de cerdos. Cienc. Tec. Agric. Ganado Porcino 1(4): 39.

Dominguez, P.L., A. Perez y A. Maylin, 1987. Total and prececal digestibility of processed swill. IV Int. Sem. Physiol Digestion in the Pig (Abstr) Warzaw.

Dominguez, P.L., L. Blanco, J. Gonzalez and A. Perez. 1988. The use of typical cuban diets based on swill and cane molasses for growing-finishing pigs. Proceeding of the VI World. Conference on Animal Production Helsinki p. 316 (Abstract)

Dominguez, P.L. y A. Cervantes, 1980. Ensilaje de citricos en la ceba de cerdos. Rasgos de comportamiento y canal. Cienc. Tec. Agric. Ganado Porcino 3(1) 77-95.

Garcia, Mary D., P.L. Dominguez, F. Martinez y M. Covas, 1996. Obtencion de humus y lombrices de tierra (Eisenia foetida) a partir de residuales porcinos y desechos de la industria azucarera. Revista Computadorizada de Produccion Porcina 3:1, 1-7.

Gonzalez, J., C.P. Diaz, P.L. Dominguez, J. Ly y Yolanda Torres, 1984. Evaluacion de los desperdicios procesados como sustituto del pienso comercial para cerdos en ceba. Cienc. Tec. Agric. Ganado Porcino 7(4): 57.

Grande, D, L. Sangines, J. Carmona, F. Perez Gil, B. Suarez y P.L. Dominguez, 1995. Potencial de la produccion porcina con residuos de consumo humano. I. Comportamiento productivo de cerdos para abasto alimentados con residuos organicos del consumo humano a diferentes niveles de sustitucion. Revista Computadorizada de Produccion Porcina 2:3, 73-82.

Mora, L.M., P.L. Dominguez, R. Calderon, J. Quintano, 1992. Nota sobre la utilizacion del bejuco de boniato (Ipomoea batatas) en dietas de cerdos recien destetados. Zootecnia de Cuba 2 (3-4) p. 85-90.

Morales, A. 1980. El clon de boniato CEMSA 74-228. Centro de Mejoramiento de Semillas Agamicas (CEMSA) Villa Clara, Cuba 26 pp.

Perez, A., J. Gonzalez, P.L. Dominguez y V. Figueroa, 1991. Efecto de la suplementacion en cerdos alimentados con miel B y desperdicios procesados. Livestock Research for Rural Development 3(3): 46.

Pineda, A., R. Chao, J. del Rio, J. Alfonso y M. Leal, 1986. Tecnologia para el procesamiento de cadaveres de animales y residuos de matadero. Jornada Interna. Instituto de Investigaciones Porcinas, La Habana, p. 5.

Ruiz, M.E., Pezo, D. and Martinez, L. 1980. El uso de camote (Ipomoea batatas (L) Lam) en la alimentacion animal. I. Aspectos agronomicos. Produccion Animal Tropical 5:157-165.