Processus d'innovation pour l'introduction de micro-organismes efficaces dans l'élevage porcin : analyse technico-économique à l'échelle du secteur privé à Cuba

Innovation process for the introduction of efficient microorganisms in pig farming: Technical-economic analysis at the scale of private sector in Cuba

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RÉSUMÉ. À Cuba, afin de garantir la production porcine dans des systèmes intensifs à grande échelle, des alternatives efficaces et sûres pour les consommateurs et l'environnement sont recherchées. Les prébiotiques et les probiotiques comptent parmi les options les plus répandues et les plus inoffensives. L'objectif de cette recherche est de contribuer, par un processus d'innovation technologique, à l'introduction d'une technologie de micro-organismes efficaces (ME) en élevage porcin au sein de la PME Carnes D'Tres. Différents ME produits dans et hors de la province de Ciego de Ávila ont été évalués d'un point de vue technique, économique et logistique, ainsi que leur effet comme additif alimentaire dans l'alimentation des porcs d'engraissement. Selon l'étude de faisabilité technique, économique et logistique, il est moins coûteux, plus pratique et plus sûr d'acheter les ME RH-Vigía en phase solide et de fabriquer les phases liquide et stabilisée sur place que d'acheter tout autre ME en phase liquide stabilisée. L'ajout de ME à l'alimentation des porcs a également eu un effet positif, notamment durant les premières semaines d'engraissement, réduisant la morbidité, augmentant le poids vif du lot et réduisant les coûts alimentaires par unité de gain de poids, par rapport aux animaux dont l'alimentation ne comprenait pas le bioproduit.

ABSTRACT. In Cuba, the aim is to guarantee pork production in large-scale intensive systems by seeking efficient and safe alternatives for consumers and the environment. Prebiotics and probiotics are among the most widely used and harmless options. This research aimed to contribute to the introduction of efficient microorganism (EM) technology in pig farming at the Carnes D'Tres SME through a process of technological innovation. EM produced both inside and outside the province of Ciego de Ávila were evaluated from technical, economic, and logistical perspectives, and the effectiveness of EM as a feed additive in the diet of fattening pigs was assessed. According to the technical, economic and logistical feasibility study, it is cheaper, more practical and safer to purchase RH-Vigía EM in its solid phase and manufacture the liquid and stabilised phases on the farm than to purchase any of the other EM in their stabilised liquid phase. Adding EM to pig feed also had a positive effect, particularly during the initial weeks of fattening. It reduced morbidity, increased the live weight of the group and lowered feed costs per unit of weight gained compared to animals whose diet did not include the bioproduct.

MOTS-CLÉS. Système de production porcine, micro-organismes polyvalents, élevage durable, comportement animal.

KEYWORDS. Pig production system, multipurpose microorganisms, sustainable pig farming, animal response.

1. Introduction

Pigs are a key source of meat globally, accounting for 34% of meat consumption worldwide [SAN 24]. Due to their prolific nature and ability to adapt to various management conditions and feeding methods, pigs are becoming an increasingly important source of animal protein for human consumption [DEL 03], alongside poultry [CUB 23].

In Cuba, the Ministry of Agriculture has paid special attention to the development of pig farming, both on a small and medium scale and in intensive production systems [PIR 07]. As a result, different production systems have been developed across the country. These systems differ in terms of the quantity and type of inputs required, including feed and medicines available to producers [PER 13a].

The principles governing pig meat production in Cuba are based on diversifying systems to increase efficiency and reduce imports. Pig farming is therefore a very important segment of the non-specialised peasant and cooperative sector. Its small- and medium-scale farms are based on agreements with the local pig company and contribute over 50% of this species' annual meat production [FAR 08].

Currently, some of the micro, small, and medium-sized enterprises (MSMEs) that have been approved in Cuba [MIN 24] are involved in intensive pig farming, including Sociedad Mercantil Carnes D'Tres S.R.L. in Ciego de Ávila municipality. This private enterprise's corporate purpose includes producing purebred pigs and processing their meat, as well as improving the production and reproduction system by introducing new technologies, breeding methods and feeding methods [UNI 24], supported by research and innovation. The company's goal is to improve the production system based on animal welfare [POR 18][SAG 19] and a circular agriculture model for waste treatment [ORT 21].

In pig production, feeding represents 70–75% of total costs depending on the system, making it the most expensive farming factor [MUR 21]. In Cuba, numerous studies have been conducted to identify domestic alternatives that would reduce grain imports. These studies have taken into account factors such as competition between pigs and humans for food, rising prices on the international market and the need to develop a sustainable food base that can support significant increases in meat production in the medium term [MED 07].

Taking into account the country's current economic situation, in order to guarantee pork production in large-scale intensive systems, alternatives that are efficient and safe for consumers and for the environment continue to be sought. Prebiotics and probiotics are one of the most widely used and harmless proposals for the purposes of (i) increasing the feed efficiency of food and (ii) improving animal health by reducing gastrointestinal diseases that also have an economic impact on the morbidity and mortality of piglets

Given the country's current economic situation, alternatives that are efficient, safe for consumers and environmentally friendly continue to be sought to guarantee pork production in large-scale intensive systems. Prebiotics and probiotics are among the most widely used and harmless proposals [BRO 11] for increasing feed efficiency and improving animal health by reducing gastrointestinal diseases, which have an economic impact on piglet morbidity and mortality [GUI 98][FLO 20][VAL 20][SOT 23].

Probiotics are a broad group of microorganisms that include, among others, cultures of bacteria, fungi, and even spore-forming and non-spore-forming microorganisms [SOA 22], which have a positive effect on animal health and production [AHU 17].

Technology based on the use of probiotic microorganisms is known as Effective Microorganisms [SUA 24], which, according to [MES 20], can be carried out in two ways: (i) mixed microbial culture of selected microorganism species, obtained from strain collection and subjected to a controlled fermentation process; and (ii) a biopreparation obtained through a traditional production process based on the anaerobic fermentation of forest litter. This process aims to use the taxonomic and functional diversity of microbial communities native to forested areas. The biopreparation is then incorporated into agricultural production units, also known as Mountain Microorganisms (MM), multipurpose autochthonous microorganisms (MAM) or beneficial autochthonous microorganisms (BAM).

Recent studies have evaluated the effect of EM technology on animal husbandry [CRU 23][MAR 23][ALC 25]. In fattening pigs, [MON 17] demonstrated that autochthonous microorganisms in unconventional diets increase average daily gain and live weight in animals of all categories, a decreased the fattening period and increased economic income for the company. Adding specific microorganisms to the drinking water of fattening pigs also favourably affects nutrient absorption and conversion efficiency in the intestine, resulting in improved production rates and reduced diarrhea incidence [VER 24].

In line with this, the main objective of this study is to contribute to the introduction of EM technology in pig farming at Carnes D'Tres SME through a process of technological innovation. To this end, the implementation of EM technology in the company's pig production was evaluated from technical and economic perspectives, as was the impact of EM as a feed supplement for fattening pigs.

2. Materials and methods

The research was carried out in the first half of 2025 at the “Dos Hermanos” farm, which is owned by the company Carnes D'Tres S.R.L. and is located on the Santo Tomás–Aeropuerto road, 7.5 km from Ceballos in the province of Ciego de Ávila. The company’s activities include improving the reproduction, growth and performance of the pig herd in a closed-cycle production system.

The entity has an intensive breeding system for purebred pigs which, at the time of the evaluation, included a production flow with 270 breeding sows, six boars and their offspring (Table 1 shows various indicators of the herd). Facilities for reproduction are used, and artificial insemination technology is employed. This process is supported by a laboratory for preparing and characterising semen, as well as facilities for maternity, pre-weaning and fattening of the animals.

Indicator	Average value
Inseminations performed per week	14.8
Technical reproductive efficiency (%)	71.2
Economic reproductive efficiency (%)	57.3
Piglets born per week	111
Piglets per litter	9.6
Birth weight (kg)	1.5
Piglets weaned per week	73
Piglets weaned per litter	8.9
Weaning weight (kg)	7.4
Number of pigs in the pre-fattening category during the week	443
Pigs converted to the fattening category during the week	74
Fattening conversion weight (kg)	16.3
Number of pigs in the fattening category in the week	1,082
Slaughter weight (kg)	93.7
Slaughter age (days)	180
Deaths in breeding (%)	2.3
Deaths in pre-fattening (%)	1.1
Deaths in fattening (%)	0.4

Table 1. *Indicators of the pig herd at the Carnes D’Tres SME during the experimental period.*

The pig farming system uses on-site produced feed, consisting of a mixture of feed (pre-starter, starter, grower and finisher) and imported raw materials (soya, maize, bran, wheat and additives), supplemented with domestic products (ground cassava, cane molasses and industrial waste from guava, mango and potato). The vast majority of these products are produced in the company's own agricultural environment.

2.1. *Technical, economic and logistical assessment for the introduction of efficient microorganism technology in pig production at the Carnes D'Tres SME*

A technical, economic and logistical feasibility study was carried out to achieve an efficient microorganism bioproduct for the entity itself. The following elements were taken into account: (i) technologies for manufacturing EM; (ii) EM manufactured in Cuba; (iii) the selling price of different types of microorganisms; (iv) the costs of producing EM with local equipment and products; (v) transportation costs; and (vi) the farm pig herd categories and recommendations for using the bioproduct.

Information on efficient microorganisms and their use in Cuba, especially for pig production, was gathered through various means, such as interviews, a review of literature, and electronic documents. Experts on the subject were interviewed and prices were calculated for different microorganisms manufactured in Cuba based on the raw materials and methods used in their production and transportation.

2.2. *Evaluation of the use of efficient microorganisms as additives in the diet of fattening pigs*

The experiment lasted 49 days. Two experimental treatments were evaluated (1. Feed with EM; 2. Feed without EM) using 40 purebred animals (20 per treatment) of the Yorkshire* Landrace* Yorkshire terminal crossbreeds, aged 90 days and with an average weight of 25 kg, in week three of the fattening category [IIP 15], housed in collective pens of 25 m² and fed a diet (Table 2) that met the animals' requirements at that stage (17% crude protein and 13 MJ metabolizable energy).

Feed	% fresh matter basis
Imported single feed (14% protein)	60
Bran o	16
Sweet biscuit (residue)	20
Mast Export additive	4

Table 2. *Diet fed to pigs during the experimental period.*

Note: The cost per kg of feed, based on the price of raw materials, was 99.23 CUP

The only difference between the two treatments was that EM was added to the experimental animals' diet at a rate of 1 litre of product per 10 kg of feed (Montejo, 2024, personal communication). The mixture was placed in 35 kg bags and left to stand for a minimum of four and a maximum of seven days before use [GAR 08].

All pigs were fed from 70 kg hoppers, which were always kept filled so that the animals had access to the mixture 24 hours a day. To record the group's consumption, marks were made on the hoppers to indicate the amount of feed supplied and rejected after 24 hours.

Veterinary services were provided three times a day (8 a.m., 11 a.m. and 3 p.m.) to identify sick animals and possible causes of illness. Sick pigs were treated in their pens. The pens were cleaned daily using a mechanical pressure washing method, and the animals were bathed at midday depending on the ambient temperature and humidity.

The following indicators were recorded: (i) average live weight (weighing at weeks 3, 6 and 10 of fattening period), (ii) feed intake (once a week), and (iii) feeding behaviour (once a week)

The following indicators were calculated: (i) weight gain, (ii) average daily gain, (iii) mortality rate, (iv) percentage of morbidity, and (v) feed cost per gram of daily weight gain

At the end of the experiment, the animals were kept in groups and received a liquid diet of feed plus sugarcane molasses and water twice a day. This covered their nutritional requirements until they reached 14 weeks of age on average. During this post-experimental stage, the animals in the experimental group were given a daily dose of 50 ml of efficient microorganisms [MON 17], which was poured into the tank where the liquid feed was prepared. The control group did not receive the microorganisms. The animals in both groups were weighed at the end of week 14 of the fattening stage.

2.3. Statistical data processing

A T-test for independent samples was performed using the SPSS ver. 22 statistical program to analyse the animals' average weight. For the other indicators, arithmetic means and statistical percentages were calculated.

3. Results and discussion

3.1. Technical, economic and logistical assessment for the introduction of efficient microorganism technology into pig production at the Carnes D'Tres SME

3.1.1. Availability and sale prices of EM present in Cuba

Table 3 provides information on several EM manufactured in Cuba, their market availability and sale price.

EM	Origin	Form marketed	**Sale Price (CUP)**	**Characterized**
ME IH- Plus	EEPF Indio Hatuey, Matanzas	Stabilised liquid phase	8 CUP/litre	Yes[1]
ME MEAG	Guantánamo	Stabilised liquid phase	Not marketed	Yes
ME- 50	Labiofam, Ciego de Ávila	Stabilised liquid phase	9.87 CUP/litre	Yes
ME RH- Vigía	Farm "Rincón Los Hondones", Ciego de Ávila	Solid phase	200 CUP/kg	Yes
MA (Autochthonous Microorganism) Ceballos	Agro-industrial Enterprise of Ceballos, Ciego de Ávila	Stabilised liquid phase	5 CUP/litre	No

Table 3. *Efficient microorganisms manufactured in Cuba, market availability and sale price.*

[1] *Joint microbiology laboratory of the IRD-ISRA-CIRAD-UCAD, Senegal (France-Senegal cooperation programme)*

These efficient microorganisms (EM) are produced in different regions of the country using local resources. They can be used in pig feed as probiotics with multiple uses, thanks to their microbial composition. This generates beneficial substances, such as antioxidants, amino acids, vitamins, enzymes and organic acids, which have countless basic functions [OJE 16]. EM are composed of live microorganisms, lactic acid bacteria (*Lactobacillus plantarum*, *Lactobacillus casei*), yeasts (*Saccharomyces cerevisiae*) and phototrophic bacteria (*Rhodopseudomonas palustris*) [QUI 21].

3.1.2. Annual requirement and expenditure of EM for the company and its entire herd

Pig farming at Carnes D'Tres SME is carried out intensively, in a closed cycle, with all categories of pigs present in the herd. Table 4 shows the amount of EM to be supplied by category, according to the product's usage recommendations. It also shows the amount of EM needed to supply the farm's herd in time periods.

Category	Daily amount of EM/animal (ml)	Number of animals	Daily amount of EM (l)	Monthly EM quantity (l)	Annual EM quantity (l)
Breeding animals	100	283	28.30	849.0	10,330
Stud animals	100	6	0.60	18.0	219
Suckling piglets	30	47	1.41	42.3	515
Piglets	60	28	1.68	50.4	613
Pre fattening	30	327	9.81	294.3	3,580
Fattening	60	1,117	67.02	2,010.6	24,462
Total		**1,808**	**108.82**	**3,264.6**	**39,719**

Table 4. *Number of animals at Carnes D'Tres and amount of EM needed to supply the herd per time period.*

Table 5 shows the annual cost of purchasing the different stabilised liquid EM necessary to supply the pig herd on the farm for one year. Transport costs must be added to the above costs. Purchasing EM in the stabilised liquid phase incurs transport and packaging costs, which depend on the distance and quantity to be loaded. It is also recommended that EM is not used more than three months after manufacture; therefore, the product should be purchased and used within this period.

Microorganisms	**Annual cost (CUP)**
ME IH- Plus	317,754
ME- 50	397,193
MA Ceballos	198,596

Table 5. *Cost of purchasing different EM (stabilised liquid phase) to supply the Carnes D'Tres pig herd for one year.*

Unlike the previous ones, the manufacturer of the efficient microorganism RH- Vigía is able to establish a production chain with the SME and market the product in its solid phase. According to the manufacturing technology, it is estimated that 20 liters of liquid phase and 200 liters of stabilised liquid phase are obtained for each kg of solid phase. Therefore, to cover the annual needs of the pig herd at Carnes D'Tres, it would be necessary to purchase 200 kg of the solid phase of RH Vigía, at a cost of 40,000 CUP.

Producing liquid and stabilised EM from the solid phase also incurs costs for the cane molasses and whey used to produce both products. Table 6 shows the quantities of these ingredients needed to produce a 200-liter tank of liquid or stabilised EM. According to these values, 1,043 liters of whey and 2,085 litres of molasses would be needed annually to produce the amount of EM that the pig herd would consume in a year.

ME	200-litre tank
Whey	5 litres
Cane molasses	10 litres
Liquid phase ME	10 litres
Water	175 litres

Table 6. *Ingredients and quantities used in the manufacture of liquid and stabilised EM.*

Whey, a by-product of cheese production, can be sold at 30 CUP per litre, while the Sugar Agroindustry Business Group (AZCUBA) has set the sale price of cane molasses at 1,500 CUP per ton. Based on these prices, a total of 34,407 CUP would be needed to purchase both products. Table 7 summarises the costs of using RH-Vigía, taking into account transportation to the farm once a year, since the solid phase of the EM can be stored for a year without deteriorating in quality.

Item	**Cost (CUP)**
Purchase of solid phase	40,000
Purchase of whey	31,279
Purchase of cane molasse	3,128
Transportation	24,500
Total	**98,907**

Table 7. *Cost of production and transport of the RH-Vigía efficient microorganisms, in solid phase, to Carnes D'Tres SME for one year of use*.

When comparing the prices of these microorganisms marketed in the stabilized liquid phase with the ones of RH-Vigía in its solid phase (see Tables 5 and 7), the latter is clearly less expensive. In addition, Carnes D'Tres SME has the necessary conditions and equipment to produce the liquid and stabilised phase of the EM, including: 200-liter plastic tanks, 20-liter drums, a tank for storing molasse, and refrigerators for preserving whey, which can be produced on the farm or nearby.

Based on the above results and assuming that the different efficient microorganisms analysed in this study could have the same efficacy, it was decided to introduce and evaluate an efficient microorganism manufactured from the solid phase of RH-Vigía EM in pig production. This has a production cost of 1.98 CUP/liter. The technology described by [EAM 18] was followed to prepare the liquid and stabilised phases of the this bioproduct, using the ingredients and quantities shown in Table 6.

3.2. Evaluation of the use of the efficient microorganisms as an additive in the diet of fattening pigs

Statistical differences were observed between the two treatments in terms of animal weight in week 6 of the fattening stage, favouring the treatment with microorganisms. However, these statistical differences were not evident in week 10 of the fattening stage (although we could consider that there is a tendency), despite the fact that the increases continued to be higher in the experimental treatment (see Table 8).

Week	**T** Treatments	**Average weight (kg)**	Standard deviation	**P**
6	Feed with EM	33.18	2.76	0.028
	Feed without EM	31.10	2.86	
10	Feed with EM	47.45	7.57	0.501
	Feed without EM	45.72	8.13	

Table 8. *Average weight reached by pigs in weeks 6 and 10 of fattening.*

[MON 17] found that adding EM to unconventional pig fattening diets significantly increased the live weight of the animals by 20 kg compared to those that did not receive this additive. However, in the present experiment, the animals did not show such differences, possibly due to the use of conventional feed that meets pigs' nutritional requirements.

Between weeks three and six of the fattening stage, four animals of the control group suffered from pneumonia, whereas only one animal in the microorganism-fed treatment group became ill (see Table 9). One animal from each group was transferred to the infirmary and ultimately died, while the remaining sick animals in the control group were treated in the same pen and recovered.

Treatment	Sick animals	Animals recovered in the pen	**%** deaths	**%** morbidity
Feed with EM	1	-	5	5
Feed without EM	4	3	5	20

Table 9. *Morbidity of experimental animals.*

Between weeks 7 and 10, the animals in both groups were in excellent health. The sick animals in the control group, had fully recovered and appeared to undergo compensatory growth. This reduced the differences in average weights, average weight gains, and average daily gains compared to the weights recorded in week 6 (Table 10).

However, by the end of the experiment, the experimental treatment group had a lower percentage of animals weighing less than 40 kg (see Table 11). In order to achieve an average slaughter weight of more than 95 kg at 14 weeks of fattening, these smaller animals would need to be regrouped.

Week	Treatment	Live weight (kg)	Weight gain (kg)	ADG (g/d)
6	Feed with EM	33.2	7.8	458
	Feed without EM	31.1	6.4	378
10	Feed with EM	47.5	14.3	680
	Feed without EM	45.7	14.6	696

Table 10. *Live weight, weight gain and average daily gain of animals at six and ten weeks of fattening*.

Treatment	Less than 40 kg	Between 40 and 49 kg	Between 50 kg and 60 kg
Feed with EM	15.8	31.6	52.6
Feed without EM	31.6	26.3	42.1
Difference	-15.8	5.3	10.5

Table 11. *Percentage of animals corresponding to different weight ranges at the end of the experiment*.

The results of the weighing in week six show that including EM in the pigs' feed improves live weight, weight gain and ADG indicators compared to the control treatment. This may be due to the microbial consortium of EM containing lactic acid bacteria and yeasts that improve digestive system function in animals that consume them, enabling better nutrient assimilation from their diet [ESC 16]. This could also be due to improvements in intestinal flora and the immune system, as well as the suppression of possible pathogens in the digestive tract [VER 24].

During fermentation, microorganisms grow and produce organic acids (e.g., lactic and acetic acids), vitamins, minerals, enzymes and amino acids, which contribute to the incorporation of enzymatic cofactors that improve digestive system function and nutrient assimilation in animals [VAL 22].

Similarly, research by [VER 24] reaffirms that using these microorganisms in the drinking water of fattening pigs has a favourable effect on nutrient absorption and conversion efficiency in the intestine. This reflects an improvement in production indices and a reduction in diarrhoea incidence when using the microbial consortium (*L. acidophilus* and *B. subtilis*).

Figure 1 highlights feed consumption of pigs during the different experimental weeks. In general, animals increased their feed intake over time, reaching 2.7 and 2.8 kg per animal, per day, in week 9 in the experimental and control treatments, respectively.

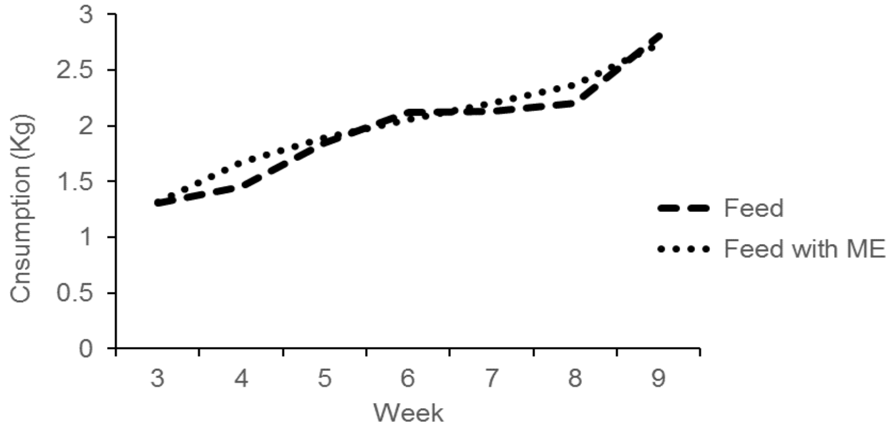

Figure 1. *Feed consumption by pigs in the different treatments during the experimental weeks*.

Adding EM to the pigs' diet did not affect their feed consumption during the experimental phase, but it did affect weight gain and therefore feed conversion (4.5–4.6 kg of feed per kg of weight gain in EM-treated and control pigs, respectively). This explains why the control pigs incurred slightly higher feed costs to gain one gram of weight than pigs that consumed feed treated with efficient microorganisms (see Table 12).

Treatment	Daily cost of feed + EM consumption	Weight gain (g/day)	Cost (CUC) per gram of weight gain
Feed with EM	202.32	595	0.36
Feed without EM	196.36	537	0.37

Table 12. *Feed costs (CUP) per gram of gain incurred by pigs in the different treatments.*

For Carnes D'Tres SME, which fatten an average of 1,080 pigs (Table 1) and can slaughter around 4,000 pigs in 3.7 cycles per year, the 0.01 CUP difference per gram of gain from adding EM to the diet would save 640 CUP per pig, resulting in approximately 2,570,000 CUP saved on feed per year.

When evaluating different concentrations of probiotics (Rhodopseudomonas spp., Lactobacillus spp. and Saccharomyces spp.) in pig feed, [QUE 21] recorded a lower feed conversion ratio (4.05–5.26 kg of feed per kg of weight) compared to the control treatment (7.46 kg of feed per kg of weight).

Other studies conducted on this species, specifically in the breeding [OJI 21][VAL 22] and pre-weaning [VAL 19][VAL 20] categories, show an improvement in animals' feed conversion when they are supplied with EM. This is attributed to the multifunctional action of microbial additives in the gastrointestinal tract of animals, which stabilises and protects the gastrointestinal ecosystem, improves digestion and nutrient absorption processes, and modulates the immune system [SOS 18].

Research by [VAL 22] indicates that providing a biopreparation with a low EM load yields better results in terms of bio-productive indicators compared to the control treatment. [QUI 21] indicate that supplementing with 10% of ME-Agroambiental increases ADG and, consequently, live weight at the end of the pre-weaning stage, which results into greater gains in the production system. However, [ORD 17] indicate that the addition of EM in protein-balanced diets has no effect on feed consumption or conversion.

The feeding behaviour of pigs was very similar in both groups (Figure 2), with the animals spending most of their time resting lying down and resting. The number of pigs consuming feed at any given time not exceeding five, indicating little competition for feed and reduced stress in this regard, due to *ad libitum* feeding from a hopper.

Figure 2. *Behaviour of pigs in the different treatments.*

In the post-experimental stage, when the animals in both groups completed week 14 of fattening, there were no significant differences between the treatments (Table 13). However, the two-kilogram weight difference calculated in week 10 of fattening (Table 8) remained, as weight gains in this last stage were similar (894 and 887 g/day for EM and control, respectively). It should be noted that neither group reached the slaughter weight indicated in the Technical Procedures Manual for Pig Farming [IIP 08] in week 14. This is due to the herd's low feed conversion ratio (16.3 kg, as indicated in Table 1).

Treatment	**Mean**	Standard deviation	**P**
Feed with EM	76.05	13.47	0.678
Feed without EM	74.12	14.21	

Table 13. *Weight (kg) reached by pigs at the end of the fattening stage.*

3.3. Prospects for the production and use of efficient microorganisms in pig production in Cuba

The results presented in this study indicate that, for the company under study, it is cheaper, more practical and safer to purchase ME RH-Vigía in its solid phase and produce the liquid and stabilised phases on the farm than to purchase any of the other MEs produced in or outside the territory in their stabilised liquid phase. There is also evidence of the positive effects of adding EM to pig feed, particularly during the initial weeks of fattening. This reduces morbidity, increases live weight and lowers feed costs per unit of weight gained compared to animals whose diet does not include this bioproduct.

In Cuba, where pig production is limited by several factors, mainly due to its dependence on feed imports because of the lack of a solid, sustainable feed base for these animals [DIA 22], the introduction of EM technology can improve feeding for this species when both conventional and alternative feeds are used.

Animals achieve higher slaughter weights at a lower cost through the consumption of EM due to improved feed digestibility and immune system function, as demonstrated in various publications [MON 17][VAL 19][LUN 16][ALC 25].

Countless studies in the country [PIR 07][IIP 12][IIP 13][MAR 23] and sufficient experience among producers in feeding herds with conventional and alternative feeds [PER 13_a][PER 13_b] exist, and can be enhanced by EM technology. In the past decade, the pig farming system was based on intensive, state-run breeding of reproductive pig herds using imported conventional feed (corn, soybeans, bran, additives, etc.) and on fattening of offspring through agreements with private producers, especially small farmers. These farmers purchased industrial feed covering between 60 and 70% of the pigs' requirements and supplemented this with alternative feed (cassava, sunflower, sorghum, agro-industrial and harvest residues, etc.) produced on their own farms.

In the new Cuban economic order, where SMEs are incorporated into food production and other sectors of the economy [GAR 23], private companies such as Carnes D'Tres, which possess breeding technologies (including artificial insemination and carcass processing), as well as the capacity to import raw materials for feed, could be tasked with developing agreements with medium and small producers. These companies possess breeding technologies, including artificial insemination and carcass processing, as well as the capacity to import raw materials for feed. They could provide purebred animals to producers at weaning time, as well as basic feed, while ensuring the proper marketing and slaughter of fattened animals.

Conversely, small and medium-sized producers could produce the liquid and stabilised phases of efficient microorganisms on their own farms, benefiting from agreements with pig farming SMEs. These producers should therefore be supported by companies or other institutions in acquiring the solid mother culture of EM and the tanks needed to manufacture the bioproduct, since most of the raw materials required to produce EM, except for cane molasses, are usually available on the farms themselves or in the surrounding area.

Another factor that could limit the introduction of EM technology in the pig sector is the acquisition of cane molasses by producers, due to the reduction in industrial cane sugar production in the country. However, several authors suggest replacing the molasses in the production of EM with cane juice [BAR 17][ROD 18], a product that can be purchased in markets or produced on farms based on planting and establishing the grass (*Saccharum officinarum L.*) in a small plot.

In summary, there are real prospects for the large-scale introduction of EM in pig feed in Cuba, which would contribute to increasing economic efficiency and recovering the pig industry in the country to some extent.

4. Bibliography

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