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Oral Administration of a Biopreparation Containing *Lactobacillus plantarum* CAM-6 Improves Productive Performance and Carcass Yields of Growing Pigs

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ABSTRACT

Background: *Lactobacilli* spp. are the most commonly used probiotic microorganisms in the swine industry to improve the productive performance and meat quality of fattening pigs. **Aim:** To determine the effect of an oral biopreparation containing *Lactobacillus plantarum* CAM-6, on the productive performance and features of growing pig carcass.

Methods: At random, 36 pigs [(Landrace × Pietrain) × Duroc] were studied for 90 days (49 at 139 days of age), in three treatments with 12 repetitions each. The treatments consisted of a basal diet BD (T0); BD+Antibiotic (T1), and BD+5 ml of a probiotic biopreparation containing *Lactobacillus plantarum* CAM-6 (T2). The productive performance and carcass traits (hot and cold) of pigs were determined.

Results: Compared to T0, T1 and T2 improved (P<0.05) live weight, mean daily gain, and food conversion, though no significant changes were observed (P>0.05) in terms of food consumption and viability. Besides, T3 (P<0.05) increased carcass yields (cold), loin (hot and cold), front legs (cold), and ribs (cold), compared to T0 and T1. On the other hand, T1 reduced carcass yield (hot and cold), loin (hot), ribs (hot), and leg (cold).

Conclusions: The administration of an oral biopreparation containing *L. plantarum* CAM-6 promoted the productive performance of fattening pigs, on a diet without additives, and a growth-stimulating antibiotic. Moreover, T2 increased yields of edible pig portions (hot and cold).

Key words: productive performance, pig, probiotics, additives (Source: *Agrovoc*)

INTRODUCTION

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Although the European Union submitted scientific evidence, and restricted the use of growth promoting antibiotics (GPA), many countries still use them widely in the diet of pigs. They are aimed to modulate the intestinal microflora and anti-inflammatory activity, which reduces the diarrheal syndrome, and stimulates the growth of these animals (Wang *et al.,* 2011). However, it has been confirmed that the use of sub-therapeutical levels of these antibiotics may increase the number of resistant strains, and transfer cross-resistance to other microorganisms (Fang *et al*., 2009).

Today, the utilization of probiotics in the water or food, has been considered as one of the main natural alternatives to GPA in swine production (Hampikyan *et al.,* 2009). Genuses *Lactobacillus* spp., *Bifidobacterium*, and *Streptococcus* spp., include species that make up a heterogeneous group of microorganisms, which are characterized by the production of lactic acid from carbohydrate fermentation (Yang *et al.,* 2015). Probiotics, especially lactic acid bacteria (LAB), have been frequently used in several areas, such as the production of foods (Molin, 2001; Schrezenmeir, and De Vrese, 2001). Moreover, several probiotic biopreparations have been developed to enable growth and viability of lactic acid bacteria, and for use in the food and drinking water of livestock productions, aimed to enhance animal productivity and health (Nazef *et al*., 2008; Giraldo *et al.,* 2015; Barba-Vidal *et al.,* 2019).

Specifically, *Lactobacillus plantarum* is a bacterial species associated to plants, though it has also been found in the gastrointestinal tract (GIT) of humans, mice, and pigs. This bacterium can ferment a broad spectrum of plant carbohydrates; it is tolerant to bile salts and a low pH. Besides, it has an antagonist potential against intestinal pathogens (Suo *et al.,* 2012). Research done by Cai *et al*. (2014) concluded that *L. plantarum* increases live weight, intestinal health, nutrient digestibility, antioxidant activity, and immunity, and it also reduces the incidence of diarrhea in pigs.

Each animal species has a particular intestinal microbiota, though there are different types of microorganisms, which are beneficial to animal production. The utilization of *Lactobacillus plantarum* CAM-6 in the diet could cause a competitive exclusion in the GIT, and promote growth, increasing yields of edible portions. The aim of this paper was to determine the effect of an oral biopreparation containing *Lactobacillus plantarum* CAM-6, on the productive performance and features of fattening pig carcass.

MATERIALS AND METHODS

Location of the experimental area

This study was done in experimental swine areas of the University of Cordoba, Berastegui venue, Cordoba, Colombia, on coordinates 7º 23’ 9° 26’ north latitude, and 74º 52’ 76º 32’ west longitude, Greenwich meridian, 30 m above sea level. The average annual temperature is 28 °C, relative humidity is 82%, and the mean annual precipitation is 1 400 mm. The location is considered a rain forest, with two well-defined seasons: rainy and dry (IDEAM, 2014).

Probiotic biopreparation, animals, and treatments

The biopreparation was made from the peel of pineapple, banana, and papaya (40%), and water (60%). It was inoculated in the *Lactobacillus plantarum* CAM-6 strain (access number 4MK523644.1), and isolated from the Zungo-creole hairless pig, at the biotechnology laboratory of the University of Cordoba.

A total of 36 castrated pigs [(Landrace × Pietrain) × Duroc] were used. The animals were 49 days old, and their initial live weight was 10-12 kg. The design and treatment groups described by Betancur, Rodríguez, and Martínez (2020) were used.

Experimental conditions During the experiment, the pigs were lodged in individual pens of 4 x 2 m, on concrete flooring. Each pen was provided with a linear, canoe-type feeder made of PVC drainpipe, placed alongside the pen, with a metallic trough with nipples. The water and food were supplied *ad libitum.*

Productive indicators: During the experimental phase, the initial and final live weights were measured, between day 49 and 139 of age, at the same time, before feeding the animals. An industrial scale was used (Mettler Toledo, US A. ± 1 g precision). The average food consumption was determined daily by the supply-rejection method, mean daily gain was determined from the initial and final live weights, and the number of experimental days, and food conversion were calculated as the amount of ingested food, with 1 kg gain of live weight.

Carcass yield: To determine the edible portions of the pigs at 139 days, four animals were chosen. The animals fasted for 12 h and received water *ad libitum.* The procedure described by Betancur, Rodríguez, and Martínez (2020) was used in the experiment. The loin, front and hind legs, and ribs were dissected from the carcass. The relative weight of the edible portions from the hot and cold carcass was measured (24 hours later), based on the live weight at sacrifice.

All the experiments were performed following the Colombian guidelines of animal welfare, and the experimental protocol endorsed by the Ethics Committee of Research at the University of Cordoba (Resolution 001, 26 January, 2016).

Statistical analysis

The data were processed by simple analysis of variance (ANOVA). Normality was verified using the Kolmogorov - Smirnov test, and variance uniformity was measured with the test of Bartlett. The differences between the means were determined by the multiple range test of Duncan (1955), with statistical software SPSS, version 21 (IBM, Armonk, NY, USA). The probability values ($p<0.05$) were used to indicate statistically significant differences.

RESULTS AND DISCUSSION

The results show that the group using the probiotic (T2) had a 6.7% live weight increase, whereas the group on antibiotics (T1) was 5.6%. Similarly, the mean daily gain had 10.35% and 8.8% increases, respectively, compared to the pigs in the control group (T0). Food conversion was better ($p<0.05$) in T2 and T1, than in T0.

The oral management of the probiotic biopreparation (T2) and the antibiotic (T1) improved ($p<0.05$) the final live weight (FLW), mean daily gain (MDG), and food conversion (FCC), in relation to the control treatment; however, food consumption (FC) and viability were not modified (unpublished data) (Table 1).

Table 1. Effect of a biopreparation of *Lactobacillus plantarum* CAM-6 on the productive performance of growing pigs (49-139 days)

	Experimental treatments				
Indicators	**T0**	**T1**	**T2**	**SE±**	**P value**
ILW (kg)	10.87	10.12	10.08	0.851	0.951
FLW (kg)	53.25^{b}	56.25^{a}	56.85^{a}	1.103	0.036
MDG (g.d^{-1})	470.88^{b}	512.55^{a}	519.66^{a}	1.516	0.046
FC (g.d^{-1})	1856	1880	1866	8.247	0.081
FCC	3.94^{a}	3.66^{b}	3.59^{b}	1.007	0.008

^{a,b} Means with unequal letters on the same row differ for $P<0.05$ (Duncan, 1955).

T0 negative control; T1 positive control (antibiotic); T2 biopreparation containing 10^9 CFU mL^{-1} of *Lactobacillus plantarum* CAM-6. ILW: initial live weight; FLW: final live weight; MDG: mean daily gain; FC: food consumption; FCC: food conversion.

The probiotic administration of *L. plantarum to* pigs has the potential to modulate intestinal microbiota. This way, beneficial intestinal bacterial populations are established, which improve the productive performance of growing pigs (Fan *et al*., 2015; Wang *et al*., 2018). Lactobacilli are known to metabolize carbohydrates, such as oligosaccharides and starch (Guevarra *et al*., 2018), which are fermented in the small intestine, and generate volatile fatty acids that improve the digestive capacity of animals. This is reflected in the faster growth speed of pigs where biopreparations are applied.

This experiment demonstrated that the administration of *L. plantarum* CAM-6 as a probiotic has a growth promoting effect, perhaps due to the greater presence of bacterial metabolites, like lactic acid and digestive enzymes, which stimulate the gastrointestinal peristalsis, and favor food digestion. Accordingly, the pig's appetite is improved, with a rise in FLW and MDG (Alexopoulos *et al.*, 2004; Danicke, and Doll, 2010). Similar responses in the productive performance of pigs were reported by Wang *et al.* (2018) when they used diets containing *L. plantarum* and fruto-olisaccharides, compared to a diet containing antibiotics.

Besides, antibiotics used in sub-therapeutical doses have demonstrated to favor animal growth, due to the bactericidal and anti-inflammatory effects in the gastrointestinal tract (Thu *et al.*, 2011), which causes thinning of the wall of enterocytes, and benefits nutrient uptake (Lekshmi*et al.*, 2017). In that sense, Loft *et al*. (2014) observed a rise of bacterial communities in the small intestine, linked to the production of energy in pigs fed on antibiotics. The results indicated that both additives (antibiotic and probiotic biopreparation) have positive effects on the digestive physiology and intestinal health of growing pigs, which favored live weight increase, and food conversion.

Table 2 shows the effect of a biopreparation with *Lactobacillus plantarum* CAM-6 on the yields of edible portions from growing pigs. T3 increased (P<0.05) carcass yields (cold), loin (hot and cold), front leg (cold), and ribs (cold), compared to T0 and T1. The animals treated with sub-therapeutic doses of the antibiotic (T1) showed a decline in carcass yield (hot and cold), loin (hot), ribs (hot), and leg (cold).

Table 2. Effect of a biopreparation with *Lactobacillus plantarum* CAM-6 on the yields of edible portions from growing pigs

	Experimental treatments				
Items (%)	**T0**	**T1**	**T2**	**SE±**	**P value**
			Hot		
Carcass	68.84[a]	64.56[b]	69.90[a]	1.225	0.050
Loin	16.32[b]	15.66[c]	18.16[a]	0.721	0.031
Front leg	6.90[ab]	6.38[b]	7.01[a]	0.187	0.008
Leg	10.09[a]	9.14[b]	9.60[ab]	0.264	0.010
Ribs	5.46[a]	4.72[b]	5.46[a]	0.207	0.009
			Cold		
Carcass	58.09[b]	54.45[c]	59.50[a]	1.285	0.036
Loin	8.34[b]	8.45[b]	10.28[a]	0.521	0.039
Front leg	6.53[b]	6.09[b]	6.76[a]	0.198	0.045
Leg	9.82[a]	8.86[b]	9.24[a]	0.259	0.045
Ribs	4.92[b]	4.69[b]	5.03[a]	0.103	0.017

[a,b] Means with unequal letters on the same row differ for P<0.05 (Duncan, 1955).
T0: negative control; T1: positive control (antibiotic); T2: biopreparation containing 10^9 $CFU.mL^{-1}$ de *Lactobacillus plantarum* CAM-6.

To date, reports of the effects of *L. plantarum* on the yields of carcass and its parts, are few. The highest yield of edible parts in animals treated with probiotics possibly owes to the fact that the strain of *Lactobacillus plantarum* CAM-6 acts on the energetic and protein metabolism of the animal. Moreover, the state of eubiosis in the gastrointestinal tract increases the replacement of intestinal cells, which improves the integrity of the mucosa and nutrient digestion to produce muscular mass (Wang *et al*., 2019). It was demonstrated by the greater final live weight of the pigs at sacrifice, after consuming the supplement containing the probiotic biopreparation (Table 2).

Interestingly, yields of edible portions in the treatment with antibiotic had the lowest percentages, with more emphasis on the cold carcass (Table 2). Continuous use of high doses of GPA is known to cause antibiotic accumulation in the muscles, liver, and kidneys. In that sense, though these mechanisms are still being studied, GPA seems to reduce water retention, and increase water loss by dripping during the process of meat maturation (Ujeuta *et al*., 2016). However, Lowell *et al*. (2017) found no variations in the yields of carcass and loin when they used tylosin phosphate as a growth promoter in the diet of pigs.

In that sense, lactic bacteria have been described to benefit the absorption of aminoacids, particularly lysine, which takes part in the synthesis of muscle tissue, and the protection of the intestine (Wang *et al*., 2017); Cai *et al.* (2014) reported greater amounts of lysine in the blood torrent when diets based on *Lactobacillus plantarum* were used. Furthermore, the modification of the intestinal microflora thanks to the action of probiotics, favors the absorption of biomolecules and other nutrients that improve yields of carcass and edible portions of pigs (Liu *et al.*, 2016; Njoku *et al*., 2015). What is more, probiotic lactobacilli modulate the expression of closely-bound proteins to keep intestinal permeability and integrity, thus leading to higher *post mortem* carcass quality (Yang *et al.*, 2015).

CONCLUSIONS

The administration of an oral biopreparation with *L. plantarum* CAM-6 had a growth promoting effect on pigs, and it improved yields of edible portions (hot and cold), of pigs. However, more discrete results were achieved in the antibiotic treatment.

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AUTHOR CONTRIBUTION

Conception and design of research: CABH, YMA, RRB data analysis and interpretation: CABH, YMA, RRB, ORC, redaction of the manuscript: CABH, YMA, RRB, ORC, CCRP.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.