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Effects of Supplementation of Probiotics on the Performance, Nutrient Digestibility and Faecal Microflora in Growing-finishing Pigs

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ABSTRACT: Two experiments were conducted to investigate the effect of dietary supplementation of *Bacillus*, *Saccharomyces* and lactic acid bacteria (LAB) on performance and nutrient digestibility in grower and finisher pigs. In Exp. 1, 80 pigs (32 females and 48 males), 28.7±0.9 kg body weight (BW), were randomly divided into 4 treatment groups balanced for sex and weight (5 pigs per pen, 4 pens per treatment). They were fed one of four diets: a basal grower (20-50 kg BW) and finisher (>50 kg BW) diet without any addition of probiotic or antibiotic (diet C), the basal diet supplemented with *Bacillus subtilis H4* (diet B), diet B supplemented with *Saccharomyces boulardi Sb* (diet BS) and diet BS supplemented with a LAB complex (diet BSL). The LAB complex consisted of *Enterococcus faecium 6H2*, *Lactobacillus acidophilus* C3, *Pediococcus pentosaceus D7*, and *Lactobacillus fermentum NC1*. In Exp. 2, 16 male pigs, 29.2±0.8 kg BW, were kept in individual pens and divided into 4 groups (4 pigs in each group). All 4 groups were given exactly the same growing-period diets (diet C, B, BS and BSL) as in Exp 1. The total faeces and urine were collected during 5 days (day 20-24) to determine nitrogen retention and total tract digestibility. In the growing period, average daily feed intake (ADFI), average daily gain (ADG) and feed conversion ratio (FCR) were not affected by diet B and BS ($p>0.05$), but ADG increased (+5.9%) ($p<0.05$) and FCR improved (+5.9%) ($p<0.05$) on diet BSL compared with the control, although ADFI was not different ($p>0.05$). Digestibility of crude protein and organic matter was higher ($p<0.05$) in diet BSL and digestibility of crude fibre was higher ($p<0.05$) in diet BS and BSL than in diet C. Nitrogen retention was not affected by diet ($p>0.05$). The faecal LAB counts were increased in grower pigs fed diet BSL ($p<0.05$) and faecal *E. coli* counts were decreased in pigs fed diets BS and BSL ($p<0.05$). In the finishing period, no effects of diet were found in ADFI, ADG, FCR, nutrient digestibility, and nitrogen retention ($p>0.05$). Faecal LAB and *E. coli* counts in the finisher pigs were not affected by diet ($p>0.05$). In conclusion, the current study demonstrates that a mixture of bacteria and yeast has the potential to be used as a probiotic dietary supplement in grower pigs. (**Key Words:** Growth Performance, Digestibility, *Bacillus*, *Saccharomyces*, Lactic Acid Bacteria, Pigs)

INTRODUCTION

Probiotics are live microorganisms which have been found to confer a health benefit on the host when administered in adequate amounts (Weichselbaum, 2009). Probiotics are mainly used to reinforce or re-establish the gut microbial balance, especially when the hosts are confronted with challenges or stress (Vanbelle, 2001). Some studies have suggested that administration with different microbes in early life can alter the composition of gut flora during the first weeks of life and have an impact on health in later life (Björkstén et al., 2001; Kero et al., 2002). It is common to supplement lactic acid bacteria (LAB) probiotics, as LAB are considered as natural microflora of the gut. Several modes of LAB action in the gut have been observed when administered orally to the host. These include production of lactic acid and antimicrobial substances, lowering the pH, and consequently reducing *E. coli* and *Enterobacteria* counts (Nousiainen and Setälä, 1998). *Bacillus spp*., with soil as their natural habitat, are also used as probiotics, either alone or combined with LAB or yeasts (Hong et al., 2005). The probiotic yeast *Saccharomyces*, which normally grows on plant material and does not occur in the gut, has been found to be effective

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in stimulating intestinal immunity and protecting the host from diahrroea (Buts et al., 1990).

In general, supplementing pig feed with probiotics has given more positive and consistent effects in weaned piglets than in grower or finisher pigs (Vanbelle, 2001). It has been claimed that the microbiota in the gut is unstable during the first week post-weaning, and that it takes two to three weeks post-weaning for the gut microbes to fully develop their fermentative capacity and to reach a high level of stability (Jensen, 1998). Thus, supplementation with probiotics can reinforce the microflora composition during the post-weaning period. However, the results from studies with probiotic supplements to grower and finisher pigs have been contradictory. For example, when supplementing basal diets for growing-finishing pigs with *Lactobacillus* probiotics, Baird (1977) observed an improvement in weight gain and feed efficiency, whereas Pollmann et al. (1980) and Harper et al. (1983) did not find any effects. Moreover, Wang et al. (2009) found that dietary supplementation with *Bacillus* probiotics in grower pigs increased daily feed intake, while Davis et al. (2008) did not observe any effects on performance.

Probiotics containing different strains of micro-organisms have different efficacy, and some strains may provide certain benefits for the host whereas others do not (Weichselbaum, 2009). Multi-strain or multi-species probiotics have been found to have more effective and consistent functionality than mono-strain or single-species probiotics (Timmerman et al., 2004). In an earlier study, we found that an LAB complex (*Enterococcus faecium* 6H2, *Lactobacillus acidophilus* C3, *Pediococcus pentosaceus* D7, *Lactobacillus fermentum* NC1) alone or combined with *Bacillus subtilis* H4 or with a mixture of the *Bacillus* and yeast (*Saccharomyces boularddi Sb*) had probiotic properties in weaned piglets (Giang et al., 2010, Unpublished). The current study was carried out to evaluate the effects of combinations of an LAB complex, *Bacillus* and yeast, supplemented to a basal diet, on performance, digestibility and faecal bacteria counts in growing-finishing pigs.

MATERIALS AND METHODS

Bacteria and yeast sources

Bacillus and yeast: *Bacillus subtilis* H4 was isolated from ileal digesta of healthy fattening pigs, and the yeast strain *Saccharomyces boulardii Sb* was obtained from the Vietnam Type Culture Collection (Institute of Microbiology and Biotechnology, Vietnam National University, Hanoi, Vietnam). They were tested *in vitro* for resistance to heat, low pH, bile salts, and enzyme activity (for *Bacillus*), and for antagonism with the pathogenic bacteria *Salmonella*, *Shigella* and *E. coli* (for *S. boulardii Sb*) (Viet et al., 2009).

LAB strains : *Enterococcus faecium* 6H2, *Lactobacillus acidophilus* C3 and *Pediococcus pentosaceus* D7 were isolated from ileal digesta from healthy fattening pigs, and *Lactobacillus fermentum* NC1 was isolated from a Vietnamese traditional fermented food (*nem chua*). The LAB strains were selected in previous tests, based on their resistance *in vitro* to heat, low pH, bile salts, and antagonism with pathogenic bacteria such as *Salmonella* and *E. coli* (Viet et al., 2006).

Animals, diets and measurements

In total 120 Landrace×Yorkshire pigs with average ages of 61-63 days which had not been given any antibiotic feed additives were selected from a pig farm located in Dong Anh district, Hanoi City, Vietnam. The pigs were fed *ad libitum* with a basal diet without any antibiotics or probiotics during 2 weeks as a pre-experimental period. After that, all pigs were weighed, and 80 pigs (32 females and 48 males) with an average body weight (BW) of 28.7±0.9 kg were selected and kept in the pig farm for the performance experiment (Exp. 1). Sixteen male pigs with a BW of 29.2±0.8 kg were selected and transferred to the Experimental Farm of the National Institute of Animal Sciences (Tu Liem District, Hanoi City, Vietnam) for the digestibility experiment (Exp. 2).

In Exp. 1, the pigs were randomly assigned (based on sex and BW) to one of 4 treatment groups (5 pigs per pen, 4 pens per treatment) and fed one of four diets: the basal diet (diet C) was in meal form, and consisted of maize meal, rice bran, cassava root meal, soybean meal, meat and bone meal, dicalcium phosphate, a vitamin and mineral premix, and synthetic amino acids, formulated following NRC (1998) recommended feeding standards for growing pigs (20-50 kg BW) and finishing pigs (>50 kg BW) (Table 1). The basal diet was supplemented with either *Bacillus subtilis* H4 (6×10^{11} CFU/ml) (diet B), with a mixture of *Bacillus subtillis* H4 (6×10^{11} CFU/ml) and *Saccharomyces boulardi Sb* (6×10^{10} CFU/ml) (diet BS), or with a mixture of *Bacillus subtilis* (6×10^{11} CFU/ml), *Saccharomyces boulardi Sb* (6×10^{10} CFU/ml) and a lactic acid bacteria (LAB) complex (diet BSL). The LAB complex consisted of *Enterococcus faecium* 6H2 (6×10^{9} CFU/ml), *Lactobacillus acidophilus* C3 (5×10^{9} CFU/ml), *Pediococcus pentosaceus* D7 (4.9×10^{9} CFU/ml), and *Lactobacillus fermentum* NC1 (6×10^{9} CFU/ml). All the bacteria strains and *Saccharomyces* were prepared in culture form and stored in a refrigerator at 4°C in separate bottles. Each day, the bacteria and yeast supplements (3 ml of each bacteria strain, and of Saccharomyces, per kg of basal diet) were mixed with a portion of the basal diet prior to feeding.

Table 1. Ingredient (% as fed basis) and chemical composition (% of dry matter) of basal diet

Item	Grower[1]	Finisher[1]
Ingredient composition		
Maize meal	39.98	32.25
Rice bran	15.00	23.50
Cassava root meal	15.00	20.00
Soybean meal (44% CP)	24.66	19.05
Meat and bone meal (50% CP)	3.50	3.50
Vitamin-mineral premix	0.25	0.25
Lysine HCl	0.025	-
Limestone	0.28	0.43
Dicalcium phosphate	0.90	0.62
Salt	0.40	0.40
Chemical composition		
Crude protein	20.5	18.3
Crude fibre	6.99	8.11
Lysine	1.08	0.90
Methionine	0.32	0.29
Methionine+cystine	0.64	0.56
Threonine	0.75	0.65
Tryptophan	0.22	0.19
Calcium	0.94	0.91
Available phosphorus*	0.46	0.40
ME, MJ/kg dry matter*	14.56	14.34

[1] Grower: 20-50 kg BW; Finisher: >50 kg BW.
* Calculated based on Composition and Nutritive Value of Animal Feeds in Vietnam (Agricultural Publishing House, Hanoi, Vietnam, 2001).

Feed intake and growth rate: The experiment lasted 75 days, with a 33 day growing period and a 42 day fattening period. The pigs were fed *ad libitum* and had free access to nipple drinkers. Each day the feed offered and refused was weighed and recorded to calculate daily feed intake. The piglets were weighed at the beginning of the experiment and at the end of each period to calculate daily weight gain and feed conversion ratio.

In Exp. 2, sixteen pigs were kept in individual pens and divided into 4 groups with 4 pigs as 4 replicates in each group. All 4 groups were given exactly the same growing-period diets (diet C, B, BS and BSL) as in Exp. 1. After 2 weeks, the pigs were moved to individual metabolism cages with 5 days for adaptation and 5 days for collection. Water was provided *ad libitum* by a nipple drinker in each cage. The pigs were fed *ad libitum* in the adaptation period to calculate mean feed intake, and then restricted to 85% of the mean feed intake in the collection period. Total faeces and urine were collected twice per day at 08.00 h and 16.00 h. Ten percent of the faeces and urine of each pig collected at each time was sampled and stored in a refrigerator at 4 °C. At the end of the last collection period, the samples of faeces and urine were pooled and sub-samples taken for analysis to calculate the total tract digestibility of crude protein, crude fibre and organic matter and nitrogen retention.

Chemical analysis and bacteria counts

Samples of feed and faeces were analyzed for dry matter (DM), crude protein (CP), crude fibre (CF) and ash according to standard AOAC (1990) methods. The faecal samples were dried at 60°C for 24 h and ground to pass through a 1-mm sieve before analysis. Amino acid contents in the feed samples were determined using an ion exchange column (Amino Quant, 1990).

Faecal bacteria count: Faecal samples were taken randomly from the rectum of two pigs per pen on the weighing days in Exp. 1. The fresh faeces samples were dissolved in sterile saline (0.9%) in a 1:10 dilution. Secondary dilutions were performed in duplicate, and were from 10^{-4} to 10^{-6} for *E. coli* counts and from 10^{-5} to 10^{-7} for total LAB counts. *E. coli* was cultured on MacConkey agar (MAC), and LAB cultured on MRS agar (Mann, Rogosa and Sharpe).

Statistical analysis

The data were analysed statistically using the GLM of Minitab Software Version 14.1. Treatment means which showed significant differences at $p<0.05$ were compared using Tukey's pair-wise comparison procedure. The data of LAB and *E. coli* counts were transformed as log10 before statistical analysis.

RESULTS

Growth performance

Effects of bacteria and yeast on average daily feed intake (ADFI), average daily gain (ADG) and feed conversion ratio (FCR) of the grower-finisher pigs are presented in Table 2.

In the growing period, supplementation with *Bacillus* alone (diet B) or combined with *Sacharomyces* (diet BS) or with the mixture of *Saccharomyces* and LAB (diet BSL) did not affect ADFI compared with the control (diet C) ($p>0.05$). However, ADG increased and FCR improved in pigs fed diet BSL compared with pigs fed the control diet ($p<0.05$), and there was a tendency to improvement in ADG of pigs fed diet BS ($p = 0.11$). There were no differences in ADG and FCR among pigs fed diets C, B and BS ($p>0.05$), or among pigs fed diets B, BS and BSL ($p>0.05$).

In the finishing period, there were no differences in ADFI, ADG and FCR among the four treatments ($p>0.05$). There was a tendency towards a gradual increase in ADG and an improved FCR in pigs fed diet B, BS and BSL compared with the control ($p>0.05$). The final live weight

Table 2. Effects of probiotics on the performance of pigs, Exp. 1

Item	Treatment*				SEM	p value
	C	B	BS	BSL		
Number of pigs	20	20	20	20		
Grower period (28.8-54.2 kg)						
Feed intake (kg/d)	1.87	1.87	1.87	1.86	0.014	0.95
Weight gain (kg/d)	0.73[a]	0.75[ab]	0.76[ab]	0.77[b]	0.008	<0.01
Feed:gain (kg/kg)	2.56[a]	2.50[ab]	2.47[ab]	2.41[b]	0.031	0.02
Finisher period (54.2-89 kg)						
Feed intake (kg/d)	2.39	2.38	2.37	2.37	0.032	0.98
Weight gain (kg/d)	0.80	0.81	0.82	0.83	0.012	0.35
Feed:gain (kg/kg)	2.98	2.93	2.90	2.84	0.071	0.61
Overall (28.8-89 kg)						
Feed intake (kg/d)	2.16	2.16	2.15	2.15	0.018	0.95
Weight gain (kg/d)	0.77[a]	0.78[ab]	0.79[ab]	0.81[b]	0.007	<0.01
Feed:gain (kg/kg)	2.80	2.75	2.72	2.66	0.043	0.17

* C = Control; B = *Bacillus*; BS = *Bacillus*+*Sacchromyces*; BSL = *Bacillus*+*Saccharomyces*+Lactic acid bacteria complex.
[a, b] Means within a row with different superscripts are significantly different (p<0.05).

of pigs fed diet BSL was significantly higher compared with the control (data not shown).

Overall, ADG were higher in pigs fed diet BSL compared with diet C (p<0.05), while no differences among pigs fed diet C, B and BS, or among pigs fed diets B, BS and BSL were found (p>0.05). There were no differences in ADFI and FCR among the four treatments (p>0.05).

Nutrient digestibility

The total tract digestibility and nitrogen retention of grower pigs are shown in Table 3. Supplementation of *Bacillus* alone (diet B) or the mixture of *Bacillus* and *Saccharomyces* (diet BS) did not affect digestibility of CP and organic matter (OM) compared with the control (p>0.05). However, pigs fed diet BS had higher digestibility of CF (p<0.05) and pigs fed diet BSL had higher digestibility of CP, CF and OM (p<0.05) compared with pigs fed the basal diet. Nitrogen retention was not affected by treatment (p>0.05). However, there was a tendency to higher nitrogen retention on diet BSL (p = 0.058) compared with the control.

Faecal bacteria counts

The results of faecal LAB and *E. coli* counts are presented in Table 4. In the grower pigs, diet BSL increased the faecal LAB count compared with diets C, B and BS (p<0.01). There were no differences in faecal LAB count among grower pigs fed diet C, B and BS (p>0.05). Faecal *E. coli* counts decreased gradually in pigs fed diets B, BS and BSL, and were lower in pigs fed diet BS and BSL compared with pigs fed diets C and B (p<0.05). There were no differences in *E. coli* counts between pigs fed diet C and B (p>0.05), or between pigs fed diet BS and BSL (p>0.05). There were no effects of diet on faecal LAB and *E. coli* counts in the finisher pigs (p>0.05).

DISCUSSION

In the current study, supplementation with *Bacillus* alone (diet B) or combined with *Saccharomyces* (diet BS) did not affect ADFI, ADG and FCR, in both growing and finishing periods, compared with the control. *Bacillus* and *Saccharomyces* are not considered as natural intestinal

Table 3. Effects of probiotics on total tract apparent digestibility of nutrients (%) and nitrogen retention (% of nitrogen intake) in grower pigs[1], Exp. 2

Items	Treatment[2]				SEM	p value
	C	B	BS	BSL		
Crude protein	86.6[a]	87.6[a]	89.0[ab]	90.4[b]	0.62	<0.01
Crude fibre	62.2[a]	64.6[a]	68.0[b]	68.5[b]	0.62	<0.01
Organic matter	87.7[a]	89.4[ab]	89.1[ab]	90.1[b]	0.50	0.03
Nitrogen retention	55.1	56.6	58.0	58.6	0.88	0.06

[1] Initially 75-77 days of age and 24 days in growing period.
[2] C = Control; B = *Bacillus*; BS = *Bacillus*+*Sacchromyces*; BSL = *Bacillus*+*Saccharomyces*+Lactic acid bacteria complex.
[a, b] Means within a row with different superscripts are significantly different (p<0.05).

Table 4. Effects of probiotics on faecal bacteria counts (log_{10} per gram of fresh sample) in grower and finisher pigs, Exp. 1

Item	Treatment[1]				SEM	p value
	C	B	BS	BSL		
Grower [2]						
Lactic acid bacteria	8.59[a]	8.81[a]	9.16[a]	10.52[b]	0.23	<0.01
E. coli	7.54[a]	6.56[ab]	6.47[b]	5.92[b]	0.24	<0.01
Finisher [3]						
Lactic acid bacteria	9.93	10.36	10.33	10.64	0.25	0.32
E. coli	6.44	6.35	6.15	6.08	0.27	0.75

[1] C = Control; B = *Bacillus*; BS = *Bacillus*+*Sacchromyces*; BSL = *Bacillus*+*Saccharomyces*+Lactic acid bacteria complex.
[2] Samples were taken on the final day of growing period (76-109 days of age).
[3] Samples were taken on the final day of finishing period (110-151 days of age).
[a, b] Means within a row with different superscripts are significantly different ($p<0.05$).

inhabitants and were reported not to colonize in the host intestines (Chesson, 1994; Kornegay and Risley, 1996). In stressed animals, such as weaned piglets, *Bacillus* and *Saccharomyces* showed positive effects in the animal gut. For example, *Bacillus* can produce some useful enzymes (α-amylase, arabinase, cellulase, dextranase, levansucrase, maltase, alkaline protease, neutral protease and β-glucanase) (Priest, 1977; Hentges, 1992) that were found to improve feed efficiency and weight gain of weaned piglets (Zani et al., 1998). *Saccharomyces* can produce antimicrobial substances (Czerucka and Rampal, 2002) and decrease the levels of potential pathogens in the gut lumen, resulting in improved performance of weaned piglets (Bontempo et al., 2006). However, in grower and finisher pigs, *Bacillus* and yeast probiotics have lesser or no effects, as the gut microbiota is more stable, and the immune status and digestibility of the feed is higher compared to weaned piglets (Jensen, 1998; Nousiainen and Setälä, 1998). In accordance with the current results, Kornegay and Risley (1996) reported that supplementation of a mixture of *Bacillus subtilis* and *B. licheniformis*, or a mixture of *B. subtilis*, *B. licheniformis* and *B. pumilus* in a finisher pig diet, did not result in any improvement in ADFI, ADG and feed efficiency. Similar results were found by Veum and Bowman (1973) when supplementing a *Saccharomyces cervisiae* culture in a grower pig diet. Contrary to our results, Davis et al. (2008) found that dietary supplementation with a 2-strain *Bacillus* complex improved gain/feed in the finishing period (from 64 kg body weight to market weight) but not in the starter and grower periods, while ADG and ADFI were not affected. One reason for the different results was that the basal diet in the study by Davis et al. (2008) contained tylosin, while the basal diet in the current study did not contain any antimicrobial feed additives. Thus, the *Bacillus* may have different activities in the presence of antibiotics. Moreover, another study by Wang et al. (2009) did not find any improvement in the performance of grower pigs fed diets supplemented with 0.05% or 0.1% of commercial *Bacillus* probiotic, but ADFI increased significantly and ADG tended to increase when the level of probiotic was 0.2%.

Interestingly, in the grower pigs, adding a LAB complex to the mixture of *Bacillus* and *Saccharomyces* (diet BSL) increased ADG (+5.9%) and improved FCR (+5.9%) compared with the control, even though the ADFI was not different. However, in the finishing period, no effects of diet BSL on the performance were observed. In post-weaned piglets, supplementation with LAB probiotics has consistently shown improvement in performance and feed efficiency (Pollmann et al., 1980; Lessard and Brisson, 1987; Tortuero et al., 1995; Huang et al., 2004). However, some studies on grower and finisher pigs reported a lack of positive effects of single-strain LAB and of multi-strain LAB probiotics supplementation (Pollmann et al., 1980; Harper et al., 1983; Apgar et al., 1993; Chen et al., 2006). Only a few studies have been conducted on supplementation with mixtures of LAB, *Bacillus* and yeasts in pig diets. The complex of *Bacillus*, yeast and LAB supplemented in diet BSL in the current study was exactly the same microbial complex as in diet LBS in our previous study (Giang et al., 2010, Unpublished) which had probiotic effects during a five week period in post-weaned piglets. The results from the current study suggest that this microbial complex also has probiotic potential in grower pigs. This is supported by Chen et al. (2005), who found improved ADG, but not ADFI or gain/feed, in grower pigs fed diets supplemented with a mixture of *L. acidophilus*, *S. cervisae* and *B. subtilis*.

The improved performance could be due to an improved digestibility on the supplemented diets as compared with the control. Moreover, N retention tended ($p = 0.059$) to be improved when the diet was supplemented with probiotics. *Bacillus* and *Saccharomyces* are able to stimulate the rate of glucose transport throughout brush border vesicles from porcine jejunum *in vitro* (Breves et al., 2000), which may have contributed to improved nutrient uptake in pigs fed the

supplemented diets. Scheuermann (1993) reported an improved N retention, but did not find any improvement in the total tract digestibility of CP in grower pigs fed a diet that contained *Bacillus* strain CIP5832. Kornegay and Risley (1996) and Wang et al. (2009) reported that *Bacillus* probiotics did not affect nutrient digestibility in grower and finisher pigs. Chen et al. (2005) found an improved digestibility of DM and N in grower pigs fed a diet supplemented with a mixture of *Lactobacillus*, *Saccharomyces* and *Bacillus*. The increased faecal LAB counts in the grower pigs fed diet BSL in the present study, indicated an increased number of LAB in the gut. Ingested LAB can increase some useful enzyme activities, such as sucrase, lactase and tripeptidase along the small intestine of pigs (Collington et al., 1990), which could have contributed to the higher digestibility in pigs fed diet BSL.

In this study, the inclusion *Bacillus* in the diets did not affect faecal LAB and *E. coli* counts in both grower and finisher pigs. These results were, in general, similar to Pollmann (1986), who reported that the faecal *Lactobacillus* and *E. coli* populations were not affected when feeding sows with a diet that contained *Bacillus*. However, Kornegay and Risley (1996) found inconsistent results with two commercial *Bacillus* probiotic products in finisher pigs. These authors reported that supplementation with one product (*Biomate 2B*) increased faecal LAB counts but did not affect faecal coliform counts, while the other product (*Pelletmate livestock*) did not increase faecal LAB counts but decreased faecal coliform counts. When supplementing the mixture of *Bacillus* and *Saccharomyces* in the current study, faecal LAB counts tended to be higher and *E. coli* counts tended to be lower in the grower pigs, indicating that *Saccharomyces* could have beneficial effects against *E. coli*. Some previous studies found that *S. boulardii* can exert antagonistic effects against several bacterial pathogens, such as *Clostridium difficile* (Corthier et al., 1986), *Salmonella typhimurium* (Rodrigues et al., 1996), and *E. coli* (Czerucka and Rampal, 2002). The inclusion of the LAB complex together with the mixture of *Bacillus* and *Saccharomyces* increased faecal LAB counts and decreased faecal *E. coli* counts in the grower pigs, but not in the finisher pigs. Thus, this indicates that the addition of further microbes to an already stable indigenous gut microbiota should not be expected to result in any change in numbers if all other conditions remain the same (Hungate, 1984).

CONCLUSIONS

The current results suggest that by combining suitable probiotic strains of *Bacillus*, *Saccharomyces* and LAB, positive effects on growth, feed conversion and nutrient digestibility can be obtained in grower pigs. However, in finisher pigs there appears to be more limited potential to improve performance and nutrient utilization by supplementing the feed with a microbial complex.

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