Acta Scientiarum
http://periodicos.uem.br/ojs
ISSN on-line: 1807-8672
https://doi.org/10.4025/actascianimsci.v48i1.75437

Effect of a postbiotic in the diet on performance and meat quality of pigs

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ABSTRACT. Postbiotics can play an essential role in feeding strategies that replace antimicrobial growth promoters and zinc oxide in diets for all phases of swine production. This study aimed to evaluate the impact of a yeast-based postbiotic on animal performance and pork meat quality. A total of 220 pigs (26.8 ± 0.1 kg of body weight and 68 days of age), the offspring of Camborough sows and PIC337 boars, were randomly assigned to four treatment groups in a 2 × 2 factorial design with ten replications. The treatments resulted from the combination of sex (female or immunocastrated male) and dietary treatment (Control – basal diet, or Postbiotic – *Saccharomyces cerevisiae* fermentation product added at 0.5 kg per ton of feed). Each replication was a pen containing 11 animals. The trial lasted 101 days. Postbiotic supplementation did not affect animal performance (final body weight, average daily gain, and feed conversion ratio). However, regarding carcass traits, loin depth and lean meat were higher in the postbiotic treatment. Meat from the postbiotic treatment showed reduced lipid oxidation (TBARS), lower pH, and lower red intensity (a* parameter). In conclusion, adding yeast-based postbiotics to the feed of growing/finishing pigs does not affect performance, but it improves pork quality.

Keywords: carcass quality; eubiotics; intestinal health; performance; sustainability.

Received on January 28, 2025.
Accepted on June 17, 2025.

Introduction

In modern swine production systems, there is a growing trend to reduce the use of antibiotics and limit the use of zinc oxide as growth promoters (Cardinal et al., 2021). Various additives and ingredients have been proposed as alternatives to support growth and performance at all stages of swine production (Ali et al., 2023). Swine production systems present two main challenges: maintaining health and achieving consistent high performance while reducing the use of antimicrobial growth promoters (AGPs). The use of postbiotics in piglets and sow nutrition is a novel concept that is already of special interest, as it can improve gut health and animal performance. Postbiotics can also play an essential role in feeding strategies that target the replacement of AGPs in all stages of a pig's life (Zhong et al., 2022).

Postbiotics, defined as preparations of inanimate microorganisms and/or their components that confer health benefits to the host (Salminen et al., 2021), are emerging as safer alternatives for clinical applications, particularly for chronic inflammatory conditions such as inflammatory bowel disease (Silva et al., 2020). Postbiotics can improve host health by supporting a healthy digestive tract and/or immune system. They can be used as a therapeutic approach to inhibit pathogens, primarily by competing with them for adhesion to the gut's mucosa and epithelium (Zhong et al., 2022).

The postbiotic composition includes microbial extracts, nonviable cells, bioamines, cell wall structures, and compounds produced by probiotic fermentation. It is associated with promoting beneficial effects in animals (Ali et al., 2023; Hao et al., 2020; Lian et al., 2024) and improving meat quality (Liu et al., 2023b); Płacheta et al., 2022; Xu et al., 2019).

These new findings provide new perspectives for evaluating, understanding, and applying them in the swine industry, but much remains to be discovered about the implementation of postbiotics on farms. We hypothesized that the inclusion of a yeast-based postbiotic additive in growing and finishing diets is beneficial for the maintenance of productive performance of the animals and pork quality. Thus, the objective of this study was to evaluate the impact of adding a postbiotic to the diet on zootechnical parameters and pork quality.

Materials and methods

This study complies with the ethical principles adopted by the Brazilian College of Animal Experimentation (*Colégio Brasileiro de Experimentação Animal* – COBEA) and was approved by the Animal Ethics Committee (*Comitê de Ética no Uso de Animais* – CEUA, protocol number 10/2021) of the Federal University of Paraná (*Universidade Federal do Paraná* – UFPR), Palotina Sector.

The trial was carried out at a swine finishing facility located in the southwest region at the municipality of Bom Sucesso do Sul, Paraná, Brazil. This commercial establishment faces the same sanitary challenges commonly encountered in the Brazilian swine industry.

A total of 220 pigs, the offspring of Camborough sows and PIC337 boars, newly coming from the nursery phase (26.8 ± 0.1 kg average body weight and 68 days of age), were distributed into four treatment groups according to a 2 × 2 factorial design with ten replications. The treatments resulted from the combination of sex (female or immunocastrated male) and dietary treatment (Control and Postbiotic). Each replication was a pen containing 11 animals. The trial lasted 101 days.

At the beginning of the trial, the animals were weighed individually using a digital scale (Urano, model UR 10000 light, 300 kg, Canoas, RS, Brazil) and identified with ear tags (Allflex, Joinville, SC, Brazil). Then, the animals were separated into two groups according to sex. Each group was distributed homogeneously among the dietary treatments based on weight. The Control group received a basal diet with no additive, while the Postbiotic group received an additive containing *Saccharomyces cerevisiae* fermentation products (Original XPC® Ultra, Diamond V Mills, Cedar Rapids, IA) at 0.5 kg per ton of feed.

Animals were housed in an east-west oriented barn measuring 80.0 × 9.6 m, with females housed to the north and males to the south, ensuring an even distribution of treatments throughout the barn. The barn was divided by a 1-meter-wide corridor and had 25 pens on each side. Each pen measured 4.20 × 3.09 m and had a compact floor, a funnel-type feeder, a nipple drinker, and a water depth at the bottom. The barn was covered with fiber cement tiles and had curtains with a side closure, anti-bird fabric, and a bandeau. The pigs were subjected to natural lighting, and the curtains were adjusted according to weather conditions during the day to provide hygienic ventilation and maintain a favorable environment for the animals. Each morning, the stall floor was scraped to remove feces. The water layer was drained and completely changed every 48 h.

During the 14-week experiment (approximately 100 days between May and August 2021), animals were given *ad libitum* access to experimental diets, which included growing and finishing phases, and seven formulations (Table 1). The feed was produced at the experimental unit's feed mill. Soybean meal and corn were stored in specific bins and crushed using sieve number 3 (6,73 mm) according to the feed production. Then, the horizontal mixer, which has a 500 kg capacity, mixed the corn, soybean meal, and premix for seven minutes. After this period, the produced feed was loaded and stored in a bin. The nutritional levels for each animals' life stages were in accordance with the Brazilian Tables of Swine Nutritional Requirements (Rostagno et al., 2011) (Table 2). The animals also had *ad libitum* access to water during the experiment.

Table 1. Ingredient composition of experimental diets in the growing and finishing phases.

Ingredients[1] (%)	Allotment	Growing 1	Growing 2	Growing 3	Finishing 1	Finishing 2	Finishing 3
Corn, 7.6% CP	676.73	706.67	736.69	766.97	780.14	741.11	751.36
Soybean meal, 46.0% CP	290.00	264.00	234.00	204.00	191.00	230.00	221.00
Dicalcium phosphate	6.2000	6.4000	6.5000	6.4000	6.4000	6.2000	6.4000
Calcitic limestone, 37%	5.9000	5.9000	6.0000	6.0000	5.8000	5.7000	4.2000
DL-Methionine, 99%	1.8000	1.0200	0.8100	0.6600	0.6000	0.9000	0.8500
L-Lysine HCl, 78%	5.0400	3.5000	3.5200	3.5300	3.5400	3.5200	3.5300
L-Threonine, 98%	1.6800	1.0600	1.0000	0.9300	1.0000	0.9900	1.0700
L-Tryptophan, 99%	0.4300	0.1000	0.1300	0.1600	0.1700	0.1300	0.1400
L-Valine, 96.5%	0.8676	-	-	-	-	-	-
Px Rono Blend MS0,1%	1.2500	1.2500	1.2500	1.2500	1.2500	1.2500	1.2500
Common salt	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
HiPhosGT20M S 100 g ·	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000	0.1000
Rovimix Sui C OVN 5	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
Ractopamine	-	-	-	-	-	0.1000	0.1000
Total batch (kg)	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000. 00

[1]CP: crude protein.

Table 2. Nutritional levels* of experimental diets in the growing and finishing phases.

Ingredients[1]	Allotment	Growing 1	Growing 2	Growing 3	Finishing 1	Finishing 2	Finishing 3
Dry matter	88.06	88.02	88.02	88.02	88.02	88.01	88.00
Metabolizable energy	3.388.95	3.398.16	3.404.20	3.411.20	3.414.70	3.406.49	3.412.59
Crude protein	20.22	18.93	17.76	16.60	16.11	17.60	17.28
Total arginine	1.27	1.19	1.10	1.01	0.97	1.09	1.06
Total lysine	1.42	1.24	1.16	1.08	1.05	1.15	1.12
Total methionine	0.48	0.40	0.36	0.33	0.32	0.37	0.36
Total methionine + cysteine	0.82	0.72	0.67	0.62	0.60	0.67	0.66
Total threonine	0.95	0.85	0.80	0.74	0.73	0.79	0.78
Total tryptophan	0.27	0.22	0.21	0.19	0.19	0.20	0.20
Total isoleucine	0.80	0.75	0.70	0.64	0.62	0.69	0.68
Total leucine	4.39	4.44	4.49	4.53	4.55	4.50	4.52
Total valine	1.00	0.87	0.82	0.76	0.74	0.81	0.79
Digestible lysine swine	1.30	1.12	1.05	0.98	0.95	1.04	1.02
Dig. methionine swine	0.45	0.36	0.33	0.30	0.29	0.34	0.33
Dig. methionine + cysteine	0.75	0.65	0.60	0.56	0.55	0.61	0.60
Dig. threonine swine	0.84	0.75	0.70	0.65	0.64	0.69	0.69
Dig. tryptophan swine	0.24	0.20	0.18	0.17	0.17	0.18	0.18
Dig. isoleucine swine	0.71	0.67	0.62	0.57	0.55	0.61	0.60
Dig. leucine swine	4.00	4.06	4.10	4.15	4.16	4.11	4.13
Dig. valine swine	0.89	0.77	0.72	0.67	0.65	0.71	0.70
Crude fat	3.00	3.08	3.15	3.22	3.25	3.16	3.18
Crude fiber	2.50	2.43	2.34	2.25	2.21	2.33	2.30
Neutral detergent fiber	11.31	11.36	11.37	11.37	11.38	11.37	11.39
Ashes	4.27	4.17	4.05	3.90	3.82	3.97	3.81
Analyzed calcium	0.47	0.47	0.47	0.46	0.45	0.45	0.40
Calcium	0.61	0.61	0.61	0.60	0.59	0.59	0.54
Analyzed phosphorus	0.43	0.43	0.42	0.41	0.41	0.42	0.42
Available phosphorus	0.39	0.39	0.39	0.39	0.38	0.38	0.39
Sodium	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Chlorine	0.44	0.41	0.41	0.41	0.41	0.41	0.41
Potassium	0.85	0.79	0.73	0.67	0.65	0.73	0.71
Copper	115.00	115.00	115.00	115.00	115.00	115.00	115.00
Choline	999.56	966.14	924.63	883.21	865.47	918.84	907.40
Vitamin A, IU	7.000.00	7.000.00	7.000.00	7.000.00	7.000.00	7.000.00	7.000.00
Vitamin D3, IU	3.500.00	3.500.00	3.500.00	3.500.00	3.500.00	3.500.00	3.500.00
Vitamin E	60.00	60.00	60.00	60.00	60.00	60.00	60.00
Menadione (K3)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Niacin	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Pantothenic acid	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Folic acid	1.00	1.00	1.00	1.0	1.00	1.00	1.00
Biotin (H)	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Thiamine (B1)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Riboflavin (B2)	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Pyridoxine (B6)	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Cobalamin (B12)	0.05	0.05	0.05	0.05	0.05	0.05	0.05

[1]Dry matter (DM) expressed on an as-fed basis; Metabolizable energy, expressed in Mcal kg^{-1} DM; other nutrients expressed as % DM. International unit (IU).
*Formulation software.

Performance parameters were monitored to evaluate pig performance. BW was assessed at the beginning of growing phase and at the end of finishing phase. The following performance variables were evaluated: initial body weight (IBW), final body weight (FBW), average daily gain (ADG), FBW adjusted to 101 days, and feed conversion ratio (FCR).

ADG was determined by calculating the difference between IBW and FBW for each pen and dividing it by the number of animals per pen and per days of housing. To determine average daily feed intake (ADFI) and FCR, the amount of feed offered and the amount left over were recorded daily. A cart with a scale and a semi-automatic feeder was used to control feed intake. An employee used the cart to fill each pen's feeder in the corridor and recorded the amount of feed each feeder received daily. ADFI was calculated by subtracting leftovers from the amount offered, and dividing it by the number of animals per pen and per days of housing. The FCR was calculated by dividing the ADFI by the ADG.

Two days before the slaughter, 20 animals from each group, Control (10 males and 10 females) and Postbiotic (10 males and 10 females) groups were selected for meat analysis according to the following criteria: absence of apparent diseases or defects such as arthritis, abscesses, otohematomas, hernias and lameness; and belonging to a medium weight range for each treatment. All animals were then slaughtered in a commercial packing plant after a 12-hour solid fasting period in compliance with the slaughter rules of the State Inspection Service Legislation. On the slaughter line, after classification, the whole carcass was weighed, allowing the yield of each carcass to be calculated. Carcasses were divided medially through the sternum and spine, and cooled below 4°C for 24 h. They were kept together during weighing and cooling and marked with a tattoo on the left shoulder to track carcass traits. The following variables were analyzed at the slaughterhouse: hot carcass weight (HCW; kg), carcass yield (%), backfat thickness (mm), loin depth (mm), and lean meat (%).

Measurements of backfat thickness (BT) and loin depth (LT) between the last thoracic vertebra (T14) and the first lumbar vertebra (L1) were obtained 30 minutes after bleeding using a Fat-O-Meater II™ probe (Frontmatec Group, Kolding, Denmark). The carcass lean meat percentage (LMP) was calculated from measurements of BT and LT, using the formula suggested by Gispert & Diestre (1994):

$$LMP = 54.449 - (0.5623 \times BT) + (0.198 \times LT).$$

For meat evaluation, 24 hours after slaughter, the *Longissimus dorsi* (LD) muscle was removed from the left side of the carcass, packed in polyamide/polyethylene bags, and transported to the university meat laboratory, chilled intact below 4°C, for further analysis. The LD was sliced transversely into 2.5 cm-thick chops (6 chops total). The slices were grouped in pairs and evaluated immediately. Then, they were evaluated for 7 days to examine the effect of postbiotics on the quality of refrigerated pork under commercial conditions.

Each sample was packaged in pairs and placed in a polystyrene tray wrapped with retractable film (PVC film 28 cm × 15 m, Giopack, Brazil) and refrigerated in an illuminated display at 4 ± 1.5°C under lighting (fluorescent lamp, 1200 lux, 12 h d^{-1}), simulating typical conditions in the Brazilian market. Chops were randomly removed at 1-, 3-, and 7-days of shelf exposure. Each slice was analyzed in triplicate for the following parameters for each treatment:

- *Lipid oxidation:* a 5 g fraction of each chop sample was mixed with 10 mL of TCA solution (7.5% TCA, 0.1% EDTA, and 0.1% gallic acid), homogenized in a turrax, and centrifuged at 4,000 rpm at 4°C for 15 min. The supernatant was filtered and mixed (1:1 V/V) with thiobarbituric acid reactive substance (TBARS) reagent (1% TBA, 562.5 mM HCl, 15% TCA). The mixture was boiled (100°C) for 15 min. Once cooled to room temperature, the absorbance was measured at 532 nm. Concentrations were determined using a standard malondialdehyde (MDA) curve (using 1,3,3-tetramethoxypropane) ranging from 0 to 60 mM. The results were expressed in mg MDA kg^{-1} of meat.
- *pH:* measured at 25°C using a digital pH meter (Hanna - HI99163, Romania) with a penetration electrode. The equipment was calibrated at 25°C using standard buffers of pH 4.0 and 7.0.
- *Texture:* analyzed in the pre-baked samples using a Stable Micro Systems TA. HDplus (Texture Technologies Corp., Godalming, Surrey, UK) texture analyzer with a Warner-Bratzler blade, according to Honikel (1998). Measurements were performed on meat fractions cut perpendicular to the muscle fiber direction, forming rectangular pieces of 1 cm^2 in cross section.
- *Instrumental color:* after exposure to oxygen for 30 min, the CIELab color parameters were recorded using a Minolta CR-400 colorimeter (Japan) under D65 illumination, 8 mm aperture and closed cone, adjusted to the lightness (L*), redness (a*) and yellowness (b*) with a 10° angle of vision. Points were selected randomly in the loin chop. The color assessment technique was based on the standards of the National Pork Producers Council (1999) (1 = light pink to 6 = dark purple red) and the instrumental color is a direct measurement recorded for L* (a measurement from dark to light; a higher value indicates a lighter color), a* (a measurement of redness; a higher value indicates a redder color), and b* (a measurement of yellowness; a higher value indicates a yellower color) by the colorimeter equipment.
- *Cooking and dripping losses:* cooking losses (CL; %) were determined using the methodology proposed by Monteschio et al. (2019). The chops were weighed and wrapped in aluminum foil. Each sample was cooked on a pre-heated grill (Grill press inox red, Philco SA, Brazil) monitored by an internal thermocouple (Incoterm, 145 mm, Incoterm LTDA, Brazil), at 200°C until the internal temperature reached 72°C. Then, the sample was removed from the heat and left at room temperature. After reaching 25°C, each chop was weighed, and the cooking loss was calculated as the percentage difference in weight before and after cooking (Equation 1):

$$CL = \left(\frac{\text{Fresh weight} - \text{Post cooking weight}}{\text{Fresh weight}}\right) \times 100$$

Drip losses (DL; %) were measured using the method described by Honikel (1998). First, a 2.5 cm chop was weighed, wrapped in a polyamide/polyethylene bag, and suspended from a hook. Then, it was refrigerated at 4 ± 1°C. After 24, 48, and 72 hours, the refrigerated sample was removed from the bag and weighed again. The drip amount was expressed as a percentage of the water lost from the initial weight (Equation 2).

$$DL = \left(\frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}}\right) \times 100$$

Performance data were analyzed for the presence of outliers (intra-pen) and subjected to a Shapiro-Wilk normality test. Any values identified as outliers were removed from the database. Subsequently, analysis of variance (ANOVA) was performed following a completely randomized design in a 2 × 2 factorial arrangement, with two dietary treatments (Control and Postbiotic) and two sexes (female and male). The average IBW of animals in each pen was included as a covariate in the statistical model. The independent effects of the factors and their interactions were tested. When the tested effects were significant, the means were considered distinct based on the ANOVA F-test.

Meat attributes were analyzed by ANOVA following a completely randomized design in a 2 x 3 factorial arrangement, with two dietary treatments and three shelf exposure periods (1, 3, and 7 days). The variables were analyzed without removing outliers. The independent effects of the factors and their interactions were tested. When the dietary treatment effect was significant, means were considered different based on the ANOVA F-test. When the period of shelf exposure effect was significant, means were compared by Tukey's test.

All statistical analyses were carried out using the Statistical Analysis System software, version 9.0 (SAS, 2002), and a significance level of 0.05 was adopted.

Results and discussion

The performance results were similar between the Control and Postbiotic groups (Table 3). However, males had greater FBW (137.74 kg), ADG (1.120 kg day^{-1}), and better FCR (2.18 kg feed kg^{-1} gain). These results were expected because, even though they were immunocastrated, the males have a different growth curve and gain more weight during the finishing phase. Moreover, the results align with the optimal performance standards for pigs on Brazilian pig farms (Andretta et al., 2018). This indicates that the inclusion of postbiotics in feed did not negatively affect performance of the animals.

Yeast-based postbiotics enhance reproductive performance, growth of progeny, and growth of nursery and growing pigs in diets for gestating sows, lactating sows, nursery pigs, and growing finishing pigs, respectively (Duarte & Kim, 2022). Maintenance or improvement in productivity may result from the modulation of intestinal microbiota provided by the postbiotic. Two main mechanisms through which postbiotics provide benefits are modulation of the immune system and improvement of intestinal barrier function (Liu et al., 2023b). In addition to these mechanisms, postbiotics can stimulate mucus production (Kim et al., 2019) and positively change the microbiome. In the current study, the similar performance results between treatments (Table 3) is probably due to the low challenge imposed on the animals on the experimental farm.

Table 3. Performance of pigs in the growing and finishing phases with feed containing the postbiotic of *Saccharomyces cerevisiae* fermentation product.

Variable[I]	Sex	Diet		Mean	SEM[II]	*P*-value		
		Control	Postbiotic			Diet	Sex	Diet x Sex
IBW (kg)	Female	27.17	26.44	26.81	0.24	0.564	0.980	0.421
	Male	26.73	26.86	26.80				
	Mean	26.95	26.65	26.80				
FBW (kg)	Female	131.23	132.84	132.04[b]	0.93	0.124	< 0.001	0.898
	Male	136.80	138.69	137.74[a]				
	Mean	134.02	135.76	134.89				
ADG (kg d^{-1})	Female	1.055	1.071	1.063[b]	0.001	0.120	< 0.001	0.889
	Male	1.111	1.130	1.12[a]				
	Mean	1.083	1.101	1.092				

ADFI (kg d^{-1})	Female	2.497	2.481	2.489	0.018	0.517	0.110	0.907
	Male	2.451	2.428	2.440				
	Mean	2.474	2.455	2.465				
FCR (kg kg^{-1} gain)	Female	2.37	2.32	2.34[a]	0.03	0.149	< 0.001	0.963
	Male	2.21	2.15	2.18[b]				
	Mean	2.29	2.23	2.26				
FBW adjusted for 101 days (kg)	Female	133.35	134.98	134.16[b]	0.95	0.125	< 0.001	0.897
	Male	139.02	140.95	139.98[a]				
	Mean	136.18	137.96	137.07				

[I]IBW: initial body weight; FBW: final body weight; ADG: average daily gain; ADFI: average daily feed intake; FCR: feed conversion ratio. [II]SEM: standard error of the mean. Means, in the same column, followed by different lowercase letters, are significantly different by F-test ($P < 0.05$).

Taking into account the data on carcass traits (Table 4), it was verified that animals that received the yeast-based postbiotic had greater loin depth and lean meat content ($P < 0.05$) than those that received the Control diet, regardless of sex. Loin depth increased by 3.84%, and lean meat increased by 1.68% in animals fed the postbiotic diet. This can be explained by the positive effect that postbiotic has on pork meat composition (Lian et al., 2024), as previously mentioned. Moreover, an independent effect of sex was found for loin depth, with higher values observed in females. In this case, loin depth increased by 6.85% in females.

Table 4. Carcass traits of pigs fed feed containing the postbiotic of *Saccharomyces cerevisiae* fermentation product.

Variable	Sex	Diet		Mean	SEM[I]	*P*-value		
		Control	Postbiotic			Diet	Sex	Diet x Sex
Hot carcass weight (kg)	Female	96.96	96.10	96.53	0.51	0.763	0.371	0.274
	Male	96.74	98.23	97.48				
	Mean	96.85	97.16	97.01				
Carcass yield (%)	Female	72.16	71.80	71.98	0.30	0.757	< 0.001	0.407
	Male	69.64	69.80	69.72				
	Mean	70.90	70.80	70.85				
Backfat thickness (mm)	Female	16.0	15.0	15.5	0.3	0.160	0.237	0.836
	Male	15.1	14.4	14.8				
	Mean	15.6	14.7	15.1				
Loin depth (mm)	Female	67.5	69.6	68.6[A]	0.8	0.034	0.001	0.695
	Male	62.7	65.7	64.2[B]				
	Mean	65.1[b]	67.6[a]	66.4				
Lean meat (%)	Female	57.38	58.36	57.87	0.19	0.011	0.326	0.953
	Male	57.06	58.00	57.53				
	Mean	57.22[b]	58.18[a]	57.70				

[I]SEM: standard error of the mean. Means, in the same column, followed by different uppercase letters, differ for sex, whereas means in the same row, followed by different lowercase letters, differ for diet by F-test ($P < 0.05$).

There was no interaction between diet and shelf exposure period ($P > 0.05$) on the meat quality parameters (Table 5). However, the results regarding meat quality show that adding the yeast-based postbiotic to the diet affected lipid oxidation (TBARS), pH, NPPC color, and the a* color parameter ($P < 0.05$). Additionally, texture after cooking, L and b parameters, and cooking and dripping losses were not affected ($P > 0.05$) by diet.

Animals supplemented with postbiotics showed less lipid oxidation, a lower pH, a lower score for NPPC color, and a higher a* parameter value than animals fed the Control diet (Table 5). For the shelf exposure period, significant effects were observed ($P < 0.05$) on TBARS, pH, and the L*, a*, and b* parameters, and cooking and dripping losses. Over the exposure period, TBARS values increased, with the highest oxidation observed at the end of seven days. Initially, the pH was higher, decreasing and stabilizing from the third day to the end of the exposure period. Color parameters (L*, a*, and b*) and drip loss increased gradually, reaching the highest values at seven days of exposure.

Supplementing pigs with yeast-based postbiotics favors meat preservation by maintaining attractive color, minimizing red discoloration, and slowing lipid oxidation. This positive effect is attributed to the modulation of inflammatory processes and reduction of oxidative processes promoted by postbiotic in the animals (Kim & Duarte, 2021; Liu et al., 2023b; Pujari & Banerjee, 2021).

Variations in L*, a*, and b* are frequently associated with changes in the content of oxymyoglobin and metamyoglobin (Vidal et al., 2022). According to Dávila-Ramírez et al. (2020), decreased redness is related to metamyoglobin formation and meat discoloration. In this study, the redness parameter remained higher in meat samples from animals fed yeast-based postbiotics, which may indicate less degradation of oxymyoglobin during storage.

Table 5. Meat quality of pigs fed feed containing the postbiotic of *Saccharomyces cerevisiae* fermentation product.

Variable[I]	Diet		Shelf exposure (days)			SEM[II]	*P*-value[III]		
	Control	Postbiotic	1	3	7		Diet	Exp	Diet x Exp
TBARS	0.721[a]	0.645[b]	0.544[C]	0.675[B]	0.831[A]	0.013	0.004	< 0.001	0.065
pH	5.61[a]	5.45[b]	5.64[A]	5.47[B]	5.49[B]	0.01	< 0.001	< 0.001	0.803
$Texture_{post\ cooking}$	6.06	5.73	6.21	5.81	5.67	0.12	0.166	0.175	0.669
Color NPPC	3.34[a]	3.17[b]	3.22	3.15	3.40	0.04	0.043	0.054	0.354
L*	46.98	46.80	43.80[C]	46.67[B]	50.20[A]	0.44	0.833	< 0.001	0.329
a*	-2.40[b]	-2.17[a]	-2.94[B]	-2.06[A]	-1.85[A]	0.06	0.039	< 0.001	0.395
b*	4.29	4.47	3.89[C]	4,40[AB]	4.87[A]	0.10	0.388	< 0.001	0.374
CL	28.55	29.17	32.86[A]	27.53[B]	26.34[B]	0.68	0.650	< 0.001	0.122
			Exposure (hours)						
			24	48	72				
DL	3.93	3.98	2.68[C]	4.01[B]	5.19[A]	0.19	0.877	< 0.001	0.896

[I]TBARS – Thiobarbituric acid reactive substances (mg of MDA kg^{-1} of meat); Texture after cooking - shear force in kgf cm^{-2}; Color NPPC - based on NPPC standards (1999) (1 = light pink to 6 = dark purple red); L*- measurement from dark to light (a higher value indicates a lighter color); a*- measure of redness (a higher value indicates a redder color); b*- measure of yellow (a higher value indicates a yellower color); CL - % cooking loss; DL - % drip loss. [II]SEM: standard error of the mean. [III]Diet: dietary treatment effect; Exp: shelf exposure period effect; Diet x Exp: interaction between dietary treatment and shelf exposure period. Means, in the same row, followed by different lowercase letters are significantly different (P < 0.05) by F-test, and means, in the same row, followed by different uppercase letters are significantly different by Tukey test (P < 0.05).

Cooking loss decreased with shelf exposure period, with lower values at the end of the exposure period (Table 5). At *post mortem*, increased lactic acid formation and decreased pH are responsible for muscle protein denaturation and solubility loss as pH approaches its isoelectric point (pI = 5.2 – 5.3), as well as decreased water retention capacity (Missotten et al., 2015). When the pH is above the pI, the proteins have a negative global charge, which causes the filaments to repel each other and create more space for water molecules. Consequently, the meat's capacity to retain water increases (Zuniga et al., 2024; Yoo et al., 2018). This fact was confirmed in this study.

It is well known that fermented feed (e.g., *Saccharomyces cerevisiae*) positively influences the sensory quality of pork, as well as its chemical-physical features, such as marbling scores, water-holding capacity, meat color, shear force, and the abundance of flavor substances (Li, 2017; Lian et al., 2024 and Liu et al., 2023b). These traits are generally related to meat quality and consumer acceptability worldwide (Lian et al., 2024).

The most widely accepted hypothesis to explain this phenomenon is that fermented feed, such as yeast sources, increases the binding of myoglobin and iron to muscle fibers, thereby improving meat color, tenderness, and water-holding capacity (Lian et al., 2024; Liu et al., 2023b). This suggests that regulating specific metabolites can positively impact pork quality when fermented feed is included in diets for pigs.

Furthermore, the microorganisms present in fermented feed produce substances responsible for special flavor properties, such as lactic acid, acetic acid, and ethanol. These substances can alter the flavor of pork (Hao et al., 2020). Some probiotics with antioxidant capacity, such as *Lactobacillus,* small peptides, and antioxidant enzymes found in fermented feed, can enhance the pork's antioxidant capacity, resulting in a fresher appearance and longer shelf life (Czech et al., 2022).

Hao et al. (2020) evaluated the effects of feeding fermented mixed feed (FMF) on growth performance, meat quality, muscle fatty acid profiles, and antioxidant ability in finishing pigs. They found that dietary FMF supplementation improved growth performance in finishing pigs. Furthermore, pigs fed FMF diets exhibited improved carcass performance, meat quality parameters (such as higher intramuscular fat, better fatty acid profile, and greater antioxidant activities in *Longissimus dorsi*), and proportions of unsaturated fatty acids, as well as enhanced antioxidant ability, compared to those fed unsupplemented diets. These results are similar to those found in this study.

Similar performance response to Hao et al. (2020) was also reported by Zuniga et al. (2024), who assessed the impact of adding a *Lactobacillus*-based probiotic (LPr) and a *Bifidobacterium*-based postbiotic (BPo) to the diet during the nursery phase. They found higher ADFI and villus height/crypt depth, suggesting that these fermented products can improve animal performance by modulating their overall health. In the present study, however, animals were only evaluated during the growing and finishing phases.

Many studies have been conducted on fermented/postbiotic products for pigs, but not all of them conclude that they directly affect pork quality (Lian et al., 2024; Price et al., 2010; Xu et al., 2019). These studies, including this one, have provided new insights into the extensification of the application of fermented feed and postbiotics in pig diets.

In summary, fermented products and postbiotic additives have been proven to be a viable alternative for feeding strategies and industrial production plans that focus on nutritional strategies in one-stage or full-cycle diets. Ultimately, consumers are concerned not only about how animals are raised but also about the nutritional value, flavor, and overall quality of pork. Thus, these alternatives are well-suited for application in the swine industry.

Conclusion

Supplementing the feed of growing and finishing pigs with the yeast-based postbiotic maintained zootechnical performance within normal production standards and improved pork quality. These results demonstrate that postbiotics can be used as a feasible tool in swine farms, making the production process more sustainable.

Data availability

Does not applicable.

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