Effects of Lactobacillus delbrueckii on Carcass Traits and Meat Quality in Finishing Pigs: Postprint

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Abstract

This study aimed to investigate the effects of dietary supplementation with Lactobacillus delbrueckii in antibiotic-free diets on carcass traits, meat quality, and nutrient composition of the longissimus dorsi muscle in finishing pigs. A total of 120 healthy "Duroc × (Landrace × Large White)" finishing pigs with an average body weight of (65.34±3.64) kg were selected and randomly divided into 2 groups, with 6 replicates per group and 10 pigs per replicate (half barrows and half gilts). The control group was fed an antibiotic-free basal diet, while the experimental group was fed the antibiotic-free basal diet supplemented with 0.1% Lactobacillus delbrueckii. The experimental period lasted 42 days. The results showed that there was no significant difference in carcass traits between the two groups of finishing pigs ($P>0.05$); compared with the control group, the spleen weight ratio and pancreas weight ratio of finishing pigs in the experimental group were significantly increased ($P<0.05$); there was no significant difference in meat quality between the two groups at 45 min post-mortem ($P>0.05$); at 24 h post-mortem, compared with the control group, the yellowness (b* value) of meat from finishing pigs in the experimental group was significantly increased ($P<0.05$), and the shear force was significantly decreased ($P<0.05$); compared with the control group, the contents of glycine, alanine, and flavor amino acids in the longissimus dorsi muscle of finishing pigs in the experimental group were significantly increased ($P<0.05$), the contents of capric acid and palmitic acid were significantly decreased ($P<0.05$), and the contents of palmitoleic acid, linoleic acid, and polyunsaturated fatty acids were significantly increased ($P<0.05$). These results suggest that supplementation of 0.1% Lactobacillus delbrueckii in antibiotic-free diets has certain improving effects on carcass traits, meat quality, and nutrient composition in finishing pigs.

Full Text

Effects of Lactobacillus delbrueckii on Carcass Traits and Meat Quality of Fattening Pigs

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Abstract: This study investigated the effects of dietary *Lactobacillus delbrueckii* supplementation on carcass traits, meat quality, and nutrient composition of the longissimus dorsi muscle in finishing pigs. A total of 120 healthy "Duroc × (Landrace × Yorkshire)" finishing pigs with an average body weight of (65.34±3.64) kg were randomly allocated to two groups, each consisting of six replicates with ten pigs per replicate (half male and half female). The control group received a basal diet without antibiotics, while the experimental group received the same basal diet supplemented with 0.1% *Lactobacillus delbrueckii*. The feeding trial lasted 42 days. The results showed no significant differences in carcass traits between the two groups (P>0.05). Compared with the control group, the experimental group exhibited significantly increased spleen weight rate and pancreatic weight rate (P<0.05). At 45 minutes post-slaughter, no significant differences in meat quality were observed between groups (P>0.05). However, at 24 hours post-slaughter, the experimental group showed significantly higher meat yellowness (P<0.05) and significantly lower shear force (P<0.05) compared to the control group. Additionally, the experimental group demonstrated significantly elevated contents of glycine, alanine, and flavor amino acids in the longissimus dorsi (P<0.05), significantly decreased decanoic acid and palmitic acid contents (P<0.05), and significantly increased palmitoleic acid, linoleic acid, and polyunsaturated fatty acid contents (P<0.05). These findings suggest that supplementation of 0.1% *Lactobacillus delbrueckii* in antibiotic-free diets can improve carcass traits, meat quality, and nutrient composition in finishing pigs.

Keywords: *Lactobacillus delbrueckii*; finishing pigs; carcass traits; meat quality; nutrient composition

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The addition of feed antibiotics to animal diets promotes growth and prevents disease, but their use has led to serious concerns including bacterial resistance, gene mutation, cross-infection, compromised immunity in livestock, and drug residues in animal products and the environment, all of which threaten human health. Consequently, researchers have been actively seeking safe, effective, and environmentally friendly alternatives, with probiotic preparations, particularly those based on *Lactobacillus*, emerging as a major focus. Numerous studies have demonstrated that oral administration or dietary supplementation with single *Lactobacillus* preparations can promote growth and prevent diarrhea in livestock and poultry. Our research group previously found that *Lactobacillus delbrueckii* as a probiotic preparation showed promising growth-promoting and anti-diarrheal effects in piglets. However, research on its application in growing-finishing pigs remains limited, and studies on its effects on meat quality are particularly scarce. Therefore, this experiment was designed to investigate the impact of dietary *L. delbrueckii* supplementation on carcass traits, meat quality, and longissimus dorsi nutrient composition in finishing pigs, providing a viable approach for antibiotic-free production and a theoretical basis for developing antibiotic-free pork.

1.1 Experimental Material

The *Lactobacillus delbrueckii* strain was screened by the Functional Microbiology Laboratory of Hunan Agricultural University' s College of Animal Science and Technology, and identified and preserved by the China Center for Type Culture Collection (preservation number M207096). After activation, the strain was sent to the Beijing Academy of Food Sciences for microencapsulation into a powder preparation (viable count 1.01×10 CFU/g).

1.2 Experimental Diets

The experiment utilized a corn-soybean meal basal diet formulated according to the nutrient requirements for finishing pigs (60–110 kg) recommended by NRC (1998). The diet was prepared as powder without antibiotics. The composition and nutrient levels of the basal diet are presented in Table 1.

Composition and nutrient levels of the basal diet (air-dry basis)

Ingredients	Content	Nutrient levels[2])	Content
Corn		Metabolic energy (ME)/(MJ/kg)	
Soybean meal		Crude protein (CP)	
Wheat bran		Calcium (Ca)	
Soybean oil		Total phosphorus (TP)	
Calcium hydrogen phosphate (CaHPO)		Available phosphorus (AP)	
Salt (NaCl)		Lysine (Lys)	
Limestone		Methionine + Cystine (Met+Cys)	
Premix[1])		Threonine (Thr)	
Total		Tryptophan (Trp)	

[1]) The premix provided the following per kg of diet: VA 2,512 IU, VD 1,200 IU, VE 34 IU, VK 1.5 mg, VB 17.6 g, riboflavin 2.5 mg, pantothenic acid 6.8 mg, nicotinic acid 20.3 mg, choline chloride 351 mg, Mn 10 mg, Fe 50 mg, Zn 50 mg, Cu 20 mg, I 0.3 mg, Se 0.3 mg.
[2]) Nutrient levels were calculated values.

1.3 Experimental Design and Management

The feeding trial was conducted at the Youxian Wangling Fourth Prison District Original Breeding Pig Farm in Hunan Province. One hundred twenty healthy "Duroc × (Landrace × Yorkshire)" finishing pigs with an average body weight of (65.34±3.64) kg were randomly divided into two groups, each comprising six replicates of ten pigs (half male and half female). The pigs were housed in pens with cement slatted floors at a stocking density of 1.544 m^2 per pig. The control group received the antibiotic-free basal diet, while the experimental group received the basal diet supplemented with 0.1% *Lactobacillus delbrueckii*. The trial lasted 42 days. During the experiment, pigs were fed twice daily with ad libitum access to feed and water. Other management and immunization procedures followed the farm' s standard practices. At the end of the 42-day trial [average body weight (91.62±4.03) kg], one pig with body weight close to the replicate average was selected from each replicate, fasted for 24 hours, and slaughtered to determine carcass traits and body component ratios. The semispinalis capitis and longissimus dorsi muscles were collected for meat quality evaluation. The left half-carcass longissimus dorsi was sampled (100 g) from the same anatomical location, sealed in plastic bags, and stored at -20°C for subsequent nutrient analysis.

1.4 Measurement Methods

1.4.1 Carcass Traits Carcass weight, dressing percentage, backfat thickness, skin thickness, and carcass length were measured according to the "Technical Regulations for Performance Testing of Lean-type Breeding Pigs" (GB 8467-1987). Lean meat percentage and loin eye area were determined using the methods described by Wu Liyang and Li Rui et al.

Lean meat percentage (%) = 76.58 - 0.13X - 1.65X , where X is live weight before slaughter (kg) and X is average backfat thickness (cm).

Loin eye area (cm^2) was calculated by weight method after tracing the loin eye 轮廓 on tracing paper with a pencil.

1.4.2 Body Component Ratios Body component ratios (%) represent the percentage of head, hooves, heart, liver, lungs, spleen, kidneys, and pancreas relative to live weight before slaughter. Leaf fat rate was calculated as: Leaf fat rate (%) = 100 × leaf fat weight / carcass weight.

1.4.3 Meat Quality Following the method of Chen Runsheng, semispinalis capitis and longissimus dorsi samples were stored at 4°C, and meat quality parameters including muscle pH and color were measured at 45 minutes and 24 hours post-slaughter. A testo 205 pH meter, PY-1 compression meter, C-LM3B digital muscle tenderness meter, and CR-400 colorimeter were used to determine pH, water-holding capacity, shear force, and meat color, respectively.

Meat color and marbling scores were evaluated according to the 5-point scale of the American NPPC color plate (1991 edition).

1.4.4 Longissimus Dorsi Nutrient Analysis Longissimus dorsi samples were thawed from -20°C storage, sliced, placed in stainless steel trays, and freeze-dried for 24 hours using an FD-1A-50 vacuum freeze dryer (Shanghai Haozhuang) at (10±5) Pa and -(45±5)°C. The freeze-dried samples were then ground for analysis. Crude protein and intramuscular fat contents were determined using the Kjeldahl and Soxhlet extraction methods, respectively. Amino acid and fatty acid contents were measured following the method of Bai Meijuan et al.

Amino acids: Approximately 0.5 g of freeze-dried meat powder was weighed into a hydrolysis tube, mixed with 10 mL of 6 mol/L HCl, sealed, and digested at 110°C for 24 hours. The digest was transferred to a 100 mL volumetric flask and brought to volume. A 5 mL aliquot was further diluted to 50 mL, and 2 mL of this solution was filtered through a 0.45 m membrane. Amino acid content was determined using a Hitachi L-8800 automatic amino acid analyzer, and the final muscle content was calculated by multiplying by the dilution factor.

Fatty acids: Approximately 0.5 g of freeze-dried meat powder was placed in a 10 mL stoppered test tube, extracted with 2 mL petroleum ether-ethyl ether (1:1 v/v) for 24 hours, then esterified with 2 mL KOH-methanol solution (0.004 mol/mL) at 50°C for 30 minutes. After adding 2 mL distilled water for phase separation, 5 L of the upper layer was analyzed using an Agilent 5890 gas chromatograph to determine individual fatty acid components.

1.5 Statistical Analysis

All data were analyzed using SPSS 17.0 software with t-tests. Results are expressed as "mean ± standard deviation," with $P<0.05$ considered statistically significant.

2.1 Effects of *Lactobacillus delbrueckii* on Carcass Traits of Finishing Pigs

As shown in Table 2, no significant differences were observed in pre-slaughter live weight between the two groups ($P>0.05$). Compared with the control group, the experimental group showed numerical improvements in dressing percentage (1.96%), lean meat percentage (0.69%), body slanting length (3.28%), and loin eye area (3.11%), along with reductions in carcass weight (0.07%), body straight length (0.53%), backfat thickness (4.93%), and skin thickness (3.70%), though none of these differences reached statistical significance ($P>0.05$).

Effects of *Lactobacillus delbrueckii* on carcass traits of fattening pigs (n=12)

Items	Control group	Experimental group	P-value
Slaughter weight/kg	104.50±4.56	102.50±3.18	
Carcass weight/kg	73.42±3.93	73.37±1.01	
Dressing percentage/%	70.25±1.74	71.63±2.21	
Lean meat percentage/%	59.65±1.04	60.06±0.80	
Body straight length/cm	94.17±6.50	93.67±1.15	
Body slanting length/cm	81.17±5.38	83.83±2.71	
Backfat thickness/cm	2.03±0.47	1.93±0.33	
Skin thickness/cm	0.27±0.05	0.26±0.03	
Loin eye area/cm²	57.19±10.09	58.97±4.23	

In the same row, values with the same or no letter superscripts indicate no significant difference (P>0.05), while different lowercase letters indicate significant difference (P<0.05). The same applies below.

2.2 Effects of ***Lactobacillus delbrueckii*** on Body Component Ratios of Finishing Pigs

As shown in Table 3, compared with the control group, the experimental group showed numerical reductions in head weight rate (0.65%), hoof weight rate (6.15%), leaf fat rate (5.98%), and kidney weight rate (5.26%), though these differences were not statistically significant (P>0.05). However, spleen weight rate and pancreatic weight rate were significantly increased by 22.73% and 22.22%, respectively (P<0.05). Heart weight rate, liver weight rate, and lung weight rate showed numerical increases of 10.20%, 5.31%, and 7.94%, respectively, but these differences were not significant (P>0.05).

Effects of *Lactobacillus delbrueckii* on body composition rate of fattening pigs (n=12), %

Items	Control group	Experimental group	P-value
Head weight rate	6.20±0.45	6.16±0.40	
Hoof weight rate	2.44±0.20	2.29±0.20	
Leaf fat rate	1.17±0.33	1.10±0.24	
Heart weight rate	0.49±0.05	0.54±0.08	
Liver weight rate	2.07±0.17	2.18±0.19	
Spleen weight rate	0.22±0.04	0.27±0.05	<0.05
Lung weight rate	1.26±0.18	1.36±0.33	
Kidney weight rate	0.38±0.03	0.36±0.03	
Pancreatic weight rate	0.18±0.02	0.22±0.08	<0.05

2.3 Effects of *Lactobacillus delbrueckii* on Meat Quality of Finishing Pigs

As shown in Table 4, at 45 minutes post-slaughter, the experimental group showed numerical improvements in redness (a*, 2.37%), yellowness (b*, 0.28%), meat color score (5.11%), pH (1.52%), pH (0.47%), and water-holding capacity (0.21%) compared to the control group, while lightness (L*) decreased by 1.65%; however, none of these differences were statistically significant (P>0.05). At 24 hours post-slaughter, the experimental group exhibited significantly higher yellowness (23.38%, P<0.05) and numerical increases in redness (5.14%), meat color score (0.71%), pH (0.98%), and pH (1.62%). Conversely, lightness (0.63%), marbling score (2.46%), water-holding capacity (8.66%), and shear force (10.00%) were numerically lower, with the reduction in shear force reaching statistical significance (P<0.05).

Effects of *Lactobacillus delbrueckii* on meat quality of fattening pigs

Items	Control group	Experimental group	P-value
45 min after slaughter			
Lightness (L*)	43.15±1.18	42.44±0.90	
Redness (a*)	4.64±0.47	4.75±0.72	
Yellowness (b*)	3.51±0.37	3.52±0.55	
Meat color	3.33±0.26	3.50±0.00	
Marbling	3.42±0.20	3.42±0.20	
pH	6.56±0.16	6.66±0.19	
pH	6.44±0.10	6.47±0.12	
Water-holding capacity/%	23.49±3.83	23.54±2.97	
24 h after slaughter			
Lightness (L*)	49.02±3.12	48.71±3.28	
Redness (a*)	6.42±1.69	6.75±1.34	
Yellowness (b*)	4.79±1.00	5.91±0.75	<0.05
Meat color	3.00±0.00	3.08±0.20	
Marbling	3.25±0.27	3.17±0.26	
pH	6.12±0.44	6.18±0.36	
pH	5.65±0.20	5.69±0.13	
Water-holding capacity/%	3.58±0.48	3.27±0.48	
Shear force/N	34.31±2.83	30.88±3.74	<0.05

pH represents pH of semispinalis capitis; pH represents pH of longissimus dorsi. Sample size was 12 for meat color and marbling. For lightness, yellowness, redness, pH, and water-holding capacity, each sample had three subsamples, resulting in 12×3=36 subsamples. For shear force, each sample had ten subsamples, resulting in 12×10=120 subsamples.

2.4 Effects of *Lactobacillus delbrueckii* on Nutrient Composition of Longissimus Dorsi in Finishing Pigs

As shown in Table 5, no significant differences were observed in crude protein and intramuscular fat contents of longissimus dorsi between the two groups (P>0.05). Compared with the control group, the experimental group showed a numerical increase in crude protein content (0.19%) and a numerical decrease in intramuscular fat content (0.39%).

Effects of *Lactobacillus delbrueckii* on CP and intramuscular fat contents of longissimus dorsi of fattening pigs (n=24), %

Items	Control group	Experimental group	P-value
Crude protein (CP)	79.57±2.28	79.72±2.20	
Intramuscular fat	7.80±0.52	7.77±0.82	

As shown in Table 6, significant differences were found in glycine, alanine, and flavor amino acid contents between groups (P<0.05), while other amino acids showed no significant differences (P>0.05). The experimental group exhibited numerical increases in aspartic acid (0.96%), threonine (0.36%), serine (2.82%), glutamic acid (2.54%), glycine (21.48%), alanine (5.54%), cysteine (1.71%), isoleucine (1.54%), leucine (4.12%), tyrosine (1.67%), phenylalanine (2.95%), lysine (2.99%), histidine (4.36%), arginine (1.64%), proline (4.41%), essential amino acids (2.04%), flavor amino acids (5.13%), and total amino acids (3.31%), while valine content decreased by 1.19%.

Effects of *Lactobacillus delbrueckii* on amino acid composition of longissimus dorsi of fattening pigs (n=24), %

Items	Control group	Experimental group	P-value
Asp[1]	6.22±0.56	6.28±0.45	
Thr[2]	2.74±0.91	2.75±0.27	
Ser	2.84±0.78	2.92±0.45	
Glu[1]	9.45±0.69	9.69±0.73	
Gly[1]	2.98±0.78	3.62±0.36	<0.05
Ala[1]	3.97±0.21	4.19±0.32	<0.05
Cys	2.33±0.19	2.37±0.22	
Val[2]	3.37±0.41	3.33±0.23	
Met[2]	1.87±0.48	1.87±0.34	
Ile[2]	3.24±0.23	3.29±0.30	
Leu[2]	6.30±0.62	6.56±0.38	
Tyr	2.39±0.57	2.43±0.17	
Phe[2]	3.05±0.10	3.14±0.20	
Lys[2]	5.36±0.86	5.52±0.76	
His	4.59±0.37	4.79±0.78	

Items	Control group	Experimental group	P-value
Arg	4.26±0.36	4.33±0.34	
Pro	2.72±0.64	2.84±0.51	
Essential amino acids (EAA)	25.93±1.21	26.46±2.02	
Flavor amino acids (FAA)	22.62±1.03	23.78±1.56	<0.05
Total amino acids (TAA)	67.68±3.24	69.92±2.66	

[1]) Flavor amino acids. [2]) Essential amino acids.

As shown in Table 7, significant differences were observed in decanoic acid, palmitic acid, palmitoleic acid, linoleic acid, and polyunsaturated fatty acid contents ($P<0.05$). Compared with the control group, the experimental group showed decreased decanoic acid (6.67%) and palmitic acid (4.88%) contents, and increased palmitoleic acid (6.84%), linoleic acid (28.48%), and polyunsaturated fatty acid (24.44%) contents. Other fatty acids showed no significant differences ($P>0.05$).

Effects of *Lactobacillus delbrueckii* on fatty acid composition of longissimus dorsi of fattening pigs (n=24), %

Items	Control group	Experimental group	P-value
Decanoic acid (C10:0)	0.15±0.03	0.14±0.01	<0.05
Lauric acid (C12:0)	0.13±0.01	0.11±0.01	
Myristic acid (C14:0)	1.47±0.14	1.36±0.15	
Pentadecanoic acid (C15:0)	0.11±0.02	0.08±0.02	
Palmitic acid (C16:0)	24.37±1.66	23.18±0.46	<0.05
Palmitoleic acid (C16:1)	3.07±0.84	3.28±0.17	<0.05
Daturic acid (C17:0)	0.44±0.04	0.34±0.03	
Cis-heptadecenoic acid (C17:1)	0.70±0.20	0.63±0.16	
Stearic acid (C18:0)	12.96±1.00	12.20±0.66	
Oleic acid (C18:1)	43.53±2.25	42.37±1.35	
Linoleic acid (C18:2)	11.20±3.57	14.39±0.72	<0.05
Linolenic acid (C18:3)	0.87±0.08	0.74±0.07	
Cis-eicosenoic acid (C20:1)	0.46±0.14	0.62±0.15	
Cis-eicosadienoic acid (C20:2)	0.53±0.06	0.55±0.05	
Saturated fatty acids	39.63±2.66	37.42±1.01	
Monounsaturated fatty acids	47.77±1.75	46.90±1.44	
Polyunsaturated fatty acids	12.60±3.55	15.68±0.76	<0.05
Unsaturated fatty acids	60.37±2.66	62.58±1.01	

3.1 Effects of *Lactobacillus delbrueckii* on Carcass Traits and Body Component Ratios

In this study, the experimental group showed improved dressing percentage and lean meat percentage compared to the control group. These parameters partially reflect animal growth and slaughter performance, consistent with previous findings by Li Rui et al. that dietary supplementation with 0.1% *L. delbrueckii* improved growth performance in finishing pigs. Research indicates that loin eye area positively correlates with carcass lean percentage, while backfat thickness shows significant or highly significant negative correlations with lean percentage and loin eye area. The increased loin eye area and lean meat percentage coupled with decreased backfat thickness in the experimental group suggest that *L. delbrueckii* supplementation can improve carcass leanness. Additionally, with similar pre-slaughter live weights, the experimental group showed decreasing trends in head weight rate, hoof weight rate, leaf fat rate, and kidney weight rate, further indicating improved carcass traits. The reduced leaf fat rate suggests that *L. delbrueckii* may regulate body fat deposition. Sharifi et al. reported that probiotic supplementation (containing 3.09×10^{1} CFU/g *L. delbrueckii*) in high-fat broiler diets reduced fat digestibility and body fat deposition while decreasing body weight, possibly related to energy metabolism regulation by intestinal probiotics.

Visceral organ weights and indices partially reflect animal physiological status. The spleen, containing abundant lymphocytes and macrophages, is the largest immune organ and plays a crucial role in humoral and cellular immunity. The pancreas secretes various digestive enzymes and is vital for digestion, while the liver and kidneys are important metabolic organs. Under normal physiological conditions, increased relative weights of these organs reflect enhanced immune, digestive, and metabolic functions. In this study, the experimental group showed significantly increased spleen and pancreatic weight rates, with heart, liver, and lung weight rates also showing upward trends. The significant elevation in spleen and pancreatic weight rates may be attributed to *L. delbrueckii* colonization in the gut, which modulates immunity and promotes nutrient digestion and absorption. Previous studies by Li Rui et al. and Gong Yu demonstrated that *L. delbrueckii* improved immune function and metabolism in suckling piglets, promoting their growth. These results collectively indicate that dietary *L. delbrueckii* supplementation can improve carcass traits while enhancing metabolic, immune, and digestive functions in finishing pigs.

3.2 Effects of *Lactobacillus delbrueckii* on Meat Quality

Numerous studies have shown that dietary *Lactobacillus* supplementation in finishing pigs can improve muscle pH and color, reduce drip loss and cooking loss, enhance water-holding capacity, decrease shear force, improve tenderness, and modulate nutrient content, thereby improving carcass and meat quality. *Lactobacillus* colonization produces beneficial metabolites such as lactic acid, reduces intestinal pH, inhibits pathogen growth, and maintains microecological balance. The various digestive enzymes produced during growth and reproduction promote nutrient digestion and utilization, while beneficial bacterial colonization reduces undigested nutrients entering the hindgut for fermentation, thereby increasing nutrient absorption. These mechanisms can alter the animal' s nutritional composition and affect meat quality. In this study, dietary supplementation with 0.1% *L. delbrueckii* increased meat yellowness and decreased shear force at 24 hours post-slaughter, improving tenderness. These results align with previous reports on meat quality improvement by *Lactobacillus* preparations. The beneficial effects of *L. delbrueckii* on pork quality may be related to these mechanisms. Furthermore, previous research indicated that 0.1% *L. delbrueckii* supplementation improved intestinal morphology, promoted nutrient digestion, absorption, and metabolism, reduced bile acid reabsorption in the gut, interfered with enterohepatic circulation to regulate lipid metabolism, and enhanced antioxidant capacity, all of which provide support for its meat quality improvement effects.

3.3 Effects of *Lactobacillus delbrueckii* on Nutrient Composition of Longissimus Dorsi

Previous studies demonstrated that dietary *Lactobacillus* supplementation can improve muscle nutrient composition. Sun Jianguang reported that *Lactobacillus fermentum* increased linoleic acid, eicosadienoic acid, arachidonic acid, and total polyunsaturated fatty acids in finishing pig muscle. Wu Liyang found that feeding pigs a microecological preparation containing *Lactobacillus* from weaning to slaughter increased essential amino acids, flavor amino acids, total amino acids, stearic acid, eicosadienoic acid, and monounsaturated fatty acids, though crude protein and fat contents remained unchanged. In this study, *L. delbrueckii* supplementation did not significantly affect crude protein and intramuscular fat contents but increased flavor amino acids and unsaturated fatty acids. Research has shown that intestinal microbiota plays an important role in regulating nutrient digestion, absorption, and metabolism, which affects nutrient content in blood and deposition in tissues. Cao Weina et al. reported that *Lactobacillus* can produce various digestive enzymes, vitamins, and amino acids, potentially influencing nutrient partitioning through neuroendocrine systems and related functional gene expression, thereby altering body nutrient composition. Hou Gaifeng found that 0.1% *L. delbrueckii* supplementation improved blood lipid profiles and reduced subcutaneous fat deposition in finishing pigs. Muscle nutrient composition and content significantly affect meat quality characteristics and reflect nutrient utilization and deposition. Amino acid and fatty acid composition are closely related to meat quality—higher contents of flavor amino acids and unsaturated fatty acids improve meat flavor, aroma, tenderness, and juiciness. Tenderness, an important indicator of meat palatability, reflects protein structural characteristics, fat distribution, and intramuscular fat content. These findings provide a basis for explaining how *L. delbrueckii* improves meat tenderness and quality.

In conclusion, dietary supplementation with 0.1% *Lactobacillus delbrueckii* can improve carcass traits, meat quality, and nutrient composition in finishing pigs, offering a viable strategy for antibiotic-free pork production.

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Note: Figure translations are in progress. See original paper for figures.