Effects of Saccharomyces cerevisiae Culture on Growth Performance, Apparent Nutrient Utilization, and Intestinal Microflora in 817 Broiler Chickens (Postprint)

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Abstract

This experiment aimed to investigate the effects of Saccharomyces cerevisiae culture (SC) on growth performance, nutrient apparent utilization, and intestinal microflora of 817 broiler chickens. A total of 600 1-day-old 817 broiler chickens with similar body weight were selected and randomly divided into 5 groups, with 6 replicates per group and 20 birds per replicate. The control group was fed a basal diet, the antibiotic group was supplemented with 20 mg/kg colistin sulfate + 2.6 mg/kg flavomycin in the basal diet, and experimental groups I, II, and III were supplemented with 2,500, 5,000, and 7,500 mg/kg SC in the basal diet, respectively; the experimental period was 60 days. The results showed: 1) During days 1-21, the average daily gain (ADG) and average daily feed intake (ADFI) of experimental groups II and III were significantly higher than those of the control group ($P<0.05$), with no significant difference from the antibiotic group ($P>0.05$); during the two phases of days 22-60 and days 1-60, the ADG of experimental group II was significantly higher than that of the control group ($P<0.05$), and the ADFI was significantly higher than that of the antibiotic group ($P<0.05$); during days 22-60, the feed-to-gain ratio and mortality rate of the three experimental groups showed no significant difference compared with the control group ($P>0.05$), but exhibited a decreasing trend during days 1-60 ($0.05 P<0.10$). 2) Experimental groups II and III significantly improved the apparent utilization of total phosphorus compared with the control group ($P<0.05$); there was no significant difference in the apparent utilization of crude protein and calcium among all groups ($P>0.05$). 3) Compared with

the control group, the number of Escherichia coli in the cecum of experimental group I was significantly reduced (P<0.05), with no significant difference from the antibiotic group (P>0.05); the number of Lactobacillus in the cecum of experimental group II and the number of Bifidobacterium in the jejunum of experimental group III were significantly higher than those of the control and antibiotic groups (P<0.05). Thus, dietary supplementation with appropriate levels of SC can increase ADFI and ADG, improve feed-to-gain ratio, enhance the utilization of total phosphorus in the diet, promote the proliferation of Lactobacillus and Bifidobacterium, and inhibit the proliferation of Escherichia coli in 817 broiler chickens; when the SC supplementation level was 5,000 mg/kg, the growth-promoting effect was optimal and superior to that of antibiotics.

Full Text

Effects of Saccharomyces cerevisiae Culture on Growth Performance, Apparent Nutrient Utilization, and Intestinal Microflora in 817 Broiler Chickens

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Abstract: This experiment was conducted to investigate the effects of Saccharomyces cerevisiae culture (SC) on growth performance, apparent nutrient utilization, and intestinal microflora in 817 broiler chickens. A total of 600 one-day-old 817 broiler chickens with similar body weight were randomly allocated into 5 groups with 6 replicates per group and 20 birds per replicate. The control group was fed a basal diet, the antibiotic group received the basal diet supplemented with 20 mg/kg colistin sulfate + 2.6 mg/kg flavomycin, and trial groups I, II, and III received the basal diet supplemented with 2,500, 5,000, and 7,500 mg/kg SC, respectively. The experimental period lasted 60 days. The results showed: 1) During days 1-21, the average daily gain (ADG) and average daily feed intake (ADFI) in trial groups II and III were significantly higher than those in the control group (P<0.05), with no significant differences compared to the antibiotic group (P>0.05). During days 22-60 and 1-60, ADG in trial group II was significantly higher than that in the control group (P<0.05), while ADFI was significantly higher than that in the antibiotic group (P<0.05). During days 22-60, feed-to-gain ratio (F/G) and mortality among the three trial groups showed no significant differences compared to the control group (P>0.05), but exhibited a decreasing trend during days 1-60 (0.05 P<0.10). 2) Trial groups II and III significantly improved apparent total phosphorus utilization compared to the control group (P<0.05). No significant differences were observed among groups in apparent utilization of crude protein or cal-

cium (P>0.05). 3) Compared with the control group, trial group I significantly reduced cecal Escherichia coli counts (P<0.05), with no significant difference from the antibiotic group (P>0.05). Trial group II significantly increased cecal Lactobacillus counts, and trial group III significantly increased jejunal Bifidobacterium counts, both compared to the control and antibiotic groups (P<0.05). In conclusion, dietary supplementation with appropriate levels of SC can increase ADFI and ADG, improve F/G, enhance total phosphorus utilization, promote proliferation of Lactobacillus and Bifidobacterium, and inhibit E. coli growth in 817 broiler chickens. The optimal supplementation level of SC is 5,000 mg/kg, which demonstrates superior growth-promoting effects compared to antibiotics.

Keywords: Saccharomyces cerevisiae culture; growth performance; apparent nutrient utilization; microflora; 817 broiler chicken

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In recent years, the irrational use of antibiotics has led to numerous problems including animal teratogenesis and carcinogenesis, drug residues in animal products, and environmental pollution, posing serious threats to food safety and human health. Following the implementation of the new Food Safety Law in 2009, greater attention has been paid to food safety, and the use of feed antibiotics—previously crucial for maintaining animal health and improving production performance—has been subjected to stricter control. This has exposed livestock and poultry to increased risks of intestinal diseases, metabolic disorders, and viral infections. Consequently, there is an urgent need to seek green and safe antibiotic alternatives to ensure healthy livestock production. Numerous studies have demonstrated that feed additives such as probiotics, prebiotics, microecological preparations, organic acids, plant extracts, and yeast culture can effectively reduce or replace the use of feed antibiotics. Saccharomyces cerevisiae culture (SC) is a yeast fermentation product rich in yeast cells and their active components, nutritional metabolites, specific nutrient media, flavoring substances, and unknown growth factors, produced under specific fermentation conditions. Research has shown that yeast culture can improve production performance, feed conversion efficiency, intestinal microbial balance, and immune function in cattle, sheep, pigs, and Arbor Acres (AA) broiler chickens, while also enhancing immune organ indices and Newcastle disease antibody titers and improving egg quality in laying hens. However, few studies have investigated its application in local small-scale broiler chickens.

The 817 hybrid broiler chicken is a locally distinctive small-sized meat-type chicken breed, developed by crossing fast-growing white-feathered broilers with commercial brown-shell laying hens. Due to its relatively longer feeding period and superior meat quality that aligns with Chinese culinary preferences, it has become the primary broiler breed for producing braised and roasted chicken products in regions such as Shandong and Henan provinces. This study utilized 817 broiler chickens as experimental subjects to investigate the effects of different SC supplementation levels compared with antibiotics on growth performance, apparent nutrient utilization, and intestinal microflora, aiming to

identify the optimal supplementation level and provide theoretical support for further practical application of SC.

1.1 Experimental Material

The SC was provided by Henan Yihong Shancheng Biotechnology Co., Ltd., with main nutritional components as follows: crude protein 25.6%, small peptides 0.59%, total amino acids 23.97%, mannan 1.78%, total acids 81.64 g/kg, and protease activity 27,000 U/kg.

1.2 Experimental Animals and Design

A total of 600 healthy one-day-old 817 broiler chickens were randomly divided into 5 groups with 6 replicates per group and 20 birds per replicate. The groups showed no significant differences in initial body weight (P>0.05). The control group was fed a basal diet formulated as a powdered complete feed according to NRC (1994) nutrient requirements. The basal diet composition and nutrient levels are shown in Table 1 . The antibiotic group received the basal diet supplemented with 20 mg/kg colistin sulfate + 2.6 mg/kg flavomycin. Trial groups I, II, and III received the basal diet supplemented with 2,500, 5,000, and 7,500 mg/kg SC, respectively. Broilers were housed in three-tier vertical cages with manual temperature control, natural lighting supplemented with artificial light, and relative humidity maintained at 50%-60%. Birds had ad libitum access to feed and water, while other immunization, disinfection, and management procedures followed conventional farm protocols.

Table 1 Composition and nutrient levels of basal diets (air-dry basis) %

Items	1-21 days of age	22-60 days of age
Ingredients		
Corn		
Flour		
Lard oil		
Soybean meal		
Cottonseed meal		
DDGS		
Corn protein meal		
CaHPO		
Limestone		
NaCl		
L-Lys		
DL-Met		
L-Thr		
NaHCO		
Premix[1])		
Total		

Items	1–21 days of age	22–60 days of age
Nutrient levels²)		
ME (MJ/kg)		
Crude protein (CP)		
Calcium (Ca)		
Available phosphorus (AP)		
Lysine (Lys)		
Methionine (Met)		
Threonine (Thr)		

[1]) The premix for 1–21 days of age provided per kilogram of diet: VA 12,600 IU, VD 3,360 IU, VE 28 mg, VK 2.24 mg, VB 2.24 mg, VB 8.4 mg, VB 3.36 mg, VB 0.028 mg, D-pantothenic acid 11.2 mg, nicotinic acid 42 mg, folic acid 1.12 mg, D-biotin 0.14 mg, choline 1.2 mg, Zn 72 mg, Fe 76 mg, Cu 7.2 mg, Mn 80 mg, I 0.56 mg, Se 0.24 mg. The premix for 22–60 days of age provided per kilogram of diet: VA 10,350 IU, VD 2,760 IU, VE 23 mg, VK 1.84 mg, VB 1.84 mg, VB 6.9 mg, VB 2.76 mg, VB 0.023 mg, D-pantothenic acid 9.2 mg, nicotinic acid 34.5 mg, folic acid 0.92 mg, D-biotin 0.115 mg, choline 1 mg, Zn 72 mg, Fe 76 mg, Cu 7.2 mg, Mn 80 mg, I 0.56 mg, Se 0.24 mg. [2]) Crude protein and calcium were measured values, while others were calculated values.

1.4.1 Growth Performance

During the feeding trial, feed consumption and mortality were recorded weekly by replicate. Body weight was measured after fasting on day 22 and day 61 (the day after trial completion) to calculate average daily feed intake (ADFI, g/d), average daily gain (ADG, g/d), feed-to-gain ratio (F/G), and mortality rate. Mortality (%) = 100 × number of dead broilers / total number of experimental broilers.

1.4.2 Apparent Nutrient Utilization

On day 35 of the feeding trial, two healthy broilers with similar body weight were randomly selected from each replicate and housed individually for a total fecal collection metabolism trial. At 08:00 on day 35, the metabolic broilers were fasted to eliminate intestinal chyme effects, with free access to water and unchanged other conditions. At 08:00 on day 37, each metabolic broiler was force-fed 50 g of the original diet, and excreta were collected by replicate at 08:00, 12:00, and 18:00 (with careful removal of feathers and debris). After collection, 10 mL of 10% hydrochloric acid was added per 100 g of excreta, which was then immediately stored at -20°C. After 48 h of collection, excreta were thawed, mixed uniformly, dried to constant weight at 65°C, equilibrated at room temperature for 24 h, weighed, ground to pass through a 40-mesh sieve, and sealed in bags for subsequent determination of crude protein, calcium, and total phosphorus content.

Crude protein, calcium, and total phosphorus were determined according to GB/T-6432-1994, GB/T-6436-2002, and GB/T-6437-2002, respectively. Apparent nutrient utilization was calculated as follows: Apparent nutrient utilization (%) = 100 × (nutrient intake - nutrient content in excreta) / nutrient intake.

1.4.3 Microflora Analysis

On day 61, one broiler from each replicate was randomly selected, euthanized by carotid artery bleeding, and immediately dissected to remove the intestines. The jejunum and cecum were isolated, and 2.0 cm segments were aseptically excised from the midpoint of each section and sent to the laboratory for plate counting. All procedures followed microbial operation protocols. Preliminary trials determined optimal dilutions of 1×10 –1×10 for E. coli, and 1×10 ^{3}–1×10 for both Lactobacillus and Bifidobacterium. E. coli was cultured on eosin methylene blue agar at 37°C for 24 h; Lactobacillus and Bifidobacterium were cultured on MRS medium and modified MRS medium, respectively, under anaerobic conditions at 37°C for 36 h. Plates with 30–300 colonies were counted, and results were expressed as log colony-forming units per gram (lg CFU/g).

1.5 Data Processing and Statistical Analysis

Raw data from each replicate were processed using Excel 2003. SPSS 17.0 software was used for one-way ANOVA, followed by Duncan' s multiple comparison tests. Differences were considered significant at $P<0.05$, while $0.05 P<0.10$ was considered a trend toward improvement or reduction. Results are presented as mean ± standard deviation (mean±SD).

2.1 Effects of SC on Growth Performance of 817 Broiler Chickens

As shown in Table 2 , during days 1–21, ADG, ADFI, and body weight at day 21 in trial groups II and III were significantly higher than those in the control group and trial group I ($P<0.05$), with no significant differences compared to the antibiotic group ($P>0.05$). For F/G, trial groups II and III were significantly lower than trial group I ($P<0.05$), but did not differ significantly from the control or antibiotic groups ($P>0.05$). Compared with the control group, mortality in the other four groups showed no significant changes ($P>0.05$), but exhibited a decreasing trend.

During days 22–60, ADG and body weight at day 60 in trial group II were significantly higher than those in the control group ($P<0.05$), with no significant differences compared to the antibiotic group ($P>0.05$). ADFI in trial group II was significantly higher than that in the antibiotic group and trial group I ($P<0.05$). No significant differences were observed in F/G or mortality among different groups ($P>0.05$).

During days 1–60, ADG and ADFI in trial group II were significantly higher

than those in the control, antibiotic, and trial group I (P<0.05), with no significant differences compared to trial group III (P>0.05). Compared with the control group, F/G and mortality in other groups showed decreasing trends (0.05 P<0.10), with trial group II showing the lowest mortality. The antibiotic group had the lowest F/G, with the ranking: antibiotic group < trial group II < trial group I < trial group III < control group.

Table 2 Effects of SC on growth performance of broiler chickens

Days of age	Items	Control group	Antibiotics group	Trial group I	Trial group II	Trial group III
1-21	Body weight (g)	39.03±1.38	39.10±1.39	39.03±1.42	39.08±1.47	39.00±1.58
	ADG (g)	6.34±0.37	8.61±1.86	6.46±0.58	9.29±1.40	9.39±1.59
	ADFI (g)	13.52±1.17	16.70±2.19	14.10±0.91	18.12±1.79	17.76±2.14
	F/G	2.13±0.11	1.98±0.24	2.19±0.08	1.96±0.12	1.92±0.23
	Mortality (%)	6.67±5.16	1.67±4.08	1.67±4.08	1.67±4.08	3.33±6.06
22-60	ADG (g)	30.24±2.08	31.14±1.53	31.20±2.86	33.69±1.03	31.83±2.39
	ADFI (g)	69.41±3.19	67.50±6.06	68.12±3.94	74.77±4.11	71.77±3.76
	F/G	2.30±0.11	2.17±0.14	2.20±0.18	2.22±0.08	2.26±0.07
	Mortality (%)	8.15±4.79	7.59±8.18	5.28±6.87	2.59±4.26	5.92±3.89
1-60	ADG (g)	21.74±1.34	23.12±1.49	22.39±1.82	25.01±1.04	23.84±1.90
	ADFI (g)	48.27±2.20	48.33±3.90	47.73±2.62	53.06±3.19	51.29±3.36
	F/G	2.22±0.10	2.09±0.10	2.14±0.16	2.12±0.07	2.15±0.07
	Mortality (%)	14.17±8.01	9.17±8.61	6.67±9.83	4.17±6.65	9.17±4.92

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

2.2 Effects of SC on Apparent Nutrient Utilization in 817 Broiler Chickens

As shown in Table 3 , the three trial groups exhibited higher apparent utilization of crude protein and calcium compared to the antibiotic and control groups,

but without significant differences (P>0.05). Crude protein apparent utilization increased by 2.63%, 1.56%, and 7.43% compared to the control group, while calcium apparent utilization increased by 16.28%, 16.35%, and 19.31% compared to the antibiotic group. Apparent total phosphorus utilization increased with increasing SC supplementation levels. Trial groups II and III showed significantly higher total phosphorus apparent utilization than the control group (P<0.05), with increases compared to trial group I and the antibiotic group, though these differences were not significant (P>0.05).

Table 3 Effects of SC on apparent nutrient utilization in broiler chickens %

Items	Control group	Antibiotics group	Trial group I	Trial group II	Trial group III
Crude protein	46.30±4.00	43.51±13.18	47.52±7.36	47.02±4.77	49.74±21.21
Calcium	42.93±3.02	45.26±14.07	52.63±11.30	52.66±9.76	54.00±16.58
Total phosphorus	68.87±7.29	78.40±3.37	80.88±1.96	82.91±4.21	90.36±3.41

2.3 Effects of SC on Intestinal Microflora in 817 Broiler Chickens

As shown in Table 4 , in the jejunum, dietary SC supplementation at different levels had no significant effect on E. coli or Lactobacillus counts compared to the control group (P>0.05). Trial group II showed the lowest E. coli count, while trial group I showed the highest Lactobacillus count. Trial group III significantly increased Bifidobacterium counts compared to the control and antibiotic groups (P<0.05), with no significant differences compared to trial groups I and II (P>0.05).

In the cecum, trial group I showed significantly lower E. coli counts than the control group (P<0.05), with no significant differences from the antibiotic group or trial groups II and III (P>0.05). Trial group II exhibited significantly higher Lactobacillus counts than the control, antibiotic, and trial group I (P<0.05), with no significant difference from trial group III (P>0.05). Trial group II showed the greatest increase in Bifidobacterium counts, though this was not significantly different from the other four groups (P>0.05). Trial group II demonstrated the best effects in inhibiting E. coli and promoting Lactobacillus and Bifidobacterium, superior to the antibiotic group.

Table 4 Effects of SC on intestinal microflora of broiler chickens lg(CFU/g)

Tissues	Items	Control group	Antibiotics group	Trial group I	Trial group II	Trial group III
Jejunum	E. coli	5.56±0.35	5.41±0.42	5.22±0.55	4.95±0.78	5.31±0.56
	Lactobacillus	5.62±0.34	5.74±0.47	5.90±0.12	5.77±0.43	5.80±0.45
	Bifidobacterium	4.47±0.13	4.56±0.42	4.84±0.51	5.05±0.40	5.39±0.38
Cecum	E. coli	5.86±0.19	5.40±0.34	5.37±0.37	5.56±0.23	5.61±0.48
	Lactobacillus	5.15±0.37	5.32±0.31	5.64±0.05	6.55±0.08	6.52±0.22
	Bifidobacterium	5.68±0.28	5.57±0.61	6.00±0.49	6.10±0.57	5.91±0.29

3.1 Effects of SC on Growth Performance of 817 Broiler Chickens

Yeast culture is rich in various substances including proteins, nucleotides, oligosaccharides (-glucan and mannan oligosaccharides), flavoring compounds, aromatic substances, enzymes, and unknown growth factors, providing abundant nutrients for animal growth and development. Studies have shown that yeast culture can increase body weight gain in broiler chickens, significantly improve ADG and F/G, and enhance calcium and phosphorus utilization in AA broilers, while also alleviating growth performance decline in cyclosporine-treated AA broilers. Afsharmanesh et al. reported that adding 2% SC to wet wheat-soybean meal-based diets significantly increased ADG in Ross 308 broilers during days 1–42. Xiao et al. found that dietary supplementation with 0.20% and 0.25% yeast culture significantly increased ADG and ADFI in broiler chickens, with no significant differences in F/G among groups—results largely consistent with our findings. Our study demonstrated that SC supplementation significantly increased ADG and ADFI in broiler chickens, with some improvement in overall F/G and mortality, though not reaching significance and showing no significant differences compared to the antibiotic group. This may be attributed to the aromatic alcohols and lipids, as well as flavor-enhancing nucleotides and polypeptides in SC, which substantially improve diet palatability and increase feed intake, thereby enhancing body weight gain. However, research results on yeast culture in broiler chickens have been inconsistent. Ghosh et al. reported that Saccharomyces cerevisiae and its cell wall components (YCW) could replace antibiotics to increase feed intake and body weight gain in Ross 308 broilers, consistent with our finding that during days 1–21, ADG and ADFI in trial group II and the antibiotic group were significantly higher than in the control group with no significant difference between them. In contrast, Zhou and Sun found that yeast culture supplementation did not significantly increase ADFI or ADG compared to the control group, a discrepancy likely due to variations in fermentation strains and production processes resulting in different SC compositions. Additionally, Zhang et al. observed that during weeks 1–3, SC and YCW supplementation

had no significant effect on body weight gain in Ross broilers compared to the control, while during weeks 4–5, both SC and YCW groups showed significantly higher body weight gain, indicating that the effects of yeast culture on broiler performance are closely related to physiological stage.

3.2 Effects of SC on Apparent Nutrient Utilization in 817 Broiler Chickens

SC contains abundant nutrients and unknown growth-promoting factors that can improve animal performance and nutrient utilization. Studies have shown that yeast culture can significantly promote nutrient absorption and metabolism in laying hens, increasing utilization of gross energy, protein, and fat, while also improving calcium and phosphorus absorption for eggshell formation. Gao reported that yeast culture supplementation in broiler diets significantly improved digestion and utilization of crude protein, calcium, and total phosphorus, reducing nutrient waste. Our results showed that SC supplementation had no significant effect on apparent utilization of crude protein or calcium, but significantly increased apparent total phosphorus utilization compared to the control group. Yu obtained similar results in AA broilers, finding that yeast culture significantly improved apparent phosphorus utilization. The exact mechanism by which SC enhances nutrient utilization remains unclear, but it may be related to functional peptides and amino acids that increase feed intake, as well as vitamins and phytase present in SC. As SC supplementation levels increase, dietary vitamin and phytase content also increase, leading to higher phosphorus utilization. Additionally, certain growth-promoting factors in SC may contribute to this effect, though further investigation is needed to elucidate the specific mechanisms.

3.3 Effects of SC on Intestinal Microflora in 817 Broiler Chickens

The animal intestine is a crucial site for nutrient digestion and absorption, harboring a microbiota primarily composed of E. coli, Lactobacillus, Bifidobacterium, and Streptococcus. This self-stabilizing ecosystem is intimately related to animal nutrition, health, and immunity. The cecum contains the most abundant intestinal microorganisms, while the jejunum (after the duodenum) is the primary site for protein, carbohydrate, and lipid absorption. Studying the composition and population of microorganisms in these regions is significant for preventing and controlling intestinal diseases in livestock and poultry. Research has shown that Saccharomyces cerevisiae, particularly mannan oligosaccharides in its cell wall, can stimulate D-mannose-rich receptors in the intestine that adhere to Gram-negative bacteria with fimbriae, such as Salmonella. Both mannan oligosaccharides and glucans can stimulate linear increases in intestinal mucin secretion, which competes with glycoproteins on the intestinal epithelium for binding to bacterial lectins, thereby reducing Salmonella colonization and harmful bacterial populations to promote intestinal health—a conclusion

confirmed by Spring et al. Furthermore, the amino acids, glucose, vitamins, and organic acids in SC can provide nutrients for gastrointestinal microorganisms, accelerate microbial metabolism, and inhibit harmful bacteria through organic acids while promoting beneficial bacteria such as Lactobacillus and cellulolytic bacteria, thereby enhancing digestion and nutrient utilization. Afsharmanesh et al. reported that SC supplementation in wheat-based diets reduced ileal E. coli counts and decreased pH, creating an acidic gastrointestinal environment that reduces proliferation of acid-sensitive pathogens and zoonotic bacteria to optimize intestinal microflora structure. In our study, SC rich in lactic acid, acetic acid, and citric acid effectively reduced jejunal and cecal pH and modulated bacterial populations. The 7,500 mg/kg SC group significantly increased jejunal Bifidobacterium counts and decreased E. coli counts to some extent, while trial groups II and III showed significantly higher cecal Lactobacillus counts compared to the control and antibiotic groups, with increased Bifidobacterium counts. These results are consistent with Xiao et al.' s findings on yeast culture effects on microflora in 1–21-day-old AA broilers.

Crumplen et al. proposed that SC improves animal performance by increasing vitamin absorption, enhancing enzyme secretion, and improving protein metabolism. Ghosh et al. suggested that SC improves F/G in Ross 308 broilers through YCW-mediated reduction in feed intake and provides higher antibody titers against Newcastle disease virus, thereby enhancing immunity and performance. Wang et al. attributed improved performance to -glucan and mannan in yeast cell walls improving intestinal mucosal immunity and enhancing nutrient absorption capacity. Our study suggests that the growth-promoting mechanism of SC likely involves multiple synergistic pathways, and further molecular mechanism studies are warranted to verify its specific modes of action.

Under our experimental conditions, the optimal dietary SC supplementation level was 5,000 mg/kg, which significantly increased ADFI and ADG in 817 broiler chickens with superior feeding effects compared to the antibiotic group. This level also significantly improved total phosphorus utilization and inhibited E. coli while optimally promoting Lactobacillus and Bifidobacterium growth, effectively modulating intestinal microflora composition and promoting animal growth.

References

[1] HUYGHEBAERT G, DUCATELLE R, VAN IMMERSEEL F, et al. An update on alternatives to antimicrobial growth promoters for broilers[J]. The Veterinary Journal, 2011, 187(2): 182–188.

[2] GAGGÌA F, MATTARELLI P, BIAVATI B. Probiotics and prebiotics in animal feeding for safe food production[J]. International Journal of Food Microbiology, 2010, 141(Suppl.): S15–S28.

[3] ZHOU L, DING X M, LUO Y H, et al. Effects of compound acidifier and microecological preparation on performance, blood biochemical indices, antiox-

idant indices, and Salmonella infection in laying hens[J]. Chinese Journal of Animal Nutrition, 2016, 28(8): 2571-2580.

[4] BAGAL V L, KHATTA V K, TEWATIA B S, et al. Relative efficacy of organic acids and antibiotics as growth promoters in broiler chicken[J]. Veterinary World, 2016, 9(4): 377-382.

[5] MA M Y, HU G L, CUI Z A, et al. Effects of saccharicterpenin and yeast culture on growth performance and immune organs of chicks[J]. China Animal Husbandry & Veterinary Medicine, 2007, 34(1): 37-39.

[6] GAO J, ZHANG H J, YU S H, et al. Effects of yeast culture in broiler diets on performance and immunomodulatory functions[J]. Poultry Science, 2008, 87(7): 1377-1384.

[7] SHEN Y B, PIAO X S, KIM S W, et al. Effects of yeast culture supplementation on growth performance, intestinal health, and immune response of nursery pigs[J]. Journal of Animal Science, 2009, 87(8): 2614-2624.

[8] RONG B H. Effects of yeast culture on performance and immune function of broiler chickens[D]. Master' s thesis. Changchun: Jilin Agricultural University, 2015: 16-24.

[9] TITI H H, DMOUR R O, ABDULLAH A Y. Growth performance and carcass characteristics of Awassi lambs and Shami goat kids fed yeast culture in their finishing diet[J]. Animal Feed Science and Technology, 2008, 142(1/2): 33-43.

[10] SUN M J, LIU C J, ZHANG Y G, et al. Effects of direct-fed yeast culture on rumen fermentation in dairy cows[J]. Chinese Journal of Animal Nutrition, 2010, 22(5): 1390-1395.

[11] ZHANG A Z, LU D X, LIU D C, et al. Effects of yeast culture on immune indices in cashmere goats[J]. Chinese Journal of Animal Nutrition, 2008, 20(2): 163-169.

[12] LIU G Z, ZHAO G X, AN S Y, et al. Effects of yeast culture on performance, intestinal wall structure, and immune function in layer chicks[J]. Shandong Poultry, 2004(10): 10-13.

[13] WU S G, LIU Z B, QI G H, et al. Effects of yeast culture on performance and egg quality of laying hens[J]. Chinese Journal of Animal Nutrition, 2010, 22(2): 365-371.

[14] LIU L R, HUA J, WANG X X, et al. Effects of antimicrobial peptides on blood immune indices and intestinal microflora in male layer chicks[J]. Chinese Journal of Animal Nutrition, 2012, 24(9): 1812-1818.

[15] WANG D M. Study on the effects of yeast culture on digestion and immune regulation in broilers[D]. Master' s thesis. Changchun: Jilin Agricultural University, 2007: 1-10.

[16] GAO J. Effects and mechanisms of yeast culture on broiler chickens[D]. PhD thesis. Beijing: Chinese Academy of Agricultural Sciences, 2008: 24-40.

[17] ZHANG S J, LIAO B L, LI X, et al. Effects of yeast cell walls on performance and immune responses of cyclosporine A-treated, immunosuppressed broiler chickens[J]. British Journal of Nutrition, 2012, 107(6): 858-866.

[18] AFSHARMANESH M, BARANI M, SILVERSIDES F G. Evaluation of wet-feeding wheat-based diets containing Saccharomyces cerevisiae to broiler chickens[J]. British Poultry Science, 2010, 51(6): 776-783.

[19] XIAO M, GAO Z H, LI X H, et al. Effects of yeast culture on growth performance, intestinal mucosal structure, and intestinal microflora in broiler chickens[J]. Chinese Journal of Animal Nutrition, 2013, 25(7): 1624-1631.

[20] GHOSH T K, HALDAR S, BEDFORD M R, et al. Assessment of yeast cell wall as replacements for antibiotic growth promoters in broiler diets: effects on performance, intestinal histo-morphology, and humoral immune responses[J]. Journal of Animal Physiology and Animal Nutrition, 2012, 96(2): 275-284.

[21] ZHOU S Q, SUN W Z. Study on effects of yeast culture and antibiotics on growth performance and immune function in broiler chickens[J]. Animal Husbandry & Veterinary Medicine, 2004, 36(11): 9-11.

[22] BROOKS P H, BEAL J D, NIVEN S, et al. Liquid feeding of pigs. . Potential for improving pig health and food safety[J]. Animal Science Papers and Reports, 2003, 21(Suppl. 1): 23-29.

[23] MORALES-LÓPEZ R, AUCLAIR E, VAN IMMERSEEL F, et al. Effects of different yeast cell wall supplements added to maize- or wheat-based diets for broiler chickens[J]. British Poultry Science, 2010, 51(3): 399-408.

[24] ZHANG A W, LEE B D, LEE S K, et al. Effects of yeast (Saccharomyces cerevisiae) cell components on growth performance, meat quality, and ileal mucosa development of broiler chicks[J]. Poultry Science, 2005, 84(7): 1015-1021.

[25] YU S H. Effects and metabolic mechanisms of yeast culture on broiler chicken performance[D]. Master' s thesis. Yangling: Northwest A&F University, 2008: 10-18.

[26] NI X Q, GONG J, YU H, et al. Analysis of bacterial community structure and diversity in the intestine of laying hens using PCR-DGGE technology[J]. Acta Veterinaria et Zootechnica Sinica, 2008, 39(7): 955-961.

[27] BAURHOO B, GOLDFLUS F, ZHAO X. Purified cell wall of Saccharomyces cerevisiae increases protection against intestinal pathogens in broiler chickens[J]. International Journal of Poultry Science, 2009, 8(2): 133-137.

[28] SPRING P, WENK C, DAWSON K A, et al. The effects of dietary mannaoligosaccharides on cecal parameters and the concentrations of enteric bacteria in the ceca of salmonella-challenged broiler chicks[J]. Poultry Science, 2000, 79(2): 205-211.

[29] KEMME P A, JONGBLOED A W, MROZ Z, et al. Digestibility of nutrients in growing-finishing pigs is affected by Aspergillus niger phytase, phytate and lactic acid levels: 1. Apparent ileal digestibility of amino acids[J]. Livestock Production Science, 1999, 58(2): 107-117.

[30] CRUMPLEN R, D' AMORE T, PANCHAL C J, et al. Industrial uses of yeast—present and future[J]. Yeast, 1989, 5(Suppl.): 3-9.

[31] WANG B X, WANG S J, GUO C H, et al. Effects of Saccharomyces cerevisiae fermentation broth on growth performance, small intestine development, and small intestinal mucosal immune function in weaned piglets[J]. Chinese Journal of Animal Nutrition, 2016, 28(12): 294-302.

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