Effects of Distillers' Grains Yeast Culture Supplementation in Diets with Different Energy Levels on Growth Performance, Carcass Composition, and Serum Biochemical Indices in Broiler Chickens: Postprint

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Abstract

This experiment aimed to investigate the effects of adding distiller' s grains yeast culture to diets with different energy levels on growth performance, carcass composition, and serum biochemical indices in broiler chickens. A total of 350 one-day-old healthy Arbor Acres male chicks were selected and randomly divided into 5 groups: Group (basal diet, control group), Group (basal diet + 0.5% distiller's grains yeast culture), Group (basal diet + 1.0% distiller's grains yeast culture), Group (basal diet with 0.21 MJ/kg reduced metabolizable energy + 0.5% distiller' s grains yeast culture), and Group (basal diet with 0.42 MJ/kg reduced metabolizable energy + 1.0% distiller' s grains yeast culture), with 7 replicates per group and 10 birds per replicate. The experimental period lasted 42 days. The results showed: 1) The average body weight of 21-day-old broilers was lowest in the control group, slightly higher in other groups, with Group showing a marked increasing trend ($P<0.10$). Compared with the control group, the feed conversion ratio of broilers in Groups and during 22-42 days of age was improved ($P<0.10$), and the feed conversion ratio of Group during 1-42 days of age was lower than that of the control group ($P>0.05$). 2) Compared with the control group, the abdominal fat rate of broilers in Group at 21 days of age was significantly reduced ($P<0.05$), and the abdominal fat rate of broilers in Group showed a decreasing trend at both 21 and 42 days of age ($P>0.05$). 3) Dietary supplementation with distiller' s grains yeast culture had no significant effects on serum total protein, albumin, uric acid, creatinine, calcium, and phosphorus contents in broilers ($P>0.05$). 4) At 21 days of age, serum glutathione peroxidase (GSH-Px) activity was lowest in the control group and significantly lower than that in Groups and ($P<0.05$); serum superoxide

dismutase activity in all treatment groups was significantly higher than that in the control group (P<0.05), and serum total antioxidant capacity (T-AOC) in Groups and was significantly higher than that in the control group (P<0.05). At 42 days of age, serum T-AOC in all treatment groups was significantly higher than that in the control group (P<0.05). In conclusion, supplementation of 0.05%~0.10% distiller' s grains yeast culture in diets with different energy levels can increase body weight gain, improve feed conversion ratio, reduce abdominal fat rate, and enhance serum antioxidant capacity in broiler chickens.

Full Text

Effects of Dietary Yeast Culture of White Distiller's Grains in Different Energy Level Diets on Growth Performance, Carcass Composition and Serum Biochemical Indices of Broilers

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Abstract

This study investigated the effects of dietary yeast culture of white distiller' s grains (YCWDG) supplementation at different energy levels on growth performance, carcass composition, and serum biochemical indices in broilers. A total of 350 one-day-old healthy male Arbor Acres broiler chicks were randomly allocated to five groups: Group (basal diet, control), Group (basal diet + 0.5% YCWDG), Group (basal diet + 1.0% YCWDG), Group (basal diet with 0.21 MJ/kg reduced metabolizable energy + 0.5% YCWDG), and Group (basal diet with 0.42 MJ/kg reduced metabolizable energy + 1.0% YCWDG). Each group comprised 7 replicates with 10 birds per replicate. The experimental period lasted 42 days. The results showed: (1) At 21 days of age, broilers in the control group had the lowest average body weight, with other groups showing slight increases, particularly Group which exhibited a significant increasing trend (P<0.10). Compared with the control, Groups and showed improved feed-to-gain ratio (F/G) during 22–42 days of age (P<0.10), and Group had lower F/G over the entire 1–42 day period (P>0.05). (2) At 21 days of age, the abdominal fat percentage of broilers in Group was significantly lower than that of the control group (P<0.05), while Group showed a decreasing trend in abdominal fat percentage at both 21 and 42 days of age (P>0.05). (3) Dietary YCWDG supplementation had no significant effects on serum total protein, albumin, uric acid, creatinine, calcium, or phosphorus concentrations (P>0.05).

(4) At 21 days of age, the control group exhibited the lowest serum glutathione peroxidase (GSH-Px) activity, which was significantly lower than that in Groups and (P<0.05). Serum superoxide dismutase (SOD) activity in all treatment groups was significantly higher than in the control group (P<0.05), and serum total antioxidant capacity (T-AOC) in Groups and was significantly higher than in the control group (P<0.05). At 42 days of age, serum T-AOC in all treatment groups was significantly higher than in the control group (P<0.05). In conclusion, supplementation with 0.5%–1.0% YCWDG in diets with varying energy levels can increase body weight gain, improve feed efficiency, reduce abdominal fat percentage, and enhance serum antioxidant capacity in broilers.

Key words: energy; yeast culture of white distiller' s grains; growth performance; carcass composition; antioxidant ability; broiler

Introduction

The search for new green feed additives to replace or reduce antibiotic usage has become a research hotspot in animal nutrition and feed science. The development and utilization of yeast culture provides a new pathway for safe and healthy livestock production. Yeast culture of white distiller' s grains is a novel health-promoting yeast product produced through solid-state high-density cultivation of yeast inoculated on white distiller' s grains, followed by controlled autolysis, peptide enrichment, and low-temperature drying. YCWDG is rich in nutrients including proteins, amino acids, oligosaccharides, vitamins, as well as beneficial peptides, digestive enzymes, and unidentified growth factors for livestock and poultry. Yeast culture has been widely applied in pigs, cattle, sheep, laying hens, and broilers, improving animal health, enhancing anti-stress capacity, and promoting production performance. However, systematic research on the effects of this novel YCWDG on broiler growth performance and health remains limited. Particularly, since YCWDG contains various digestive enzymes and active components that can promote nutrient digestion and absorption, whether its supplementation in reduced-energy diets can promote broiler growth and the potential for dietary metabolizable energy savings have not been reported. Therefore, this study used fast-growing white-feathered broilers as experimental animals to systematically investigate the effects of YCWDG on growth performance, carcass quality, and serum biochemical indices under practical production conditions, and to further evaluate its efficacy in low-metabolizable-energy diets, thereby providing technical support for YCWDG application in broiler production.

1.1 Materials

The yeast culture of white distiller' s grains was provided by LOAD Biological Environmental Technology (Gulin) Co., Ltd. The nutritional composition (measured values) was: crude protein 24.80%, crude fat 5.85%, crude fiber 13.91%, crude ash 9.15%, moisture 10.60%, -glucan 2.20%, mannan 2.80%, and apparent

metabolizable energy for poultry 10.82 MJ/kg.

1.2 Experimental Design and Diets

A single-factor randomized design was employed. A total of 350 healthy male Arbor Acres broiler chicks were randomly divided into five groups: Group (basal diet, control), Group (basal diet + 0.5% YCWDG), Group (basal diet + 1.0% YCWDG), Group (basal diet with 0.21 MJ/kg reduced metabolizable energy + 0.5% YCWDG), and Group (basal diet with 0.42 MJ/kg reduced metabolizable energy + 1.0% YCWDG). Each group contained 7 replicates with 10 birds per replicate. The experimental design is shown in Table 1 . Diets were formulated according to the Chinese Agricultural Industry Standard (NY/T 33 –2004) "Feeding Standard of Chicken." Diet composition and nutrient levels are presented in Table 2 .

Table 1 Experimental design

Table 2 Composition and nutrient levels of diets (air-dry basis)

1.3 Management

Broilers were raised in four-tier cages (90 cm × 90 cm × 40 cm) with nipple drinkers, allowing ad libitum access to feed and water. The room temperature was maintained at 35°C for the first 3 days, then reduced by 3°C weekly until reaching a constant 24°C. Continuous 24-hour lighting (15–20 lx) was provided from 1 to 42 days of age. Throughout the experiment, management procedures followed standard protocols with routine vaccination programs.

1.4 Measurements

1.4.1 Growth Performance On days 21 and 42, birds were weighed by replicate after fasting to calculate average body weight and average daily gain (ADG). Feed consumption was recorded by replicate to determine average daily feed intake (ADFI) and feed-to-gain ratio (F/G) for the starter (1–21 days), grower (22–42 days), and overall (1–42 days) periods. Mortality was recorded daily to calculate mortality rate.

1.4.2 Carcass Composition On days 21 and 42, one broiler per replicate with body weight close to the replicate mean was selected for slaughter. Breast muscle, leg muscle, and abdominal fat were separated. Dressing percentage, breast muscle rate, leg muscle rate, and abdominal fat rate were calculated according to the "Poultry Performance Calculation Methods" of the National Poultry Breeding Commission:

- Dressing percentage (%) = 100 × eviscerated weight / pre-slaughter weight
- Breast muscle rate (%) = 100 × breast muscle weight / eviscerated weight
- Leg muscle rate (%) = 100 × leg muscle weight / eviscerated weight

- Abdominal fat rate (‰) = 1000 × abdominal fat weight / (eviscerated weight + abdominal fat weight)

Pre-slaughter weight was measured after 12 hours of feed withdrawal.

1.4.3 Meat Quality On day 42, one broiler per replicate with body weight close to the replicate mean was slaughtered. The left breast muscle was removed to determine meat quality parameters (pH, drip loss, cooking loss, and shear force) using methods described by Ma et al. [6].

1.4.4 Serum Biochemical Indices On days 21 and 42, one broiler per replicate with body weight close to the replicate mean was selected. Blood samples (5 mL) were collected from wing veins and centrifuged at 3,000 r/min for 10 minutes to obtain serum, which was stored at -20°C. Serum total protein (TP) was determined by the biuret method, albumin (ALB) by the bromocresol green method, uric acid (UA) by the uricase-peroxidase coupling method, creatinine (CREA) by the picric acid colorimetric method, calcium (Ca) by the o-cresolphthalein complexone method, and phosphorus (P) by the ferrous sulfate-phosphomolybdic acid method. Kits were purchased from Nanjing Jiancheng Bioengineering Institute and analyzed using a CHEM-5 semi-automatic biochemical analyzer.

Serum antioxidant indices: GSH-Px activity and T-AOC were measured by colorimetry, SOD activity by xanthine oxidase method, and malondialdehyde (MDA) content by thiobarbituric acid method using Nanjing Jiancheng Bioengineering Institute kits according to manufacturer instructions.

1.5 Statistical Analysis

Data were processed using Excel 2016 and analyzed by one-way ANOVA using SPSS 16.0. Duncan' s multiple comparison test was applied when significant differences were detected. Significance was declared at $P<0.05$. Results are expressed as means ± standard deviation.

Results and Analysis

2.1 Effects on Growth Performance

As shown in Table 3 , dietary YCWDG supplementation in different energy level diets did not significantly affect body weight at 21 or 42 days of age ($P>0.05$). The 21-day body weight was lowest in the control group (Group), with other groups showing slight increases ($P>0.05$), particularly Group which demonstrated a significant increasing trend ($P<0.10$). No significant differences were observed in ADG or ADFI among groups during any growth period ($P>0.05$). Compared with the control, Groups and showed improved F/G during 22-42 days of age ($P<0.10$), and Group had lower F/G over the entire 1-42 day period ($P>0.05$). Regarding mortality, Group had the lowest rate across all

growth periods, though no significant differences were detected among groups (P>0.05).

Table 3 Effects of dietary yeast culture of white distiller' s grains in different energy level diets on growth performance of broilers

2.2 Effects on Carcass Composition and Meat Quality

As shown in Table 4 , significant differences were observed in 21-day abdominal fat percentage among groups (P<0.05), while other carcass indices remained unchanged (P>0.05). At 21 days of age, Group exhibited significantly lower abdominal fat percentage compared with the control (P<0.05). Group showed a decreasing trend in abdominal fat percentage at both 21 and 42 days of age, though not statistically significant (P>0.05). Dietary YCWDG supplementation had no significant effects on meat quality parameters (pH, drip loss, cooking loss, and shear force) at market age (P>0.05).

Table 4 Effects of dietary yeast culture of white distiller' s grains in different energy level diets on carcass composition and meat quality of broilers

2.3 Effects on Serum Biochemical Indices

As shown in Table 5 , dietary YCWDG supplementation had no significant effects on serum total protein, albumin, uric acid, creatinine, calcium, or phosphorus concentrations (P>0.05). At 21 days of age, Groups and showed increasing trends in serum total protein compared with the control (P<0.10). The control group had the lowest serum calcium at 21 days and phosphorus at 42 days, while Group had the highest values, though differences were not significant (P>0.05).

Table 5 Effects of dietary yeast culture of white distiller' s grains in different energy level diets on serum biochemical indices of broilers

2.4 Effects on Serum Antioxidant Indices

As shown in Table 6 , notable differences in serum antioxidant indices were observed among groups. At 21 days of age, the control group had the lowest serum GSH-Px activity, which was significantly lower than that in Groups and (P<0.05). Serum SOD activity in all treatment groups was significantly higher than in the control group (P<0.01), with Group showing the highest value. Serum T-AOC in Groups and was significantly higher than in the control group at 21 days of age (P<0.01). At 42 days of age, T-AOC in all treatment groups was significantly higher than in the control group (P<0.01). No significant differences in serum MDA content were detected among groups (P>0.05).

Table 6 Effects of dietary yeast culture of white distiller' s grains in different energy level diets on serum antioxidant indices of broilers

Discussion

3.1 Effects on Growth Performance

Yeast culture, primarily composed of yeast cell metabolites and fermented culture medium, is a novel microecological additive that improves feed palatability and digestibility, enhances animal immunity, and promotes healthy growth. Wu et al. [7] reported that dietary yeast culture supplementation improved laying rate and average egg weight while reducing mortality in laying hens. Supplementing diets of Hy-Line brown male chicks with 2.5% and 5.0% yeast culture increased ADG, significantly reduced F/G, and improved survival rate [8]. Xiao [9] demonstrated that yeast culture significantly increased ADG and ADFI in broilers, with 0.15% and 0.20% supplementation increasing intestinal villus height and reducing crypt depth. Consistent with these findings, the present study showed that dietary supplementation with 0.5% and 1.0% YCWDG increased body weight gain and improved feed conversion efficiency in broilers. Moreover, YCWDG supplementation in low-energy diets also improved growth performance, achieving comparable results to normal-energy diets, suggesting potential application value for low-energy broiler diets supplemented with 0.5%–1.0% YCWDG. The growth-promoting mechanism remains unclear, but based on current results and previous reports, YCWDG may provide essential nutrients (vitamins, minerals, organic acids, peptides, and oligosaccharides) while nourishing intestinal microorganisms and regulating gut microbial balance. Active yeast cells consume oxygen in the intestine, promoting anaerobic microbial growth and reducing free radical production, thereby alleviating oxidative damage and maintaining intestinal mucosal integrity to facilitate broiler growth [10]. However, the specific active components responsible for these functions and their synergistic effects require further investigation. In this study, all experimental birds remained healthy without disease symptoms, and YCWDG supplementation reduced mortality, consistent with Guo and Zhang [5], confirming that YCWDG can enhance broiler constitution and anti-stress capacity.

3.2 Effects on Carcass Composition and Meat Quality

Detailed research on yeast culture effects on poultry carcass composition and meat quality is limited. In this experiment, YCWDG had no significant effects on dressing percentage, breast muscle rate, or leg muscle rate, indicating no special role in muscle yield. However, the low-energy YCWDG group showed significantly lower abdominal fat percentage at 21 days compared with the high-energy group, and all YCWDG groups had lower abdominal fat percentage than the control at 42 days. This aligns with previous findings that yeast culture reduced serum triglyceride and low-density lipoprotein concentrations in broilers [9], suggesting YCWDG may regulate lipid metabolism. pH, water-holding capacity, and shear force are important meat quality indicators reflecting taste, tenderness, color, and nutritional value. Yu [10] reported that yeast culture reduced shear force and drip loss in broiler meat, indicating improved meat quality. However, the present study found no significant effects of YCWDG on breast

muscle pH, drip loss, cooking loss, or shear force at market age. Under these experimental conditions, YCWDG did not affect meat quality, which may be related to animal physiological status, dietary nutrition levels, and environmental factors. Therefore, further research is needed to evaluate YCWDG effects on meat quality under different conditions.

3.3 Effects on Serum Biochemical Indices

No significant differences in serum total protein, albumin, uric acid, or creatinine concentrations were observed among groups, indicating that YCWDG does not affect protein metabolism during broiler development. The slight increase in serum total protein in YCWDG groups is similar to previous reports of yeast culture significantly increasing serum total protein in broilers [8]. Serum calcium and phosphorus concentrations reflect mineral nutritional status. In this study, no significant differences in serum calcium were detected among groups, though YCWDG increased serum phosphorus. This is consistent with Liu et al. [11], who reported that yeast culture increased serum phosphorus but not calcium in layer chicks. Additionally, studies have shown that dietary yeast culture increased apparent phosphorus digestibility by 11.4–16.8% [12] and significantly reduced nitrogen and phosphorus excretion in 19-day-old broilers [13]. This may be attributed to the high phytase activity in yeast culture, which improves phytate phosphorus utilization. Thus, dietary yeast culture supplementation can enhance nutrient digestibility and reduce phosphorus excretion, benefiting environmental protection.

3.4 Effects on Serum Antioxidant Indices

GSH-Px is a ubiquitous enzyme that catalyzes hydrogen peroxide decomposition, protecting cell membrane structure and function. SOD catalyzes superoxide anion dismutation to hydrogen peroxide, preventing free radical generation. MDA is a lipid peroxidation product commonly used as a biomarker of oxidative stress. T-AOC is a comprehensive indicator of antioxidant capacity. As a complex fermentation product, yeast culture can enhance antioxidant enzyme activity, effectively scavenge free radicals, and reduce reactive oxygen species damage [9]. Studies have shown that dietary yeast culture increased serum SOD activity in broilers [11,14], and yeast cell or cell wall supplementation improved antioxidant capacity in muscle [15]. In this study, dietary YCWDG significantly increased serum GSH-Px and SOD activities and T-AOC in broilers, confirming its antioxidant effects and consistent with previous research. The antioxidant activity may be related to various nutrients including vitamin C, vitamin E, copper, manganese, zinc, selenium, and other unknown growth factors. Mannan oligosaccharides have been shown to significantly increase blood SOD and GSH-Px activities in pigs and chickens [16], and YCWDG contains 2.8% mannan oligosaccharides, suggesting this component may contribute to its antioxidant effects, though further verification is needed. Additionally, the effects of yeast culture on antioxidant capacity appear age-dependent. In this study, YCWDG

primarily affected serum antioxidant indices at 21 days of age, with diminished effects at 42 days. This may be because young chicks have underdeveloped cardiovascular, digestive, and immune systems with weaker resistance to oxidative stress, allowing YCWDG to effectively regulate redox status, whereas mature chickens have stronger anti-stress capacity, making YCWDG effects less pronounced.

Conclusion

Dietary supplementation with 0.5%–1.0% yeast culture of white distiller's grains, including in energy-reduced diets, can increase body weight gain, improve feed conversion ratio, reduce abdominal fat percentage, and significantly enhance serum antioxidant capacity in broilers.

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