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Effects of Yeast Culture on Production Performance, Egg Quality, and Egg Hygiene Indicators of Laying Hens (Postprint)

Authors: Zhang Jiaqi, Qin Yuchang, Li Junguo, Li Jun, Niu Libin, Yu Zhiqin

Date: 2017-11-07T00:00:00+00:00

Abstract

This experiment aimed to investigate the effects of yeast culture (YC) on production performance, egg quality, and egg hygiene indices in laying hens. A total of 2,304 Lohmann Brown laying hens at 210 days of age were randomly divided into 4 groups with 3 replicates per group and 192 hens per replicate. The control group (YC0 group) was fed a corn-soybean meal basal diet, while the experimental groups (YC0.2, YC0.4, and YC0.6 groups) were fed experimental diets supplemented with 0.2%, 0.4%, and 0.6% yeast culture, respectively. The experimental period lasted 9 weeks. The results showed: 1) Compared with the control group, the YC0.4 and YC0.6 groups had significantly increased average egg weight ($P<0.05$) and significantly reduced broken egg rate ($P<0.05$); the YC0.2, YC0.4, and YC0.6 groups had significantly reduced soft-shelled egg rate ($P<0.05$). 2) Compared with the control group, the YC0.4 and YC0.6 groups had significantly increased shell thickness ($P<0.05$); the YC0.2, YC0.4, and YC0.6 groups had significantly decreased lightness value (L*) and significantly increased yellowness value (b*) of yolk color ($P<0.05$); the YC0.6 group had significantly increased redness value (a*) of yolk color ($P<0.05$). 3) Compared with the control group, at weeks 3 and 9 of the experiment, the YC0.2, YC0.4, and YC0.6 groups had significantly reduced coliform bacteria count on eggshell surface ($P<0.05$); at weeks 3 and 6, the YC0.4 group had significantly reduced total bacterial count on eggshell surface ($P<0.05$). 4) Compared with the control group, the YC0.6 group had significantly increased apparent digestibility of crude protein, energy, and dry matter ($P<0.05$). 5) Compared with the control group, the YC0.2, YC0.4, and YC0.6 groups had significantly reduced cecal Lactobacillus count ($P<0.05$). It can be concluded that dietary supplementation with 0.4% and 0.6% yeast culture can improve egg quality and feed digestibility in laying hens; dietary supplementation with 0.2%, 0.4%, and 0.6% yeast culture can all improve production performance, reduce coliform bacteria count, and inhibit Salmonella production in the cecum of laying hens. Taking all factors into consideration, the appropriate supplementation level of yeast culture in laying hen diets is 0.4%.

Full Text

Effects of Yeast Culture on Performance, Egg Quality and Egg Health Indicators of Laying Hens

ZHANG Jiaqi[1], QIN Yuchang[2], LI Junguo[1],[3],*, LI Jun[1], NIU Libin[1], YU Zhiqin[1]

[1]Feed Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China

[2]Institute of Animal Science, Chinese Academy of Agricultural Sciences, Beijing 100081, China

[3]Key Laboratory of Feed Biotechnology, Ministry of Agriculture, Beijing 100081, China

Abstract: This experiment was conducted to investigate the effects of yeast culture (YC) on performance, egg quality and egg health indicators of laying hens. A total of 2,304 Roman brown laying hens at 210 days of age were randomly allocated into 4 groups with 3 replicates per group and 192 hens per replicate. Hens in the control group (YC0) were fed a corn-soybean meal basal diet, while those in the experimental groups (YC0.2, YC0.4 and YC0.6) were fed the basal diet supplemented with 0.2%, 0.4% and 0.6% YC, respectively. The experiment lasted for 9 weeks. The results showed: 1) Compared with the control group, the average egg weight of YC0.4 and YC0.6 groups was significantly increased (P<0.05), and the broken egg rate was significantly decreased (P<0.05); the soft egg rate of YC0.2, YC0.4 and YC0.6 groups was significantly decreased (P<0.05). 2) Compared with the control group, the eggshell thickness of YC0.4 and YC0.6 groups was significantly increased (P<0.05); the lightness (L_) value of yolk color of YC0.2, YC0.4 and YC0.6 groups was significantly decreased (P<0.05), while the yellowness (b_) value was significantly increased (P<0.05); the redness (a*) value of yolk color of YC0.6 group was significantly increased (P<0.05). 3) Compared with the control group, at weeks 3 and 9 of the experiment, the coliform count on eggshell surface of YC0.2, YC0.4 and YC0.6 groups was significantly decreased (P<0.05); at weeks 3 and 6, the total bacterial count on eggshell surface of YC0.4 group was significantly decreased (P<0.05). 4) Compared with the control group, the apparent digestibility of crude protein, energy and dry matter of YC0.6 group was significantly increased (P<0.05). 5) Compared with the control group, the cecal Lactobacillus count of YC0.2, YC0.4 and YC0.6 groups was significantly decreased (P<0.05). In conclusion, dietary supplementation with 0.4% and 0.6% YC can improve egg quality and feed digestibility; dietary supplementation with 0.2%, 0.4% and 0.6% YC can improve laying hen performance, reduce coliform counts and inhibit Salmonella production in the cecum. Considering all factors, the appropriate supplementation level of YC in laying hen diets is 0.4%.

Keywords: yeast culture; laying hens; performance; egg health indicator; cecal microbe; intestinal mucosal morphology

Introduction

Antibiotics have long played a crucial role in livestock and poultry production, significantly improving performance, reducing disease incidence, and lowering feeding costs. However, antibiotic usage has also caused a series of problems, including antibiotic residues, development of antimicrobial resistance, and environmental pollution. As consumers increasingly demand green, safe, and pollution-free animal products, finding alternatives to antibiotics has become imperative. Yeast culture (YC) is rich in oligosaccharides, probiotics, and beneficial microorganisms, which not only promote growth and enhance immunity but also overcome the disadvantages of antibiotic resistance. Over the past decade, numerous studies have demonstrated positive effects of YC on ruminants, pigs, and poultry. Research indicates that YC can improve poultry performance, enhance immunity, alleviate stress, adsorb toxins, and protect the environment. Zeng et al. reported that dietary supplementation with 2.0% YC promoted broiler growth and improved performance. Zhou et al. demonstrated that 0.3% YC enhanced broiler immunity and increased survival rate of young broilers. Liu et al. found that YC alleviated stress in young laying hens and maintained internal environment stability. Yue et al. showed that YC had toxin-adsorbing functions that reduced intestinal diseases. Zhou et al. reported that 0.3% YC improved phosphorus utilization in broiler diets, thereby improving environmental conditions. Zhang et al. noted that 0.3% YC improved egg quality and performance in laying hens. Currently, YC application in poultry has focused primarily on broilers, with limited research on laying hens that has only examined effects on performance and egg quality. Fewer studies have investigated YC effects on egg safety and intestinal health of laying hens. Therefore, this study aimed to investigate the effects of dietary YC supplementation on laying hen performance, egg safety, egg quality, and intestinal mucosal structure to provide a theoretical basis for further promotion and application of YC in laying hen diets.

1.1 Experimental Animals and Design

The yeast culture was provided by Angel Yeast Company, produced through anaerobic fermentation of a specific solid medium under controlled process conditions using high-performance YC as the strain, followed by concentration and drying. This biological product consists of three main components: modified culture medium, yeast cells, and metabolites. The modified medium includes oligosaccharides and peptides. The YC comprises proteins, amino acids, peptides, vitamins, minerals and chelates, nucleic acids from intracellular components, and β-glucan and mannan oligosaccharides from cell walls. The metabolites consist of peptides, organic acids, alcohols, lipids, amino acids, nucleic acids, enzymes, and unknown growth factors.

A total of 2,304 Roman brown laying hens at 210 days of age were randomly divided into 4 groups with 3 replicates per group and 192 hens per replicate, with no significant differences in body weight among replicates ($P>0.05$). The corn-soybean meal basal diet was formulated according to NRC (1994) nutrient requirements, with composition and nutrient levels shown in Table 1 . The control group (YC0) received the basal diet, while experimental groups (YC0.2, YC0.4 and YC0.6) received the basal diet supplemented with 0.2%, 0.4% and 0.6% YC, respectively. The experiment lasted 9 weeks. Hens were housed in an open-sided chicken house with three-tier cage systems, and feeding management and environmental conditions were strictly consistent. Hens had free access to feed and water with frequent small additions.

1.2.1 Laying Hen Performance

Daily records were kept for egg number, total egg weight, and mortality for each replicate, with weekly feed intake recorded. Laying rate, feed-to-egg ratio, average egg weight, broken egg count, soft egg count, and mortality rate were calculated.

1.2.2 Egg Quality

At the end of weeks 3, 6, and 9, 10 eggs were randomly selected from each replicate to determine egg weight, egg shape index (length/width), yolk color, eggshell strength, Haugh unit, yolk index (yolk weight/egg weight), and eggshell thickness. The Haugh unit was calculated as: HU = 100 × log(H - 1.7W^0.37 + 7.57), where H is thick albumen height (mm) and W is egg weight (g).

1.2.3 Egg Hygiene Indicators

At the end of weeks 3, 6, and 9, 10 eggs were randomly collected from each replicate of each group to compare total bacterial count, coliform count, and Salmonella count on eggshell surface and inside eggs. Eggs were placed in sterilized beakers, and the shells were moistened with sterile physiological saline. Sterile cotton balls were used to thoroughly wipe the eggshell surface, which were then rinsed repeatedly in the beaker. Wiping solutions from 5 eggs of the same replicate were combined and mixed thoroughly. The eggshell wiping solution was then serially diluted 10, 100, 1,000, and 10,000 times with physiological saline, and total bacterial count, coliform count, and Salmonella count on eggshell surface and inside eggs were detected using methods provided in GB 4789–2010.

1.2.4 Nutrient Apparent Digestibility

Feed and excreta were collected from each replicate to determine the apparent digestibility of crude protein, energy, and dry matter using the acid-insoluble ash method.

1.2.5 Intestinal Mucosal Morphology

At the end of week 9, 2 hens with similar body weight were randomly selected from each replicate and slaughtered. Digesta from the gizzard, proventriculus, duodenum, jejunum, and ileum were immediately placed in 10 mL stoppered glass tubes containing 0.5 mmol/L KOH, and pH changes were measured with a pH meter at 24 h. Live weight and slaughter weight were recorded. Digestive organ index was calculated as: organ weight (mg) / live weight (g). Additionally, at week 9, 2 hens with similar body weight were randomly selected from each replicate and slaughtered. A 5 cm segment from the middle of the duodenum was rinsed with Tris buffer, cut into 5 equal parts, and fixed in 10% neutral formalin solution. Paraffin sections were prepared using conventional methods, stained with hematoxylin and eosin, and villus height and crypt depth were measured under an optical microscope. Villus height was measured from the villus tip to the crypt opening, and crypt depth was measured from the invagination between adjacent villi. The average of 5 sections per tissue was used as the villus height and crypt depth values, and the villus height/crypt depth (V/C) ratio was calculated.

1.2.6 Cecal Microflora

At the end of week 9, 2 hens with similar body weight were randomly selected from each replicate, slaughtered, and cecum with digesta was collected in autoclaved 10 mL centrifuge tubes and stored in a laboratory refrigerator for inoculation and culture analysis. Total cecal bacterial count and counts of Escherichia coli, Lactobacillus, and Salmonella were detected using methods provided in GB 4789–2010, expressed as lg(CFU/g) of bacterial count per gram of intestinal content.

1.3 Statistical Analysis

Data were recorded in Excel 2007, preliminarily processed, and then analyzed using one-way ANOVA with SAS 9.2 software. Duncan' s multiple comparison test was used to examine significant differences at $P<0.05$. Results were expressed as "mean ± standard deviation."

2.1 Effects of Yeast Culture on Laying Hen Performance

The effects of dietary YC supplementation on laying hen performance are shown in Table 2 . Compared with the control group, YC0.4 and YC0.6 groups showed significantly increased average egg weight ($P<0.05$) and significantly decreased broken egg rate ($P<0.05$). The soft egg rate of YC0.2, YC0.4 and YC0.6 groups was significantly decreased ($P<0.05$). No significant differences were observed among groups in laying rate, feed-to-egg ratio, or mortality rate ($P>0.05$).

2.2 Effects of Yeast Culture on Egg Quality

The effects of dietary YC supplementation on egg quality are presented in Table 3 . Compared with the control group, eggshell thickness of YC0.4 and YC0.6 groups was significantly increased ($P<0.05$), with no significant difference between YC0.4 and YC0.6 groups ($P>0.05$). The lightness (L*) value of yolk color in YC0.2, YC0.4 and YC0.6 groups was significantly decreased (P<0.05), while the yellowness (b*) value was significantly increased ($P<0.05$). The redness (a*) value of yolk color in YC0.6 group was significantly increased ($P<0.05$). No significant differences were found among groups in eggshell strength, egg shape index, yolk ratio, or Haugh unit ($P>0.05$).

2.3.1 Effects of Yeast Culture on Microbial Count on Eggshell Surface

The effects of dietary YC supplementation on microbial count on eggshell surface are shown in Table 4 . Compared with the control group, at weeks 3 and 9, the coliform count on eggshell surface of YC0.2, YC0.4 and YC0.6 groups was significantly decreased ($P<0.05$). At weeks 3 and 6, the total bacterial count on eggshell surface of YC0.4 group was significantly decreased ($P<0.05$). Salmonella was not detected among groups at weeks 3 and 9. At week 9, no significant differences were observed among groups in total bacterial count on eggshell surface ($P>0.05$).

2.3.2 Effects of Yeast Culture on Microbial Count Inside Eggs

The effects of dietary YC supplementation on microbial count inside eggs are presented in Table 5 . At weeks 3, 6, and 9, no significant differences were observed among groups in total bacterial count, coliform count, or Salmonella count inside eggs (P>0.05). At all time points, total bacterial count, coliform count, and Salmonella count were below detection limits in all groups.

2.4 Effects of Yeast Culture on Nutrient Apparent Digestibility

The effects of dietary YC supplementation on nutrient apparent digestibility are shown in Table 6 . Compared with the control group, YC0.6 group showed significantly increased apparent digestibility of crude protein, energy, and dry matter (P<0.05). No significant differences were observed among YC0.4, YC0.6 and control groups in apparent digestibility of crude protein, energy, and dry matter (P>0.05).

2.5.1 Effects of Yeast Culture on Digesta pH in Gastrointestinal Sections

The effects of dietary YC supplementation on digesta pH in gastrointestinal sections are presented in Table 7 . No significant differences were observed among groups in pH of digesta from gizzard, proventriculus, duodenum, jejunum, or ileum (P>0.05). With increasing YC supplementation level, pH of proventriculus digesta showed a gradual decreasing trend.

2.5.2 Effects of Yeast Culture on Gastrointestinal Indexes

The effects of dietary YC supplementation on gastrointestinal indexes are shown in Table 8 . No significant differences were observed among groups in gizzard index, proventriculus index, jejunum index, ileum index, carcass ratio, or pancreas index (P>0.05). The duodenum index of YC0.4 group was significantly higher than other groups (P<0.05), and the liver index of YC0.4 group was significantly higher than YC0 and YC0.2 groups (P<0.05).

2.5.3 Effects of Yeast Culture on Cecal Microbial Count

The effects of dietary YC supplementation on cecal microbial count are presented in Table 9 . No significant differences were observed among groups in cecal E. coli count or total bacterial count (P>0.05), although cecal E. coli count showed a gradual decreasing trend with increasing YC supplementation. Compared with the control group, cecal Lactobacillus count of YC0.2, YC0.4 and YC0.6 groups was significantly decreased (P<0.05). Salmonella was detected only in the cecal flora of the control group, while no Salmonella was detected in YC0.2, YC0.4 and YC0.6 groups.

2.5.4 Effects of Yeast Culture on Intestinal Mucosal Morphology

The effects of dietary YC supplementation on intestinal mucosal morphology are shown in Table 10 . No significant differences were observed among groups in duodenal crypt depth (P>0.05). Compared with the control group, duodenal villus height and V/C ratio of YC0.2 and YC0.4 groups were significantly increased (P<0.05), with YC0.4 group showing the highest duodenal villus height and V/C ratio.

3.1 Effects of Yeast Culture on Laying Hen Performance

Yeast culture is rich in amino acids, peptides, B vitamins, mannan oligosaccharides, organic acids, minerals, digestive enzymes, and unknown growth factors beneficial to livestock and poultry. These substances can promote nutrient absorption and utilization, thereby potentially improving laying hen performance. Zhou et al. reported that dietary supplementation with 0.5–1.0 g/kg mannan oligosaccharide improved broiler feed intake and daily weight gain, enhancing performance. Wu et al. demonstrated that 0.2% YC supplementation decreased feed-to-egg ratio and mortality while increasing laying rate and average egg weight, prolonging peak production and effectively improving laying hen performance. In this experiment, compared with the control group, 0.4% YC supplementation significantly increased average egg weight and significantly decreased broken egg rate and soft egg rate, with a trend toward reduced feed-to-egg ratio, laying rate, and mortality, reflecting improved laying hen performance. Previous studies have reported that YC supplementation can improve intestinal microflora and mucosal structure, facilitating nutrient digestion, which may contribute to improved performance.

3.2 Effects of Yeast Culture on Egg Quality

Li et al. reported that 0.2% YC supplementation increased yolk weight, albumen height, and Haugh unit without significantly affecting eggshell strength or yolk color. Jin et al. found that 0.3% YC had no significant effect on egg shape index but improved yolk color, eggshell thickness, eggshell strength, and Haugh unit. Wu et al. reported that YC improved yolk color without significantly affecting other parameters. In this experiment, increasing YC supplementation level resulted in thicker eggshells, increased yolk ratio, significantly decreased lightness value of yolk color, and significantly increased redness and yellowness values, while egg shape index and Haugh unit remained unchanged. These inconsistent results among studies may reflect that YC supplementation has no significant effect on egg quality. After consuming YC, absorbed nutrients may be transferred to eggs, and B vitamins, peptides, mannan oligosaccharides, and organic acids in YC may improve various egg quality parameters, though the specific mechanisms require further investigation.

3.3 Effects of Yeast Culture on Egg and Cecal Microbial Count

The avian intestine contains abundant microorganisms, with Lactobacillus and Bifidobacterium as dominant species playing important roles. The balance between beneficial and harmful microorganisms reflects poultry health status. Xu et al. reported that amino acids, mannan oligosaccharides, and organic acids in YC can adsorb and kill pathogenic microorganisms entering the intestine, protect intestinal mucosa, and provide a suitable microecological environment for intestinal microorganisms. Zhang et al. noted that mannan oligosaccharides are difficult to degrade by digestive enzymes but can be absorbed by beneficial bacteria, favoring their colonization, inhibiting harmful bacteria, and promoting nutrient digestion and absorption. Xiao et al. demonstrated that 200 mg/kg YC supplementation increased Lactobacillus and Bifidobacterium counts in jejunum, ileum, and cecum of broilers while decreasing E. coli count and inhibiting Salmonella. Yu et al. found that 2.5 g/kg YC supplementation increased Bifidobacterium and Lactobacillus counts in ileum and cecum of broilers without significantly affecting E. coli count. Regarding eggshell surface microorganisms, at week 3, increasing YC supplementation decreased total bacterial and coliform counts; at week 6, total bacterial count showed little change while coliform count significantly decreased; at week 9, total bacterial count showed no trend while coliform count significantly decreased. Differences among groups in total bacterial and coliform counts gradually diminished over time. The trend in coliform count change was consistent with Xiao' s findings, and the diminishing differences may reflect hens' adaptation to YC, with more pronounced effects initially that decreased over time. Therefore, YC supplementation during peak production is recommended for optimal effects. Regarding egg interior microorganisms, total bacterial, coliform, and Salmonella counts were below detection limits in all groups at all time points, likely due to clean housing conditions and timely manure removal. Regarding cecal microorganisms, YC supplementation decreased cecal Lactobacillus and E. coli counts, had no significant effect on total cecal bacterial count, and inhibited Salmonella. The reduction in cecal E. coli count and Salmonella inhibition are consistent with Yu et al., while the decreased Lactobacillus count differs from their results, possibly because Bifidobacterium and Lactobacillus together constitute dominant cecal microflora in laying hens, and both should be considered together when evaluating effects on beneficial bacteria.

3.4 Effects of Yeast Culture on Nutrient Apparent Digestibility

Zhang et al. demonstrated that 5 g/kg YC supplementation significantly improved energy and dry matter apparent digestibility in nursery pigs while decreasing crude protein and phosphorus apparent digestibility. Zhou et al. found that YC supplementation improved apparent digestibility of dry matter, organic matter, neutral detergent fiber, and acid detergent fiber in sheep. Dou et al. also reported that YC supplementation improved apparent digestibility of crude protein, ether extract, energy, and acid detergent fiber. In this experiment, YC supplementation improved apparent digestibility of crude protein, energy, and dry matter in laying hens, promoting nutrient digestion and absorption. This may be because YC contains digestive enzymes, improved gastrointestinal microflora facilitates nutrient digestion and absorption, and YC is rich in mannan oligosaccharides that can enhance digestive enzyme activity.

3.5 Effects of Yeast Culture on Intestinal Mucosal Morphology

The small intestine is the primary organ for nutrient digestion and absorption, and its capacity often reflects the digestive ability of laying hens. The small intestine contains numerous villi, and villus height, crypt depth, and V/C ratio represent the absorptive surface area. Generally, decreased crypt depth indicates increased maturation rate of intestinal epithelial cells and enhanced absorptive function; increased villus height indicates enhanced absorptive function; and higher V/C ratio indicates better mucosal condition. Xiao et al. reported that 0.2% YC supplementation increased villus height and V/C ratio while decreasing crypt depth in duodenum, jejunum, and ileum of broilers. Xu et al. found that YC supplementation improved intestinal mucosal morphology, increased villus height, and thickened intestinal wall in crucian carp. In this experiment, YC supplementation increased duodenal villus height, crypt depth, and V/C ratio, promoting villus growth and facilitating nutrient digestion and absorption. This differs from Xiao et al.' s finding that YC decreased crypt depth, possibly because villus height and crypt depth together determine V/C ratio and should not be studied separately, and V/C ratio is more appropriate for representing absorptive capacity. Mechanistic research on YC effects on intestinal mucosal morphology in laying hens is limited and requires further investigation.

Conclusion

Dietary supplementation with 0.4% and 0.6% yeast culture can improve egg quality and feed digestibility in laying hens. Supplementation with 0.2%, 0.4% and 0.6% yeast culture can improve laying hen performance, reduce coliform counts, and inhibit Salmonella production in the cecum. Considering all factors comprehensively, the appropriate supplementation level of yeast culture in laying hen diets is 0.4%.

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