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Effect of yeast cell wall powder with different particle sizes on the growth performance, serum metabolites, immunity and oxidative status of broilers

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ABSTRACT

The current study was conducted to investigate the effects of yeast cell wall (YCW) powder processed to different particle sizes on the growth performance, serum metabolites, immunity and antioxidant status of broilers. A total of 144 one-day-old Arbor Acres broiler chicks were allocated into 3 dietary treatments consisting of 6 replicates with 8 chicks per replicate, and received a basal diet and basal diet supplemented with either 1 g/kg coarse or fine grinding YCW powder until 42 days of age, respectively. Treatments did not affect growth performance of broilers. Compared with the control group, total cholesterol content in serum ($P = 0.032$) and bursa weight ($P = 0.019$) was increased by the inclusion of YCW at 42 day. Fine rather than coarse grinding YCW powder increased ileal secretory immunoglobulin A (SIgA, $P = 0.040$) and immunoglobulin G (IgG, $P = 0.019$) content at 21 day. Additionally, birds fed diets containing fine grinding YCW showed increased ileal total superoxide dismutase (T-SOD) activity ($P = 0.049$) at 21 day whereas decreased malondialdehyde (MDA) accumulation at 42 day ($P = 0.021$), respectively. In conclusion, the ability to improve immune function and intestinal oxidative status of broilers was more pronounced in fine grinding YCW powder.

1. Introduction

Yeast cell wall (YCW) as a functional feed additive is now widely used in modern poultry production. Mannan oligosaccharides and 1,3/1,6 β-glucans are two major components of the YCW that can modulate immunity and protect the intestinal mucosa against invading microorganism (Shashidhara and Devegowda, 2003; Ganner and Schatzmayr, 2012). Mannan oligosaccharides are polysaccharide–protein complexes that are indigestible to monogastric animals and can inhibit colonization of pathogenic microorganism in the intestinal tract by binding pathogenic bacteria which possess mannose-specific type-I fimbriae and by its prebiotic activity (Shoaf-Sweeney and Hutkins, 2008; Ganner and Schatzmayr, 2012). β-glucans are polymers of glucose that can also be derived from YCW, bacteria, fungi, and cereals such as oats, barley, and rye (Huff et al., 2007). Numerous studies have described the possible immunomodulating mechanism of β-glucans including enhanced

Abbreviations: ADFI, average daily feed intake; ADG, average daily gain; FCR, feed conversion ratio; ELISA, enzyme-linked immunosorbent assay; IgG, immunoglobulin G; IgM, immunoglobulin M; MDA, malondialdehyde; ROS, reactive oxygen species; SIgA, secretory immunoglobulin A; T-SOD, total superoxide dismutase; YCW, yeast cell wall.

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functional status of macrophages; increased cytokine production and oxidative burst by macrophages, neutrophils, and dendritic cells; promoted chemokine production by epithelial cells; and increased leukocyte activity (Lowry et al., 2005; Kogan and Kocher, 2007; Volman et al., 2008; Ganner and Schatzmayr, 2012).

Studies have demonstrated that the inclusion of yeast products to broilers diets can increase growth performance, improve intestinal morphology, promote the development of immune organs, stimulate intestinal immunoglobulin secretion, and prohibit the colonization of pathogenic bacteria including *Escherichia coli* and *Salmonella* (Santin et al., 2001; Gao et al., 2008; Morales-López et al., 2009; Haldar et al., 2011; Muthusamy et al., 2011; Reisinger et al., 2012). Also, YCW components supplementation has been reported to reduce malondialdehyde (MDA) accumulation, an end product of lipid oxidation, in the breast meat of broiler chickens (Zhang et al., 2005), and improve the oxidative status in weanling piglets (Sauerwein et al., 2007), suggesting that YCW also possesses antioxidant capacity.

Fine grinding technology can be used to decrease the particle sizes of wheat bran, ginger root or green tea, which can subsequently increase their surface area, dispersibility, bioaccessibility and the free radical scavenging ability (Zhou et al., 2004; Zhao et al., 2009; Hemery et al., 2011; Hu et al., 2012; Rosa et al., 2013). It has been reported that particle size plays an important role in affecting the bioavailability of green tea (Li et al., 2008) and ginger root (Zhao et al., 2009). In an in vivo study, Wu et al. (2014) reported that fine grinding oolong tea powder (*Camellia sinensis*) would be more effective in decreasing fat deposition and improving meat quality and antioxidant activity in meat ducks when compared with the coarse one. In broilers, Zhang et al. (2009) also found that efficacy of ginger root (*Zingiber officinale*) was mediated by its particle size, and the ability to improve antioxidant status was more pronounced in fine grinding ginger. Little was known about the effect of YCW particle size on broilers. We hypothesized that YCW under fine grinding treatment would exhibit a higher bioavailability than its counterpart under coarse grinding process in vivo. The current study was therefore conducted to compare the effects of two YCW powders processed to different particle size on the growth performance, serum metabolites, immunity and antioxidant status of broilers.

2. Materials and methods

2.1. Husbandry, diets and experimental design

All procedures were approved by Nanjing Agricultural University Institutional Animal Care and Use Committee.

YCW powder used in this study was provided by Nanjing Nature Biotech Co., Ltd. (Nanjing, Jiangsu, P.R. China). The chemical compositions and active ingredients of YCW provided by the manufacture were listed in the following: moisture, 42.1 g/kg; crude protein, 248 g/kg; mannan oligosaccharides, 208 g/kg; β-glucans, 322 g/kg. YCW was pulverized to powder with different mean particle sizes categorized as coarse (49 μm) and fine (13 μm) by a jet mill (LHJ-50, Zhengyuan Powder Engineering Equipment Co., Ltd., Weifang, Shandong, P.R. China). Mean particle sizes of YCW powder were determined by the laser diffraction scattering method (Mastersizer 2000, Malvern Instruments Ltd., Worcestershire, UK). The detailed method of producing YCW powder was outside the scope of the paper and cannot be described due to commercial sensitivity.

In the present study, 150 male and 150 female one-day-old Arbor Acres broiler chicks obtained from a commercial hatchery were chosen before grouping (sex can be distinguished by color marked in the feather and wing mark), 4 male and 4 female with similar hatching weight were then picked from the 150 male and 150 female chicks, respectively, and equally allocated into one cage of the three-level cages. Finally, a total of 144 chicks with similar weight (initial weight, 36.7 ± 0.2 g) were allocated into 3 dietary treatments consisting of 6 replicates (one cage per replicate) of 8 chicks each replicate (4 males and 4 females/cage), and subsequently received a basal diet and basal diet supplemented with either 1 g/kg coarse or fine grinding YCW powder until 42 days of age, respectively. Ingredient composition and nutrient content of basal diet are presented in Table 1. Birds were allowed free access to mash feed and water in three-level cages (120 cm × 60 cm × 50 cm; 0.09 m^2 per chick) in a temperature-controlled room with continuous lighting. The temperature of the room was maintained at 32–34 °C for the first 3 day and then reduced by 2–3 °C per week to a final temperature of 20 °C. Birds were vaccinated against Newcastle disease and infectious bursal disease at 11 day of age. At 21 and 42 day of age, birds were weighed after feed deprivation for 12 h and feed intake was recorded by replicate (cage) to calculate average daily feed intake (ADFI), average daily gain (ADG), and feed conversion ratio (FCR). Birds that died during the experiment were weighed, and the data were included in the calculation of FCR.

2.2. Sample collection

At 21 and 42 day of age, 1 male bird from each cage was randomly selected and weighed after feed deprivation for 12 h. Blood samples (around 5 mL each) were taken from wing vein and centrifuged at 4450 × *g* for 15 min at 4 °C to separate serum, which was frozen at −20 °C until further analysis. After blood collection, chickens were euthanized and necropsied immediately. After decapitation, cecum samples (left side) were quickly removed aseptically, and the *Salmonella* and *E. coli* colonies in cecal contents were determined. Bursa, thymus and spleen were then collected and weighed to obtain the relative organ weights using the following formula: relative weight of immune organ (g/kg) = immune organ weight (g)/body weight (kg). Approximately 20 cm of jejunal and ileal segments were opened longitudinally and the contents were flushed with