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Effects of Dietary *Saccharomyces cerevisiae* on Growth Performance and Meat Quality in Broilers

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효모(*Saccharomyces cerevisiae*)의 급여가 육계의 생산성과 계육의 품질에 미치는 영향

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ABSTRACT : An experiment was conducted to investigate whether *Saccharomyces cerevisiae*(*S. cerevisiae*) could improve the growth performance and meat quality of broiler chicks. Day old 160 male broiler chicks were fed one of the two experimental diets without (0.0 %) or with *S. cerevisiae* (3.0 %) for five wks. Each treatment consisted of eight cages with 10 chicks per cage. Feed and water were provided *ad libitum*. Although not significant, BW gains of *S. cerevisiae* fed chicks tended to increase during 4~5 wk of age. The addition of *S. cerevisiae* into the control diet significantly lowered the shear force in raw drumstick meat ($P<0.05$). After 10 d of incubation, significantly lower levels of oxidation products were found ($P<0.05$) in drumstick meats and skin samples from broiler chicks fed diets enriched with *S. cerevisiae* compared to those of the control group, while in breast meats the significant difference was monitored after 6 d of incubation. It is concluded that dietary *S. cerevisiae* could improve the tenderness and oxidative stability of broiler meats.

(Key words: *S. cerevisiae*, growth performance, meat tenderness, oxidative stability, broilers)

INTRODUCTION

Yeasts are single celled, heterotrophic organisms that exist in a wide range of habitats. Yeasts in the genus *Saccharomyces* are among the most useful microorganisms. Various strains of *Saccharomyces cerevisiae (S. cerevisiae)* have been used in food and brewing industries. In addition, *S. cerevisiae* has long been fed to animals as a feed additive.

Recently, interest in meat quality has arisen by the need to supply the consumers with a consistent, high quality product at an affordable price. It is known that taste and sensory characteristics of meat can be influenced by diet, and a few literature data (Akiba *et al.*, 2001; Lee *et al.*, 2002) showed that enrichment of diets with yeast could favorably improve broiler meat quality. For example, edible meats from broiler chicks fed a diet containing *S. cerevisiae* exhibited increased tenderness (Bonomi *et al.*, 1999), and increased water holding capacity (Lee *et al.*, 2002). The effect of *S. cerevisiae* supplementation on oxidative stability of chicken meat was not extensively studied albeit there are indicatives (Meyer *et al.*, 1994; Ampel *et al.*, 2000) that *S. cerevisiae* may possess antioxidant property.

During the past five decades, the growth performance of broilers has improved tremendously owing to the development of nutrition and genetics. Today, however, the broiler industry must focus more attention on public concerns such as environment and food safety. Thus, the poultry industry must develop alternatives to antibiotics growth promoters to maintain efficient poultry production and produce safe poultry products.

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In this regard, probiotics such as yeasts could be the most promising alternatives to antibiotics.

The present experiment was conducted to evaluate the effects of dietary *S. cerevisiae* on growth performance and meat quality traits in broiler chicks.

MATERIALS AND METHODS

1. Animals, Diets and Experimental Design

Day-old 160 male broiler chicks (Ross) purchased from a local hatchery were randomly housed in wire floored, suspended cages in a temperature controlled room. Continuous lighting was provided throughout the experimental period. Room temperature was gradually decreased from 32℃ on Day 0 to 25℃ on Day 21 and was kept constant thereafter. There were two dietary treatments, each consisting of 8 replicates. A replicate was identical to a cage with 10 birds so that each treatment had 80 chicks. Broiler starter and finisher diets were formulated (Table 1) to contain either 0 % or 3.0 % yeast (*S. cerevisiae,* Choheung Chemical Industrial Co. Ltd., Ansan, Kyunggi do, Korea) at the expense of soybean meal. The yeast was in a granular form that contained 45.6 % crude protein, 4.5 % crude fat, and 8.5 % crude ash, respectively, according to the manufacturer's specifications. The colony forming units of the yeast was counted to be 1.3×10^{10}/g. Feed and water were provided *ad libitum* throughout the experiment that lasted 35 d.

2. Body Weight and Feed Intake Measurements

Body weight was measured by cage at 1, 21 and 35 d of age. Feed intake was monitored by cage at 21 and 35 d of age. Feed intake per cage and weight gain per cage used to calculate feed/gain ratios.

3. Collection of Meat and Skin Samples

On the last day of 35 d feeding trial, one bird from each cage was selected and slaughtered by cervical dislocation. Immediately after slaughter, left and right breast and drumstick meats with skins on them were sampled. One half of breast and drumstick meats sampled were stored at 4℃ prior to the measurement of shear force. The rest of the samples, *i.e.*, breast and drumstick meat, and skin samples were stored at -20℃ for the lipid oxidation assay.

Table 1. Composition of the control diet[1]

Ingredients	Starter (1~3 wk)	Finisher (4~5 wk)
Yellow corn (%)	59.742	64.252
Soybean meal (%)	28.26	27.833
Corn gluten meal (%)	6.261	3.00
Soybean oil (%)	2.00	1.828
Dicalcium phosphate (%)	1.762	1.218
Limestone (%)	0.936	1.126
Salt (%)	0.40	0.40
DL methionine (50%) (%)	0.359	0.139
L lysine HCl (98%) (%)	0.08	0.004
Vitamin premix[2] (%)	0.10	0.10
Mineral premix[3] (%)	0.10	0.10
Total (%)	100.00	100.00
Calculated composition		
ME (kcal/kg)	3,100	3,100
CP (%)	21.00	19.00
Ca (%)	1.00	0.90
Total P (%)	0.719	0.619
Available P (%)	0.45	0.35
Methionine (%)	0.50	0.38
Lysine (%)	1.10	1.00

[1] The experimental diets were formulated by adding 3.0% yeast (*S. cerevisiae*) to the control diet at the expense of soybean meal. The yeast was in a granular form which contained 45.6% CP, 4.5% crude fat, and 8.5% crude ash, and its cfu was 1.3×10^{10}/g.

[2] Provided followings per kilogram of diet: vitamin A, 5,500 IU; vitamin D_3, 1,100 IU; vitamin E, 11 IU; vitamin B_{12}, 0.0066mg; riboflavin, 4.4 mg; pantothenic acid, 11 mg (Ca pantothenate: 11.96 mg); choline, 190.96 mg (choline chloride 220 mg); menadione, 1.1 mg (menadione sodium bisulfite complex 3.33 mg); folic acid, 0.55 mg; pyridoxine, 2.2 mg (pyridoxine hydorchloride, 2.67 mg); biotin, 0.11 mg; thiamin, 2.2 mg (thiamin mononitrate 2.40 mg); ethoxyquin, 125 mg.

[3] Provided followings mg per kilogram of diet: Mn, 120; Zn, 100; Fe, 60; Cu, 10; I, 0.46 and Ca, min: 150, max: 180.

4. Measurement of Shear Force

Intact breast and drumstick meat samples were cut into square shape (35×25×6 mm), and then subjected to the measurement of shear force. An application of cutting force to the meat samples was performed using a TA XT2 Texture Analyzer equipped with a TA 7 Warner Bratzler Blade (Stable Micro Systems Ltd. Surrey, England, UK). Maximum shear force (g) was applied three times (n=3) per sample. Shear force is expressed as hardness of meat.

5. Measurement of TBARS Values

When required for analysis, breast and drumstick meat samples that had been stored at 20℃ were thawed at 4℃, and homogenized (PH91, SMT Company, Japan). Six sub samples weighing approximately 2.5 g each from breast and drumstick samples were weighed into 50 mL screw capped centrifuge tubes and subsequently incubated (Sli 600ND, Eyela, Japan) at 30℃ for 0, 1, 3, 6, 10, 15 and 21 d. Following incubation, each sub sample was immediately subjected to malondialdehyde acid (MDA) assay for measuring the extent of lipid oxidation. MDA, a secondary oxidation product, was determined by the method as described earlier (Sushil and Meliss, 1997) with minor modifications. Each sample was added with 6 mL of 2 % trichloroacetic acid and concussed for 5 min. The mixture was then adjusted to become 12.5 mL with distilled water and filtered through a Whatman No. 1 filter paper. A 3 mL filtrate was added with 3 mL of 5 mM 2 thio barbituric acid (TBA) and held at room temperature in a darkroom for 15 h. The absorption rate of the mixture was then measured at 530 nm. The amounts of 2 thio barbituric acid per kg of sample. The measurement of oxidative stability in skin samples was the same as outlined for breast and drumstick samples except for the homogenization step. Intact skin samples were incubated from 0 to 21 d. Immediately after incubation, samples were homogenized (Polytron PT MR 2100, Switzerland bv Kinemacia AG.) with 6 ml of 20 % trichloroacetic acid and further processed as described above in order to measure the TBARS values.

6. Statistical Analysis

All data were subjected to one way ANOVA using the GLM procedure (SAS, 2000). The level of statistical significance was pre set at P<0.05.

RESULTS AND DISCUSSION

1. Growth Performance

Growth performance from this feeding trial was shown in Table 2. Though not statistically meaningful, the BW gain tended to improve by the supplement of *S. cerevisiae* during the whole period of feeding experiment. Feed intake throughout the experiment was not affected by dietary treatments. Although not significant, the feed/gain ratios were lower in birds fed on *S. cerevisiae* than those of the control. The feed/gain ratios were improved 2.5 % during 0~3 wk of age, 4.8 % during 4~5 wk of age, and 3.9 % during 0~5 wk of age, compared to the control.

Our study indicates that dietary *S. cerevisiae* can improve the growth performance of broiler chicks. Several workers (Valdivie, 1975; Stanley *et al.*, 1993; Onifide *et al.*, 1999) also reported that the growth rate increased when broiler chicks were fed *S. cerevisiae*.

2. Shear Force of Meat

Table 2. Effect of dietary *S. cerevisiae* on growth performance of broiler chicks

	Control	3 % *S. cerevisiae*
0~3 wk		
Body weight gain, g/bird	572.4±37.1[1]	590.4±43.6
Feed intake, g/bird	931.0±62.5	934.4±34.3
Feed/gain	1.63±0.10	1.59±0.09
4~5 wk		
BW gain, g/bird[2]	949.7±44.3[b]	992.9±37.3[a]
Feed intake, g/bird	1776.7±61.3	1766.1±101.6
Feed/gain	1.87±0.11	1.78±0.10
0~5 wk		
Body weight gain, g/bird	1522.1±75.1	1583.0±74.0
Feed intake, g/bird	2707.6±96.5	2700.5±115.2
Feed/gain	1.78±0.11	1.71±0.06

Mean±SD. [a,b] P<0.05.

As shown in Fig. 1, the addition of 3 % *S. cerevisiae* to a corn soybean meal control diet lowered shear force in drumstick meat ($P<0.05$); however, such difference was not detected in breast meat.

The Warner Bratzler shear force determination is a widely accepted method to determine meat tenderness (Shackleford, *et al.*, 2001). Tenderness is the sum of the mechanical strength of skeletal muscle tissue after rigor mortis, and the weakening of the structure during the post mortem storage (Takahashi, 1996). It is the most important textural characteristic of meat and has the greatest influence on consumer acceptance of meat. Post mortem aging is widely known to improve tenderness. The amount of collagen in muscle has been used as a measure of muscle desirability or tenderness. The result (Fig. 1) suggests that the dietary supplementation of *S. cerevisiae* increases meat tenderness of broilers, though the reason is not clear. The probable reason is that *S. cerevisiae* prevents glycogen loss in drumstick muscle and so improves meat texture. Likewise, Immonen *et al.* (2000) reported lower shear force values in meats of high and intermediate glycogen contents compared to meats of low glycogen content.

There are some other factors which affect the tenderness. According to Silva *et al.* (1999), cooking loss and juiciness were significantly ($P<0.001$) correlated with tenderness. Many researchers speculated that increased water holding capacity of meat of high pH contributes to their increased tenderness (Bouton *et al.*, 1971, 1973; Jeremiah *et al.*, 1991; Purchas, 1990, 1993; Guignot *et al.*, 1994; Dransfield, 1996).

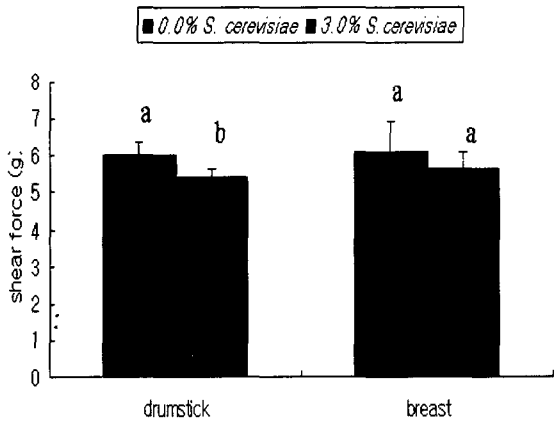

Fig. 1. Effect of dietary *S. cerevisiae* on shear force of drumstick and breast meats of broiler chicks (a,b: $P<0.05$).

3. TBARS Values of Meat and Skin

The effect of *S. cerevisiae* on oxidative stability in breast and drumstick meats, and skin samples were shown in Figs. 2, 3 and 4, respectively. Upon incubation, TBARS values increased gradually in breast and drumstick meats (Fig. 2 and 3) while more dramatic increase was evident in skin samples (Fig. 4). After 10 d of incubation, significantly lower TBARS values ($P<0.05$) of both drumstick meats and skin samples from broiler chicks fed diets enriched with *S. cerevisiae* than those from control chicks. In breast meats, this effect of lowering the

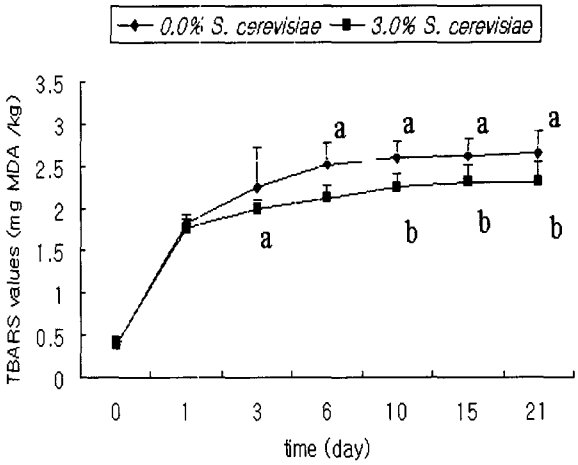

Fig. 2. Effect of dietary *S. cerevisiae* on TBARS values of breast meats. All data points are mean TBARS values from 8 replicates standard deviation (a,b: $P<0.05$).

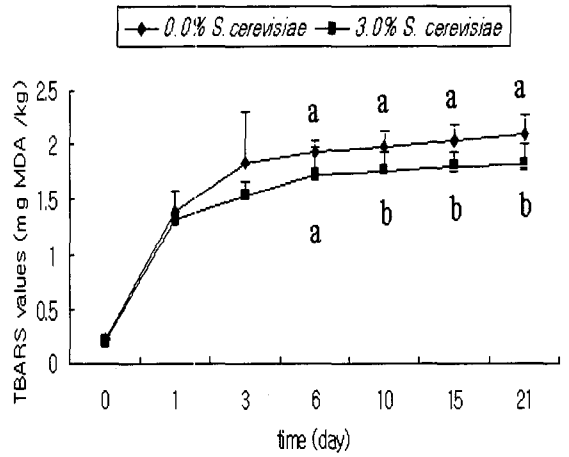

Fig. 3. Effect of dietary *S. cerevisiae* on TBARS values of drumstick meats.

All data points are mean TBARS values from 8 replicates standard deviation (a,b : $P<0.05$).

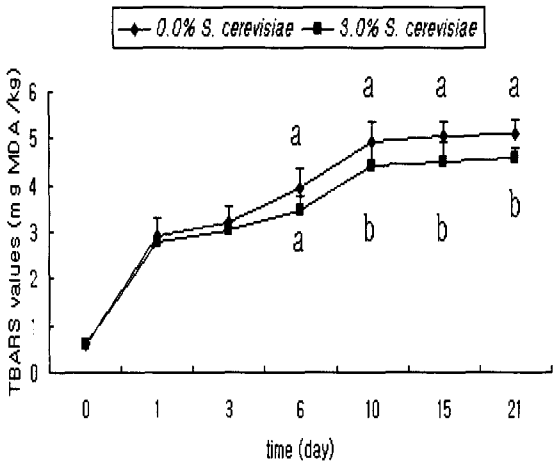

Fig. 4. Effect of dietary *S. cerevisiae* on TBARS values of skin. All data points are mean TBARS values from 6 replicates standard deviation (a,b: $P<0.05$).

TBARS values ($P<0.05$) by yeast feeding was monitored after 6 d of incubation.

The results (Fig. 2, 3, and 4) provide the evidence that supplementation of *S. cerevisiae* into a corn soybean meal base control diet could increase the oxidative stability of broiler meat and skin. It may indicate that there are some antioxidant factors in *S. cerevisiae,* or *S. cerevisiae* may make the meat and skin containing less oxidative fat (or fatty acids). Some researchers reported that there are some antioxidant factors in *S. cerevisiae*, such as thioredoxin peroxidase (acts as a peroxidase), glucose tolerance factor fractions (acts as an antioxidant), copper zinc superoxide dismutase (acts as oxidation retarding factor) (Meyer *et al.*, 1994; Ampel *et al.*, 2000; Kim *et al.*, 2001). Many other researchers also back up such view that *S. cerevisiae* presents antioxidant properties or some oxidant defense systems (Chen *et al.*, 1998; Jamieson, 1998; Bastin *et al.*, 2002).

In contrast to the viewpoint described above, the graphs in Figs. 2, 3, and 4 show that the speeds of oxidation were the same in both treatments at the early stage of incubation, but the TBARS values in chicks fed *S. cerevisiae* did not increase further, indicating that the further oxidation was not happened. If an antioxidant(s) from *S. cerevisiae* contributes to lower the TBARS values, the graph from 3.0 % *S. cerevisiae* fed birds would show a sigmoid flexure at the early stages of incubation. At present, a clear explanation for an antioxidant effect of *S. cerevisiae* is not available, but it may well be that the oxidative fat or fatty acids content is different between *S. cerevisiae* fed chicks and control chicks. Several investigators also reported that dietary yeast significantly decreased the lipid deposition in both broiler chicks (Akiba *et al.*, 1982; Bolden *et al.*, 1984; Mendonca *et al.*, 1984; Takahashi and Jensen, 1984) and laying hens (Akiba *et al.*, 1983; Bolden and Jensen, 1985; Brenes *et al.*, 1985; Takahashi and Jensen, 1985).

It can be concluded from this experiment that dietary *S. cerevisiae* at the level of 3.0 % could stimulate growth performance, tenderize meat, and decrease the degree of oxidation in broiler meat and skin in broiler chicks.

적 요

효모(*Saccharomyces cerevisiae*)의 급여가 육계의 생산성과 몇 가지 육질요인들의 개선효과가 있는지 알기 위하여 사양실험을 실시하였다. 갓 부화한 160수의 수컷 병아리 (Ross strain)를 두 처리로 나눈 후, 각각 0%와 3.0%의 *S. cerevisiae*를 함유한 사료를 5주간 급여하였다. *S. cerevisiae* 급여구는 무급여구에 비하여 체중이 무거운 경향을 보였으나 유의성은 없었다. *S. cerevisiae* 첨가는 신선한 다리근육 (drumstick meat)의 전단력을 유의하게 감소시켰으나 ($P<0.05$), 삶은 다리근육에서는 이러한 효과가 관찰되지 않았다. 흉근과 다리근육 및 피부조직의 산화 안정성은 *S. cerevisiae* 첨가에 의하여 유의하게 개선되었다 ($P<0.05$). 결론적으로 사료에 3% 수준의 *S. cerevisisae* 첨가는 계육의 연도와 산화 안정성을 개선시키는 것으로 나타났다.

(색인 : *Saccharomyces cerevisiae*, 육계, 성장능력, 계육의 연도, 계육의 산화안정성)

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