Effects of Graded Levels of Dietary *Saccharomyces cerevisiae* on Growth Performance and Meat Quality in Broiler Chickens*

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ABSTRACT : An experiment was conducted to investigate the effects of various dietary levels of *Saccharomyces cerevisiae* (*SC*) on the growth performance and meat quality (i.e., tenderness and oxidative stability) of Ross broiler chickens. Two hundred and forty day-old broiler chicks were fed four experimental diets with graded levels of *SC* at 0.0, 0.3, 1.0 and 3.0%. Each treatment consisted of six cages with 10 chicks per cage. Feed and water were provided *ad libitum* throughout the experiment that lasted for 5 wk. Birds were switched from starter to finisher diets at 3 wk of age. The average BW gains of broiler chickens increased (linear $p<0.05$) during either 0-3 or 0-5 wk of age as dietary *SC* levels increased. A linear effect ($p<0.05$) of SC on feed intake during either 4-5 wk or 0-5 wk of ages was also monitored. The addition of *SC* to the control diet significantly lowered shear forces in raw breast, raw thigh, and boiled drumstick meats (linear $p<0.05$). Upon incubation, 2-thio-barbituric acid-reactive substances (TBARS) values increased gradually in breast and thigh meats while more dramatic increase was noted in skin samples. The TBARS values of either breast or thigh meats were not significantly affected ($p>0.05$) by dietary treatments up to 10 d of incubation. At 15 d of incubation, TBARS values of breast and thigh meats from all *SC*-treated groups were significantly lower ($p<0.05$) than those of the control. It appears that dietary *SC* could enhance growth performance of broiler chickens, and improve tenderness and oxidative stability of broiler meats. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 5 : 699-703)***

Key Words : *S. cerevisiae*, Growth Performance, Meat Qualities, Broiler Chickens

INTRODUCTION

Various strains of *Saccharomyces cerevisiae* (*SC*) have long been fed to animals as a source of unknown growth factor. It was reported that feeding *SC* to chickens improved weight gain and feed/gain ratio (Onifade et al., 1999, 2000). On the other hand, Madriqal et al. (1993) failed to observe the positive effect of feeding *SC* on body weight in broiler chickens. In addition to growth performance, there are literature data (Akiba et al., 2001; Lee et al., 2002) showing that enrichment of diets with yeast could favorably improve broiler meat quality. Specifically, edible meats sampled from broiler chickens fed a diet containing *SC* exhibited increased tenderness (Bonomi et al., 1999) and increased water-holding capacity (Lee et al., 2002). However, the effect of *SC* supplementation on oxidative stability of chicken meat was not extensively studied although there are indications (Meyer et al., 1994; Ampel et al., 2000) that *SC* may possess antioxidant property. Thus, the present study was conducted to evaluate the effects of graded levels of dietary *SC* on growth performance and meat quality of broiler chickens.

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MATERIALS AND METHODS

Animals, diets and experimental design

Day-old 240 male broilers (Ross×Ross) chicks were allotted to 24 wire-floored, suspended cages in a temperature-controlled room according to the completely randomized design. Continuous lighting was provided throughout the 5-wk experimental period. The room temperature was gradually decreased from 32°C on Day 0 to 25°C on Day 21 and was kept constant thereafter. There were four dietary treatments consisting of six replicates per treatment. A replicate was identical to a cage with 10 birds so that each treatment had 60 chicks. Broiler starter and finisher diets (Table 1) were formulated according to the NRC (1994) recommendation and used as a basal diet (*SC* 0%). Three levels of baker's *SC* (Choheung Chemical Industrial Co. Ltd., Ansan, Kyunggi-do, Korea) were added to the control diet to give 0.3, 1.0, or 3.0% *SC* in diets, respectively, at the expense of soybean meal. Feed and water were provided *ad libitum* throughout the experiment that lasted 35 d.

Body weight and feed intake measurements

Body weight (BW) was measured by cage at 1, 21 and 35 d of ages. Feed intake was monitored by cage at 21 and 35 d of ages. Feed intake per cage and weight gain per cage

Table 1. Composition of the control diet[1]

Ingredients	Starter (0-3 wk)	Finisher (4-5 wk)
Corn (%)	59.26	64.63
Soybean meal (44%) (%)	20.52	18.92
Corn gluten meal (%)	9.43	7.17
Rapeseed meal (%)	5.00	3.00
Soybean oil (%)	2.00	3.00
Tricalcium phosphate (%)	1.78	1.27
Limestone (%)	0.88	1.08
Salt (%)	0.40	0.40
DL-methionine (50 %) (%)	0.34	0.16
L-lysine HCl (%)	0.19	0.17
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 (%)	21.50	19.00
Ca (%)	1.00	0.90
Available P (%)	0.45	0.35
Methionine (%)	0.50	0.38
Lysine (%)	1.10	1.00

[1] The four experimental diets were formulated by replacing soybean meal with yeast (*S. cerevisiae)* at 0 (control), 0.3, 1.0 and 3.0%, respectively.

[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}, 0.0066 mg; 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 per kilogram of diet: Mn, 120 mg; Zn, 100 mg; Fe, 60 mg; Cu, 10 mg; I, 0.46 mg; and Ca, min: 150 mg, max: 180 mg.

were used to calculate feed/gain ratios.

Collection of meat and skin samples

On the last day of 5-wk feeding trial, one bird from each cage (replicate) close to mean BW was slaughtered by bleeding the carotid artery. Immediately after the slaughter, chickens were de-feathered, and trimmed to obtain breast, thigh and drumstick meats with skins on them. Then, one half of breast and thigh meats, and whole skins sampled were stored at -20°C until required for the lipid oxidation assay. The rest of breast and thigh meats, and whole drumstick meats were stored at 4°C prior to the measurement of shear force.

Measurement of shear force

Both raw and boiled 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 (kg) was applied three times (n = 3) per sample. Shear force is defined as hardness of meat.

Measurement of TBARS values

When required for analysis, breast and thigh meat samples stored at -20°C were thawed at 4°C, deskinned and homogenized. Six sub-samples weighing approximately 2.5 g each from breast and thigh samples were weighed into 50 ml screw-capped centrifuge tubes and subsequently incubated at 30°C for 0, 1, 3, 6, 10 and 15 d, respectively, to compare the oxidative stability. 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 of Sushil and Meliss (1997) with minor modifications. The amounts of TBARS were expressed as mg MDA per kg of sample. The oxidative stability in skin samples was also measured as outlined for breast and thigh samples except for the homogenization step. Intact skin samples were incubated from 0 to 15 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.

Statistical analysis

All data were evaluated by one-way ANOVA using the GLM procedure (SAS, 2000). Polynomial contrasts (linear, quadratic and cubic) were used to test the effects of graded levels of *SC* on BW gain, feed intake, feed/gain ratio, and shear force. In addition, significant differences of mean TBARS values between dietary treatments were analyzed by repeated measures and Tukey test in the GLM procedure (SAS, 2000). The level of statistical significance was pre-set at $p<0.05$.

RESULTS AND DISCUSSION

Growth performance

The growth performance of broiler chickens fed graded levels of *SC* is shown in Table 2. At 3 wk of age, the BW gains were linearly ($p<0.05$) increased by on average 4.2, 7.8 and 13.2% in birds fed on 0.3, 1.0 and 3.0% *SC*, respectively, as compared to those fed the basal diet with 0% *SC*. Growth-promoting effect of *SC* that observed at 3 wk of age was also observed at 5 wk of age. Feed intake per bird at 3 wk of age was not affected ($p>0.05$) by dietary treatments. However, feed intake increased as the *SC* levels in the diets increased (linear $p<0.05$) during either 4-5 wk of age or 0-5 wk of age. The feed/gain ratios tended to be lower in all *SC*-fed groups, however, no significant difference was detected between the control and *SC* treatments ($p>0.05$).

The growth rates of this study corroborates well with earlier studies showing the positive effect of feeding yeast on growth performance in chickens (Valdivie, 1975;

Table 2. Effect of graded levels of *S. cerevisiae* (*SC*) supplementation on growth performance of broiler chickens

Growth performance/bird	SC* (%)				Pooled SEM**	Polynomial contrasts		
	0.0	0.3	1.0	3.0		Linear	Quadratic	Cubic
0-3 wk								
BW gain (g)	604	631	654	689	17.1	p<0.05	NS***	NS
Feed intake (g)	1,073	1,081	1,085	1,120	30.1	NS	NS	NS
Feed/gain	1.78	1.72	1.67	1.64	0.065	NS	NS	NS
4-5 wk								
BW gain (g)	801	866	860	863	19.9	NS	NS	NS
Feed intake (g)	1,482	1,511	1,561	1,560	22.3	p<0.05	NS	NS
Feed/gain	1.86	1.75	1.82	1.82	0.029	NS	NS	NS
0-5 wk								
BW gain (g)	1,405	1,498	1,515	1,553	28.2	p<0.05	NS	NS
Feed intake (g)	2,556	2,594	2,644	2,685	41.6	p<0.05	NS	NS
Feed/gain	1.82	1.73	1.75	1.73	0.034	NS	NS	NS

* Values are expressed as the means with six replicates per treatment.
** SEM: standard error of mean.
*** NS: not significant.

Table 3. Effect of graded levels of *S. cerevisiae* (*SC*) supplementation on shear force in broiler meats

Shear force (kg)	SC* (%)				Pooled SEM**	Polynomial contrasts		
	0.0	0.3	1.0	3.0		Linear	Quadratic	Cubic
Raw breast	6.74	6.29	6.02	5.80	0.109	p<0.05	NS***	NS
Raw thigh	6.14	5.89	5.58	5.40	0.162	p<0.05	NS	NS
Cooked drumstick	5.13	4.82	5.02	4.40	0.166	p<0.05	NS	NS

* Values are expressed as the means with six replicates per treatment.
** SEM: standard error of mean.
*** NS: not significant.

Onifade et al., 1999). On the contrary to this study, Madriqal et al. (1993) reported that dietary *SC* failed to improve the BW gain of chickens.

It has been shown that the addition of yeast into broiler diets could prevent the colonization of *Salmonella* whether or not the chickens inoculated with *Salmonella* were subsequently challenged with transportation stress (Line et al., 1997; 1998). Feeding *SC* var. *boulardii* to poults increased BW gain that could be associated with improved intestinal lumen health (Bradley et al., 1994). Similarly, addition of 0.2% cell-wall component of *SC* in broiler diet significantly increased BW gains with a reduction in crypt depth and an increase in villus height when compared to the control group (Santin et al., 2001). Thus, it is likely that *SC* could either improve the efficacy of immune response or stabilize intestinal microflora, or both, thus leading to better growth performance of broiler chickens as shown in this study.

Shear force of meat

The addition of *SC* to a corn-soybean meal based control diet significantly lowered the shear force in raw breast, raw thigh and cooked drumstick meats (linear $p<0.05$; Table 3). The shear force values of raw breast and thigh meats tended to be higher than that from cooked drumstick. This study suggests that the dietary supplementation of *SC* could improve meat tenderness of broilers in a dose-dependent manner, though the reason is not clear. The probable reason is that *SC* prevents glycogen loss in drumstick muscle and so improves meat texture. There are some other factors which affect the meat tenderness. According to Silva et al. (1999), cooking loss and juiciness were significantly ($p<0.001$) correlated with tenderness. Bouton et al. (1973) speculated that increased water holding capacity of meat of high pH contribute to their increased tenderness. The ultimate pH values also contribute to tenderness (Bouton et al., 1971; Purchas, 1990; Jeremiah et al., 1991; Guignot et al., 1994).

TBARS values of meat and skin

The effects of dietary *SC* on TBARS values of breast and thigh meat samples, and skin samples were shown in Figure 1, 2 and 3, respectively. Initial TBARS values were comparable among breast and thigh meats, and skin samples, ranging from 0.18 to 0.36 mg MDA per kg of samples at the beginning of incubation. Upon incubation, TBARS values increased gradually in breast and thigh meats (Figures 1 and 2) while more dramatic increase in skin samples (Figure 3). The slopes of the increase in TBARS values against incubation time were relatively slack in breast and thigh meats as compared with those in skin samples. The TBARS values of either breast or thigh meat was not significantly affected ($p>0.05$) by dietary treatments up to 10 d of incubation. At 15 d of incubation, the TBARS values of both breast and thigh meat samples from broiler chickens fed diets supplemented with *SC* was

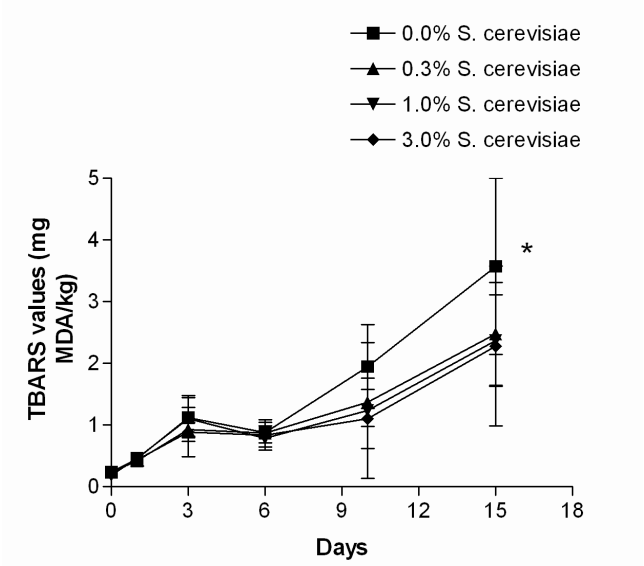

Figure 1. Effect of graded levels of *S. cerevisiae* supplementation on 2-thio-barbituric acid-reactive substances (TBARS) values of breast meat. All data points are mean TBARS values from 6 replicates±standard deviation. Asterisk (*) indicates that TBARS values of the control group versus the groups fed diet containing 0.3, 1.0 and 3.0% *S. cerevisiae* were statistically different ($p<0.05$).

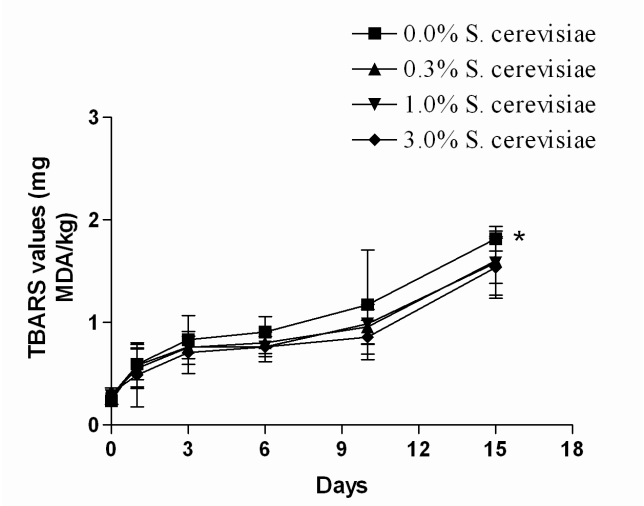

Figure 2. Effect of graded levels of *S. cerevisiae* supplementation on 2-thio-barbituric acid-reactive substances (TBARS) values of thigh meat. All data points are mean TBARS values from 6 replicates±standard deviation. Asterisk (*) indicates that TBARS values of the control group versus the groups fed diet containing 0.3, 1.0 and 3.0% *S. cerevisiae* were statistically different ($p<0.05$).

significantly lower ($p<0.05$) than those of control chickens. The TBARS values measured at 15 d of incubation ranged from 1.54 to 1.82 mg MDA per kg of thigh meat and from 2.28 to 3.57 mg MDA per kg of breast meat. The TBARS values of skin samples measured at 15 d of incubation was apparently higher than those of thigh meat ranging from

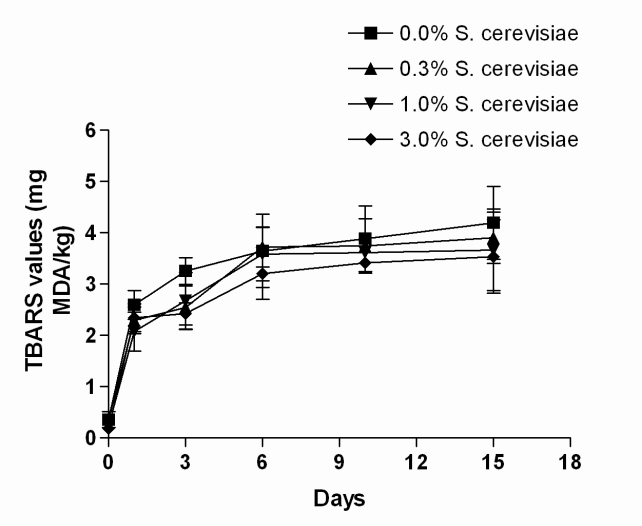

Figure 3. Effect of graded levels of *S. cerevisiae* supplementation on 2-thio-barbituric acid-reactive substances (TBARS) values of skin. All data points are mean TBARS values from 6 replicates±standard deviation.

3.54 to 4.20 mg per kg of skin samples and those of breast samples being intermediate.

The results (Figures 1 and 2) provide the evidence that supplementation of *SC* into a corn-soybean meal based control diet could increase the oxidative stability of broiler meat in dose-dependant manner. It may indicate that there are some antioxidant factors in *SC* or *SC* may make the meat containing less oxidative fat (or fatty acids). Previous studies (Meyer et al., 1994; Ampel et al., 2000) indicated that some antioxidant factors are present in *SC*. However, as shown in Figure 1, 2 and 3, the speeds of oxidation were the same in all treatments at the early stage of incubation. If an antioxidant(s) from *SC* contributed to the lowered oxidation, the graphs should show different patterns at the early stages of incubation. Alternatively, this study may indicate that meats from the chickens fed *SC* contain less oxidative fat (or fatty acids). Although fatty acid compositions of meats were not measured in this study, it has been reported that lipid deposition was significantly lowered by feeding yeast to broiler chickens (Akiba et al., 1982; Bolden et al., 1984; Mendonca et al., 1984; Takahashi and Jensen, 1984) and to laying hens (Akiba et al., 1983; Bolden and Jensen, 1985; Brenes et al., 1985; Takahashi and Jensen, 1985).

It can be concluded from this study that feeding of *SC* to broiler chickens could improve growth performance in a dose-dependent manner. Dietary *SC* can also improve meat tenderness and the oxidative stability of broiler meats.

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