한국가금학회지 제 44권 제 3호, 161～172 (2017)
Korean J. Poult. Sci. Vol.44, No.3, 161～172 (2017)
http://dx.doi.org/10.5536/KJPS.2017.44.3.161

Determination of The Growth Performances and Meat Quality of Broilers Fed *Saccharomyces cerevisiae* as a Probiotic in Two Different Feeding Intervals

W. H. D. Shemil Priyan Macelline[1,2*], Hyun Min Cho[2*], H. K. Thilini Awanthika[1], Samiru Sudharaka Wickramasuriya[1,2], Dinesh. D. Jayasena[1], R. M. Himali Tharangani[1], Zhang Song[3] and Jung Min Heo[2†]

[1]Department of Animal Science, Uva Wellassa University, Badulla 90000, Sri Lanka

[2]Department of Animal Science and Biotechnology, Chungnam National University, Daejeon 34134, Republic of Korea

[3]New Hope Lanka Ltd, No. 255A, Kurunduwatte Road, Ekala, Ja-ela. Sri Lanka.

ABSTRACT This study was conducted to determine the effect of *Saccharomyces cerevisiae* (SC) as a dietary probiotic and evaluated the most suitable feeding interval for this probiotic on growth performance, carcass yield, and meat quality parameters in broiler chickens. In total, 1,050 one-day-old Cobb 500 chicks were randomly assigned to one of seven dietary treatment groups, in a 2 × 3 factorial arrangement with 3 SC dosages (0.6%, 1%, and 1.4%) and two feeding intervals [long term (LT) for 35 days and short term (ST) for 28 days after hatching], with a negative control diet (NC; 0% SC). Triplicate experiments were performed with 50 birds per cage. Broilers fed a diet including SC showed increased (p<0.01) daily gain and feed efficiency compared to the control. Further, broilers fed the 1.4% SC supplemented diet showed a significantly increased (p<0.01) average daily gain (ADG) and feed conversion ratio (FCR) compared to broilers fed the 0.6% and 1% SC incorporated diets. Similarly, broilers fed an LT SC diet showed a greater (p<0.01) increase in ADG and FCR compared to broilers fed an ST SC diet. Moreover, broilers fed an LT SC diet displayed a reduced (p<0.05) meat pH, gizzard weight, and increased (p<0.05) meat water-holding capacity compared to broilers fed an ST SC diet. Broilers fed the 1.4% SC supplemented diet showed increased (p<0.05) thigh muscle weight compared to broilers fed the 0.6% and 1% SC supplemented diets. In conclusion, broilers fed LT SC diets showed improved growth performance and carcass quality parameters compared to broilers fed ST SC diets, and the NC diet, from hatching to day 35.

(Key words: broilers, feed conversion ratio, probiotic, water holding capacity)

INTRODUCTION

Feed additives play an important role in commercial broiler industry, which provides a positive health benefit for broilers (Biernasiak and Slizewska, 2009). Antimicrobial growth promoters (AGP) as a feed additive provide effective growth and feed efficiency (Niewold, 2007). Increasing restrictions on the use of AGP caused a search for the AGP alternatives (Niewold, 2007). Prebiotics and probiotics are critical alternatives that have potential to reduce enteric disease in poultry and subsequent contamination of poultry products (Patterson et al., 2003). Probiotics are live microbial feed supplement that beneficially affects the host animal by improving microbial balance in the gut (Fuller, 1989). It was reported (Ahmad, 2006; Shareef, 2009; Shabani et al., 2012) incorporating a probiotic into the feed had greater growth performance for broilers. In addition, probiotic work as a good replacement for antibiotic via maintain the host animal gut microbial balance and reinforcing the natural defense against the intestinal diseases and pathogenic activities (Hassanein and Soliman, 2010).

Saccharomyces cerevisiae (SC) is a very common fungus known as ‘Yeast’ that used as a fermenting agent for baking, distilling and brewing industries (Hammond, 1993; Rose and Vijayalakshmi, 1993; Watson, 1993). The cell wall of SC contains chitin, mannan, and glucagon, which works as an immune stimulant and prebiotic sources (Li and Gatlin, 2003). Moreover, yeast cell wall contains 1,3～1,6 D glucagon and mannan-oligosaccharides that act as natural growth promotors (van Leeuwen et al., 2005; Ghosh et al., 2007). In addition, SC cell wall contains able to minimize the aflatoxin effect in poultry through biodegradation (Parlat et al., 2001).

Previous studies investigated the SC effect (0.1～2.0% dosages) on broiler performance and meat quality parameters

* These authors have contributed equally to this work.
† To whom correspondence should be addressed : jmheo@cnu.ac.kr

without concerning the SC feeding interval (Stanley et al., 1993; Karaoglu and Durdag, 2005; Zhang et al., 2005; Paryad and Mahmoudi, 2008). Broilers fed SC and SC cell wall contains incorporated diets showed significantly higher body weight gain compared to the broilers fed negative control diet (Zhang et al., 2005). Moreover, these studies reported that broiler fed a diet with the high dosage of SC (over 1.5%) had positive growth performance compared to the broiler fed low dosage (less than 0.5%) diet. In a previous study, observed results indicated that the broiler fed a diet supplement with probiotic (0.1%, 0.2%) significantly increased body weight, average daily feed intake and feed conversion at the starter phase compared to the broilers fed a diet without probiotic (Bai et al., 2013). Despite the importance of dietary SC supplementation on broiler performance, there were limited studies evaluate the effect of SC feeding interval on the performance of broilers. Therefore, the main objective of this research was to determine the effect of SC on growth performance and meat quality parameters of broilers from hatch to 35 days of age. Apart from that, the secondary objective was to determine the interaction effect of dosage and feeding interval (duration) on the broiler growth and meat quality parameters.

MATERIALS AND METHODS

1. Experiment Facility and Diets

This study was conducted in the research facility of the New Hope Lanka Ltd. located in the Minuwangoda, Western Province, Sri Lanka. Maize and soybean meal based basal diets were formulated using "Cobb 500" specification for each phase of rearing separately (Table 1). *Saccharomyces cerevisiae* (strain-brawers' yeast, Dingtao Yongxing Food Co., Ltd. Dingdeng Line, Dingtao Xian, Heze Shi, Shandong Sheng, China) was supplemented as top dress into basal diet in the proportion of 0.6, 1.0 and 1.4% respectively for produce 6 diets. *Saccharomyces cerevisiae* was supplemented in two feeding intervals including long term (LT) for 35 days after hatch and short term (ST) for 28 days after hatch for the each dosage level of SC.

2. Experimental Design and Management

A total of 1050, one-day-old broiler chicks (Cobb 500, Bairaha Farms PLC., Sri Lanka) were used in this experiment. At the beginning, birds were divided into seven treatment groups (Table 2) with three replicate pens per treatment (50

Table 1. Ingredient composition of basal ration (as-fed basis)

Item		Composition (%)		
		Starter (d 1~14)	Grower (d 15~28)	Finisher (d 29~35)
Maize		42.50	44.00	46.50
Broken rice		10.75	12.75	13.75
Rice polish		5.50	6.50	7.25
Soya bean meal		25.75	23.55	20.00
Meat and bone meal		6.50	4.50	4.00
Vegetable oil		1.40	2.00	3.25
Corn gluten meal		4.75	4.25	3.25
Fish meal		0.50	0.30	0.00
Iodinated salt		0.30	0.33	0.25
Limestone		0.23	0.21	0.22
DCP[1]		0.34	0.31	0.31
Lysine		0.46	0.44	0.43
Threonine		0.10	0.08	0.07
Methionine		0.27	0.25	0.23
Vitamin premix[2]		0.04	0.04	0.04
Mineral premix[3]		0.21	0.21	0.21
Other additives[4]		0.41	0.29	0.26
Calculated composition	Crude protein (%)	23.11	20.03	19.93
	Crude fat (%)	3.55	4.21	5.92
	Ca (%)	1.02	1.00	0.95
	Available *p* (%)	0.54	0.51	0.49
	ME[4] (kcal/kg)	2900	3000	3100

[1] Dicalcium phosphate.

[2] Vitamins: A 7,000 IU, D_3 1,400 IU, E 20 mg, K 1 mg, B_1 1 mg, B_2 3 mg, B_6 1.5 mg, B_{12} 15 μg, calcium pantothenate 10.7 mg, folic acid 0.2 mg, niacin 12 mg, biotin 30 μg.

[3] Minerals: Co 0.2 mg (as cobalt sulphate), Cu 10 mg (as copper sulphate), iodine 0.5 mg (as potassium iodine), iron 60 mg (as ferrous sulphate), Mn 40 mg (as manganous oxide), Se 0.3 mg (as sodium selenite), Zn 100 mg (as zinc oxide).

[4] Toxin binder (Mycofix, BIOMIN Animal Nutrition GmbH, Erber Campus, Getzersdorf, Austria), phytase (Microphytase5000, Shandong, China), xylanase (Rovabio advance, Adisseo, Place du Général de Gaulle 92160 Antony-Franc.

birds per each replicate). Chicks were reared in the electric brooder from hatch to day 10. After brooding, each treatment group was moved to growing pens (0.11 m^3 spaceper bird). Each pen was equipped with two feeders and two bell waterers. *ad-libitum* access to experimental diets and clean water were facilitated throughout the experiment period. Lighting was continuous and the temperature was maintained 33℃ for first three days and gradually decreased to room temperature (25±2℃) until end of the experiment. The birds were vaccinated with IB vaccine (vaccination for Infectious Bronchitis, via eye drops) on day 1, Ranicket vaccine (Vaccination for New Castle Disease, via water) on day 7 and Gumboro (Infectious Bursal Disease; IBD, via water) vaccine on days 10, 17 and 23 respectively.

3. Growth Performance

Body weights were recorded on day 1 and end of the experiment period (day 35) in each replicate cage separately. Feed intake was recorded daily as feed disappearance in the feeder. Mortality was recorded for each treatment separately throughout the experiment when death occurred. Average daily gain, mortality corrected average daily feed intake and feed conversion ratio (FCR) of birds were calculated.

4. Post-Mortem Procedure

Birds were subjected to 10 hours feed withdrawal prior to the slaughtering at the end of the experimental period (day 35). One bird from each treatment with the closets median body weight was selected and euthanized via cervical dislocation (Houshmand et al., 2011; Nuwan et al., 2016). Body weights of the each bird were recorded prior to the slaughtering. Evisceration was done manually followed by the bleeding.

5. Data Collection after Slaughtering

Table 2. Experimental design

Duration[1]	Short term			Long term			Negative control group (SC 0%)
SC dosage[2] (%)	0.6	1.0	1.4	0.6	1.0	1.4	

[1] *Saccharomyces cerevisiae* incorporated duration.
[2] *Saccharomyces cerevisiae* incorporated dosage.
[3] *Saccharomyces cerevisiae.*

Carcass weight, thigh muscle weight and breast muscle weight, were measured from each slaughtered bird separately. Measured carcass parameters were expressed as a proportion of live body weight of the respective bird. Internal organs weight were weighted by using analytical balance (Model-321 LX, Shanghai, China) and expressed the organ weight in proportion to the live body weight.

6. Analysis of Meat Quality Parameters

1) pH of the Meat

One gram of breast meat sample was minced using the mincing machine (TS-JR12A, Teng Sheng Food Machinery Co., Ltd., Guangdong, China). Minced meat samples were placed into the falcon tubes (Biologix-model; 10-9152, Ying Xiu Road High-Tech Industrial Development Zone Jinan, Shandong, China) and mixed with added 9 mL of distilled water. These tubes with samples were set into the vortex meter (XINFU-SK-1, Hebi City Thermal meter instrument factory, Henan, China) for homogenizing the samples (2,000 rpm in 30 minutes). After homogenization, samples were filtered using filter papers (Whatsman No.4, Whatman International Ltd., Maidstone, England). Thereafter, filtrate was separated and checked the pH value using calibrated pH meter (pHep®-HI96107, Hanna Instruments Italiya SRL, Ronchidi Campanile PD, Italy).

2) Determine the Cooking Loss

Cooking loss of the meat samples was evaluated according to the method described by Lakshani et al. (2016) with a little modification. A 30 g of breast meat sample was separated from carcass from the each slaughtered bird. After that, the sample was vacuum packed and sealed in polyethylene bags. Then, the sample was kept in a water bath (JONILAB® JN-WB001, JOAN Lab Instrument Co. Ltd, Zhejiang Province, China) at 85℃ for 30 minutes, and the allowed to cool room temperature. Finally, the sample was unpacked, surface dried and weighted respectively (Jeon et al., 2010). The cooking loss is equal to the weight loss after cooking and it interprets as a percentage of initial weight (Onenc et al., 2004).

3) Determine the Water Holding Capacity

To determine the water holding capacity. 2 g of breast meat sample was measured from each replicate bird. Each meat sample was wrapped by using filter paper (Whatsman no. 4, Whatman International Ltd., Maidstone, England). Subsequently, sample was subjected to standard 10 kg weight pressure for 5 minutes. Then after, final weight of the sample was measured. Water holding capacity of the meat was expressed as the weight loss of the meat samples as a percentage of the initial weight (Hamm, 1961). Water holding capacity (WHC) was calculated using the following equation, where W_i and W_f are the initial and final weights of sample, respectively (Lakshani et al., 2016)

$$WHC = 100 - \left[\frac{(W_i - W_f) \times 100}{W_i}\right]$$

7. Chemical Analysis of Meat

Proximate analysis for breast meat sample of each treatment was conducted according to the method of AOAC (1995) as modified by Jayasena et al. (2013) including moisture, crude protein, crude fat (ether extract) and crude ash. To evaluate the moisture 2.5 g of breast meat sample was dried at 103℃ for 4 hours in the dry oven (model-GZF6020, Lanphan Ltd. Henan, China). Soxhlet extraction system (DKZW-4, China) was used to measure crude fat contents of the sample by allowing eight hours ether extraction. Crude protein content of the breast meat sample was measured using Kjeldahl method (VAPO45, Gerhardt Ltd., Germany). Ash content was measured after ignited the 2 g of sample in a furnace (SX-4-10, China) set at 550℃ for 4 hours.

8. Sensory Evaluation

Sensory evaluation was performed to evaluate the effect of SC supplementation in broiler feed on meat sensory quality parameters. Thirty panelists were used as the replicates for the sensory evaluation. Breast meat samples from each treatment groups were used without adding salt or spice to evaluate the sensory qualities according to the Jayasena et al. (2013) without salt or spice. Five-point hedonic scale (1=dislike very much, 2=dislike slightly, 3=neither like nor dislikes, 4=like slightly and 5=like very much) was used as the sensory index for evaluating the meat sensory qualities. Color, appearance, juiciness, taste, odor and overall acceptability were used as the sensory parameters. All the samples were coded with three digit numbers when presented to panelists in order to minimize the bias of panelist during the evaluation (Nuwan et al., 2016).

9. Statistical Analysis

Data were subjected to factorial analysis using the General Linear Models (GLM) procedures of two-way ANOVA of Statistical Analysis System (Version 22; IBM SPSS 2013) for determine the main factor (dosage or duration) effects and interaction effects of main factors without concerning negative control group. One-way ANOVA was performed to determine the significance difference between NC and SC treatment groups. Pen was considered as the experimental units for growth performance measures. Selected birds were used as the experiment units for analyses carcass quality, organ weight, and meat quality parameter data. Differences between means were tested using Duncan multiple range significant difference test when it appropriate (P<0.05 and P<0.01). The score given by each panelist on each sensory parameters were analyzed using Friedman nonparametric test using the procedure of Statistical Analysis System (Version 22; IBM SPSS 2013).

RESULTS AND DISCUSSION

1. Growth Performance

Effect of dietary SC levels and its feeding intervals on growth performance of broilers from hatch to day 35 is presented in Table 3.

In the present study, broilers fed a diet supplemented with SC improved (P<0.01) weight gain and feed conversion ratio compared to the broilers fed NC diet from hatch to day 35. Comparatively, broilers fed a NC diet showed 10.95% lower weight gain and 14.56% higher FCR over birds fed a diet containing SC. The improvement was observed as leaner and quadratic way in the aspect of polynomial orthogonal contrast. Similarly, previous studies observed that the broilers fed a diet supplemented with SC improved weight gain and FCR compared to the broilers fed a diet without SC (Madrigal et al., 1993; Santin et al., 2001). Moreover, Miles and Bootwalla (1991) observed directly fed microbes as probiotic improved growth performance of broilers. These improved results related with the balanced microbial population in the gastro-

Table 3. The effect of *Saccharomyces cerevisiae* on growth performance of broiler chickens from 1 to 35 days of age

Treatments			ADG (g/day/bird)	ADFI (g/day/bird)	FCR
NC[1]			52.89	94.57	1.79
NC+0.6 S[2]			57.57	89.90	1.56
NC+1.0 S			57.05	89.71	1.57
NC+1.4 S			60.15	91.24	1.52
NC+0.6 L[3]			59.37	90.57	1.53
NC+1.0 L			57.36	89.43	1.56
NC+1.4 L			60.62	88.85	1.47
Pooled SEM[4]			0.44	0.81	0.02
P value of contrast[5]	NC vs NC+0.6S		**	*	**
	NC vs NC+1.0S		**	*	**
	NC vs NC+1.4S		**	NS	**
	NC vs NC+0.6L		**	NS	**
	NC vs NC+1.0L		**	*	**
	NC vs NC+1.4L		**	**	**
Significant level of factorial analysis	Duration[6]		**	NS	**
	Dosage[7]	Leaner[8]	**	NS	**
		Quadratic[8]	**	NS	**
	Dosage × Duration		NS	NS	NS

[1] Negative control.
[2] Short term.
[3] Long term.
[4] Standard error of mean.
[5] Significant level: NC $P>0.05$, * $P<0.05$, ** $P<0.01$.
[6] SC incorporation ratio (0.6% or 1% or 1.4%).
[7] Whether SC supplied short term or long term.
[8] Orthogonal polynomial contrast coefficient were used to determine linear and quadratic effect.
ADFI: Average daily feed intake, ADG: Average daily gain, FCR: Feed conversion ratio.

intestinal tract which has an important role in the health and growth performance of the broilers (Thongsong et al., 2008). Further reported, the effect of natural growth promoters presented by SC such as 1,3~1,6 D-glucagon and Mannanoligosaccharide help to gain significant body weight of broilers from hatch to day 42 (Shareef and Al-Dabbagh, 2009; Koc et al., 2010).

Broilers fed a NC diet showed a higher feed intake ($p<0.05$) compared to the broilers fed a diet with SC in the present study. Habibi et al. (2013) also observed higher feed intake in broiler fed a diet without probiotics compared to its counterpart. Previously reported that less nutrient absorption in the broiler caused higher feed intake to maintain their nutrition requirements (Koenen et al., 2004). Therefore, observed difference in feed intake of broiler fed NC diet and broilers fed a diet including SC resulted in based on the efficiency of nutrient utilization in broilers (Habibi et al., 2013).

Moreover, Koc et al. (2010) mentioned that the effect of natural growth promoters such as 1,3~1,6 D-glucagon and Mannan oligosaccharide present in SC cell wall helps to gain significant body weight of broilers from hatch to day 42. Mannan oligosaccharide content is approximately 50% of the carbohydrate fraction of SC cell wall and this effect can be attributed to the trophic effect of the product of intestinal microflora (Shareef and Al-Dabbagh, 2009). In order to that, manna oligosaccharides help to control pathogenic sources such as *Salmonella* and *E. coli* in broiler gut (Shareef and Al-Dabbagh, 2009). On the other hand, Mannan-oligosaccharide act as a nutritional compound to the beneficial bacteria that avoid the colonization of pathogenic bacteria and SC has higher vitamin B and mineral compounds (Shareef and Al-Dabbagh, 2009).

Broilers fed a diet supplement with SC for long term showed higher weight gain ($p<0.01$), low feed conversion ratio ($p<0.01$) compared to broiler fed short-term SC diet. In contrast, the results of Bai et al., (2013) mentioned that the effect of probiotic on broiler's body weight significant at the early age stages of the broilers. However, there is not a sufficient evidence to explain the effect of probiotic supplement duration for the broiler growth performance. Although, Sanders and Veld (1999) reported that the multi-strain probiotic supplement in long term had a greater performance than the single strain in broiler gut health.

In our present study, broilers fed an increased level SC dosage showed the positive significant effect on growth performance. Broilers fed a higher dosage (>1.0%) of SC diets gave higher ($p<0.01$) body weight, low FCR compared to the broilers fed low dosage of SC at day 35 also reported by the Aluwong et al. (2013).

2. Meat Quality

Meat quality also a very important parameter that reflects the dietary treatment effect in broiler studies. Table 4 showed SC effect on broiler breast meat. Broilers fed a diet with or without SC not obtained significant pH values for their breast meat. These results corroborate the findings of Pelicano et al. (2003) who mentioned probiotic did not effect on pH of the broiler meat. Furthermore, inconsistency results shown by the study of El-Kelawy and Sh ELnaggar (2016) regarding "Japanese" quails' fed a diet contain SC at the age of 49 days.

Table 4. Effects of the supplementation of *Saccharomyces cerevisiae* on the pH, cooking loss and water holding capacity of broiler chicken meat

Treatments			pH	CL (%)	WHC (%)
NC[1]			5.60	9.28	78.89
NC+0.6 S[2]			6.00	10.75	72.92
NC+1.0 S			6.16	11.77	67.14
NC+1.4 S			5.90	11.17	71.27
NC+0.6 L[3]			5.83	11.28	70.91
NC+1.0 L			5.50	12.24	74.48
NC+1.4 L			5.73	12.02	73.09
Pooled SEM[4]			0.04	0.71	1.60
P value of contrast[5]	NC vs NC+0.6S		NS	NS	*
	NC vs NC+1S		NS	NS	**
	NC vs NC+1.4S		NS	NS	**
	NC vs NC+0.6L		NS	NS	**
	NC vs NC+1L		NS	*	NS
	NC vs NC+1.4L		NS	*	NS
Significant level of factorial analysis	Duration[6]		**	NS	*
	Dosage[7]	Leaner[8]	NS	NS	NS
		Quadratic[8]	NS	NS	NS
	Dosage × Duration		NS	NS	**
Dosage × Duration			NS	NS	NS

[1] Negative control.
[2] Short term.
[3] Long term.
[4] Standard error of mean.
[5] Significant level: NC $P>0.05$, * $P<0.05$, ** $P<0.01$.
[6] SC incorporation ratio (0.6% or 1% or 1.4%).
[7] Whether SC supplied short term or long term.
[8] Orthogonal polynomial contrast coefficient were used to determine linear and quadratic effect.
CL: Cooling loss, WHC: Water holding capacity.

Breast meat of the broilers fed a diet with SC for long term showed less ($p<0.01$) pH value compared to the broilers fed a diet with SC for short term. Similarly, Abdulla et al. (2017) mentioned that the probiotic activity would be able to reduce ($p<0.05$) the broiler breast meat pH value at the age of 42 days.

Broilers fed NC+1L and NC+1.4L diets had higher ($p<0.05$) cooking loss of the breast meat compared to the broilers fed NC diet. The results of Pelicano et al. (2003) mentioned that broilers fed a SC mixed probiotic diet did not show any effect on cooking loss of the broiler breast meat. Nevertheless, according to the Barbut et al. (2001), there was a correlation between pH value and the cooking loss of broiler meat.

Water holding capacity is an important parameter on meat nutrition value and flavor profile. Water-soluble nutrients and flavor precursors were subjected to loss with the water loss of meat resulting less tender (Pelicano et al., 2003). Broilers fed a diet with SC for short-term breast meat gave less ($p<0.05$) WHC compared to the meat of broilers fed NC diet. Ali (2010) and Pelicano et al. (2003) found that probiotic treated broiler groups gave higher ($p<0.05$) breast meat WHC compared to birds fed a probiotic absent diet at the age of 42 days. Apart from that, broilers fed SC contained diet for long term shown higher ($p<0.05$) breast meat WHC than broilers fed a diet with SC for short term. In another hand, when considering the duration-dosage combination of SC, broilers fed NC+1.4L and NC+1.4S diets showed a higher ($P<0.01$) meat WHC than other SC fed groups. Previous studies do not consider the duration and dosage combination effect of SC or probiotic on WHC of the broiler meat.

3. Carcass Organ Measurements

The internal organ weight percentage to live body weight of the slaughtered birds showed in Table 5. Obtained results did not indicate the effect of SC on broiler internal organ weight compared to NC fed group. Previous studies regarding the probiotic effect on broilers' internal organ weight did not show significant values (Maiolino et al., 1992; Jin et al, 1997). As same as, Koc et al. (2010) confirmed the above finding on

Table 5. Effects of the supplementation of *Saccharomyces cerevisiae* on internal organ weight relative to the live body weight of the broiler chickens

Treatment		Liver (%)	Gizzard (%)	Heart (%)	Small intestine (%)
NC[1]		2.68	1.06	0.25	3.35
NC+0.6 S[2]		2.37	1.09	0.54	3.14
NC+1.0 S		2.67	1.30	0.40	3.34
NC+1.4 S		1.95	1.56	0.43	3.60
NC+0.6 L[3]		2.03	1.07	0.50	3.70
NC+1.0 L		2.72	0.97	0.47	3.63
NC+1.4 L		3.62	0.66	0.43	2.88
Pooled SEM[4]		0.40	0.28	0.05	0.38
P value of contrast[5]	NC vs NC+0.6S	NS	NS	NS	NS
	NC vs NC+1.0S	NS	NS	NS	NS
	NC vs NC+1.4S	NS	NS	NS	NS
	NC vs NC+0.6L	NS	NS	NS	NS
	NC vs NC+1.0L	NS	NS	NS	NS
	NC vs NC+1.4L	NS	NS	NS	NS
Significant level of factorial analysis	Duration[6]	NS	*	NS	*
	Dosage[7] Leaner[8]	NS	NS	NS	NS
	Dosage[7] Quadratic[8]	NS	NS	NS	NS
	Dosage × Duration	**	NS	NS	NS

[1] Negative control.
[2] Short term.
[3] Long term.
[4] Standard error of mean.
[5] Significant level: NC $P>0.05$, * $P<0.05$, ** $P<0.01$.
[6] SC incorporation ratio (0.6% or 1% or 1.4%).
[7] Whether SC supplied short term or long term.
[8] Orthogonal polynomial contrast coefficient were used to determine linear and quadratic effect.

heart and liver weights of the 42 days old broilers. In another hand, Koc et al. (2010) mentioned broilers fed direct SC gave less ($p<0.05$) gizzard weight compared to broilers fed SC absent diet. Interestingly, results obtained from current study also showed, broilers fed a SC incorporated diet for long term had less ($p<0.05$) gizzard weight compared to broilers fed SC for short term. The NC+1.4S diet fed broilers showed a higher ($p<0.01$) liver weight compared to the other treatment groups while showing the dosage-feeding interval effect of SC. Farhoomand and Dadvend (2007) obtained a higher ($p<0.05$) liver weight from broilers fed a diet containing 0.5% SC compared to the broilers fed SC with low level (<0.5%) from hatch to day 42. Pathogenic microorganism such as *Salmonella* can damage the liver physiology and cause of its detrimental growth (Li and Gatlin, 2003). SC as a probiotic would minimize the activity of pathogenic bacteria by making barriers to pathogenic bacteria colonization (Li and Gatlin, 2003) resulting proper liver growth.

Broilers fed SC for long-term had a higher ($p<0.05$) small intestine weight compared to the broilers fed SC for short term. The study of Awad et al. (2009) observed that the broilers fed a diet contain probiotic did not give significant weight of small intestine compared to the broiler fed a diet without probiotic at the age of day 35. However, previous studies expressed that broilers fed a diet containing SC can improve villas development in the small intestine (Reisinger et al., 2011, Gao et al., 2008, Zhang et al., 2005). The comparison of SC supplemented duration effect on small intestine weight had not sufficient evidence to explain using previous studies.

4. Chemical Composition of the Meat

The nutritional composition of the meat also an important parameter to determine the broiler meat quality. The proximate analysis has done for searching health benefits, nutritional compositional changes of the meat. The proximate analysis result of broilers' breast meat in different treatments showed in Table 6. Obtained results about chemical composition of breast meat from current study did not show a significant effect among the broilers fed a diet with SC and broilers fed a NC diet. El-Kelawy and Sh ELnaggar (2016) also reported the same results about SC effect on broiler meat nutritional composition. Nevertheless, the results of Yalçın et al. (2013) said, broilers fed a diet with 0.4% dosage of SC gave less ($P<0.01$) abdominal fat contain at the age of 42 days.

5. Carcass Measurements

Carcass weight, Breast muscle weight, and thigh muscle weight are somewhat economically important characters of

Table 6. Effects of dietary *Saccharomyces cerevisiae* on the proximate composition of chicken breast meat

Treatment			Moisture (%)	CP (%)	Ash (%)	EE (%)
NC[1]			73.89	23.00	1.07	5.11
NC+0.6S[2]			74.81	23.56	0.84	5.02
NC+1.0S			75.05	24.81	0.97	4.85
NC+1.4S			75.31	22.51	0.84	4.95
NC+0.6L[3]			75.05	26.46	0.84	4.90
NC+1.0L			73.82	24.08	0.75	4.22
NC+1.4L			73.83	23.89	0.81	4.48
Pooled SEM[4]			1.21	1.49	0.23	0.21
P value of contrast[5]	NC vs NC+0.6S		NS	NS	NS	NS
	NC vs NC +1S		NS	NS	NS	NS
	NC vs NC+1.4S		NS	NS	NS	NS
	NC vs NC+0.6L		NS	NS	NS	NS
	NC vs NC+1L		NS	NS	NS	NS
	NC vs NC+1.4L		NS	NS	NS	NS
Significant level of factorial analysis	Duration[6]		NS	NS	NS	NS
	Dosage[7]	Leaner[8]	NS	NS	NS	NS
		Quadratic[8]	NS	NS	NS	NS
	Dosage × Duration		NS	NS	NS	NS

[1] Negative control.
[2] Short term.
[3] Long term.
[4] Standard error of mean.
[5] Significant level: NC P>0.05, [*] P<0.05, [**] P<0.01.
[6] SC incorporation ratio (0.6% or 1% or 1.4%).
[7] Whether SC supplied short term or long term.
[8] Orthogonal polynomial contrast coefficient were used to determine linear and quadratic effect.
CP: Crude protein, EE: Ether extract.

Table 7. Effects of the supplementation of *Saccharomyces cerevisiae* on the carcass parameters of broiler chickens

Treatments			CW (%)	BM (%)	TW (%)
NC[1]			71.65	22.68	18.38
NC+0.6S[2]			72.56	22.88	17.55
NC+1.0S			74.18	23.12	16.85
NC+1.4S			76.37	22.49	18.13
NC+0.6L[3]			72.58	21.70	16.22
NC +1.0L			72.08	24.31	17.73
NC+1.4L			72.79	25.29	19.26
Pooled SEM[4]			1.40	1.03	0.47
P value of contrast[5]	NC vs NC+0.6S		NS	NS	NS
	NC vs NC +1S		NS	NS	NS
	NC vs NC+1.4S		NS	NS	NS
	NC vs NC+0.6L		NS	NS	NS
	NC vs NC +1L		NS	NS	NS
	NC vs NC+1.4L		NS	NS	NS
Significant level of factorial analysis	Duration[6]		NS	NS	NS
	Dosage[7]	Leaner[8]	NS	NS	**
		Quadratic[8]	NS	NS	NS
	Dosage × Duration		NS	NS	NS

1[1] Negative control.
[2] Short term.
[3] Long term.
[4] Standard error of mean.
[5] Significant level: NC P>0.05, [*] P<0.05, [**] P<0.01.
[6] SC incorporation ratio (0.6% or 1% or 1.4%).
[7] Whether SC supplied short term or long term.
[8] Orthogonal polynomial contrast coefficient were used to determine linear and quadratic effect.
CW: carcass weight, BW: Breast muscle weight, TW: Thigh muscle weight.

the broiler carcass. Effect of SC on carcass measurements of “Cobb 500” broilers fed different dietary treatments showed in Table 7. Broilers fed a diet with SC did not provide significant values on carcass weight, thigh muscle weight and breast muscle weight when compared to the broilers fed NC diet. The results about carcass weight lined with the Denli et al. (2003) results that obtained from broilers fed a diet with *Lactobacillus* at the age of 42 days. In opposing, Pelicano et al. (2003) showed a significantly decreased (p<0.05) carcass weight from birds fed a diet with probiotic compared to the control diet. The study of Roshanfekr and Mamooee (2009) on broilers showed significantly high (p<0.05) breast muscle weight from the broilers fed a diet with 0.2% commercial probiotic at the age of 42 days.

Considering the dosage of SC, higher (p<0.05) thigh muscle weight showed by the broilers fed an increased level (1.4

Table 8. Friedman result for sensory evaluation - estimated median values

Treatments	Appearance	Taste	Odor	Color	Juiciness	Tenderness	Overall acceptability
NC[1]	4.00	4.07	3.89	4.00	4.21	4.21	3.64
NC+0.6L[2]	4.00	4.00	3.54	4.00	4.00	4.00	4.00
NC+1.0L	4.00	4.00	4.11	3.79	4.14	3.93	4.00
NC+1.4L	4.00	3.76	3.61	4.14	4.00	4.00	3.93
NC+0.6S[3]	4.00	3.93	3.68	4.07	4.00	4.00	3.93
NC+1.0S	3.86	4.14	4.11	4.00	3.71	4.00	3.93
NC+1.4S	4.14	4.00	3.32	4.00	3.93	3.86	4.07
P value[4]	NC	NC	*	NC	NC	NC	NC

[1] Negative control.
[2] Long term.
[3] Short term.
[4] Significant level: NC P>0.05, * P<0.05, ** P<0.01.

%) of SC compared to the broilers fed reduced level (0.6%, 1%) of SC regardless of feeding duration in the present study.

6. Sensory Evaluation of Meat

Sensory evaluation test results for light boiled breast meat is presented in Table 8. Only odor of the meat was improved (p<0.01) by the SC fed broilers' meat in NC+1L and NC+1S. Others sensory qualities had not shown any significant effect between treatments. According to the previous studies, there was widespread agreement about sensory quality and the intramuscular lipid content (Park et al., 2016). Apart from that, the result of the Nakano (1999) suggested that the fat in the meat was converted into the favorable fat in the presence of probiotic for preferable sensory qualities.

CONCLUSION

Broilers fed a diet with SC showed a high growth performance (ADG and FCR) compared to those are in the negative control group (NC). Beside of that high dosage and long term SC fed broilers showed a better growth performance. Broilers fed a diet with high dosage-long term SC combination gave a higher breast muscle WHC compared to the broilers fed a low dosage-short term SC diet.

ACKNOWLEDGEMENTS

The authors acknowledge the support provided by New Hope Lanka Ltd., Sri Lanka.

REFERENCES

Abdulla NR, Mohd Zamri, AN, Sabow, AB, Kareem KY, Nurhazirah S, Ling FH, Sazili AQ, Loh, TC 2017 Physico-chemical properties of breast muscle in broiler chickens fed probiotics, antibiotics or antibiotic-probiotic mix. Journal of Applied Animal Research 45:64-70.

Ahmad I 2006 Effect of probiotics on broilers performance. International Journal of Poultry Science 6:593-597.

Ali FHM 2010 "Probiotics feed supplement" to improve quality of broiler chicken carcasses. World J Dairy Food Sci 5:93-99.

Aluwong T, Kawu M, Raji M, Dzenda T, Govwang F, Sinkalu V, Ayo J 2013 Effect of yeast probiotic on growth, antioxidant enzyme activities and malondialdehyde concentration of broiler chickens. Antioxidants, 2:326-339.

AOAC 1995 Official Methods of Analysis. 16th edn. Association of Official Analytical Chemists, Washington, DC, USA.

Awad WA, Ghareeb K, Abdel-Raheem S, Böhm J 2009 Effects of dietary inclusion of probiotic and synbiotic on growth performance, organ weights, and intestinal histomorphology of broiler chickens. Poultry Science 88:49-56.

Bai SP, Wu AM, Ding XM, Lei Y, Bai J, Zhang KY, Chio JS 2013 Effects of probiotic-supplemented diets on growth performance and intestinal immune characteristics of broiler chickens. Poultry Science 92:663-670.

Barbut S 2001 Poultry product processing: An Industry Guide. Taylor and Francic Group, Boca Raton.

Biernasiak J, Slizewska K 2009 The effect of a new probiotic preparation on the performance and faecal microflora of broiler chickens. Veterinarni Medicina 54:525-531.

Denli M, Okan F, Celik K 2003 Effect of dietary probiotic, organic acid and antibiotic supplementation to diets on broiler performance and carcass yield. Pakistan Journal of Nutrition 2:89-91.

El-Kelawy M, Sh ELnaggar A 2016 Inclusion of *Saccharomyces cerevisiae* in diet of Japanese quail. 1-effect on growth performance, some blood plasma constituents and carcass characteristics. Egyptian Poultry Science Journal December 2016; 36:1269-1282.

Farhoomand P, Dadvend A 2007 Carcass weight, growth performance and internal organs size of broilers fed graded levels of *Saccharomycese cervisiae* supplemented diets. Pakistan Journal of Biological Sciences 10:1870-1874.

Fuller R 1989. Probiotics in man and animals. J Appl Bacteriol 66:365-378.

Gao J, Zhang HJ, Yu SH, Wu SG, Yoon I, Quigley J, Gao YP, Qi GH 2008 Effects of yeast culture in broiler diets on performance and immunomodulatory functions. Poultry Science 87:1377-1384.

Ghosh HK, Halder G, Samanta G, Paul SK, Pyne SK 2007 Effect of dietary supplementation of organic acid and mannan oligosaccharide on the performance and gut health of Japanese quail (*Coturnix coturnix japonica*). Asian J Poult Sci 1:1-7.

Habibi S, Khojasteh S, Jafari M 2013 The effect of Bactocell and protexin probiotics on performance and carcass characteristics of broiler chickens. Journal of Novel Applied Sciences 2:565-570.

Hamm R 1961 Biochemistry of meat hydration. Advances in Food Research 10:355-463.

Hammond JR 1993 Brewer's yeast. The Yeasts 5:7-67.

Hassanein SM, Soliman NK 2010 Effect of probiotic (*Saccharomyces cerevisiae*) adding to diets on intestinal microflora and performance of Hy-line layers hens. Journal of American Science. 6:159-169.

Houshmand M, Azhar K, Zulkifli I, Bejo M, Kamyab, A 2011 Effects of nonantibiotic feed additives on performance, nutrient retention, gut pH, and intestinal morphology of broilers fed different levels of energy. The Journal of Applied Poultry Research 20(2): 121-128.

Jayasena DD, Jung S, Kim HJ, Bae YS, Yong HI, Lee JH, Jo C 2013 Comparison of quality traits of meat from Korean native chickens and broilers used in two different traditional Korean cuisines. Asian-Australasian Journal of Animal Sciences 26(7):1038-1046.

Jeon HJ, Choe JH, Jung YK, Kruk ZA, Lim DG, Jo CR 2010 Comparison of the chemical composition, textural characteristics, and sensory properties of North and South Korean native chickens and commercial broilers. Korean Journal for Food Science of Animal Resources, 30:171-178.

Jin LZ, Ho YW, Abdullah N, Jalaludin S 1997 Probiotics in poultry: modes of action. World's Poultry Science Journal 53:351-368.

Karaoglu M, Durdag H 2005 The influence of dietary probiotic (*Saccharomyces cerevisiae*) supplementation and different slaughter age on the performance, slaughter and carcass properties of broilers. International Journal of Poultry Science 4:309-316.

Koc F, Samli H, Okur A, Ozduven M, Akyurek H, Senkoylu N 2010 Effects of *Saccharomyces cerevisiae* and/or mannanoligosaccharide on performance, blood parameters and intestinal microbiota of broiler chicks. Bulgarian Journal of Agricultural Science 16:643-650.

Koenen ME, Kramer J, Van Der Hulst R, Heres L, Jeurissen SHM, Boersma WJA 2004 Immunomodulation by probiotic lactobacilli in layer-and meat-type chickens. British Poultry Science 45:355-366.

Lakshani P, Jayasena DD, Jo C 2016 Comparison of quality traits of breast meat from commercial broilers and spent hens in Sri Lanka. Korean Society of Poultry Science 43: 55-61.

Li P, Gatlin DM 2003 Dietary brewer's yeast and the prebiotic Grobiotic™ AE influence growth performance, immune responses and resistance of hybrid striped bass (*Morone chrysops* M. *saxatilis*) to *Streptococcus iniae* infection.

Aquaculture 4:445-456.

Madrigal SA, Watkins SE, Skinner JT, Adams MH, Waldroup A, Waldroup PW 1993 Effect of an active yeast culture on performance of broilers. Poultry Sci 72(Suppl 1), 87.

Maiolino R, Fioretti A, Menna LF, Meo C 1992 The efficiency of probiotics in diets for broiler chickens. Nutrition Abstract and Reviews Series B 62:482.

Miles RD, Bootwalla SM 1991 Direct-fed microbials in animal production. Direct-fed Microbials in Animal Production. A Review 117-132.

Nakano M 1999 Influence of a probiotic on productivity, meat components, lipid metabolism, caecal flora and metabolites, and raising environment in broiler production. Nihon Chikusan Gakkaiho 70:207-218.

Niewold TA 2007. The nonantibiotic anti-inflammatory effect of antimicrobial growth promoters, the real mode of action? A Hypothesis Poultry Science 86:605-609.

Nuwan KS, Wickramasuriya SS, Jayasena DD, Tharangani RH, Song Z, Yi YJ, Heo JM 2016 Evaluation of growth performance, meat quality and sensory attributes of the broiler fed a diet supplemented with curry leaves (*Murraya koenigii*). Korean Society of Poultry Science 43:169-176.

Onenc A, Serdaroglu M, Abdraimov K 2004 Effect of various additives to marinating baths on some properties of cattle meat. European Food Research and Technology 218: 114-117.

Park YH, Hamidon F, Rajangan C, Soh KP, Gan CY, Lim TS, Liong MT 2016 Application of probiotics for the production of safe and high-quality poultry meat. Korean Journal for Food Science of Animal Resources 36:567-576.

Parlat SS, Oguz H 2001 Biological suppression of aflatoxicosis in Japanese quail (*Coturnix coturnix japonica*) by dietary addition of yeast (*Saccharomyces cerevisiae*). Research in Veterinary Science 71:207-211.

Patterson JA, Burkholder KM 2003. Application of prebiotics and probiotics in poultry production. Poultry Science 82: 627-631.

Pelicano ERL, De Souza PA, De Souza HBA, Oba A, Norkus EA, Kodawara LM, De Lima TMA 2003 Effect of different probiotics on broiler carcass and meat quality. Revista Brasileira de Ciência Avícola 5:207-214.

Paryad A, Mahmoudi M 2008 Effect of different levels of supplemental yeast (*Saccharomyces cerevisiae*) on performance, blood constituents and carcass characteristics of broiler chicks. African Journal of Agricultural Research 3: 835-842.

Roshanfekr H, Mamooee M 2009 Effect of dietary antibiotic, probiotic and prebiotic as growth promoters, on growth performance, carcass characteristics and hematological indices of broiler chickens. Pakistan Journal of Biological Sciences12:52-57.

Rose AH, Vijayalakshmi G 1993 Baker's yeasts. The Yeasts 5:357-397.

Sanders ME, Veld JH 1999 Bringing a probiotic containing functional food to the market: Microbiological, product, regulatory and labeling issues. Antonie Van Leeuwenhoek 76:293-315.

Santin E, Maiorka A, Macari M, Grecco M, Sanchez JC, Okada TM, Myasaka AM 2001 Performance and intestinal mucosa development of broiler chickens fed diets containing *Saccharomyces cerevisiae* cell wall. The Journal of Applied Poultry Research 10:236-244.

Shabani R, Nosrati M, Javandel F, AlawGothbi AA, Kioumarsi H 2012 The effect of probiotics on growth performance of broilers. Ann Biol Res 3:5450-5452.

Shareef AM, Al-Dabbagh ASA 2009 Effect of probiotic (*Saccharomyces cerevisiae*) on performance of broiler chicks. Iraqi J Vet Sci 23(Suppl I):23-29.

Stanley VG, Ojo R, Woldesenbet S, Hutchinson DH, Kubena LF 1993 The use of *Saccharomyces cerevisiae* to suppress the effects of aflatoxicosis in broiler chicks. Poultry Science 72:1867-1872.

Thongsong B, Kalandakanond-Thongsong S, Chavananikul V 2008 Effects of the addition of probiotic containing both bacteria and yeast or an antibiotic on performance parameters, mortality rate and antibiotic residue in broilers. The Thai Journal of Veterinary Medicine 38:17-26.

Van Leeuwen P, Verdonk JMAJ, Kwakernaak C 2005 Effects of fructooligosaccharide (OF) inclusion in diets on performance of broiler chickens. Confidential Report 5:I00650.

Watson DC 1993 Yeasts in distilled alcoholic-beverage production. The Yeasts 5:215-44.

Yalçın S, Eser H, Cengiz S, Eltan O 2013 Effects of dietary yeast autolysate (*Saccharomyces cerevisiae*) on performance, carcass and gut characteristics, blood profile, and antibody production to sheep red blood cells in broilers. The Journal of Applied Poultry Research 22:55-61.

Zhang AW, Lee BD, Lee SK, Lee KW, An GH, Song KB, Lee CH 2005 Effects of yeast (*Saccharomyces cerevisiae*) cell components on growth performance, meat quality, and ileal mucosa development of broiler chicks. Poultry Science 84:1015-1021.

Received Jun. 12, 2017, Revised Sep. 20, 2017, Accepted Sep. 20, 2017