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Effects of supplementing broiler diets with *Saccharomyces cerevisiae* at different levels and frozen storage on the meat quality traits of breasts and drumsticks

Einfluss der Zulage von *Saccharomyces cerevisiae* zu Broilerfutterrationen in unterschiedlicher Höhe und der tiefgefrorenen Lagerung auf die Qualität von Brust- und und Unterkeulenfleisch

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Introduction

Poultry products are generally consumed as frozen, in Turkey. Meanwhile, the consumption of frozen cut up pieces of poultry carcass is more and more increasing. But, the self-life of frozen poultry meat may be limited due to lipid oxidation during storage time. In recent years, the use of some antioxidant additives in diets has become crucial and their capacity to prevent lipid oxidation in frozen meat during storage has been investigated. Yeast has been used for this aim. As known, yeasts can act as probiotics in the gastrointestinal tract by inhibiting mould growth (LINE et al., 1998; AFSHARMANESH et al., 2010). *Saccharomyces cerevisiae* has long been fed to farm animals, and it is one of the most widely commercially used types of yeast showing an antioxidant property (MEYER et al., 1994; AKSU et al., 2005a; ZHANG et al., 2005). In some studies, it has been reported (IGNACIO, 1995; ONIFADE et al., 1998; KUMPRECHTOVÁ et al., 2000; MIDILLI and TUNCER, 2001; KARAOGLU and DURDAG, 2005; GAO et al., 2008) that feeding *Saccharomyces cerevisiae* to broiler chicks could improve growth performance. In addition to growth performance of broilers, there are studies showing that enrichment of diets with yeast could favorably improve the quality of meat from broilers (BONOMI et al., 1999; KARAOGLU et al., 2004, 2006; AKSU et al., 2005a; ZHANG et al., 2005).

Lipid oxidation is a major cause of quality deterioration in chicken, turkey, lamb, beef and pork meat, and it causes loss of nutritional value and generates and accumulates compounds that may pose risks to human health (KANNER, 1994; MIN and AHN, 2005, 2009). Similarly, poultry meat is easily spoiled as microorganisms on the meat spread and multiply under suitable conditions, especially during processing and storage. These circumstances lead to a shorter shelf life with potential risks for human health. Therefore, by adding probiotics, organic acids, antimicrobials and antioxidants to the diets of farm animals, it is possible to prevent oxidation and microbial spoilage and to extend its shelf life. Shelf life of meat and meat products can be prolonged by different methods. Freezing or frozen storage is an important preservation method for meat and meat products, and is a long-term storage form that entails several months or years. On the other hand, ELEFTHERIADOU et al. (2010) determined that oxidation levels of chicken breast samples increased significantly during frozen storage at –18°C for 180 days. SOYER et al. (2010) reported that frozen storage has strong effects on the susceptibility of chicken muscle lipids to oxidative reactions, and as a result of its high polyunsaturated fatty acid content, chicken meat is particularly prone to lipid oxidation during frozen storage.

The poor processing standards and storage conditions can result in high microbial counts from frozen broilers. In freezing, water is unavailable for bacteria, thus they are dormant and there is no multiplication of pathogens. Freezing and/or prolonged frozen storage generally reduced, but did not render the meat completely free from microbial contaminants. Also, Gram-positive bacteria are relatively resistant and Gram-negatives show the greatest sensitivity (BARBUT, 2002; JAMES, 2005).

There are some researches that *Saccharomyces cerevisiae* has a positive effect on meat quality, carcass parts and performance of broiler chickens (BONOMI et al., 1999; KARAOGLU et al., 2004, 2006; KARAOGLU and DURDAG, 2005; AKSU et al., 2005a; ZHANG et al., 2005; GAO et al., 2008). But, the effect of *Saccharomyces cerevisiae* supplementation as probiotic on oxidative stability, colour and microbial properties of frozen-stored broiler cut up meats such as breast and drumstick has not been studied. Hence, present study was carried out to determine the effect of diets containing probiotic (0.0%, 0.1% and 0.02% *Saccharomyces cerevisiae*) on meat quality of breast and drumstick from broilers during frozen storage.

Material and Methods

Ross-308 day-old male broiler chicks were obtained from a commercial broiler breeder flock (KÖY-TÜR: Integrated Poultry Co, Erzurum/TURKEY) and were housed in the Application and Research Farm of Agricultural Faculty, Ataturk University. The chicks were weighed and distributed randomly into three treatment groups, eight replicates, allocated to equally sized pens containing 14 chicks each. The probiotic was added and mixed to the basal diets. The experimental groups consisting of three dietary treatments were: P_0 basic diet without probiotics (0 g/kg), P_1 basic diet plus 0.1% probiotic (1 g/kg) and P_2 basic diet plus 0.2% probiotic (2 g/kg). Commercial probiotic source was *115-Biogallinox* (Techniques et Biochimie Appliquees, 116–118 Avenue Beaurepaire, 94100 Saint Maur des Fosses, France) containing *Saccharomyces cerevisiae* (SC) ($4x10^8$ CFU/g). All chicks were fed *ad libitum* in three dietary groups for 49 days. Birds were fed a starter diet from day 1 to 21, and a finisher diet until 49 days. The basic diet was formulated to meet the nutritional requirements of the broiler chicken (NRC, 1994). Feed composition was analyzed by AOAC methods (1984), and feed composition used in trial is shown in Table 1.

Table 1. Composition of starter and finisher diets

Zusammensetzung der Basisfutterrationen

	Starter diet	Finisher diet
Ingredients and composition (g kg^{-1} feed)		
Ground corn	462.9	462.3
Soybean meal (48% CP)	221.4	210.0
Fullfatsoy	125.0	100.0
Ground wheat	99.0	108.0
Fish meal	4.00	25.0
DCP	16.3	17.3
Ground limestone	5.90	13.0
Salt (NaCl)	2.50	2.60
Soya oil	15.30	33.10
Poultry fat	–	15.0
Lysine	–	0.80
DL-methionine	2.35	2.50
Choline cloride	0.35	0.40
Trace mineral premix[1]	3.00	3.00
Vitamin premix[2]	5.00	5.00
Coccidiostat	1.00	1.00
Lasolocyde	–	1.00
Analysis (%)[3]		
Dry matter	94.00	93.00
Crude protein	22.00	20.00
MJ/kg	12.55	12.97

[1]: Trace mineral mixure provides in milligrams per kg of diet: Mn, 70; Zn, 50; Fe, 30; Cu, 5, Se, 0.3.

[2]:Vitamin mixure provides per kg of diet: vitamin A 8000 IU; cholecalciferol 1000 IU; α- tocopheryl acetate 15 mg/kg; menadione 3 mg/kg; riboflavin 5 mg/kg; niacin 40 mg/kg; thiamin 2 mg/kg; folic acide 0.6 mg/kg; vitamin B_{12} 15 µg/kg;

[3]: Analysed by AOAC (1984)

Slaughtering and dissecting

Slaughtered chicks were used as experimental materials at the end of the feeding period. Ninety birds (P_0: 30, P_1: 30; P_2: 30) were slaughtered for analyses of colour (L*, a* and b* values), microbiological counts, TBARS and pH values of breast and drumstick meats during storage. Birds were held without food for 10 hours before slaughtering, electrically stunned, killed by neck cut, bled for 120 s and semi-scalded 50–54°C for 30 s, before mechanical plucking in a rotary drum plucker. Then birds were eviscerated manually, washed and allowed to drain 10 min. After eviscerating, carcasses were stored at 3 ± 0.5°C for 24 h. Then the carcasses were dissected and breast fillets and drumstick meat was obtained from carcass (PINGEL et al., 1998; BARBUT, 2002; AKSU et al., 2007). The breast and drumstick meat was separately packaged aerobically by wrapping with single stretched film material put in polystyrene trays.

Storage of the Samples

Aerobically packaged breast (90 samples: P_0: 30, P_1: 30; P_2: 30) and drumstick (90 samples: P_0: 30, P_1: 30; P_2: 30) samples were stored at −18 ± 0.5°C for 150 days. Thiobarbituric acid reactive substance (TBARS), pH, total aerobic mesophilic, psychrotrophic, lactic acid and *Enterobacteriacea* counts were determined after 0, 15, 30, 60, 90 and 150 days of the frozen storage. L*, a* and b* values were measured on days 0, 15, 30, 90 and 150 of frozen storage.

Microbiological Analysis

A 25 g meat was aseptically taken from the each sample and placed in stomacher bags, with 225 ml of saline solution (NaCl 0.85%) and homogenized in the stomacher (Lab Stomacher Blander 400 – BA 7021, SewardMedical, London, U.K.) at 260 rpm and 20°C for 1 min. Serial dilutions of the homogenates were prepared and the surface plate method was used for enumeration. Total aerobic mesophilic bacteria (TAMB) was enumerated on Plate Count Agar (PCA, Oxoid) and incubated at 30°C for 48 h. Psychrotrophic bacteria (PB) were enumerated on Plate Count Agar (PCA, Oxoid) after incubation at 10°C for 7 days. The de Man Rogosa Sharpe Agar (MRS, Oxoid) was used for lactic acid bacteria (LAB), and plates were anaerobically incubated at 30°C for 48 h. *Enterobacteriacea* were plated on Violet Red Bile Dextrose Agar (VRBD, Oxoid) after anaerobically incubation at 30°C for 2 days (BAUMGART et al., 1993).

Determination of TBARS

For the TBARS analysis, 1 g of sample was taken from each sample and 6 ml TCA solution was added (7.5% TCA, 0.1% EDTA, and 0.1% propyl gallate, 1-propil galat was dissolved in 3 milliliter ethanol). The mixture was filtered through Whatman 1 after homogenization for 15–30 s. Then, 1 mL filtrate was added to 1 mL of 0.02 M thiobarbituric acid solution. This mixture was kept in a boiling water bath for 40 min then cooled and centrifuged at 2000 × g for 5 min and the absorbance measured at 532 nm (Shimadzu, UV 160). TBARS values were determined as μmol malonaldehyde/kg (TARLADGIS et al., 1962; LEMON, 1975; AKSU, 2009).

Determination of Colour Values

The colour on surfaces of the samples was determined in the CIELAB system using a portable Minolta Colorimeter (CR-400, Minolta Co, Osaka, Japan), excluding gloss, using pulsed xenon lamp a source of light. The instrument was calibrated to standard white plate before analysis [L* = 0, darkness; L* = 100, lightness (darkness/lightness); a*; +a* = red, -a* = green and b*; +b* = yellow, -b* = blue].

Statistical Analysis

Data were analyzed with Statistical Packages for the Social Sciences (SPSS) using General Linear Models (SPSS, 1997) for the completely randomized experimental design, with a 3 × 2 × 6 factorial arrangement. The model included the probiotic levels (P_0, P_1 and P_2), meat types (breast and drumstick) and storage times (0, 15, 30, 60, 90 and 150 days) as main effects, and all their interactions. The differences among means were tested by Duncan's multiple range test (significance $P < 0.05$). The results of the statistical analysis are shown as mean values and standard errors in tables.

Results and Discussion

TBARS values were significantly higher for the control diet compared to the other groups fed on diets including 0.2% and 0.1% probiotic ($P < 0.01$) (Table 2). There was a significant difference in TBARS content among meat types ($p < 0.01$), and the highest value was obtained in the drumstick ($P < 0.05$) (Table 2). Similarly, TBARS values were affected by the storage time ($P < 0.01$), and this value increased during storage time. The highest value was obtained as 15.3 μmol malonaldehyde/kg at the end of the storage ($P < 0.05$) (Table 2). Meat type × storage time interaction resulted in a significant effect on the TBARS values of breast and drumstick meats during frozen storage ($P < 0.01$). As can be seen in Figure 1, the greatest changes in TBARS values of meat types occurred in the drumstick. However, in the breast fillets changes in TBARS values were lower than in drumstick during frozen storage. Some researchers reported that increase of lipid oxidation in drumstick meat is based on two reasons: fat and myoglobin contents of meat. Both fat content and proportion of unsaturated fatty acids in drumsticks were higher than those in breast meat. Thus, TBARS values more quickly increased in drumsticks than in breast (Mahajan et al., 2000; Castellini et al., 2002; Cherian et al., 2002; Aksu et al., 2005a; Aksu et al., 2007; Soyer et al., 2010). However, Min and Ahn (2005) reported that differences in the amount of polyunsaturated fatty acids and total fat had little effect on the oxidative stability of raw meat as most lipids are stored in adipose tissues where the amounts of prooxidants are low. On the other hand, myoglobin content of drumstick meat is higher than that of breast, thus, myoglobin can increase TBARS values of drumstick meat. Baron and Andersen (2002) and Min and Ahn (2009) reported that muscle has a large number of endogenous prooxidants such as myoglobin and ionic irons, and myoglobin can catalyze lipid oxidation. In the present study, initially TBARS values of breast and drumstick meat have been similar for 0, 15, 30 and 60 days of storage time, thereafter, TBARS values for the drumstick increased dramatically. At the end of storage, TBARS values of breast and drumstick meats were 10.6 and 20.0 μmol malonaldehyde/kg, respectivelly. It is clearly determined that lipid oxidation in breast and drumstick meat can be better protected by the use of a diet containing a probiotic during frozen storage than using a diet without probiotic. Similarly, Aksu et al. (2005a) reported that probiotic treatments significantly affected TBARS values for poultry meat during refrigirated storage. Accordingly, Zhang et al. (2005) observed a positive effect of feeding *Saccharomyces cerevisiae* on TBARS values of broiler meats.

Table 2. Microbiological counts, TBARS and pH values of breast and drumstick meats stored at –18 ± 0.5°C for 150 days

Keimzahlen, TBARS und pH-Werte für Brust- und Schenkelfleisch nach Lagerung bei –18 ± 0,5°C über 150 Tage

	Total Aerobic Mesophilic Bacteria[1]	Psychrotrophic Bacteria[1]	Lactic acid Bacteria[1]	TBARS[2]	pH
		Probiotic Levels (P)			
P_0 (Control, 0.0%)	3.81 b	3.63	2.63 c	12.05a	6.10 b
P_1 (SC, 0.1%)	4.00 a	3.69	3.20 a	11.10 ab	6.08 b
P_2 (SC, 0.2%)	3.77 b	3.57	2.98 b	10.48 b	6.20 a
Standard Error	0.053	0.103	0.073	0.481	0.017
Significance	**	Ns	**	**	**
		Meat Type (MT)			
Breast	3.94 a	3.59	3.13 a	9.40 b	5.85 b
Drumstick	3.79 b	3.67	2.73 b	13.01 a	6.40 a
Standard Error	0.030	0.059	0.042	0.278	0.010
Significance	**	Ns	**	**	**
		Storage Time (ST, days)			
0	3.75 b	3.48 cd	2.77 c	7.34 d	6.03 c
15	3.79 b	3.70 bc	3.08 a	7.53 d	6.06 bc
30	3.64 b	3.16 e	2.82 bc	9.74 c	6.19 a
60	3.65 b	3.82 b	3.02 ab	11.74 b	6.16 a
90	3.73 b	3.26de	3.03 ab	15.57 a	6.11 b
150	4.63 a	4.37 a	2.90 ab	15.32 a	6.20 a
Standard Error	0.053	0.103	0.073	0.481	0.024
Significance	**	**	*	**	**
		Interactions			
P × ST	**	Ns	**	Ns	**
P × MT	**	**	**	Ns	**
ST × MT	Ns	*	**	**	Ns

[1] log cfu/g, [2]µmol MDA/kg,
Ns: Not significant, * P < 0.05, ** P < 0.01
a-e: Means in the same column and in the same section having the same letters are not significantly different at P > 0.05.
SC: *Saccharomyces cerevisiae*

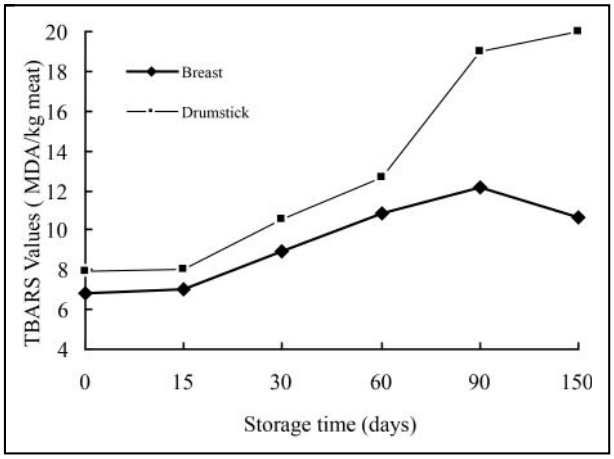


Figure 1. Meat type × storage time interactions for TBARS values

Teilstück × Lagerdauer-Interaktionen für die TBARS-Werte

There was a significant effect ($p < 0.01$) of probiotic levels on pH values and the highest pH value was determined for the 0.2% probiotic group compared to control and 0.1% probiotic groups. Similar results were found by AKSU et al. (2005a) for breast and drumstick meat stored at 3 ± 0.5°C for 12 days, and by KARAOGLU et al. (2004) for whole

carcasses stored at 3 ± 0.5°C for 24 hours. Also, meat type and storage time had a significant effect ($p < 0.01$) on pH values, and this value was higher in drumstick meat than in breast meat (Table 2). There were significant differences among storage days, and the highest pH values were determined after 30, 60, and 150 days of storage (Table 2). Increase of pH in frozen meat during storage may arise from freezing causing denaturation and oxidation of proteins. The storage time × probiotic levels ($p < 0.01$) and probiotic levels × meat types ($p < 0.01$) interactions significantly affected pH values (Table 2, Figures 2a and b). The highest pH values were found for P_2 probiotic level (0.2%). The increase in pH values of the samples from the probiotic treatments was lower than those of the control group samples during frozen storage (Figure 2a). While the pH value was not significantly affected by probiotic levels in drumstick meat, it was significantly different for breast meat. The lowest values were observed for the 0.1% probiotic level (Figure 2b). Generally, pH values of drumstick meat were higher than that of breast meat (QIAO et al., 2002; AKSU et al., 2005a, b).

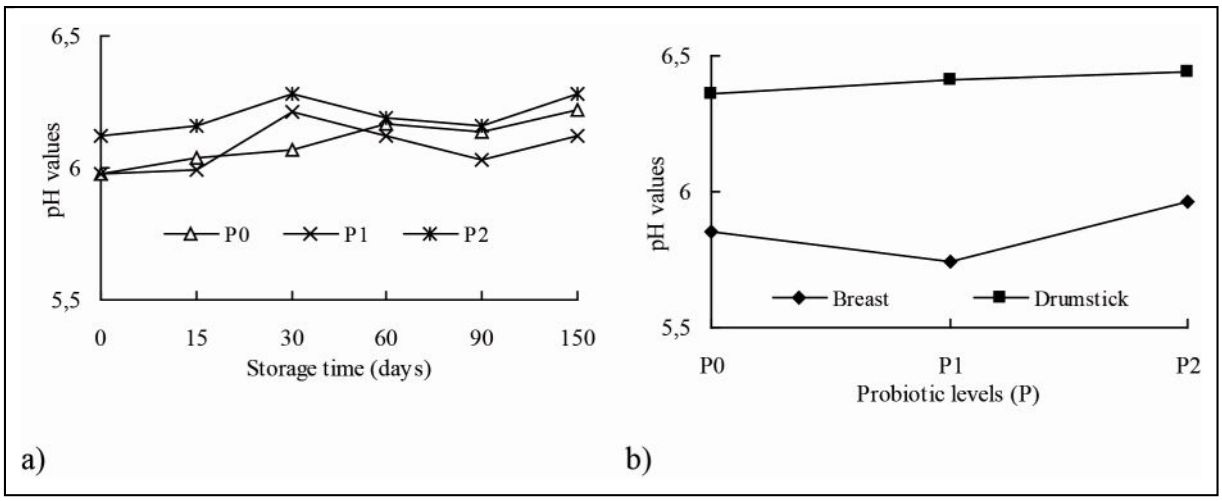


Figure 2. Probiotic levels × storage time (a) and probiotic levels × meat type (b) interactions for pH value.

Zulagehöhe des Probiotikums × Lagerdauer- (a) und Zulagehöhe des Probiotikums × Teilstück- (b) Interaktionen für den pH-Wert

Dietary probiotic levels had significant effects on total aerobic mesophilic bacteria (TAMB) counts ($P < 0.01$). The addition of 0.2% probiotic to the diet increased inhibition of TAMB ($P < 0.05$). Meat type had a significant effect on TAMB counts ($p < 0.01$). These counts have been higher in breast meat samples than in drumstick meat samples (Table 2). Furthermore, time of storage, probiotic levels × storage time (Figure 3a) and probiotic levels × meat type interactions (Figure 3b) were highly significant for TAMB counts ($P < 0.01$). As seen in Table 2 and Figure 3a, the increase in TAMB counts of the P_2 group samples was lower than in the control and P_1 group during frozen storage. However, the lowest TAMB counts were found in the P_2 samples for breast and drumstick meats (Figure 3b). AKSU et al. (2005a) determined that TAMB counts of drumstick meat were lower than of breast meat. The psychrotrophic bacteria (PB) are commonly associated with refrigerated foods (0–7°C) and cause food spoilage. In addition, they can survive for a long time during frozen storage. The differences among probiotic levels and meat types in PB counts were not significant ($p > 0.05$). However, storage time ($P < 0.01$), probiotic levels × meat type ($P < 0.01$) and storage time × meat type ($P < 0.05$) interactions had significant effects on PB counts (Table 2). As seen in Table 2 and Figure 4b, the increase in PB counts was lower in breast samples than in drumstick samples during frozen storage. However, there were significant differences in pH between 90 and 150 days of storage time ($p < 0.05$). The lowest PB counts were determined in the breast samples of treatment P_2 (Figure 4a). ABU-RUWAIDA et al. (1996) determined that mean counts of PB at –12°C did not change during nine months of frozen storage. However, the number of viable bacteria decreased slightly in carcasses stored at –18°C. AKSU et al. (2005a) found out that the use of 0.2% probiotic in the diet resulted in significantly lower PB counts in broiler breast and drumstick meats. Highly significant effects of probiotic levels, meat type, storage time, probiotic levels × storage time, probiotic levels × meat types and meat type × storage time interactions ($p < 0.01$) were observed on lactic acid bacteria (LAB) counts (Table 2). These counts were higher in P_1 samples than in control and P_2 samples. LAB counts were higher in breast samples than in drumstick samples during frozen storage (Table 2, Figure 5a). As can be seen in Figure 5a, the greatest changes in

LAB of breast meat occurred between 90 and 150 days. Similarly, within probiotic levels LAB counts of breast meats were higher than of drumstick meats (Figure 5b). In the present study, also the counts of *Enterobacteriaceae* of breast and drumstick meats were determined during storage time. At the beginning of storage these counts amounted to < 2.00–3.38 log cfu/g. *Enterobacteriaceae* counts decreased until 30 days of storage to levels below detection (< 2.00 log cfu/g). The poor processing standards and storage conditions can result in high microbial counts in frozen broiler meat. *E. coli* and coliforms counts of broiler carcasses decreased with increasing time of frozen storage, but the rate of decrease was greater at lower temperatures (–18°C) than at higher temperatures (–12 and –5°C) (JAMES, 2005). *Enterobacteriaceae* counts can decrease when probiotics are used in broiler diets (ENDO and NAKANO, 1999; AKSU et al., 2005a).

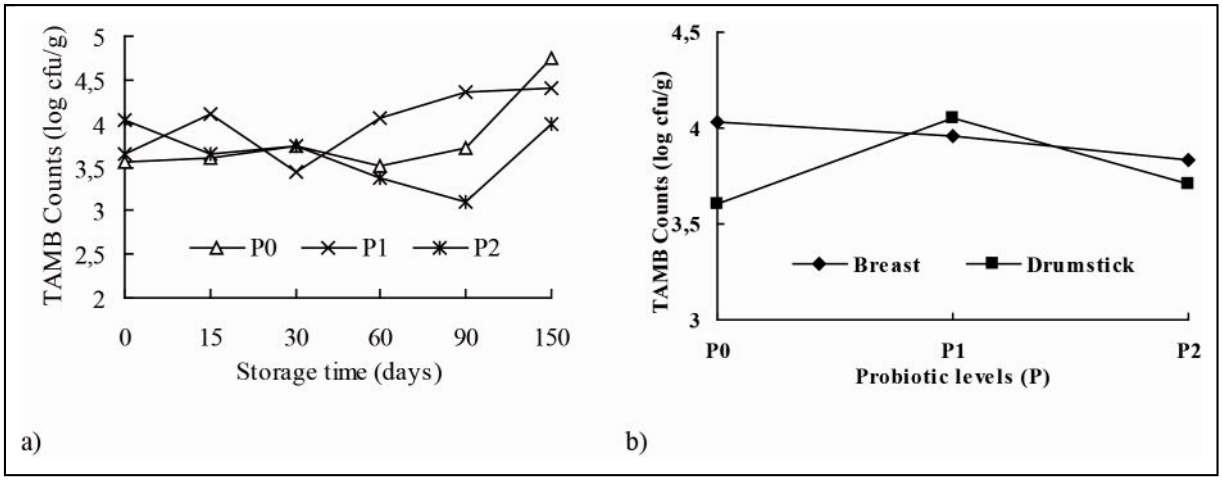


Figure 3. Probiotic levels × storage time (a) and probiotic levels × meat type (b) interactions for total aerobic mesophilic count.

Zulagehöhe des Probiotikums × Lagerdauer- (a) und Zulagehöhe des Probiotikums × Teilstück- (b) Interaktionen für die Gesamtzahl aerober, mesophiler Keime

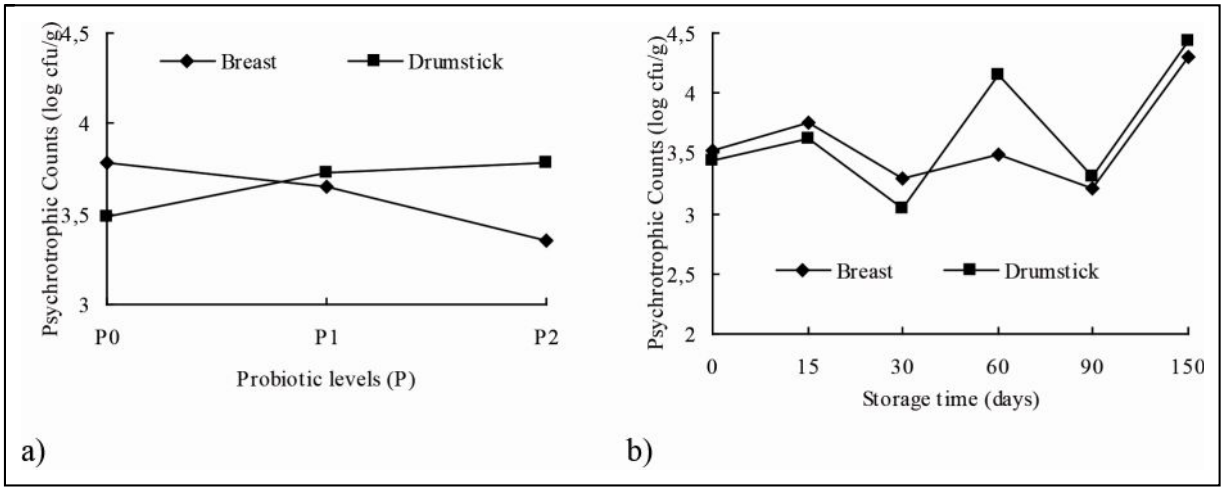


Figure 4. Probiotic levels × meat type (a) and storage time × meat type (b) interactions for psychrotrophic count

Zulagehöhe des Probiotikums × Lagerdauer- (a) und Lagerdauer × Teilstück- (b) Interaktionen für die psychotrophe Keimzahl

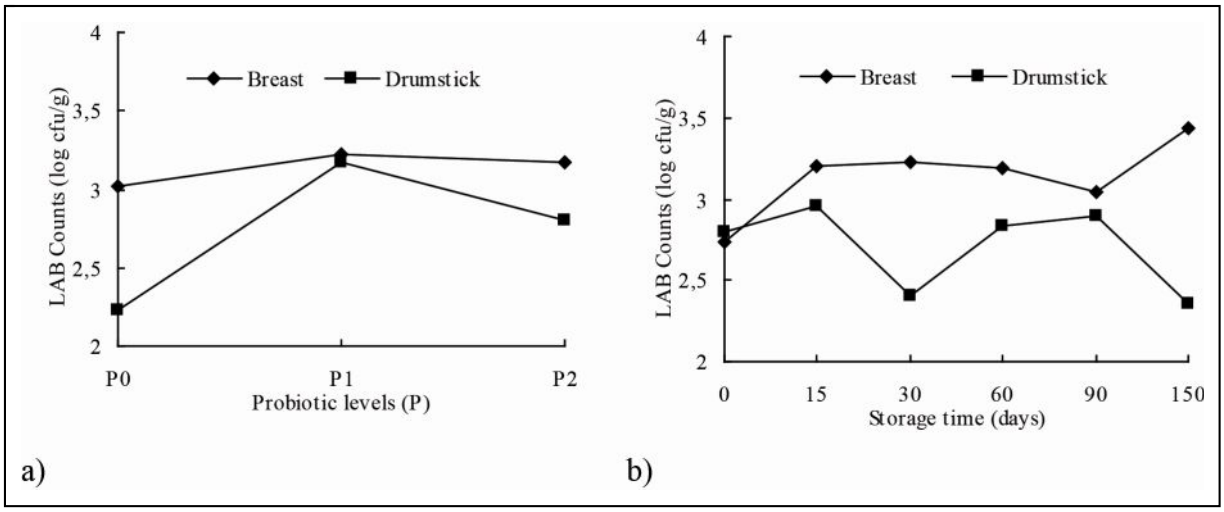


Figure 5. Probiotic levels × meat type (a) and storage time × meat type (b) interactions for lactic acid bacteria count

Zulagehöhe des Probiotikums × Teilstück- (a) und Lagerdauer × Teilstück- (b) Interaktionen für die Milchsäure bildenden Keime

The difference in L* values was not significant among probiotic levels and storage times ($p > 0.05$), while the difference in b* values was significant among meat types ($p < 0.01$). The L* values of breast meats were lower ($p < 0.05$) than those of drumstick meats (Table 3). Although the use of probiotic in broiler diets had an insignificant ($p > 0.05$) effect on a* values, the effects of meat type ($p < 0.01$) and storage time ($p < 0.01$) were significant. The a* values of breast meats were lower ($p < 0.05$) than those of drumstick meats. Similarly, BARBUT (2002) reported that a* value of drumstick meat is higher than of breast meat due to high myoglobin content in the drumstick. Chicken breast muscle is predominantly composed of white fibers which have a low myoglobin level and, therefore, a light color. Also, the lowest a* value occurred at the beginning of the frozen storage time (Table 3). The differences among P_0, P_1 and P_2 groups in b* values were significant ($p < 0.05$), and the highest value was obtained in the P_2 group. The lowest b* value occurred in the P_1 group. The b* values differed significantly among storage days ($P < 0.01$) and meat types ($P < 0.01$). The b* values of drumstick meats were higher ($p < 0.05$) than those of the breast meats. However, probiotic levels × storage time ($P < 0.05$), probiotic levels × meat type ($P < 0.05$) and storage time × meat type ($P < 0.05$) interactions were significant for b* values (Table 3). As seen in Table 3 and Figure 6a, the increase in b* values until 90 days of frozen storage was lower in P_1 samples than in P_0 and P_1 samples. The lowest b* values during frozen storage were determined in drumstick samples (Figure 6b). As can be seen in Figure 6b, the greatest changes in breast meat occurred between 0 and 15 days, however, there were no significant differences in b* values between 15 and 150 days of storage time. Similarly, significant differences in b* values were determined for breast and drumstick meats, with b* values of breast meats being higher than for drumstick meats (Figure 6c). In a study carried out by KARAOGLU et al. (2004) the use of probiotic in broiler diets did not affect L*, a* and b* values of breast and drumstick meats, but L*, a* and b* values of breast and drumstick meats were significantly different. On the other hand, frozen storage influence colour values. HENRY et al. (2010) found that the frozen storage time (-18°C for 540 days) caused an increase in the colour of turkey breast meat.

Table 3. Colour values of breast and drumstick meat stored at –18 ± 0.5°C for 150 days.

Farbkennwerte für Brust- und Schenkelfleisch nach Lagerung bei –18 ± 0,5°C über 150 Tage

	L* value	a* value	b* value
		Probiotic Levels (P)	
P_0 (Control, 0.0%)	49.06	5.81	6.74 ab
P_1 (SC, 0.1%)	48.29	6.16	6.28 b
P_2 (SC, 0.2%)	48.71	6.05	7.80 a
Standard Error	1.260	0.285	0.400
Significance	Ns	Ns	*
		Types of Meat (TM)	
Breast	47.77 b	4.90 b	7.81 a
Drumstick	49.54 a	7.12 a	6.08 b
Standard Error	0.650	0.233	0.327
Significance	**	**	**
		Storage Time (ST, days)	
0	51.78	3.54 b	3.91 b
15	47.03	6.20 a	7.06 a
30	48.02	6.66 a	7.88 a
90	46.62	6.52 a	7.61 a
150	49.98	7.12 a	8.25 a
Standard Error	1.028	0.368	0.516
Significance	Ns	**	**
		Interactions	
P × ST	Ns	Ns	*
P × TM	Ns	Ns	*
ST × TM	Ns	Ns	*

Ns: Not significant, * P < 0.05, ** P < 0.01
a, b; Means in the same column and in the same section having the same letters are not significantly different at P > 0.05.
SC: *Saccharomyces cerevisiae*

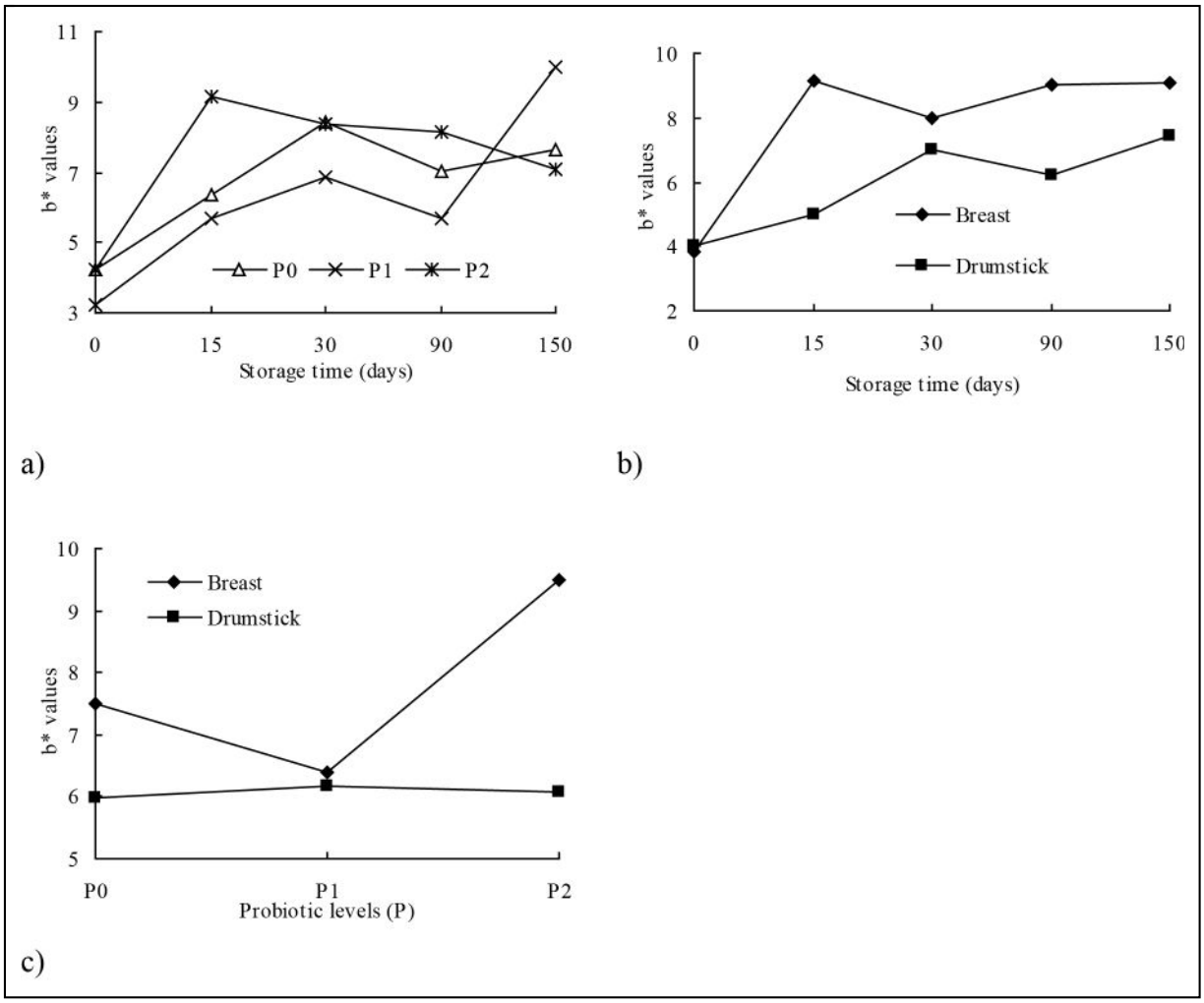


Figure 6. Probiotic levels × storage time (a), storage time × meat type (b) and probiotic levels × meat type (c) interactions for b* value

Zulagehöhe des Probiotikums × Lagerdauer- (a), Lagerdauer × Teilstück- (b) und Zulagehöhe des Probiotikums × Teilstück- (c) Interaktionen für den b*-Wert

Conclusions

The study indicates that 0.2% probiotic can be used in broiler diets to increase oxidative stability of breast and drumstick meat during frozen storage. The population of spoilage bacteria such as *Enterobacteriaceae*, total aerobic mesophilic and psychrotrophic in broiler breast and drumstick meats during frozen storage were partially decreased by the use of 0.2% probiotic. Obtained parameters indicate that broiler breast fillets and drumstick meat can be stored at –18°C up to 150 days. As a conclusion, the use of 0.2% probiotic in broiler diet is a good way to decrease the lipid oxidation and microbiological spoilage in poultry meat products during frozen storage while maintaining the quality of poultry meat products. These results may be useful to obtain high quality poultry meat and meat products. It has been assumed that the results of the current study are important and practicable.

Summary

The effects of diets supplemented with probiotics at different levels and of frozen storage on lipid oxidation, microbial counts, pH and colour in broiler breast and drumstick meats were studied. Chickens were fed with diets containing different levels of probiotic (P_0 0.0%, P_1 0.1% and P_2 0.2%; containing *Saccharomyces cerevisiae* ($4x10^8$ cfu g^{-1})) until 49 days of age. The carcasses were stored at 3 ± 0.5°C for 24 h after slaughtering and eviscerating. After standard dissection of the carcasses, breast fillets and drumstick were aerobically packaged, frozen, stored at –18°C for 150 days and analyzed after 0, 15, 30, 60, 90 and 150 days of frozen storage.

Oxidation levels decreased ($P < 0.01$) for both breast and drumstick samples from probiotic treatments in comparison to the control group during frozen storage. In general, lipid oxidation in samples increased ($P < 0.01$) during frozen storage. The type of meat had a significant effect on lipid oxidation ($P < 0.01$). The level of probiotics in diet, type of meat and storage time had significant effects on total aerobic mesophilic, lactic acid bacteria, *Enterobacteriaceae* and pH values of breast and drumstick meat. Psychrotrophic bacteria counts were only affected by storage time ($p < 0.01$). The L* and a* values were not changed by the dietary treatments ($p > 0.05$), while b* value was affected ($p < 0.05$). The b* value of samples from the treatment with 0.2% probiotic was significantly higher than that of broilers fed the diet with 0.1% probiotic ($P < 0.05$). The type of meat had a significant effect on L*, a* and b* values ($P < 0.05$), while frozen storage time affected a* and b* values ($P < 0.05$).

Key words

Broiler meat, probiotic, *Saccharomyces cerevisiae*, lipid oxidation, microbial quality, colour, frozen storage

Zusammenfassung

Einfluss der Zulage von *Saccharomyces cerevisiae* zu Broilerfutterrationen in unterschiedlicher Höhe und der tiefgefrorenen Lagerung auf die Qualität von Brust- und und Unterkeulenfleisch

In der vorliegenden Studie wurde der Einfluss unterschiedlicher Zulagen eines Probiotikums zum Futter auf Lipidoxidation, Keimzahlen, pH-Wert und Farbe von Broiler Brust- und Schenkelfleisch nach tiefgefrorener Lagerung untersucht. Die Broiler wurden über 49 Tage mit drei verschiedenen Futterrationen gefüttert: P_0 – 0,0% Zulage, P_1 – 0,1%, P_2 – 0,2%. Das Produkt enthielt $4x10^8$ KBE/g *Saccharomyces cerevisiae*. Nach der Schlachtung und dem Ausnehmen wurden die Schlachtkörper zunächst bei 3 ± 0,5°C über 24 h gelagert. Nach einer standardisierten Zerlegung der Schlachtkörper wurden das Brustfleisch und das Schenkelfleisch unter Sauerstoffatmosphäre verpackt, tiefgefroren und bei –18°C über 150 Tage gelagert. Nach 0, 15, 30, 60, 90 und 150 Tagen wurden Indikatoren der Lipidoxidation, der Keimentwicklung und der Qualitätseigenschaften bestimmt.

Die Zulage des Probiotikums zum Futter bewirkte im Vergleich zur Kontrollgruppe eine signifikante Verminderung der Oxidation im Brust- und Schenkelfleisch während der tiefgefrorenen Lagerung ($P < 0,01$). Generell nahm die Lipidoxidation über die Lagerdauer zu ($P < 0,01$). Es gab signifikante Unterschiede im Ausmaß der Oxidation zwischen den Teilstücken ($P < 0,01$). Die Höhe der Zulage des Probiotikums, das Teilstück und die Lagerdauer haben sich signifikant auf die Gesamtzahl an aeoroben, mesophilen Keimen, an Milchsäure produzierenden Keimen, an *Enterobacteriaceae* und auf den pH-Wert im Brust- und Schenkelfleisch ausgewirkt. Dagegen wurde die Zahl an psychrotrophen Bakterien nur durch die Lagerdauer beeinflusst ($P < 0,01$). Von den Farbkennwerten wurde nur der b*-Wert über die Fütterung beeinflusst ($P < 0,05$), während keine Effekte auf die L*- und a*-Werte vorlagen ($P > 0,05$). Der b*-Wert war bei den Teilstücken aus der Behandlung 0,2% Probiotikum signifikant höher als bei einer Zulage von 0,1% ($P < 0,05$). Die L*-, a*- und b*-Werte waren zwischen den Teilstücken signifikant unterschiedlich ($P < 0,05$), während die Lagerdauer nur die a*- und b*-Werte beeinflusste ($P < 0,05$).

Stichworte

Broiler, Fleisch, Probiotika, *Saccharomyces cerevisiae*, Lipdoxidation, mikrobiologische Qualität, Farbe, Gefrierlagerung

References

ABU-RUWAIDA, A.S., W.N. SAWAYA, B.H. DASHTI, Z.H. BAROON, H.A. ALOTHMAN, 1996: Microbiological shelf-life and quality of frozen broiler chickens stored under simulated market temperatures. Fleischwirt. **76**, 827-830.

AFSHARMANESH, M., M. BARANI, F.G. SILVERSIDES, 2010: Evaluation of wet-feeding wheat-based diets containing *Saccharomyces cerevisiae* to broiler chickens. Brit. Poultry Sci. **51**, 776-783.

AKSU, M.I., M. KARAOGLU, N. ESENBUGA, M. KAYA, M. MACIT, H.W. OCKERMAN, 2005a: Effect of dietary probiotic on some quality characteristics of raw broiler drumsticks and breast meat. J. Muscle Foods. **85**, 306-317.

AKSU, M.I., M. KARAOGLU, M. KAYA, N. ESENBUGA, M. MACIT, 2005b: Effect of dietary Humate on the pH, TBARS and microbiological properties of vacuum and aerobic-packed breast and drumstick meats broilers. J. Sci. Food Agr. **85**, 1485-1491.

AKSU, M.I., H. IMIK, M. KARAOGLU, 2007: Influence of dietary sorghum (*Sorghum vulgare*) and corn supplemented with methionine on cut-up pieces weights of broiler carcass and quality properties of breast and drumsticks meat. Food. Sci. Technol. Int. **13**, 361-367.

AKSU, M.I., 2009: Fatty acid composition of beef intermuscular, sheep tail, beef kidney fats and its effects on shelf life and quality properties of Kavurma. J. Food Sci. 74, 65-72.

A.O.A.C., 1984: Official methods of analysis of the association of official analytical chemist. 14th ed., The William Byrd. Press, Inc., Richmond, Virginia.

BONOMI, A., B.M. BONOMI, A. QUARANTELLI, A. ORLANDI, 1999: Organic chromium in the feeding of broiler chickens. Rew. Sci. Aliment. **28**, 385-397.

BARBUT, S., 2002: Poultry Products Processing, An Industry Guide. CRC Press LLC, 2000 N.W. Corporote Blvd. Boca Raton, Florida, USA. 129 pp.

BARON, C.P., H.J. ANDERSEN, 2002: Myoglobin-induced lipid oxidation. A Review. J. Agric. Foot Chem. **50**, 3887-3897.

BAUMGART, J., J. FIRNHABER, G. SPCHER, 1993: *Mikrobiologische Untersuchung von Lebensmitteln*, Behr's Verlag. Hamburg, Germany.

CASTELLINI, C., C. MUGNAI, A. DAL BASCO, 2002: Effect of organic production system on broiler carcass and meat quality. Meat Sci. **60**, 219-225.

CHERIAN, C., R.K. SELVARAJ, M. GOECER, P.A. STITT, 2002: Muscle fatty acid composition and thiobarbituric acid-reactive substances of broilers fed different cultivars of sorghum. Poult Sci. **81**, 1415-1420.

ELEFTHERIADOU, A., G. SAMOURIS, M. LOANNIDOU, E. KASABIDOU, 2010: Changes in lipid oxidation and fatty acid composition in pork and poultry meat during refrigerated and frozen storage. Arch. Lebensmittelhyg. 61, 173-178.

ENDO, T., M. NAKANO, 1999: Influence of a probiotic on productivity, meat components lipid metabolism, caecal flora and metabolites and raising environment in broiler production. Anim. Sci. **70**, 207-218.

GAO, J., H.J. ZHANG, S.H. YU, S.G. WU, I. YOON, J. QUIGLEY, Y.P. GAO, G.H. QI, 2008: Effects of yeast culture in broiler diets on performance and immunomodulatory functions. Poultry Sci. **87**, 1377-1384.

HENRY, F.C., T.J.P. SILVA, R.M. FRANCO, M.Q. FREITAS, D.E. JESUS-EFO, 2010: Effect of gamma radiation on frozen turkey breast meat quality. J. Food Safety. **30**, 615-634.

IGNACIO, E.D., 1995: Evaluation of the effect of yeast culture on the growth performance of broiler chick. Poultry Sci. **74**, (Suppl. 1), 196 (Abstr).

JAMES, S.J., 2005: Refrigeration and the safety of poultry meat, Volume 14. Food safety control in the poultry industry (Edited by G. C. Mead) 353-356 p. Woodhead Publishing Limited and CRC Press LLC, Abington Hall, Abington Cambridge CB1 6AH, UK.

KANNER, J., 1994: Oxidative processes in meat and meat products: Quality implications. Meat Sci. **36**, 169-189.

KARAOGLU, M., M.I. AKSU, N. ESENBUGA, M. KAYA, M. MACIT, H. DURDAG, 2004: Effect of dietary probiotic on the pH and colour characteristics of carcasses, breast fillets and drumsticks of broilers. Anim. Sci. **78**, 253-259.

KARAOGLU, M., H. DURDAG, 2005: The influence of dietary probiotic (*Saccharomyces cerevisiae*) supplementation and different slaughter age on the performance, slaughter and carcass properties of broilers. Int. J. Poultry. Sci. **4**, 309-316.

KARAOGLU, M., M.I. AKSU, N. ESENBUGA, M. MACIT, H. DURDAG, 2006: pH and colour characteristics of carcasses of broilers fed with dietary probiotics and slaughtered at different ages. Asian-Aust. J. Anim. Sci. **19**, 605-610.

KUMPRECHTOVÁ, D., P. ZOBAG, I. KUMPRECHT, 2000: The effect of *Saccharomyces cerevisia* Sc47 on chicken broiler performance and nitrogen output. Czech. J. Anim. Sci. **45**, 169-177.

LEMON, D.W., 1975: An Improved TBA Test for Rancidity New Series Circular, No:51. Halifax-Laboratory, Halifax, Nova Scotia.

LINE, E.J., J.S. BAILEY, N.A. COX, N.J. STERN, T. TOMPKINS, 1998: Effect of yeast-supplemented feed on *Salmonella* and *Campylobacter* populations in broilers. Poultry Sci. **77**, 405-410.

MAHAJAN, P., J. SAHOO, P.C. PANDA, 2000: Effects of piobiotic (Lacto-Sacc) feding and season on poultry meat quality. Indian Poultry Sci. Assoc. **35**, 297-301.

MEYER, A.S., R. KAREN, A.N. JENS, 1994: Critical assessment of the applicability of superoxide dismutase as an antioxidant in lipid foods. Food Chem. **51**, 171-175.

MIDILLI, M., S.D. TUNCER, 2001: The effects of enzyme and probiotic supplementation to diets on broiler performance. Turk. J. Vet. Anim. Sci. **25**, 895-903.

MIN, B., D.U. AHN, 2005: Mechanism of lipid peroxidation inmeat and meat products-a review. Food Sci. Biotechnol. **14**, 152-163.

MIN, B., D.U. AHN, 2009: Factors in various fractions of meat homogenates that affect the oxidative stability of raw chicken breast and beef loin. J. Food Sci. **74**: C41-C48.

NRC, 1994: National Research Council Nutrient Requirements of Poultry. 9th rev. Ed. National Academy Press, Washington, DC.

ONIFADE, A.A., G.M. BABATUNDE, S.A. AFONJA, S.G. ADEMOLA, E.A. ADESINA, 1998: The effect of a yeast culture addition to a low-protein diet on the performance and carcass characteristics of broiler chickens. Poultry Sci. **77**, (Suppl. 1) 44-49.

PINGEL, H., M. WICKE, G. v. LENGERKEN, 1998: *Gewinnung und Qualität von Geflügelfleisch. Qualität von Fleisch und Fleischwaren Band 1*, Deutscher Fachverlag, Germany. 301–334 pp.

QIAO, M., D.L. FLETCHER, J.K. NORTHCUTT, D.P. SMITH, 2002: The relationship between raw broiler breast meat color and composition. Poultry Sci. **81**, 422-427.

SPSS, 1997: Statistical Packages For The Social Sciences, SPSS for Windows Release 10.01, SPSS Inc.

SOYER, A., B. OZALP, U. DALMIS, V. BILGIN, 2010: Effects of freezing temperature and duration of frozen storage on lipid and protein oxidation in chicken meat. Food Chem. **120**, 1025-1030.

TARLADGIS, B.G., A.M. PEARSON, L.J.R. DUGAN, 1962: The Chemistry of the 2-thiobarbituric acid test for the determination of oxidative rancidity in foods, I. Some important side reactions. J. Am. Oil Chem. Soc. **39**, 34-39.

ZHANG, A.W., B.D. LEE, S.K. LEE, K.W. LEE, G.H. AN, K.B. SONG, C.H. LEE, 2005: Effects of yeast (*Saccharomyces cerevisiae*) cell components on growth performance, meat quality, and ileal mucosa development of broiler chicks. Poultry Sci. **84**, 1015-1021.

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