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

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This research was carried out to determine the effects of sorghum (BS = basal diets containing 30% sorghum), corn (BC = basal diets containing corn) and supplemental methionine (BSM = diet BS plus 0.69% methionine, BCM = diet BC plus 0.69% methionine) in broiler diets on the cold carcass weight and cut-up pieces weight of broilers and some chemical, physical and microbiological properties of breast and drumstick meats. A total 240 male (120) or female (120) broiler chicks (*Ross*-308) were allocated to four dietary treatments (BS, BSM, BC, and BCM groups) in a completely randomized experimental design. At the end of the trial all chicks were slaughtered, and then were stored at 3°C for 24 h. After standard dissection of carcasses, cut-up pieces are weighed. The breasts and drumstick muscles were analyzed for moisture, pH, ash, fat, thiobarbituric acid reactive substances (TBARS), color (L^*, a^*, and b^*), total psychrotrophic, lactic acid, *Micrococcus/Staphylococcus*, *S. aureus*, and Enterobacteriaceae counts. Although cold carcass and cut-up pieces weights were positively affected from supplemental methionine containing corn diet. However, weight were not influenced by supplemental methionine in diet containing sorghum and the other groups. While the highest whole breast weight is determined from broilers fed with corn and 0.69% methionine (BCM), the highest drumstick weight was determined from broilers fed with only sorghum (BS). The weights of cold carcasses and cut-up pieces of male broilers were higher than that of female. Except for redness (a^* value), other parameters are affected by treatments. The effects of type of meat (breast and drumstick meats) and gender were also variable. The moisture, pH, TBARS, fat, a^*, *Micrococcus/Staphylococcus* and Enterobacteriaceae count were lower ($p<0.05$) in breast fillets than drumstick muscles. The moisture, fat, L^*, lactic acid bacteria, *Micrococcus/Staphylococcus* and *S. aureus* counts were lower ($p<0.05$) in female broiler meats than male broiler meats.

Key Words: broiler, sorghum, corn, methionine, cut-up pieces, color, microbiological quality

INTRODUCTION

Cereals supply a majority of the calories, proteins, vitamins, and minerals to the bulk of populations in developing nations (Chaven and Kadam, 1989). However, some of them, such as sorghum may contain large amounts of toxic and antinutritional substances, like polyphenols and tannins (Salunkhe et al., 1990; Pariza, 1996). As known, these substances reduce the nutritional value of feed by interfering with bioavailability, and digestibility of carbohydrates and proteins (Salunkhe et al., 1990). The presence of tannins in feed can lower feed efficiency, depress growth performance, decrease some mineral absorption and increase excretion of the proteins and some essential amino acids by damaging mucosal lining of the alimentary tract (Reddy and Pierson, 1994). Additionally, tannins inhibit enzymatic activity, affecting protein digestion, and they may react with amino acids, thus decreasing their biological availability to the animal. Furthermore, amino acids lysine and threonine contents in sorghum are low compared with the corn. Calculations of chemical score by actual feeding tests have shown that sorghum has limiting amino acids,

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especially in sulfur amino acid contents, such as methionine, cystine, and cysteine (Sikka and Cuhari, 1979).

There are many studies about partially usability of sorghum in place of corn in avian species diets (Sell and Rogler, 1984; Karaoğlu et al., 2005a; İmik et al., 2006). However, there was no information about the effect of sorghum and corn supplemented with methionine on the cut-up pieces weights and meat quality properties of broilers. The aim of the present study was to determine comparatively the effects of sorghum (BS = basal diets containing 30% sorghum), corn (BC = basal diets containing corn) and supplemental methionine (BSM = diet BS plus 0.6 9% methionine, BCM = diet BC plus 0.69% methionine) in broiler diets on the cold carcass weight and cut-up pieces weight of broilers and some chemical, physical, and microbiological properties of breast and drumstick meats.

MATERIAL AND METHODS

One-day old, a total of 240 *Ross*-308 broiler chicks (120 males and 120 females) were randomly allocated to four dietary treatments and housed in batteries from 1 to 21 days, and in grower broiler pens from 21 to 39 days in the Application and Research Farm of the Veterinary Faculty, Ataturk University, Erzurum, Turkey. Each treatment group was divided into six subgroups, comprising five birds each, for male and female groups. Feed and water were offered *ad libitum*. All birds were fed a starter diet from day 1 to 21, and a grower diet to 39 days. Diets were formulated according to NRC (NRC, 1984) recommendations. Feed composition was analyzed by AOAC methods (AOAC, 1990) (Table 1). Crude protein, crude fat and crude ash values of corn and sorghum used in basal diets were 8.5, 3.8 and 1.36% and 9.5, 4.9 and 2.76%, respectively. Table 2 depicts the ingredients (%) of the experimental diets. The four dietary treatments were: (1) BS = basal diets containing 30% sorghum; (2) BSM = diet BS plus 0.69% methionine; (3) BC = basal diets containing corn; and (4) BCM = diet BC plus 0.69% methionine during experimental period for both of the sex of broilers.

At the end of the feeding period, 60 birds (30 males and 30 females) were selected at random from each treatment group. Prior to slaughtering, the birds were held without feed for 10 h, slaughtered by a neck cut, bled for 120 s and semi-scalded at 52–54°C for 30 s before mechanical picking in a rotary drum plucker. The birds were eviscerated manually, washed and allowed to drain 10 min (Yalcın et al., 1999). After eviscerating, carcasses were stored at 3°C for 24 h, and then the carcasses were dissected (Mathes et al., 1997; Pingel et al., 1998; Barbut, 2002) as defined Table 3, after weighing cold carcass; and cut-up pieces was weighted. The moisture, pH, total ash, thiobarbutiric acid reactive substances (TBARS), total fat, L^*, a^*, b^*, total psychrotrophic bacteria, lactic acid, *Micrococcus/staphylococcus*, *S. aureus*, and Enterobacteriaceae counts of breasts and drumsticks from the four treatment groups for both of sex were determined.

The moisture, total ash, and total fat values of the samples were determined according to the methods of Gökalp et al. (2001). The pH value of the samples was determined with a pH meter (Schott L 6880, Lab Star pH), by using a direct probe by thrusting the probe into the breast and drumstick muscle. TBARS were determined by using the muscle extraction procedure of Lemon (1975). The TBARS values were expressed as (mol MDA per kg meat. The color measurements (L^*, a^*, b^*) were carried out using a tristimulus colorimeter (Minolta Chroma Meter Measuring Head CR-200, Minolta, Osaka, Japan).

The microbiological analysis of the samples was determined according to the methods of Baumgart et al. (1993). Sample solutions for microbiological analyses were prepared by homogenizing a 25 g sample with 225 mL physiological saline water (0.85 NaCl %) in a Stomacher for 1 min (Lab Stomacher Blander 400-BA 7021, Seward Medical). Then, serial dilutions were performed in sterile solution. Surface spreading technique was used by spreading 0.1 mL of the appropriately diluted sample to the surface of the media. Total psychrotrophic count was estimated by

Table 1. Nutritional levels of basal diet used in trials.

	Broiler starter diet				Broiler finisher diet			
Nutrient	BS	BSM	BC	BCM	BS	BSM	BC	BCM
ME, kcal/kg	3221.9	3204.1	3197.0	3175.5	3237.2	3215.8	3222.0	3200.5
Crude Protein %	21.89	22.34	21.66	22.25	20.26	20.86	20.29	20.89
CF, %	3.11	3.07	3.05	3.05	3.01	2.99	2.97	2.95
EE, %	9.89	9.86	9.51	9.50	9.48	9.47	9.50	9.46
Ca, %	0.87	0.87	0.87	0.87	0.85	0.85	0.85	0.85
P, %	0.64	0.64	0.63	0.63	0.63	0.63	0.62	0.62
Tannin, %	0.67	0.67	–	–	0.67	0.67	–	–

BS = basal diets containing 30%sorghum BSM = diet BS plus 0.6 9% methionine; BC = basal diets containing corn; BCM = diet BC plus 0.69% methionine
ME = metabolizable energy; CP = crude protein; CF = crude fiber; EE = ether extract.

Table 2. Ingredients of the experimental diets (%).

	Broiler starter diet			
	Experimental diets[1]			
Item	BS	BSM	BC	BCM
Corn	18.00	18.00	48.00	48.00
Sorghum	30.00	30.00	–	–
Wheat	9.70	9.50	9.10	8.40
Soybean meal	28.60	28.10	29.90	29.90
Fish meal	3.00	3.00	3.00	3.00
Soy oil	6.8	6.8	6.10	6.10
Molasses	0.20	0.20	0.20	0.20
Limestone	1.00	1.00	1.00	1.00
Salt	0.24	0.25	0.24	0.25
Dicalcium-P	1.20	1.20	1.20	1.20
Methionine	0.28	0.97	0.28	0.97
Lysine	0.70	0.70	0.70	0.70
Cystine	0.20	0.20	0.20	0.20
Vit-Min Prem.	0.08	0.08	0.08	0.08
	Broiler finisher diet			
	Experimental diets[1]			
Item	BS	BSM	BC	BCM
Corn	19.00	19.00	48.00	48.00
Sorghum	30.00	30.00	–	–
Wheat	10.50	9.80	9.60	8.90
Soybean meal	28.00	28.00	30.20	30.20
Fish meal	2.00	2.00	2.00	2.00
Soy oil	6.50	6.50	6.20	6.20
Molasses	0.20	0.20	0.20	0.20
Limestone	1.00	1.00	1.00	1.00
Salt	0.24	0.25	0.24	0.25
Dicalcium-P	1.30	1.30	1.30	1.30
Methionine	0.28	0.97	0.28	0.97
Lysine	0.70	0.70	0.70	0.70
Cystine	0.20	0.20	0.20	0.20
Vit-Min Prem.	0.08	0.08	0.08	0.08

[1]: Diets: BS = basal diets containing 30%sorghum; BSM = diet BS plus 0.6 9% methionine; BC = basal diets containing corn; BCM = diet BC plus 0.69% methionine, CP: Crude protein; [2]:Vitamin-mineral mixure provides in milligrams 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 çg/kg; Mn, 70; Zn, 50; Fe, 30; Cu, 5, Se, 0.3.

Table 3. Description of the weights of cut-up pieces of broiler carcass.

Variable	Weight description (g)
Cold carcass	Whole carcass weight stored 3 ± 0.5°C for 24 h
Neck	Weight of front portion of front back
Wing drumette	Weight the proximal portion of the both wings
Winglet	Weight of distal portion of both wings
Wing tip	Weight of tip portion of both wings
Whole breast	Weight of whole breast (Breast fillets, skin on breast fillets and upper portion with bone of breast fillets)
Breast fillet	Weight of breast fillets
Whole legs	Weight of drum and thigh with spine
Thigh	Weight of the proximal portion of the both legs
Drumstick	Weight of the distal portion of the both legs
Hind back	Weight of upper portion with bones of both legs
Tail	Weight of tail with cartilage tissue

spreading on Plate Count agar, and incubating at 10°C for 7 days. *Micrococcus/Staphylococcus* were determined on Mannitol Salt Phenolred agar and incubating at 30°C for 2 days. Lactic acid bacteria were incubated anaerobically on De Man Rogosa Sharpe Agar at 30°C for 2–3 days, respectively. Enterobacteriaceae determination was carried out by spreading 0.1 mL on Violet Red Bile Dextrose Agar and incubation at 30°C for 2–3 days. The number of *S. aureus* was determined by spreading 0.1 mL on Baird-Parker's egg yolk tellurite agar (20%), and incubated at 37°C for 24–48 h. Bacteria counts were expressed as logarithmic colony-forming units per gram of sample (log cfu/g).

Statistical evaluations were performed using the SPSS/package (1996) using a completely randomized design procedure. The model 1 included effects of treatments (BS, BSM, BC, and BCM) and sex (male and female) as main effect on each cut-up pieces weights. The model 2 included treatments (BS, BSM, BC, and BCM), meat kinds (breast, drumstick), and sex (male and female) as main effect on chemical and microbiological properties of meats. The differences among means were tested by Duncan's multiple range test (significance $p<0.05$). The results of statistical analysis are shown as mean value ± standard deviation in tables.

RESULTS AND DISCUSSION

Diet treatments affected significantly ($p<0.05$) cold carcass and cut-up pieces (Table 4). Corn and methionine in basal diet caused 187, 155, and 94 g increase in cold carcass weight according to BC, BSM, and BS, respectively. There was no difference between BSM and BC groups in terms of cold carcass weight. Although treatments had a significant effect ($p<0.05$) on whole breast (breast meat + front back) weight, it had no effect ($p>0.05$) on only breast meat weight. The highest values were determined in BCM group for whole breast. There was no difference among the other groups. Whole legs (hind back + thigh + drumstick), thigh, and drumstick weights were significantly ($p<0.01$) affected by BS, BSM, BC, and BCM diets. While the highest values for whole legs and thigh weight were determined in BS group, the highest value for drumstick weight was found in BCM group (Table 4). There was a significant ($p<0.05$) difference in wing drumette, winglet, and wing tip weight among treatments groups, and those values generally decreased in BS and BSM groups. Also, treatments had an effect ($p<0.01$) on weight of neck, and the highest value was determined in BCM group (Table 4).

Table 5 summarizes the effects of diets with the BS, BSM, BC, and BCM on cold carcass and cut-up pieces weight of carcass for male and female broilers. Sex had a significant effect ($p<0.01$) on both cold carcass weight

Table 4. Weight of cold carcass and cut-up pieces of broiler carcass.

	Weight[1] (g)				
	BS	BSM	BC	BCM	Significance
Cold carcass weight	1576.67 ± 84.58 ab	1515.33 ± 130.54 b	1483.00 ± 247.14 b	1670.67 ± 311.75 a	*
Whole breast	606.33 ± 54.18 b	610.67 ± 53.68 b	566.00 ± 102.41 b	680.00 ± 135. 06 a	*
Breast meat	388.37 ± 99.88	385.33 ± 51.75	368.00 ± 54.44	442.67 ± 84.65	NS
Whole legs	326.00 ± 31.48 a	292.50 ± 24.32 c	294.33 ± 52.03 bc	315.17 ± 62.79 ab	**
Hind back	83.17 ± 17.08	75.33 ± 12.72	75.17 ± 16.85	72.00 ± 17.95	NS
Thigh	140.0 ± 16.14 a	118.33 ± 12.24 b	121.50 ± 20.66 b	133.50 ± 28.16 b	**
Drumstick	106.08 ± 15.04 ab	93.67 ± 12.29 c	101.17 ± 16.74 b	108.83 ± 20.93 a	**
Wing drumette	46.33 ± 8.04 a	34.83 ± 6.46 b	38.83 ± 5.94 b	41.50 ± 9.91 b	*
Winglet	36.17 ± 5.08 a	32.67 ± 5.28 bc	31.00 ± 6.35 c	35.00 ± 6.35 ab	*
Wing tip	15.33 ± 3.45 a	12.17 ± 2.89 b	12.67 ± 2.99 b	13.33 ± 3.77 ab	*
Tail	36.00 ± 15.28	34.67 ± 12.04	30.67 ± 6.65	37.33 ± 6.02	NS
Neck	106.33 ± 7.53 b	102.67 ± 19.21 b	113.33 ± 18.18 ab	127.00 ± 19.99 a	**

[1]a–c: Values within the same row followed by different letters are significantly different at $p > 0.05$. **: $p < 0.01$, NS: Nonsignificant.
See Table 1 for diets composition.

and cut-up pieces weight (except for breast meat and tail), males had higher values than females.

The moisture values were significantly affected by treatment ($p < 0.01$), sex ($p < 0.05$), and kind of meat ($p < 0.05$, breast fillet and drumstick). The use of methionine with BS, and BC in broiler diets decreased moisture values ($p < 0.05$), and the highest moisture values were determined in the BS and BC group (Table 6). Differences were observed among type of meat in moisture values, and moisture values in breast fillets were lower ($p < 0.05$) than drumstick meats. Also, moisture values of meats of male broilers have higher than that of female broilers. The use of BS, BSM, BC, and BCM in the diet significantly ($p < 0.01$) affected ash amount, and the highest amount ($p < 0.05$) was obtained in the BS group. The high crude ash content of the sorghum may lead to this result. Sorghum had higher crude ash (2.76%) than that of the corn (1.36%). Similarly, Pond et al. (1995) determined that some varieties of corn (1.4–1.8%, as dry matter basis) had lower crude ash than those of sorghum (2.1% as dry matter basis). The use of methionine in broiler diets decreased ash accumulation as compared with or without methionine groups ($p < 0.05$). The ash amount in breast tissue was higher (Table 6) than drumstick meats. Also, the fat amount ($p < 0.01$) was significantly affected by treatment, sex and kind of meat. The highest fat contents were determined in the groups without methionine ($p < 0.05$) (Table 6). These results showed that the use of methionine in the diet decrease fat accumulation in the broiler meats. As expected, fat amount of breast meats had lower than drumstick meats. USDA reported that moisture, ash and fat values of broiler meats were 74.9–75.9%, 4.3–1.6%, and 0.98–0.94%, respectively (USDA, 1999). Cherian et al. (2002) also found that total fat amount of leg muscles of birds fed different cultivars sorghum have higher than that of breast meats.

Table 5. Weight of cold carcass and cut-up pieces of male and female broiler carcass as weight.

	Weight[1] (g)		
	Males	Females	Signifinance
Cold carcass weight	1711.00 ± 186.02 a	1411.83 ± 103.25 b	**
Whole breast	671.83 ± 95.96 a	559.67 ± 57.41 b	**
Breast meat	411.33 ± 78.89	380.83 ± 74.63	NS
Whole legs	342.50 ± 35.92 a	274.00 ± 24.30 b	**
Hind back	85.17 ± 14.79 a	67.67 ± 12.79 b	**
Thigh	142.50 ± 16.50 a	114.17 ± 15.31 b	**
Drumstick	115.46 ± 13.61 a	89.42 ± 7.38 b	**
Wing drumette	46.92 ± 7.22 a	36.33 ± 4.63 b	**
Winglet	37.35 ± 4.84 a	29.67 ± 3.90 b	**
Wing tip	15.33 ± 3.12 a	11.42 ± 2.42 b	**
Tail	32.83 ± 10.39	36.50 ± 10.34	NS
Neck	122.50 ± 19.52 a	102.17 ± 10.36 b	**

[1]a,b: Values within the same row followed by different letters are significantly different at $p > 0.05$.
**: $p < 0.01$, NS: Nonsignificant.

BS, BSM, BC, and BCM treatments and kind of meat significantly ($p < 0.01$) affected pH values. pH Values in those fed with only corn (BM) were lower ($p < 0.05$) than the other treatment groups. Also, breast meats have lower pH values than drumsticks meats. A lot of researchers reported that pH values of breast meats obtained from broiler carcasses lower than those of drumsticks. For example, Castellini et al. (2002) found that pH values of breast and drumsticks of broilers were 5.96 and 6.18, respectively. Aksu et al. (2005a) also reported that pH values in breast fillets (average 5.94 ± 0.16) obtained from broiler carcasses were lower than drumsticks (average 6.61 ± 0.15).

TBARS measures malonaldehyde content in meat and is the most frequently used test to determine lipid oxidation. TBARS also related to warmed-over flavor and hexanal content in meats (Shu et al., 1995). In the present study, TBARS values were affected by the

Table 6. The effect of treatment, sex and type of meat on the moisture, pH, total ash, total fat, TBARS, fat, and color values of samples.

	Mean ± SD[1]							
	Moisture (%)	pH	Total ash (%)	Total fat (%)	TBARS (μmol malonaldehyde/kg)	*L**	*a**	*b**
Diet[2]								
BS	75.71 ± 1.40 a	6.13 ± 0.27 a	1.21 ± 0.10 a	1.92 ± 1.16 a	5.43 ± 2.10 b	53.87 ± 4.86 a	7.36 ± 3.58	5.39 ± 2.69 a
BSM	75.34 ± 0.99 ab	6.14 ± 0.30 a	1.01 ± 0.13 c	1.41 ± 0.48 b	6.76 ± 1.96 a	49.26 ± 3.76 b	7.20 ± 3.17	2.15 ± 1.53 c
BC	75.64 ± 0.41 a	5.92 ± 0.16 b	1.11 ± 0.10 b	1.91 ± 1.05 a	6.06 ± 1.55 a	49.75 ± 3.51 b	7.34 ± 2.83	4.07 ± 1.92 b
BCM	75.23 ± 1.38 b	6.09 ± 0.31 a	0.98 ± 0.20 c	1.39 ± 1.28 b	5.63 ± 1.77 b	48.75 ± 2.97 b	6.44 ± 2.87	4.32 ± 1.97 ab
Significance	*	**	**	**	**	**	NS	**
Sex								
Male	75.62 ± 1.12 a	6.06 ± 0.24	1.07 ± 0.19	1.95 ± 1.12 a	5.74 ± 1.84 b	51.61 ± 4.45 a	7.16 ± 3.21	3.63 ± 2.27
Female	75.36 ± 1.07 b	6.08 ± 0.30	1.08 ± 0.13	1.36 ± 0.84 b	6.47 ± 1.92 a	49.20 ± 3.80 b	7.01 ± 3.00	4.33 ± 2.40
Significance	*	NS	NS	**	**	**	NS	NS
Type of meat								
Breast	74.73 ± 0.51 b	5.83 ± 0.06 b	1.17 ± 0.10 a	0.86 ± 0.25 b	4.78 ± 1.38 b	50.34 ± 3.93	5.35 ± 1.73 b	3.87 ± 2.37
Drumstick	76.26 ± 0.95 a	6.30 ± 0.16 a	0.98 ± 0.16 b	2.46 ± 1.02 a	7.43 ± 1.36 a	50.47 ± 4.66	8.82 ± 3.19 a	4.10 ± 2.35
Significance	**	**	**	**	**	NS	**	NS

[1]a,b: Values within the same column followed by different letters are significantly different at $p > 0.05$. **: $p < 0.01$, *: $p < 0.05$, NS: Nonsignificant.
[2]See Table 1 for diets composition.

treatment (BS, BSM, BC, and BCM) ($p < 0.01$), sex ($p < 0.01$) and kinds of meat ($p < 0.01$). Among treatment groups the lowest TBARS values were observed in BS and BCM groups ($p < 0.05$). There was no significant difference between BSM and BC groups (Table 6). Sorghum contains high levels of tannin and other phenolic compounds (El-Khalifa and El-Tinay, 1994); tannins have strong antioxidant effect (Du et al., 2002). Thus, low TBARS value in BS group may due to high amounts of tannins in sorghum (BS). TBARS values of female broilers had higher than male broilers. As the fat content of the drumstick muscle, they have higher TBARS values than breast fillets (Table 6). These results agreed with previous reports indicating that TBARS values of breast fillets lower than that of drumstick meats (Aksu et al., 2005a, b, 2006). Castellini et al. (2002) reported that TBARS values were 1.82 mg MDA/kg in breast fillets, and 2.58 mg MDA/kg in drumstick meats from fresh broiler carcasses. But, Cherian et al. (2002) determined that TBARS values of leg muscles of birds fed different sorghum cultivars were lower than in breast meat, and there were significant differences among cultivars respect to this parameter.

Treatments significantly affected L^* and b^* color values ($p < 0.01$). The highest L^* and b^* values was found in BS group. L^* value was lower in female group than the male group ($p < 0.01$). On the other hand, a^* value was significant difference among the meat types (breast and drumstick meats), and the drumstick meat had higher a^* value (Table 6). Some researchers found similar results in drumstick and breast meats of broiler (Castellini et al., 2002; Karaoğlu et al., 2004, 2006). Myoglobin is responsible for color variations, and it is the most abundant pigment in meats. This increase in redness (a*) of drumstick meats seemed to be due the high level of myoglobin in the drumstick. Qiao et al. (2002a) reported that L^*, a^*, and b^* values of fresh breast fillets were 49.62, 3.25, and 4.93, respectively. Qiao et al. (2002b) in another study, determined that mean L^*, a*, and b^* values of breast were 62.07 ± 0.54, 4.38 ± 0.22, and 9.68 ± 0.25, respectively. Castellini et al., (2002) found that L^*, a*, and b^* values of breast and drumsticks in fresh broiler carcasses were 59.23, 4.96, 5.16, and 52.86, 5.78, 4.95, respectively. Karaoğlu et al. (2005b) reported that mean color values of breast and drumsticks (L^*, a^*, and b^*) were 47.10 ± 2.45 and 51.25 ± 2.74, 3.53 ± 1.54 and 4.89 ± 2.15, 6.09 ± 2.24 and 6.40 ± 2.21, respectively. Du et al. (2002) determined that L^*, a^*, and b^* values of broiler breast meats from birds fed a control diet or sorghum were 51.38–51.71, 4.62–4.63, and 9.28–9.38, without differences in L^* and b^* values of raw broiler meats by dietary sorghum treatments.

Microbiological properties of breast and drumstick meats were affected by diet treatments. While the effects of treatment on total aerobic psychrotrophic bacteria counts were found significant ($p < 0.05$), the effects of sex and type of meat were no significance on total aerobic psychrotrophic bacteria counts. This count was higher in BS group samples than those of the other group samples (Table 7). The psychrotrophic microorganisms commonly associate with refrigerated foods (0–7°C) and cause food spoilage, and psychrotrophic microorganisms can cause both a variety off flavor and physical defects for many foods in 10^6–10^8 counts. Also, Aksu et al. (2005a) found out that psychrotrophic microorganism counts of broiler drumstick and breast fillets were 5.15 and 5.11 log cfu/g as mean values at 3°C for 12 days, and this value was

Table 7. The effect of treatment, sex and type of meat on the total psychrotrophic, lactic acid, *Micrococcus/Staphylococcus*, *S. aureus*, and Enterobacteriaceae in samples.

	Counts (Mean ± SD, log cfu/g)				
	Total psychrotrophic bacteria	Lactic acid bacteria	*Micrococcus/ Staphylococcus*	Enterobacteriaceae	*S. aureus*
Diet[2]					
BS	4.55 ± 0.33 a	3.78 ± 0.22 a	3.71 ± 0.20 a	3.51 ± 0.20 a	3.01 ± 0.15 a
BSM	4.31 ± 0.34 b	3.28 ± 0.35 d	3.37 ± 0.29 b	3.04 ± 0.28 b	2.76 ± 0.55 bc
BC	4.21 ± 0.37 b	3.65 ± 0.32 b	3.34 ± 0.41 b	3.05 ± 0.44 b	2.60 ± 0.44 c
BCM	4.23 ± 0.18 b	3.46 ± 0.28 c	3.42 ± 0.13 b	2.83 ± 0.67 c	2.86 ± 0.18 ab
Significance	*	**	**	**	**
Sex					
Male	4.38 ± 0.34	3.62 ± 0.22 a	3.64 ± 0.26 a	3.06 ± 0.43 b	3.04 ± 0.19 a
Female	4.27 ± 0.26	3.47 ± 0.43 b	3.28 ± 0.23 b	3.15 ± 0.54 a	2.57 ± 0.39 b
Significance	NS	**	**	*	**
Type of Meat					
Breast	4.30 ± 0.33	3.60 ± 0.35 a	3.41 ± 0.39 b	3.02 ± 0.42 b	2.77 ± 0.40
Drumstick	4.35 ± 0.33	3.49 ± 0.34 b	3.51 ± 0.26 a	3.19 ± 0.54 a	2.84 ± 0.38
Significance	NS	**	*	**	NS

[1]a–d: Values within the same column followed by different letters are significantly different at $p > 0.05$. **: $p < 0.01$, *: $p < 0.05$, NS: Nonsignificant.
[2]See Table 1 for diets composititon.

3.89 log cfu/g for 0 days of storage. Álvarez-Astorga et al. (2002) determined that psychrotrophic counts were 7.07 log cfu/g for retail broiler leg meats. Lactic acid bacteria counts were highly affected by treatment, sex, and meat type ($p < 0.01$). While the highest lactic acid bacteria count was determined in BS group, the lowest count was found in BCM group. Also, male group and breast meats have higher lactic acid bacteria counts than female and drumsticks ($p < 0.05$). Aksu et al. (2005a, b) obtained similar results in studies on broiler meats. The use of BS, BSM, BC, and BCM in broiler diets had significant effect on *Micrococcus/Staphylococcus* count, and the highest *Micrococcus/Staphylococcus* count was observed in BS group. The effect of sex ($p < 0.01$) and meat type ($p < 0.05$) on the *Micrococcus/Staphylococcus* counts was found significant. The counts were lower in breast fillets and female than drumstick meats and male (Table 7). It was observed that there was a significant difference in Enterobacteriaceae counts in all treatment groups, sex, and meat types. The highest Enterobacteriaceae count among treatment groups was determined in BS group. The higher Enterobacteriaceae counts were observed in drumstick meats and female. Also, Enterobacteriaceae counts had higher in drumstick meats than breast meats. Mahajan et al. (2000) and Aksu et al. (2005a) found that higher Enterobacteriaceae count in muscle of leg than in breast fillets during storage. Although the effect of meat type was not significant on *S. aureus* counts ($p > 0.05$), the treatment and sex had highly significant effect on *S. aureus* counts ($p < 0.01$, Table 7). Waldroup (1996) reported that *S. aureus* counts in poultry meat varied between < 3 and > 5 $\log_{10}$ cfu/g. Álvarez-Astorga et al. (2002) determined that average *S. aureus* count for broiler leg meats was 2.47 log cfu/g, and Al-Mohizea et al. (1994) found that *S. aureus* count for broiler meats was 2.78 $\log_{10}$ cfu/cm^2.

CONCLUSION

The effect of the treatment was variable on all of the parameters studied. Generally, the highest cold carcass and cut-up pieces weights were observed in BS and BCM groups. The results related to the cold carcass and cut-up pieces weights suggested that low-tannin sorghum (without methionine) can be partially replaced with corn up to 30% in broiler diets. As an expected, the higher cold carcass and cut-up pieces weights were obtained from male broilers. On the other hand, female broiler meats have lower fat content than that of the males. Additionally, supplementing diets with methionine (BSM and BCM) decreased fat accumulation in broiler breast and drumstick meats.

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