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Some characteristics of meats from the chickens fed with *Lamiaceae* spices: Proximate composition, lipid oxidation, color and sensory properties

Ausgewählte Parameter der Fleischqualität von Broilern nach Fütterung mit phytogenen Verdauungsförderern (Gewürze = Lamiaceae): Chemische Vollanalyse, Fettoxidation, Farbe und sensorische Eigenschaften

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Summary

The objective of this study was to investigate the effects of spice feeding on some chemical and sensory properties of chickens. For this purpose, in addition to the control group with only basal diet, the treatment broilers were fed with 3.5 % and 7.0 % of Izmir oregano *(Origanum onites)* only and 3.5 and 7.0 % of spice mix [Izmir oregano; black thyme *(Thymbra spicata)* and summer savory *(Satureja hortensis)* at the ratio of 1:1:1] for 40 days. The effect of spice-feeding treatment on the proximate composition, lipid oxidation, color and sensory properties of chicken breast and thigh samples were investigated in different storage periods (0, 3 and 6 days). The treatments showed no significant effect on the proximate composition except for the fat content and sensory attributes of the samples while a significant decrease was observed in lipid oxidation values with 3.5 % of mixed spice. Spice-feeding treatments resulted in a significant decrease in the TBA values of the samples, and the lowest TBA value was with the broiler groups fed with 3.5 % of mixed spice. Color of the chicken meats was influenced from the spice-feeding treatment especially with 3.5 % of Izmir oregano. The highest *a** and *b** values were observed in the broiler groups fed with 3.5 % or 7.0 % of Izmir oregano. In conclusion, the spice-feeding resulted in better storage stability in the chicken samples with no indication of undesirable sensory properties.

Keywords: Broiler, spice-feeding, proximate composition, lipid oxidation, sensory properties

Zusammenfassung

Ziel der Untersuchungen war die Feststellung des Einflusses der Verfütterung von Gewürzen auf chemische und sensorische Eigenschaften von Broilerfleisch. Dazu wurden Broiler einer Mast von 40 Tagen in einer Kontrollgruppe (Grundfütterung) sowie in vier Fütterungsgruppen mit 3.5 bzw. 7.0 % Izmir-Oregano *(Origanum onites)* und mit 3.5 bzw. 7.0 % einer Gewürzmischung [Izmir-Oregano, schwarzer Thymian *(Thymbra spicata)* und Sommer-Bohnenkraut *(Satureja hortensis)* im Verhältnis 1:1:1] unterzogen. Der Einfluss dieser Fütterung auf die chemische Vollanalyse, die Fettoxidation, sowie Farb- und sensorische Eigenschaften von Brust- und Schenkelfleisch wurden nach unterschiedlicher Lagerdauer (0, 3, 6 Tage bei 4 °C) ermittelt. Es ergab sich kein Einfluss bei der Vollanalyse der Schlachtkörper mit Ausnahme des Fettgehalts und sensorischer Eigenschaften, wobei eine signifikante Erniedrigung der Fettoxidation mit 3,5 % der Gewürzmischung erfolgte. Die Gewürz-Fütterung führte generell zu niedrigeren TBZ-Werten (Thiobarbitursäure-Zahl) mit dem höchsten Effekt bei 3.5 % Izmir-Oregano. Die gleiche Fütterung beeinflusste auch die Fleischfarbe am stärksten. Die höchsten Farbwerte *a** und *b** ergaben sich nach Fütterung mit 3.5 bzw. 7.0 % Izmir-Oregano. Zusammenfassend lässt sich feststellen, dass die Gewürzfütterung zu besserer Lagerungs-Stabilität von Broilerfleisch führte, ohne dass Verschlechterungen der sensorischen Eigenschaften auftraten.

Schlüsselwörter: Broiler, Fütterung mit phytogenen Verdauungsförderern, Schlachtkörper-Zusammensetzung, Fettoxidation, sensorische Eigenschaften

Introduction

Meat chickens, also known as broilers, have received a great attention as pure breeds or varieties in the commercial poultry industry to increase their market share. Therefore, over a long period of years, producers have focused their efforts to improve meat yield of commercial broiler type chickens as a primary choice. In the past, broilers had been raised in a certain period of time; but currently the chicks could be slaughtered even in a less than seven weeks when the proper feeding regimes applied. However, this process has also brought out some problems, for instance; taste and flavor in the rapidly growing chickens were not satisfactorily developed, as well as oxidative and microbiological stability of their meats were not sufficient (Richardson and Mead, 1999). Lipid oxidation and microbiological deteriorations in meat and meat products may lead to some important problems during the processing and storage (Fernandez-Lopez et al., 2005). Prevention or retardation of the lipid oxidation during the processing or storage of meat has been essential research subjects to maintain the quality and safety of the products, and in the food industry, synthetic antioxidants have generally been used to solve these problems. However, today's consumer has been demanding the foods containing no synthetic preservatives due to the fact the increased consumer consciousness about food and health interactions. Considering the tendency of consumers, spices and/or their extracts in foods as natural antioxidants and antimicrobials have been welcomed as a good alternative to the synthetic preservatives (Rey et al., 2005). Spices and their extracts could also be incorporated into the rations of poultries to benefit from their antioxidant and antimicrobial effects. Accordingly, it has been speculated that the dietary manipulation in the chicken breeding would offer a great potential to enhance the taste and flavor of poultry meats. Furthermore, some researchers have indicated that some herbal additives in their rations could improve the oxidative stability of the chicken meats (Nam et al., 1997; Giannenas et al., 2005). Apart from their antioxidant effect in their tissue, some other beneficial physiological effects of spices have been brought an extensive animal studies during the past decades (Srinivasan, 2005a). Among these researches are their beneficial effects on the lipid metabolism (Srinivasan et al., 2004). Also spices are well recognized to stimulate gastric function and they are generally believed to intensify salivary flow and gastric juice secretion and, hence, aid in digestion (Srinivasan, 2005b). Some researchers reported the essential oil and extract of thyme positively affected gastrointestinal microfauna in broilers (Bolukbasi et al., 2006; El-Ghousein & Al-Beitawi, 2009). Also, these scientists determined that essential oil and extract of thyme and sage were significantly improved feed conversion ratio and growth performance, body weights and total protein values. In this respect, the effect of dietary supplementation with spices should be investigated on meat quality parameters of the broilers like proximate composition, storage stability and sensory properties as well.

Turkey is the origin of thyme, oregano and several other spices used in a variety of meat products and traditional meat dishes. It was reported that Turkey handled the 70–80 % portion of thyme and oregano trade around the world. Commercially exported spice species have largely belonged to the *Thymus, Thymbra, Origanum* and *Satureja* genera of the Lamiaceae family (Bayram, 2003). Also, there have been several research reports for their antioxidant and antimicrobial activities (Sagdic, 2003; Ozkan et al., 2003; Sagun et al., 2006). Although, the country is rich in herbs and seasoning plants, no adequate number of studies has taken place on improving the meat quality of the broilers fed with natural herbs and spices. This might be a potential for the poultry industry to utilize herbs and spices in their production range since the dietary treatment would offer a great possibility to improve animal health and their products. Some studies conducted previously have shown that the dietary supplementation of extracts of rosemary and sage (Lopez-Bote et al., 1998) or essential oil of oregano (Botsoglou et al., 2002; Simitzis et al., 2008) could improve the oxidative stability of broiler meat products during the refrigerated storage. In this study, however, the spices were incorporated into diet of broilers, not as a form of essential oil or their extracts. Therefore, the present study was aimed to evaluate the effect of dietary supplementation of Izmir oregano and the mix of Izmir oregano, black thyme and summer savory on some quality parameters of chicken meat during the refrigerated storage.

Materials and Methods

Animals and diets

In this study, Ross 308 genotype commercial broilers *(Gallus gallus domesticus)* were separated into five homogeneous treatment groups (n: 12 birds); (1) control group broilers fed with no spice; (2) 3.5 % of Izmir oregano; (3) 7.0 % of Izmir oregano; (4) 3.5 of spice mix and (5) 7.0 % of spice mix. Spice mix was 1:1:1 of Izmir oregano *(Origanum onites),* black thyme *(Thymbra spicata)* and summer savory *(Satureja hortensis).* Fresh and fine ground spices were mixed thoroughly with the commercial broiler feed according to the % supplement ratio (w/w), and the entire broiler were fed (ad libitum) for 40 days. The broilers were cage-raised in a temperature-controlled room. The temperature of the room was 32±3 °C in the first week, 29±2 °C during the following week, and 25±3 °C thereafter. Twenty four hours of lighting per day was provided. The composition of the experimental basal diets is shown in Table 1. After the broilers were slaughtered under commercial conditions, breast and thigh of the carcasses were excised and then packed with sterile stomacher bags (Nasco Whirl-Pak, Atkinson, WI) and stored at 4 °C for 6 days. The samples were minced using a sterile blender (Warring Blender 8011ES, USA), and all analyses were conducted with these ground samples except for sensorial analysis.

pH and proximate composition

Ten grams of ground meat samples were blended with 50 ml distilled water using a high speed vortex for 1 minute (Sallam et al., 2004), and pH values were measured at 20 ºC using a calibrated pH meter (Hanna 8314, Romania). The samples were analyzed for its moisture, protein, ash and fat contents according to the methods of AOAC International (1999). The results were expressed as percentage of wet weight.

Determination of essential oil composition of the spices

Five hundred grams of ground spice samples were subjected to steam distillation for 3 h using a Clevenger-type apparatus. Essential oils compositions were analyzed by a

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GC-MS/Quadrupole detector using a Shimadzu QP 5050 system (Shimadzu, Duisburg, Germany), fitted with an FFAP (polyethylene glycol+2nitroterephthalate) capillary column (50mx0.32mm i.d., film thickness 0.25 µm). Detector and injector temperature were set at 230 °C. The temperature program for FFAP column was 120 °C (1 min) to 230 °C at a rate of 6 °C /min and then holding at 230 oC for 35 min. Helium was used as a carrier gas at a flow rate of 14 psi (split 1:10 mL/min) and injection volume of each sample was 1 ml. The ionization energy was set at 70 eV. Qualitative analysis was based on the comparison of retention times and the computer mass spectra libraries using Wiley GC/MS Library and Nist, Tutore Libraries. The percentage composition was computed from the GC peak areas (Sagdic et al., 2009).

Color

Meat color was measured using a chromameter (Lovibond RT Series Reflectance Tintometer, U.K.) set on the *L**, *a**, *b** system (Mitsumoto et al., 2005) following the AMSA guidelines for color measurements (Hunt et al., 1991). The measurements were made directly upon the muscle samples and carried out five times, one on the middle and four on the different parts of the samples.

Thiobarbituric acid assay

Lipid oxidation was measured as outlined by Ulu (2004). Ten grams of ground meat samples were homogenized with 35 ml of cold (4 ºC) perchloric acid (4 %) and 1 ml butilated hydroxy toluen at high speed for 1 minute using an Ultra-Turrax homogenizer (Janke and Kunkel, IKA-Labortechnik, GmbH and Co., Staufen, Germany). The mixture was filtered through Whatman No.4 filter paper and washed with 5 ml distilled water. The filtrate was adjusted to 50 ml with 4 % perchloric acid, and then 5 ml of 0.02 M thiobarbituric acid (TBA) reagent was added into the 5 ml of filtrate, and they were incubated at 80 ºC for 40 min. Following the incubation, the mixture was cooled under tap water, and absorbance of the mixture was determined by a spectrophotometer (Shimadzu, UV-VIS 1700, Tokyo-Japan) at 532 nm wavelengths. Five ml of distilled water and 5 ml of 0.02 M TBA solution were used as blank. The results were expressed as mg malondialdehyde (MDA)/kg sample.

Sensory analysis

Chicken meat samples were cooked on a grill (Tefal, France) for 3 min, then they were served warm (around 35 ºC) in random order to an average 10 member trained panel (graduate students and staff of Food Engineering Department). Training comprised of presenting the treatments in preliminary sessions to the panelists to familiarize them with the attributes evaluated. The chicken samples were evaluated in raw and cooked forms. For the evaluation of the cooked samples, panelists were asked to evaluate surface color, texture, crispness, juiciness, taste and flavor, off flavor or odor parameters. Surface color and odor were the sensory parameters for evaluation of the raw samples. Cooked and raw meat samples were presented to the panelists in individual sensory booths illuminated with white fluorescent light. Panelists cleansed their palates with distilled water and bread prior to proceeding to the next sample. Samples were rated on a nine-point hedonic scale (1 = dislike extremely, 9 = like very much).

Statistical Analysis

Each parameter was tested in triplicate samples with two replications. Conventional statistical methods were used to calculate means and standard deviations. Collected data was subjected to statistical analysis using the SAS statistical software (SAS, 1988) with one-way allocation. Significant differences between the means were further analyzed using the Duncan's Multiple Range Test.

Results and discussion

pH and proximate composition

Tables 2 indicates that in general, no significant effect of spice feeding and storage time was observed on the pH and proximate composition of the breast and thigh samples of the chickens except for the fat content. At the 0th day of storage, it was noted that spice-feeding had a decreasing effect (P<0.05) on the fat contents of both breast and thigh muscles of broilers, and the lowest (P<0.05) fat content was observed in the 7.0 % of spice mix fed group. These results could be expected due to the fact that some spices might have the hypolipidemic (lipid-lowering) influence on animal metabolism. The hypolipidemic effect of spices was attributed to their stimulating effect on bile acid production by the liver and its secretion into bile, which play a major role in fat digestion and absorption (Bhat et al., 1984; Platel & Srinivasan, 2000). Some spices were also shown to stimulate pancreatic digestive enzymes, like lipase, amylase and protease playing a crucial role in digestion (Platel and Srinivasan, 2000). For instance, garlic, onion and red pepper were shown to be hypotriglyceridemic, preventing accumulation of fat in liver (Babu and Srinivasan, 1997). This was attributed to the essential oil component of these spices in the experimentally induced animals (Kempaiah and Srinivasan, 2006). In this study, the possible hypolipidemic effect of 7.0 % of spice mix fed broiler group was evident be-

TABLE 1: *Composition of experimental diets.*

Ingredients	Terms of Basal Diets			
	1st	2nd	3rd	4th
Usable phosphorus, %	0.5	0.4	0.1	0.42
Calcium, %	1.1	1.1	0.94	0.89
Methionine, %	0.53	0.5	0.48	0.43
Cystine, %	0.43	0.41	0.4	0.37
Lysine, %	1.42	1.32	1.24	1.08
Analyzed Composition (%)				
Dry matter	90.85	90.88	90.03	90.16
Crude protein	23	22	21	19
Crude fat	8.14	8.55	8.85	8.36
Crude cellulose	4.05	1.1	4.1	4.2
Ash	5.13	6.03	5.48	5.2
Thyme, %*	0, 3.5 or 7	0, 3.5 or 7	0, 3.5 or 7	0, 3.5 or 7
Metabolic energy (kcal/kg)	3 100	3 160	3 220	3 280

1st term: The first 14 days, 2nd term: between the 15th and 25th days, 3rd term: between the 26th and 35th days, 4th term: after 36th days to slaughter. *: The different type of thyme had added to the feed in different ratio.

TABLE 2: *Effect of spice-feeding treatment and storage time on the pH and proximate composition values of the breast and thigh meats samples stored at 4 ºC.*

Characteristics	Storage Time (day)	Control	3.5 % Izmir oregano	7 % Izmir oregano	3.5 % Mixed spices	7 % Mixed spices
Breast						
pH	0	$5.82^{Aa}\pm0.02$	$5.87^{Aa}\pm0.06$	$5.90^{Aa}\pm0.01$	$5.80^{Aa}\pm0.13$	$5.78^{Aa}\pm0.08$
	3	$5.78^{Aba}\pm0.01$	$5.84^{Aa}\pm0.00$	$5.82^{Aa}\pm0.02$	$5.80^{Aa}\pm0.01$	$5.76^{Aa}\pm0.02$
	6	$5.71^{Ab}\pm0.05$	$5.77^{Aa}\pm0.06$	$5.80^{Aa}\pm0.05$	$5.78^{Aa}\pm0.05$	$5.76^{Aa}\pm0.04$
Ash %	0	$1.05^{Aa}\pm0.01$	$1.02^{Aa}\pm0.01$	$1.07^{Aa}\pm0.00$	$0.99^{Aa}\pm0.06$	$1.06^{Aa}\pm0.10$
	3	$1.10^{Aa}\pm0.00$	$1.07^{Aa}\pm0.00$	$1.09^{Aa}\pm0.07$	$1.02^{Aa}\pm0.01$	$1.10^{Aa}\pm0.00$
	6	$1.04^{Aa}\pm0.07$	$1.07^{Aa}\pm0.04$	$1.05^{Aa}\pm0.06$	$1.06^{Aa}\pm0.02$	$1.11^{Aa}\pm0.02$
Fat %	0	$4.92^{Aa}\pm0.16$	$4.28^{BAa}\pm0.37$	$3.94^{BACa}\pm0.03$	$3.13^{BCa}\pm0.23$	$2.91^{Ca}\pm0.23$
	3	$4.89^{Aa}\pm0.72$	$4.40^{Aa}\pm1.05$	$4.16^{Aa}\pm1.04$	$2.99^{Aa}\pm0.13$	$2.76^{Aa}\pm0.50$
	6	$5.03^{Aa}\pm0.32$	$4.33^{Aa}\pm0.22$	$4.05^{Aa}\pm1.24$	$3.02^{Aa}\pm0.08$	$2.81^{Aa}\pm0.02$
Moisture %	0	$70.20^{Aa}\pm1.51$	$71.35^{Aa}\pm1.61$	$70.34^{Aa}\pm2.01$	$71.85^{Aa}\pm1.47$	$71.35^{Aa}\pm0.08$
	3	$71.35^{Aa}\pm0.28$	$70.20^{Aa}\pm1.21$	$71.39^{Aa}\pm0.73$	$71.28^{Aa}\pm0.59$	$71.23^{Aa}\pm1.23$
	6	$69.88^{Aa}\pm0.51$	$72.05^{Aa}\pm0.13$	$71.27^{Aa}\pm1.24$	$70.82^{Aa}\pm0.40$	$71.82^{Aa}\pm0.40$
Protein %	0	$20.57^{Aa}\pm0.25$	$20.30^{Aa}\pm0.07$	$19.68^{Aa}\pm0.88$	$19.43^{Ab}\pm0.21$	$21.48^{Aa}\pm0.12$
	3	$22.37^{Aa}\pm0.77$	$19.42^{Aa}\pm0.94$	$20.34^{Aa}\pm0.55$	$20.41^{Aa}\pm0.39$	$21.38^{Aa}\pm0.01$
	6	$21.13^{Aa}\pm1.28$	$21.30^{Aa}\pm0.53$	$21.11^{Aa}\pm0.16$	$19.67^{Ab}\pm0.21$	$21.53^{Aa}\pm0.27$
Tight						
pH	0	$6.16^{Aa}\pm0.08$	$6.28^{Aa}\pm0.02$	$6.35^{Aa}\pm0.04$	$6.33^{Aa}\pm0.12$	$6.20^{Aa}\pm0.17$
	3	$6.16^{Aa}\pm0.02$	$6.24^{Aa}\pm0.04$	$6.29^{Aba}\pm0.00$	$6.27^{Aa}\pm0.07$	$6.13^{Aa}\pm0.13$
	6	$6.12^{Aa}\pm0.10$	$6.22^{Aa}\pm0.01$	$6.16^{Ab}\pm0.03$	$6.21^{Aa}\pm0.02$	$6.06^{Aa}\pm0.00$
Ash %	0	$0.89^{Aa}\pm0.00$	$0.98^{Aa}\pm0.04$	$1.02^{Aa}\pm0.13$	$0.92^{Aa}\pm0.05$	$0.94^{Aa}\pm0.03$
	3	$0.93^{Aa}\pm0.00$	$1.02^{Aa}\pm0.06$	$0.99^{Aa}\pm0.01$	$0.94^{Aa}\pm0.09$	$0.95^{Aa}\pm0.06$
	6	$0.86^{Ba}\pm0.02$	$0.94B^{Aa}\pm0.02$	$0.96^{Aa}\pm0.01$	$0.89^{BAa}\pm0.01$	$0.94^{BAa}\pm0.02$
Fat %	0	$14.32^{Aa}\pm1.15$	$12.51B^{Aa}\pm0.47$	$11.54^{BAa}\pm0.10$	$10.01^{Ba}\pm0.09$	$9.35^{Ba}\pm0.06$
	3	$14.75^{Aa}\pm1.70$	$11.96^{Aa}\pm1.62$	$11.25^{Aa}\pm0.41$	$9.61^{Aa}\pm0.10$	$9.15^{Aa}\pm0.13$
	6	$15.20^{Aa}\pm0.12$	$12.73B^{Aa}\pm0.14$	$10.91^{BCa}\pm0.72$	$9.97^{Ca}\pm0.05$	$9.21^{Ca}\pm0.02$
Moisture %	0	$67.78^{Aa}\pm0.85$	$66.47^{Aa}\pm2.26$	$69.04^{Aa}\pm0.78$	$69.55^{Aa}\pm0.40$	$69.74^{Aa}\pm0.26$
	3	$68.70^{Aa}\pm1.11$	$68.56^{Aa}\pm0.37$	$68.66^{Aa}\pm0.28$	$68.42^{Aa}\pm0.22$	$67.94^{Aa}\pm0.32$
	6	$66.87^{Aa}\pm2.08$	$66.22^{Aa}\pm0.38$	$68.78^{Aa}\pm0.25$	$68.88^{Aa}\pm1.73$	$68.97^{Aa}\pm0.83$
Protein %	0	$15.92^{Aa}\pm0.47$	$15.72^{Aa}\pm0.03$	$17.21^{Aa}\pm0.73$	$16.12^{Aa}\pm0.48$	$15.83^{Aa}\pm1.00$
	3	$15.50^{Aa}\pm0.75$	$16.76^{Aa}\pm0.95$	$17.24^{Aa}\pm0.52$	$16.11^{Aa}\pm0.77$	$15.89^{Aa}\pm0.01$
	6	$16.22^{Aa}\pm0.25$	$17.32^{Aa}\pm1.80$	$16.19^{Aa}\pm0.15$	$17.21^{Aa}\pm0.41$	$17.23^{Aa}\pm0.04$

^{AB} Means with different capital letters in the same row compare the spice concentration and variety and show significant differences at $P<0.05$. ^{ab} Means with lowercase on the same column compare the storage times and show significant differences at $P<0.05$.

cause it had the lowest fat content among the treatment groups, which is consistent with the literature. The digestive stimulant action of combinations of some selective spices was also evidenced in some references (Platel et al., 2002). In the light of this knowledge, it could be concluded that Izmir oregano, black thyme and summer savory might also have hypolipidemic (lipid-lowering) influence in the broiler metabolism. These experimental spices affected only the lipid levels in the evaluated muscle tissues without negatively changing the levels of other nutritional components, e. g. ash, fat, moisture and protein as could be seen in the proximate composition data for broiler breast and thigh muscles (Table 2).

TBA values

The changes in TBA values of breast and thigh samples with respect to spice-feeding treatment and storage time are shown in Figs. 1 and 2, respectively. TBA values of the thigh samples which had higher lipid content were higher than those of the breast samples. Similarly, Nam et al. (1997) observed that oxidative changes in thigh were more extensive than that of breast muscle, due to the higher lipid content. The statistical analyses revealed that the type of meat had a significant ($P<0.05$) effect on TBA values. As can be seen from the figures, refrigerated storage increased ($P>0.05$) the TBA values of both breast and thigh samples, and the highest amounts of TBA values were determined in the control group. In other words, lipid oxidation increased during the storage time in both breast and thigh samples, which could be expected because the increasing effect of storage time on the lipid oxidation is well known. However, spice-feeding treatment significantly ($P<0.05$) retarded lipid oxidation, that is, the lowest TBA value was observed in the 3.5 % of spice mix fed broiler group. These results were in agreement with the literature where the antioxidant effects of some spices have been well documented. Some researches showed that different antioxidants were effective on the retardation of lipid oxidation of lamb (Simitzis et al., 2008), turkey (Botsoglou et al., 2003; Govaris et al., 2007) and broilers (Botsoglou et al., 2002; Giannenas et al., 2005; Tang et al., 2001). Oregano, black thyme and summer savory have also been well known for their antioxidative properties (Botsoglou et al., 2002; Bozkurt, 2006). Two primary phenols carvacrol and thymol are responsible from the antioxidant properties of these spices that constitute about majority of the essential oil and their precursors, g-terpinene and r-cymene, the two monoterpene hydrocarbons (Yanishlieva et al., 1999). Accordingly, Table 3 indicates the similar GC-MS results which revealed that carvacrol was the major and γ-terpinene and ρ-cymene were the minor constituents in the essential oils among the other chemical constituents of the spices studied. Carvacrol and thymol and their precursors would react with lipid and hydroxyl radicals converting them into stable products (Yanishlieva-Maslarova, 2001). Additionally, some other spice compounds were reported to inhibit lipid peroxidation by quenching oxygen free radicals and by enhancing the activity endogenous antioxidant enzymes; superoxide dismutase, catalase, glutathione peroxidase and glutathione transferase in the animal tissues (Srinivasan, 2005a). Briefly, dietary supplementation with Izmir oregano and its mixture with black thyme and summer savory could retard the lipid oxidation of the chicken muscles as the spice form like their essential oils stated in the literature. Accordingly, Lauridsen et al. (1997) reported that oxidative reactions at localized sites of phospholipid membranes could be effectively inhibited by the dietary supplementation which was proven as a simple and convenient strategy to introduce a natural antioxidation in the phospholipid membranes.

Color

The data obtained for the L^* lightness, a^* redness and b^* yellowness values of thigh and breast samples stored at 4 ºC are shown in Table 4. As seen from the table, storage time

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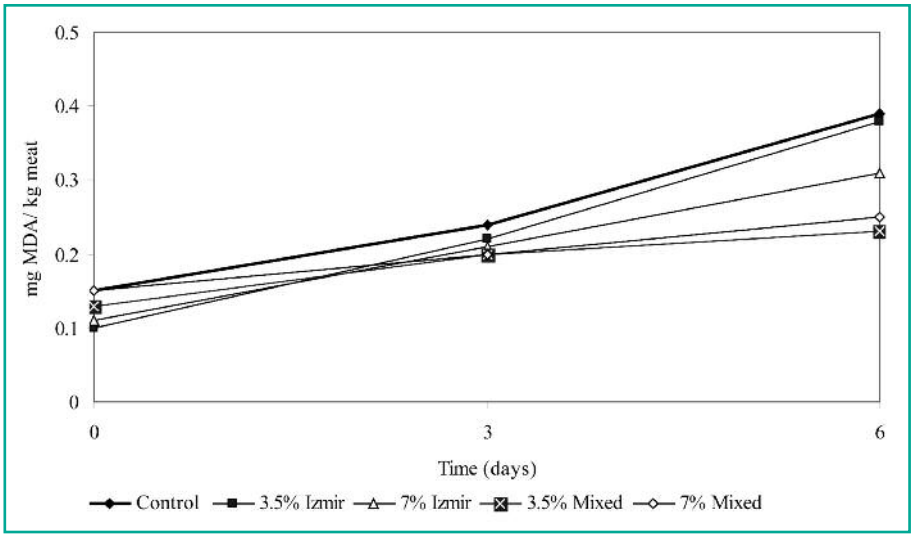

FIGURE 1: *Effect of spice-feeding treatment and storage time on the TBA values (mg malone dialdehyde/kg meat) of breast meat stored at 4 ºC.*
Control: control group broiler fed with no spice – 3.5 % Izmir: broiler group fed with 3.5 % of Izmir oregano – 7 % Izmir: broiler group fed with 7.0 % of Izmir oregano – 3.5 % Mixed: broiler group fed with 3.5 of spice mix – 7 % Mixed: broiler group fed with 7.0 % of spice mix. (Spice mix: Izmir oregano, black thyme and summer savory the ratios of 1:1:1).

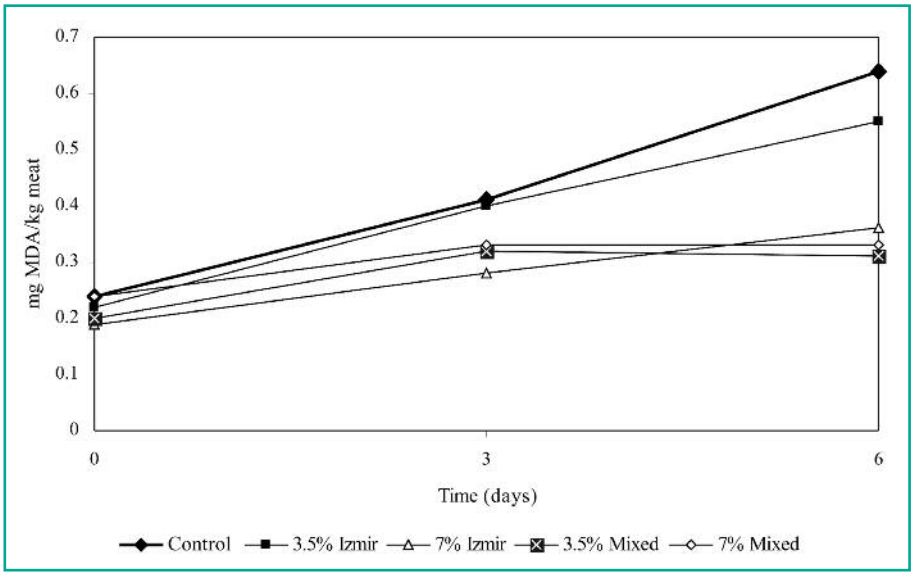

FIGURE 2: *Effect of spice-feeding treatment and storage time on the TBA values (mg malone dialdehyde/kg meat) of thigh meat stored at 4 ºC.*
Control: control group broiler fed with no spice – 3.5 % Izmir: broiler group fed with 3.5 % of Izmir oregano – 7 % Izmir: broiler group fed with 7.0 % of Izmir oregano – 3.5 % Mixed: broiler group fed with 3.5 of spice mix – 7 % Mixed: broiler group fed with 7.0 % of spice mix. (Spice mix: Izmir oregano, black thyme and summer savory the ratios of 1:1:1).

did not affect the color values of both breast and thigh meats, and the color values were affected by the dietary supplementation with the spice or their mix except for the L^* values (brightness) of breast meat. However, spice-feeding decreased ($P<0.05$) the L^* of the thigh meat. Similar result was obtained by Hernandez- Hernandez et al. (2009) who determined the lower L^* values in the pork batter treated with oregano extracts than that of the control.

On the other hand, the highest a^* and b^* values were observed in the broiler groups fed with 3.5 % or 7.0 % of Izmir oregano. This could have been due to the fact that among the spices studied was Izmir organo, the only spice species in which thymol was detected (Table 3). As well known, thymol is a very effective phenolic substance preventing oxidation. Oxidation decreases the redness, consequently a^* values. Accordingly, Kroll and Rawell (2001) reported that phenol acids oxidize to quinones that, in turn, react with lysine, cystein, methionin and tryptophan in the myoglobin molecule. This reaction promotes myoglobin polymerization, exposing the heme moiety. In this study, thymol containing Izmir oregano was an efficient antioxidant, preventing red heme-pigments undergoing oxidation to brown metmyoglobin. It was also reported that red color in meats is related to reduced iron (Fe^{+2}), resulting prevention of oxidation, and similar results were also reached by Hernandez- Hernandez et al. (2009) who observed more reddish pork batters with added ethanol dried oregano extracts. Higher a^* and b^* values in *longissimus thoracis* muscle from lambs fed with the oregano supplemented diet than those in the control muscle were also determined by Simitzis et al. (2008) who attributed the reason of this phenomena to dietary oregano essential oil supplementation modifying indirectly meat color, probably by decreasing myoglobin oxidation and activating mechanisms that modify pigment distribution in animal tissues. In general, our findings showed that feeding the broilers with thyme had a slight effect on the color of breast and thigh samples. Similarly, Manso et al. (2009) determined that feeding with vegetable oils didn't affect the color of lipid and muscle tissue of lamb.

Sensory analysis

The type of thyme variety and their concentration used in the diet didn't affect the sensorial attributes of samples (data not shown). In general thigh and breast samples were perceived similarly for the intensity of all flavor attributes. No significant differences ($P>0.05$) were observed on comparing the surface color, texture, crispness, flavor and odor, strange flavor and odor in cooked breast meat samples and odor in raw breast meat samples. Similarly feeding with the thyme did not have any difference on surface color, texture, crispness, juiciness, flavor and odor, strange flavor and odor in the cooked thigh meat samples and odor in raw thigh meat samples. Juiciness and surface color of the raw breast meat were affected by the thyme concentration while it had affected only the surface color of the raw thigh meat. Briefly, feeding the broilers with spice and storage time did not

TABLE 3: *Chemical components of the essential oils of Izmir oregano (Origanum onites), summer savory (Satureja hortensis) and black thyme (Thymbra spicata).*

Components	*O. onites* %	*S. hortensis* %	*T. spicata* %
Fenchone	–	–	1.20±0.28
Camphor	–	–	1.10±0.53
Bornylacetate	–	–	1.26±0.12
2-caren-4-ol	–	–	0.67±0.29
A-cadinal	–	–	0.16±0.06
Myrcene	0.47±0.01	2.27±0.08	–
A-Terpinene	0.61±0.08	2.88±0.01	–
Γ-Terpinene	2.61±0.02	21.98±0.02	12.75±0.22
ρ-Cymene	2.93±0.02	14.19±0.02	8.58±0.13
Linalool	11.85±0.10	–	–
B-Caryophyllene	0.96±0.08	1.44±0.03	5.01±0.11
Terpinen-4-ol	0.92±0.04	–	–
Thymol	9.34±0.17	–	–
Carvacrol	70.27±0.17	56.95±0.15	69.2±0.3

–: Not detected.

generally have a remarkable effect on the sensorial attributes of the samples except for the juiciness of the breast meat and the surface colors of the breast and thigh meats. In general, these results were in agreement with those of some researchers who did not find any effect of dietary supplementation on the flavor attributes of beefs (Miller et al., 1996; Wismer et al., 2008). In the current study, we should also note that in spite of our trained panel who determined statistically insignificant differences among the chicken meats, some people who consumed the spice fed chickens claimed that they found them different and/or better from their previous experiences with some commercial chickens. This type of speculations needed to be valued by some other related scientist believing the benefit of the spices.

TABLE 4: *Effect of spice-feeding treatment and storage time on the color values of breast and thigh meat samples stored at 4 °C.*

		Storage Time (day)	Control	3.5 % Izmir oregano	7 % Izmir oregano	3.5 % Mixed spices	7 % Mixed spices
Breast		0	53.15^{Aa}±1.79	53.47^{Aa}±0.06	53.77^{Aa}±0.86	52.17^{Aa}±0.86	50.53^{Aa}±3.80
	L*	3	51.04^{Aa}±0.41	51.59^{Aa}±6.82	52.20^{Aa}±7.63	51.15^{Aa}±0.43	51.76^{Aa}±1.06
		6	52.56^{Aa}±2.04	52.61^{Aa}±1.78	51.82^{Aa}±1.01	52.51^{Aa}±1.01	50.28^{Aa}±0.34
		0	4.29^{Ba}±0.46	7.15^{Aa}±0.56	4.86^{BAa}±0.51	4.71^{Ba}±0.59	4.92^{BAa}±1.86
	a*	3	4.70^{Ba}±0.17	7.41^{Aa}±1.71	4.44^{Ba}±0.16	4.39^{Ba}±0.79	4.47^{Ba}±1.15
		6	4.86^{BAa}±1.16	7.36^{Aa}±1.38	4.35^{Ba}±0.37	4.02^{Ba}±1.42	4.70^{BAa}±0.61
		0	11.14^{Ba}±0.08	13.16^{Aa}±1.28	11.01^{Ba}±0.09	9.30^{Ba}±1.01	9.68^{Ba}±0.25
	b*	3	10.01^{Ba}±0.04	13.27^{Aa}±1.81	10.90^{Ba}±0.32	10.18^{Ba}±025	9.79^{Ba}±0.79
		6	10.35^{Aa}±1.74	12.88^{Aa}±2.40	10.60^{Aa}±0.51	9.72^{Aa}±2.38	9.40^{Aa}±0.37
Thigh		0	56.66^{Aa}±3.00	51.38^{BAa}±2.38	53.82^{BAa}±1.92	50.22^{Ba}±2.32	50.45^{Ba}±0.12
	L*	3	55.78^{Aa}±0.19	50.81^{Ba}±0.26	53.77^{BAa}±3.13	49.70^{Ba}±2.51	51.10^{BAa}±1.30
		6	56.24^{Aa}±2.80	51.15^{BAa}±1.39	53.78^{BAa}±2.23	50.13^{Ba}±3.08	50.86^{Ba}±0.99
		0	7.86^{Aa}±0.46	7.52^{Aa}±0.55	8.10^{Aa}±0.60	6.28^{Aa}±1.35	5.76^{Aa}±1.32
	a*	3	7.73^{BAa}±0.20	7.61^{BAa}±0.63	8.35^{Aa}±0.36	6.35^{BCa}±0.26	5.98^{Ca}±1.18
		6	7.51^{BAa}±1.02	7.28^{BAa}±0.45	8.15^{Aa}±0.74	6.64^{BAa}±0.78	5.85^{Ba}±0.62
		0	11.90^{BAa}±0.77	13.06^{Aa}±0.22	12.10^{BAa}±1.39	9.32^{Ba}±1.91	10.75^{BAa}±1.11
	b*	3	12.34^{BAa}±1.04	12.62^{Aa}±0.70	11.99^{BAa}±1.64	9.21^{Ba}±1.02	10.90^{BAa}±1.52
		6	12.08^{BAa}±0.28	12.83^{Aa}±2.62	12.43^{BAa}±1.90	8.90^{Ba}±0.12	10.71^{BAa}±0.36

[AB] Means with different capital letters in the same row compare the spice concentration and variety and show significant differences at $P<0.05$. [ab] Means with lowercase on the same column compare the storage time and show significant differences at $P<0.05$.

Conclusions

It had been speculated that the dietary manipulation in the poultry breeding would improve the taste and flavor of their meats. Again, some researchers had noted that some herbal additives in feed rations could also improve the oxidative stability of the chickens. Considering the results of this study, the dietary supplementation of Izmir oregano or its combination with black thyme and summer savory appear to be an alternative to both synthetic additives and essential oils of these spices used for some quality parameters of chicken meats. Also, incorporation of these spices whether alone (Izmir oregano) or in mixed form influenced the meat quality characteristics positively, mainly by lowering the lipid level as well as retarding lipid oxidation in breast and thigh muscles. In conclusion, it can be stated that the spice-feeding of broiler type chickens resulted in better storage stability in the chicken samples with no indication of undesirable sensory properties. However, bland taste and flavor problems of the today's rapidly growing chickens, e. g. commercial broilers have still deserved attention of the related scientists.

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References

AOAC International. (1999): In Official Methods of Analysis of AOAC International. 16th edn. Gaithersburg, MD, USA: AOAC International.

Babu PS, Srinivasan K (1997): Influence of dietary capsaicin and onion on the metabolic abnormalities associated with streptozotocin induced diabetes mellitus. Molecular and Cellular Biochemistry 175, 49–57.

Bayram E (2003): *Kekik yetistiriciligi.* Tarımsal Uygulama ve Arastırma Merkezi Yayın Bulteni: 42, Ege Universitesi, Izmir.

Bhat BG, Srinivasan MR, Chandrasekhara N (1984): Influence of curcumin and capsaicin on bile secretion and composition in the rat. Journal of Food Science and Technology 21, 225–227.

Bolukbasi SC, Erhan MK, Ozkan A (2006): Effect of dietary thyme oil and vitamin E on growth, lipid oxidation, meat fatty acid composition and serum lipoproteins of broilers. South African Journal of Animal Science 36, 189–196.

Botsoglou NA, Christaki E, Fletouris DJ, Florou-Paneri P, Spais AB (2002): The effect of dietary oregano essential oil on lipid oxidation in raw and cooked chikken during refrigerated storage. Meat Science 62, 259–265.

Botsoglou NA, Grigoropoulou SH, Botsoglou E, Govaris A, Papageorgiou G (2003): The effect of dietary oregano essential oil and α-tocopheryl acetate on lipid oxidation in raw and cooked turkey during refrigerated storage. Meat Science 65, 1193–1200.

Bozkurt H (2006): Utilization of natural antioxidants: Green tea extract and *Thymbra spicata* oil in Turksh dry-fermented sausage. Meat Science 73, 442–450.

El-Ghousein SS, Al-Beitawi NA (2009): The Effect of Feeding of Crushed Thyme (*Thymus vulgaris* L.) on Growth, Blood Constituents, Gastrointestinal Tract and Carcass Characteristics of Broiler Chickens. Journal of Poultry Science 46, 100–104.

Fernandez-Lopez J, Zhi N, Aleson-Carbonell L, Perez-Alvarez JAV, Kuri (2005): Antioxidant and antibacterial activities of natural extracts: application in beef meatballs. Meat Science 69, 371–380.

Giannenas IA, Florou-Paneri P, Botsoglou NA, Christaki E, Spais AB (2005): Effect of supplementing feed with oregano and/or α-tocopheryl acetate on growth of broiler chickens and oxidative stability of meat. Journal of Animal and Feed Sciences 14, 521–535.

Govaris A, Florou-Paneri P, Botsoglou E, Giannenas I, Amvrosiadis I, Botsoglou N (2007): The inhibitory potential of feed supplementation with rosemary and/or α-tocopheryl acetate on microbial growth and lipid oxidation of turkey breast during refrigerated storage. LWT – Food Science and Technology 40, 331–337.

Hernandez-Hernandez E, Ponce-Alquicira E, Jaramillo-Flores ME, Guerrero Legarreta I (2009): Antioxidant effect rosemary (*Rosmarinus officinalis* L.) and oregano (*Origanum vulgare* L.) extracts on TBARS and colour of model raw pork batters. Meat Science 81, 410–417.

Hunt MC, Acton JC, Benedict RC, Calkins CR, Cornforth DP, Jeremiah LE (1991): Guidelines for meat color evaluation. Chicago, American Meat Science Association and National Live Stock and Meat Board, USA.

Kempaiah RK, Srinivasan K (2006): Beneficial influence of dietary curcumin, capsaicin and garlic on erythrocyte integrity in high fat fed rats. The Journal of Nutritional Biochemistry 17, 471–478.

Kroll J, Rawel HM (2001): Reactions of plant phenols with myoglobin: Influence of chemical structure of the phenol compounds. Journal of Food Science 66, 48–58.

Lauridsen C, Buckley DJ, Morrissey PA (1997): Influence of dietary fat and vitamin E supplementation on alpha-tocopherol levels and fatty acid profiles in chicken muscle membranal fractions and on susceptibility to lipid peroxidation. Meat Science 46, 9–22.

Lopez-Bote CJ, Gray JI, Gomaa EA, Flegal CJ (1998): Effect of dietary administration of oil extracts from rosemary and sage on lipid oxidation in broiler meat. British Poultry Science 39, 235–240.

Manso T, Bodas R, Castro T, Mantecon AR (2009): Animal performance and fatty acid composition of lambs fed with different vege+ oils. Meat Science 83 (3), 511–516.

Miller RK, Rockwell LC, Lunt DK, Carstens GE (1996): Determination of the flavor attributes of cooked beef from cross-bred Angus steers fed corn-or barley based diets. Meat Science 44, 235–243.

Mitsumoto M, O'grady MN, Kerry JP, Buckley DJ (2005): Addition of tea catechins and vitamin C on sensory evaluation, colour and lipid stability during chilled storage in cooked or raw beef and chicken patties. Meat Science 69, 773–779.

Nam KT, Lee HA, Min BS, Kang CW (1997): Influence of dietary supplementation with linseed and vitamin E on fatty acids, α-tocopherol and lipid peroxidation in muscles of broiler chicks. Animal Feed Science and Technology 66, 149–158.

Ozkan, G, Sagdic O, Ozcan M (2003): Inhibition of pathogenic bacteria by essential oils at different concentrations. Food Science and Technology International 9, 85–88.

Platel K, Srinivasan K (2000): Influence of dietary spices or their active principles on pancreatic digestive enzymes in albino rats. Nahrung 44, 42–46.

Platel K, Alkananda R, Saraswathi G, Srinivasan K (2002): Digestive stimulant action of three Indian spice mixes in experimental rats. Nahrung 46, 394–398.

Rey AI, Hopia A, Kivikari R, Kahkonen M (2005): Use of natural food/plant extracts: cloudberry *(Rubus chamaemorus),* beetroot (*Beta vulgaris* "Vulgaris") or willow herb *(Epilobium angustifolium)* to reduce lipid oxidation of cooked pork patties. LWT-Food Science and Technology 38, 363–370.

Richardson RI, Mead GC (1999): Poultry meat science: Poultry science symp., No. 25, pp: 456. New York, USA, CABI Publ.

Sagdic O, Ozkan G, Aksoy A, Yetim H (2009): Bioactivities of essential oil and extract of *Thymus argaeus* Turkish endemic wild thyme. Journal of the Science of Food and Agriculture 89, 791–795.

Sagdic O (2003): Sensitivity of four pathogenic bacteria to Turkish thyme and oregano hydrosols. LWT-Food Science and Technology 36, 467–473.

Sagun E, Durmaz H, Tarakci Z, Sagdic O (2006): Antibacterial activities of the extracts of some herbs used in Turkish herby cheese against *Listeria monocytogenes* serovars. International Journal of Food Properties 9, 255–260.

Sallam KhI, Ishioroshi M, Samejima K (2004): Antioxidant and antimicrobial effects of garlic in chicken sausage. LWT-Food Science and Technology 37, 849–855.

SAS (1988): SAS/STAT User's guide (6.03); SAS Institute, Inc.: Cary, New York.

Simitzis PE, Deligeorgis SG, Bizelis JA, Dardamani A, Theodosiou I, Fegeros K (2008): Effect of dietary oregano oil supplementation on lamb meat characteristics. Meat Science 79, 217–223.

Srinivasan K, Sambaiah K, Chandrasekhara N (2004): Spices as beneficial hypo-cholesterolemic food adjuncts: a review. Food Reviews International 20, 187–220.

Srinivasan K (2005a): Spices as influencers of body metabolism: an overview of three decades of research. Food Reviews International 38, 77–86.

Srinivasan K (2005b): Role of spices beyond food flavoring: nutraceuticals with multiple health effects. Food Reviews International 21, 167–188.

Tang SZ, Kerry JP, Sheehan D, Buckley DJ, Morrissey PA (2001): Antioxidative effect of dietary tea catechins on lipid oxidation of long-term frozen stored chicken meat. Meat Science 57, 331–336.

Ulu H (2004): Evaluation of three 2-thiobarbuturic acid methods for the measurement of lipid oxidation in various meats and meat products. Meat Science 67, 683–687.

Wismer WV, Okine EK, Stein A, Seibel MR, Goonewardene LA (2008): Physical and sensory characterization and consumer preference of corn and barley-fed beef. Meat Science 80, 857–863.

Yanishlieva NV, Marinova EM, Gordon MH, Raneva VG (1999): Antioxidant activity and mechanism of action of thymol and carvacrol in two lipid systems. Food Chemistry 64, 59–66.

Yanishlieva-Maslarova NV (2001): Inhibiting oxidation. (edited by J. Pokorny, N. Yanishlieva, M. Gordon), in Antioxidants in Food-Practical Applications. pp. 22–70. Cambridge, England, Woodhead Publishing Limited, CRC Press.

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