The use of thyme and orange essential oils blend to improve quality traits of marinated chicken meat

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ABSTRACT Poultry meat contains large quantities of polyunsaturated fatty acids, which lead to oxidative deterioration. Plant essential oils (EO) and natural compounds, with antioxidant properties, may be used to alleviate this problem. Two replications were conducted to evaluate the effects of a mixture (1:1) of thyme and orange oils (EO) on the quality characteristics and the oxidative stability of chicken meat (breast and wing). For each replication, 24 fresh breast fillets and 24 wings were procured from a local grocery store. The EO were added to marinade solution to achieve a final concentration of 0.55% sodium chloride, 0.28% polyphosphate, and 0.05% wt/vol of EO blend. Breasts and wings were split in 2 different groups with homogenous pH and lightness and vacuum tumbled in 2 treatments, a 0.5% EO and a control (CON, no EO). Each group was tested for pH, Commission Internationale d'Eclairage color (lightness, L*; redness, a*; yellowness, b*), moisture content, marinade uptake, purge loss, cook yield, and shear force. Susceptibility to lipid oxidation was determined on fresh and frozen meat by TBA reactive substance analysis (induced oxidation from 0 to 150 min at 37°C). The EO breasts had lower purge loss compared with CON meat. Breast did not show any color, pH, marinade uptake, cooking yield, shear force, or moisture differences due to treatment, although cooked EO breast was slightly less red than CON. The EO wings presented higher a* and b* values after marination and lower purge loss and shear force than CON. No differences were detected on wings for color, pH, marinade uptake, cooking yield, or moisture between EO and CON wings. Both fresh and frozen EO breasts and EO wings were less susceptible to the lipid oxidation during all induced oxidation times compared with CON breasts and wings. In conclusion, EO had a positive effect on broiler breast and wing lipid oxidation without negatively affecting meat quality traits.

Key words: broiler, chicken meat, essential oil, meat quality, lipid oxidation

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INTRODUCTION

Appearance, aroma, and taste characteristics are the most important terms that define consumer acceptability of food. The increasingly high demand for convenient foods caused a rapid growth in the production of ready-to-eat food category. Those products are very susceptible to oxidative quality deterioration, especially under stress (high temperature and exposure to light and metal during storage) because they are usually made with ingredients containing unsaturated fatty acids (Brewer, 2011). Lipid oxidation is the main cause of food spoilage due to rancidity and organoleptic deterioration.

The use of antioxidants in common ingredients has been shown to reduce oxidation. The interest in spices and aromatic herbs has recently increased because of their ability to prevent oxidation and microbiological spoilage of food, possibly better than many currently used synthetic antioxidants. These properties depend on many substances (including vitamins, flavonoids, terpenoids, arotenoids, phytoestrogens, and minerals) and on their natural antioxidant compound content (Suhaj, 2004). Consumers prefer products labeled without artificial ingredients (Brewer, 2011), with organic or natural food ingredients and additives with familiar names perceived to have healthy properties (Joppen, 2006). Food companies are adapting their production to address consumer demands regarding sustainable sources of meat and ingredients and respect for the environment (Berger, 2009).

Meat containing unsaturated fatty acids is very sensitive to lipid oxidation especially during storage, because polyunsaturated fatty acid esters are easily oxidized by molecular oxygen. This kind of oxidation is called autoxidation and proceeds by a free radical chain mechanism (Brewer, 2011). Free radical scaven-

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gers have been used to terminate the chain reaction. Poultry meat is particularly sensitive to oxidative deterioration due to its high content of polyunsaturated fatty acids (Barroeta, 2007). Oxidative rancidity is the most important cause of raw and cooked meat quality deterioration during refrigerated and frozen storage (Cavani et al., 2009).

Thyme and orange essential oils (**EO**) are potential natural antioxidants that could be applied to poultry meat. *Thymus vulgaris*, *Thymus mastichina*, *Thymus caespititius*, and *Thymus camphorate* all have very high antioxidative activities like α-tocopherol and BHT (Miguel et al., 2004). Thyme EO presents very high free radical-scavenging ability and contrasts lipid oxidation induced by both Fe^{2+}/ascorbate and Fe^{2+}/H_2O_2 (Bozin et al., 2006). Youdim et al. (2002) reported that EO antioxidant activity ranks as follows: thyme oil, thymol, carvacrol, γ-terpinene, myrcene, linalool, p-cymene, limonene, 1,8-cineole, and α-pinene. However, although thymol is the most effective antioxidative EO component, the aromatic nature of its thyme extract aroma compounds would likely give unwanted flavors to foods (Brewer, 2011).

Isolated functional compounds (fiber and polyphenols) derived from citrus byproducts interest the food industry because they retard oxidative changes in food and promote increased quality and nutritional values (Fernandez-Lopez et al., 2007). Hundreds of compounds form the mixture of citrus oils, and these can be classified into 3 fractions: terpene hydrocarbons, oxygenated compounds, and nonvolatile compounds. In general plants with high level of polyphenols are important natural antioxidants. Citrus peels and seeds contain high levels of phenolic compounds, in particular phenolic acids and flavonoids (Yusof et al., 1990).

Meat marination is used by the poultry processing industry and by restaurants to improve meat quality traits, such as functional characteristics (tenderness and juiciness), and add flavor ingredients. Boneless skinless chicken breasts in the United States are typically vacuum tumbled because the mechanical tumbling action promotes marinade uptake and improves the meat quality (flavor, juiciness, tenderness, and cooking yield), resulting in both improved quality and economic benefit (Smith and Acton, 2001).

Therefore, the objective of this study was to evaluate the effect of thyme and orange EO blend (1:1) on broiler meat quality characteristics. Additionally, the effect of the blend on the oxidative stability of lipids in raw and frozen meat stored at −18°C for 12 and 90 d was determined.

MATERIALS AND METHODS

Materials and Treatments

A mixture (1:1) of thyme and orange EO was applied to boneless skinless chicken breasts (from 120 to 275 g) and whole wings (from 75 to 110 g) in 2 replicate trials to determine effect on quality traits and susceptibility to lipid oxidation.

For each replication, a total of 24 chicken breast and 24 whole wings were obtained from a local grocery store. Breasts and wings were bought fresh and nonmarinated, and with the same use-by date (3–4 d postmortem). They were separated into 2 experimental groups (for each replication 12 samples/group) to achieve homogeneous average pH values and lightness (L*). Breasts and wings were vacuum tumbled with marinade (solution/meat ratio 10%) to test the effect of the EO blend: control group (**CON**) was marinated with a solution containing 6% of sodium chloride and 3% of a commercial blend of polyphosphates; EO group was marinated with the same solution used for the control group with the addition of the EO mixture (1:1) of thyme and orange to obtain a final concentration of 0.5% (vol/vol) in the marinade solution. Final concentration on meat was of 0.55% sodium chloride and 0.28% polyphosphate for CON group and 0.55% sodium chloride, 0.28% polyphosphate, and 0.05% wt/vol EO blend for EO group. The phosphate mixture used during marination was BRIFISOL 512 (BK Giulini Corporation, Simi Valley, CA). For both replications the marinade temperature ranged from 3.7 to 10.8°C and marinade pH ranged from 7.06 to 7.28.

Per typical industry practice, marinade pH was not adjusted. Breasts and wings were separately mixed with marinade and were vacuum (78 kPa) tumbled with a lab-scale tumbler (model MC-25, Inject Star of Americas Inc., Brookfield, CT) at 20 rpm for 20 min at room temperature. Following marination, samples were analyzed for pH, color (L*, a*, b*), moisture absorption (marinade uptake), purge loss, cooking yield, and moisture content. The pH, color, and moisture content were measured in both raw and cooked meat. After cooking, shear force (Warner-Bratzler, **WB**) was assessed.

From each marinated sample (breast and wing), an aliquot of meat was taken and used to determine the susceptibility to lipid oxidation (TBA reactive substances; **TBARS**) on marinated meat. The remaining part of the aliquot was individually packed in plastic bags and frozen at −18°C until TBARS determination on frozen meat (12 and 90 d of storage).

Analytical Methods

Color Measurement. The CIE (1978) color profile (L*, a*, b*) was measured with a reflectance colorimeter (Chroma Meter model CR-400, Konica Minolta Corp., Ramsey, NJ) with C illuminant source. Colorimeter was calibrated using a standard white (Y = 93.9, x = 0.3130, and y = 0.3190) ceramic tile. Breast fillet (pectoralis major) color was determined on the cranial, medial surface (bone side) in an area without obvious color defects, including discolorations, hematomas, blood spots, bruises, or any other condition that could affect the reading (Petracci and Baéza, 2011). Wing color was measured on the thicker portion of the skin, where the axial feathers were fixed.

pH Measurement. The Jeacocke (1977) modified procedure of iodoacetate method was used to determine pH on raw, marinated, and cooked chicken meat (breast and wing). Approximately 2.5 g of meat was collected from each breast and from each middle portion of the whole wing, manually minced, and homogenized for 30 s in 25 mL of iodoacetate (5 m*M*) and potassium chloride (150 m*M*) solution. The pH of the homogenate was determined using a pH meter (Fisher Scientific Accumet Portable AP10 equipped with electrode Accumet 13–620–299 SN7254039P, Thermo Fisher Scientific Inc., Waltham, MA) calibrated at pH 4.0 and 7.0.

Marinade Uptake. The calculation of marinade uptake was based on the difference between raw and marinated sample weight for both breast fillets and whole wings. Marinade uptake was presented in percentage (grams absorbed/100 g of muscle).

Purge Loss. Breast fillets and whole wings, after weighing for marinade uptake, were also used to determine purge loss. Samples were placed on a plastic grid inside a stainless steel tray, covered with stainless steel top, and stored under refrigeration (2 to 3°C) for 24 h. Samples were reweighed, and the calculation of purge loss was based on the difference between the sample's weight 24 h postmarination and the weight of marinated samples. Purge loss was expressed in percentage (grams lost/100 g of muscle).

Cooking Yield. Marinated breast fillets, after purge loss determination, were cut to obtain a parallelepiped sample (8.5 × 5.5 × 2.5 cm). The tip or lower third of the marinated wings was removed and the remaining portion (drummette and flat) was used to determine cooking yield. After recording the weights, samples were placed in plastic cooking bags, vacuum sealed, and cooked in a water bath at 85°C to achieve 80°C at the sample core. Cooking yield was expressed in percentage of cooked weight divided by raw weight. Calculations for percentage marinade uptake, percentage purge loss after 24 h, and percentage cook yield were as follows: % marinade uptake = (marinated weight − raw weight)/raw weight × 100; % purge loss = (marinated weight − 24 h marinated weight)/marinated weight × 100; and % cook yield = cooked weight/raw weight × 100.

Shear Force. Cooked breasts and wing were respectively cut in 2 × 2 × 5 cm and in 1.5 × 1.5 × 5 parallelepiped samples. Wing samples were obtained by removing forearm muscles located over radius bone (extensor metacarpi radials, superficial pronator, and major long digital flexor muscles). Then samples were sheared in a perpendicular direction respective to muscle fibers using a triangular blade slot attached to the Warner-Bratzler shear machine (G-R Electrical Mfg. Co., Manhattan, KS) for the determination of the kilograms of peak force necessary to cut the samples.

Moisture. Moisture analysis was carried out on raw, marinated, and cooked breast and wings. The percentage of moisture was determined according to the Association of Official Analytical Chemists (AOAC, 1990) procedure.

TBARS Analysis. The susceptibility of iron-induced lipid oxidation of muscle tissue homogenates was determined (Kornbrust and Mavis, 1980). The TBARS were measured on the homogenates incubated at 37°C and tested at fixed time intervals (0, 30, 60, 90, and 150 min). Meat protein content was determined using the Lowry procedure (Lowry et al., 1951). The TBARS was expressed as nanomoles of malonaldehyde (**MDA**) per milligram of protein. The TBARS analysis was tested on fresh and frozen (stored for 12 and 90 d, respectively) breast and wings.

Statistical Analysis

The results were analyzed by using 2-way ANOVA option of the GLM procedure of SAS software (GLM, SAS software, SAS Institute Inc., 2000). The model tested the main effects of marination treatment solution (CON and EO), replication, and the interaction term; no significant interactions were observed. A significance level of $P > 0.05$ was used for the analysis.

RESULTS AND DISCUSSION

The effects of thyme and orange EO blend on breast and wing quality traits are reported in Tables 1 and 2, respectively. Before marination, EO samples of breast showed no difference in lightness (L*) compared with CON samples, which indicated there is no effect on marination due to inherent meat differences (no dark, firm, and dry or pale, soft, and exudative-like meat was used). Moreover, after marination, there were also no differences in EO or CON groups (lightness, L*; redness, a*; yellowness, b*), with the exception of lower redness values for cooked meat (2.18 vs. 2.64, respectively). However, before marination, skin color of EO wings was significantly more red (2.85 vs. 2.27). After marination, wings were not significantly different for lightness, but significantly more red (3.69 vs. 2.50) and more yellow (11.95 vs. 9.41). The redness values could have been influenced by the color before marination. Yellowness values could have been influenced slightly by the color of the added EO. Cooked EO wings did not show differences in color, either in EO or CON samples.

Meat pH values before vacuum marination were the same for both EO and CON samples (breast and wing). The importance of these results is to report that the meat from both groups had the same inherent characteristics before marination; thus, the postmarination results were not affected. Moreover, marinated and cooked EO meat (breast and wing) did not show any difference compared with the control.

Poultry meat color and pH were determined in this study because these parameters significantly affect the performance of marinade and water holding capacity (Petracci et al., 2004; Barbut et al., 2005). Little infor-

Table 1. Quality traits of broiler breast (pectoralis major) marinated without (CON) or with essential oils (EO; n = 24/group)

	CON		EO		
Trait	Mean	SEM	Mean	SEM	*P*-value
Color[1]					
Raw meat					
L*	54.68	0.49	54.48	0.56	NS
a*	1.78	0.22	1.88	0.24	NS
b*	11.96	0.57	13.19	0.43	NS
Marinated meat					
L*	50.61	0.41	50.57	0.45	NS
a*	1.80	0.18	1.79	0.16	NS
b*	11.00	0.41	11.97	0.36	NS
Cooked meat					
L*	79.25	0.27	79.35	0.28	NS
a*	2.64	0.12	2.18	0.13	**
b*	17.04	0.43	17.29	0.30	NS
pH					
Raw meat	5.92	0.02	5.92	0.02	NS
Marinated meat	6.26	0.02	6.24	0.04	NS
Cooked meat	6.27	0.01	6.30	0.02	NS
Marinade uptake (%)	8.71	0.53	8.42	0.47	NS
Purge loss (%)	1.29	0.09	0.85	0.05	***
Cooking yield (%)	78.15	0.54	76.64	0.63	NS
Shear force (kg)	1.43	0.06	1.57	0.06	NS
Moisture (%)					
Raw meat	75.44	0.40	75.42	0.28	NS
Marinated meat	77.10	0.36	76.81	0.35	NS
Cooked meat	70.56	0.23	70.80	0.25	NS

[1]L*, Lightness; a*, redness; b*, yellowness.

**$P \leq 0.01$; ***$P \leq 0.001$.

mation was available regarding EO and natural antioxidants applied to chicken meat via marinade in regard to quality characteristics and lipid oxidation. However, results from this study showed partial agreement with several previous experiments that used EO and natural antioxidants on different kinds of meat and meat prod-

Table 2. Quality traits of broiler wings marinated without (CON) or with essential oils (EO; n = 24/group)

	CON		EO		
Trait	Mean	SEM	Mean	SEM	*P*-value
Color[1]					
Raw wing skin					
L*	74.71	0.31	74.57	0.27	NS
a*	2.27	0.41	2.85	0.57	*
b*	9.61	0.63	10.15	0.35	NS
Marinated wing skin					
L*	74.25	0.27	75.00	0.35	NS
a*	2.50	0.43	3.69	0.61	***
b*	9.41	0.67	11.95	0.50	***
Cooked wing skin					
L*	66.05	0.51	67.26	0.38	NS
a*	1.09	0.39	0.80	0.47	NS
b*	26.25	0.89	25.28	0.82	NS
pH					
Raw meat	6.45	0.02	6.45	0.02	NS
Marinated meat	6.68	0.03	6.69	0.02	NS
Cooked meat	6.66	0.01	6.68	0.01	NS
Marinade uptake (%)	7.48	0.21	7.74	0.40	NS
Purge loss (%)	4.57	0.31	2.45	0.10	***
Cooking yield (%)	94.05	0.27	93.50	0.16	NS
Shear force (kg)	2.94	0.24	2.42	0.21	*
Moisture (%)					
Raw meat	74.70	0.42	74.49	0.44	NS
Marinated meat	77.26	0.39	77.05	0.52	NS
Cooked meat	75.14	0.46	75.10	0.28	NS

[1]L*, Lightness; a*, redness; b*, yellowness.

*$P \leq 0.05$; ***$P \leq 0.001$.

Table 3. Susceptibility to lipid oxidation (determined by TBA reactive substance analysis and expressed in nmol of malonaldehyde per mg of protein) of fresh and frozen broiler breast (pectoralis major) marinated without (CON) or with essential oils (EO; n = 24/group)

	CON		EO		
Time (min)	Mean	SEM	Mean	SEM	*P*-value
Raw meat					
0	0.380	0.038	0.279	0.014	**
30	0.542	0.064	0.286	0.017	***
60	0.743	0.070	0.377	0.025	***
90	0.933	0.078	0.414	0.035	***
120	1.056	0.079	0.482	0.045	***
150	1.204	0.082	0.587	0.072	***
Frozen meat stored for 12 d					
0	0.379	0.019	0.230	0.012	***
30	0.617	0.038	0.306	0.014	***
60	0.831	0.048	0.399	0.021	***
90	1.034	0.053	0.477	0.026	***
120	1.185	0.056	0.590	0.047	***
150	1.373	0.074	0.688	0.057	***
Frozen meat stored for 90 d					
0	0.604	0.057	0.304	0.014	***
30	1.110	0.124	0.413	0.020	***
60	1.451	0.141	0.508	0.019	***
90	1.675	0.157	0.607	0.020	***
120	1.841	0.154	0.695	0.028	***
150	2.013	0.145	0.792	0.034	***

**$P \leq 0.01$; ***$P \leq 0.001$.

ucts. A study on bologna sausages did not show any pH or color differences between meat formulas with or without citrus waste water, EO, or both (Viuda-Martos et al., 2009). Mohamed and Mansour (2012) did not find significant changes on beef patty formula pH values when natural herbal extracts were added. Other research found that pH of turkey thighs treated with aqueous extract of rosemary, sage, and thyme was not affected by the marinade (Mielnik et al., 2008).

The cooking yield and the quantity of marinade solution absorbed by the meat during the marinating process (marinade uptake) were not affected by treatment. The EO breasts and EO wings showed significantly lower purge loss values compared with CON breast and wing samples (0.85 vs. 1.29%, and 2.45 vs. 4.57%, respectively). Mielnik et al. (2008) demonstrated adding aqueous extracts of rosemary, sage, and thyme to marinated turkey thighs that resulted in no difference

Table 4. Susceptibility to lipid oxidation (determined by TBA reactive substance analysis and expressed in nmol of malonaldehyde per mg of protein) of fresh and frozen broiler wings marinated without (CON) or with essential oils (EO; n = 24/group)

	CON		EO		
Time (min)	Mean	SEM	Mean	SEM	*P*-value
Raw meat					
0	0.320	0.025	0.236	0.012	***
30	0.428	0.038	0.272	0.013	***
60	0.532	0.049	0.311	0.014	***
90	0.593	0.060	0.351	0.020	***
120	0.685	0.072	0.390	0.021	***
150	0.778	0.080	0.453	0.034	***
Frozen meat stored for 12 d					
0	0.501	0.060	0.240	0.011	***
30	0.757	0.126	0.301	0.012	***
60	0.930	0.154	0.356	0.021	***
90	1.086	0.171	0.401	0.028	***
120	1.173	0.188	0.459	0.038	***
150	1.242	0.185	0.500	0.048	***
Frozen meat stored for 90 d					
0	0.495	0.059	0.278	0.025	***
30	0.874	0.135	0.523	0.067	***
60	1.060	0.154	0.642	0.085	***
90	1.244	0.170	0.744	0.102	***
120	1.377	0.185	0.842	0.121	***
150	1.494	0.197	0.870	0.121	***

***$P \leq 0.001$.

in purge loss or cooking loss. A different type of experiment was conducted to feed broilers with a combination of oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), and cinnamon (*Cinnamomum* sp.); meat from the treated birds showed no difference purge loss compared with the control meat (Bobko et al.,2012). The different results for purge and cooking loss obtained in the current experiment were likely due to species (chicken vs. turkey) and EO application (feeding vs. marination) differences from the prior studies.

The WB shear force values from EO breast were not different from CON samples (Table 1). However EO wings as shown in Table 2 were more tender than CON wings (2.4 vs. 2.9 kg, respectively). Both the breast and wing samples WB values in this study were lower than the WB shear value of 3.6 kg, which has been reported as the upper limit for very tender meat (Lyon and Lyon, 1991). Wing samples have not typically been subjected to WB shear, so no research was found to directly compare these findings to prior research. Somewhat different meat products have been evaluated for the effect of EO on objective texture. Viuda-Martos et al. (2009) found that EO did not affect bologna sausage texture. Another study showed no differences in juiciness or firmness of beef burger formulas made with antioxidants (Mohamed and Mansour (2012). A direct comparison of these results to the present study was not possible due to differences in animal species and product form (whole muscle vs. ground meat).

The moisture content of the unmarinated, marinated, and cooked EO meat (breast and wing) was not different compared with the control (Tables 1 and 2). These result agree with earlier studies that showed no significant difference of moisture content on beef and mechanically deboned poultry meat patties (Mohamed and Mansour, 2012). However, Viuda-Martos et al. (2009) observed lower moisture content of sausage formulas treated with citrus waste water, thyme, and oregano EO compared with the control, but this result could had been caused by some soluble solids dissolved in the citrus waste water.

The susceptibility to lipid oxidation on both breast and wings (fresh or frozen for 12 or 90 d at −18°C) between EO and CON samples is shown in Tables 3 and 4, respectively. Samples marinated with EO presented lower lipid oxidation susceptibility compared with the control during all the induced oxidation time intervals. The results indicate that fresh and 12 d frozen breast showed lower values of TBARS than the 90 d frozen breast, as would be expected. Also, the TBARS values observed in the present study were much lower than levels reported as the threshold for acceptability of rancidity in beef and lamb, 1.0 and 2.28 mg of MDA/kg of sample, respectively (Ripoll et al., 2011; Campo et al., 2006). The values remain lower even though the values in this study were presented as nanomoles of MDA per milligram of protein.

Previous studies have shown adding antioxidants to various meats, including turkey, beef, pork, and fish, reduced oxidation (Formanek et al., 2001; Tang et al., 2001; Mielnik et al., 2003; Nam and Ahn, 2003; Mielnik et al., 2008). Other natural additives with antioxidant activity also reduced oxidation in lamb and ground beef (McKenna et al., 2003; Mohamed et al., 2011). Various EO have been used to reduce oxidations and TBARS values in bologna and beef patties with or without mechanically deboned poultry meat (Viuda-Martos et al., 2009; Mohamed and Mansour, 2012). The rate of peroxidation on chicken meat stored for 3 wk at 4°C was decreased by the use of balm and thyme EO (Fratianni et al., 2010).

In conclusion, TBARS analysis showed that fresh and frozen meat (12 and 90 d) marinated with thyme and orange EO blend presented lower lipid susceptibility to oxidation on both breast and wing samples. Results also showed that EO did not affect color, pH, marinade uptake, cook yield, or moisture content. Overall, the mixture of thyme and orange EO produced a protective effect against lipid oxidation without negatively affecting meat quality characteristics. Future research is necessary to study the sensorial properties of poultry meat marinated with thyme and orange EO.

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