The effect of oregano oil and tannic acid combinations on the quality and sensory characteristics of cooked chicken meat

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Summary and Implications

The antioxidant effect of oregano essential oil and tannic acid combinations on the ground chicken breast and thigh meats were studied. Six treatments were prepared. Cooked meat samples were individually vacuum-packaged in oxygen-impermeable vacuum bags and then cooked in-bag to an internal temperature of 75 ℃ and were analyzed for lipid and protein oxidation, color, and volatiles at 0, 3, and 7 days of storage. The significant differences among the treatments were very clear in cooked meat samples. Thigh meat patties showed higher TBARS, total carbonyl, and volatiles values compared to the breast meat during storage. The combination of 200 ppm oregano oil and 10 ppm tannic acid showed the most significant effects ($P < 0.05$) on TBARS, total carbonyl, and off odor volatile formation for both breast and thigh meat. Oregano oil (200 ppm) and 10 ppm tannic acid combination also showed positive effects on the sensory scores of chicken thigh meat. In conclusion, the combination of 200 ppm oregano oil and 10 ppm tannic acid could be a good natural replacement for the synthetic antioxidants in the ground chicken meat.

Introduction

Oregano essential oil and tannins are extracted from plants and have strong antioxidant properties. The antioxidant effect of oregano essential oil is due to its high polyphenol content such as carvacrol, and thymol. Tannins are the secondary poly-phenol compounds produced by plants to protect themselves from external herbivores and diseases. These compounds have biological, metal ion chelating, antioxidant, and protein precipitating activities. In addition, tannins showed positive effect on meat color stability due to their chemical structures which have two or three phenolic hydroxyl groups on phenyl ring. Using one type of natural antioxidant to replace synthetic antioxidant is not enough as many researchers have reported. Therefore, a combination of antioxidants with different antioxidant mechanisms should be considered to increase their effectiveness. Several studies found positive effect of using oregano oil and tannic acid in meat preservation. The objectives of this study were: 1) to evaluate combination effect of tannic acid and oregano oil on the quality and storage stability of cooked ground chicken thigh or breast meat, and 2) to select the best tannic acid-oregano oil combinations to control lipid oxidation, protein oxidation, and off-odor of cooked ground chicken meat.

Material and Methods

The breast and thigh muscles of broilers were separated and ground twice a through a 10-mm and a 3-mm plates before use. Six different treatments including 1) (none added), 2) 100 ppm Oregano essential oil + 5 Tannic acid, 3) 100 Oregano essential oil + 10 Tannic acid, 4) 200 ppm Oregano essential oil + 5 Tannic acid, 5) 200 Oregano essential oil + 10 tannic acid and 6) 5 ppm butylatedhydroxy anisole (BHA) for breast or 14 ppm for thigh meat (based on fat content) were prepared. The raw meat samples were packaged in oxygen impermeable vacuum bags (O_2 permeability, 9.3 mL O_2/m^2/24 h at 0 °C), and the meats were cooked in-bag in a 90 ℃ water bath until the internal temperature of the meat reached to 75 ℃. After cooling, the cooked meat was transferred to a new oxygen-permeable bag (polyethylene, 4 x 6.2 mil), and stored at 4 ℃ for up to 7 days, and analyzed for lipid and protein oxidation and volatiles at 0, 3, and 7 days of storage. Lipid oxidation was determined using a TBARS method. Volatiles were analyzed using a Solatek 72 Multimatrix-Vial Auto-sampler/Sample Concentrator 3100 connected to a GC/MS. Protein oxidation was determined by the 2,4-dinitrophenylhydrazine method and sensory characteristics were evaluated using trained sensory panels.

Statistical analysis

Data were analyzed using the procedures of Generalized Linear Model. Mean values and standard error of the means (SEM) were reported. The significance was defined at $P < 0.05$ and Tukey test or Tukey's Multiple Range test were used. Pearson correlation coefficient was used to determine the relation between TBARS, total carbonyl, and hexanal.

Results and Discussion

Lipid Oxidation: TBARS values of all treatments were significantly lower than that of the control ($p < 0.05$) at day 3 and 7. The highest combination effect was found when 200 ppm oregano oil and 10 ppm of tannic acid was used (Table 1). Cooked meat is more susceptible to lipid oxidation than raw meat because of the denaturation of antioxidant enzymes and the structural damages in membrane, which can expose phospholipids to pro-oxidant environment in cooked meat. The TBARS values of cooked ground thigh meat were higher than the cooked breast meat but the antioxidant effects were very similar in both breast and thigh meat. The higher TBARS values of thigh meat than breast are due to the higher fat and polyunsaturated fatty acid content, which increases their oxidation susceptibility to free radicals.

Protein Oxidation: The highest total carbonyl value was found in cooked thigh meat (control), which reached to 4.58 nmol/mg protein (Table 2). Again, the combination of 200 ppm oregano oil and 10 ppm tannic acid had the highest effect in preventing carbonyl formation in cooked meat. Positive relations between TBARS values and total carbonyl formation were found during storage in both breast and thigh chicken meats.

Volatiles production: The volatiles compounds tables of day 0 and 3 (both breast and thigh meat) were not shown in this paper in order to decrease the table number. Generally, the amounts and number of volatiles compounds increased during storage time in both breast and thigh cooked meat patties. Among the carbonyl compounds, hexanal increased by five- to six-fold in untreated patties during the 7-day storage time. However, cooked thigh meat had higher volatiles values than the breast cooked meat (Tables 3-4). The higher volatile values in thigh meat were due to their different chemical composition such as fat, water holding capacity, and polyunsaturated fatty acid. Control samples showed the highest aldehyde values among the treatments. Combination of 200 ppm oregano oil and 10 ppm of tannic acid showed the highest effects in inhibiting the volatile formation in both breast and thigh cooked meat during storage. In addition, it showed significant effect ($P < 0.05$) on aldehydes, and other volatiles which are responsible for the off-odor and rancidity of ground chicken meat during storage time. Very high correlation coefficient between TBARS, total carbonyl, and hexanal values were found during storage time (Table 5). Among aldehydes, hexanal and pentanal were the most predominant compounds affected by the combination of 200 ppm oregano oil and 10 ppm tannic acid. The volatile profile also showed some terpenoids such as camphene and limonene when ground chicken meats mixed with oregano oil, and their amounts increased as the amount of oregano oil increased. These compounds are responsible for the spice odor of meat added with oregano oil. Combination of 200 ppm oregano oil and 10 ppm tannic acid also showed significant effect ($P < 0.05$) on most of aldehydes related-lipid oxidation such as propanal, hexanal, and pentanal in cooked thigh meat. The combination (200 ppm oregano oil and 10 ppm tannic acid) treatment showed lower volatile formation than the BHA treatment in both breast and thigh cooked meat patties during storage.

Sensory evaluation: Sensory panels could not distinguish the treatment differences in cooked meat due to cooking effect on volatiles related to oregano odor (Table 6). Combination of 10 ppm of tannic acid and 200 ppm oregano oil treatment reduced oxidation odor score significantly ($P < 0.05$). In addition, combination of 10 ppm of tannic acid and 200 ppm oregano oil treatment showed the highest score on the overall acceptability for cooked meat patties.

Conclusion

Tannic acid and oregano essential oil at level 200 ppm and 10 ppm showed positive effect on the decreasing TBARS values, total carbonyl, and deteriorate off-odor volatile formation. Data of lipid oxidation, protein oxidation, and volatile agreed with the sensory evaluation results. In conclusion the combination of 200 ppm oregano oil and 10 ppm tannic acid could be a good replacement for the synthetic antioxidant (BHA) in the ground chicken meat.

Table 1. Table 1. TBARS values of cooked ground chicken meat with different combination level of oregano oil and tannic acid at 4℃.

Time	Control	CM1	CM2	CM3	CM4	BHA (5 ppm)
Breast meat	---------- TBARS (mg MDA/kg Meat) ----------					
Day 0	0.21^{az}	0.18^{az}	0.19^{ay}	0.21^{az}	0.19^{ay}	0.21^{az}
Day 3	1.36^{ay}	0.87^{by}	0.77^{bcx}	0.74^{bcy}	0.57^{cx}	0.96^{by}
Day 7	2.03^{ax}	1.32^{bcx}	0.97^{cdx}	0.88^{dx}	0.75^{dx}	1.50^{bx}
Thigh meat						BHA (14 ppm)
Day 0	1.23^{az}	1.10^{az}	1.09^{az}	0.97^{az}	0.94^{ay}	1.27^{az}
Day 3	3.40^{ay}	1.64^{cy}	1.36^{dy}	1.11^{ey}	1.01^{ey}	1.88^{by}
Day 7	3.48^{ax}	2.58^{bcx}	2.32^{cdx}	2.07^{dx}	1.75^{ex}	2.82^{bx}

$^{a-e}$ Values with different letter within a row are significantly different (P < 0.05). n = 4.
$^{x-z}$ Values with different letter within a column are significantly different (P < 0.05).
Treatments: Control, CM1: 100 ppm oregano oil + 5 ppm tannic acid; CM2: 100 ppm oregano oil + 10 ppm tannic acid; CM3: 200 oregano oil + 5 Tannic acid; CM4: 200 ppm oregano oil + 10 tannic acid; and BHA.

Table 2. Effect of adding different level of oregano oil and tannic acid on protein oxidation of cooked chicken patties during storage time.

Time	Control	CM1	CM2	CM3	CM4	BHA (5 ppm)
Breast meat						
Day 0	1.00^{az}	1.05^{ay}	0.99^{ay}	0.98^{ay}	0.98^{az}	1.01^{az}
Day 3	1.69^{ay}	1.45^{abxy}	1.31^{bx}	1.26^{bxy}	1.15^{by}	1.42^{aby}
Day 7	2.15^{ax}	1.75^{abx}	1.41^{bx}	1.34^{bx}	1.30^{bx}	1.76^{abx}
Thigh Meat						BHA (14 ppm)
Day 0	1.55^{az}	1.45^{ay}	1.42^{az}	1.42^{az}	1.37^{ay}	1.48^{az}
Day 3	3.10^{ay}	2.63^{bx}	2.16^{cy}	1.75^{dy}	1.51d^{xy}	2.67^{by}
Day 7	4.58^{ax}	3.03^{bx}	2.52^{cx}	2.06^{dx}	1.70^{dx}	3.21^{bx}

$^{X-z}$ Value with different letter within a column are significantly different (p<0.05). n = 4.
Treatments: Control, CM1: 100 ppm oregano oil + 5 ppm tannic acid; CM2: 100 ppm oregano oil + 10 ppm tannic acid; CM3: 200 oregano oil + 5 Tannic acid; CM4: 200 ppm oregano oil + 10 tannic acid; and BHA.

Table 3. Profile of volatiles cooked **breast** meat chicken patties with different level of oregano oil and tannic acid at day 7.

Compound	Control	CM1	CM2	CM3	CM4	BHA (5 ppm)
	---------- Total Ion counts*10^4 ----------					
Pentane	697[a]	0[c]	0[c]	0[c]	0[c]	195[b]
Propanal	2156[a]	127[b]	0[b]	0[b]	0[b]	0[b]
2-propanone	1899[a]	2412[a]	2766[a]	2672[a]	2676[a]	2441[a]
2-propanol	274[ab]	172[b]	149[b]	394[a]	426[a]	152[b]
Heptane	137[a]	0[c]	0[c]	0[c]	0[c]	52[b]
Butanal	198[a]	0[b]	0[b]	0[b]	0[b]	0[b]
Pentanal	10241[a]	244[bc]	81[c]	91[c]	81[c]	994[b]
Octane	405[a]	348[a]	101[c]	98[c]	92[c]	227[b]
Hexanal	84538[a]	3741[bc]	1269[c]	1165[c]	1014[c]	9363[b]
Heptanal	449[a]	0[b]	0[b]	0[b]	0[b]	0[b]
Nonanal	63[a]	0[b]	0[b]	0[b]	0[b]	0[b]
α-Pinene	0[b]	241[a]	216[a]	278[a]	282[a]	0[b]
Camphene	0[d]	243[bc]	165[c]	280[ab]	369[a]	0[d]
Limonene	0[b]	52[b]	55[b]	146[a]	196[a]	0[b]
β-Myrcene	0[b]	70[b]	57[b]	517[a]	433[a]	0[b]
γ-Terpinene	0[b]	203[b]	208[b]	1362[a]	1156[a]	0[b]
Sabinene	0[b]	0[b]	0[b]	140[a]	154[a]	0[b]

Different letter (a-c) within a row are significantly different ($P < 0.05$), n=4.
Treatments: Control, CM1: 100 ppm oregano oil + 5 ppm tannic acid; CM2: 100 ppm oregano oil + 10 ppm tannic acid; CM3: 200 oregano oil + 5 Tannic acid; CM4: 200 ppm oregano oil + 10 tannic acid; and 5 ppm BHA.

Table 4. Profile of volatiles cooked **thigh** meat chicken patties with different level of oregano oil and tannic acid at day 7.

Compound	Control	CM1	CM2	CM3	CM4	BHA (14 ppm)
	---------- Total Ion counts*10^4 ----------					
Pentane	474[a]	0[c]	0[c]	0[c]	0[c]	176[b]
2-Propanone	4064[ab]	4622[a]	2824[bc]	2807[bc]	2465[c]	3714[abc]
2-Propanol	2983[a]	1620[b]	938[b]	809[b]	742[b]	629[b]
Hexane	243[a]	173[ab]	139[bc]	0[d]	0[d]	83[c]
Cyclohexane	152[a]	106[b]	0[c]	0[c]	0[c]	143[a]
Pentanal	2477[a]	375[c]	150[c]	44[c]	76[c]	1154[b]
Heptane	347[a]	0[b]	0[b]	0[b]	0[b]	57[b]
Octane	1337[a]	627[bc]	494[c]	478[c]	458[c]	850[b]
Hexanal	88685[a]	5573[c]	1871[c]	1652[c]	832[c]	25172[b]
Heptanal	395[a]	0[c]	0[c]	0[c]	0[c]	135[b]
Octanal	70[a]	0[b]	0[b]	0[b]	0[b]	0[b]
α-Pinene	0[d]	434[bc]	333[c]	517[ab]	669[a]	0[d]
Camphene	0[d]	246[c]	283[bc]	449[b]	638[a]	0[d]
Limonene	0[c]	43[b]	53[b]	140[a]	144[a]	0[c]
β-Myrcene	0[c]	129[b]	100[b]	245[a]	280[a]	0[c]
γ-Terpinene	0[c]	319[b]	309[b]	638[a]	792[a]	0[c]
Sabinene	0[c]	0[c]	0[c]	41[b]	59[a]	0[c]

[a-d]Different letter within a row are significantly different ($P < 0.05$), n=4.
Treatments: Control, CM1: 100 ppm oregano oil + 5 ppm tannic acid; CM2: 100 ppm oregano oil + 10 ppm tannic acid; CM3: 200 oregano oil + 5 Tannic acid; CM4: 200 ppm oregano oil + 10 tannic acid; and 14 ppm BHA.

Table 5. Correlation Coefficients of TBARS, total carbonyl, hexanal values during storage time of control treatment.

Cooked Breast				Cooked Thigh			
Var	TBA	CAR	HEX	**Var**	TBA	CAR	HEX
TBA	1	0.98262*	0.94888*	TBA	1	0.98085*	0.96005*
CAR	0.98262*	1	0.97103*	CAR	0.98085*	1	0.99116*
HEX	0.94888*	0.97103*	1	HEX	0.96005*	0.99116*	1
TYPE	TBA	CAR	HEX	**TYPE**	TBA	CAR	HEX
MEAN	1.1999	1.6147	42431.75	MEAN	3.8995	3.0758	48814.5
STD	0.8042	0.4976	35156.5	STD	2.517	1.3	36767.26

Pearson Correlation Coefficients, N = 12, Prob > | r | under HO: Rho = 0

Table 6. Sensory attribute of ground cooked thigh chicken meat patties.

TRT	Cooked chicken	Oregano odor	Oxidation odor	Overall acceptability
Control	4.6[b]	0.7[d]	5.3[a]	4.1[c]
CM1	5.9[ab]	2.1[cd]	4.7[ab]	4.6[c]
CM2	6.4[ab]	2.9[bc]	3.5[ab]	5.7[bc]
CM3	6.7[ab]	4.7[a]	2.3[b]	7.5[ab]
CM4	7.9[a]	4.3[ab]	2.6[b]	7.9[a]
BHA	6.6[ab]	1.1[d]	3.1[ab]	7.3[ab]

Treatments: Control, CM1: 100 ppm oregano oil + 5 ppm tannic acid; CM2: 100 ppm oregano oil + 10 ppm tannic acid; CM3: 200 oregano oil + 5 Tannic acid; CM4: 200 ppm oregano oil + 10 tannic acid; and 5 ppm BHA. n=10.
Sensory attributes: samples were evaluated on day 0.
[a-d]Means within same column with different superscripts are different ($P < 0.05$).