SINGLE AND COMBINATION EFFECTS OF MUGWORT AND ASCORBIC ACID ON LIPID OXIDATION AND COLOR STABILITY DURING REFREGRTRATED STORAGE IN PORK PATTIES

Ko-Eun Hwang[1], Yong-Jae Kim[1], Yun-Sang Choi[2], Yun-Kyung Ham[1], and Cheon-Jei Kim[1*]

[1] Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Republic of Korea

[2] Research Group of Convergence Technology, Korean Food Research Institute, Seongnam 463-746, Republic of Korea

Abstract – The effects of mugwort extract (ME) and ascorbic acid (AC), added singly or in combination, on color stability and lipid oxidation of pork patties stored for 12 days were investigated. The color values (color difference, hue, and chroma values) of all samples were significantly affected by adding ME (either alone or with AC). A combination of AC + ME (0.05% AC + 0.1% ME), for which the values of lipid and myoglobin oxidation were lower at the end of the storage period. Therefore, the results demonstrated that antioxidant combination may be a promising method of maintaining the storage quality of pork meat during refrigerated period.

Key Words – antioxidants, shelf-life, pork meat.

I. INTRODUCTION

The application of natural preservatives to increase the shelf stability of meat products is a promising technology since many plants, herb, spice, and vegetables substances have antioxidant and antimicrobial properties. Furthermore, in recent years, consumers increasingly demand, if possible, higher quality and healthier meat products that are free of conventional chemical substances [1].

Mugwort (*Artemisia princeps* Pamp.) is mostly applied as a food additive or preservative, and as a component of antioxidant material, not only to retard lipid oxidation in food, but also to improve the quality and shelf stability of food in Oriental countries, including Korea [2].

Ascorbic acid is a 'generally recognized as safe' (GRAS) substance and can be applied at no more than 500 ppm or 11.6 mg/cm^2 of product surface to delay discoloration. Also, ascorbic acid, when used in combination with other antioxidants, functions synergy to promote their antioxidative effects [3, 4].

Previous studies have demonstrated the beneficial effects of antioxidants combination to extend shelf stability preventing oxidation of lipid and pigment. However, the investigation of their activity in a range of food systems is still needed for successful application in meat and meat products. Thus, the objective of the present research was to evaluate the effect of mugwort either singly, or in combination with ascorbic acid, on the inhibition of both lipid and pigment oxidations of raw ground pork patties during refrigerated storage.

II. MATERIALS AND METHODS

Preparation of mugwort extracts (ME)

Commercial samples of dried mugwort were purchased from a local market on *Ganghwa* Island in Korea. After separating the leaves from the dried mugwort, they were ground using a blender for 1 min. Ten grams of ground leaves were mixed with 200 mL of 50% ethanol overnight (24 h) in a shaker at room temperature. The extracts were filtered through filter paper No. 1 and then evaporated with a rotary evaporator at < 50°C. The concentrated product represented ME (pH, 6.12±0.02; L*-value, 29.21± 0.05; a*-value, 1.76±0.33; b*-value, −0.77±0.25).

Preparation of pork patties

Fresh pork hams and back fats were purchased from a local processor at 48 h postmortem. All subcutaneous and intramuscular fat as well as visible connective tissue were removed from the fresh ham muscles, and the back fat was collected. The pork hams and back fat were initially ground using a meat grinder equipped with 8 mm plate. An antioxidant of ascorbic acid (AC; Sewoo Inc, Seoul, South Korea) and mugwort extract was prepared according to the formulations: Control (no antioxi-dant added), AC (0.05% AC), ME (0.1% ME) and AC+ME (0.05% AC + 0.1% ME). For each batch of pork patties, pork meat (60%), back fat (20%), and ice (20%), salt (NaCl, 1.5%), and

antioxidant were mixed using a mixer for 10 min. After mixing, pork patties were then anaerobically packaged in PE/nylon film bags, spread to a thickness of 2.5 cm and, stored at 4±1°C for 12 days.

Color instrument

Color changes in the pork patties during storage were monitored with a colorimeter (Chroma meter CR-210, Minolta, Japan) using an 8-mm diameter measuring area and a 50-mm diameter illumination area. The total color differences between the control (days 0) and treatments with different antioxidant at each storage time were calculated by: $\Delta E = [(L^*-L_0^*)^2 + (a^*-a_0^*)^2 + (b^*-b_0^*)^2]^{½}$. Additionally, the hue (H°) and chroma (C*: saturation) values were determined using the formula, Tan $^{-1}(b^*/a^*)$ and $(a^2+b^2)^{1/2}$, respectively. Color readings were measured on ten randomly chosen spots on the pork patties and were utilized as an estimate of meat discoloration.

Metmyoglobin (MetMb) percentage

The percentage of MetMb (%) was determined as described by Bekhik *et al*. [5], using the formula of Krzywicki [6]:

%MMb = {−2.51(A572/A525)+0.777(A565/A525) +0.8 (A545/A525)+0.8(A545/525)+1.098}×100

Thiobarbituric acid reactive substances (TBARS) values

Lipid oxidation was assessed in triplicate using the TBARS method of Tarladgis *et al*. [7] with minor modifications and was expressed as mili-grams of malondialdehyde (MD) per kilogram of patty.

Statistical analysis

All data were subjected to the analysis of variance (ANOVA) using general linear model (GLM) procedure of SPSS 18.0 software (SPSS Inc., Chicago, IL, USA), with three replications, which was used as the storage periods and antioxidant type. When significant (P<0.05) treatment effects were shown, Duncan's multiple range test was used to compare the mean values. Mean values and standard error of the means (SEM) were reported.

III. RESULTS AND DISCUSSION

The changes in ΔE, H°, and C* values were analyzed during storage and are depicted in Table 1. Amongst all antioxidant samples, the formulations with ME (either alone or with AC) had higher ΔE values compared to that of the control. Higher ΔE results indicated a greater relative change in color compared to the meat's original color.

The H° values of all patty formulations ranged from 28.56 to 34.08 with counts increasing from 40.47 to 46.66 after 12 days. Also, significant increase in H° values was observed in ME (either alone or with AC) compared to control.

Samples treated with ME (either alone or with AC) displayed lower C* values compared to the control and AC. In addition, C* values showed a significant (P<0.05) decreasing trend in control and all treatment during storage periods progressed.

Table 1. Change in color difference (ΔE), hue (H°), and chroma (C*) values of pork patties containing different antioxidant during refrigerated storage

	Days of storage	Control[1]	AC	ME	AC+ME	SEM[2]
ΔE	0	-	0.94^{Bd}	1.75^{A}	1.65^{A}	0.05
	3	-	1.35^{Bc}	1.70^{A}	1.67^{A}	0.05
	7	-	1.60^{Ab}	1.68^{A}	1.50^{A}	0.06
	12	-	1.70^{Aca}	1.67^{A}	1.79^{A}	0.05
SEM		-	0.05	0.03	0.04	
H°	0	30.61^{Cd}	28.56^{Dd}	34.08^{Ad}	33.25^{Bd}	0.17
	3	35.56^{Bc}	31.05^{Cc}	37.25^{Ac}	35.73^{Bc}	0.18
	7	40.11^{Ab}	35.43^{Cb}	40.27^{Ab}	38.69^{Bb}	0.17
	12	46.66^{Aa}	40.47^{Da}	44.63^{Ba}	42.81^{Ca}	0.20
SEM		0.75	0.61	0.61	0.53	
C*	0	165.48^{Aa}	156.31^{Ba}	149.15^{Ca}	145.62^{Da}	0.52
	3	133.76^{Db}	141.22^{Ab}	135.63^{Cb}	138.18^{Bb}	0.24
	7	117.32^{Cc}	130.84^{Ac}	124.24^{Bc}	131.27^{Ac}	0.48
	12	115.72^{Ad}	116.22^{Ad}	108.63^{Bd}	116.29^{Ad}	0.40
SEM		1.23	1.77	1.65	1.52	

[1]Control, no antioxidant; AC, ascorbic acid 0.05%; ME, mugwort extract 0.1%; AC+ME, ascorbic acid 0.05% and mugwort extract 0.1%.

[2] SEM: Standard error of the mean (n = 24).

Means with different superscripts are significantly different (P<0.05).

A-D: antioxidant effects, a-d: storage day effects.

Previous studies suggested that the ΔE and H° values increased over time, resulting from a decrease in C*, which has been used to follow meat discoloration [8]. However, the color changes did not occur as a consequence of lipid or myoglobin oxidation, since raw pork patties with ME (either alone or with AC) had the highest

oxidative stability, showed the greatest color changes, and the metmyoglobin content was lower than those of control (Table 2). This could be due to the specific color of mugwort (brownish) extracts which were likely transferred to the pork patties, causing a modification of the patty color.

As can be seen in Table 2, MetMb (%) increased throughout storage in control and all treatments. After 7 days of storage, the control sample reached 40.95% of MetMb. Djenane *et al*. [4] reported that 40% metmyoglobin caused meat rejection by consumers. In addition, the presence of the AC+ME would contribute to maintaining acceptable MetMb level (below 40%) throughout the whole storage time.

Table 2. Change in metmyoglobin (MetMb, %) and TBARS values (mg MD/kg) of pork patties containing different antioxidant during refrigerated storage

Days of storage		Control[1]	AC	ME	AC+ME	SEM[2]
MetMb	0	28.76^{Ad}	26.34^{Cd}	27.82^{Bd}	26.03^{Cd}	0.06
	3	35.11^{Ac}	32.53^{Cc}	34.52^{Bc}	30.32^{Dc}	0.05
	7	40.95^{Ab}	33.62^{Cb}	36.71^{Bb}	31.30^{Db}	0.06
	12	44.62^{Aa}	38.07^{Ca}	41.72^{Ba}	35.02^{Da}	0.06
SEM		1.29	0.93	1.15	0.86	
TBARS	0	0.20^{d}	0.19^{d}	0.20^{d}	0.20^{c}	0.00
	3	0.36^{Ac}	0.28^{Bc}	0.25^{Cc}	0.20^{Dc}	0.01
	7	0.47^{Ab}	0.43^{Bb}	0.39^{Cb}	0.28^{Db}	0.01
	12	0.58^{Aa}	0.53^{Ba}	0.48^{Ca}	0.37^{Da}	0.01
SEM		0.03	0.03	0.03	0.02	

[1] Control, no antioxidant; AC, ascorbic acid 0.05%; ME, mugwort extract 0.1%; AC+ME, ascorbic acid 0.05% and mugwort extract 0.1%.

[2] SEM: Standard error of the mean (n = 9).

Means with different superscripts are significantly different (P<0.05).

A-D: antioxidant effects, a-d: storage day effects.

TBARS represent the secondary product, mainly aldehydes, which contribute to off-flavors in oxidized meat and meat matrix [2]. The result of TBARS analyses is shown in Table 2. The results indicated that samples containing antioxidants combinations (0.05% AC + 0.05% ME) had significantly lower MD concentrations at the end of the storage period than those containing singly antioxidants. These results seem to support the reason why synergistic effect of antioxidant combination.

IV. CONCLUSION

Antioxidant combination (0.05% ascorbic acid + 0.05% mugwort extract) was much more useful for preventing lipid and myoglobin oxidation in raw pork patties than that of control, single antioxidant. Because of concerns regarding the safety and toxicity of synthetic antioxidants, the antioxidant combination may prove useful as a safe and natural health-promoting antioxidant for the food industry.

ACKNOWLEDGEMENTS

This study was supported (2013-A423-0047) by the Brain Korean 21 Plus (BK 21 Plus) Project from Ministry of Education (Republic of Korea).

REFERENCES

1. Vasilatos, G. C., & Savvaidis, I. N. (2013). Chitosan or rosemary oil treatments, singly or combined to increase turkey meat shelf-life. International Journal of Food Microbiology 166: 54-58.
2. Hwang, K. E., Choi, Y. S., Choi, S. M., Kim, H. W., Choi, J. H., Lee, M. A., & Kim, C. J. (2012). Antioxidant action of *ganghwayakssuk* (*Artemisia princeps* Pamp.) in combination with ascorbic acid to increase the shelf-life in raw and deep fried chicken nuggets. Meat Science 95: 593-602.
3. Grobbel, J. P., Dikeman, M. E., Yancey, E. J., Smith, J. S., Kropf, D. H., & Milliken, G. A. (2006). Effects of ascorbic acid, rosemary, and Origanox™ in preventing bone marrow discoloration in beef lumbar vertebrae in aerobic and anaerobic packaging systems. Meat Science 72: 47-56.
4. Djenane, D., Sánchez-Escalante, A., Beltrán, J. A., & Roncalés, P. (2002). Ability of α-tocopherol, taurine and rosemary, in combination with vitamin C, to increase the oxidative stability of beef steaks packaged in modified atmosphere. Food Chemistry 76: 407-415.
5. Bekhik, A. E. D., Geesink, G. H., Ilian, M. A., Morton, J. D., & Bickerstaffe, R. (2003). The effects of natural antioxidants on oxidative processes and metmyoglobin reducing activity in beef patties. Food Chemistry 81: 175-187.
6. Krzywicki, K. (1982). The determination of heam pigment in meat. Meat Science 7: 29-35.
7. Tarladgis. B.G., Watts B. M., Younthan M. T., & Dugan L. R. (1960) A distillation method for the quantitative determination of malonaldehyde in rancid foods. Journal of the American Oil Chemists' Society 37: 403-406.
8. Bañón, S., Díaz, P., Rodríguez, M., Garrido, M. D., & Price A. (2007). Ascorbate, green tea and grape

seed extracts increase the shelf-life of low sulphite beef patties. Meat Science 77: 626-633.