ANTIOXIDANT ACTION OF MUGWORT EXTRACT ALONE AND IN COMBINATION WITH ASCORBIC ACID IN CHICKEN NUGGETS

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Abstract – We investigated the inhibition of lipid oxidation of chicken nuggets by the natural antioxidants ascorbic acid (Aa), mugwort extracts (ME) and their combination (Aa + ME). The color difference (Δ*E*) values of all treatments, except for Aa (0.05% ascorbic acid), were higher than those of the control as the amount of ME increased. All antioxidant combinations were effective at delaying lipid oxidation when compared to the control or Aa. A combination of Aa + ME 0.1 (0.05 % ascorbic acid + 0.1% mugwort extract) was most effective for delaying lipid oxidation such as thiobarbituric acid reactive substances (TBARS), peroxide (POV), and conjugated dienies (CD).

Key Words – Antioxidant, Mugwort, Lipid oxidation, Chicken nuggets

I. INTRODUCTION

Chicken lipids have relatively high levels of unsaturated fatty acids, which are considered a health benefit by consumers. However, higher unsaturated content may affect the oxidative stability of chicken meat, because the unsaturated fatty acids tend to oxidize. Lipid oxidation limits the shelf life of meat and meat products by reducing quality and accelerating deterioration. This may produce changes in meat quality parameters such as color, flavor, odor, texture, and even nutritional value [1].

The continuous use of such synthetic chemicals may cause health hazards such as teratogenic and carcinogenic effects in laboratory animals and primates. Due to concerns about the toxicological safety of artificial additives, the use of spices and herbs has increased considerably in the last few decades as a response to consumer' demand for natural and healthy foodstuffs.

Mugwort (*Artemisia princeps* Pamp.) is widely used as a food or food additive in Korea. It can be found in markets in various forms such as cakes, emulsified sausages, sauces, and noodles. This plant contains bioactive compounds such as phenolics, alkaloids, and vitamins A, B_1, B_2, and C as well as various minerals [2].

Ascorbic acid is very effective for increasing the shelf-life and stabilizing the color of meat and meat products. However, ascorbic acid either promotes or inhibits lipid oxidation reactions in meat products, depending on its concentration. Ascorbic acid acts as a synergist when used in combination with other antioxidants by promoting their antioxidant effects [3].

In the present study, lipid oxidation was investigated in chicken nuggets prepared with two different antioxidants, a mugwort extract (ME) and ascorbic acid (Aa), during 12 days at 4°C.

II. MATERIALS AND METHODS

2.1. Preparation of mugwort extracts (ME)

Commercial samples of dried mugwort were purchased from a local market. Ten grams of ground leaves were extracted with 200 mL of 50% ethanol overnight in a shaker at room temperature. The extracts were filtered through filter paper and evaporated with a rotary evaporator at < 50°C.

2.2. Chicken nugget preparation and processing

Fresh chicken breasts (*Muscularis pectoralis*) with chicken skin were obtained locally. The chicken nugget was processed using Hwang et al. (2011) methods [2].

2.3. Preparation of the antioxidant combination

An antioxidant combination of Aa and ME extract was prepared according to the formulations: Control (no antioxidant added), Aa (0.05% ascorbic acid), ME 0.05 (0.05% mugwort extract); ME 0.1 (0.1% mugwort extract), Aa + ME 0.05 (0.05% ascorbic acid + 0.05% mugwort extract), and Aa + ME 0.1 (0.05% ascorbic acid + 0.1% mugwort extract).

2.4. Color difference (ΔE)

The colorimetric difference between a sample and a white standard reflectance plate, color difference (ΔE^*), was calculated using the equation: $\Delta E^* = [(L^*-L)^2 + (a^*-a)^2 + (b^*-b)^2]^{½}$ ($L^* = 97.83$, $a^* = -0.43$, $b = +1.98$).

2.5.Lipid extraction for peroxide value (POV) and conjugated dienes (CD)

Lipid extraction was conducted according to the method of Folch [4] using a chloroform:methanol solvent system (2:1).

2.6. Peroxide values (POV)

Lipid extracted from the sample was determined by AOAC methods (2007) [5]. The lipid sample (0.5 g) was treated with 25 mL of solvent mixture (acetic acid:chloroform mixture; 3:2). The mixture was shaken thoroughly and 1 mL of saturated potassium iodide solution was added. The mixture was kept in the dark for 10 min, 30 mL of distilled water was added, and the mixture was mixed. One milliliter of starch solution (1%, w/v) was added as an indicator. POV was determined by titrating the iodine liberated from potassium iodide with standardized 0.01 N sodium thiosulfate solutions.

2.7. Conjugated dienes (CD)

CD was determined using a modified method adapted from Juntachote et al. (2006) [6]. Extracted sample lipids (0.015 g) were massed into a 25 mL volumetric flask, brought to volume with iso-octane and mixed. The CD concentration was calculated using a 25,000 M^{-1} cm^{-1} molar extinction coefficient. The results are expressed as µmol per mg meat lipid sample.

2.8. Thiobarbituric acid-reactive substances (TBARS)

Lipid oxidation was assessed using the TBARS method of Tarladgis et al. (1960) [7]. Lipid oxidation was assessed using the TBARS method of Tarladgis, Watts, Younthan, & Dugan (1960) with minor modifications. Absorbances were measured using a UV/VIS spectrophotometer (Optizen 2120 UV plus, Mecasys Co. Ltd., Seoul, South Korea) at 538 nm against a blank prepared with 5 mL distilled water and 5 mL TBA reagent. TBARS values were calculated from a standard curve (8-50 nmol) of malondialdehyde (MDA), which was freshly prepared by acidification of 1,1,3,3-tetraethoxy propane (TEP). Reagents were obtained from Sigma-Aldrich (St. Louis, MO, USA). TBARS levels were calculated as mg MDA/kg samples.

2.9. Statistical analysis

An analysis of variance was performed on all the variables measured using the general linear model (GLM) procedure of the SAS statistical package (SAS, Cary, NC, USA) (2010) [8]. Duncan's multiple range tests ($p<0.05$) was used to determine differences between treatment means.

III. RESULTS AND DISCUSSION

Colors expressed as color difference (ΔE) was analyzed during storage and are depicted in Fig. 1.

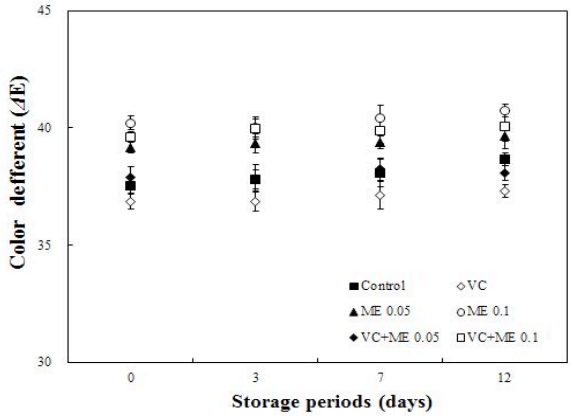

Fig. 1. Changes in color difference values on chicken nuggets formulated with natural antioxi-dant combination during storage at 4°C

(■) Control: no antioxidant, (◇) Aa: chicken nuggets containing ascorbic acid 0.05%, (▲) ME 0.05: chicken nuggets containing mugwort extract 0.05%, (○) ME 0.1: chicken nuggets containing mugwort extract 0.1%, (◆) Aa+ME 0.05: chicken nuggets containing ascorbic acid 0.05% and mugwort extract 0.05%, (□) Aa+ME 0.1: chicken nuggets containing ascorbic acid 0.05% and mugwort extract 0.1%.

The color values of the chicken nuggets may have been influenced by the ME because the lightness and redness values decreased with increasing ME level, whereas the yellowness values increased significantly with increasing ME content (lightness, redness and yellowness data not shown). The total color differences in chicken samples increased with increasing levels of ME. This could be attributed to the brownish color of the ME.

The results from the CD analysis in chicken nuggets are illustrated in Fig. 2. The CD results showed that the Control, Aa, and ME 0.05 had significantly increased ($P < 0.05$) during 3 days of refrigeration, which decreased until the end of storage.

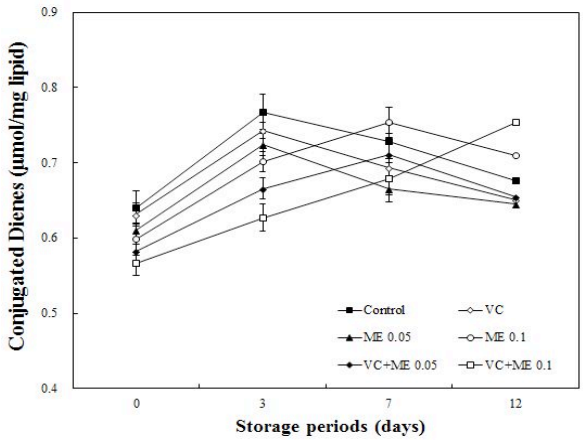

Fig. 2. Changes in CD values on chicken nuggets formulated with natural antioxidant combination during storage at 4°C

Treatments are the same as in Fig.1.

After 12 days of refrigeration, chicken nuggets treated with Aa + ME 0.1 were the most resistant to oxidation, as evidenced by the lowest value, followed by ME 0.05, ME 0.1, and Aa + ME 0.05. The antioxidant mixture (Aa + ME) retarded lipid oxidation during storage. This effect was expected due to the synergistic effect of ascorbic acid with mugwort extract.

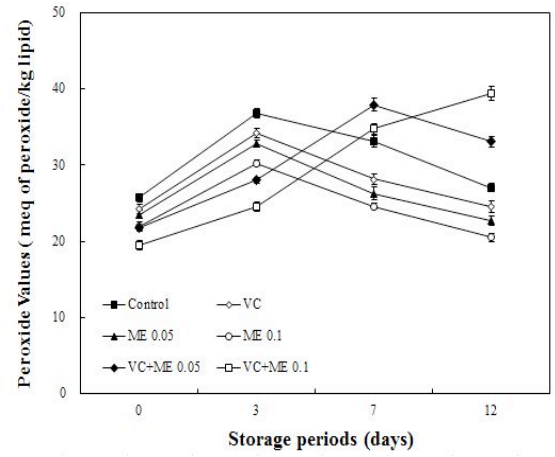

Fig. 3. Changes in POV values on chicken nuggets formulated with natural antioxidant combination during storage at 4°C

Treatments are the same as in Fig.1.

Fig. 3 shows the POV results as affected by the various levels of ME in combination with Aa. The trend was similar to the CD measurement in which the strength of anti-oxidative protection increased with increasing ME concentration in chicken nugget samples. The chicken samples with Control, Aa, ME 0.05, and ME 0.1 presented a maximum POV after 3 days storage at 4ºC, which was followed by a decline. In the present study, the antioxidant combination (Aa + ME) appeared to effectively control peroxide levels of chicken nuggets during the entire storage period ($P < 0.05$). Samples containing Aa + ME 0.1 were more effective in lowering the increase in POV in chicken samples than the other treatments.

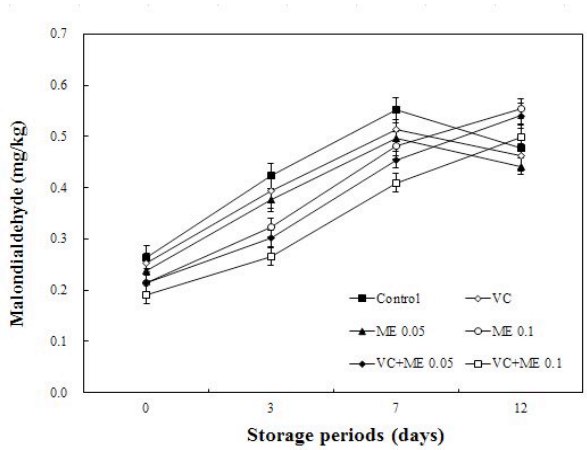

Fig. 4. Changes in TBARS values on chicken nuggets formulated with natural antioxidant combination during storage at 4°C

Treatments are the same as in Fig.1.

The result of TBARS analyses is shown in Fig. 4. As the storage period progressed, lipid oxidation in the control and all tested samples increased significantly. However, TBARS values were significantly lower at any day of storage in samples containing ME (either alone or with ascorbic acid), so TBARS formation was almost totally inhibited. Additionally, the TBARS values of the chicken nugget samples, except for those of ME 0.1, Aa + ME 0.05, and Aa + ME 0.1, increased at the beginning of storage and then began to decrease at day 12. According to our results, ascorbic acid showed a synergistic antioxidant effect when used in combination with ME. Aa + ME 0.1 was the most efficient treatment to maintain retarded oxidation in chicken nuggets under storage.

IV. CONCLUSION

The results suggest that adding an antioxidant combination reduced the oxidative stress and peroxidation of chicken nuggets stored for 12 days under normal refrigeration temperature, which may extend the shelf life of chicken meat. Aa + ME 0.1 (0.05% ascorbic acid + 0.1 % mugwort extract) was most effective for delaying lipid oxidation (CD, POV, and TBARS formation).

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