Effects of Addition of *Rhus verniciflua* Stokes Extract and Gallic Acid on the Quality Characteristics of Hanwoo (Korean Cattle) Beef Patties Stored in High Oxygen-Modified Atmosphere Package

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Abstract— **The effect of addition of *Rhus verniciflua* Stokes (RVS; 0.02% or 0.04%) water extract and gallic acid (0.02%) on the storage quality of Hanwoo (Korean cattle) beef patties (containing 2.5% NaCl and 1.5% grapeseed oil) was estimated in high oxygen-modified atmosphere packaging (HiOx-MAP) condition (70% O_2/20% CO_2/10% N_2) at 8 ℃ for 12 days. The addition of RVS extract and gallic acid did not influence (P > 0.05) the pH value but retarded the production of TBARS and carbonyl. The antioxidant effect on lipid oxidation was in following the order: 0.04% RVS extract > 0.02% gallic acid > 0.02% RVS extract. Higher (P < 0.05) myofibrillar fragmentation index exhibited in patties with RVS extract and gallic acid after 6 days of storage than in the control. Lower L* value and higher a^* value were remained by the addition of RVS extract and gallic acid over time. Red color stability was in following the order: 0.04% RVS extract > 0.02% RVS extract > 0.02% gallic acid. In conclusion, RVS extract and gallic acid showed strongly antioxidant activity and were the most effective for improving the color and lipid oxidation stability, respectively, in beef patties stored in HiOx-MA.**

Keywords— ***Rhus verniciflua* Stokes extract, gallic acid, HiOx-MAP, beef patties.**

I. INTRODUCTION

High oxygen-modified atmosphere package (HiOx-MAP; 70~80% O_2/20~30% CO_2) is most commonly used for display of fresh meat. The advantages of this package are the improvement of color stability by high concentration of oxygen and the antimicrobial effect by carbon dioxide [1]. But HiOx promoted lipid oxidation, discoloration, and protein oxidation in meat products during long-term storage [2, 3]. In addition, the problems of HiOx-MAP bring economic losses to meat industry. Thus, in order to prevent the quality deterioration, antioxidants should be used in meat products. However, natural-based antioxidants have been recently required for meat industry, because of hazards of synthetic antioxidants [4, 5].

Rhus verniciflua Stokes (RVS) belongs to the *ivy* (Anacardiaceae), and in Korea, its extract has been used as sub-material for healthy chicken soup [6]. Many researchers have been verified bioactive compounds, such as butein, butin, gallic acid, fisetin, fustin, sulfuretin, and quercetin [7, 8, 9], and physiological activities, such as antioxidant, anticancer, antimutagenic, anti-inflammatory, antithrombotic, and anti-obesity [10, 11, 12]. Gallic acid (3,4,5-trihydroxybenzoic acid) is also rich in grape, gall nut, sumac, oak, and green tea [13, 14] and have powerful antioxidant and anti-cancer effects [15, 16].

Therefore, the objective of this research was to investigate the effect of addition of RVS extract and gallic acid on the quality characteristics of Hanwoo (Korean cattle) beef patties during storage in HiOx-MAP.

II. MATERIALS AND METHODS

A. Preparation of RVS extract

Three-hundreds grams of RVS heartwood powder and 5000 mL of deionized water were boiled at 100℃ for 3 hr. After cooled, RVS extract was filtered with a Whatman filter paper No. 1 and a 0.45 μm syringe filter. The soluble matter content of RVS extract was 0.5% with a refractometer (PAL-03S, Atago Co., Ltd., Japan).

B. Preparation of experimental patties

Fresh top round (fat content: 6.33%; pH: 5.53) from 27 months-old-Hanwoo (Korean cattle) steer was chopped through 6 mm and 4 mm plates and divided into 4 groups for preparing the control, 0.02% gallic acid-, 0.02% RVS extract-, and 0.04% RVS extract-added patties. All groups were composed of 2.5% NaCl, 1.5% grapeseed oil, and 7.95% water. For packaging, 90 g of sample was placed into a polystyrene barrier foam tray and filled with 70% O_2/20% CO_2/10% N_2/ using a MAP machine (MAP-E1, HyperVac Co., Korea) equipped with a 3 gas mixer (MAP Mix 9001, PBI Dansensor, Denmark). All samples were stored at 8±0.3℃ for 12 days.

C. pH

The pH value of sample homogenate (10 g of sample/100 mL of deionized water) was measured by SevenEasy pH meter (Mettler-Toledo GmbH, Switzerland).

D. TBARS and DNPH-carbonyl

TBARS (2-thiobarbituric acid reactive substances) was determined by Sinnhuber and Yu [17]. DNPH-carbonyl was measured by described as Oliver et al. [18].

E. Myofibrillar fragmentation index

Myofibrillar fragmentation index (MFI) was performed as described by Culler et al. [19]. Protein concentration was determined by biuret method [20].

F. Color measurement

CIE a^* value (redness) at sample surface was measured using a chroma meter (CR-400, Konica Minolta Sensing, Inc., Japan).

G. Statistical analysis

Data was analyzed by ANOVA (Analysis of variance) of SPSS [21]. Significant differences among means were determined by the Duncan's multiple range tests at $P < 0.05$.

III. RESULTS AND DISCUSSION

Fig. 1 shows the effect of addition of RVS extract and gallic acid on pH value of Hanwoo (Korean cattle) beef patties during storage in HiOx-MAP. During the storage periods, the pH value of patties was 5.50 to 5.66. In these results, addition of RVS extract and gallic acid did not affect significantly ($P > 0.05$) pH value of patties. Similarly, Hayes et al. [22] also obtained in beef patties stored in HiOx-MAP (80% O_2/20% CO_2) at 4℃ for 12 days that there were no significant differences in pH values between patties non-added and added polyphenol compounds (ellagic acid, sesamol, or olive leaf extract).

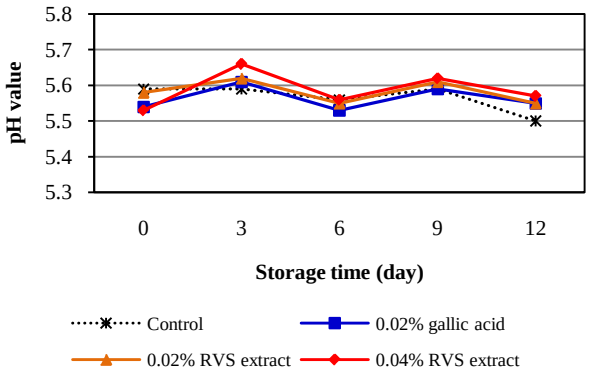

Fig. 1 Effect of addition of RVS extract and gallic acid on pH value of Hanwoo (Korean cattle) beef patties during storage in HiOx-MAP.

Fig. 2 shows the effect of addition of RVS extract and gallic acid on TBARS level and DNPH-carbonyl content of patties during storage. Addition of RVS extract and gallic acid lowered significantly ($P < 0.05$) TBARS development in patties during all storage periods. Particularly, at 6 day of storage, the control patty had about 7.5 to 10 times of TBARS level, when compared with RVS extract- and gallic acid-added patties. From 9 days of storage, 0.04% RVS extract-added patty showed significantly ($P < 0.05$) lower TBARS level, and from 3 days of storage, 0.02% gallic acid-added patty showed significantly ($P < 0.05$) lower level than 0.02% RVS extract-added patty. In study of salted-cooked beef, Liang et al. [23] have observed that addition of RVS extract inhibited generation of TBARS and peroxide during refrigerated

storage. Moreover, antioxidant effects of RVS extract on the TBARS, peroxide, and conjugated dienes have been reported by Kim et al. [24] in storage experiment of Gangjung (Korean traditional fried snack). Accumulation of carbonyl (Fig. 2) in patties was also inhibited by addition of RVS extract and gallic acid. From 3 days of storage, RVS extract- and gallic acid-added patties showed significantly ($P < 0.05$) lower carbonyl content than the control patty. However, during the storage periods, there were no significant effects on carbonyl content by addition level of RVS extract and type of additives (RVS extract and gallic acid) at 0.02% of addition level.

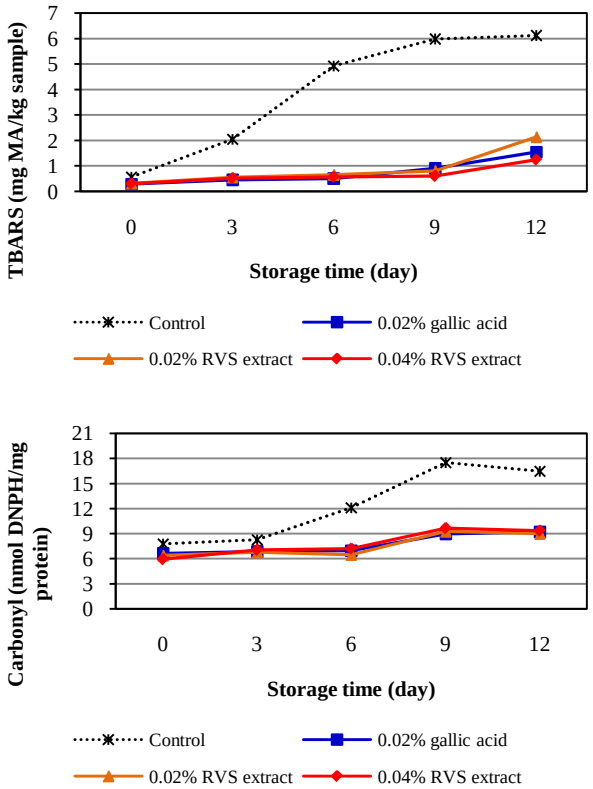

Fig. 2 Effect of addition of RVS extract and gallic acid on TBARS level and DNPH-carbonyl content of Hanwoo (Korean cattle) beef patties during storage in HiOx-MAP.

As shown in Fig. 3, during the storage periods, decrease rate of MFI was faster in the control patty compared to RVS extract- and gallic acid-added patties. As well, from 6 days of storage, MFI was significantly ($P < 0.05$) lower in the control patty than in RVS extract- and gallic acid-added patties. But, in similar to results of carbonyl, there was no significant difference in MFI between RVS extract- and gallic acid-added patties during all periods. In these results, reduction of MFI during the storage means aggregation of myofibrillar proteins by protein oxidation [25].

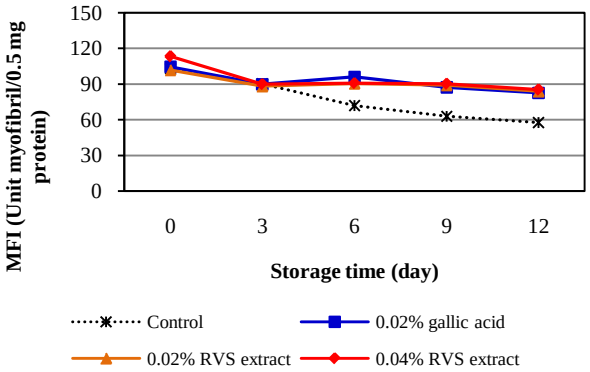

Fig. 3 Effect of addition of RVS extract and gallic acid on MFI of Hanwoo (Korean cattle) beef patties during storage in HiOx-MAP.

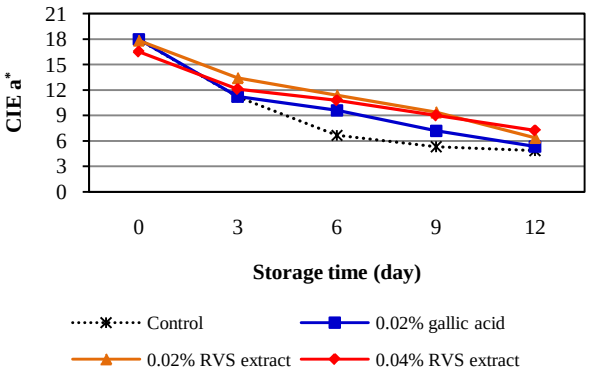

Fig. 4 Effect of addition of RVS extract and gallic acid on CIE a* value of Hanwoo (Korean cattle) beef patties during storage in HiOx-MAP.

CIE a* value (Fig. 4) of patties during the storage was stabilized by addition of RVS extract and gallic acid. From 3 days of storage, RVS extract-added patties had significantly ($P < 0.05$) higher a* value than the control and gallic acid-added patties. Particularly, 0.04% RVS extract-added patty had the reddest ($P < 0.05$) color at 21 day of storage. But gallic acid-added patty showed significantly ($P < 0.05$)

higher a^* value from 6 days of storage, when compared with the control patty.

IV. CONCLUSIONS

Both RVS extract and gallic acid protected effectively beef patties from chemical oxidation and discoloration by HiOx-MAP. Especially, RVS extract kept redder color for long-term storage and gallic acid inhibited strongly lipid oxidation.

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