EFFECT OF ORGANIC ACIDS AND 50% CARBON DIOXIDE-PACKAGING ON THE QUALITY CHARACTERISTICS OF SLICED BACON DURING STORAGE

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***Abstract*—The objective of this study was to investigate the effect of organic acids and 50% carbon dioxide-packaging on the quality characteristics of sliced bacon during storage. The sample were treated with either 5% sodium acetate/sodium diacetate or non-treated (control), packaged in modified atmosphere packaging (MAP) containing 50% CO_2/50%N_2 and 100% N_2, and then stored at 5°C for 22 days. Organic acids increased the pH value and inhibited lipid oxidation, volatile basic nitrogen (VBN) formation, and anaerobic bacteria of 8 to 18 day. 50% CO_2-packaging, either alone or with organic acids, inhibited VBN formation, but was not more effective in redness than 100% N_2-packaging alone.**

***Index Terms*— MAP, sliced bacon, sodium acetate, sodium diacetate.**

I. INTRODUCTION

Bacon is the cured meat product prepared from prok belly (Yi and Chen, 2003). For this kind of food, the additives is needed to improve the taste as well as to improve the chemical, physical properties, and shelf life. Several food additives were used in pork products, such as sodium acetate, potasium lactate (Jensen, Prestat, Ryan, Robbins, Homco-Ryan & McKeith, 2003), lactic acid (Shrestha & Ming, 2004), and sodium citrate (Stephens, Dikeman, Unruh, Haub & Tokach, 2006).

Sodium acetate and sodium diacetate generally were used because of its color improvement effects. Sodium acetate effectively improves the color stability of enhanced pork (Jensen *et al.*, 2003). Sodium acetate also improves the color stability of enhanced pork when its combined with potasium lactate (Jensen *et al.*, 2003), but negatively affects the flavor of pork products (Stephens *et al.*, 2006).

Eventhough many research reported the effects of additives to the pork, very small studied about its combination effects with MAP. The objective of this study was to investigate the effect of organic acids and 50% carbon dioxide-packaging on the quality characteristics of sliced bacon.

II. MATERIALS AND METHODS

A. Sample preparation and experimental design

Bacon were prepared into two groups, one group was treated with 5% organic acids (46-55% sodium acetate and 6-15% sodium diacetate) based on total bacon weight and the other was non-treated (control). All groups were smoked at 120°C for 30 min and sliced into about 3 mm-thickness. Three slices of bacon were placed on the tray (Max. O_2 transmission rate=0.1 cc/cm^2 at 23°C, 0% RH; Max. moisture vapor transmission rate= 2.0 g/24 hr-254 cm^2 at 38°C, 100% RH, Cryovac Sealed Air Corp., USA) for the following packaging methods. Tray was sealed with O_2 barrier film (Max. O_2 transmission rate=0.10 g/24 hr-254 m^2 at 4,4°C, 100% RH; Lid 1050, Cryovac Sealed Air Corp., USA), and filled with gas with two different composition (50% CO_2+50% N_2 and 100% N_2) by using a modified atmosphere packaging machine (Hypervac, Korea) equipped with the gas mixture (MAP Mix 9001 ME, PBI Dansensor, Denmark). All samples were stored in a refrigerator with temperature 5°C for 22 days, and the quality parameters were assessed in lean meat portion.

B. pH determination

Ten grams of bacon was added with 100 ml distilled and then homogenized by 10,000 rpm for 1 min using homogenizer (PH91 SMT Co., Ltd., Japan). The pH value of sample solution was measured by using a pH meter (SevenEasy pH, Mettler-Toledo GmbH, Switzerland).

C. TBARS value

The TBARS (2-thiobarbituric acid reactive substance) value was measured according to Sinhuber and Yu (1977). Briefly, 0.5 g sample was mix with 3 drops of antioxidants solution, 3 ml of TBA solution, and 17 ml of 25% TCA. The mixture was heated at 98^{o}C for 30 min, and centrifuged at 3,500 rpm for 30 min. An absorbance of supernatant was measured at 532 nm using a spectrophotometer (UV-mini-1240, Shimadzu, Japan). The result was calculated as milligram malonaldehid (MA) per kilogram sample.

D. VBN value

The VBN (volatile basic nitrogen) value was measured according to Kohsaka (1975). Briefly, 5 g sample was homogenized with 30 ml 5% TCA using a homogenizer (Ultra Turrax T25 basic, Ika Werke Gmbh & Co., Germany) at 13,500 rpm for 2 min. The homogenate was made up to 50 ml of final volume with 5% TCA and filtered using Whatman filter paper No. 1. One millimeter of filterate and 1 ml of borate buffer were placed in outer and inner of Conway dish, respectively, and incubated at 37^{o}C for 100 min. The inner solution were titrated with 0.01N HCl.

E. Instrumental color

The surface color were monitored by measuring the CIE a* (redness) using a chroma meter (CR-400, Konica Minolta Sensing Inc., Japan).

F. Aerobic and anaerobic bacterial count

Ten gram sample was homogenized with 90 ml of 0.1% peptone using a Stomacher (Lab Blender 400, Seward Laboratory, U.K.) at low speed for 2 min. The population of aerobic and anaerobic were determined by using plate count agar (Difto, USA). The agar was incubated at 30^{o} C for 48 hr. The populations were expressed as log CFU per gram sample.

G. Statistical analysis

All data were analyzed by using SPSS 14.0 (2005). The data were analyzed by one way analysis of variance. Mean of data were compared using Duncan's multiple range tests with examination for significant differences (p<0.05).

III. RESULTS AND DISCUSSION

A. pH value

Fig.1 showed the combination effects of organic acids and MAP to the pH value of sliced bacon. The pH value of origin sample in 0 day of the control was lower compared to organic acids treatment. The lower pH value of organic acids treatments was related with the acid form of sodium acetate and sodium diacetate. During the storage, the addition of organic acids increased the pH value of bacon both in 50% CO_2-MAP and 100% N_2-MAP. The increasing of pH value as the effect of organic acids also was found in lactate-enhanced beef (Kim, Keeton, Smith, Maxim, Yang & Savell, 2009) and beef patties (Suman *et al.*, 2010). Comparing between the MAP methods, fluctuating pH value was found during storage both in 50% CO_2-MAP and 100% N_2-MAP. In the control, 50% CO_2-MAP resulted a lower pH value in 6 and 8 day and slightly higher in 10 to 22 day compared to 100% N_2-MAP. In organic acids treatments, 50% CO_2-MAP resulted lower pH value from 6 to 14 day, and slightly higher in 20 and 22 day of storage compared to 100% N_2-MAP. Viana, Gomide and Vanetti (2005) reported that MAP did not show strong variation in pH of fresh pork loin.

B. TBARS value

Addition of sodium acetate and sodium diacetate to the bacon resulted different effects on two different MAP methods. Organic acids lowered the lipid oxidation (presented by lower TBARS value, Fig 2.) in 50% CO_2-MAP from 4 to18 day. Contrast effects was shown in 100% N_2-MAP, in which organic acids resulted a higher lipid oxidation than the control until 14 day, and lowered lipid oxidation from 18 to 22 day. Previous research showed that organic acids delayed lipid oxidation in refrigerated sliced salmon (Sallam, 2007). Kim *et al.* (2009) also noted that organic acids addition with phosphate minimized the lipid oxidation in fresh beef. Comparing the MAP methods, the control under 100% N_2-MAP showed lower TBARS value than 50% CO_2-MAP. Same results were obtained by Lund, Hviid and Skibsted (2007). They reported 100% N_2-MAP with antioxidants inhibited the TBARS formation.

C. VBN value

Generally, VBN value increased as the increased of storage day. Arashihar, Hisar, Kaya and Yanik (2004) reported that VBN increased as the increased of storage time in Air-P, vacuum and MAP. Fig 3. showed that the addition of organic acids to the bacon lowered the protein deteroriation (represented by lower VBN value) both in 50% CO_2-MAP and 100% N_2-MAP. This results is in agreement with Lin and Lin (2002), who reported that organic acids lowered VBN value in low-fat chinese style sausage. Packaging with 100% N_2-MAP generally resulted higher VBN value than 50% CO_2-MAP both in the control and organic acids treatments.

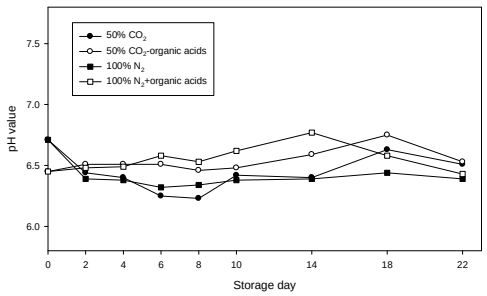

Fig. 1. Effect of organic acids and 50% CO_2-MAP on the pH value of sliced bacon during storage at 5°C.

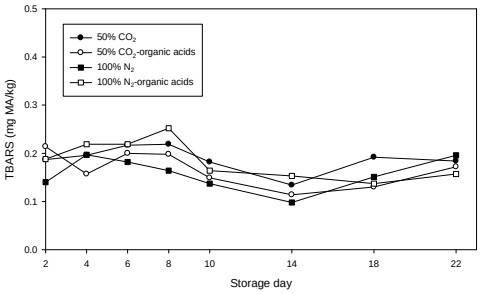

Fig. 2. Effect of organic acids and 50% CO_2-MAP on the TBARS value of sliced bacon during storage at 5°C.

D. Instrumental color

The a* value is presented in Fig. 4. Organic acids resulted higher a* value of bacon under 50% CO_2-MAP. Jensen *et al.* (2003) reported that enhancing lactate/diacetate in choped pork maintained higher a* value during display. Organic acids showed negative effects on the redness under 100% N_2-MAP. Negative effect of organic acid (sodium tripolyphosphate) in the redness value of pork loin were reported by Hayes, Desmon, Troy, Buckley and Mehra (2005).

E. Microbiology

Fig. 5. showed the gowth of aerobic bacteria during the storage. No different was found in aerobic bacteria among the treatments until 4 day as the effects of organic acids and MAP methods. Aerobic bacteria was around 2-2.5 log CFU/g in all treatments by 4 d of storage, and exponential phase started from 4 to 14 day. During this period, organic acids showed antibacterial effects in detaining the growth of aerobic bacteria in 100% N_2-MAP. Organic acids increased the aerobic bacterial counts in 50% CO_2-MAP on 6 and 8 day. It is known that organic acid have microbial reducing ability. Antibacterial effect of organic acids was reported by Lawrence, Dikeman, Hunt, Kastner and Johnson (2003) in which calcium salts lowered the microbial plate counts in beef. Another research reported that 3% or 4% sodium lactate reducted the population of bacteria on cooked beef (Miller and Acuff, 2006). The survival and the growth of pathogenic microorganism are affected by MAP (Blakistone, 1999). Comparing between MAP methods, 50% CO_2-MAP resulted lower total colony of aerobic bacteria than in 100% N_2-MAP in the control bacon from 4 to 14 day. No difference was found in total colony from 14 to 22 day. Carbon dioxide is well known as antibacterial agent in MAP. Smith, Ramaswamy and Simpson (1990) described that 20-60% CO_2 are required for effectiveness against aerobic spoilage.

The growth of anaerobic bacteria was shown in Fig. 6. The addition of organic acids detained the growth of anaerobic bacteria both in 50% CO_2-MAP and 100% N_2-MAP. Especially in 50% CO_2-MAP, organic acids inhibited the total colony of anaerobic bacteria form 8 to 18 day, while in the last day of storage, no difference was found. Critical points of bacteria related with the safety for consumers (7 log CFU/g), were reached at 18 day in the control, and by 18 to 22 day in organic acid treatments. In 100% N_2-MAP, addition of organic acids effectively inhibited the total colony of anaerobic bacteria, from 2 to 18 day.

IV. CONCLUSION

The Combination of organic acids and 50% CO_2-MAP is recommended for sliced bacon packaging. In this study, the combination of organic acids and 50% CO_2-MAP showed positive effects in pH value, lipid oxidation and protein deteroriation. This combination showed weak antibacterial effects, in which only in 8 to 18 day anaerobic bacterial counts was lower. Further research is needed in order to evaluate the corelation of organic acids concentration with MAP.

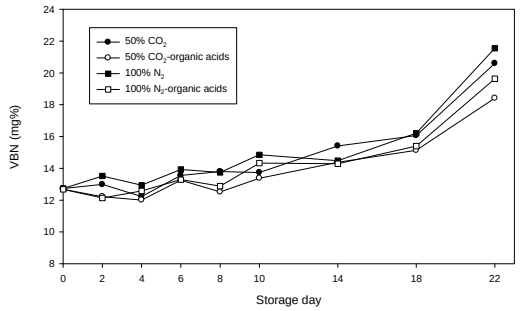

Fig. 3. Effect of organic acids and 50% CO_2-MAP on the VBN value of sliced bacon during storage at 5° C.

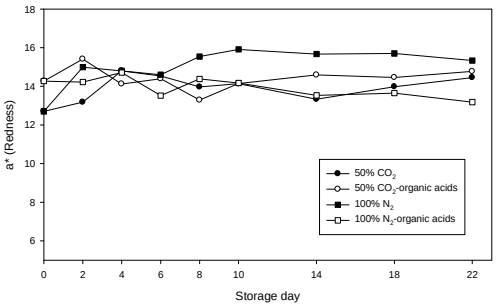

Fig. 4. Effect of organic acids and 50% CO_2-MAP on the a* value of sliced bacon during storage at 5°C.

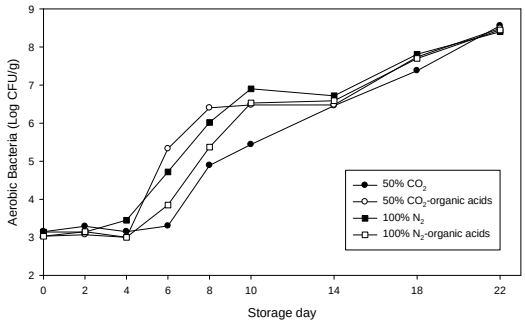

Fig. 5. Effect of organic acids and 50% CO_2-MAP on the aerobic bacterial counts of sliced bacon during storage at 5°C.

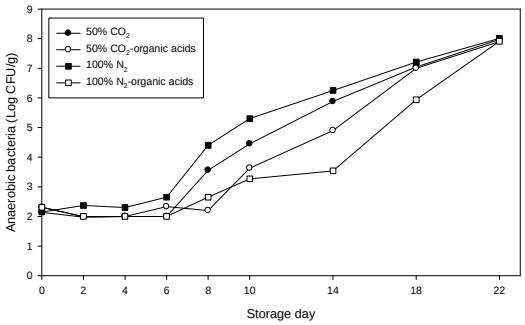

Fig. 6. Effect of organic acids and 50% CO_2-MAP on the anaerobic bacterial counts of sliced bacon during storage at 5°C.

ACKNOWLEDGEMENT

This study was supported by Technology Development Program for Agriculture and Forestry (108061-03-2-HD120), Ministry for Agriculture, Forestry and Fisheries, Republic of Korea.

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