EFFECT OF CHITOSAN ON PREMATURE BROWNING IN GROUND BEEF PATTIES

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***Abstract* — Our objective was to evaluate the usefulness of chitosan to minimize premature browning in refrigerated ground beef patties stored under aerobic packaging and high-oxygen modified atmosphere packaging. Ground beef patties (15% fat) with chitosan (1% w/w) or without chitosan (control) were packaged individually in aerobic packaging (AP) or high-oxygen modified atmosphere packaging (HO; 80% oxygen + 20% carbon dioxide), and stored for 3 days at 2°C. At the end of storage, raw surface redness was evaluated, patties were cooked to internal endpoint temperatures of either 66°C or 71°C, and internal cooked redness was determined. Chitosan-treated patties in AP as well as HO exhibited greater ($P < 0.05$) surface redness than controls. However, incorporation of chitosan increased ($P < 0.05$) interior redness of cooked patties stored only in AP, not ($P > 0.05$) in HO. Control and chitosan patties in AP demonstrated greater ($P < 0.05$) interior cooked redness at 66°C than at 71°C, whereas there was no effect ($P > 0.05$) of endpoint temperature in HO. The results of the present study suggested that incorporation of 1% chitosan could be utilized to minimize premature browning in ground beef patties stored under AP.**

***Index Terms* — Chitosan, Ground beef, Premature browning.**

I. INTRODUCTION

Cooking-induced myoglobin denaturation results in the characteristic dull-brown color of cooked beef. USDA (1997) recommends cooking ground beef to an internal temperature of 71°C to ensure destruction of the pathogen *Escherichia coli* O157:H7. However, consumers generally consider the dull-brown appearance of cooked beef as a reliable indicator of doneness and safety. Premature browning (PMB) is a condition in cooked ground beef where myoglobin denaturation, and subsequent browning, happens at a temperature lower than what is necessary to destroy foodborne pathogens.

Several extrinsic (packaging, antioxidant, and storage) factors influence the incidence of PMB in ground beef by altering myoglobin redox state and thermal stability (Suman et al., 2005; John et al., 2004; Mancini et al., 2010). Antioxidants such as erythorbate and lactate improve color stability of fresh meats. However, investigations undertaken by Suman et al. (2005) and Sepe et al. (2005) suggested that incorporation of erythorbate in ground beef minimized the incidence of PMB. On the other hand, lactate had no effect on PMB and internal cooked color of ground beef patties (Mancini et al., 2010).

Chitosan is a natural carbohydrate polymer from chitin and exerts antioxidant effect in ground beef. Darmadji and Izumimoto (1994) documented that incorporation of 1% chitosan in refrigerated minced beef was effective in minimizing lipid oxidation-induced quality deterioration. Studies by Georgantelis et al. (2007) demonstrated that chitosan improved lipid and color stability of frozen ground beef patties under aerobic packaging. Furthermore, our recent studies (Suman et al., 2010) reported that incorporation of chitosan minimized lipid oxidation and surface discoloration of refrigerated ground beef in a packaging-specific manner.

While several studies examined the effects of chitosan on color stability and lipid oxidation in fresh ground beef, the effect of chitosan on PMB was not investigated. Therefore, the objective of the present study was to evaluate the influence of chitosan on PMB in refrigerated ground beef patties.

II. MATERIALS AND METHODS

A. Preparation and storage of patties

Chubs (n = 8) of fresh coarse ground beef (15% fat, 4.5 kg) were obtained from a local purveyor. Each chub was sub-divided into two 2.25-kg batches. Chitosan (low molecular weight) was added to one batch to achieve a final concentration of 1% (w/w). The second batch received no chitosan and served as control. Control and chitosan-treated ground beef were mixed with hands for 5 minutes and ground through a 4.8-mm plate. Ground beef patties (100 g) were hand-prepared and assigned to 2 packaging systems: aerobic packaging (AP) and high-oxygen modified atmosphere packaging (HO; 80% oxygen + 20% carbon dioxide). Patties designated for AP were placed individually on Styrofoam trays, over soaker pads, and were over-wrapped with oxygen-permeable polyvinyl chloride fresh meat film. Patties assigned for HO were placed individually on Styrofoam trays, over soaker pads, and packaged with a Koch MultiVac 500 (Bunzl Koch Supplies, Kansas City, MO, USA), using Prime Source pouches (4 mil, Bunzl Koch Supplies, Kansas

City, MO, USA) and certified gas blend (Airgas East, Cheshire, CT, USA). Packaged patties were stored at 2°C for 3 days, in darkness, before raw color analyses and cooking.

B. Raw surface color evaluation

At the conclusion of storage, packages were opened, and *a** (redness) values were measured immediately at three random locations on each patty using a HunterLab MiniScan XE Plus colorimeter (HunterLab Associates, Reston, VA, USA) with 2.54-cm diameter aperture, illuminant A, and 10° standard observer (AMSA, 1991).

C. Cooking and internal cooked color evaluation

Immediately after raw surface color evaluation, patties were cooked to an internal temperature of either 66°C (typical PMB temperature) or 71°C (USDA-recommended temperature) in George Foreman clam-shell grills (Salton Inc., Columbia, MO, USA), with grill surface temperature maintained at 180°C. Patty internal temperature was monitored using a probe thermometer inserted into the geometric center. Patties were removed from the grill, when the desired endpoint temperature was reached, and were placed in a pouch (4 mil, Bunzl Koch Supplies, Kansas City, MO, USA), and submerged in ice for five minutes to minimize any post-cooking temperature rise. Five minutes after removal from the grill, cooked patties were sliced parallel to the grilled surfaces. Redness (*a** value) of the freshly cut interiors was measured at three random locations using a HunterLab MiniScan XE Plus spectrophotometer (HunterLab Associates, Reston, VA, USA) with 2.54-cm diameter aperture, illuminant A, and 10° standard observer (AMSA, 1991).

D. Statistical analysis

The experimental design was a split-plot with a randomized complete block in the whole-plot (n = 8). Each chub served as a block and each chub half received either 1% chitosan or no chitosan. Within the sub-plot, patties were assigned to combinations of packaging and endpoint temperature. Data were analyzed using the Mixed Procedure (SAS, 2007).

III. RESULTS AND DISCUSSION

The results of raw surface *a** value are presented in figure 1. Chitosan patties in AP as well as HO exhibited greater ($P < 0.05$) *a** values (redness) than their control counterparts. This finding suggested that incorporation of chitosan improved surface red color stability of ground beef patties stored under oxygen-rich environments. Our findings agreed with Georgantelis et al. (2007), who reported that chitosan incorporation at 1% level improved color stability of frozen ground beef patties.

Results of internal redness (*a**) of cooked patties are presented in figure 2. Chitosan, packaging, and endpoint temperature influenced ($P < 0.05$) a* value. At 66°C and 71°C, chitosan patties in AP exhibited greater ($P < 0.05$) internal redness (greater *a** value) than controls. In contrast, chitosan and control patties in HO did not demonstrate ($P > 0.05$) any differences in internal cooked redness at both endpoint temperatures. While internal redness of patties in AP decreased ($P < 0.05$) with an increase in endpoint temperature, no differences ($P > 0.05$) were observed between HO patties cooked to 66°C and 71°C. Interiors of chitosan patties from AP cooked to 66°C (typical PMB temperature) demonstrated greater ($P < 0.05$) redness than control ones. Consumers may tend to consider these chitosan patties as uncooked and thus would be inclined cook them for longer time enabling the destruction of foodborne pathogens. Furthermore, chitosan-treated patties stored in AP retained more interior redness than controls even at 71°C.

The observed effect of chitosan on PMB is different from those reported for lactate (Mancini et al., 2010). Lactate at 2.5% level exerted no effect on PMB in patties; control and lactate-treated patties exhibited no differences in internal redness when cooked to 66°C or 71°C. On the other hand, erythorbate was effective in minimizing PMB in refrigerated ground beef under aerobic packaging as well as in high-oxygen modified atmosphere packaging (Suman et al., 2005). Nevertheless, the effect of erythorbate on PMB was less prominent in high-oxygen modified atmosphere packaging than in aerobic packaging.

IV. CONCLUSION

With increasing consumer concerns about the health effects of synthetic antioxidants, use of natural antioxidants is becoming highly relevant in the meat industry. Although chitosan is used as an antioxidant in fresh meats, its use in cooked beef products is relatively novel. The findings of the present study indicated that incorporation of 1% chitosan in refrigerated ground beef patties minimized PMB in a packaging-specific manner. Chitosan minimizes PMB in patties stored under aerobic packaging, but was ineffective in high-oxygen modified atmosphere packaging. Cooked patties containing chitosan will appear more red, and consumers may tend to cook them for a longer duration, which ensures pathogen destruction. The beef industry may utilize chitosan as a natural ingredient to improve safety and color stability of refrigerated ground beef retailed under aerobic over-wrap packaging.

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Figure 1: Influence of chitosan and packaging on raw surface *a** value of refrigerated ground beef patties.
a-b Means without common superscripts are different (P < 0.05).
AP = Aerobic packaging; HO = 80% oxygen + 20% carbon dioxide modified atmosphere packaging.

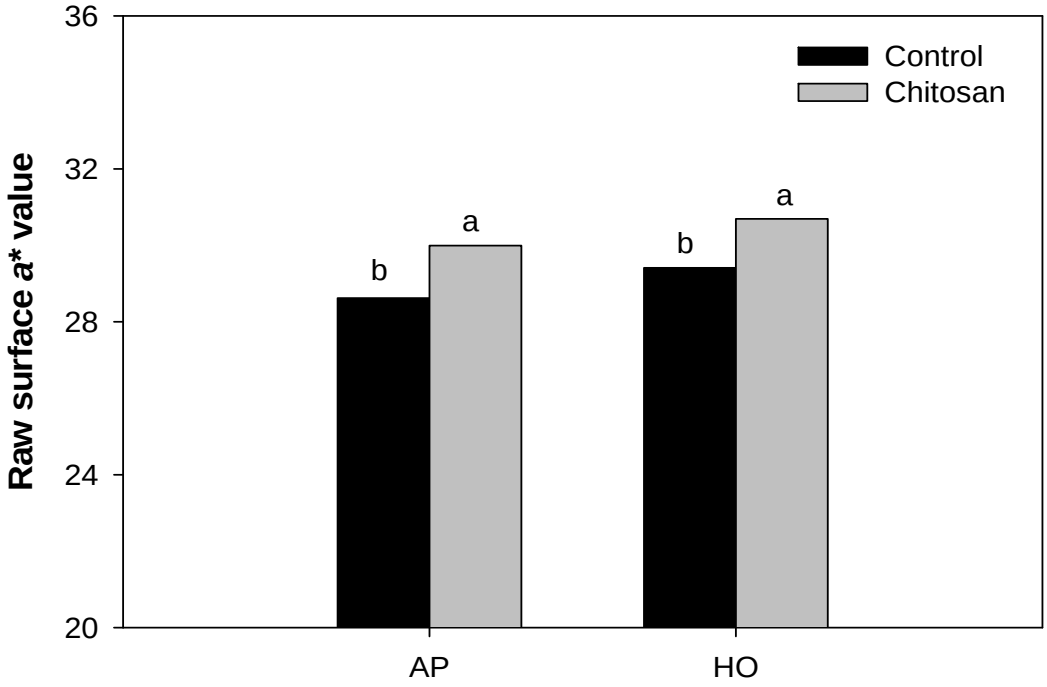

Figure 2: Influence of chitosan, packaging, and endpoint temperature on internal *a** value of cooked beef patties.
a-d Means without common superscripts are different (P < 0.05).
AP = Aerobic packaging; HO = 80% oxygen + 20% carbon dioxide modified atmosphere packaging.