ACTIVATED LACTOFERRIN ANTIMICROBIAL SPRAY ENHANCES SENSORY AND SHELF LIFE CHARACTERISTICS OF CASE-READY FRESH BEEF

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Background

Sensory and shelf life characteristics of perishable fresh meat products are the primary basis of any purchase intent. Consumers associate beef that is not bright cherry-red as unacceptable from a wholesomeness and freshness standpoint. When the percentage of oxidized myoglobin reaches 40 to 60%, muscle tissue will begin to exhibit characteristics of pigment discoloration and appear brown (Lawrie, 1985). Generally, at this point the products are discounted in price, discarded, or reworked into further processed items. The ability to increase color stability and discoloration from spoilage holds great profit potential.

Activated Lactoferrin (ALF) is a novel formulation of commercial (normal) lactoferrin for enhancing antimicrobial function by using a specific molecular-milieu optimization process (Naidu, 20001). This all-natural ALF formulation acts as a powerful deterrent to pathogenic or spoilage bacteria that may be present on meat or a processing equipment (Naidu & Nimmagudda, 2003). ALF is the first intervention technology with 'microbial blocking action" that detaches or prevents attachment of microorganisms to bio-surfaces and inhibition of growth multiplication of pathogens in a variety of applications (Naidu, 2002; Naidu et al., 2003).

Objectives

The main objective of this study is to assess the ability of ALF to enhance retail overall acceptability panel ratings as a result of reduced total plate counts while retaining desirable organoleptic characteristics of case-ready fresh beef strip loin steaks.

Methods

Sample Collection and Postmortem Handling. USDA Select, A maturity, yield grade 1 and 2 beef carcasses (n=40) either treated with ALF using a high-pressure spray or not treated (NT, control) were selected at random. Paired strip loins were acquired. One of each pair was randomly selected to receive ALF treatment of subprimals. After treatment, all strip loins (n=80) were individually identified, vacuum packaged, and tested. Paired strip loin samples were assigned randomly to a postmortem aging treatment of 14, 21, 28, or 35 d. The samples were allowed to age for the respective storage period at refrigeration temperatures. At the conclusion of the storage period, each strip loin was fabricated into halves and each half was fabricated into 2.54 cm steaks (n=4) using sanitized equipment and procedures. One half of each strip loin was chosen randomly to receive ALF treatment.

Retail Packaging and Shelf Life Evaluation. Each sample (n = 40 per treatment; treatments = 4) assigned to retail case display was placed in 0.6 EVOH modified atmosphere packaging (MAP) tray and sealed with Cryovac 1050 film within 20 minutes of retail fabrication. Packaging utilized the Mondini CVS 0.1-S MAP system (Harpack, Easton, MA). The optimal modified atmosphere of packages was 80% O_2 and 20% CO_2. All MAP samples were displayed in commercial retail display coffin cases under cool-white fluorescent light (1,600 to 1,900 lux) at 2 to 4°C for 14 days. Samples were subjectively evaluated twice daily (8:00 am and 5:00 pm) by a trained panel for lean color (8=bright cherry red; 1=extremely dark brown), fat color (8=creamy white; 1=dark brown or green), percentage discoloration (7=none; 1=complete), and overall appearance (7=extremely desirable, 1=extremely undesirable).

Total plate counts (TPC) of subprimals (n = 80) were taken from the fat surface of the strip loin after aging, prior to fabrication into steaks. Retail TPC (n = 320) were taken on the day of fabrication and after 14 days of retail display under MAP. Samples were diluted with peptone in a sterile stomacher bag and pummeled for 1 minute. The homogenate was spread plated on tryptic soy agar. Plates were incubated at 25°C for 48 hours, counted and reported in TPC per g.

Sensory Evaluation. Panelists trained for sensory analysis according to the American Meat Science Association (1995) guidelines were subjected to pure ALF to identify and establish subsequent flavors associated with the product's lexicon. Steaks (n = 160) were MAP packaged in the same manner as retail shelf-life samples for 6 days to allow exposure to modified atmosphere. Samples were then removed from MAP and repackaged in individual vacuum packages. Steaks were randomly selected for cooking day and order, then tempered for 24 hours at 4°C prior to cooking. Steaks were broiled in an impingement oven (Lincoln Impinger, Model 1132-00-A) at 180°C to an internal temperature of 65°C (medium degree of doneness). Temperatures were monitored by a Digi Sense type T thermocouple (Model 91100-20, Cole-Palmer Instrument Company, Vernon Hills, IL). During product testing, each session consisted of six trained panelists. Two cubic portions (1.3 cm x 1.3 cm x cooked steak thickness) from each sample were served warm to panelists under red light to masque variability. The average of the 2 portions was recorded. Samples were evaluated on tenderness (8=extremely tender; 1=extremely tough), juiciness (8=extremely juicy; 1=extremely tough), cooked beef flavor (3=strong; 1=not detectable), off flavor (3=strong; 1=not detectable), and overall acceptability (7=extremely desirable; 1=extremely undesirable). Between samples, panelists cleansed palate with unsalted cracker and distilled water.

Estimates of lipid oxidation on the surface of samples are made using the thiobarbituric acid (TBA) analysis. Results were recorded as thiobarbituric acid reactive substances (TBARS), which represent mg malondialdehyde (MDA) equivalents per kg of fresh beef. Warner-Bratzler shear force value measurements were obtained for each sample as a prediction of tenderness utilizing the Instron program software.

Generalized least squares (PROC GLM Version 8, SAS Institute, Cary, NC) was used to measure the effects of postmortem storage time and ALF treatment on retail shelf life, sensory analysis, thiobarbituric acid analysis, Warner Bratzler shear force, and total plate counts of paired strip loins. The model included 4 levels of postmortem storage time (14, 21, 28, 35 d) and of ALF application (control and treatment at subprimal and steak level). A predetermined significance level of $P < 0.05$ was used. Mean separation was completed using Least Significance Difference.

Results and Discussion

Retail Shelf Life Evaluation. ALF treatment demonstrated a statistically significant retail display as shown in *Table-1*. Regardless of postmortem storage time, steaks treated with a single application of ALF (i.e., NT/ALF or ALF/NT) remained brighter and consequently received higher, more desirable lean color ratings as compared to the remaining treatment groups [i.e., NT/NT (control group) or ALF/ALF]. During display days 4 through 6, steaks that received a single ALF treatment were brighter and displayed more cherry-red lean color when compared to their double treated (i.e., ALF/ALF) and control counterparts. Furthermore, the NT/ALF and ALF/NT samples exhibited longer

display times with acceptable lean color scores during the initial 9 days of display. Samples with a single ALF treatment, exhibited approximately an additional 48-h retail display with an acceptable lean color compared to the control beef steaks. These data suggested that ALF is an effective treatment for improving the retail color stability of MAP stored beef products.

When stratified by ALF application and postmortem storage time, steaks sprayed with a single ALF treatment originating from loins stored for either 14 or 21 days displayed less discoloration (i.e., <10% lean surface discoloration) for approximately 10 and 24 hours more than ($P<0.05$) control steaks, respectively. Results notably indicated that a single ALF application (ALF/NT and NT/ALF) retarded lean discoloration during critical retail display day when samples were approaching unacceptability thresholds. Following a 28-day storage period, all steaks treated with ALF exhibited less lean surface discoloration compared to the control counterparts. However, following extended postmortem storage periods (i.e., 35 days postmortem), steaks receiving the double treatment application, i.e. ALF/ALF, showed less ($P < 0.05$) surface discoloration when compared to NT/ALF, ALF/NT and control samples.

Following 14 days of postmortem aging, control strip loin subprimals were found contaminated. In contrast, steaks sprayed with ALF prior to MAP, contained significantly less TPC than the remaining steaks following a 14 day postmortem aging period. Strip loin steaks aged for 28 days that received the ALF/NT treatment application displayed significantly ($P < 0.05$) lower TPC than control steaks.

Sensory Analysis. ALF treatment of steaks with either a single- or double-dose of ALF resulted in statistically favored ($P < .05$) steaks in terms of detectable off flavors when compared to the control steaks. Analysis of tenderness, juiciness, and flavor intensity and overall acceptability ratings revealed no differences ($P > 0.05$) between treatment groups. These sensory data confirmed that preferred organoleptic properties of beefsteaks remain unaffected by ALF treatment *(Table-2)*.

Based on Warner-Bratzler shear force analysis, all treatment means were considered "tender" and these data clearly implied that ALF treatment did not adversely affect tenderness of fresh beef processed under commercial postmortem handling and storage conditions.

TABLE-1: Effects of ALF treatment on lean color scores of retail display steaks

Retail Display	Overall lean color score			
	ALF/ALF[2]	ALF/NT	NT/ALF	Control
Day-1	8.00	8.00	8.00	8.00
Day-2	6.90^{x}	6.86^{x}	6.87^{x}	6.67^{y}
Day-3	6.58^{xy}	6.77^{x}	6.72^{x}	6.18^{y}
Day-4	5.98^{y}	6.37^{x}	6.58^{x}	5.73^{z}
Day-5	5.88^{y}	6.17^{x}	6.43^{x}	5.35^{z}
Day-6	5.21^{y}	5.94^{x}	5.81^{x}	4.87^{z}
Day-7	4.77^{xy}	5.39^{x}	5.10^{x}	4.11^{y}
Day-8	4.26^{xy}	4.81^{x}	4.32^{x}	3.93^{y}
Day-9	3.82^{xy}	4.18^{x}	4.25^{x}	3.23^{y}
Day-10	3.46	3.64	3.04	2.91
Day-11	2.59	2.87	2.64	2.70
Day-12	2.22	2.22	2.42	1.72
Day-13	1.35	1.33	1.41	1.46
Day-14	1.27	1.35	1.33	1.43

Lean Color Score: **8**= Bright Cherry-Red, **7**= Moderately Bright Cherry, **6**= Cherry-Red, **5**= Slightly Dark Red, **4**= Moderately Dark Red or Brown, **3**= Dark Red or Brown, **2**= Very Dark Brown, **1**= Extremely Dark Brown
^{xyz} Means in a row without a common superscript letter differ ($p<0.05$)

TABLE-2: Palatability attributes for strip loin steaks stratified by ALF treatment.

Trait	Palatability Attributes			
	ALF/ALF	ALF/NT	NT/ALF	Control
Tenderness[a]	6.23	6.12	6.13	6.23
Juiciness[b]	5.98	5.72	5.63	5.87
Flavor intensity[c]	1.84	1.82	1.78	1.89
Off flavor[d]	1.30^{y}	1.35^{y}	1.41^{y}	1.52^{x}
Acceptability[e]	5.14	5.33	5.35	4.97

[a]**Tenderness**: 1=extremely tough, 8=extremely tender
[b]**Juiciness**: 1=extremely dry, 8=extremely juicy
[c]**Flavor intensity**: 1=extremely bland, 8=extremely intense
[d]**Off flavor**: 3=Strong, 1=Not Detectable
[e]**Overall Acceptability**: 1=extremely undesirable, 7=extremely desirable
^{xy} within a row, LS means without a common superscript letter differ ($p<0.05$)

Conclusions

This study demonstrated that incorporation of ALF via high-pressure spray to carcasses, subprimals or retail fresh beef cuts has significantly improved the retail stability and microbiological keeping quality of fresh retail beef cuts. Therefore, ALF application as a final step in a multiple-hurdle decontamination system and ALF treatment of subprimals at packaging and fabrication for retail display could provide a safe, wholesome, fresh beef. ALF could serve as a 'safety belt' for both processing and post-processing protection of beef against potential pathogens as well as spoilage organisms.

References

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