THE UTILIZATION OF MODIFIED ATMOSPHERIC-PACKAGING (MAP) ASSOCIATED WITH OXYGEN SCAVENGERS TO PREVENT THE TRANSIENT DISCOLORATION OF RUMP AND STRIPLOIN STEAKS

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Retail slices of rump (*Gluteus medius*, GM) and striploins (*Longissimus dorsi*, LD) steaks were master packaged under CO_2 and stored at 1 ± 1^oC for 14, 28, 35, and 42 days. A commercial oxygen scavenger (ATCO HV1000®) was also tested to achieve an oxygen-free atmosphere. Controls without O_2 scavengers were prepared in the same manner. At each storage time, two master-packs with and two without the oxygen scavenger were opened, and the trays were placed in a retail-display case at 4 ± 2^oC for 1, 24, and 48h. The low growth rate of aerobic psychrophilic flora on the beefsteaks clearly demonstrated the bacteriostatic effect of CO_2 during storage. The maximum level of bacterial growth reached during retail display was approximately 10^6 UFC/g after 42 days of storage in MAP. The steaks stored in master-packs with the oxygen scavenger bloomed to the desired red color associated with freshly cut meat in the display case for the entire storage period, except in the case of GM steaks that showed a cycle of transient discolorations. The rump and striploins steaks stored without oxygen scavenger failed to bloom. After 42 days of storage, the acceptability of the rump and striploins steaks stored in oxygen-free atmosphere was 49% and 77%, respectively.

Key Words: modified atmosphere, CO2, transient discoloration, rump and striploins steaks

Introduction

The color of fresh meat is the most important quality parameter to attract the consumer at the time of purchase. A bright-red color is desired for beef offered for retail sale. The coloration of fresh beef depends on the relative amounts of three forms of myoglobin: reduced myoglobin (ruby), oxymyoglobin (red), and metmyoglobin (brown). The atmosphere of the packaged meat can affect the color. A transient discoloration can occur during the initial storage period in packaging with a modified atmosphere that has a low concentration of oxygen. If the amount of residual oxygen is not excessive (<0.06%), the transient discoloration of beef striploins will be resolved in two days (Gill & McGinnis, 1995). However, slices of tenderloins, which have a lower stability to color oxidation, undergo two cycles of transient discoloration when stored in a CO_2 atmosphere for 4 and 7 days due to the presence of residual oxygen (Tewari, Jayas, Jeremiah et al., 2001). This difference in color stability within different meat cuts is the result of metmyoglobin-reducing activity (MRA) or other reducing factors (O'Keeffe & Hood, 1981a,b).

Objectives

The objective of the present study was to assess, under pilot plant conditions, the efficacy of a commercial self-activating oxygen scavenger to prevent transient discoloration of fresh beef with different oxidative color stability, such as rump and striploins beefsteaks stored under pure CO_2 in master-packs at 1±1°C.

Methodology

Vacuum-packaged eye of rump and striploins were cut into approximately 10-15-mm-thick slices and were placed in an expanded polystyrene tray on a liquid soak pad. Each tray was over-wrapped with clear PVC thermosealed film (11μm, Goodyear®) presenting a high O_2 transmission rate of about 12,232 cm^3 (STP)/m^2/day at 25°C, 75% R.H. and 1 atm. After sealing, four trays with rump and four with striploins were placed in an alternated manner inside of a master-pack (434 x 582 mm) with an O_2 transmission rate of 19 mL (STP)/m^2/day at 25ºC, 75% R.H. and 1 atm. The master-packs filled with 3.5 L of pure CO_2/kg of meat were evacuated using a 'double vacuum-flush' cycle, and sealed using a gas flushing system (A300, CVP Systems Ltd., USA). Immediately before sealing, a commercial oxygen scavenger formulated to reduce 1000cm^3 of O_2 (ATCO® HV1000, Standa Industrie, France) was placed into each master-pack. Moreover, master-packs without O_2 scavengers were prepared in the same way to represent the residual oxygen effects on the meat color. All packs were stored in a cold chamber in the dark for up to 42 days at 1±1°C. After 14, 28, 35, and 42 days of storage, the master-packs were removed from the chamber. The O_2 concentration (%) was analyzed immediately before opening the master-packs using an O_2 gas-analyzer (PBI Dansensor). After the gas analysis, the rump and striploin trays were taken from the master-packs and randomly placed in an illuminated (fluorescent light) retail-display case in ambient air at 5±1°C for 48h for subjective and objective color evaluations. The data was obtained through the transparent shrink film on each day of retail display. Color instrumental measurement was carried out with a portable spectrophotometer (model CM 508d, Minolta Co. Inc., New Yersey, USA). The average of eight readings was recorded for each steak of tray. The reflectance port size was 25mm. The illuminant was D_{65}, the observer angle was 10° and the specular component was excluded.

The red visual color of steaks was evaluation on a non structured scale of 9 cm, anchired with colored chips from Munsell´s Atlas which followed the color changes occurring in fresh meat, where 0 cm = none red color; 5.5 red; 7 = brownish red and 9 cm = reddish brown color. Lean discoloration was scored on a six-point scale where 1 = no discoloration, 2 = 5% discoloration, 3 = 5 – 15% discoloration, 4 = 15-25% discoloration, 5 = 25-35% discoloration, 6 = 35-100% discoloration and global appearance was anchored on seven point scale where 1 = extremely unacceptable, 2 = moderately unacceptable, 3 = slightly unacceptable, 4 = neither acceptable nor unacceptable, 5 = slightly acceptable, 6 = moderately unacceptable and 7 = extremely unacceptable.

The acceptance of the meat color by consumers was evaluated 42 days after storage under MAP through the application of a Test of Central Localization.

The effects of packaging system (with and without scavenger system), storage time (14, 28, 35 e 42 days) and display time (1 and 48h) and that of their interaction effects were evaluated by analysis of variance – ANOVA (SAS Institute Incorporated, Cary, North Carolina, USA, 1988). When $p<0.05$, significant effects were observed. The experiment was replicated 8 times.

Results & Discussion

On the processing day, the meat showed a normal pH (5.5 ± 0.12). However, during the storage under MAP (0, 14, 28, 35, and 42 days), the rump and striploin steaks packed with and without oxygen scavengers showed low pH variations (<0.03). A non-significant quantity of air was kept inside of a few master-packs after the thermosealing. The residual concentration of oxygen in the master-packs with oxygen scavengers was lower than 0.1% after 14 days post-storage. The Table 1 summarises the results of the variance analysis (ANOVA) for color parameters of steaks stored into different packaging systems (with or without scavengers). The saturation index (C*), which is an indicator of color intensity, clearly showed the need for oxygen scavengers in the master-pack for the occurrence of the re-blooming of the color. During the MAP storage all steaks stored with oxygen scavengers had highest C*, visual red and appearance (<0.000) when compared to steaks stored without scavengers, where the oxidation of the red color on the beef surface was followed by a significant reduction of these parameters. Within the CIELAB system, the re-blooming with time for rump steaks is seen clearly in a large increase in C* and R_{630}-R_{580} with decrease in L*, h* values. Rump steaks stored under MAP in the presence of oxygen scavengers had a discoloration percentage significantly inferior to the steaks stored without scavengers (<0.000) (Table 1), although up to the 14^{th} day under MAP, these steaks had a similar discoloration percentage when compared those products stored without oxygen scavengers that had the visual color and the overall appearance seriously impaired. This discoloration was resolved in the subsequent storage periods when the concentration of oxygen was <0.1%.

Beef striploins stored under MAP with oxygen scavengers bloomed to the desired red color associated with freshly cut meat 1h after displaying in air and had almost no discoloration despite of the measurable oxygen residual, whereas steaks without oxygen scavengers showed a superior discoloration ($p>0.05$) and failed to bloom for all storage times. The irreversible discoloration observed in these steaks stored without oxygen scavenger was probably the result of excessive residual O_2 in these master-packs during the storage period under MAP (0.7-3.2%).

The color parameters did not differ significantly during the aerobic exposure (48 h) after each storage period under MAP.

After 42 days of storage under MAP, the trays with rump with oxygen scavengers were considered acceptable by 49% and striploins by 77% of the 80 consumers that responded ‘probably would buy’ or ‘certainly would buy’ these products. The fat of the steaks stored under MAP with oxygen scavengers was infiltrated with the meat pigment, and it conferred a pinkish color to the tissue exposed to air, thus influencing positively the acceptance of the products.

The perception of a greater volume of exudates, by certain consumers, in the trays with rump steaks probably had a significant impact at the purchase time. A greater

volume of liquid in trays can be prevented with a pad that has a better absorption capacity.

Conclusions

Self-activating oxygen scavenger in association with MAP under CO_2 was more successful for LD than GM steaks in preventing transient discoloration and extending the shelf life of fresh beef. Effective removal of air is critical for extending the storage life of retail-ready fresh beef products in master-packaged under a CO_2 atmosphere. Better results could be obtained by evacuating the master-packs within a machine with vacuum chamber, which is designed to optimize the removal of air from the master-packs at the time of sealing.

References

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Tables and Figures

Table 1. Results of the variance analysis on color characteristics.

Effect		L*	C*	h*	C	visual red[b]	Discolor (%)[d]	Global appearance
Packaging		**	***	*	***	***	***	***
Storage		***	***	***	***	NS	NS	***
Display		NS	NS	NS	*	***	***	***
Packaging *Storage	GM	NS	***	NS	***	NS	NS	**
Packaging * Display		NS	*	NS	NS	***	***	***
Storage*Display		NS	NS	NS	**	NS	NS	**
Packaging *Storage* Display		NS	NS	NS	NS	NS	NS	***
Packaging		*	***	NS	NS	***	***	***
Storage		NS	NS	NS	NS	***	*	***
Display		NS	NS	NS	NS	NS	*	***
Packaging *Storage	LD	NS	*	NS	NS	***	***	***
Packaging * Display		NS	NS	NS	NS	NS	NS	NS
Storage*Display		NS	NS	NS	NS	***	*	*
Packaging *Storage* Display		NS	NS	NS	NS	NS	NS	*

Packaging system: Masterpack system with or without oxygen scavengers.

L*=lightness; $C^* = (a^{*2} + b^{*2})^{1/2}$; h*: arctan(b*/a*)

Visual red (lean): 0 cm = none; red color = 5.5; brownish red = 7 and 9 cm = reddish brown

Discoloration %: 1 = no discoloration, 2 = 5% discoloration, 3 = 5-15% discoloration, 4 = 15-25% discoloration, 5 = 25-35% discoloration, 6 = 35-100% discoloration.

*** $p<0.001$

** $p<0.01$

* $p<0.05$

NS: not significant ($p>0.05$)