PHISICO-CHEMICAL CHANGES OF FRESH BEEF FROM CROSSBRED BRAHAMN HEIFERS DURING STORAGE

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Abstract - To study the effects of packaging type (overwrap and vacuum) and storage time (1, 3, and 7 days) on color stability, myoglobin attributes, and lipid oxidation stability of fresh beef (*M. semimembranosus*) stored at 3 °C in refrigerator. The interaction of packaging and storage time affected myoglobin and thiobarbituric acid reactive substances (TBARS) (P<0.05). Overwrap-packed beef had a greater lightness (L*), hue angle (h*), lightness change (ΔL*), total color differences (ΔE), metmyoglobin (MMb), oxymyoglobin (OMb) and TBARS (P<0.05), and increased with shelf-life (P<0.05) compared to vacuum-packed beef. However, the decrease in redness (a*), redness change (Δa*), and deoxymyoglobin (DMb) were observed (P<0.05) over time. Therefore, beef stored in a vacuum package could maintain a better shelf life.

Key words - beef, packaging type, storage time

I. INTRODUCTION

Freshness of raw meat color is one of the first qualities that interest consumers and influence their decisions. The extending color stability is therefore necessary for suppliers [1]. The muscle color comes from myoglobin, which can be changed into three different forms: deoxymyoglobin (DMb, purplish-red), oxymyoglobin (OMb, bright cherry red), and metmyoglobin (MMb, brown), depending on its binding to oxygen [2]. Meat deterioration depends on several factors, including species, animal genetics and feeding background, postmortem changes, packaging and display time, and light exposure [1], which especially affects meat color, pigment, and lipid oxidation. To preserve and provide a longer shelf life, several researches with different packaging and time were conducted [3]. For retail display packaging, conventional overwrap is widely used; however, the vacuum packaging has been newly developed. These packages have been used to maintain meat quality attributes as well [4]. However, the results of several studies were sometimes different. The objective of this study was to investigate the effects of packaging and storage time on the quality changes of beef. The attributes of raw beef color, myoglobin, and lipid oxidation were evaluated at 1, 3, and 7 days.

II. MATERIALS AND METHODS

A total of eighteen crossbred Brahman beef cattle from previous feeding trial, 15-18 years old with average body weight at 203.31±21.35 kg, were slaughtered and determined for carcass traits and meat quality. Fresh meats from round cuts (*semimembranosus* muscles) were obtained from these beef. Summarized data of meat quality attributes of the beef is shown in Table 1. The right sides of the round meat were cut into 3×3×3 cm^3. Three chops were kept in tray overwrapping with air permeable film, and other equal slices were aluminum foil vacuum bag packaged. All meat samples were stored in a refrigerator at 2-4°C for 1, 3, and 7 days. The meat color and myoglobin were tested and the samples were immediately frozen at -30°C, avoiding oxidation until analysis for TBARS. Lightness (L*), redness (a*), and yellowness (b*) of meat were tested by using Minolta CR-10 colorimeter according to the CIELAB color system [5]. L*, a*, and b* were used to calculate, chroma (C*), hue angle (h*), color changes (ΔL*, Δa*, Δb*, ΔC*, and Δh*), and total color difference (ΔE). Myoglobin derivatives were evaluated according to the

method of Faustman and Phillips (2001). The spectrophotometry method of Buege and Aust [6] was used to determine the secondary products of lipid oxidation, expressed as milligram of malondialdehyde per kilogram of meat. All data from the experimental measurement was submitted to ANOVA for 2 × 3 factorial arrangements in CRD, two packaging types, and three storage times using PROC GLM of the Statistical Analysis Systems Institute [7].

Table 1 Summary statistics of *semimembranosus* muscles quality using in the experiment (n=18)

Items	Min.	Max.	Mean	SD
L*	30.46	35.86	33.02	1.60
a*	11.80	15.00	13.70	1.14
b*	6.60	10.80	8.56	1.18
C*	14.54	17.55	16.21	0.88
h*	23.88	41.99	32.03	4.92
pH	5.33	6.00	5.67	0.16
Drip loss (%)	3.10	5.16	4.23	0.58
Cooking loss (%)	26.67	32.86	30.50	1.52
WBSF (kg/cm^2)	4.10	4.63	4.26	0.12
Moisture (%)	72.44	73.30	72.89	0.25
Crude protein (%)	22.40	23.60	22.88	0.30
Fat (%)	2.81	3.40	3.12	0.16
Ash (%)	1.04	1.17	1.11	0.04
α-toc (μg/g meat)	1.01	2.60	1.93	0.51

Min = minimum, Max = maximum WBSF = Warner-Bratzler shear force, α-toc = α-tocopherol

III. RESULTS AND DISCUSSION

As shown in Tables 2 and 3, packaging or storage time had no effect on b*, Δb*, ΔC*, and Δh* colors. Overwrap-packed beef had higher L*, ΔL, ΔE ($P<0.01$), and h* ($P<0.05$) values than vacuum-packed beef. In contrast to a* and Δa* colors, the vacuum-packed beef had a stronger redness and more redness stability than overwrap group. Moreover, L*, h*, ΔL*, and ΔE ($P<0.01$) values also statistically increased over time. The decrease of a* value with a significantly influence ($P<0.01$) was found on 7-d postmortem. At 7-d of storage, the total color difference was also greater ($P<0.01$) than beef stored at 3 and 1 days. The reduction of redness and the increase of whiteness could be related to an increase in lipid oxidation when the meat is exposed to air or light [8]. Increasing of the h* value was associated with decreasing of the a* value, as supported by Kim *et al.* [9] who noted that higher h* meant lower a* as well as more MMb. Finally, the total color differences value was more in beef from the overwrap (2.81) than the vacuum (2.16) group, and linearly increased over time (1.97, 2.45, and 3.04, respectively). There has been little work done for measurement of the ΔE in meat. However, the increase in ΔE has been correlated with the high value of lightness, chroma, and TBARS, linking to more meat discoloration.

Table 4 showed that the meat of longer storage time in both groups was significantly darker (higher MMb, 20 vs. 16%, $P<0.05$) than beef from shorter period. The MMb of more than by 20% causes problems in the meat industry [10]. At 40% or more, meat was unaccepted by consumers [11]. The purple meat significantly increased (higher DMb, $P<0.01$) in the vacuum-packed beef, but in the overwrap-packed beef, the value decreased after 1-d of storage. The linearly decreased of DMb concentration during storage in overwrap-packed beef could also be due to high oxygen binding with myoglobin. However, after 3-d of storage, the bright cherry red (more OMb) increased in the overwrap group but decreased in the vacuum group. The relative myoglobin derivatives was the combination of O_2 and myoglobin pigment [2], when combined with oxygen, the purple pigment (DMb) changed from dark red to bright-cherry red (OMb) and then oxidized to brown color (MMb).

Table 2 Effects of packaging type and storage time on color stability of beef

Items	L*	a*	b*	C*	h*
Package (A)					
Overwrap	34.93^a	13.42^b	8.87	16.10	33.51^a
Vacuum	33.75^b	13.74^a	8.77	16.32	32.55^b
Storage time (B)					
1-d	33.59^c	13.77^a	8.58	16.25	31.95^b
3-d	34.58^b	13.62^a	8.98	16.33	33.40^a
7-d	35.15^a	13.32^b	8.91	16.05	33.74^a
P-value					
A	<0.01	<0.01	0.49	0.05	0.04
B	<0.01	<0.01	0.07	0.11	<0.01
A*B	0.75	0.48	0.62	0.31	0.87

[a,b,c] Different letters in column indicate significantly different (P<0.05).

Table 3 Effects of packaging type and storage time on color changes of beef

Items	ΔL*	Δa*	Δb*	ΔC*	Δh*	ΔE
Package (A)						
Overwrap	1.91[a]	-0.28[b]	0.32	-0.10	1.48	2.81[a]
Vacuum	0.73[b]	0.03[a]	0.22	0.11	0.53	2.16[b]
Storage time (B)						
1-d	0.57[b]	0.08[a]	0.02	0.04	-0.08	1.97[b]
3-d	1.26[b]	-0.07[ab]	0.42	0.12	1.38	2.45[b]
7-d	2.13[a]	-0.37[b]	0.36	-0.16	1.72	3.04[a]
P-value						
A	<0.01	0.01	0.69	0.15	0.27	<0.01
B	<0.01	0.02	0.40	0.32	0.20	<0.01
A*B	0.86	0.70	0.85	0.54	0.95	0.73

[a,b] Different letters in column indicate significantly different (P<0.05).

The beef packed under overwrap (0.304) had more rancidity (P<0.01) than those beef from vacuum condition (0.220 mg MDA/kg meat) where the rancidity gradually increased over time. The lower MDA value in vacuum-packaged meat could be explain by the limitation of oxygen to induce the oxidation reaction of lipid during storage [12]. Finally, the TBARS values for 7-d storage time of all conditions were below 0.5 mg/kg meat, and the value reached to 0.5-1.0 regarding off-odor [13]. Therefore, the beef still in normal condition.

Table 4 Effects of packaging type and storage time on myoglobin and lipid oxidation of beef

Items	MMb	DMb	OMb	TBARS
Packaging (A)				
Overwrap	20.04[a]	33.41[b]	47.13[a]	0.304[a]
Vacuum	16.71[b]	42.81[a]	42.66[b]	0.220[b]
Storage time (B)				
1-d	15.74[c]	39.08[a]	45.18[ab]	0.236[b]
3-d	17.66[b]	37.08[b]	45.27[a]	0.273[a]
7-d	21.73[a]	34.02[c]	44.24[b]	0.278[a]
P-value				
A	<0.01	<0.01	<0.01	<0.01
B	<0.01	<0.01	0.06	<0.01
A*B	<0.01	<0.01	<0.01	<0.01

[a,b,c] Different letters in column indicate significantly different (P<0.05).

IV. CONCLUSION

The results of this study revealed that myoglobin and TBARS were affected by packaging and storage time. Packaging influenced lightness, redness, hue angle, lightness change, redness change, total color differences, metmyoglobin, and lipid oxidation values. The lightness, hue angle, lightness change, and total color difference also increased with storage time, which indicates a reduction of meat quality. The vacuum-packed beef showed greater redness and less oxidation and total color differences than overwrap-packed beef. Based on color properties, myoglobin attributes, and TBARS the shelf life quality of all packaging extended to 7-d, except MMb in overwrap. It have been therefore concluded that beef stored in vacuum packaging could improve beef color, myoglobin, and lipid stability.

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