

Lipid Oxidation and Color Changes of Fresh Camel Meat Stored Under Different Atmosphere Packaging Systems

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Abstract

Lipid oxidation, color and sensory attributes of fresh camel meat stored at 4°C were affected by modified atmosphere packaging conditions (AP: Air packaging, VP: Vacuum packaging, MAP: 60% CO₂+40% N₂). The a* value were lower in samples packed under vacuum than in the other groups. Modified atmosphere packaging camel meat had no significantly (P<0.05) different TBARS value and the levels of TBARS were not positively correlated with storage time. Our study showed that even though oxidative rancidity (TBARS) increased with storage time in air-packaged samples, it did not result the deterioration of sensory quality until day 14. Sensory panel results were in general agreement with the physicochemical changes, suggesting that the MAP had a significant impact on the quality of refrigerated camel meat. Modified atmosphere packaging of fresh camel meat accompanied by refrigeration storage enhanced product shelf life for 21 days without undesirable and detrimental effects on its sensory acceptability.

Keywords: Oxidation; Camel; Sensory evaluation; Color

Introduction

Extension of the shelf-life of meat was one of the technological necessities to meet the demands of consumers. In this respect, increasing attention was put on packaging techniques. Modified atmosphere packaging (MAP) is the recent innovation that has been gaining importance as preservation technique to improve the shelf-life of meat. Retention of meat color was better in MAP than in either vacuum packaging or in air [1]. Modified atmosphere packing has been used for increased distribution range and longer shelf-life. The effects and roles of the gases normally used in the modified atmospheres (O₂, CO₂ and N₂) have been extensively reported [2-4]. Hood and Mead (1995) indicated that the effects which the mixture of gas produces in meat quality, such as color and shelf life, are the principal factors that should be considered when choosing the gas mixture [5]. In addition, Gill affirmed that the principal factors to be addressed in the preservation of chilled meat are the retention of an attractive, fresh appearance for the product displayed, and the retardation of bacterial spoilage [3]. Several studies have been carried out on the physical, chemical composition, sensory properties and nutritive values of camel meat [6-11]. No data has been published on the preservation of fresh camel meat by modified atmosphere packaging. Our objective was to investigate the color and lipid oxidation changes of fresh camel meat using modified atmosphere packaging under refrigeration.

Material and Methods

Sampling preparation and packaging

Camel meat samples were obtained at a slaughter house (Tehran, Iran). Any visible fat was removed from the muscle tissues. A Turbovac packaging machine, model A 200, (Henkelman, Netherlands) was used for packing. Meat samples were randomly assigned to one of the three types of different atmospheres packaging (AP: Air packaging, VP: Vacuum packaging, MAP: 60% CO₂+40% N₂) using sterile polyester polyethylene (PET/Poly) pouches (thickness – 62 μm).

Lipid oxidation

Lipid oxidation was evaluated by the determination of thiobarbituric acid reactive substances (TBARS) using the extraction method

described by Witte, et al. [12]. Twenty grams of the minced meat were blended with 50 mL of cold solution containing 20% trichloroacetic acid in 2M phosphoric acid for 2 min. The resulting slurry was then transferred into a 100 mL volumetric flask. The slurry was diluted to 100 mL with double-distilled water, homogenized by shaking and filtered through Whatman no. 1 filter paper. 5 mL of the filtrate was then pipetted into a test tube and 5 mL of fresh chilled 2-thiobarbituric acid (0.005 M in double distilled water) was added. The test tube was shaken well and placed in the dark at room temperature (25°C) for 15 h to develop the color reaction. The resulting color was measured in a spectrophotometer at 530 nm to calculate the TBARS value. The results were expressed as mg malonaldehyde/kg meat.

Color measurement

Color was recorded using a Minolta Chroma meter CR-400 KON made in Japan. Readings at per sample, in the center of the steak was taken. CIELAB system, L* (lightness), a* (redness) and b* (yellowness) were measured [13].

Chroma (c*ab) was calculated as Eq. (1): $C^*ab = [(a^*(^2) + b^*(^2))]^{1/2}$

Furthermore, the hue angle (h*ab) was calculated as Eq. (2): $h^*ab = \arctan (b^*/a^*)$

Sensory analysis

Camel meat samples were evaluated by eight semi-trained panelists. The panelists consisted of staff members in the Dept. of Meat Science, University of Tehran. Panelists were given an orientation for

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30 min about appearance (color), odor, texture and overall quality of fresh camel meat. Acceptability of raw meat was evaluated using a 9-point hedonic scale, where 9=like extremely, 8=like very much, 7=like moderately, 6=like slightly, 5=neither like nor dislike, 4=dislike slightly, 3=dislike moderately, 2=dislike very much, and 1=dislike extremely [14]. Scores from 6 to 9 were considered acceptable [15]. Evaluation was performed under cool white fluorescent light in the sensory laboratory. The same meat samples were evaluated over storage times. The shelf life limit was defined as the point when 50% of the panelists rejected the sample.

Statistical analysis

The data were analyzed using analysis of variance to determine the effects of MA type (1, 2, 3, and 4) on the parameters of meat quality: color, lipid oxidation and SF. When the differences among types of MA were significant ($P < 0.05$), Tukey's test was carried out to check the differences between pairs of groups. The effect of storage for each treatment packing on meat quality was analyzed using Tukey's test at a significance level of $P < 0.05$. Data were analyzed using the SAS (1988) statistical package [16].

Results and Discussions

Lipid oxidation

TBARS values for different atmosphere packaged camel meat samples are shown in figure 1. Duration of the storage affected the overall TBARS formation of the meat ($P < 0.01$). The amounts of malondialdehyde (MDA) increased during chilled storage with significant difference ($P < 0.05$). Time had significant influence ($P < 0.01$) on the development of oxidation in aerobically packaged camel similarly to the anaerobically packaged (Figure 1). The amounts of MDA formed during chilled storage were in the range 0.20-0.28 mg/kg meat and reached 0.58 and 89 mg/kg meat for MA-Packaging and Air-Packaging on the 21st day respectively, indicating a low degree of lipid oxidation. Modified atmosphere packaging camel meat had not significantly ($P < 0.05$) different TBARS value and the levels of TBARS weren't positively correlated with storage time. After 21 days of storage the highest TBARS values were found in AP. A comparison was made between the values of the TBARS formed in the common intervals of the three types of storage of camel meat samples. Air-Packaged samples showed higher content of TBARS when subsequently chilled, compared to the vacuum-packaged and MA-Packaged meat. In AP, VP and MAP, the amounts of TBARS formed in the course of storage were far below the critical value of 3 mg/kg at which rancidity is detected

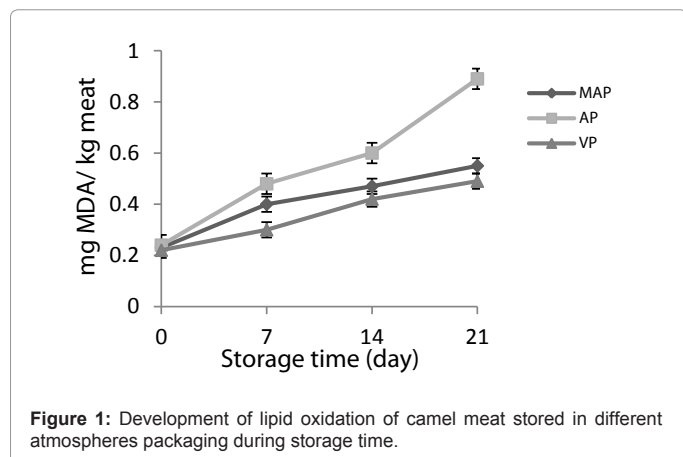


Figure 1: Development of lipid oxidation of camel meat stored in different atmospheres packaging during storage time.

[17]. It could be supposed that the low intensity of oxidative processes was due to the raising mode of the studied animals which provided natural antioxidants, such as vitamin E, carotenoids, etc. [18]. It was shown that pasture [19] increased significantly the content of vitamin E in bovine muscles and hence reduces the development of oxidation in meat.

Color

Results of color measurement are shown in (Table 2). Initial values for L^* , a^* , b^* and Chroma were 34.49, 20.12, 7.59 and 22.74 respectively. The L^* value increase by 21 days with time in all groups and reached significant levels ($P < 0.05$) in AP, with this usually being attributed to the oxidation of heme pigments [20]. The lowest L values after 21 days corresponded to samples under Vacuum packaging which showed significant differences with samples under Air. Parameter b^* (yellowness) increased by 21 days for of storage only in for camel meat during storage under Air, but no significant differences were found among samples packed under vacuum and MAP at the end of 21 days for yellowness. Differences in b^* along the storage period could be related to the intensity of the oxidation process that takes place during storage and might tend to increase yellowness of samples by rancidity, although no measures of oxidation intensity are available to support this hypothesis. The a^* (redness) value in Air-Packaging decreased significantly ($P < 0.01$) at the same storage time. On the other hand, a decrease in a^* values due to oxygen content in AP would reflect myoglobin oxidation. Mercier et al. (1998), have observed an increase in the hue angle ($\arctan b^*/a^*$) of stored turkey pectorals muscle, suggesting a degree of change from red to yellow, an indication of increased oxidation with time [21]. In the present study, calculation of hue angle values (not reported) showed an increase for Air-Packaged camel meat during storage, whereas in Vacuum-Packaged samples, values for camel meat remained relatively stable. The more rapid changes in L^* , a^* and b^* value of Air Packaged samples suggest that this gas is responsible for the determination of colour. Moore and Gill (1987) also found increases in L^* and b^* values with time, in agreement with our results [22]. The increase in b^* may be associated with the transformation of the meat pigment and the formation of meat myoglobin, which is faster at relatively low oxygen concentration [23]. Our results show that a mixture with 30% CO_2 and 70% N_2 maintains a good colour for up to 21 days at $4 \pm 1^\circ C$ in the absence of O_2 . Chroma showed an opposite co-variation with L^* . In both parameters there were significant differences among groups only from 21 days onward. The forward stepwise logistic regression model of acceptance was statistically significant ($P < 0.01$) and showed that this acceptance was affected ($P < 0.01$) by Chroma, time storage and MAP. Samples stored under MAP gases were accepted for a longer time than the other groups. Gas composition in packs (Table 1) was associated with the changes in colour and the probability of being accepted. In agreement with other authors [24] our study found a slower discoloration of samples stored with higher proportions of CO_2 , this being more evident in MAP treatment.

Sensory analysis

The camel meat was evaluated for changes in surface color, texture, and odor by semi-trained panelists. By the end of the storage time (at day 21), MAP were acceptable (scores > 6) and significant differences ($P < 0.05$) were found between other packaging system for all sensory attributes. The surface color of the samples in MAP was not severely discolored and remained acceptable even after 21 days storage. Storage time effect within treatment indicated that surface discoloration increased ($P < 0.05$) especially at day 14 in Air-Packaged samples (Table 2). At day 21, surface colour of samples packed with MAP remained

Treatment / Time		MAP	AP	VP
L*	Day 1	33.89 ± 0.89 d	32.90 ± 0.45 d	34.59 ± 1.01 c
	Day 7	34.69 ± 1.32 c,x	34.69 ± 0.62 c,x	35.66 ± 0.29 bc,y
	Day 14	37.65 ± 0.95 a,x	35.29 ± 1.04 b,z	36.08 ± 1.14 a,y
	Day 21	35.32 ± 0.59 b, y	37.21 ± 0.70 a, x	35.31 ± 0.39 b, y
a*	Day 1	19.90 ± 0.71 a,x	18.30 ± 0.55 a,y	19.83 ± 0.87 a,xy
	Day 7	18.81 ± 0.40 ab,x	16.73 ± 0.63 b,y	18.70 ± 0.40 ab,x
	Day 14	17.42 ± 0.78 b,y	13.50 ± 0.38 c,z	18.48 ± 0.45 ab,x
	Day 21	16.54 ± 0.38 c,xy	12.84 ± 0.49 d,y	17.22 ± 0.26 b,x
b*	Day 1	7.90 ± 0.35 b	8.58 ± 0.50 c	8.17 ± 0.44 b
	Day 7	8.17 ± 0.29 ab,y	9.39 ± 0.64 bc,x	8.20 ± 0.63 b,y
	Day 14	8.35 ± 0.52 ab,y	10.48 ± 0.55 b,x	9.13 ± 0.36 ab,xy
	Day 21	8.88 ± 0.39 a, y	12.10 ± 0.48 a,x	9.37 ± 0.42 a, y
Chroma	Day 1	21.92 ± 0.55 a,xy	20.19 ± 0.46 a,y	22.11 ± 0.42 a,x
	Day 7	21.14 ± 0.37 ab,xy	19.53 ± 0.49 a,y	21.57 ± 0.46 ab,x
	Day 14	19.86 ± 0.75 b,y	18.07 ± 0.55 b,z	20.90 ± 0.39 ab,x
	Day 21	19.62 ± 0.33 b,xy	17.70 ± 0.45 b,y	20.37 ± 0.82 b, x

a, b, c values in the same column with different superscripts are significantly different (p <0.05). x, y, z values in the same row with different superscripts are significantly different (p <0.05). MAP: modified atmosphere packaging, AP: Air packaging, VP: Vacuum packaging

Table 1: Mean± SD of Values of colour (L*, a*and b*) of camel meat stored in different atmospheres packaging during storage time.

Treatment / Time		MAP	AP	VP
Appearance	Day 1	8.19 a	7.86 a	8.10 a
	Day 7	7.91 a,x	6.19 b,y	7.45 ab,xy
	Day 14	7.45 a,x	5.88 c,y	7.13 ab,x
	Day 21	6.80 a,x	4.38 d,y	5.81 b, xy
Odor	Day 1	7.88 a	7.75 a	7.91 a
	Day 7	7.62 a,x	7.03 ab,y	7.54 ab,x
	Day 14	7.02 a,x	6.19 b,y	6.90 ab,x
	Day 21	6.67 a,x	5.86 b,y	5.91 b,y
Texture	Day 1	8.70 a	8.40 a	8.70 a
	Day 7	7.90 ab	7.61ab	8.00 ab
	Day 14	7.00 bc,x	6.57 b,y	7.10 bc,x
	Day 21	6.60 c,x	5.54 b,z	5.90 c,y
Overall Quality	Day 1	8.43 a	8.31a	8.64 a
	Day 7	7.60 ab,xy	6.89 b,y	7.91 ab,x
	Day 14	6.97 b,x	5.99 c,y	6.62 b,xy
	Day 21	6.61 b,x	4.96 d,z	5.87 c, y

a, b, c, d values in the same column with different superscripts are significantly different (p <0.05).

x, y, z values in the same row with different superscripts are significantly different (p <0.05).

MAP: modified atmosphere packaging, AP: Air packaging, VP: Vacuum packaging.

Table 2: Sensory attributes of camel meat stored in different atmospheres packaging during storage time.

unchanged (P>0.05). The data suggest that the MAP with high CO₂ protected the surface color. The colour and odor changes in meats are highly dependent upon packaging condition [25]. Panelists rejected Air-Packaged samples after 14 days storage at 4°C but MAP increased the shelf life of fresh camel meat refrigerated at 4°C by more than 21 days.

Conclusion

In this study we have observed the evolution of the main parameters that affect camel meat quality (colour, lipid oxidation and shear force) when preserved in modified atmospheres with different mixtures of

gas. For colour, however, values obtained indicated that MAP was the best of those tested. Modified atmosphere packaged fresh camel meat with high CO₂ reduced the increasing rate of lipid oxidation during storage. Our study showed that even though oxidative rancidity (TBARS) increased with storage time in all packed samples, it did not result the deterioration of sensory quality in MAP. This indicates that lipid oxidation is not a major problem in MA-packaged fresh camel meat stored at 4°C up to 21 days. In summary, packaging with MAP (60% CO₂+40% N₂) of fresh camel meat accompanied by refrigeration storage enhanced product shelf life at least for 3 weeks without undesirable and detrimental effects on its sensory acceptability.

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