INDIRECT ESTIMATE OF METMYOGLOBIN IN LAMB MEAT UNDER DIFFERENT MODIFIED ATMOSPHERE SYSTEMS

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Abstract – The aim of the present study was to evaluate the estimated metmyoglobin content in lamb meat (*Longissimus lumborum*) packaged in three different modified atmosphere packaging (MAP) systems (vacuum, 75% O_2 + 25% CO_2 and 100% CO_2) during 28 days of storage at 1±1 ºC. Estimated levels of metmyoglobin on the meat surface was measured by reflectance (R630:R580) method at intervals of 7 days during a storage period of 28 days. Headspace analysis was carried out during the storage time. There was a significant reduction (P<0.05) in metmyglobin percentage along the storage time for meat submitted to 75% O_2 + 25% CO_2. Lamb meat packaged under vacuum showed higher values for metmyoglobin compared to the other treatments. The lowest level was found for MAP containing 100% CO_2, where no variation was detected (P>0.05) during the 28 days of storage. Furthermore, it may be concluded that the formation of metmyoglobin was reduced under the absence of O_2 presented by 100% CO_2 treatment and also under high levels of O_2 presented by 75% O_2 + 25% CO_2 treatment. On the other hand, the residual O_2 levels in the package headspace of samples packaged under vacuum apparently induced the metmyoglobin formation.

Key Words – color stability, gas composition, lamb.

I. INTRODUCTION

Meat color is one of the most important sensory attributes for the fresh meat, since contributes directly to the consumer buying decision, where freshness is associated to a brilliant red color [1, 2, 3].

Modified atmosphere packaging systems have been used to keep microbial quality and color maintenance during storage of refrigerated fresh meat [4]. Typical employed gaseous composition includes 20 to 30% CO_2 and 70 to 80% O_2. CO_2 acts as a bacteriostatic agent, while O_2 is responsible for the brilliant red color of meat (oxymyoglobin). Nevertheless, in some instances, specific concentrations of O_2 can promote lipid and myoglobin oxidation in a short period of time, reducing the meat quality [5, 6, 7].

Myoglobin is a hydro soluble intracellular protein responsible for the muscle color and it can be found as oxymyoglobin, deoxymyoglobin or metmyoglobin, according to environment along the storage [8]. Myoglobin, when exposed to high concentrations of O_2 is converted in oxymyoglobin, containing Fe^{++} which shows a brilliant red color. Under low concentrations of O_2, deoxymyoglobin is formed and meat shows a purple red color. This compound is quite unstable and when in contact with O_2 is oxidized by the action of free radicals, producing metmyoglobin, the pigment of a brownie color (Fe^{+++}). Oxymyoglobin can also be directed turned into metmyoglobin under low concentrations of O_2 [3].

In face of the above, the objective of this study was to evaluate the effect of different MAP systems (vacuum, 75% O_2 + 25% CO_2 and 100% CO_2) on metmyoglobin formation in lamb loins (*Longissimus lumborum)* stored for 28 days under refrigeration (1±1ºC).

II. MATERIALS AND METHODS

A. Meat packaging

Lamb *Longissimus lumborum* (loins) from 30 animals, aged 5-6 months and weighing 35 to 40

kg were packed individually into high barrier plastic bags, stored at 1±1°C for 28 days, according to the following modified atmosphere systems: 1) Vacuum, 2) 75% O_2 + 25% CO_2 and 3) 100% CO_2. The experiment was repeated three times and the results were analyzed using analysis of variance (ANOVA) with SAS (Statistical Analysis Software) version 9.1.3. The means were compared using Tukey's test at 5% significance level. The experimental results were fit using regression models to examine the variations that occurred throughout the storage period and among treatments.

After 24 hours of slaughter, carcasses were deboned and loins were obtained between the 1st and 6th lumbar vertebrae. Lean meat were packaged in Dry-lock type polystyrene trays (Model 21P LinStar, Mark LINPAC,) measuring 140 x 178 x 25 mm and absorption of 25 ± 5 g of water and these trays were individually packaged into high barrier film plastic bags with dimensions of 180 x 370 mm (Code BB2800, Mark CRYOVAC). According to the manufacturer, the main properties of this multilayer package are: maximum rate of permeability to O_2 25 cm^3/m^2.day (1 atm/23°C/0% RH) and rate of maximum permeability to water vapor 10 gH_2O/m^2.day (1 atm/38°C/90% RH). For those treatments containing gas injection, it was used a ratio of about 5:1 of gas volume (mL) per meat mass (g). Packaged meat cuts were stored under refrigeration (1±1ºC) during 28 days and to estimate the percentage of metmyoglobin, wavelengths of 580 and 630 nm were evaluated by performing analyzes of objective color at intervals of 7 days.

B. Color measurement and estimate of metmyoglobin

The samples were subjected to objective color evaluation using a portable colorimeter (Model XE MiniScan, Mark HunterLab) with CIELab system assessment, using the illuminant D65, observation angle of 10º and open cell with 30 mm. Six readings at different points of the meat surface were taken after 30 minutes of samples exposition to atmosphere. The objective color measures allowed to estimate metmyoglobin concentration, by using a simplified method of the difference in reflectance (R630:R580) values obtained from spectral curves [9, 10, 11].

III. RESULTS AND DISCUSSION

A significant effect ($P<0.05$) was found for metmyoglobin concentration for all the treatments employed in this study, along the whole storage period (Figure 1).

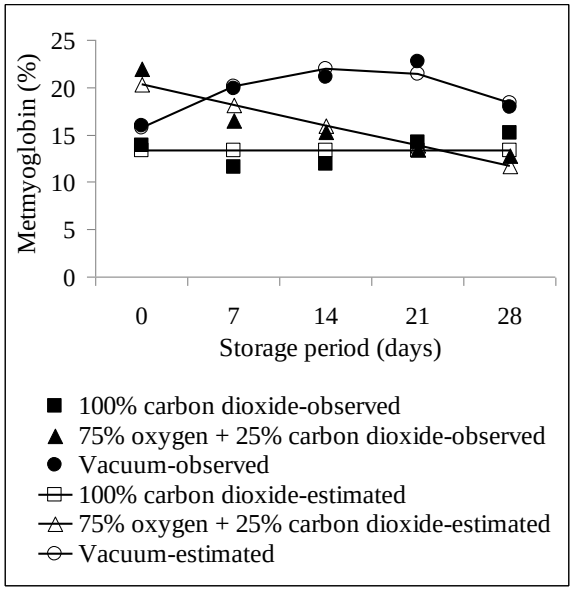

Figure 1. Metmyoglobin formation in refrigerated fresh lamb loin submitted to different packaging systems along 28 days of storage

The metmyoglobin content in lamb meat was significantly reduced (from 22.00 to 12.80±2.10%) when packaged under 75% O_2 + 25% CO_2. This behavior occurred probably due to the high O_2 concentrations along the refrigerated storage (Figure 2). In this condition the pigment was found mainly in an oxygenated form. This scenario was predictable, since that formation of metmyoglobin is reduced at high O_2 levels in the packaging headspace, favoring the formation of oxymyoglobin, and consequently keeping the desirable color for longer periods of time and before metmyoglobin turns superficially visible [3]. In addition, a deeper penetration of O_2 into the muscle can

contribute to avoid metmyoglobin formation [12].

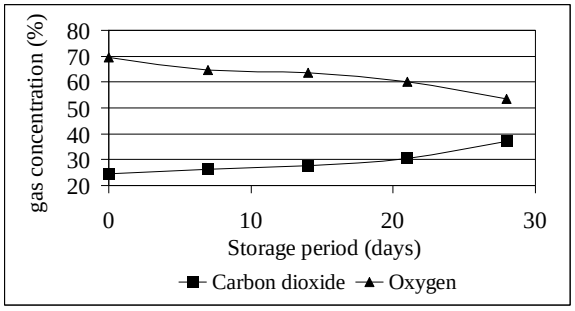

Figure 2. Headspace packaging O_2 and CO_2 concentrations using 75% O_2 + 25% CO_2

Data reported in the scientific literature have shown that beef loin stored at 2°C for up to 60 days and packaged under MAP containing O_2 + CO_2, showed low levels of metmyoglobin until 16 days of storage when compared to samples submitted to vacuum and 100% CO_2. Nevertheless, O_2 + CO_2 samples showed higher levels of metmyoglobin from the 24th day of storage until the end of the experiment, with concentrations higher than 42%, becoming unacceptable [13].

Considering the samples that were stored under vacuum, a quadratic behavior was verified for metmyoglobin concentration, with significant increases up to 21 days of storage, from average concentrations varying from 15.95 to 22.70±2.10%. From this point to the end of the experiment, there was a reduction of metmyoglobin levels reaching 17.90%. This behavior could be explained by the low O_2 residual levels in the package headspace (Figure 3) observed up to 21 days of storage. These levels were probably enough to promote the metmyoglobin formation and afterwards by the absence of this gas until the end of storage, reducing the pigment oxidation. Compared to the other treatments, samples packaged under vacuum, at 28 days of storage showed higher concentrations of metmyoglobin.

The lowest percentage of metmyoglobin was verified for samples packaged under 100% CO_2. These samples did not significantly differ ($P>0.05$) along the storage period, showing an average metmyoglobin level of 13.33±2.65% this behavior occurred due to the absence of O_2 (Figure 4) in this packaging system which was efficient in avoiding metmyoglobin formation.

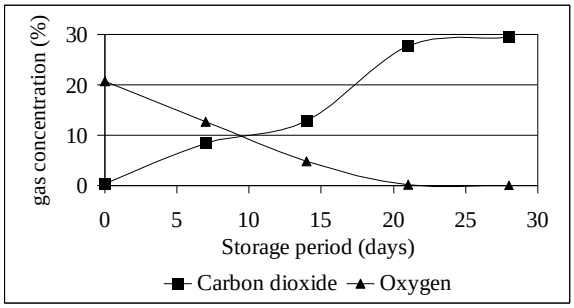

Figure 3. Headspace packaging O_2 and CO_2 concentrations using vacuum

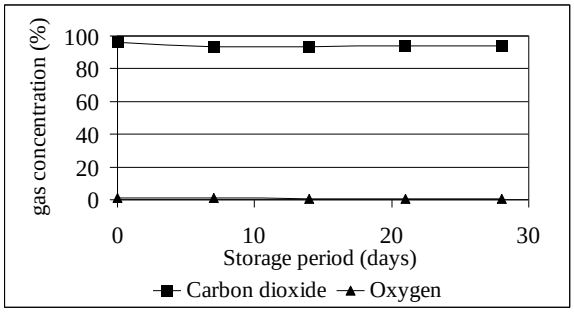

Figure 4. Headspace packaging O_2 and CO_2 concentrations using 100% CO_2

All metmyoglobin percentage estimated in this study for the three evaluated treatments were below 25%. Thus, it can be inferred that lamb meat kept an acceptable appearance over the 28 days of storage, since only >40% of metmyoglobin results in consumer buying inhibition and product refusal [14] due to an undesirable brown aspect [15].

IV. CONCLUSION

The metmyoglobin concentration in lamb loin stored under refrigeration was influenced by the employed packaging systems. The residual oxygen levels found in packaged samples under vacuum probably favored the metmyoglobin formation. On the other hand, high O_2 levels in MAP containing 75% O_2 + 25% CO_2 or in complete absence as found in the system

containing 100% CO_2 protected the myoglobin from oxidation over the 28 days of storage.

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