Effect of modified atmosphere packaging systems on lamb meat appearance during refrigerated storage

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Abstract—**One of the most important quality parameters related to appearance of fresh meat is the brilliant red color. The maintenance of the color is dependent upon the oxygen level into the packaged product headspace. In order to extend fresh meat shelf life, several technologies have been applied, modified atmosphere among them. The use of a bacteriostatic gas, such as CO2, in the packaging headspace systems can contribute to keep quality for longer periods of time. Nevertheless, meat color and appearance can be altered according to the gas composition, and can affect consumer's preference. Thus, the objective of this work was to evaluate the effect of different modified atmosphere packaging systems on the lamb meat appearance. Lamb Longissimus lumborum were packed individually into high barrier plastic bags, stored at 1±1°C for 28 days, according to: 1) Vacuum, 2) 75%O2+25%CO2 and 3) 100%CO2. Objective color (L*, a* and b* parameters) and preference ranking test (50 consumers were used to evaluate packaged samples appearance) were carried out at each 7 days. The 100%CO2 system caused a decrease (p<0,05) in a* value when compared to other treatments and 75%O2+25%CO2 treatment showed the higher (p<0,05) b* value. There were no difference in L* value among all modified atmosphere systems. Regarding sensory ranking test, 100%CO2 showed the lowest consumer preference during all the evaluated period. The other two treatments did not differ between then along the refrigerated storage. This consumer's behavior was probably due to the browner color of lamb meat stored under 100%CO2.**

Keywords—**Sheep meat, color stability, sensory evaluation.**

I. INTRODUCTION

The color of meat is one of the most important sensory attributes that directly influence the purchase decision and final acceptance of the product, as the consumer looks at the discoloration on the surface as an indicator of freshness and safety [1]. The myoglobin, responsible for the pigmentation of skeletal muscles, can be found in the form of oxymyoglobin, deoxymyoglobin or metmyoglobin, according to the time of shelf life and storage conditions [2]. The deoxymyoglobin has a purplish-red color and when it is subjected to high concentrations of oxygen, becomes bright red (oxymyoglobin). This form of myoglobin is unstable in contact with O_2 and through oxidation reaction will become metmyoglobin, presenting brown color [3,4,1].

Meat is a highly perishable product due to its high nutrient content, high water activity and pH close to neutrality. In order to extend storage period of meat, one must employ appropriate methods of preservation. Among the methods used to extend the shelf life of fresh meat one can cite the use of modified atmosphere packaging. Currently the food industry uses two technologies to reduce products deterioration: vacuum application or introduction of gas mixture in predetermined proportions after evacuation and before the closing of the package. In both systems, the product should be involved with a film presenting low gases permeability [5, 6]. The gas or gas mixture to be used depends on the type of food to be packaged, permeability of package and temperature of storage and distribution [7].

Oxygen (O_2) is commonly used to preserve the color of fresh red meat at high percentages, but this inevitably ends up favoring the development of aerobic spoilage microorganisms, but avoiding the proliferation of anaerobes ones [4,7]. This component keeps the myoglobin oxygenated and, in this context,

fresh meat is usually stored in packages containing 60 to 85% O2 [8].

Carbon dioxide (CO_2) is a gas with bacteriostatic and fungistatic characteristics, which inhibits or reduces the aerobic and anaerobic microbial growth. The most commonly proportion of this gas used in meat is 20 to 40% [7]. The use of a bacteriostatic gas, such as CO_2, in the package headspace can contribute to keep quality for longer periods of time, but meat color and appearance can be altered according to the gas composition, which can affect consumer's preference.

Thus, the objective of this work was to evaluate the effect of different modified atmosphere packaging systems on lamb meat color and appearance.

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.

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 (BB2800, 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. Objective color and sensory evaluation were carried out at each 7 days. Samples with 28 days of storage were not sensory evaluated because of visible microbiological spoilage.

B. Color measurement

The samples were subjected to color evaluation using a portable colorimeter (XE MiniScan, 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 took after 30 minutes of samples exposition to atmosphere.

C. Sensory evaluation

Fifty consumers were recruited among students, teachers and employees of FZEA/USP in Pirassununga-São Paulo, where the selection criterion was just to like lamb meat. It was applied a preference ranking test [9]. Consumers received at the same time, in randomized order, samples of the three types of packaging systems coded with three-digit numbers. They were instructed to rank the samples in an increasing way according to their overall appearance preference.

III. RESULTS AND DISCUSSION

In the analysis of objective color in relation to L * values it was not detected significant difference ($p<0.05$) among treatments, storage time and no interaction among treatments along the studied period. Treatments vacuum, 75%O_2+25%CO_2 and 100%CO_2 showed L* values of 36.95±1.05, 38.47±1.05 and 36.32±1.05, respectively.

The a* values did not vary ($p>0.05$) along of the time, but showed differences ($p<0.05$) among treatments. The redness was lower in the treatment containing 100%CO_2 (13,01±0.54) when comparing to the other two ones, which had overall averages of 15.35±0.54 (vacuum) and 16.47±0.54 (75%O_2+25%CO_2).

With respect to the parameter b*, there was also significant variation ($p>0.05$) only among the treatments, being the intensity of yellow greater in 75%O_2+25%CO_2 (14.36±0.58) in detriment of others, which showed overall averages of 12.43±0.58 for vacuum and 10.95±0.58 for 100%CO_2.

The oxygenation occurs from about 5 mm deep in relation to the surface of meat cut and the surface color depends on chemical state of myoglobin and also the balance between O_2 availability of surface and tissue respiration [10, 11, 12]. High O_2 levels promote oxygenation of the meat pigment and in this way, maintain and prolong the color for a period of time before the metmyoglobin becomes visible on the surface [1]. However, the presence of low residual levels of O_2 (up to 0.1%) favors the oxidation of myoglobin to metmyoglobin formation and consequent browning of the meat during storage [13,14,15,16]. In this study it was found that the packaging system containing 100%CO_2 had a greater discoloration with a grayish appearance (Figure 1). This result is consistent with information from the literature that concentrations above 30% CO_2 increase the degree of discoloration of red meat [17].

The sensory preference ranking test results were statistically evaluated according to the Friedman test, using the table of Newell and Mac Farlene [9]. From this table, the critical difference value among treatments is 24. In the four time intervals of storage evaluated the attitude of consumers towards the appearance of the loins (packaged meat) was the same, with the samples packaged in vacuum and under an atmosphere containing 75%O_2+25%CO_2 were preferred ($p<0.05$) compared to samples subjected to 100%CO_2 injection (Table 1). This lower sensory acceptability is probably associated with low a* value intensity found along the storage period, which promoted a worsening in appearance, since this is the factor responsible for the intensity of red color and consequently a reasonable indication of meat acceptance [18].

Table 1 Results of preference ranking test (sums of consumers order of preference).

	Storage time (days)			
Treatment	0	7	14	21
Vacuum	121[a]	120[a]	124[a]	128[a]
75%O_2+25%CO_2	120[a]	124[a]	121[a]	107[a]
100%CO_2	59[b]	56[b]	55[b]	65[b]

IV. CONCLUSIONS

Lamb meat packaged with 100%CO_2 showed the least desirable appearance during all the evaluated storage period when compared to meat packaged with 75%O_2+25%CO_2 or under vacuum. Even though this treatment presented a greater microbiological stability (data not presented in this paper), more studies are necessary about the use of modified atmosphere systems to lamb meat, possibly with different mixtures of gases, in order to combine the microbial preservation with a more acceptable product appearance.

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Fig. 1 - Lamb Longissimus lumborum packaged in different modified atmospheres: VC = Vacuum, O2+CO2 = 75%O2+25%CO2 and CO2 = 100%CO2

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