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Characteristics of vacuum-packed sheep meat stored under fluorescent light

Características da carne ovina embalada a vácuo e armazenada sob luz fluorescente

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Highlights

Storage time increases meat lipid oxidation and bacteria count.
The absence and presence of light do not change meat quality during storage.
Discoloration by oxidation of pigments begins to occur soon after slaughter.

Abstract

This study aimed to evaluate the possible variations of physicochemical and microbiological characteristics of frozen sheep meat, vacuum-packed under fluorescent light exposure at different storage times. Sixteen *Longissimus lumborum* muscles from male Ile de France lambs were collected for meat quality analyses of pH, color, shear force, weight loss due to cooking, water holding capacity, lipid oxidation, mesophilic and psychrotrophic microorganisms, and enterobacteria. The samples were randomly identified and stored in a horizontal freezer under the incidence of fluorescent light (IL) and no incidence of light (NL) for 30 and 60 days plus the control treatment (day 0). An interaction was observed between treatments for pH and water holding capacity (p<0.05), with superior results for IL-30 and NL-60, respectively. However, the other variables showed differences only regarding the main effects, mainly in terms of time (p<0.05). The contents of *L*, a** and *b*, C*, O/M,* weight loss due to cooking, and lipid oxidation increased as the meat was stored longer (p<0.05). The shear force did not differ between treatments (p>0.05). Meat microbiological quality was not affected by the lightness factor, except for enterobacteria (p<0.05), in which the IL treatment had lower counts of these microorganisms. Therefore, the physicochemical and microbiological characteristics were not affected by the incidence of light. However, the meat undergoes changes as the storage time under freezing increases.

Key words: Lambs. Color. Lighting condition. Microbiology. Lipid oxidation. Shelf life.

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Resumo

O objetivo do estudo foi avaliar as possíveis variações das características físico-químicas e microbiológicas da carne ovina congelada, embalada a vácuo sob exposição de luz fluorescente em diferentes tempos de armazenamento. Dezesseis músculos *Longissimus lumborum* de cordeiros machos da raça Ile de France foram coletados para as análises de qualidade da carne de pH, cor, força de cisalhamento, perdas de peso por cocção, capacidade de retenção de água, oxidação lipídica, microrganismos mesófilos, psicrotróficos e enterobactérias. As amostras foram identificadas e armazenadas aleatoriamente em freezer horizontal sob a Incidência de luz fluorescente (CL) e sem Incidência de luz (SL) por 30 e 60 dias mais o tratamento controle (dia 0). Houve interação entre os tratamentos para pH e capacidade de retenção de água (p<0,05), observando resultados superiores para CL-30 e SL-60 respectivamente. Entretanto, para as demais variáveis foram encontradas diferenças apenas nos efeitos principais, principalmente de tempo (p<0,05). O teor de *L*, a** e *b*, C*, O/M,* perdas de peso por cocção e a oxidação lipídica aumentaram à medida que a carne ficou mais tempo armazenada (p<0,05). A força de cisalhamento não diferiu entre os tratamentos (p>0,05). A qualidade microbiológica da carne não foi afetada pelo fator luminosidade, exceto para enterobactérias (p<0,05) em que o tratamento CL apresentou menor contagem desses microrganismos. Dessa forma conclui-se que as características físico-químicas e microbiológicas não foram afetadas pela Incidência de luz. No entanto, a carne sofre alterações à medida que aumenta o tempo de estocagem sob congelamento.
Palavras-chave: Cordeiros. Cor. Condição de iluminação. Microbiologia. Oxidação lipídica. Vida de prateleira.

Introduction

The world sheep population reached 1.2 billion animals in 2016, which represents 30.6% of the global domestic ruminant population (Food and Agriculture Organization of the United Nations [FAOSTAT], 2017). Different changes have been taking place in Brazil over the years, such as significant growth in the market, reaching increasingly relevant positions in agribusiness, and contributing positively to the country's economy. The great growth potential of sheep farming is given by the great capacity to carry out a complete cycle of its production in 8-9 months, expand its production rates, and meet consumer demand, showing great importance in Brazil, both economically and socially.

According to data from the Instituto Brasileiro de Geografia e Estatística (IBGE) (2021), Brazil has a little more than 20.5 million head of sheep, with the Northeast region holding 70.6% of this total, followed by the South (18.7%), Midwest (4.9%), North (2.8%), and Southeast (3%). The State of São Paulo has a herd of 322,000 sheep, accounting for 52.3% of the total number of animals in the Southeast region.

Meat is the main commercialized product, mainly in the semi-arid area (Santos et al., 2017). In addition to supplying the population with animal protein of high biological value at a lower price compared to meat from other ruminant animals (Toro-Mujica et al., 2015), it is inserted in different typical regional recipes.

However, consumption is still not well culturally accepted, and Brazil cannot meet the domestic demand for sheep meat, requiring imports from countries such as Argentina, Australia, Uruguay, and New Zealand. Brazilian imports of sheep meat between January and June 2021 totaled just over US$ (FOB) 8 million to supply the domestic market (Via Agronegócio, 2021).

Always related to a quality indicator, the meat appearance must remain unchanged during the various stages of the product's life. However, color is one of the most important characteristics, responsible for attracting consumers' purchase intention (Li et al., 2012).

Therefore, understanding which factors determine product quality during storage is essential to meet product demand and acceptance (Miller, 2020). The level of consumer demand has led the market to demand that slaughterhouses supply meat and carcasses with appropriate quality characteristics, such as color, tenderness, and juiciness.

In this context, studies have shown that, among the factors that affect the quality characteristics after slaughter and during meat processing and storage, contact with oxygen and light induces chemical changes that initiate the processes of lipid and protein oxidation and the development of changes in color, odor, and taste (Papuc et al., 2017).

The adoption of techniques that aim to prevent the contact of the product with oxygen, such as vacuum packaging, which aims to restrict access to oxygen, is one of the main strategies used by the food industry to inhibit oxidative reactions and prevent these changes effectively (Kim et al., 2013).

Thus, vacuum packaging acts as a protection against external oxygen and preserves moisture, providing stability in the meat color and quality (Sarantópoulos & Dantas., 2015). According to Hutchings (1994), storage in the dark helps to preserve the red color of fresh meat, as color degradation is associated with the heat dissipated by the lamps on the display counters.

The way and time of storage of sheep meat are important to provide the consumer with quality meat and increase the shelf life of the product. Therefore, this study aimed to evaluate the possible variations of physicochemical and microbiological characteristics of frozen sheep meat, vacuum-packaged under fluorescent light exposure at different storage times.

Material and Methods

The experiment was carried out in accordance with the ethical principles for testing on animals (Protocol No. 04/2021-CEUA) determined by the Council for Ethics in the Use of Animals (CEUA) of the School of Agricultural and Technological Sciences - Unesp, Campus of Dracena.

Experimental animals

Sixteen male Ile de France lambs with an average slaughter weight of approximately 40.53±3.84 kg of live weight and four months of age reared in a confinement system of a rural property located in Botucatu, São Paulo, 390 km away from Dracena, were used. The animals received a total diet with 90% concentrate and 10% grass hay, provided twice a day with a 10% adjustment for leftovers.

Sample collection

The lambs were weighed at the end of the experiment and sent to a slaughterhouse located in São Manuel, São Paulo, 21 km away from Botucatu and 370 km away from Dracena. Carcasses were identified during slaughter for sample collection. The average carcass weight was 20.71±2.23 kg, and the carcass yield was 50.86 ± 1.52%.

Subsequently, the carcasses were taken to a cold room and samples of the Longissimus lumborum muscle from two half-carcasses were collected 24 hours later and transported in coolers with ice to the Laboratory of Technology and Science of Meat at Unesp (Campus of Dracena).

Transversal cuts of approximately 2 cm thick were made, and the samples were separated, identified, vacuum packed, and placed in a horizontal freezer under fluorescent lighting with an 18 W tube lamp and 100-240V3 50/60Hz power without lighting. The evaluations described below were carried out according to the storage times 0, 30, and 60 days after slaughter.

pH and color

The pH was determined using a digital potentiometer for direct puncture with a thermometer attached (Model HI 99163; Hanna Instruments, Woonsocket, RI, USA), previously calibrated with pH 4.0 and 7.0 buffer solutions (Merck, Darmstadt, Germany), according to the method proposed by Beltrán et al. (1997).

Meat color was determined using a color meter (CR-410-Konica Minolta, Camera Co., Ltd., Osaka, Japan) at two different points in the samples. The readings were performed according to the CIELAB system, registeing the reflectance of light in three dimensions: L* (lightness), a* (red index), and b* (yellow index), according to the methodology described by Honikel (1998).

The values of chroma (C*) and global color changes (ΔE) were obtained according to MacDougal (1994) and the oxymyoglobin and metmyoglobin (O/M) content present on the surface of the meat was determined according to Olivo and Shimokomaki (2001), using the coordinates of red content (a*) and yellow intensity (b*), obtained in colorimetric determinations, with the following formulas: $C^* = ((a^*)2+(b^*)2)0.5$, $\Delta E = (\Delta L2+\Delta a2+\Delta b2)0.5$, and $O/M = (a^*/b^*)$.

Water holding capacity, weight loss due to cooking, lipid oxidation, and shear force

Water holding capacity (WHC) was determined using 2 g of each sample, which was placed on circular filter papers between two plastic plates under a weight of 10 kg for 5 minutes, according to the modified methodology by Hamm (1961), calculated by the difference in sample weight before and after being subjected to external force, expressed in %.

The weight loss due to cooking (WLC) was determined by weighing each sample and placing them in a water bath at 71 °C for 35 minutes. Then, the sample was taken and cooled, and the temperature was measured using an infrared thermometer until reaching a temperature of 25 °C, following the methodology by Holman (2015). The sample

was weighed again to determine the WLC, which was calculated by the difference in weight of the sample before and after being subjected to heat treatment, expressed in %.

Shear force (SF) was obtained using the WLC samples after refrigeration at 4 °C for 12 h. Five muscle cylinders with 1.27 cm in diameter were taken from each sample using a bench drill and placed with the fibers oriented perpendicularly to the TA-SBA blades for cutting and shear testing with a texturometer device (TA-SBA CT3, Brookfield AMETEK, Middleboro, MA, USA). The device descended at a speed of 200 mm/min (Holman, 2015).

The equivalent oxidation in malondialdehyde was used to evaluate the lipid oxidation by the TBARS (thiobarbituric acid-reactive substance) methodology, according to Wyncke (1970). Ten grams of meat samples were homogenized with 50 mL of 7.5% trichloroacetic acid (TCA) solution for 2 minutes using an Ultra-Turrax mixer. Subsequently, an aliquot of 5.0 mL was filtered, mixed with 5.0 mL of thiobarbituric acid (TBA) solution (0.020 mol/L), and placed in a water bath (100 °C) for 30 minutes. The absorbance of the samples was measured at 532 nm in a spectrophotometer (BEL Photonics, model V-M5) in duplicates and expressed in milligrams of malonaldehyde (MDA) per kilogram of meat, using a standard curve with a concentration range from 0.008 to 0.013 of linearity, constructed with 1,1,3,3-tetraethoxypropane (TEP).

Meat microbiology

The Compendium of Methods for the Microbiological Examination of Foods (Downes & Ito, 2001) was taken as a reference for microbiological analyses. The analyses consisted of mesophilic and psychrotrophic bacteria and coliforms.

Experimental design and analysis of results

The experiment was completely randomized in a 2x2+1 factorial scheme, with two treatments (no incidence of light and incidence of fluorescent light on the display) and two storage periods (30 and 60 days) plus the control treatment (day 0), which were evaluated shortly after slaughter, with sixteen replicates per treatment.

The data were analyzed using SAS OnDemand for Academics (SAS Institute Inc., Cary, NC, USA), and data normality was confirmed using the Shapiro-Wilk test ($W \geq 0.05$). A contrast was performed for the factorial scheme to compare the control treatment with the others, using the PROC GLM command. Dunnett's test was used to examine differences between treatments. Effects were considered statistically significant at $p \leq 0.05$.

Results and Discussion

Results

The samples stored for a period of 30 days with the incidence of light (IL) and no incidence of light (NL) did not undergo alteration in the b* and O/M indices ($p>0.05$, Table 1). In contrast, storage time at 60 days IL and NL reduced the L* index and increased the a* and C* values by 3.66, 6.55, and 3.58%, respectively. The highest evidence that the meat began to change color was obtained

after 60 days of storage, regardless of the type of light incidence, with a reduction of 5.52, 49.73, and 35.10% in the values for the variables L*, b*, and O/M, respectively, relative to the control.

Table 1
Meat color of Ile de France lambs subjected to different storage periods under different light sources

	Storage time		Mean	SE	C x T	IL	T	T x L
	30 days	60 days						
*L**				0.712	0.005	0.334	0.045	0.059
With light	39.85 ± 2.07	38.77 ± 3.88	39.31					
Without light	40.82 ± 2.61	39.09 ± 3.12*	40.00					
Mean	40.38a	38.90b	39.64					
Control	41.96 ± 2.15							
a*				0.502	0.339	0.091	0.018	0.783
With light	17.74 ± 2.89	19.10 ± 2.40	18.42					
Without light	17.02 ± 1.55	18.10 ± 1.56	17.56					
Mean	17.38a	18.60b						
Control	18.53 ± 1.08							
b*				0.252	<.0001	0.372	0.068	0.611
With light	5.74 ± 1.12*	5.40 ± 0.85*	5.57					
Without light	5.63 ± 1.42*	5.52 ± 0.86*	5.58					
Mean	5.68	5.46	5.57					
Control	3.72±0.59							
O/M				0.165	<.0001	0.124	0.399	0.854
With light	3.51 ± 0.79*	3.34 ± 0.58*	3.42					
Without light	3.22 ± 0.79*	3.11 ± 0.46*	3.16					
Mean	3.36	3.22	3.29					
Control	5.07 ± 0.63							
C*				0.092	0.064	0.353	0.008	0.669
With light	6.76 ± 0.50	7.05 ± 0.38	6.90					
Without light	6.71 ± 0.40	6.92 ± 0.28	6.81					
Mean	6.73a	6.98b						
Control	6.67 ± 0.24							

L* = lightness; a* = intensity of the red color; b*= intensity of the yellow color; O/M= oxymyoglobin and metmyoglobin ratio; C* = chroma. SE = standard error. C x T = control x treatment; IL = incidence of light; T = time; T x L = time x incidence of light. Means followed by an asterisk in the column differ from the control by the Dunnett test (p<0.05). Means followed by different lowercase letters in the rows and different uppercase letters in the columns differ (p<0.05) from each other by the Tukey test.

No interaction was observed between storage time and the incidence of light in the evaluations of the parameters related to color quality mentioned above, as well as for shear force (SF), weight loss due to cooking (WLC), and lipid oxidation (MDA) (p>0.05, Table 2).

Table 2
Meat physicochemical characteristics of Ile de France lambs subjected to different storage periods under different light sources

	Storage time		Mean	SE	C x T	IL	T	T x L
	30 days	60 days						
SF (kgf)				1.921	0.838	0.787	0.855	0.667
With light	29.10 ± 8.26	29.57 ± 4.53	29.33					
Without light	30.45 ± 9.55	29.26 ± 8.30	29.85					
Mean	29.77	29.41						
Control	30.03 ± 6.81							
WLC (%)				0.453	<.0001	0.180	0.256	0.180
With light	33.69 ± 1.63*	33.59 ± 2.16*	33.64					
Without light	33.69 ± 1.16*	34.82 ± 2.36*	33.75					
Mean	33.69	34.20						
Control	26.25 ± 1.50							
MDA (kg1)				0.109	<.0001	0.534	0.006	0.862
With light	0.97 ± 0.34	1.26 ± 0.31*	1.11					
Without light	0.88 ± 0.35	1.21 ± 0.51*	1.04					
Mean	0.92a	1.23b						
Control	0.27 ± 0.60							
pH				0.020	0.002	0.174	0.294	<.0001
With light	5.84 ± 0.07	5.74 ± 0.05	5.79					
Without light	5.74 ± 0.09	5.79 ± 0.08	5.76					
Mean	5.79	5.76						
Control	5.71 ± 0.10							
WHC (%)				0.092	<.0001	0.039	<.0001	0.020
With light	88.97 ± 4.37	77.11 ± 4.95	83.04					
Without light	89.27 ± 3.75	81.93 ± 5.14	85.60					
Mean	89.12	79.52						
Control	91.24 ± 2.80							

SE = standard error. C x T = control x treatment; IL = incidence of light; T = time; T x L = time x incidence of light. Means followed by an asterisk in the column differ from the control by the Dunnett test (p<0.05). Means followed by different lowercase letters in the rows and different uppercase letters in the columns differ (p<0.05) from each other by the Tukey test.

Samples subjected to SF did not change (p>0.05) during the periods of 30 and 60 days of storage under IL and NL sources. However, these treatments increased WLC by 22.38% compared to the control.

Samples analyzed after 60 days of storage showed an increase in lipid oxidation (p<0.05) of 25.20% compared to the control. Also, the oxidation process started to occur soon after slaughter, intensifying this process at 60 days IL and NL by 74.88% relative to the control.

An interaction (p<0.05) was observed between storage time and light source for pH and WHC (Table 2). The pH was higher (p<0.05) for storage at 30 days and IL storage compared to the same period and absence of light (Table 3).

Table 3
Slicing of the interaction lightness x storage of pH and water holding capacity (WHC)

Variables	Lightness	Storage	
		30	60
pH	NL	5.74 ± 0.09 Aa	5.79 ± 0.08 Aa
	IL	5.84 ± 0.07 Ba	5.74 ± 0.05 Bb
WHC (%)	NL	33.69 ± 3.75 aA	34.82 ± 5.14 bA
	IL	33.69 ± 4.37 aA	33.59 ± 4.95 bB

NL = no incidence of light, IL = incidence of light. Means followed by different lowercase letters in the rows and different uppercase letters in the columns differ (p<0.05) from each other by the Tukey test.

The WHC index showed similar values with storage at 30 days and IL and NL (p>0.05). Higher variations were noticed in storage with 60 days higher NL (p<0.05). Light sources influenced WHC at 60, reducing 3.24 and 0.29% in NL and IL, respectively (Table 3).

Regarding the microbiological quality (Table 4), the storage time influenced the increase in the microbial load of all evaluated organisms (p<.0001). The mesophilic bacteria in sheep meat when stored at 60 days had a growth of 14.95% higher than the control.

The storage time for psychrotrophic bacteria and coliforms increased by 37.42 and 49.75%, respectively, relative to the control. The coliform group was also affected by the incidence of light, and the NL treatment accelerated the growth of coliforms by 21.96%. The highest coliform count was obtained in the 60 NL storage, with 55.02% compared to the control.

Table 4
Analysis of mesophilic and psychrotrophic bacteria and coliforms in the meat of Ile de France lambs subjected to different storage periods under different light sources

	Storage time		Mean	SE	C x T	IL	T	T x L
	30 days	60 days						
Mesophiles (log CFU/g)				0.073	<.0001	0.870	<.0001	0.297
With light	2.76 ± 0.22	3.17 ± 0.35*	2.96					
Without light	2.70 ± 0.26	3.26 ± 0.31*	2.98					
Mean	2.73 a	3.21b						
Control	2.67 ± 0.31							
Psychrotrophic (log CFU/g)				0.099	0.745	0.254	<.0001	0.468
With light	2.17 ± 0.25	3.91 ± 0.52	3.04					
Without light	2.21 ± 0.24	3.10 ± 0.46	2.65					
Mean	2.19a	3.50b						
Control	2.56 ± 0.44							
Coliforms (log CFU/g)				0.163	<.0001	0.024	<.0001	0.501
With light	0.90 ± 0.75*	1.81 ± 0.71*	1.35A					
Without light	1.17 ± 0.61*	2.29 ± 0.37*	1.73B					
Mean	1.03a	2.05b						
Control	0.90 ± 0.75							

SE = standard error. C x T = control x treatment; IL = light incidence; T = time; T x L = time x incidence of light. Means followed by an asterisk in the column differ from the control by the Dunnett test ($p<0.05$). Means followed by different lowercase letters in the rows and different uppercase letters in the columns differ ($p<0.05$) from each other by the Tukey test.

Discussion

A small variation was observed in the meat pH interaction values of all evaluated treatments (Table 3). However, the values were not negatively affected and remained within the acceptable range of 5.5 to 5.8. The pH variation is highly related to the lactic acid bacteria count and lactic acid production (Simeoni, 2014). This study did not evaluate lactic acid microorganisms, but this type of bacteria makes up the group of mesophilic bacteria, which presented progressive growth during storage time (Table 4). Therefore, pH variations are assumed to be related to the incidence of lactic acid bacteria. Simeone et al. (2014) also mentioned that vacuum-packed meat demonstrated a succession of the dominance of these microorganisms, reduction in pH values, and selection of more resistant bacteria (Simeoni, 2014).

The WHC results presented a behavior similar to that of pH. Moreover, this variable showed small variations in the interaction values (Table 4) because the water holding capacity is related to the speed of pH drop

during post-mortem glycolysis and the final pH of the meat (Joo, 2018). These reactions cause denaturation and loss of solubility of muscle proteins, that is, the number of negative charges. Most of the meat proteins are at an isoelectric point when the final pH reaches a point below the ideal (5.5 to 5.8), that is, there is a higher number of negative charges in the structure causing retraction of the muscle fibers, making it difficult for water molecules to enter the meat structure, contributing to a low water retention capacity. However, pH values above the isoelectric point favor excess positive charges, increasing the space between fibers for water molecules (Jacob & Pethick, 2014).

Weight loss due to cooking followed is a characteristic influenced by the water retention capacity of the meat structures and, consequently, influenced by the final pH of the meat, following the results obtained by them (Table 2). Moreover, this variable is affected soon after slaughter, showing high results at 30 and 60 days.

Regarding SF, the treatments did not influence the meat tenderness, not affecting the structure of the muscle fibers (Table 2). Currently, the most used method to evaluate the tenderness of the meat is through the Warner-Bratzler shear force, which allows the evaluation of the resistance (tension) of the cut. Thus, the higher the shear force, the higher its hardness.

According to Abuelfatah et al. (2016), lipid oxidation usually occurs after a long period or under inadequate storage conditions, which is limited by oxidative rancidity. In this study, the MDA value is higher at the end of the storage period, increasing with each analyzed period (Table 2). The observed difference in MDA values during the period occurs because the compounds that contribute to oxidative development are mainly formed during storage (Ahn et al., 2007).

According to Terra et al. (2006), TBARS values up to 1.59 mg of malondialdehyde per kilogram of sample are considered low to be perceived by sensory analysis and do not cause problems for human health. In contrast, Soldatou et al. (2009) mentioned that TBA values for lamb meat of 4.4 mg MDA per kg of meat mark the onset of lipid oxidation/rancidity.

The storage time affected the L* variables (Table 1) but remained within the standard range cited by some authors. Important mean values from 31.4 to 40.0 for L*, 12.27 to 20.0 for a*, and 3.34 to 5.65 for b* are described for the general acceptance of lamb meat (Holman et al., 2017). Storage time also changed the red content of the meat (a*) (Table 1). The intensity of red is directly related to the amount and state of myoglobin present in the meat. Low oxygen conditions in vacuum-packed meats can lead to myoglobin oxidation with the formation of metmyoglobin, thus increasing the a* value (Tomasevic et al., 2019). Myoglobin oxidation and lipid oxidation in meat occur during the storage period and both are chemically interrelated, which results in a color change and the emergence of unpleasant odors in the meat (Leão et al., 2017). Free radicals produced during lipid oxidation can change the chemical form of the heme group and initiate myoglobin oxidation, with a loss of product color (Abuelfatah et al., 2016). This fact is evidenced by the increase in b* (Table 1), which indicates the increasing metmyoglobin content in the meat and the

reduction in O/M content values (Table 1). Color saturation (C*) (Table 1) and the O/M ratio (Table 1), which is calculated based on the results of a* and b*, justifies the increasing metmyoglobin content throughout storage, suggesting that the increase of values of these variables is usually followed by the meat discoloration process in the different evaluated treatments, promoting higher values in comparison to the meat of the control treatment. In addition, global color changes (Figure 1) did not differ between treatments, but the change in meat color is classified by the ΔE index as a very clear perception of color differences by the human eye (Prändl et al., 1994) in the treatments NL-30, NL-60, NL-30, and NL-60 relative to the control.

The results of the microbiological analysis of the meat indicated an increase in the microbial load of mesophilic and psychrotrophic bacteria and coliforms. According to Normative Instruction No. 60 of the Ministério da Saúde - Agência Nacional de Vigilância Sanitária (ANVISA) (2019), all microorganisms are within the maximum limit considered acceptable of 106 CFU/g (6 log CFU/g) for mesophiles and psychrotrophic bacteria, and 102 CFU/g (2 log CFU/g) for coliforms.

Lamb meat is within acceptable standards for consumption despite the treatments influencing the development of bacteria. An increase in these microorganisms is expected, as the population of deteriorating bacteria increases during storage time even under refrigerated conditions, with the main microorganisms involved in the meat deterioration process being psychrotrophic bacteria (Forsythe, 2013), accelerated by factors such as pH and water activity. In general, fresh meat has water activity and pH conducive to the growth of microorganisms (Jayasena & Jo, 2013).

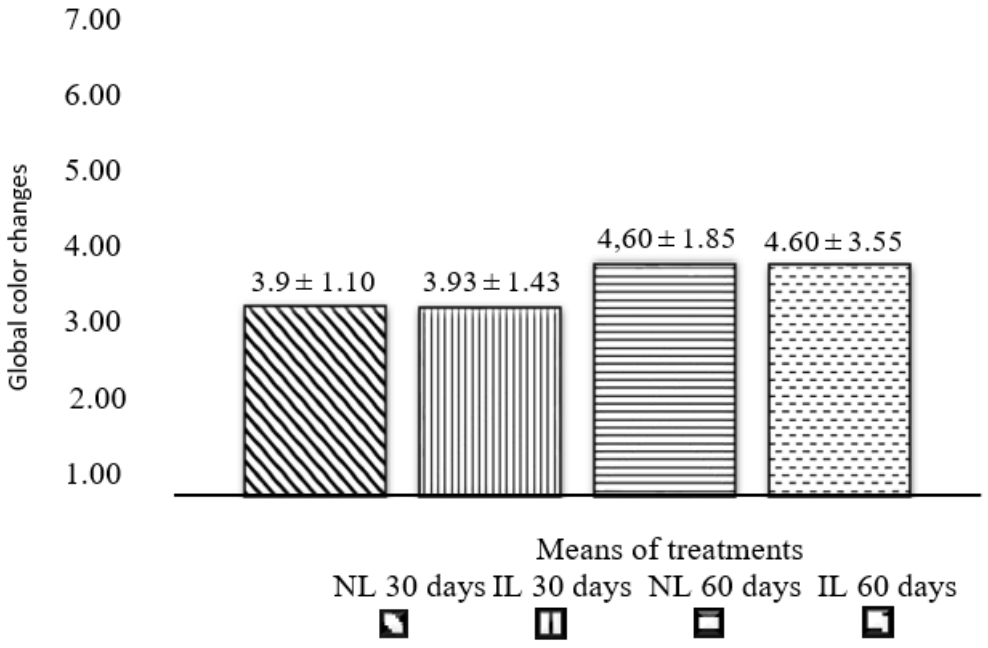

Figure 1. Global color changes

Conclusion

The light incidence factor affects only the characteristics of lipid oxidation and coliforms. On the other hand, meat undergoes changes in color, weight loss due to cooking, and mesophyll and psychrotrophic counts as the storage time under freezing increases, regardless of the type of light. However, the microbiological quality over 60 days of storage is considered adequate for consumption. Vacuum-packed sheep meat stored with or without light for 30 and 60 days of storage is within the indicative parameters of quality considered suitable for consumption.

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