CHANGES IN MEAT COLOR DYNAMICS IN AUBRAC CATTLE: EVALUATION OF M. SEMITENDINOSUS AT VARIOUS POSTMORTEM INTERVALS

B.M. Mădescu[1*], M. Matei[1], M.A. Davidescu[1], I. Bolohan (Acornicesei)[1], R. Lazăr[1], M.M. Ciobanu[2], D. Simeanu[1], P.C. Boișteanu[1]

[1]Faculty of Food and Animal Sciences, "Ion Ionescu de la Brad" Iasi University of Life Sciences, 8 Mihail Sadoveanu Alley, 700489 Iasi, Romania
[2]Faculty of Agriculture, "Ion Ionescu de la Brad" University of Life Sciences, 3 Mihail Sadoveanu Alley, 700489 Iasi, Romania

Abstract

This study aimed to evaluate the changes in meat color over time in Aubrac cattle of both genders. The focus was specifically on M. Semitendinosus, with color values of the meat assessed at 0, 24, and 48 hours postmortem. The CIE Lab color space allows colors to be represented in a three-dimensional system. The L, a, and b* values correspond to lightness, the red-green color component, and the yellow-blue color component. These values facilitate the evaluation and description of meat color. Analyzing the lightness of M. Semitendinosus, it is observed that, in the case of males, there are significant differences between the mean lightness values at 0, 24, and 48 hours postmortem, with average values ranging from 32.80 to 30.16. We can see that, with regard to all analyzed color parameters (brightness, hue intensity, meat color intensity, color saturation, and hue index) observed in the anatomical region under study, there are significant differences between males and females.*

Key words: *Aubrac cattle, color, meat, quality*

INTRODUCTION

Beef consumption has significant importance for human health for several reasons. Beef is a rich source of high-quality proteins, which are essential for the development and maintenance of tissue health and the immune system. It also contains a wide range of vitamins and minerals, such as vitamin B12, iron, zinc, and selenium, which are necessary for the optimal functioning of the human body. One of the new trends in Romanian agriculture is the raising of Aubrac cattle[1]. This beef cattle breed, originating from the Aubrac region in France, is appreciated for the superior quality of its meat and its adaptability to various breeding conditions, and in Romania's hilly, mountainous, and even plain areas, it seems to adapt very well.

Raising Aubrac cattle in Romania is an example of diversifying agricultural activities and adapting to market demands. This trend not only brings benefits to farmers but also to consumers, who gain access to high-quality meat from breeds with distinct and unique characteristics [2].

Aubrac beef is valued for its fine texture, juiciness, and rich flavor. It is considered high-quality meat, with excellent marbling and a high content of healthy fats [2]. These characteristics make Aubrac beef highly sought after on both the local and international markets.

The color of beef is one of the most important factors in evaluating its quality, both for consumers and the food industry [3]. Visual perception plays a key role in the purchase decision, and an attractive meat

*Corresponding author: bianca.madescu@iuls.ro
The manuscript was received: 15.10.2024
Accepted for publication: 08.11.2024

color can be an indicator of freshness, the animal's health, and processing methods. Generally, high-quality beef is characterized by a deep red color, which indicates an adequate content of myoglobin, the protein responsible for meat pigmentation. Color variations, ranging from bright red to darker shades, can be influenced by several factors, such as the animal's age, diet, the aging process, or exposure to oxygen [4]. Therefore, the assessment of beef color not only reflects freshness but also contributes to evaluating the nutritional and commercial quality of the product [5].

The Semitendinosus muscle is a striated muscle located in the posterior region of the thigh in cattle, and it is part of the "hamstring" muscle group. It extends from the pelvis to the tibia, playing an essential role in the animal's movement functions. The Semitendinosus works in conjunction with other muscles in this region to facilitate hip extension and knee flexion, which are crucial for the daily activities of cattle, such as walking and running.

Morphologically, the Semitendinosus muscle is characterized by a long, slender structure with well-developed muscle fibers. Although it is not as marbled as other more desirable cuts, such as the Longissimus dorsi, the meat derived from this muscle is valued for its firm texture and its potential to be used in various culinary preparations [4].

The color of the Semitendinosus muscle is an important indicator of meat quality and is influenced by several factors, including the level of muscle activity and the content of myoglobin. This protein, responsible for transporting oxygen in muscles, gives meat its red hue, and a higher concentration of myoglobin correlates with a darker color of the muscle [6]. Thus, the Semitendinosus muscle is typically characterized by a shade of dark red due to its frequent use in the motor activities of cattle.

Color variations observed in the Semitendinosus muscle can also be influenced by the age of the animal; older cattle tend to have meat with a darker hue. Additionally, exposure to oxygen post-slaughter can alter the appearance of the color, with the muscle initially becoming bright red and subsequently darkening to brownish shades if not properly protected [7]. A uniform and attractive color of the meat is an indicator of freshness and quality, and in the case of the Semitendinosus muscle, an intense red hue is preferred by consumers [8].

MATERIAL AND METHOD

The study commenced with the establishment of a herd of Aubrac cattle, consisting of both male and female animals. Following the slaughter process, 30 samples were collected from the carcasses of the Aubrac breed, specifically focusing on the color analysis of the Semitendinosus muscle.

In evaluating the color of meat, all relevant parameters are objectively expressed through the light that is emitted from the muscle tissue towards the observing surface, which characterizes the color based on five coordinates: L, a, b, C, and h°[9].

The assessment of beef sample color was conducted using the Konica Minolta Chroma Meter CR-410. This device functions as a reflection spectrophotometer, enabling the measurement of sample color using various colorimetric scales, including XYZ, Yxy, Lab*, Hunter Lab, L Ch, and Munsell.

The CIE Lab* color space provides a three-dimensional framework for expressing colors. The components L*, a*, and b* correspond to brightness, the red-green color dimension, and the yellow-blue color dimension, respectively. These parameters facilitate the evaluation and characterization of the color of a meat sample. The L* value indicates the brightness level, while the a* and b* values represent the hue and intensity of the color [10].

By analyzing these parameters, insights into the color profile of the meat can be gathered, allowing for comparisons among different samples regarding their visual attributes.

Chroma (C*) reflects the intensity or saturation of the color, indicating the vibrancy or richness of a specific hue. Higher chroma values signify more intense and vibrant colors. The chroma values can vary from zero (neutral or grey) to a maximum value (pure and vivid color).

The hue angle (H*), or hue, specifies the position of a particular hue within the color spectrum. It identifies whether the color is red, green, blue, yellow, and so forth. The hue angle is expressed in degrees, ranging from 0° (red) to 360° (returning to red).

The Chroma Meter CR-410 features a 50 mm measurement surface and is employed for assessing reflected colors and color differences across various industries [11].

The color determination procedure includes the following steps: the device was powered on and switched to PC mode, after which the SpectraMagicTM NX software was launched, and the device was linked to the computer to confirm the connection. Calibration was performed using a white calibration plate, and the samples were prepared for analysis [12]. For accurate color readings, the measurement tube was positioned on the meat surface to prevent external light from interfering with the device's light source [13].

Data were automatically recorded in the software, and upon completion of the measurements, the document was saved with the specified filename.

For the interpretation and analysis of the results, the SPSS (Statistical Package for the Social Sciences) software was utilized, applying various statistical methods.

RESULTS

The color of meat is an essential factor in evaluating the quality of this product, significantly impacting consumer perception and commercial value. In the case of the Semitendinosus muscle from Aubrac cattle, a breed valued for its meat characteristics, determining the color is crucial for understanding its nutritional and organoleptic properties.

This research focuses on the comparative analysis of the meat color obtained from both males and females of this breed, considering that the sex of the animal can influence the visual appearance and quality of the meat.

The results obtained from this analysis will be discussed in the context of their importance to the meat industry, aiming to provide a better understanding of the quality of beef and consumer preferences.

Table 1. presents the values for the L* parameter, which measures the lightness of the meat from Aubrac cattle at different time intervals (0, 24, and 48 hours). This parameter reflects the degree of brightness or darkness of the meat sample, an essential aspect in evaluating the visual quality of the product.

Table 1. Results regarding the brightness of the meat

Maturation time	Gender	M. Semitendinosus		
		$\bar{X} \pm SD$	Min.	Max.
L* - 0 h	M	30.16 ± 0.40^{y}	29.46	30.78
	F	42.91 ± 0.57^{x}	41.76	43.72
L* – 24 h	M	32.80 ± 0.12^{x}	32.63	32.99
	F	22.63 ± 10.66^{y}	6.98	35.52
L* - 48 h	M	31.78 ± 0.18^{y}	31.49	32.02
	F	42.05 ± 0.30^{x}	41.56	42.42
OVERALL	M	31.58 ± 1.12^{y}	29.46	32.99
	F	35.86 ± 11.23^{x}	36.98	43.72

x & y: There are no significant differences (P > 0.05) between any two means within the same column indexed by the same letter. L - meat brightness level; M - males, F - females*

Table 2. summarizes the results for the a* parameter, which indicates the intensity of color along the red-green axis. Positive values indicate a shift towards red, a crucial element in the perception of meat freshness and quality.

Table 2. Results regarding the hue of the meat

Maturation time	Gender	M. Semitendinosus		
		$\bar{X} \pm SD$	Min.	Max.
a* - 0 h	M	10.40 ± 0.16^{y}	10.16	10.67
	F	15.84 ± 0.72^{x}	14.77	16.85
a* – 24 h	M	12.86 ± 1.71^{y}	10.54	15.20
	F	18.23 ± 0.25^{x}	17.84	18.50
a* - 48 h	M	12.89 ± 0.32^{y}	12.32	13.37
	F	15.94 ± 0.28^{x}	15.57	16.31
OVERALL	M	12.05 ± 1.54^{y}	10.16	15.20
	F	16.67 ± 1.21^{x}	14.77	18.50

x & y: There are no significant differences (P > 0.05) between any two means within the same column indexed by the same letter. a* - meat hue; M - males, F - females

Table 3. presents the variation in the b* parameter, which reflects the intensity of color along the yellow-blue axis. This measurement contributes to the evaluation of the yellow hues in the meat color, influencing the overall appearance and visual perception of the product.

Table 3. Results regarding the color intensity of the meat

Maturation time	Gender	M. Semitendinosus		
		$\bar{X} \pm SD$	Min.	Max.
b* - 0 h	M	3.28 ± 0.20^{y}	2.95	3.58
	F	5.89 ± 0.43^{x}	5.29	6.33
b* – 24 h	M	6.24 ± 0.77^{y}	5.07	7.34
	F	9.85 ± 0.33^{x}	9.31	10.22
b* - 48 h	M	4.24 ± 0.09^{y}	4.10	4.38
	F	5.48 ± 0.29^{x}	5.17	5.93
OVERALL	M	4.59 ± 1.32^{y}	2.95	7.34
	F	7.07 ± 2.03^{x}	5.17	10.22

x & y: There are no significant differences (P > 0.05) between any two means within the same column indexed by the same letter. b - the intensity of the meat color; M - males, F - females*

Table 4. illustrates the values for Chroma, a parameter that describes the saturation of the color, indicating the intensity and purity of the meat hue. Chroma is an important indicator of the visual appeal and the perceived color by the consumer.

Table 4. Results regarding the color saturation (Chroma) of the meat

Maturation time	Gender	M. Semitendinosus		
		$\bar{X} \pm SD$	Min.	Max.
C* - 0 h	M	10.90 ± 0.16^{y}	10.66	11.21
	F	16.90 ± 0.74^{x}	15.70	17.89
C* – 24 h	M	14.33 ± 1.62^{y}	11.81	16.78
	F	20.72 ± 0.30^{x}	20.17	21.09
C* - 48 h	M	13.57 ± 0.30^{y}	13.05	13.99
	F	16.86 ± 0.29^{x}	16.42	17.33
OVERALL	M	12.93 ± 1.75^{y}	10.66	16.78
	F	18.16 ± 1.90^{x}	15.70	21.09

x & y: There are no significant differences (P > 0.05) between any two means within the same column indexed by the same letter. C - the saturation of the meat color; M - males, F - female*

Table 5. details the Hue angle, which represents the color tone by expressing the relationship between a* and b*. This parameter indicates the general hue of the meat and is a key factor in determining the evolution of color over time.

Tabel 5. Results regarding the hue of meat color (Hue index)

Maturation time	Gender	M. Semitendinosus		
		$\bar{X} \pm SD$	Min.	Max.
H° - 0 h	M	72.50 ± 1.06^{x}	70.70	74.31
	F	69.59 ± 1.31^{y}	67.88	71.55
H° – 24 h	M	63.90 ± 3.86^{x}	55.89	69.33
	F	61.63 ± 0.79^{y}	60.18	62.94
H° - 48 h	M	71.79 ± 0.60^{x}	70.56	72.93
	F	71.02 ± 0.96^{x}	69.29	72.20
OVERALL	M	69.40 ± 4.55^{x}	55.89	74.31
	F	67.41 ± 4.32^{y}	60.18	72.20

x & y: There are no significant differences (P > 0.05) between any two means within the same column indexed by the same letter. H°- *the hue of the meat color; M - males, F - females*

DISCUSSIONS

The results for the L* parameter (table 1.), which reflects the lightness of the meat, show significant differences between males and females at 0 hours post-slaughter. The values obtained are 30.16 ± 0.40 for males and 42.91 ± 0.57 for females, indicating a clear difference in the perceived lightness of the meat between the two sexes.

Generally, a higher L* value signifies lighter-colored meat, particularly in females, whose lightness is significantly higher than in males. This difference can be attributed to several factors, including muscle composition, the proportion of intramuscular fat, and the level of myoglobin. Males typically have a higher myoglobin content, which gives the meat a darker color, explaining the lower L* value.

The statistically significant differences between males and females, as marked by the letter indices (x and y), suggest that this variation is not random but has a clear biological basis related to the sex of the animals. It is possible that females have a higher amount of fat interspersed within the muscle, leading to greater light reflection and, consequently, a higher L* value. Analyzing the lightness of the M. Semitendinos, it is observed that, in the case of males, there are significant differences between the mean values of lightness levels at 0, 24, and 48 hours post-slaughter, with average values ranging from 32.80 to 30.16. The differences in the lightness of M. Semitendinos in males, observed at 0, 24, and 48 hours post-slaughter, can be attributed to biochemical processes, moisture evaporation, structural changes in the muscles, and variations in intramuscular fat composition.

The results for the a* parameter (table 2), which reflects the intensity of color on the red-green axis, show significant differences between males and females in the M. semitendinosus muscle. The mean values of overall are 12.05 ± 1.54 for males and 16.67 ± 1.21 for females, indicating a higher intensity of red color in females compared to males.

The a* parameter is an essential indicator of meat color, where higher values suggest a more intense red hue, often associated with the perception of freshness and higher quality meat. The observed differences between males and females can be explained by:

Myoglobin content: Males generally have a higher myoglobin content, which, while contributing to a darker color, can lead to a lower a* value, as myoglobin oxidizes differently over time, resulting in a

darker, less reddish hue. Females, with a lower myoglobin content, may initially have meat with a more intense red color.

Intramuscular fat distribution: Females tend to have a higher proportion of intramuscular fat, which can contribute to a different light reflection and thus a higher a* value, making the red in the meat appear more intense.Hormonal and metabolic differences: Hormonal differences between males and females may influence muscle metabolism and, consequently, the way pigments in the meat are formed and maintained.

The statistically significant differences between males and females, indicated by the letter indices (x and y), suggest a clear sex-related variation, thus influencing the quality and visual perception of the meat. From the meat industry's perspective, these results highlight the importance of the animal's sex in determining meat color, a key aspect in attracting consumers. Analyzing the color intensity (table 3) in the case of M. Semitendinosus, it is observed that, for males, there are significant differences between the mean values of color intensity at 0, 24, and 48 hours post-slaughter.

Analyzing the results obtained for color intensity (a*) and color saturation (C*), we observe a clear correlation between these two parameters in the case of the M. semitendinosus muscle. In males, the a* values of 12.05 ± 1.54 indicate a lower intensity of red color, while in females, the a* values of 16.67 ± 1.21 suggest a more pronounced red hue. This aligns with the obtained C* values (table 4), which are 12.93± 1.75 for males and 18.16± 1.90 for females. The significant differences observed in both results suggest that females not only have a higher intensity of red color (a*), but also a higher saturation (C*), indicating meat perceived as more vibrant and appealing.

Analyzing the hue of color (table 5) in the case of M. semitendinosus, it is observed that, both in males and females, there are significant differences between the mean values of meat hue at 24 hours compared to the values obtained at 0 and 48 hours post-slaughter.

The determination of meat hue in Aubrac cattle is important for assessing the appearance and quality of the meat. An appropriate and attractive hue can indicate a quality product, while deviations from the desired hue may indicate potential changes or issues in the production process or the state of the meat.

CONCLUSIONS

The analysis of color parameters for the M. semitendinosus muscle revealed significant differences between males and females regarding intensity (a*), saturation (C*), and hue (Hue) of the meat. The results showed that females exhibit a higher intensity of red color and a more pronounced saturation, suggesting meat perceived as more vibrant and appealing to consumers. In contrast, males, despite having a higher myoglobin content, show lower values for these parameters, indicating a darker hue and lower saturation.

The differences observed in the hue of the meat at 24 hours post-slaughter compared to the values at 0 and 48 hours suggest that the aging period significantly influences color perception. These findings underscore the importance of considering the sex of the animal in assessing meat quality, with important implications for the meat industry, particularly regarding consumer preferences and marketing strategies.

REFERENCES

1. Madescu, BM; Lazar, R; Ciobanu, MM; Boisteanu PC Morph-productive characteristics of Aubrac cattle breed: a sistemativ review. *Scientific Papers. Series D. Animal Science*, **2021**, LXIV (2).
2. Madescu, BM; Lazar, R; Neculai Valeanu, AS; Porosnicu, I; & Boisteanu, PC Bodymeasurements on the Aubrac cattle

breed: a review. *Scientific Papers Animal Science and Biotechnologies*, **2022**, 55 (2).
3. Davidescu, MA; Ciorpac, M; Madescu, BM; Porosnicu, I; Creanga S Analysis of the Genetic diversity of endangered cattle breeds based on studies of genetic markers. *Scientific Papers Animal Science and Biotechnologies*, **2021**, Vol. 54, pp. 60-63.
4. Bostami ABMR; Mun HS; & Yang CJ Longissimus dorsi muscle's chemical composition, fatty acid pattern, and oxidative stability in Korean Hanwoo finishing cattle following slaughtering and stunning with or without brain disruption and state of consciousness. *Foods*, **2023**, 12 (5).
5. Chmiel, M; Slowinski, M; Dasiewicz, K; & Florowski, T Application of a computer vision system to classify beef as normal or dark, firm, and dry. *Journal of Animal Science*, **2021**, 90 (11), 4126–4130.
6. Cho, S; Kang, SM; Kim, YS; Kim, YC; Van Ba, H; Seo, HW; Lee, EM; Seong, PN; & Kim, J. H Comparison of drying yield, meat quality, oxidation stability and sensory properties of bone-in shell loin cut by different dry-aging condition. *Korean Journal for Food Science of Animal Resources*, **2018**, 38 (6), 1131–1143.
7. Gatellier, P; Mercier, Y; Juin, H; & Renerre, M Effect of finishing mode (pasture or mixed diet) on lipid composition, colour stability and lipid oxidation in meat from Charolais cattle. *Meat Science*, **2004**, 69 (1), 175–186.
8. Węglarz, A; Meat quality defined based on pH and colour depending on cattle category and slaughter season. *Czech Journal of Animal Science*, **2010**, 55(12), 548–556.
9. Abasi S, Minaei S, Jamshidi B, Fathi D Dedicated non-destructive devices for food quality measurement: A review. *Trends Food Sci Technol.* **2018**;78:197–205.
10. Girolami, A; Napolitano, F; Faraone, D; Braghieri A Measurement of meat color using a computer vision system. *Meat Science*, **2013**, 93:111–118.
11. Larraín, RE; Schaefer, DM; Reed JD Use of digital images to estimate CIE color coordinates of beef. *Food Research International*, **2008**, Volume 41, Issue 4 , Pages 380-385.
12. Bolohan, I; Lazar, R; Madescu, BM; Bolohan, RM; Davidescu, MA; Boisteanu, PC *Stability of Poultry Meat During Refrigerated Storage, based on the Packaging Used.* Scientific Papers Animal Science And Biotechnologies, 2024, vol.57, no. 1, pag. 173-173.
13. Di, Wu; Da-Wen, Su Colour measurements by computer vision for food quality control – A review. *Trends in Food Science & Technology*, **2013**, Volume 29, Issue 1, Pages 5-20.