Scientific Papers. Series D. Animal Science. Vol. LXVII, No. 2, 2024
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

MORPHOSTRUCTURAL CHARACTERIZATION OF *Longissimus dorsi* MUSCLE TISSUE OF AUBRAC CATTLE

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Abstract

The purpose of this paper was to highlight the results of the morphostructural characterization of Longissimus dorsi muscle tissue of the Aubrac breed, exploited in Romania. The present research focused on a population of 38 cattle, including both males and females, raised in a semi-intensive farming system. Longitudinal measurements (major and minor diameter, mean, DM/Dm ratio, length) as well as transverse measurements (diameter, area) of muscle fibres were conducted, and the results were statistically interpreted. In terms of determining the length of muscle fibres in the longitudinal section, significant differences between genders are observed. In males, the large diameter recorded values of 77.17 µm, while in females, it was 64.73 µm. Regarding the determination of the area of muscle fibres in cross-sectional analysis, significant differences were noted between males and females (in males, it`s an average of 2226.83 µm$^2$, while in females it`s 1576.60 µm^2). This shows that in the Aubrac breed, the area of muscle fibres in meat content can vary by gender. In conclusion, longissimus dorsi muscle is particularly important and valuable in the beef industry.

Key words*: beef cattle, Longissimus dorsi, morphostructure, quality.*

INTRODUCTION

One of the oldest cattle breeds in France is the Aubrac cattle breed, originating from the Aubrac mountains in the southern Massif Central. Initially, the cattle were raised as a dual-purpose breed, as their milk was used in the production of Laguiole cheese. Over time, particularly after the post-war period, the Aubrac breed has been predominantly raised for meat production. Its adaptable characteristics and efficient growth qualities have made Aubrac a popular choice for the meat industry. Representatives of the Aubrac breed generally have a medium build. Adult cows weigh between 550 and 800 kg and stand 130 cm tall, while bulls stand 140 cm tall and weigh between 900 and 1200 kg (Madescu et al., 2022).

Aubrac cattle are easy to maintain as they efficiently consume any type of feed. They quickly adapt to grazing on large, resource-poor pastures without significantly impacting their productivity. The Aubrac breed is renowned for the exceptional quality of its meat, with distinctive flavors and tenderness. A high level of marbling highlights the distinct flavor and delicate texture of meat from the Aubrac breed (Madescu et al., 2021). The breed, age, sex, and health status of the animals, as well as the methods of breeding, feeding, slaughtering, and processing, all have an impact on the quality of beef. One of the most important factors is marbling, which refers to the even distribution of fat within the muscle tissue and is essential for a fine texture and rich flavor. Additionally, the color, texture, and taste of the meat are key aspects of assessing quality. Animals raised naturally and grass-fed without additives, as well as those from responsible farming systems, can produce high-quality meat (Vidu et al., 2015). Certifications and standards that attest to the conditions of breeding and processing can also be important indicators of beef quality. Overall, superior-quality beef is valued for its distinctive aroma, succulent texture, and rich taste. The term "meat" refers to the muscular tissue of the slaughtered animal, together with the tissues naturally connected to it: fat, bones, tendons, aponeuroses, connective tissue, blood

vessels, nerves, lymph nodes, by-products, and organs.

From a morphological standpoint, meat comprises: muscle tissue, striated; connective tissue; adipose tissue; bone tissue; blood vessels; and the proportion of various tissues that make up meat depends on the animal's breed, age, sex, and fattening state (Sadeghinezhad et al., 2016). The average proportion of components in bovine meat is: 58% muscle tissue, 18% bones, 12% fat, and 12% connective tissue with blood vessels and nerves. Therefore, it is evident that muscle tissue, which also makes up the majority of the animal's body, represents the majority of meat.

Connective tissue represents the second morphological component of meat. It is found in all segments of the animal's body and is a determining factor in the quantity and quality of meat (Stimbirys et al., 2016). The proportion of this tissue influences characteristics such as tenderness, color, water loss capacity through boiling, meat juiciness, and marbling finesse. The structure of adipose tissue. This represents a specialized form of connective tissue. The third tissue is adipose tissue, which is composed of fat cells covered with a protoplasmic membrane containing the nucleus (Fabbri et al., 2021). The basic morphological unit of adipose tissue is the adipose cell of fibrocellular origin.

The longissimus dorsi muscle is a large and elongated muscle located on the lateral side of the vertebral column in cattle. It extends along the thoracic and lumbar regions, starting from the cervical region to the base of the tail (Choat et al., 2006). This muscle is responsible for the extension, flexion, and rotation of the vertebral column in animals. Additionally, it acts as a stabilizer of the vertebral column and plays an important role in trunk movements.

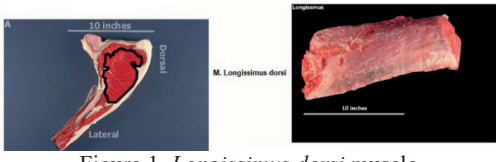


Figure 1. *Longissimus dorsi* muscle (processed photograph)

The *Longissimus dorsi* muscle is one of the most valuable muscles in the beef industry. It is prized for its organoleptic qualities, such as its tender texture and rich flavor (Fabbri et al., 2021). From this muscle, some of the most popular and esteemed beef cuts are obtained, such as the ribeye, the middle loin (T-bone, porterhouse), the New York strip steak, and the striploin roast (Choat et al., 2006). The histological structure of muscles is highly relevant, both theoretically and practically, regarding meat quality. It influences a range of physical, chemical, and technological properties of meat, significantly impacting its texture, juiciness, taste, and overall quality. An important aspect of histological structure is the fineness and density of muscle fibers. Thin and dense muscle fibers are associated with tender and visually appealing meat, as they allow for easy cutting and provide a more uniform texture. Conversely, thicker and less dense muscle fibers can result in tougher and less tender meat (Dransfield et al, 2003).

Additionally, the size of muscle bundles and the proportion of muscle and connective tissue have a significant impact on meat characteristics. Larger muscle bundles can influence the appearance of meat and may be associated with more voluminous meat. At the same time, the optimal proportion of muscle tissue to connective tissue can contribute to juicier and more flavorful meat (Foggi et al., 2021).

All these aspects related to the histological structure of somatic muscles are essential in determining the quality of Aubrac beef. By understanding and monitoring these characteristics, high-quality meat with pleasant texture, juiciness, and excellent taste can be achieved, thus meeting consumer requirements (Chriki et al., 2013).

MATERIALS AND METHODS

The study involved examining a total of 38 cattle, comprising both males and females, with ages ranging from 15 to 18 months, which were reared under a semi-intensive farming system. After slaughter, samples were collected from the carcasses obtained from Aubrac breed animals, and the morphostructure of the *Longissimus dorsi* muscle was analyzed. Subsequently, for interpreting and understanding the results, the SPSS (Statistical Package for the Social Sciences) analysis software was used, applying statistical methods such as ANOVA (Analysis of Variance) and the Tukey Test.

Histological technique - The dimensions of the specimen were approximately 2 cm in length and 1 cm in height, to allow for rapid penetration of the fixative throughout the sample (Figure 2). After a fixation period of at least 24-48 hours, the specimens will be sectioned with sharp blades to obtain a much thinner thickness, and then they will be placed into fresh fixative.



Figure 2. Cross-sectional view of Aubrac cattle beef (original photo)

The embedding in paraffin occurred in four successive phases: dehydration, clarification, impregnation with paraffin, and actual embedding. Histological sectioning of the paraffin was performed using a microtome, which provided the opportunity to obtain sections with a thickness of 5-6 µm. The sections were stained using the Hematoxylin-Eosin-Methyl Blue (HEM) method.



Figure 3. Stages of processing and obtaining histological slides (original photo)

After obtaining the desired slides, they were subjected to microscopic analysis, where longitudinal measurements (major diameter, minor diameter, mean diameter, DM/Dm ratio, length) and transverse measurements (diameter, area) of the muscle fibers were performed (Figure 3).

The Leica 1CC50w microscope is a model used for histological analysis. It utilizes transmitted light to visualize the structure and composition of tissues at a microscopic level. It is equipped with multiple objectives for various magnification levels and has an adjustable illumination source for optimal contrast (Figure 4).

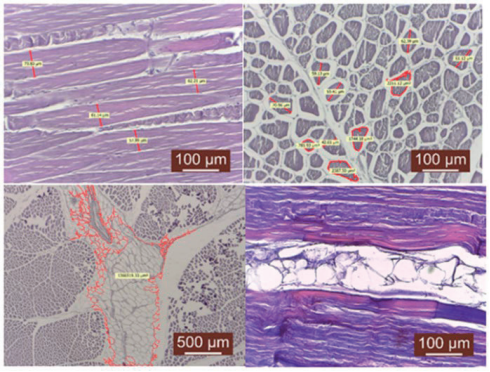


Figure 4. Analysis of histological slides under the microscope (original photo)

Additionally, it features precise focusing mechanisms and binocular eyepieces and tubes for simultaneous observation or stereoscopic visualization.

Subsequently, the obtained results underwent rigorous statistical analysis to be interpreted in detail. This involved the use of appropriate statistical methods to assess the significance and correlations between the obtained results. Various techniques were employed to extract relevant information from the data obtained. The statistical interpretation of the results provided a deeper understanding of the differences and relationships within the dataset, allowing for the formulation of conclusions and generalizations regarding the study parameters. This process of statistical interpretation provided a solid foundation for understanding and interpreting the results obtained in the present research.

RESULTS AND DISCUSSIONS

Longitudinal measurements (major diameter, minor diameter, mean diameter, DM/Dm ratio, length) as well as transverse measurements

(diameter, area) of the muscle fiber were conducted. Table 1 highlights the mean values obtained within the *Longissimus dorsi* muscle, categorized by sex, following the muscle analysis.

Table 1. Morphostructure of the *Longissimus dorsi*, Psoas, Semitendinosus, and Deltoid muscles

Specification (µm)	**Gender**	**Muscle region**		
		M. Longissimus Dorsi		
		$\bar{X}$±SD	Min.	Max.
*Major diameter (DM)	M	77.17 ± 5.34^{xA}	69.30	83.67
	F	64.73 ± 4.63^{yC}	57.42	72.77
*Minor diameter (Dm)	M	63.37 ± 3.22^{xA}	59.31	68.51
	F	53.05 ± 2.13^{yC}	49.22	55.97
* Mean diameter ($D\bar{x}$)	M	70.27 ± 2.47^{xA}	66.65	75.07
	F	58.89 ± 2.47^{yB}	53.82	63.00
*DM/Dm ratio	M	1.22 ± 0.12^{xB}	1.02	1.38
	F	1.22 ± 0.10^{xB}	1.04	1.41
*Length	M	558.77 ± 19.79^{yA}	540.20	590.20
	F	587.68 ± 12.91^{xA}	562.00	608.00
**Mean diameter	M	71.11 ± 2.65^{xA}	65.88	74.31
	F	59.56 ± 3.53^{yC}	53.34	64.57
**Cross -section area (µm²)	M	2226.83 ± 233.15^{xA}	1769.34	2574.93
	F	1576.60 ± 310.37^{yB}	1116.42	2006.31

Note: *Longitudinal section of muscle fiber; **Transversal section of muscle fiber; x & y: There are no significant differences (P > 0.05) between any two means within the same column with the same letter index; A, B, and C: There are no significant differences (P > 0.05) between any two means within the same row with the same letter index; M – males, F – females.

In the course of the conducted research, significant differences were observed between the average diameter of muscle fibers in males compared to that recorded in females, in the case of M. *Longissimus dorsi*. This indicates that, in the Aubrac breed, gender can influence the thickness of muscle fibers, with an average value of 70.27 ± 2.47 µm in males, while in females, it is lower, at 58.89 ± 2.47 µm, showing significant differences between sexes.

Additionally, for instance, significant differences are noted between sexes regarding the ratio of the large diameter to the small diameter, with males recording an average value of 1.22 ± 0.12 µm, while females have a value of 1.22 ± 0.10.

Regarding the determination of muscle fiber length in longitudinal sections, significant differences between sexes are observed, with males having an average value of 558.77 ± 19.79 µm and females having an average value of 587.68 ± 12.91 µm. This shows that, in the Aubrac breed gender can influence the length of muscle fibers. By examining the longitudinal sections of muscles, valuable information can be obtained about the distribution, density, and size of muscle fibers, as well as the proportion of muscle tissue and connective tissue (Foggi et al., 2021). These aspects are essential in determining the quality of meat, as they influence its texture, juiciness, and tenderness.

Moreover, within the conducted research, activities also focused on determining the mean diameter and area of the cross-sectional area of the muscle fiber in both sexes.

On the cross-sectional section, significant differences are observed between the mean diameter of muscle fibers in males (71.11 ± 2.65 µm) compared to that recorded in females (59.56 ± 3.53 µm), in the case of the *Longissimus dorsi* muscle.

These findings indicate that, in the Aubrac beef cattle breed, gender may have implications for the mean diameter of muscle fibers within the region under study.

The mean diameter of muscle fibers is an important measure of muscle structure in beef cattle bred for meat production. This parameter indicates the average thickness of muscle fibers within a particular muscle and can influence the quality and characteristics of the meat. On the other hand, a smaller diameter of muscle fibers may be associated with more tender and delicate meat, as these fibers can be softer and less dense. This may be desirable for certain types of meat,

such as high-quality beef, which is valued for its fine texture and succulence.

Regarding the determination of muscle fiber area in cross-section, significant differences are observed in males (2226.83 ± 233.15 µm) compared to those recorded in females (1576.60 ± 310.37 µm), in the case of M. *Longissimus dorsi*. This indicates that, in the Aubrac breed, gender can influence the muscle fiber area in the meat content.

The term "muscle fiber area" refers to the entire surface that a particular muscle's muscle fibers cover, and it can reveal details about the density and distribution of muscle fibers within the muscle tissue. A larger area of muscle fibers may indicate better muscle development and a higher fiber density. This can contribute to better-marbled and more muscular beef (Sadeghinezhad et al., 2016). Higher muscle fiber density can also influence the texture and juiciness of the meat, providing a more enjoyable chewing sensation and a richer taste. On the other hand, a smaller area of muscle fibers may be associated with a finer and more delicate meat structure. This can create an easier and less resistant chewing sensation during consumption.

In the conducted research, in order to provide a more concrete understanding of the morphostructure of the meat derived from the Aubrac cattle breed, along with the analysis of the samples under the microscope, the adipose tissue content was also examined. The adipose tissue within the structure of the *Longissimus dorsi* muscle in the Aubrac cattle breed (Figure 5) represents an important component that influences the characteristics of the meat, such as appearance, texture, and taste.

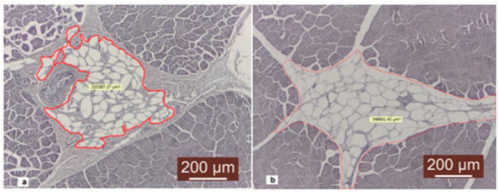


Figure 5. Highlighting of adipose tissue from the *Longisimus dorsi* muscle (a - male; b - female)

The presence of intramuscular fat in the *Longissimus dorsi* muscle contributes to the tenderness and juiciness of the meat. The quantity and distribution of fat within the muscle can vary depending on several factors, including the age, diet, and level of activity of the animal (Haderlie et al., 2023). From the obtained images, we can observe that Aubrac cattle exhibit remarkable marbling in the Longissimus dorsi muscle, which can impart the meat with a distinct texture and juiciness.

CONCLUSIONS

In conclusion, based on the morphostructural analysis of the meat, significant differences were found between sexes regarding the diameter and length of muscle fibers, as well as the mean diameter and area of muscle fibers. These differences can be influenced by several factors, including the hormonal composition and genetic characteristics of the animals. In general, beef muscle fibers from males (bulls) may be larger and thicker than those from females. This is due to the higher production of anabolic hormones such as testosterone in males. Testosterone stimulates muscle growth and hypertrophy of muscle fibers, leading to more developed and thicker muscle fibers in bulls. On the other hand, beef from females may have a higher amount of intermuscular adipose tissue. This can influence the texture and taste of the meat, giving it greater succulence and tenderness compared to that from males. Obtaining these results contributes to the advancement of scientific knowledge and a deeper understanding of the characteristics of meat from Aubrac cattle. This information can be used in further research to explore aspects related to nutrition, genetics, and processing technologies that could enhance the quality and value of meat from Aubrac cattle.

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