# RESEARCH ON THE CHARACTERIZATION OF BEEF PROTEINS

**Bianca-Maria Mădescu[1*], Roxana Lazăr[1], M.M. Ciobanu[1], P.C. Boişteanu[1]**

*[1]Faculty of Animal Sciences, University of Agricultural Sciences and Veterinary Medicine of Iaşi, Romania*

**Abstract**

*The objective of this research was to characterize a group of six proteins (myosin, actin, myoglobin, globulin, collagen and elastin) that are found in beef, presenting their physical and chemical parameters, but also the proportion of amino acids of each protein. Also, the molecular functions, biological processes and location of each protein studied were presented. For all six muscle proteins were calculated parameters using the ProtParam program. Myosin is high in leucine (9.5%) and glutamic acid (9.4%), actin in alanine (7.7%) and glycine (7.5 %%), myoglobin in alanine (11.7%), lysine (11.7 %%) and leucine (11.0%), globulin in leucine (10.5%) and serine (8.9%), collagen in glycine (26.6%) and proline (19.1%) and elastin is largely represented by glycine (30.8%) and alanine (20.7%). Based on the results, it can be concluded that beef proteins are of high biological value with a large number of essential amino acids, which are indispensable to the human body.*

**Key words:** amino acids, beef, proteins

## INTRODUCTION

Proteins are, after water, the most important constituents of animal organism. Myofibrillar proteins are located in myofibrils, contributes to the filamentous organization of the muscle and participates directly to the mechanochemical process of contraction and stiffness muscle. These represent the fraction of the richest protein in muscle tissue (54-70% of total muscle tissue protein). Myofibrillar proteins, from a technological point of view, contributes to the tenderness of the meat, determines the ability to water retention and hydration of meat, the capabilities of fat emulsification and gelling [1]. Myofibrillar proteins by the high intake of essential amino acids, contributes about 70% of the nutritional value of meat. Myofibrillar proteins have intermediate solubility between sarcoplasmic and stromal proteins (insoluble in water, but soluble in saline solutions with an ionic strength greater than 0,3 or in pH controlled solutions) [3]. Knowledge of the properties of myoglobin is of great importance in assessing the organoleptic qualities, freshness and appreciation of color changes in meat. By laboriously fixing oxygen in the air in the form of oxymioglobin, the red color of the meat intensifies. Globulin is a pseudoglobin that precipitates easily by dialysis of weak alkaline solutions and can be passed back into the solution by adding salts at a pH between 7 and 8. It coagulates and has enzymatic properties. Collagen is the main protein of connective tissue in meat and is a protein of lower biological value due to the fact that it does not contain tryptophan, cysteine and cystine [9]. The imbalance is mainly caused by the excessive glycocol content, which represents 1/3 of all amino acids at this level, and by proline and hydroxyproline, which is a precursor of collagen and which initially has a relatively simple structure and is soluble in water. Elastin is the protein present in elastic fibers, has a composition similar to collagen, but has some negative properties, such as the absence of gelatinizing capacity and low or no coefficient of digestive use [2]. Elastin macromolecules are resistant to acid or

*Corresponding author:
biancamadescu@yahoo.com
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alkaline hydrolysis, as well as to the action of strong digestive enzymes.

## MATERIAL AND METHODS

For all six muscle proteins (myosin, actin, myoglobin, globulin, collagen and elastin) were calculated using the ProtParam program (a tool for calculating various physical and chemical parameters for a specific protein stored in Swiss-Prot or TrEMBL or for a user introduced protein sequence), the following parameters: molecular weight, theoretical pI, protein composition in amino acids, atomic composition and high average hydropathicity [expasy.org].

Each protein corresponds to a specific code from the UniProtKB database: Myosin - code P79114, gene name MYO10; Actin - code P60712, gene name ACTB; Myoglobin - code P02192, gene name MB; Globulin - code F1N5M2, gene name GC; Collagen - code P02453, gene name COL1A1 and Elastin - code P04985, gene name ELN [www.uniprot.org].

## RESULTS AND DISCUSSION

Proteins are macromolecular organic substances formed by simple or complex chains of amino acids, such as: Alanine (Ala), Arginine (Arg), Aspargine (Asn), Aspartic (Asp), Cisteyne(Cys), Glutamine (Gln), Glutamic acid (Glu), Glycine (Gly), Histidine (His), Isoleucine (Ile), Leucine (Leu), Lysine (Lys), Methionine (Met), Phenylalanine (Phe), Proline (Pro), Serine (Ser), Threonine (Thr), Tryptophan (Trp), Tyrosine (Tyr), Valine (Val).

**Myosins** are actin-based motor molecules with ATPase activity. Unconventional myosins serve in intracellular movements. MYO10 binds to actin filaments and actin bundles and functions as plus end-directed motor. The tail domain binds to membranous compartments containing phosphatidylinositol 3,4,5-trisphosphate, which are then moved relative to actin filaments. Stimulates the formation and elongation of filopodia. Regulates cell shape, cell spreading and cell adhesion. Plays a role in formation of the podosome belt in osteoclasts.

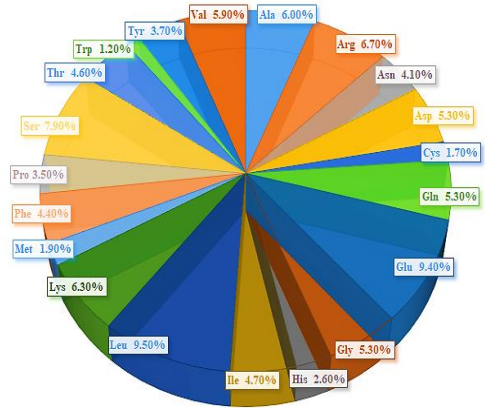


Figure 1. The proportion of amino acids contained in myosin in beef

Myosin is high in leucine (9.5%) and glutamic acid (9.4%), but is low in tryptophan (1.2%), cysteine (1.7%) and methionine (1.9%).

Molecular function: actin-dependent ATPase activity, actin filament binding, ATP binding, calmodulin binding, microfilament motor activity, phosphatidylinositol-3,4,5-trisphosphate binding and plus-end directed microfilament motor activity.

Biological process: actin filament organization, cytoskeleton-dependent intracellular transport, regulation of cell shape, regulation of filopodium assembly, sensory organ development, sensory perception of sound, signal transduction and vesicle transport along actin filament [6].

Subcellular location: cytoscheleton, plasma membrane and cytosol.

**Actin** is a highly conserved protein that polymerizes to produce filaments that form cross-linked networks in the cytoplasm of cells. Actin exists in both monomeric (G-actin) and polymeric (F-actin) forms, both forms playing key functions, such as cell motility and contraction. In addition to their role in the cytoplasmic cytoskeleton, G- and F-actin also localize in the nucleus, and regulate gene transcription and motility and repair of damaged DNA [8].

In vertebrates 3 main groups of actin isoforms, alpha, beta and gamma have been identified. The alpha actins are found in

muscle tissues and are a major constituent of the contractile apparatus. The beta and gamma actins coexist in most cell types as components of the cytoskeleton and as mediators of internal cell motility.

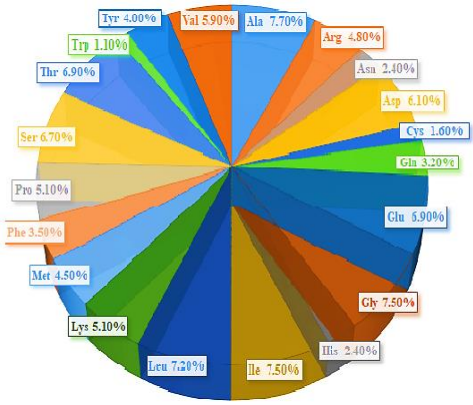


Figure 2. The proportion of amino acids contained in actin in beef

Actin is rich in alanine (7.7%) and glycine (7.5 %%), but is low in tryptophan (1.1%), and cysteine (1.6%) [11].

Molecular function: ATP binding, identical protein binding, kinesin binding, nitric-oxide synthase binding, protein kinase binding, structural constituent of postsynaptic actin cytoskeleton and Tat protein binding.

Biological process: adherens junction assembly, apical protein localization, axonogenesis, cell motility, cellular response to cytochalasin B, establishment or maintenance of cell polarity, morphogenesis of a polarized epithelium, negative regulation of protein binding, protein localization to adherens junction, regulation of norepinephrine uptake, regulation of protein localization to plasma membrane, regulation of transepithelial transport, regulation of transmembrane transporter activity and synaptic vesicle endocytosis [11].

Subcellular location: cytoscheleton and nucleus.

Table 1 The physical and the chemical parameters for myosin and actin proteins, calculated using the application ProtParam

| Myofibrillar proteins | Myosin | Actin |
|---|---|---|
| Number of amino acids | 2,052 | 375 |
| Molecular weight | 235,839 DA | 41,737 DA |
| Theoretical pI | 5.99 | 5.29 |
| Total number of atoms | 32,924 | 5,828 |
| Grand average of hydropathicity (GRAVY) | -0.576 | -0.2 |

**Myoglobin** serves as a reserve supply of oxygen and facilitates the movement of oxygen within muscles.

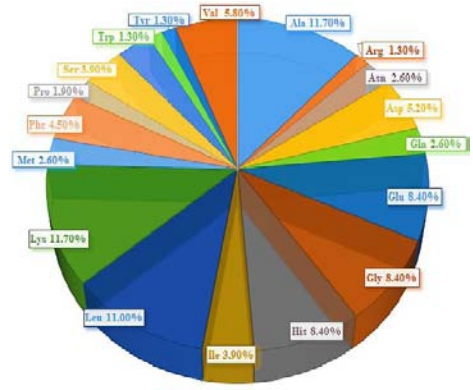


Figure 3. The proportion of amino acids contained in myoglobin in beef

Myoglobin is rich in alanine (11.7%), lysine (11.7 %%) and leucine (11.0%), while tryptophan, tyronine and arginine are found only in a proportion of 1.3 each [12].

Molecular function: heme binding, metal ion binding, oxygen binding, oxygen carrier activity.

Biological process: brown fat cell differentiation, enucleate erythrocyte differentiation, heart development, oxygen transport and response to hypoxia [5].

**Globulin** involved in vitamin D transport and storage, scavenging of extracellular G-actin, enhancement of the chemotactic activity of C5 alpha for neutrophils in inflammation and macrophage activation [14].

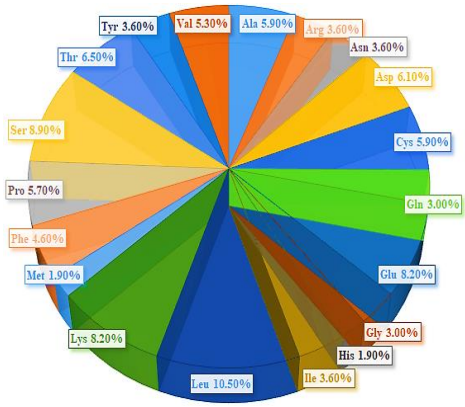


Figure 4. The proportion of amino acids contained in globulin in beef

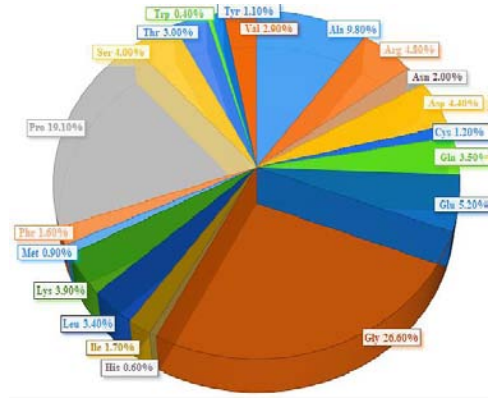


Figure 5. The proportion of amino acids contained in collagen in beef

Globulin has a high content of leucine (10.5%) and serine (8.9%), while it is low in methionine (1.9%) and histadine (1.9%).

Molecular function: vitamin D binding and vitamin transmembrane transporter activity [15].

Table 2. The physical and the chemical parameters for myoglobin and globulin proteins, calculated using the application ProtParam

| Sarcoplasmic proteins | Myoglobin | Globulin |
|---|---|---|
| Number of amino acids | 154 | 474 |
| Molecular weight | 17,078 DA | 53,536 DA |
| Theoretical pI | 6.90 | 5.42 |
| Total number of atoms | 2,412 | 7,426 |
| Grand average of hydropathicity (GRAVY) | -0.364 | -0.336 |

**Collagen** is the main protein of connective tissue in beef and forms fibril [3].

Molecular function: extracellular matrix structural constituent, identical protein binding, metal ion binding, platelet-derived growth factor binding and protease binding.

Collagen is largely represented by glycine (26.6%) and proline (19.1%), while the content of tryptophan (0.4%), histadine (0.6%), methionine (0.9%) and tyronine (1.1%) are low.

Biological process: blood vessel development, bone trabecula formation, cartilage development involved in endochondral bone morphogenesis, cellular response to amino acid stimulus, cellular response to mechanical stimulus, collagen-activated tyrosine kinase receptor signaling pathway, collagen biosynthetic process, collagen fibril organization, embryonic skeletal system development, endochondral ossification, extracellular matrix organization, face morphogenesis, intramembranous ossification, negative regulation of cell-substrate adhesion, ossification, osteoblast differentiation, positive regulation of canonical Wnt signaling pathway, positive regulation of cell migration, positive regulation of epithelial to mesenchymal transition, positive regulation of transcription, DNA-templated, protein localization to nucleus, protein transport, response to mechanical stimulus, sensory perception of sound, skeletal system development, skin development, skin morphogenesis and tooth mineralization.

**Elastin** is the major structural protein of tissues such as aorta and nuchal ligament, which must expand rapidly and recover completely [3]. Molecular determinant of the late arterial morphogenesis, stabilizing arterial structure by regulating proliferation and organization of vascular smooth muscle[10].

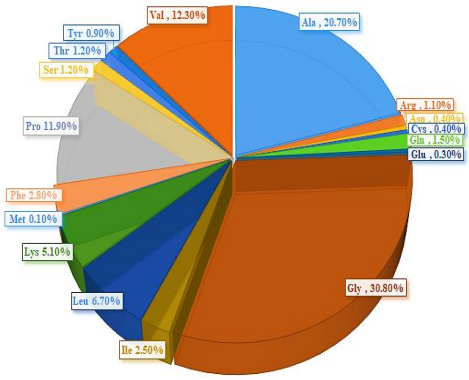


Figure 6. The proportion of amino acids contained in elastin in beef

Elastin is largely represented by glycine (30.8%) and alanine (20.7%), while the content of glutamic acid (0.3%), cysteine (0.4%), asparagine (0.4%) %) and tyronine (0.9%) are low.

Molecular function: extracellular matrix structural constituent.

Subcellular location: extracellular matrix.

Elastin is formed through the cross-linking of its soluble precursor tropoelastin. Cross-linking is initiated through the action of lysyl oxidase on exposed lysines to form allysine [13].

Subsequent spontaneous condensation reactions with other allysine or unmodified lysine residues result in various bi-, tri-, and tetrafunctional cross-links. The most abundant cross-links in mature elastin fibers are lysinonorleucine, allysine aldol, desmosine and isodesmosine [7].

Table 3. The physical and the chemical parameters for collagen and elastin proteins, calculated using the application ProtParam

| Stromal proteins | Collagen | Elastin |
|---|---|---|
| Number of amino acids | 1,463 | 747 |
| Molecular weight | 138,938 DA | 64,229 DA |
| Theoretical pI | 5.60 | 10.65 |
| Total number of atoms | 19,073 | 9,274 |
| Grand average of hydropathicity (GRAVY) | -0.799 | 0.685 |

## CONCLUSION

Meat, as such or processed, has great significance in human nutrition. It has an important energy and plastic role, constituting a complete food, with high nutritional and biological value, and processed under certain conditions, the products obtained are also convenient in terms of price. Therefore, globally and nationally, the aim is to increase quantity, improve quality and increase the economy of meat products. Proteins are the most valuable elements of beef, by their contribution in essential amino acids in human nutrition.

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