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CHEMICAL COMPOSITION OF *CERVUS ELAPHUS* MEAT BY AGE AND BREED

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ABSTRACT

The aim of the work was to evaluate and compare the basic chemical composition (water, protein, fat, and cholesterol content) of the *musculus biceps femoris* of free-range and farmed deer, as well as by age. 80 pcs individuals were evaluated in the experiment, of which 40 pcs were farmed, and 40 pcs were free-range. Based on the results, we can conclude that the chemical composition of the thigh muscle of farmed and free-range deer older than 2 years had higher ($p \leq 0.05$) cholesterol values (0.041 g.100 g^{-1}; 0.041 g.100 g^{-1}) than deer under 2 years (0.035 g.100 g^{-1}; 0.037 g.100 g^{-1}). In deer over 2 years old compared to deer under 2 years old, a significant difference ($p \leq 0.05$) was also found in the water content (72.735 g.100 g^{-1}:71.563 g.100 g^{-1}). Comparing deer by sex, we found significant differences ($p \leq 0.05$) in fat content (0.854 g.100 g^{-1} - male:0.555 g.100 g^{-1} - female) in deer from farmed farms. Comparing the sum without sex, we did not find significant differences between farmed and wild deer ($p \geq 0.05$). Overall, it can be stated that both farmed and wild deer are carriers of high amounts of protein and water and low fat and cholesterol content.

Keywords: deer, meat, chemical composition, breeding

INTRODUCTION

The need for animal protein is continuously rising due to the world's expanding population, which has recently resulted in a rise in meat consumption worldwide **(OECD/FAO, 2022)**. In the human diet, meat is a vital source of protein. However, because of the food security crisis, animal diseases, and the advice to restrict the consumption of red meat because of its high fat and cholesterol content, red meat may harm one's health **(Binnie *et al.*, 2014).** Alternative meat sources, including horses, pigeons, ostriches, and wild or farmed game, are being sought in response to the rising demand for meat **(Polawska *et al.*, 2013).** A solution and unconventional substitute for red meat from domestic ruminants is game meat. The word "game" also refers to cervid meat, whether it is farmed or wild, and its consumption is generally rising **(Costa *et al.*, 2016; Kudrnáčová *et al.*, 2018; Tesařová *et al.*, 2018; Fantechi *et al.*, 2022)**. Game meat consumption in the EU ranges from 0.08 kg/capita/year (Poland, Portugal) to 8.4 kg/capita/year in Andalusian hunting families **(Milczarek *et al.*, 2021)**. Better disease control and health management are possible with farmed game species than with wild animals. Europe raises a variety of game species, primarily cervids, such as reindeer (*Rangifer tarandus*), fallow deer (*Dama dama*), and red deer (*Cervus elaphus*) **(Kudrnáčová *et al.*, 2018; Esattore *et al.*, 2022)**. In contrast to conventional farmed meats, such as beef and pork, deer meat (*Cervus elaphus*), also referred to as venison, is renowned for its high nutritional value while maintaining comparatively low fat and cholesterol content **(Hoffman & Wiklund, 2006).** However, several factors, such as the animal's sex, feed, degree of physical activity, and whether it is farmed or wild, affect the chemical composition of venison, including its water, fat, protein, and cholesterol content. Changes in meat quality, nutritional makeup, and consumer preferences are affected by these factors **(Daszkiewicz *et al.*, 2015; Kudrnáčová *et al.*, 2018)**. The production system (wild vs. farmed), season, environment, and climate all have an impact on the quality of game meat in addition to the previously listed criteria. As a result, game meat quality might vary greatly **(Milczarek *et al.*, 2021)**. Customers' decisions to eat game meat are also greatly influenced by product knowledge, and both hunters and consumers often worry about the safety of game meat **(Thulin, Malmsten & Ericsson, 2015; Marescotti *et al.*, 2021)**.

Venison is becoming more well-known as a premium and environmentally friendly substitute for traditional red meats. Health-conscious consumers find it especially appealing. Deer meat, because of its chemical composition, low fat level, high protein level, and nutritive and energy values, is a favourable food for adolescents, convalescents, diabetics, patients with cardiovascular diseases. **(Hoffman & Wiklund, 2006; Briggs, Petersen & Kris-Etherton, 2017)**. The natural vegetation that wild game and pasture-bred deer eat affects the chemical makeup of their meat, making it rich in vital nutrients and helpful bioactive compounds, unlike industrially raised livestock **(Pogorzelska-Przybyłek *et al.*, 2021)**. A thorough understanding of game meat's chemical makeup, including its water content, protein, fat, cholesterol levels, and colour attributes, is necessary to evaluate its nutritional value, sensory qualities, and storage stability considering the growing demand for natural, minimally processed meat products.

The aim of the work was to evaluate and compare the basic chemical composition of the *biceps femoris muscle* of red deer (*Cervus elaphus*) from family farms and hunting grounds in terms of age and sex.

MATERIAL AND METHODS

In the verified experiment, 80 pcs *Cervus elaphus* from hunting grounds and farm breeding were used as biological material. Deer came from farm breeding (n = 40 pcs, 10 males and 10 females up to 2 years, 10 males and 10 females over 2 years) and from hunting grounds (n = 40 pcs, 10 males and 10 females up to 2 years, or 10 males and 10 females over 2 years). male. The time from shooting to dissection did not exceed 4 hours, and chemical analysis was initiated within 24 hours of killing. The animals were obtained by de-sedation. and in cooling boxes (4 °C) transported to the Food Institute of SPU Nitra. The deer bodies were then subjected to a complete slaughter dissection. For the chemical composition of muscle tissue (basic analysis), we took muscle tissue samples from the *musculus biceps femoris* **(Trembecká *et al.*, 2016)**. After deboning and homogenization, we took a 100 g sample from the muscle under study, which was used for chemical analysis. The chemical composition of the muscle was processed by Fourier transform infrared spectroscopy (FTIR), using a Nicolet 6700 instrument at the Slovak Agricultural Research Centre in Nitra, where we evaluated the content of water, total protein, fat, and cholesterol in g.100 g^{-1}.

Statistical analysis

The obtained data were subjected to analysis of variance (ANOVA) using SAS software (version 9.3, Enterprise Guide 4.2, USA). The tables present the results as mean with standard deviation (SD) **(SAS, 2008)**. Scheffe's test was used to evaluate statistical evidence, and differences were considered significant at $p \leq 0.05$.

RESULTS AND DISCUSSION

The results of the basic chemical composition of the *biceps femoris* muscle of deer by breed, sex and age are presented in Tables 1 to 5.

Table 1 Chemical composition of the *musculus biceps femoris* of farmed deer by age and without gender difference (g.100 g^{-1})

Parameter	Protein	Fat	Water	Cholesterol
2 years and over	23.462	0.776	73.354	0.041[a]
up to 2 years	23.380	0.653	73.083	0.035[b]
p-value	0.649	0.454	0.762	0.046

Note: mean±*SD* (standard deviation); a, b = means significant differences between column (P≤0.05) determined with Scheffe's test.

In terms of the age of farm deer (Table 1), we can state that the higher protein content (+0.082 g.100 g^{-1}) and fat content (+0.123 g.100 g^{-1}) was in deer over 2 years of age compared to deer under 2 years of age, but without significant differences (p≥0.05). The cholesterol content in farm deer was significantly lower (p≤0.05), by 0.006 g.100 g^{-1} in deer under 2 years of age.

Table 2 Chemical composition of the *musculus biceps femoris* of farmed deer by gender and without age difference (g.100 g^{-1})

Parameter	Protein	Fat	Water	Cholesterol
male	23.456	0.854[a]	73.336	0.038
female	23.388	0.555[b]	73.105	0.038
p-value	0.705	0.037	0.797	0.897

Note: mean±*SD* (standard deviation); a, b = means significant differences between column (P≤0.05) determined with Scheffe's test.

By evaluating the basic chemical composition of farm deer by sex (Table 2), we found a higher fat content by 0.299 g.100 g^{-1} (p≤0.05) in males compared to females. Other indicators (water, protein and cholesterol content) were balanced (p≥0.05).

Table 3 Chemical composition of *musculus biceps femoris* of deer from hunting grounds by age and without gender difference (g.100 g^{-1})

Parameter	Protein	Fat	Water	Cholesterol
2 years and over	23.124	0.755	72.735[a]	0.041[a]
up to 2 years	23.109	0.695	71.563[b]	0.037[b]
p-value	0.950	0.558	0.042	0.029

Note: mean±*SD* (standard deviation); a, b = means significant differences between column (P≤0.05) determined with Scheffe's test.

In contrast to farmed deer by age (Table 3), we found significant differences (p≤0.05) in wild deer, in addition to cholesterol, also in water content. Protein and fat content were higher in wild deer over 2 years old, which was a similar tendency in farmed deer, but without significant differences (p≥0.05).

Table 4 Chemical composition of the *musculus biceps femoris* of deer from hunting grounds by gender and without age difference (g.100 g^{-1})

Parameter	Protein	Fat	Water	Cholesterol
male	23.002	0.735	72.674	0.039
female	23.224	0.730	71.953	0.040
p-value	0.310	0.958	0.203	0.812

Note: mean±*SD* (standard deviation).

The content of protein, fat, water and cholesterol (Table 4) in the thigh muscle of deer was balanced by gender and no significant differences were found in fat content by gender, as was the case in farm deer (p≥0.05).

Table 5 Chemical composition of the *musculus biceps femoris* of deer without gender and age difference (g.100 g^{-1})

Parameter	Protein	Fat	Water	Cholesterol
Hunting area	23.426	0.721	73.233	0.038
Farm breeding	23.118	0.733	72.296	0.040
p-value	0.192	0.918	0.140	0.443

Note: mean±*SD* (standard deviation).

Overall, comparing the chemical composition of the biceps femoris muscle between farmed and wild deer (Table 5), we found no significant differences (p≥0.05).

Water was the predominant component, ranging from 71 to 74 g.100 g^{-1} across all groups. Significant differences were observed in wild deer, where older animals (>2 years) had higher water content than younger ones (p≤0.05), while no significant differences were detected in farmed animals. This suggests that hydration status in wild populations is more affected by physiological maturity and environmental conditions, whereas controlled feeding systems mitigate such variations. The high-water content, consistent with earlier reports **(Volpelli *et al*., 2003; Lorenzo *et al*., 2019)**, contributes to tenderness and juiciness of venison but simultaneously increases susceptibility to oxidative and microbial spoilage **(Daszkiewicz *et al*., 2012)**.

Protein levels remained high across all groups (>23 g.100 g^{-1}) with minimal variation due to age, sex, or production system. These findings confirm venison as a reliable source of high-quality protein, comparable with or superior to conventional red meats **(Hoffman & Cawthorn, 2014; Lorenzo *et al*., 2019)**. Its relatively low collagen content enhances digestibility and supports its classification as a premium protein source **(Pogorzelska-Przybylek *et al*., 2021)**. The stability of protein across categories also indicates that environmental and biological factors have limited influence on this component.

Intramuscular fat levels were low in all samples (<1 g.100 g^{-1}). In farmed deer, males exhibited significantly higher fat levels than females (p≤0.05), whereas no sex-related differences were observed in wild populations. A slight but non-significant increase in fat was detected in older animals in both production systems. These observations support the view that controlled feeding conditions promote fat deposition in males, while the energy expenditure associated with free-ranging conditions limits such differences **(Strazdiņa *et al*., 2013; Tomović *et al*., 2016)**. Compared to beef and pork, venison remains substantially leaner **(Hoffman & Wiklund, 2006)**, strengthening its dietary appeal for health-conscious consumers.

Cholesterol levels were relatively low, ranging from 35 to 41 mg.100 g^{-1}, and did not differ significantly between farmed and wild deer. However, age-related differences were evident: younger animals consistently showed lower cholesterol levels than older ones (p≤0.05). These findings suggest that lipid metabolism during growth influences cholesterol deposition in muscle tissue. The measured values are lower than those reported for beef and pork (80–100 mg.100 g^{-1}) and comparable to or below levels found in chicken **(Volpelli *et al*., 2003; Wiklund *et al*., 2003)**. Venison thus represents a nutritionally favourable red meat alternative for individuals seeking to control dietary cholesterol intake.

Overall, venison showed a consistent chemical profile, characterized by high protein content, low intramuscular fat, and relatively low cholesterol. The most pronounced differences were observed in fat (higher in farmed males) and cholesterol (lower in younger animals), while water content was affected primarily in wild populations by age. These parameters, although variable within narrow ranges, are nutritionally and technologically relevant as they influence meat juiciness, tenderness, lipid stability, and shelf life. Taken together, the results confirm venison's value as a lean, protein-rich, and health-oriented alternative to conventional livestock meat, with predictable quality traits across production systems.

CONCLUSION

Venison, a naturally lean and nutrient-rich meat, has several health advantages and fits well with the current dietary trends that prioritize minimally processed, clean, and sustainable foods. Because of this, venison is a desirable option for customers that value environmental sustainability and their own health. The chemical makeup of venison emphasizes its benefits as a high-nutrient, health-promoting red meat substitute. Its high protein level makes it a major source of bioavailable protein, and its high-water content adds to its tenderness and palatability. Its nutritional appeal is further enhanced by its remarkably low levels of fat and cholesterol. Venison has a lot of promise for use in functional food development and diets focused on health because of these qualities. To investigate processing techniques that maximise its shelf life, oxidative stability, and sensory qualities, more investigation is necessary.

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