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COMPARISON OF THE NUTRITIONAL VALUE OF MEAT FROM FARM-RAISED AND WILD FALLOW DEER (*DAMA DAMA*)

J. WACH[1], M. KOMOSA[2], K. SERWAŃSKA-LEJA[3,4#], B. BABIŃSKI[1], W. NOWICKI[1]

[1]Department of Animal Physiology and Physiotherapy, Bydgoszcz University of Science and Technology, Mazowiecka 28, 85-084 Bydgoszcz, Poland
[2] Poznan Medical Academy of Applied Sciences in Poznan, Świerzawska 18, 60-321 Poznań, Poland
[3]Department of Animal Anatomy, Faculty of Veterinary Medicine and Animal Sciences, Poznan University of Life Sciences, Wojska Polskiego 71c, 60-625 Poznan, Poland
[4]Department of Sports Dietetics, Poznan University of Physical Education, Królowej Jadwigi 39/27, 61-871 Poznan, Poland

SUMMARY

The research involved a comparison of the nutritional value of meat from farm-raised and wild European fallow deer bucks. Meat samples from the saddle and haunch were assayed for the contents of macroelements, amino acids and minerals. The results show that farm-raised fallow deer meat is of higher biological value. There was a statistically highly significant difference in fat content in the leg and Na and K content in both cuts of meat from fallow deer kept in farmed vs. wild conditions. Statistically significant differences were also noted between the two groups for the content of some amino acids: Asp, Ser, and Glu. In many countries fallow deer are used to produce high quality meat with very high nutritional value. However, there are only few publications dealing with the nutritional value of fallow deer meat.

KEY WORDS: meat; fallow deer; nutrition; maintenance

Corresponding author e-mail: katarzyna.leja@up.poznan.pl
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INTRODUCTION

In recent years there has been a marked global increase in the consumption of meat from animals of the family Cervidae, mainly due to growing consumer interest in healthy food (Dannenberger et al., 2013; Reitzernova et al., 2023). Meat from the family Cervidae, owing to its high nutritional value, i.e. its content of protein, fat, mineral compounds and vitamins, can be a real alternative to traditional meat products. Over the years the effect of many factors, such as gender, age and nutrition, on the quality of wild animal meat has been investigated (Wiklund et al., 2006; Żochowska-Kujawska et al., 2009; Dannenberger et al., 2013; Daszkiewicz et al., 2015; Reitzernova et al., 2023). Many authors have confirmed that meat from wild animals has a lower content of fat and cholesterol and a higher content of protein, essential amino acids, vitamins, mineral salts, and unsaturated fatty acids, as well as more favourable proportions of nutrients than farm-raised meat (Żochowska et al., 2006; Marchiori and de Felicio, 2003; Flis, 2016), due to the specific living conditions of wild animals. A markedly more active lifestyle, migration in search of abundant feeding grounds, and seasonal availability and variability of food are factors which directly contribute to differences in the chemical composition of wild animal meat as compared with farm-raised meat. The number of farms raising animals of the family Cervidae is continually growing, due to increasing demand for game meat – exceeding its potential acquisition from wild populations, a decrease in the rate of return in traditional agriculture, and increasing interest in health-promoting food of high nutritional value and known origin. One Cervidae species popularly farmed for meat performance is fallow deer (*Dama dama*) (Zatta and Frank, 2007; Tan et al, 2012; Czajkowska et al., 2023). Alongside red deer, the fallow deer is one of the most important wild animal species kept in farm conditions, not only because of the high quality of the meat, but also due to its ecological flexibility and high adaptability. Fallow deer also owe their popularity to their low aggressiveness and low maintenance requirements (Saccà et al., 2001). The morphological composition of meat and its physical and chemical properties, including amino acid composition, are a consequence of the specific way of life of wild animals (Dzierżyńska-Cybulko and Fruziński, 1997; Skorupski and Wierzbicka, 2014; Daszkiewicz et al., 2015). At the same time, raw meat obtained in different countries or even in different hunting grounds may differ significantly within a single species. The modern, informed consumer increasingly pays attention to the biological, nutritional and culinary value of meat, which is mainly associated with the content of fat, water, and collagen, their proportions, the content of protein, and its biological value (Hoffman and Wiklund, 2006; Ramanzin et al., 2010; Seenger et al., 2008). Meat quality is influenced by many factors, including protein content, which is a measure of the ability to meet human amino acid requirements.

The aim of the research was to compare selected meat quality traits of two populations of fallow deer (*Dama dama*) – living in natural hunting grounds and kept in a farm system.

MATERIAL AND METHODS

The research material was carcasses of fallow deer bucks (n=10) that had been culled in the Zamrzenica Forest Inspectorate in the Kujawsko-Pomorskie Province (50°30′N; 17°46′E). The animals were killed instantaneously with shots to the head or upper neck. To minimize ante-mortem stress effects, the animals were shot from a hide, thus ensuring that they were unaware of the hunter's presence (in accordance with the Act of October 13, 1995 in force in Poland – Hunting Law). The age of the animals was 18–20 months.

Farm-raised fallow deer (n=10) were obtained from the Bomafar fallow-deer breeding farm in Dąbrówka (52°34′N; 15°49′E), Lubuskie Province. Throughout the year the animals enjoyed unlimited access to pasture land (stocking rate of 15/ha), while their diet in winter consisted mainly of haylage supplemented with cereals. Throughout the year the animals enjoyed *ad libitum* access to water and mineral licks.

Male and female fallow deer were obtained during the 2013/2014, 2014/2015, and 2015/2016 hunting seasons. The animals were slaughtered in compliance with applicable veterinary regulations (Regulation of the Minister of Agriculture and Rural Development of 8 October 2002 on detailed veterinary conditions required for the slaughter of wild animals). Immediately after a cull or slaughter, meat was sampled from the saddle and haunch, cut into small pieces, and thoroughly mixed to maintain the homogeneity of the sample. Averaged samples from both primary cuts were taken for analysis. Meat sampling points are shown in Fig. 1.

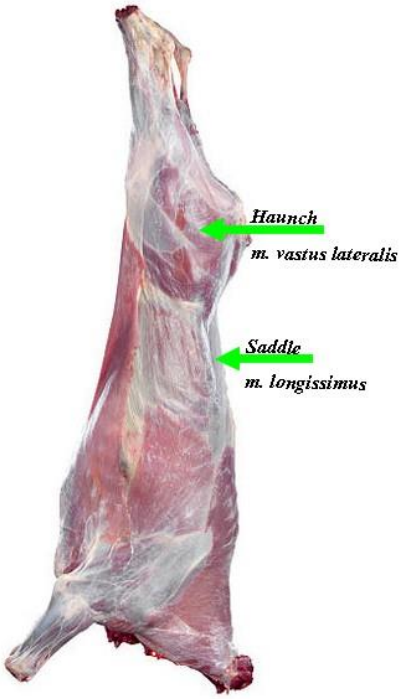

Figure 1. Fallow deer carcass. Sites where muscles were sampled for analysis are labelled *m. vastus lateralis* and *m. longissimus dorsi*

Microscopic images were recorded on a computer disc using a Nikon Ci-L microscope equipped with a Nikon DS-Fi3 camera with resolution of 5.9 MPix and NIS ELEMENTS software, enabling linear and planimetric measurements and digital analysis of the microscopic images. The muscle was stained by the H&E method.

The analysis of the chemical composition of the meat included determination of the content of dry matter, total protein and fat (Dzierżyńska-Cybulko and Fruziński, 1997). The analysis was performed on 250 g samples of minced and well-mixed meat, using the FoodScan™ Meat Analyzer (Foss), which uses near-infrared transmission in the 850–1050 nm range and is equipped with ANN calibration (developed using a model of artificial neural networks). The measurement results were expressed in g/100 g fresh weight. The content of amino acids in the samples was determined with the Automatic Amino Acid Analyzer AAA-400 (INGOS) using the methodology described by Moore & Stein (Hoffman and Wiklund, 2006). Amino acids, i.e. threonine (Thr), serine (Ser), proline (Pro), glycine (Gly), valine (Val), isoleucine (Ile), and leucine (Leu), were determined following the method proposed by INGOS (Czech Republic). Freeze-dried meat samples were hydrolysed in 6 N HCl for 22 hours at 110°C, in the presence of nitrogen. Once the hydrolysate was evaporated, the amino acids were dissolved in buffer at pH 2.2 and subjected to chromatographic analysis using the amino acid analyser. Each sample was analysed in two replicates. All results were processed and calculated as mean total weight in the meat samples by multiplying the concentration of each amino acid in the sample by the total weight of the tissue. Following wet mineralization using the Milestone Ethos Plus microwave mineralizer, the meat samples were assayed to determine the content of Na, K, Mg, Ca (according to standard PN-EN 15505:2009), Fe, Cu, and Zn (according to standard PN-EN 14084:2004) by flame atomic absorption spectroscopy (FAAS), with the Thermo Scientific ICE 3000 spectrometer.

After confirming the normality of distributions for the groups, the significance of differences between means was verified using Student's t-test. Statistical analysis of the results was performed using the Statistica 10 and Microsoft Office Standard OLP EDU software.

RESULTS AND DISCUSSION

The quality of meat from wild animals differs considerably from that of farm animals due to seasonal fluctuations, sex, habitat conditions, and diet composition. The results confirm that fallow deer meat is an excellent source of protein and has high nutritional value. Its protein content ranged from 22.05 to 23.17 g/100 g, which is higher than in meat from farm animals (Table 1). Similar results were recorded by Bleier et al. (2013), who found more protein in wild animal meat.

Table 1.
Proximate chemical composition of meat from two carcass parts

Parameter [g/100 g]	Haunch		Saddle	
	Farm-raised	Wild	Farm-raised	Wild
Protein	22.47 ± 0.75	23.17 ± 0.51	22.05 ± 0.22	22.18 ± 0.44
Fat	0.81±0.05[a]	0.68±0.07[b]	0.83 ± 0.08	0.74 ± 0.07
Water	72.75 ± 0.65	73.80 ± 0.56	71.86 ± 0.49	72.26 ± 0.61

Mean ± standard deviation. a, b – significant differences for the parameter ($p < 0.05$)

A higher content of fat was noted in farm-raised fallow deer than in wild fallow deer, in both the haunch and the saddle, but the differences were significant only in the first case (0.81 vs 0.68 g/100

g). The results coincide with observations by Dahlan and Norfarizan–Hanoon (2008), who reported a higher fat content in farm-raised animal meat than in the meat of fallow deer in the wild. Similar results were recorded by Volpelli et al. (2003), who found a higher fat content and lower water content in the meat of farm-raised fallow deer receiving a supplemented diet than in meat from wild animals. Many other authors note that fallow deer meat contains a small amount of fat (Dahlan and Norfarizan-Hanoon, 2008). Similar results for wild ruminants were reported by Secchiari et al. (2001), who demonstrated that the fat content was very often below 1%. Cordan et al. (2002), on the other hand, found that the fat of wild animal meat is more beneficial for the human body owing to its higher concentration of polyunsaturated fatty acids. Game meat has a high content of water, in a free state or bonded with proteins. In the present study, the content of water was higher in wild fallow deer, in both the saddle and the haunch, although there were no significant differences. The results are in agreement with literature reports. Dzierżyńska-Cybulko and Fruziński (1997) found higher water content in the muscles of animals with an active lifestyle. In addition, in both free-living and farm-raised fallow deer the longissimus dorsi and vastus lateralis muscle are made of many fine fibres, which is characteristic of cervids. This is significant for the consumer, as it has a beneficial effect on the tenderness of the meat. The proportions of individual types of muscle fibres, which is one of the most important factors affecting meat quality, depend on the diet, breed, sex, age and physical activity of animals (Fig. 2 and Fig. 3).

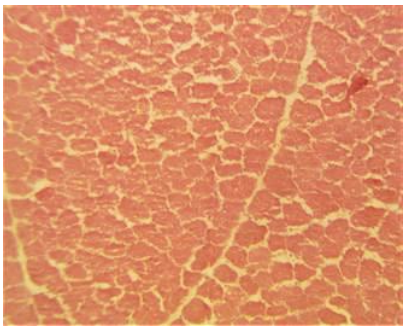

Figure 2. Microstructure of the longissimus dorsi (saddle) muscle. H&E staining, magnification 10x.

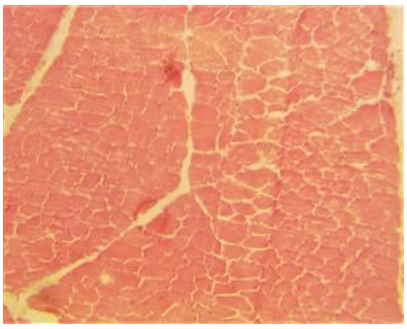

Figure 3. Microstructure of the vastus lateralis muscle (haunch). H&E staining, magnification 10x

The results of the analysis of the content of minerals in meat from various carcass parts of farm-raised and wild fallow deer are provided in Table 2. Significant differences ($P \leq 0.05$) between farm-raised and wild animals were recorded only for Na and K. The content of Na in the haunch of farm-raised fallow deer was significantly higher (59.38 mg/100 g) than in wild fallow deer (47.69 mg/100 g). A similar relationship was observed for the saddle, in which the Na content was 79.54 mg/100 g in farm-raised fallow deer and 63.37 mg/100 g in wild fallow deer. For the other mineral nutrients assayed, i.e. Mg, Ca, Fe, Zn and Cu, no significant differences between fallow-deer groups were noted.

Table 2.
Mineral composition of meat of various carcass parts

mg/100 g	Haunch		Saddle	
	Farm-raised	Wild	Farm-raised	Wild
Na	59.38 ± 3.44[a]	47.69 ± 1.08[b]	79.54 ± 6.75[a]	63.37 ± 5.05[b]
K	449.38 ± 4.06[a]	364.49 ± 9.48[b]	416.50 ± 8.33[a]	399.16 ± 33.16[b]
Mg	29.69 ± 0.31	26.02 ± 0.54	27.29 ± 0,37	27.66 ± 0.89
Ca	1.78 ± 0.13	1.17 ± 0.66	3.38 ± 0.32	3.29 ± 0.14
Fe	3.21 ± 0.12	3.54 ± 0.31	3.39 ± 0,17	3.44 ± 0,11
Zn	1.99 ± 0.18	2.26 ± 0.14	2.48 ± 0,13	3.52 ± 1,58
Cu	0.25 ± 0.01	0.23 ± 0.02	0.22 ± 0,04	0,23 ± 0,01

Mean ± standard deviation a, b – significant differences for the parameter ($p < 0.05$)

A comparison was made of the amino acid composition of the saddle and haunch of fallow deer bucks from the hunting grounds and those raised under farm conditions. The results are presented in Table 3.

Table 3.
Amino acid composition of the meat of two carcass parts

Amino acid	Haunch		Saddle	
	Farm-raised	Wild	Farm-raised	Wild
Asp	86.98 ± 8.74	83.13 ± 4.04	107.11 ± 1.33[a]	98.64 ± 1.92[b]
Thr	47.54 ± 1.02	43.46 ± 5.14	57.50 ± 0.78	54.69 ± 1.06
Ser	36.74 ± 6.98	33.25 ± 6.20	44.67 ± 1.58[a]	34.85 ± 2.46[b]
Glu	128.93 ± 4.01[a]	120.38 ± 2.73[b]	139.30 ± 4.31	139.47 ± 4.06
Pro	41.94 ± 18.40	34.44 ± 3.01	46.20 ± 1.38	45.86 ± 3.72
Gly	53.83 ± 18.62	40.54 ± 1.20	47.94 ± 2.96	48.09 ± 1.37
Ala	36.96 ± 3.57	34.53 ± 1.59	41.55 ± 0.93	38.73 ± 0.51
Val	41.64 ± 3.19	40.68 ± 2.20	49.43 ± 2.74	45.06 ± 1.12
Ile	36.80 ± 1.28	38.38 ± 0.21	46.92 ± 2.67	40.14 ± 0.73
Leu	76.86 ± 2.41	67.39 ± 7.79	91.87 ± 0.94	89.32 ± 0.63
Tyr	37.61 ± 0.14	38.11 ± 2.13	48.76 ± 1.52	45.61 ± 1.14
Phe	39.67 ± 4.08	38.16 ± 1.40	49.21 ± 0.90	45.52 ± 1.39
His	34.50 ± 3.33	37.20 ± 2.42	43.94 ± 1.65	39.79 ± 0.84
Lys	91.26 ± 1.07	85.71 ± 4.30	102.53 ± 2.57	98.15 ± 1.22
Arg	68.82 ± 7.21	64.29 ± 2.68	81.17 ± 2.08	76.80 ± 1.81
∑ amino acids	860.08	799.65	998.1	940.72

Mean ± standard deviation. a, b – significant differences for the parameter ($p < 0.05$)

The contents of individual amino acids in the haunch ranged from 34.50 (His) to 128.93 (Glu) $g \cdot kg^{-1}$ in farm-raised fallow deer and from 33.25 (Ser) to 120.38 (Glu) $g \cdot kg^{-1}$ in wild fallow deer. A different distribution of results was observed for the saddle. The content of amino acids ranged from 41.55 (Ala) to 139.30 (Glu) $g \cdot kg^{-1}$ in farm-raised fallow deer and from 34.85 (Ser) to 139.47 (Glu)

$g \cdot kg^{-1}$ in wild fallow deer. In the haunch samples, significant differences ($p \leq 0.05$) were recorded for Glu. The other differences were non-significant. In the case of the saddle, significant differences ($p \leq 0.05$) were observed only for Asp and Ser.

Next to the basic meat components, i.e. protein and fat, mineral nutrients are crucial for the nutritive value of meat. The content of these nutrients in meat depends on many factors, e.g. the quality of animal feed, the age and sex of the animals, and the region they live in. According to Kalafova et al. (2003), mineral deficiencies can be a consequence of the physiological condition of animals as well as maintenance conditions. The content of minerals in meat is mainly analysed in farm ruminants. There are relatively few literature reports on wild ruminants, and the available reports mainly concern deer meat.

The present research found no differences in the content of minerals between the groups. Dzierżyńska-Cybulko and Fruziński (1997) report that the content of mineral salts in fallow deer meat is similar to that of other game animals. The results of the analysis of minerals carried out in our study showed that in the meat of both farmed and free-living fallow deer the content of potassium was highest, followed by Na, Mg, Fe, Zn, Ca, and Cu. Compared to the meat of other animals, the meat of both the farmed and free-living fallow deer was very rich in potassium. According to studies on the meat of farm animals (Moore et al., 1963; Price and Schweigert, 1994; Giorgetti et al., 1996, Moreiras et al, 2004), the potassium content in meat was 150–171 mg 100 g for cattle, 172–175 mg/100 g for pigs, 248–259 mg/100 g for poultry, and 295–350 mg/100 g for sheep. Comparable results were obtained by Kritzinger (2002), who found that potassium is the dominant mineral in the meat of the African wild impala (*Aepyceros melampus*). Dzerżyńska-Cybulko and Fruziński (1997) also showed a similar level of iron in their own research, stating that it is quite low in fallow deer compared to other wild animals. Haem iron contained in meat is easily absorbed and utilized by the human body (Worthington and Monsen, 1990). This is confirmed by the research of Rodler (2009), who concluded that iron from meat is absorbed up to 30% more than iron from plant sources. The significant differences in the content of Na were probably due to Na supplementation in the form of licks, which the animals had free access to and used according to their perceived need for sodium, among other minerals. According to ALAlami and Cooper (2007), high sodium content may affect the taste of meat. In free-living cervids, apart from forest and meadow plants, cultivated plants such as potatoes, beets and cereals also make up a significant portion of the diet. Jacel et al. (2010) drew attention to the fact that manure obtained in the pig fattening process is often used to fertilize farmland. As a consequence, zinc can potentially accumulate in plants, which are subsequently eaten by wild animals. These suggestions may explain the reasons for the differences observed in zinc content in the meat of wild and farmed animals. No differences in copper content were observed between the two groups.

Given the abundance of minerals in fallow deer meat, it is very important to analyse the concentrations of selected minerals in the tissues of game animals, which enables the assessment of the impact of the meat on consumer health. Venison is increasingly said to have a positive effect on the functioning of the human body, and its inclusion in the diet helps in the treatment of certain diseases, such as diabetes or metabolic diseases.

Amino acid composition as an indicator of protein quality defines meat quality very accurately. Knowledge of the amino acid profile is extremely important, as some amino acids cannot be synthesized by people and thus must be supplied with the diet (Özden and Erkan, 2011). Some amino

acids which are not crucial in terms of nutrition, such as arginine, glycine and proline, are important for regulating gene expression and cell signalling and for adequate functioning of the cardiovascular system, as well as for the development of brown adipose tissue (Tan et al., 2012). Amino acids are also responsible for regulating NO synthesis and antiviral activity and are involved in protein methylation, acetylation and ubiquitination.

Proteins are the most important component of meat. They are of primary importance in determining both the sensory and functional properties of meat. Differences in the nutritional value of meat and the amino acid composition of individual muscles can cause differences in the taste of meat. Of the 18 important amino acids in human nutrition, 8–10 (depending on age) cannot be synthesized by the human body and therefore must be supplied in food. These are the exogenous (essential) amino acids: isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine and arginine, as well as histidine in the case of infants.

CONCLUSIONS

The content of fat and minerals was higher in the meat of fallow deer kept in farm conditions.

The maintenance method has a noticeable effect on the total content of amino acids in meat from various parts of the carcass.

The differences demonstrated in the chemical composition, amino acid profile and mineral content of the carcasses of farmed fallow deer carcasses and animals obtained from hunting grounds suggest that separate technological processes should be used for their optimal culinary preparation.

The more favourable amino acid profile and higher content of minerals in farmed fallow deer meat suggests that their meat is of better quality.

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