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THE AMINO ACID AND FATTY ACID PROFILE OF EUROPEAN BADGER (*MELES MELES*) MEAT

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ABSTRACT

The aim of the present study was to quantify the amino acid and fatty acid composition of European badger *(Meles meles)*. Biological material consisted of 12 individuals of both sexes, harvested from hunting grounds in Slovakia. An automatic analyzer, AAA 400, was used to determine the amino acid profile, and for the measurement of the fatty acid profile, the gas chromatography FAME synthesis was used. In our study, we observed that the most prevalent amino acids in badger meat were Lys (2.17±0.26 g.100 g^{-1}), Leu (1.93±0.23 g.100 g^{-1}), and Arg (1.61±0.19 g.100 g^{-1}). Unsaturated fatty acids dominated the fatty acids profile of badger meat. The most prevalent group was MUFA (46.57±1.47 g.100 g^{-1}). Our results conclude that badger meat could be an interesting addition to a human diet because of its favorable fatty acid composition.

Keywords: badger, meat, amino acid, fatty acid

INTRODUCTION

The European badger (*Meles meles*) is widely spread across nearly all of Europe and some parts of Asia and is able to inhabit both wild and urbanized areas **(Proulx *et al.*, 2016; Macdonald *et al.*, 2018)**. Badgers are classified in the order Carnivora. However, they use various food resources, both locally and seasonally **(Aulagnier *et al.*, 2009; Byrne *et al.*, 2012)**. Badgers behave as opportunistic foragers, and in habitats that lack earthworms, their primary food source, badgers feed on other resources, such as rabbits, insects, and fruits. This only highlights the dietary flexibility of this species and its omnivorous diet **(Rosalino *et al.*, 2005; Gomes *et al.*, 2019)**.
Determining amino acids is critical for determining the nutritional value of meat. Tryptophan or phenylalanine are, in fact, necessary amino acids for humans. That is, they cannot be synthesized by the organism and must thus be obtained through the diet **(Gatellier *et al.*, 2009)**. Like most animal production traits, fatty acid composition is influenced by genetic and environmental factors – feeding and diet **(Nürnberg *et al.*, 1998)**. It should be noted that fatty acid composition varies throughout tissues, including intra- and intermuscular and abdominal and subcutaneous adipose tissue. The level of saturation typically increases with increasing distance from the animal's exterior, but there is further heterogeneity amongst muscles or subcutaneous fat depots that are similarly placed **(De Smet *et al.*, 2004)**.
Wild game meat is regarded as important in the diet, and its consumption has increased in recent years. Consumers are increasingly interested in meat from animals raised in conditions as close to natural as possible. This demand is clearly met by the game, distinguished by high nutritional value and specific sensory qualities required by consumers **(Strazdina *et al.*, 2013)**. An alternative wild species whose meat is seen to be healthy and is being imported into the First World countries in increasing amounts is ostrich. From mammals, nutria (*Myocastor coypus*), a semi-aquatic rodent, could be a healthy alternative food that complies with current healthy and dietary recommendations for low-fat, low-cholesterol diets **(Hoffman & Wiklund, 2006; Saadoun *et al.*, 2006).**
Aim of our study was to determine amino acid and fatty acid profile of European badger meat. For our study we selected three muscles from badger carcass: shoulder (*m. deltoideus*), thigh (*m. semimembranosus*) and back (*m. longissimus thoracis et lumborum*). With increasing interest in meat of animals raised as natural as possible and demand for lean and diet meat we believe European badger could be suitable source of such food. Amino acid and fatty acid profile of badger meat could be a valuable information for consumers and dietitian experts alike for creating healthier diet in the future.

MATERIAL AND METHODS

Biological material

Biological material, European badger carcasses, were harvested from hunting grounds localized in Nové Zámky and Rožňava, Slovak republic. For the purposes of experiment 12 individuals (8 males and 4 females) were utilized. The eviscerated carcasses were transported from hunting grounds to Institute of Food Sciences and stored for 24 h *post mortem* to reach a carcass temperature of 4°C. After 24 hours samples were taken from the following muscles: *musculus deltoideus* (MD), *musculus semimembranosus* (MSM), and *musculus longissimus thoracis et lumborum* (LTL).
All animals used in this study were handled following the national legislation on animal welfare **(DL n. 126, 07/07/2011, EC Directive 2008/119/EC)**. European badgers (*Meles meles*) were slaughtered in compliance with Regulation 1099/2009 of the European Union on the protection of animals at the time of killing.

Amino acid composition

Amino acid (AA) composition of the shoulder, thigh and back muscles of European badger was measured using an automatic AA analyzer AAA 400 (INGOS Prague, Czech Republic) as in our previous study **Haščík *et al.* (2021)**. Results are expressed as g.100 g^{-1} of muscle dry matter.

Fatty acid composition

Total fat content was quantified by Soxhlet extraction with petroleum ether following the procedure described by the ISO 12966-2:2017: preparation of methyl esters of fatty acids, animal and vegetable fats, and oils. Gas chromatography of fatty acid methyl esters was employed for the analysis of the individual profile as suggested by **Trembecká *et al.* (2016).**

Statistical analysis

To perform statistical analysis, XLSTAT software was used (XLSTAT Addinsoft, statistical and data analysis solution, 2021, New York, NY, USA). To compare results of individual measurements ANOVA analysis with Duncan test was used.

RESULTS AND DISCUSSION

Amino acid composition

During our measurement, we observed that European badger meat was abundant in essential amino acids. Only Tryptophan was not present. Only Cys values varied significantly ($P \leq 0.05$) among observed muscles when subjected to ANOVA comparison. On average, Cys was less abundant amino acid detected in badger meat. On the other hand, Lys was the most present amino acid in badger meat. The complete amino acid profile of selected badger muscles is presented in **Table 1.**

Table 1 Amino acid composition of selected muscles of European badger (g.100 g^{-1})

Amino acid	Shoulder (MD)	Thigh (MSM)	Back (LTL)	*P-value*
Thr	0.89 ± 0.03^{a}	0.97 ± 0.05^{a}	0.92 ± 0.03^{a}	0.33
Val	0.95 ± 0.02^{a}	0.96 ± 0.03^{a}	0.94 ± 0.02^{a}	0.93
Met	0.84 ± 0.03^{a}	0.87 ± 0.03^{a}	0.86 ± 0.02^{a}	0.68
Ile	0.98 ± 0.03^{a}	1.03 ± 0.04^{a}	1.03 ± 0.03^{a}	0.48
Leu	1.86 ± 0.06^{a}	1.98 ± 0.08^{a}	1.95 ± 0.06^{a}	0.47
Phe	0.96 ± 0.03^{a}	1.02 ± 0.04^{a}	1.00 ± 0.03^{a}	0.54
Lys	2.08 ± 0.06^{a}	2.21 ± 0.08^{a}	2.20 ± 0.07^{a}	0.40
Cys	0.28 ± 0.01^{b}	0.32 ± 0.01^{a}	0.29 ± 0.01^{ab}	0.03
His	1.11 ± 0.04^{a}	1.11 ± 0.04^{a}	1.07 ± 0.03^{a}	0.69
Arg	1.55 ± 0.05^{a}	1.65 ± 0.06^{a}	1.64 ± 0.05^{a}	0.40

Values are given as mean±SEM (standard error); n=12; Thr = threonine; Val = valine; Met = methionine; Ile = isoleucine; Leu = leucine; Phe = phenylalanine; Lys = lysine; Cys = cysteine; His = histidine; Arg = arginine; MD = *musculus deltoideus*; MSM = *musculus semimembranosus*; LTL = *musculus longissimus thoracis et lumborum*; a, b represents statistically ($P \leq 0.05$) significant difference in a row.

At the time of writing this article, we could not find another scientific publication that was focused on or included the AA composition of badger tissues. Nevertheless, it is essential to add that many factors may influence meat's nutritional content and flavor, including breed, nutrition, feeding style, and animal age. Meat contains a variety of proteins, carbs, fats, and other nutrients. AAs are not only necessary components of proteins but also influence the synthesis of other muscle components. Furthermore, amino acids are significant components of the meat's flavor **(Khan *et al.*, 2015; Ma *et al.*, 2019)**. For comparison with other wild animal species, we listed the AA composition of our result with the result of other authors in **Table 2.**

Fatty acid composition

In European badger meat's fatty acid (FA) profile, we observed little variability among the three observed muscles. Only heptadecanoic, oleic, linoleic, and eicosapentaenoic acid values showed significant differences ($p \leq 0.05$) among observed badger muscles. As we can observe, unsaturated fatty acids (MUFA and PUFA) prevailed over saturated fatty acids in all observed badger muscles. Also, Omega 6 FA were much more prevalent than Omega 3. From an individual FA point of view, the most prevalent were palmitic and oleic acid. Several factors, such as breed, sex, age, diet, geographical location, climate, and the methodology used, can affect the fatty acid composition of meat **(Sartowska *et al.*, 2014)**. **Zalewski *et al.* (2007)** conducted a similar study with Eurasian badger harvested in Poland. The authors reported that the FA profile of Eurasian badger muscle tissue was quantitatively dominated by SFA, namely palmitic, stearic, and myristic acid. Our study observed that stearic acid was most prevalent in the SFA group (on average 24.43 ± 0.26 g.100 g^{-1}). The authors also noted that from the group of MUFAs observed in the muscular tissue of Eurasian badger, oleic acid is most prevalent, which aligns with our findings. A characteristic feature of badger's tissues is a high (almost 4%) level of myristic acid **(Zalewski *et al.*, 2007)**, but we could not confirm this claim. We believe that differences in the FA profile could be explained by a badger omnivorous diet and different primary food sources in different geographical regions. **Hamulka *et al.* (2021)** determined FA profiles of adipose tissue obtained from various wild animals, including badgers. They reported that badger adipose tissue contained 48, 36, and 15% of MUFA, SFA, and PUFA, respectively. This distribution is comparable with our measured results in muscle tissue. **Martysiak-Żurowska *et al.* (2009)** reported that tissues of the captured animals (raccoon, beaver, and badger) contained vaccenic acid (C18:1,11t), typical for ruminants. The occurrence of this fatty acid was observed in our study as well. The profile of fatty acids in European badger muscles is shown in **Table 3**.

Table 2 Comparation of AA composition of various wild animals (g.100 g^{-1})

Amino acid	Badger (muscles average)	Axis deer (Ugarković *et al.*, 2020)	Red deer (Strazdina *et al.*, 2011)	Boar (Strazdina *et al.*, 2011)	Beaver (Strazdina *et al.*, 2015)
Thr	0.93 ± 0.02	1.00 ± 0.00	3.73 ± 0.43	2.46 ± 0.05	0.08 ± 0.01
Val	0.95 ± 0.01	1.06 ± 0.01	3.47 ± 0.16	3.22 ± 0.16	0.93 ± 0.04
Met	0.86 ± 0.01	0.59 ± 0.00	1.56 ± 0.17	2.05 ± 0.08	0.39 ± 0.02
Ile	1.01 ± 0.02	0.95 ± 0.00	3.22 ± 0.10	2.71 ± 0.16	1.09 ± 0.02
Leu	1.93 ± 0.04	1.70 ± 0.01	5.55 ± 0.25	5.42 ± 0.16	1.52 ± 0.06
Phe	0.99 ± 0.02	1.03 ± 0.00	2.8 ± 0.17	2.27 ± 0.15	0.10 ± 0.01
Lys	2.17 ± 0.04	1.92 ± 0.01	6.19 ± 0.24	5.03 ± 0.09	1.71 ± 0.09
Cys	0.30 ± 0.01	0.20 ± 0.00	NM*	NM*	NM*
His	1.09 ± 0.02	0.99 ± 0.01	2.31 ± 0.19	2.13 ± 0.10	1.00 ± 0.01
Arg	1.61 ± 0.03	1.39 ± 0.00	4.92 ± 0.36	4.81 ± 0.06	1.42 ± 0.05

Values are given as mean±SEM (standard error); Thr = threonine; Val = valine; Met = methionine; Ile = isoleucine; Leu = leucine; Phe = phenylalanine; Lys = lysine; Cys = cysteine; His = histidine; Arg = arginine; *NM – not measured.

Table 3 FA composition of selected muscles of European badger (g.100 g^{-1})

Fatty acid	Shoulder (MD)	Thigh (MSM)	Back (LTL)	*P-value*
Lauric (C12:0)	0.11 ± 0.00^{a}	0.12 ± 0.00^{a}	0.12 ± 0.00^{a}	0.08
Myristic (C14:0)	1.39 ± 0.02^{a}	1.34 ± 0.01^{a}	1.37 ± 0.01^{a}	0.14
Palmitic (C16:0)	24.53 ± 0.08^{a}	24.46 ± 0.07^{ab}	24.30 ± 0.06^{b}	0.07
Heptadecanoic (C17:0)	0.33 ± 0.01^{a}	0.30 ± 0.01^{a}	0.24 ± 0.03^{a}	0.04
Stearic (C18:0)	10.80 ±0.12^{b}	10.86 ± 0.07^{a}	10.78 ± 0.083^{b}	0.90
Oleic (C18:1cis-9)	29.64 ± 0.86^{a}	35.54 ± 1.03^{a}	28.20 ± 2.05^{a}	0.00
Vaccenic (C18:1trans-11)	4.68 ± 0.06^{a}	4.68 ± 0.03^{b}	4.82 ± 0.04^{b}	0.08
Linoleic (C18:2cis-9,12)	13.22 ± 0.60^{a}	11.26 ± 0.24^{a}	11.86 ± 0.43^{a}	0.02
Conjugated Linoleic (C18:2trans-10, cis-12)	0.14 ± 0.01^{a}	0.13 ± 0.00^{a}	0.13 ± 0.00^{a}	0.16
α-Linolenic (C18:3cis-9,12,15)	0.19 ± 0.01^{a}	0.19 ± 0.01^{a}	0.18 ± 0.01^{a}	0.36
Eicosenoic (C20:1cis-11)	0.27 ± 0.03^{a}	0.31 ± 0.05^{a}	0.32 ± 0.03^{a}	0.52
Arachidonic (C20:4cis-5,8,11,14)	1.51 ± 0.07^{a}	1.54 ± 0.10^{a}	1.71 ± 0.10^{a}	0.31
Eicosapentaenoic (C20:5cis-5,8,11,14,17)	0.11 ± 0.01^{a}	0.09 ± 0.01^{b}	0.09 ± 0.01^{b}	0.03
Docosapentaenoic (C22:5cis-7,10,13,16,19)	0.14 ± 0.00^{a}	0.13 ± 0.00^{a}	0.13 ± 0.00^{a}	0.06
Docosahexaenoic (C22:6cis-4,7,10,13,16,19)	0.04 ± 0.00^{a}	0.036 ± 0.00^{a}	0.03 ± 0.00^{a}	0.36
Omega 3	0.63 ± 0.02^{a}	0.65 ± 0.02^{b}	0.65 ± 0.01^{b}	0.77
Omega 6	16.60 ± 0.77^{a}	14.48 ± 0.42^{b}	14.33 ± 0.43^{b}	0.03
∑ SFA	35.06 ± 0.47^{b}	33.25 ± 0.39^{a}	33.14 ± 0.41^{b}	0.01
∑ MUFA	46.57 ± 0.42^{a}	49.19 ± 0.52^{a}	46.89 ± 0.45^{a}	0.00
∑ PUFA	19.16 ± 0.73^{a}	18.40 ± 0.33^{a}	19.38 ± 0.44^{a}	0.57

Values are given as mean±SEM (standard error); n=12; SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; MD = *musculus deltoideus*; MSM = *musculus semimembranosus*; LTL = *musculus longissimus thoracis et lumborum*; a, b represents statistically ($P \leq 0.05$) significant difference in a row.

The fatty acid composition of meat, particularly the ratio of polyunsaturated fatty acids to saturated fatty acids, is more important for health reasons than the total fat content **(MacRae *et al.*, 2005)**. It is critical to understand the fatty acid makeup of meat from various species in order to make an informed decision about the optimal protein source. increased polyunsaturated fatty acid levels in game meat) can be directly connected to a larger proportion of polar lipids in leaner game meat/venison **(Hoffman & Wiklund, 2006).** In **Table 4** shows various wild animals' fatty acid composition to compare our results.

Table 4 Comparation of FA composition of various wild animals (g.100g^{-1})

Fatty acid	Badger (muscles average)	Badger (adipose tissue) (Hamulka *et al.*, 2021)	Hare (*longissimus thoracis et lumborum*) (Valencak *et al.*, 2015)	Boar (*m. longissimus thoracis et lumborum*) (Valencak *et al.*, 2015)	Red deer stag (*m. semitendinosus*) (Polak *et al.*, 2008)
Lauric (C12:0)	0.11 ± 0.00	0.09 ± 0.01	NM*	NM*	0.16 ± 0.04
Myristic (C14:0)	1.35 ± 0.01	1.37 ± 0.01	0.4 ± 0.04	0.2 ± 0.02	4.30 ± 0.32
Palmitic (C16:0)	24.43 ± 0.04	21.49 ± 0.09	14.4 ± 0.07	18.6 ± 0.4	23.62 ± 1.16
Heptadecanoic (C17:0)	0.31 ± 0.01	0.31 ± 0.01	0.8 ± 0.004	0.6 ± 0.01	0.32 ± 0.09
Stearic (C18:0)	10.81 ± 0.05	12.48 ± 0.04	15.9 ± 0.09	13.6 ± 0.1	13.04 ± 0.68
Oleic (C18:1cis-9)	31.13 ± 0.97	43.98 ± 0.04	5.9 ± 0.1	7.9 ± 0.09	10.57 ± 0.82
Vaccenic (C18:1trans-11)	4.73 ± 0.03	trace	NM*	NM*	NM*
Linoleic (C18:2cis-9,12)	12.11 ± 0.029	NM*	NM*	NM*	9.57 ± 0.76
Conjugated Linoleic (C18:2trans-10, cis-12)	0.13 ± 0.00	12.53 ± 0.02	33.5 ± 0.4	42.8 ± 0.2	0.09 ± 0.03
α-Linolenic (C18:3cis-9,12,15)	0.19 ± 0.01	1.18 ± 0.01	3.4 ± 0.01	0.8 ± 0.02	3.55 ± 0.46
Eicosenoic (C20:1cis-11)	0.30 ± 0.02	1.05 ± 0.01	NM*	NM*	NM*
Arachidonic (C20:4cis-5,8,11,14)	1.59 ± 0.05	0.26 ± 0.00	16.9 ± 0.2	11.5 ± 0.08	5.24 ± 0.60
Eicosapentaenoic (C20:5cis-5,8,11,14,17)	0.09 ± 0.00	trace	2.4 ± 0.06	0.8 ± 0.01	0.24 ± 0.02
Docosapentaenoic (C22:5cis-7,10,13,16,19)	0.13 ± 0.00	NM*	5.04 ± 0.03	2.1 ± 0.02	2.72 ± 0.25
Docosahexaenoic (C22:6cis-4,7,10,13,16,19)	0.04 ± 0.00	trace	1.06 ± 0.02	0.3 ± 0.005	0.40 ± 0.09
Omega 3	0.64 ± 0.01	1.44 ± 0.00	11.9 ± 0.08	4.1 ± 0.04	6.97 ± 0.77
Omega 6	15.14 ± 0.37	13.72 ± 0.05	50.4 ± 0.2	54.3 ± 0.2	18.66 ± 1.53
∑ SFA	33.81 ± 0.29	36.05 ± 0.05	31.6 ± 0.2	33.1 ± 0.2	42.42 ± 1.61
∑ MUFA	47.55 ± 0.33	48.01 ± 0.01	6.1 ± 0.1	8.4 ± 0.04	31.72 ± 0.89
∑ PUFA	19.98 ± 0.30	15.16 ± 0.05	62.3 ± 0.2	58.4 ± 0.2	25.87 ± 2.12

Values are given as mean±SEM (standard error); SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; NM – not measured.

CONCLUSION

Nowadays, badger fat is the only valuable part of badger carcass because of its use in medicine. Our study presented the amino acid and fatty acid profile obtained from three muscles of European badger. Our results suggest that badger meat could be an interesting addition to the human diet, given its favorable fatty and amino acid composition. However, further multidisciplinary study, including food safety, toxicology, or sensory analysis, is still needed.

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