Agronomy Research **13**(4), 1096–1103, 2015

Investigation of beaver meat obtained in Latvia

V. Strazdina[1,*], V. Sterna[2], A. Jemeljanovs[3], I. Jansons[1] and D. Ikauniece[1]

[1]Institute of Food Safety, Animal Health and Environment BIOR, Instituta street 1, Siguldas nov., Latvia, LV 2150; [*]Correspondence: vitastrazdina@inbox.lv
[2]Department of Agro–ecological Research**,** State Stende Cereals Breeding Institute**,** 'Dižzemes', Dižstende, Lībagi parish, Talsi County, Latvia
[3]Faculty of Veterinary medicine, Latvia University of Agriculture, K. Helmaņa street 8, Jelgava, Latvia, LV 3004

Abstract. There is a high interest on the part of consumers to obtain meat from animals which have been reared as close to natural conditions as possible. Game meat, characterised by high nutritional value and specific organoleptic qualities, complies also to this claim. Game animals, including beaver, meat provide an excellent investment, diversification of many consumer meals. The meat of wild animals is more favourable for human health because it has lower saturated fatty acids. Investigations about biochemical composition of beaver meat are not very common worldwide.
The aim of study was evaluate biochemical composition of beaver meat hunted in Latvia. Therefore protein, amino acids, fat, ash, cholesterol content and fatty acid composition of beaver meat samples were done.
Conclusion was made that beaver meat samples protein content was 20.07–22.68% and fat content 3.31–5.27%. The sum of essential amino acids in beaver meet samples was determined from 0.99 mg 100 g^{-1}, less than other game meat. While the content of polyunsaturated fatty acids in meat samples of beaver (42.54%) was significantly higher than content of saturated (26.80%) or monounsaturated (27.42%) fatty acids. Ratio of polyunsaturated fatty acids n–6 : n–3 in beaver meat samples were 1.26, PUFA : SFA in beaver meat samples were 1.60 and cholesterol content 49.51 mg 100 g^{-1} was lower in comparison of domestic or wild animals meat. From this point of view beaver meat is very healthy source of fat.

Key words: wild animals, beaver, meat, biochemical composition.

INTRODUCTION

Over the recent years, the popularity of wild game meat has increased and game is considered an important addition for human consumption. Currently, among consumers, there is increased interest in meat from animals kept in conditions as close as possible to the natural ones and beaver meat one of them. There are several reasons behind this fact: the high biological value of game meat has high protein content with broad spectrum of essential amino acids, low fat content with rich composition of poly-unsaturated fatty acids in comparison with meat of domestic animals. The game meat is an important source of B-group vitamins, micro- and macro-nutrients, and considerably high iron content; moreover it is free from drug residues and growth hormones (Serratosa et al., 2006).

It is clear that protein plays a role in promoting optimal health. New research reveals increasingly complex roles for protein and amino acids in regulation of body composition and bone health, gastrointestinal function and bacterial flora (Millward et al., 2008). The amino acid profile is important because some amino acids cannot be synthesized by human organism and therefore must be supplied by the diet. Since the amino acid composition of proteins from food animals is similar to human muscle, muscles are an excellent source of the amino acids needed for growth, repair, and human body after maintenance. Meat is one of the key proteins and essential amino acids sources (Tudor et al., 2009). Average game meat protein content reported 21–25% and contains all essential amino acids (Paleari et al., 2003).

Iron is an essential mineral, which plays a role in a variety of body functions. It is important in the early stage of students cognitive development (Lozoff et al., 2000), and for women in childbearing age (Ferguson et al., 2000). The iron deficiency can cause symptoms such as fatigue, decreased immunity (Ministry of Health, 2006). Many foods in the diet contain iron, but this iron is not always easily absorbed by your body. Heme iron is found in meat, fish and poultry, and is the form of iron that is most readily absorbed from stomach and taken up into your body after you eat it. Eating meat generally boost your iron levels far more than eating non-heme iron. It is concluded that the red meat is only source of zinc in the diet (Groff & Gropper, 2000).

The beavers *(Castor fiber)* are the largest rodents in Latvia. They are herbivorous (Zalewski et al., 2009). Beaver carcass meat fat characterise the high concentration of unsaturated fatty acids, ranging from 68.3–79.2% and that polyunsaturated fatty acids were dominant (Jankowska et al., 2005). However, wild beaver fat contains twice as much polyunsaturated fatty acid as the fat of farm beavers (Korzeniowski et al., 1999). This is likely because the main composition of the wild beaver diet (aquatic flora) is rich in polyunsaturated fatty acids. Polyunsaturated fatty acids are not synthesized by human organism therefore these must be committed with products of animal origin, mostly fish, but wild animal's meat is also good source, in particular, the beaver meat.

The current limited consumption of beaver meat may be partly due to the lack of public knowledge of its nutritional quality. Several papers have reported the composition of this mammal meat in Lithuania and Poland and underlined its high quality protein and high percentage of polyunsaturated fatty acids (Jankowska et al., 2005; Razmaite et al., 2011). Only small number of studies on biochemical composition of game meat in Latvia has been done (Jemeljanovs et al., 2012; Strazdina et al., 2013). An evaluation of beaver meat biochemical composition could increase the interest in wider consumption and hunting of the beavers in Europe.

Therefore aim of our investigation was to analyse the compositional characteristics and to evaluate the nutritional quality of beaver meat.

MATERIALS AND METHODS

Overall there 16 meat samples of beaver were analysed. Research object was the *biceps femoris* (as the largest and most valuable cut) obtained from beavers.

Protein content was determined as total nitrogen content by Kjeldahl method and using coefficient 6.25 for calculation (ISO 937:1974).

For amino acid analysis dried, defatted meat samples were treated with constant boiling 6N hydrochloric acid in an oven at around 110°C for 23 h. Amino acids were

detected by using reversed-phase HPLC/MS (Waters Alliance 2695, Waters 3100, column XTerra MS C18 5 μm, 1x100 mm). Mobile phase (90% acetonitrile: 10% deionized water) 0.5 ml min^{-1}, column temperature 40°C.

Intramuscular fat content estimation was made by Soxhlet method with hydrolysis procedure (boiling in the hydrocloric acid) using SoxCap 2047 and SOX TEH 2055 equipment (FOSS) (LVS ISO 1443:1973).

For fatty acid analysis homogenized meat samples were prepared for GLC (gas-liquid chromatography) analysis using direct saponification with KOH methanol followed by a derivatization with (trimethylsilyl) diazomethane by the method of Aldai et al. (2006). An ACME, model 6100, GLC (Young Lin Instrument Co.) equipped with a flame ionisation detector, an Alltech AT–FAME analytical column (fused silica 30 m and i.d. 0.25 mm), carrier gas He (2 mL min^{-1}) was used. The individual FAMEs (fatty acid methyl esters) were identified according to similar peak retention times using standard mixture Supelco 37 Component FAME Mix.

Cholesterol content was detected by Blur colorimetric method using spectrometer (Shmanenkov & Alijeva, 1973).

The ash content was determined after incineration at 525 ± 15°C 5 h^{-1} (ISO 936:1996).

Micronutrient amount of meat was measured according to ISO 6869:2002. Methods are based on comparison of radiation absorption emitted by free metal atoms that are forming by spraying incinerated sample and the concentrations of certain metal solutions in the flames. The atomic absorption was measured by using spectrometer AAnalyst 200.

RESULTS AND DISCUSSION

Biochemical composition of analysed beaver meat samples hunted in Latvia, Lithuania and Poland are presented in the Table 1.

Table 1. The biochemical composition of beaver meat samples

Source	Dry matter, %	Protein, %	Fat, %	Crude ash, %	Fe, mg 100 g^{-1}	Zn, mg 100 g^{-1}
Current study	24.93 ± 1.65	21.39 ± 1.32	4.29 ± 0.98	1.13 ± 0.00	0.84 ± 0.86	10.64 ± 0.79
Lithuania[1]	23.50 ± 0.23	21.60 ± 0.12	0.51 ± 0.08	1.09 ± 0.00	~	~
Poland[2]	27.56 ± 1.58	21.70 ± 0.61	3.90 ± 1.59	1.29 ± 0.10	~	~

[1] Razmaite et al., 2011; [2] Jankowska et al., 2005; average ± standard deviation; ~ not specified

The research demonstrated that the protein content is same in beaver meat samples harvested in different places (21–22%). The intramuscular fat content of investigated samples was 4.29% being higher than in Lithuanian (0.51%) or Polish (3.9%) study. It is known that the fat content of meat most affected by nutrition. The nutrition basis of the Eurasian beaver is composed of about 200 plant species and the composition of the diet is dependent on the availability of the food resources in their living habitat and season (Razmaite et al., 2011). Although the intramuscular fat content differed among investigations, beaver muscles can be considered as low-fat meat.

Lean red meat is an excellent source of trace elements, especially of iron and zinc (Li et al., 2005). The human system has an excellent capacity of processing the iron

compounds found in meat.The average content of iron and zinc in beaver meat samples detected respectively 10.84 ± 0.86 mg 100 g^{-1} and 10.64 ± 0.79 mg 100 g^{-1}. Fimreite et al. (*electronic resource)* reported that content of zinc ranged from 15.20 to 62.20 (ppm ww) in beaver muscles hunted in Norway.

The nutritional value of meat is determined mainly by amino acid content and composition. The composition of amino acids and the sum of essential amino acids determined in beaver meat harvested in Latvia was presented in Table 2.

Table 2. The amino acid content in the beaver meat samples

Amino acids, g 100 g^{-1}	Mean content, g 100 g^{-1} raw meat	Amino acids, g 100 g^{-1}	Mean content, g 100 g^{-1} raw meat
Valine	0.93 ± 0.15	Aspartic acid	1.61 ± 0.31
Isoleucine	1.09 ± 0.06	Serine	0.67 ± 0.09
Leucine	1.52 ± 0.22	Glutamine	2.95 ± 0.56
Lysine	1.71 ± 0.34	Proline	0.82 ± 0.19
Threonine	0.08 ± 0.02	Glycine	0.85 ± 0.14
Tryptophan	0.33 ± 0.03	Alanine	1.36 ± 0.08
Phenylalanine	0.10 ± 0.02	Tyrosine	0.61 ± 0.09
Methionine	0.39 ± 0.09	Oxyproline	0.86 ± 0.08
Arginine	1.42 ± 0.20	The sum of essential AA*	7.63
Histidine	1.00 ± 0.05	Tryptophan : Oxyproline	3.8

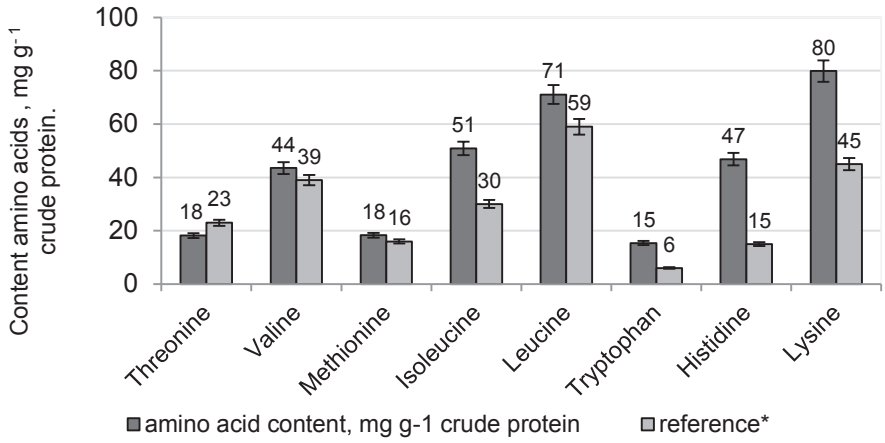
*- Σ essential amino acids (AA), g 100 g^{-1} = Thr + Val + Met + Ile + Leu+ Trp + His + Lys.

The results of investigation show that the sum of essential amino acids calculated 7.63 g 100 g^{-1} wet meat. The recommended intake of total irreplaceable or essential amino acids is 83.5 mg^{-1} on kg of body weight per day (WHO/FAO/UNU, 2007), it is 5.8 g per human with body weight 70 kg. The ratio of essential to non-essential amino acids was 0.63.

As shown in Table 2. beaver muscle protein contained a high level of glutamic acid, which is main amino acid responsible for taste of meat – 2.95 g 100 g^{-1} raw meat. It is lower than showed results of investigations in Lithuania – 3.3 g 100 g^{-1} raw meat (Razmaite et al., 2011). The sequence of other amino acids is similar to other meats, namely aspartic acid, lysine, leucine, arginine, isoleucine, alanine, histidine, valine, glycine, threonine and methionine in decreasing amounts.

Tryptophan is one of valuable amino acid. The content of tryptophan is used as full value protein measure in product. Content of oxyproline is major as measure of connective tissue protein. Therefore ratio Tryptophan : Oxyproline is one of major indicators of nutrition value of product, this ratio in beaver meat samples calculated 3.8, it is similar with beef (3–4) but lower than pork (7.2) (Jemeljanovs et al., 2012).

When compared essential amino acids of beaver meat samples to the reference amino acid pattern of adults (Fig. 1) almost all detected scores were > 100 (except threonine).



* – WHO/FAO/UNU (2007)

Figure 1. Amino acids provided by beaver meat.

Nowadays, histidine is considered to be an essential amino acid because of the detrimental effects on haemoglobin concentrations (Report of a Joint WHO/FAO/UNU Expert Consultation; WHO/FAO/UNU, 2007). Results of study show that beaver meat histidine amount determined three times higher in comparison with reference.

This comparison confirms that beaver muscle protein is of high quality and well-balanced in amino acid composition. The assumed amino acid score showed that biological value or the anticipated ability absorbed protein from beaver meat to fulfil human amino acid requirements is high.

Nutritional quality of meat is highly dependent on fatty acid composition of intramuscular fat. Composition of fatty acids, especially ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids (SFA) is more significant for human health than total fat content. The composition of fatty acids, ratio n–6 : n–3 and PUFA : SFA, level of cholesterol in beaver meat samples assumed in Table 3.

Fatty acids more of all influenced cholesterol level in human blood are myristic, lauric and palmitic acid.-From results of investigation we can establish that myristic and lauric acid drawn up less than 2% of all fatty acids and the average content of palmitic acid in beaver meat samples detected 11.09% from all fatty acids. Razmaite et al. (2011) reported that 23.05% palmitic acid was detected in beaver ham and 12.96% of all From nutritionists point of view 'ideal fat' SFA : MUFA : PUFA ratio is 33.33% : 33.33% : 33.33% (Medeiros et al., 2002). From results of investigation shown in Fig. 2, must be concluded that the sum of MUFA in beaver meat (27.42% of all fatty acids) is quite close to 'ideal'.

The ratio polyunsaturated fatty acids to saturated was calculated 1.60, which was high. WHO/FAO (2003) and Wood et al. (2003) reported that recommended ratio PUFA : SFA must be higher than 0.4 and that domestic animals it has too low (Wood et al., 2003). Medeiros et al. (2002), reported that PUFA : SFA ratio of beef samples is 0.38. The results of beaver meat evaluation in Lithuania showed that this ratio 1.28 in thigh and 2.37 in tail (Razmaite et al., 2011).

Recently, nutritionists have focused not only to level of PUFA, but also to balance between them, therefore the n–6 : n–3 ratio lower than 4 was suggested by World health

Organization (WHO/FAO 2003). As it is shown in the Table 3, in the fatty acids of beaver meat this ratio was 1.26, which was significantly lower than the reference n–6 : n–3 ratio pattern.

Table 3. Fatty acid composition of beaver meat samples (% of total fatty acids)

Symbols	Fatty acid	Mean value	SD
	Saturated fatty acids(SFA)		
C 12:0	Lauric	0.05	0.01
C 14:0	Myristic	1.43	0.01
C 15:0	Pentadecylic	0.76	0.09
C 16:0	Palmitic	11.09	0.52
C 17:0	Margaric	0.11	0.03
C 18:0	Stearic	13.36	1.85
	Monounsaturated fatty acids (MUFA)		
C 14:1	Myristoleic	1.43	0.01
C 15:1	cis-10-Pentadecenoic	0.16	0.00
C 16:1	Palmitoleic	6.37	0.52
C 17:1	Heptadecenoic (*cis*-10)	0.92	0.06
C 18:1 n-9cis	Oleic	15.02	1.02
C 18:1 n-9tr	Elaidic	3.30	0.12
C 20:1 n-9	Eicosenoic	0.06	0.01
C 20:1 n-11	Gadoleic	0.04	0.00
C 22:1 n-9	Erucic	0.12	0.02
	Polyunsaturated fatty acids (PUFA)		
C 18:2 n-6	Linoleic	18.83	2.61
C 18:3 n-3	α-Linolenic	17.86	1.32
C 18:3 n-6	γ-Linolenic	0.07	0.01
C 20:2	Eicosadienoic	0.01	0.01
C 22:2 n-6	Cis-13,16-docosadienoic	0.24	0.02
C 20:3 n-6	Dihomo-γ-linolenic	0.18	0.03
C 20:4 n-6	Arachidonic	4.49	0.52
C 20:5 n-3	Eicosapentaenoic	0.84	0.07
C 22:6 n-3	Docosahexaenoic	0.02	0.01
n-3*		18.71	2.13
n-6**		23.81	0.86
n-6 : n-3		1.26	0.90
PUFA : SFA		1.60	0.03
Cholesterol, mg 100 g^{-1}		49.51	4.21

* – Σ_{n-3} = $20:3_{n-3}$ + $C22:6_{n-3}$ + $C22:5_{n-3}$ + $C20:5_{n-3}$ + $C18:4_{n-3}$ + $C18:3_{n-3}$

** – Σ_{n-6} = $C22:2_{n-6}$ + $C20:2_{n-6}$ + $C18:3_{n-6}$ + $C22:4_{n-6}$ + $C20:3_{n-6}$ + $C18:2_{n-6}$ + $C20:4_{n-6}$

The average cholesterol content of beaver meat samples was 49.51 mg 100 g^{-1}, which was significantly lower than cholesterol content of beef – 76.31 mg 100 g^{-1} (Jemeljanovs et al., 2012). Nowadays, the food quality concept includes not only safety and technological quality, but also nutritional value and food diversification is considered as quality. Therefore consumption of beaver meat should suggest as meat diversification, is high quality protein source, lower cholesterol content and a better PUFA : SFA; n–6 : n–3 ratios for human health.

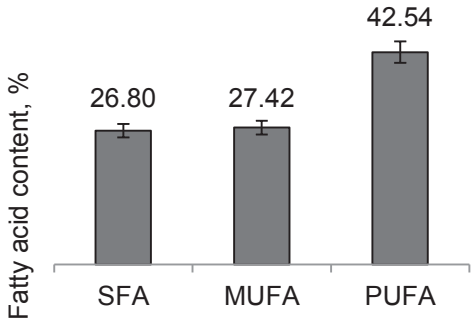


Figure. 2. The sum of saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) in beaver meat (% of total fatty acids).

CONCLUSIONS

Beaver muscle protein is good in quality and well-balanced in amino acid composition as the level of essential amino acids determined 7.63 g $100g^{-1}$ raw meat. The amino acid score showed that biological value or the anticipated ability absorbed protein from beaver meat to fulfil human amino acid requirements is high.

In beaver meat, the content of monounsaturated (27.42%) saturated (26.63%) and polyunsaturated (42.54% of all fatty acids) are well balanced. The ratio polyunsaturated fatty acids to saturated was calculated 1.60 and ratio n–6 : n–3 – 1.26 are considered as advantageous for human health.

REFERENCES

Aldai, N., Osoro, K., Barron, L.J.R. & Najera, A.I. 2006. Gas-liquid chromatographic method for analysing complex mixtures of fatty acids including conjugated linoleic acids (cis9trans11 and trans10cis12 isomers) and long-chain (n–3 or n–6) polyunsaturated fatty acids: Application to the intramuscular fat of beef meat. *J. Chromatogr. A*. **1110**(31), 133–139.

Ferguson, E.L., Scheaff, C.M., Bourn, D.M., Nixon, M. & Parnell, W.R. 2000. *Folate Status of Representative Populations in Dunedin: Issues for folate fortification*. Dunedin: Department of Human Nutrition and Department of Food Science, University of Otago. 64 pp.

Fimreite, N., Parker, H., Rosell, F., Hosen, D.A., Hovden, A. & Solheim, A. 2001. Cadmium, Copper, and Zinc in Eurasian beaver (Castor *fiber*) from Bø. Norway and Norwegian University of Science and Technology, *./electronic resource / http://link.springer.com/article/10.1007%2Fs001280152*. Accessed on 22 Nov., 2015.

Groff, J.L. & Gropper, S.S. 2000. *Advanced Nutrition and Human Metabolism*. 3rd ed. Wadsworth Thomson Learning; Belmont, CA, USA, 115 pp.

Jankowska, B., Źmijewski, T., Kwiatkowska &A., Korzeniowski, W. 2005. The composition and properties of beaver (*Castor fiber*) meat. *Eur. J. Wildlife Res.* **51**, 283–286.

Jemeljanovs, A., Zitare, I., Konsonoka, I.H., Krastina, V., Proskina, L., Jansons, I. & Strazdina, V. 2012. Evaluation of meat used for human consumption in Latvia. *Proc. Latnian Academy Sci. Section B.* **66**(678), 87–95.

Korzeniowski, W., Jankowska, B., Kwiatkowska, A. & Żmijewski, T. 1999. Chemical composition of European beaver (*Castor fiber L.*) meat. *Nat. Sci*. **3**, 291–300.

Li, D., Siriamornpun, S., Wahlqvist, M.L., Mann, N.J., & Sinclair, A.J. (2005). Lean meat and heart health. *Asia Pac J Clin Nutr.* Vol. **14**(2), 113–119.

Lozoff, B., Jimenez, E., Hagen, J., Mollen, E., Wolf, A.W. 2000. Poorer behavioral and developmental outcome more than 10 years after treatment for iron deficiency in infancy. *Pediatrics*. **105**(4), 51.

Medeiros L.C., Busboon I.R., Field R.A., Williams I.C., Miller G.I. & Holmes B 2002. Nutritional Content of Game Meat. /electronic resource / *http://www.wyomingextension.org/agpubs/pubs/B920R.pdf* Accessed on 18 December, 2015.

Millward, D., Layman, D., Tomé, D. & Schaafsma, G. 2008. Protein quality assessment: impact of expanding understanding of protein and amino acid needs for optimal health. *Am.J Clin. Nutr.* **87**,1576S–1581S.

Ministry of Health 2006. National Health and Medical Research Council (NHMRC). Nutrient Reference Values for Australia and New Zealand including Recommended Dietary Intakes. Canberra: NHMRC, Wellington: Ministry of Health. 317 pp.

Paleari, M.A., Moretti, V.M., Beretta, G., Mentasti, T. & Bersani, C. 2003. Cured products from different animal species. *Meat Sci*. **63**(4), 485–489.

Razmaite, V., Sveistiene, R. & Svirmickas, G.J. 2011. Compositional Characteristics and Nutritional Quality of Eurasian Beaver (*Castor fiber*) meat. *Czech J. Food Sci.* **29**(5), 480–486.

Serratosa, J., Blass, A., Rigau, B., Mongrell, B., Rigau, T., Tortadès, M., Tolosa, E., Aguilar, C., Ribó O. & Balagué J. 2006. Residues from veterinary medicinal products, growth promoters and performance enhancers in food-producing animals: a European Union perspective. *Rev. sci. tech. Off. int. Epiz*. **25**(2), 637–653.

Strazdina, V., Jemeljanovs, A. & Sterna, V. 2013. Nutrition value of wild animal meat. *Proc. Latnian Academy Sci. Section B*. **67**(4–5), 373–377. */electronic resour*ce / *http://www.degruyter.com/view/j/prolas.2013.67.issue-4-5/prolas-2013-0074/prolas-2013-0074.xml?format=INT* Accessed on 22 December, 2015.

Shmanenkov, N.A. & Alijeva, F. F. 1973. *Methodological guidelines for the study of lipid metabolism in farm animals*. Borovsk, 115 pp. (in Russian).

Tudor, L., Lie, L.I., Tudor, L.A. & Mitranescu, E. 2009. The physic-chemical quality for refrigerated wild boar meat. *Lucrari Stiintifice - Universitatea de Stiinte Agricole a Banatului Timisoara, Medicina Veterinara*. **42**(2), 310–314

WHO/FAO/UNU 2007 Protein and amino acid requirements in human nutrition. Report of a Joint WHO/FAO/UNU Expert Consultation, World Health Organization Technical Report Series 935. WHO, Geneva.284 pp.

WHO/FAO 2003 Diet, nutrition and the prevention of chronic diseases. Report of a Joint WHO/FAO Expert Consultation, World Health Organization Technical Report Series 916. WHO, Geneva.160 pp.

Wood, J.D., Richardson, R.I., Nute, G.R., Fisher, A.V., Campo, M.M. & Kasapidou, E. 2003. Effects of fatty acids on meat quality: a review. *Meat Sci.* **66**(1), 21–32.

Zalewski, K., Martysiak-Żurowska, D., Chylińska–Ptak, M. & Nitkiewicz, B. 2009. Characterization of Fatty Acid Composition in the European Beaver (*Castor fiber L.*). *Polish J. Environ. Stud*. **18**(3), 493–499.