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Fatty acid profile in fat obtained from edible part of land snails harvested in Poland

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Abstract

Introduction: The objective was to determine the content of fatty acids in edible snail fat by snail species, collection site, and processing stage. **Material and Methods:** The research material comprised 180 edible fat samples from the three genera of edible snails collected in Poland: free-living *Helix pomatia* (HP) and two cultivated *Cornu* subspecies: *C. aspersa maxima* (CAM) and *C. aspersum aspersum* (CAA). All snails came from the Greater Poland and Lower Silesian Provinces: HP from their natural habitat and CAM and CAA from heliciculture farms. The studies focused on the raw meat, cooked meat, and frozen meat processing stages. Fatty acid (FA) profiles were determined by the gas chromatography method. **Results:** *Helix pomatia* fat showed a higher saturated fatty acid (SFA) content, whereas the fat of *Cornu* genus snails had a higher unsaturated fatty acid (UFA) component, *i.e.* monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA). Thermal processing of snail meat increased all the determined SFA and decreased all the PUFA values, and increased the content of C18:1, C20:1, and C22:1 acids in the MUFA group. The material collection site had limited impact on FA content as differences were noted only in levels of C18:1, C18:2 n6, and C20:5. The differences pertained only to the fat of farmed snails of the *Cornu* genus. **Conclusion:** Due to the high content of UFA and a favourable ratio of n6:n3 acids and PUFA:SFA, snail fat can be regarded as nutritionally valuable.

Keywords: land snails, fat, fatty acids.

Introduction

The rapidly growing sector of food production has promoted the development and marketing of new types of animal-based protein sources. Snail meat is one of the protein sources which could instance a new alternative to traditional sources of protein and at the same time satisfy the sophisticated culinary taste of consumers. Currently, Poland is one of the major producers and suppliers of snail meat for the European markets (29).

Compared to meat of other species of slaughter animals, snail meat is relatively low in total fat, content of which ranges from 0.48% in *Cornu* genus snails up to 1.23% in the *Helix pomatia* species (19). The nutritional value of snail meat is related not only to its low fat content but also to the balanced proportionality between fatty acid groups as well, primarily unsaturated fatty acid (UFA) content, and of this mainly polyunsaturated fatty acids (PUFA) that are one of the determinants of the biological value of food. The fat obtained from the edible portion of snail meat contains more UFA than saturated fatty acids (SFA). The factors of critical importance for chemical composition of snail meat and its lipid profile are the snail genus, its collection site, and the manner of processing this meat for human consumption. Concerning *Helix pomatia*, UFA make up 63.7% of total fatty acids, in that 19.65% are MUFA and 25.83% PUFA. The fatty acid profile in *Cornu* genus snail meat is closely associated with the snail farming system and feeding regimen. The fat of free-living *Cornu* snails contains around 55.04% of UFA, in that 20.66% are MUFA and 34.38% are PUFA (5). However, the fat of farmed *Cornu* snails shows a higher level of UFA as compared to that of free-living ones. The data available

in literature indicate that UFA can constitute even up to 70%–80% of total fatty acids (15, 16).

The aim of the studies was to determine the variation in fatty acid level in fat of snails collected in Poland in relation to snail species, its collection site, and processing stage.

Material and Methods

The research material comprised a total of 180 snail meat specimens (30 for each species of snail and each region) obtained from three genera of edible snails, *i.e*. *Helix pomatia* (HP), *Cornu aspersa maxima* (CAM), commonly named the large grey snail, and *Cornu aspersum aspersum* (CAA), the small grey snail. HP snails were picked in nature in the Greater Poland Province (Region A) and Lower Silesian Province (Region B). They were harvested as allowed by the Ministry of Environmental Protection regulations from April 20 until May 31 (24). The shell diameter of the collected snails exceeded 30 mm as mandated. Grey snails (CAM, CAA) came from the heliciculture farms located in the same provinces: Greater Poland (Farm A) and Lower Silesian (Farm B). The CAM and CAA snails were gathered in September during the autumn harvest season. The studies focused on the edible portion of snail muscle, which is the foot with a collar and a fragment of the mantle. A laboratory specimen comprised 20 snail carcasses blended with a handheld device to achieve homogeneity of the material. The studies included three stages of snail meat processing: raw meat (immediately after its removal from the shell), cooked meat (obtained from a production line), and frozen meat (after three-month storage at −18ºC). The specimens were drawn independently from these three stages.

Chemical analysis. The fatty acid profile was determined using the gas chromatography method (4, 20, 21). Fat extracted from the edible portion of snail was weighed and added to glass ampoules at 100 mg each, then saponified in 0.5 N methanolic KOH solution, evaporated at 80ºC, and finally esterified in 14% BF_3 in methanol (3). The obtained esters were salted out with saturated KCl solution. Chromatographic separation was performed in a Varian CP 3800 gas chromatograph (now Agilent Technologies, USA) equipped with a split/splitless injector (260°C) and flame ionisation detector (FID) (260°C). The chromatograph was fitted with a CP WAX 52CB column (Agilent Technologies) of 60 m length and inner diameter 0.25 mm. The initial column temperature 120°C with a 2°C/min increased to 210°C. Helium was used as carrier gas. The retention time readouts from the chromatograph served to identify particular fatty acids, while the relative percentage of fatty acids was calculated using the software package Galaxie Chromatography Data System (Agilent Technologies).

Statistical analysis. The obtained results were analysed statistically with statistica 9.1 (StatSoft, USA) and expressed as arithmetic means. The normal distribution in each group was checked with the Shapiro-Wilk test. The influence of each variability factor on the determined parameters was established using one way analysis of variance (ANOVA). Rejecting the null hypothesis that all the means are equal, Tukey's post-hoc *t*-test with multiple confidence intervals was applied to compare the groups for statistically significant differences. These differences between the means were determined at the significance level $P = 0.01$.

Results

The SFA profile in the fat of each snail species is presented in Table 1. It was demonstrated that HP snail fat had higher SFA content than CAA and CAM fat. SFA constituted from 34.84% to 39.26% of total fat in HP, whereas in CAM this fat made, up from 28.32% to 33.8% and 29.35% to 33.93% in CAA. Determination of 11 SFA in HP fat was made and the main components were: stearic acid (C18:0), palmitic acid (C16:0), and behenic acid (C22:0). These three acids made up 89.14% of total saturated acids, while others occurred in markedly lower quantities. The CAA and CAM fat was found to contain eight saturated fatty acids and like the HP fat, the predominant components were stearic (C18:0), palmitic (C16:0), and behenic acids (C22:0). A comparison of SFA content between snail species revealed that lauric acid (C12:0), pentadecanoic acid (C15:0), arachidic acid (C20:0), and all other FA were determined in significantly higher amounts in HP fat. In CAA and CAM fat, however, the levels of SFA were comparable.

Thermal processing increased the saturated fatty acid content, and the finding was confirmed in the case of all SFA determined. Freezing caused a further rise in saturated fatty acid amounts, but this pertained only to arachidic acid (C20:0) and behenic acid (C22:0).

It was also found that the material collection site did not significantly affect SFA content in snail fat since there were no significant differences recorded in SFA levels in helicicultured snails between Farms A and B, nor between regions A and B in the case of edible snails collected from the wild.

The MUFA profile in the fat of the three analysed snail species is presented in Table 2. HP fat was characterised by a lower MUFA content as against the CAA and CAM fat, whereas the MUFA levels in the fat of CAM and CAA snails was comparable. MUFA in Roman snail fat accounted for 19.55%–20.16%, 24.22%–35.59% in CAM and 23.89%–33.72% in CAA fat. HP fat was confirmed to contain eight MUFA with the main component of oleic acid (C18:1). It is noteworthy that the presence of nervonic acid (C24:1) was established only in the fat obtained from raw meat

of Roman snails. CAM and CAA fat contained seven MUFA and like HP fat, oleic acid (C18:1) was the predominant component. The percentage of oleic acid (C18:1) averaged 79.58% and ranged between 70.74% in HP fat and 86.74% in CAA fat obtained from Farm B.

Cooking contributed to the increased contents of C18:1, C20:1, and C22:1 acids and decreased levels of C14:1, C15:1, C16:1, and C17:1 acids. Heat treatment caused nervonic acid (C24:1) not to be detected in the fat of cooked and frozen HP meat. MUFA content in frozen meat was comparable to that in cooked meat.

Table 1. Saturated fatty acid (SFA) composition (%) in fat obtained from edible part of *Helix pomatia* (HP), *Cornu aspersum maxima* (CAM), and *Cornu aspersum aspersum* (CAA)

Fatty acid	Stage of snail meat processing	Heliciculture Farm A			Heliciculture Farm B		
		HP n = 10	CAM n = 10	CAA n = 10	HP n = 10	CAM n = 10	CAA n = 10
C 12:0	raw	0.12 aA	0.35 bA	0.37 bA	0.16 aA	0.31 bA	0.36 bA
	cooked	0.17 aB	0.43 bB	0.42 bB	0.19 aB	0.39 bB	0.41 bB
	frozen	0.18 aB	0.45 bB	0.43 bB	0.2 aB	0.41 bB	0.42 bB
C 13:0	raw	0.43 A	0	0	0.39 A	0	0
	cooked	0.55 B	0	0	0.52 B	0	0
	frozen	0.58 B	0	0	0.55 B	0	0
C 14:0	raw	0.47 aA	0.34 bA	0.33 bA	0.47 aA	0.35 bA	0.35 bA
	cooked	0.52 aB	0.38 bB	0.37 bB	0.54 aB	0.4 bB	0.41 bB
	frozen	0.54 aB	0.38 bB	0.38 bB	0.56 aB	0.43 bB	0.44 bB
C 15:0	raw	0.25 aA	0.29 bA	0.28 bA	0.25 aA	0.28 bA	0.29 bA
	cooked	0.3 aB	0.33 bB	0.34 bB	0.3 bB	0.32 bB	0.35 bB
	frozen	0.31 aB	0.34 bB	0.35 bB	0.32 bB	0.33 bB	0.35 bB
C 16:0	raw	10.16 aA	8.36 bA	8.93 bA	10.28 aA	8.27 bA	8.66 bA
	cooked	11.24 aB	10.13 bB	10.17 bB	11.39 aB	10.26 bB	10.22 bB
	frozen	11.32 aB	10.31 bB	10.5 bB	11.45 aB	10.34 bB	10.51 bC
C 17:0	raw	1.13 aA	0.23 bA	0.27 bA	1.11 aA	0.21 bA	0.28 bA
	cooked	1.15 aB	0.26 bB	0.36 bB	1.14 aB	0.25 bB	0.33 bB
	frozen	1.16 aB	0.28 bB	0.38 bB	1.15 aB	0.29 bB	0.36 bB
C 18:0	raw	14.31 aA	12.18 bA	12.28 bA	14.37 aA	12.23 bA	12.89 bA
	cooked	15.51 aB	13.74 bB	13.87 bB	15.64 bB	13.83 bB	13.77 bB
	frozen	15.87 aB	13.66 bB	13.96 bB	15.84 bB	13.91 bB	13.94 bB
C 20:0	raw	0.63 aA	1.34 bA	1.29 bA	0.65 aA	1.33 bA	1.22 bA
	cooked	0.72 aB	1.42 bB	1.34 bB	0.75 aB	1.4 bB	1.29 bB
	frozen	0.81 aC	1.52 bC	1.40 bC	0.84 aC	1.48 bC	1.38 bC
C 22:0	raw	6.5 aA	5.63 bA	5.6 bA	6.69 aA	5.34 bA	5.49 bA
	cooked	6.92 aB	6.0 bB	6.0 bB	6.99 aB	6.03 bB	6.12 bB
	frozen	7.58 aC	6.55 bC	6.52 bC	7.62 aC	6.61 bC	6.53 bC
C 23:0	raw	0.22 A	0	0	0.21 A	0	0
	cooked	0.24 B	0	0	0.25 B	0	0
	frozen	0.24 B	0	0	0.24 B	0	0
C 24:0	raw	0.62 A	0	0	0.63 A	0	0
	cooked	0.66 B	0	0	0.67 B	0	0
	frozen	0.67 B	0	0	0.68 B	0	0
Σ SFA	raw	34.84	28.72	29.35	35.21	28.32	29.54
	cooked	37.98	32.69	32.87	38.38	32.88	32.9
	frozen	39.26	33.49	33.92	38.4	33.8	33.93

a, b – the mean values for each fatty acid differ significantly within region/Farm A or B at $P \leq 0.01$ horizontally; A, B, C – the mean values differ significantly within each fatty acid at $P \leq 0.01$ vertically
* – significant differences between sites of snail collection

The snail collection site had limited impact on the MUFA level as significant differences were reported only in oleic acid (C18:1) content in the fat of the *Cornu* snail species obtained from Farm A. On this farm, the values were lower. These relationships occurred at all processing stages.

Table 3 presents the PUFA profile in the fat of the three examined snail species. It was found that HP fat had lower PUFA content than CAA and CAM snail fat. Regarding *Cornu* snails, the PUFA level varied according to the raw material collection site. PUFA made up from 30.89% to 39.68% in HP fat, from 31.54% to 44.58 % in CAM, and from 33.09% to 46.65% in CAA. Of all known PUFA, the presence of eight acids was confirmed in *Helix pomatia* fat, and the main components were linoleic acid (C18:2 n6) and eicosadienoic acid (C20:2 n11, 14). C20:3 n3 acid was not determined in the fat of this snail species. *Cornu aspersa maxima* snail fat was found to contain nine PUFAs, and C18:2 n6 acid was most abundant. A high percentage of C20:3 n6,9 acid was also detected, while the other PUFA identified were present in smaller amounts.

Table 2. Monounsaturated fatty acid (MUFA) composition (%) in fat obtained from edible part of *Helix pomatia* (HP), *Cornu aspersa maxima* (CAM), and *Cornu aspersa aspersa* (CAA)

Fatty acid	Stage of snail meat processing	Region A/Helicilculture farm A			Region A/Helicilculture farm B		
		HP n = 10	CAM n = 10	CAA n = 10	HP n = 10	CAM n = 10	CAA n = 10
C 14:1	raw	0.14 aA	0.26 bA	0.26 bA	0.13 aA	0.27 bA	0.3 bA
	cooked	0.09 aB	0.2 bB	0.18 bB	0.11 aB	0.22 bB	0.24 bB
	frozen	0.08 aB	0.2 bB	0.19 bB	0.12 aB	0.21 bB	0.2 bB
C 15:1	raw	0.15 aA	0.22 bA	0.25 bA	0.18 aA	0.25 bA	0.23 bA
	cooked	0.12 aB	0.15 bB	0.17 bB	0.14 bB	0.16 bB	0.16 bB
	frozen	0.13 aB	0.16 bB	0.16 bB	0.15 bB	0.15 bB	0.15 bB
C 16:1	raw	1.36 aA	0.73 bA	0.8 bA	1.48 aA	0.82 bA	0.82 bA
	cooked	1.03 aB	0.51 bB	0.5 bB	1.11 aB	0.71 bB	0.69 bB
	frozen	1.02 aB	0.51 bB	0.54 bB	1.13 aB	0.65 bB	0.63 bB
C 17:1	raw	0.28 aA	0.12 bA	0.14 bA	0.23 aA	0.14 bA	0.11 bA
	cooked	0.21 aB	0.08 bB	0.09 bB	0.2 aB	0.1 bB	0.08 bB
	frozen	0.23 aB	0.08 bB	0.07 bB	0.19 aB	0.10 bB	0.08 bB
C 18:1	raw	13.83 aA	20.36 bA*	19.56 bA*	13.65 aA	26.64bA	25.81 bA
	cooked	15.57 aB	23.47 bB*	23.18 bB*	15.63 aB	30.79 bB	28.74 bB
	frozen	15.69 aB	23.5 bB*	23.40 bB*	15.7 aB	30.8 bB	29.02 bB
C 20:1	raw	1.75 aA	2.52 bA	2.87 bA	1.8 aA	2.78 bA	2.57 bA
	cooked	2.84 aB	3.45 bB	3.73 bB	2.75 aB	3.63 bB	3.62 bB
	frozen	2.85 aB	3.43 bB	3.96 bB	2.81 aB	3.67 bB	3.61 bB
C 22:1	raw	0.03 aA	0.01 bA	0.01 bA	0.04 aA	0.01 bA	0.01 bA
	cooked	0.05 aB	0.03 bB	0.02 bB	0.06 aB	0.02 bB	0.02 bB
	frozen	0.06 aB	0.03 bB	0.03 bB	0.06 aB	0.02 bB	0.02 bB
C 24:1	raw	2.01	0	0	2.3	0	0
	cooked	0	0	0	0	0	0
	frozen	0	0	0	0	0	0
Σ MUFA	raw	19.55	24.22	23.89	19.83	30.91	29.85
	cooked	19.91	24.78	24.25	20.0	31.48	33.55
	frozen	20.06	27.88	28.13	20.16	35.59	33.72

a, b – the mean values for each fatty acid differ significantly within region/Farm A or B at $P \leq 0.01$ horizontally; A, B – the mean values differ significantly within each fatty acid at $P \leq 0.01$ vertically

* – significant differences between sites of snail collection

Table 3. Polyunsaturated fatty acid (PUFA) composition (%) in fat obtained from edible part of *Helix pomatia* (HP), *Cornu aspersa maxima* (CAM), and *Cornu aspersa aspersa* (CAA)

Fatty acid	Stage of snail meat processing	Region/Helicriculture Farm A			Region/Helicriculture Farm B		
		HP n = 10	CAM n = 10	CAA n = 10	HP n = 10	CAM n = 10	CAA n = 10
C 18:2 n6	raw	17.95 aA	32.42 bA*	34.34 bA*	17.87 aA	27.42 bA	27.4 bA
	cooked	16.95 aB	30.42 bB*	31.84 bB*	16.59 aB	24.55 bB	25.12 bB
	frozen	16.69 aB	30.43 bB*	31.71 bB*	16.47 aB	25.51 bB	25.02 bB
C 18:3 n3	raw	2.47 aA	3.5 bA	3.7 bA	2.54 aA	3.7 bA	3.85 bA
	cooked	1.57 aB	1.82 bB	2.22 bB	1.4 aB	2.8 bB	2.86 bB
	frozen	1.42 aB	1.45 bB*	2.21 bB	1.41 aB	2.7 bB	2.44 bB
C 18:3 n6	raw	0.35 aA	0.25 bA	0.25 bA	0.34 aA	0.29 bA	0.27 bA
	cooked	0.27 aB	0.15 bB	0.18 bB	0.22 aB	0.15 bB	0.17 bB
	frozen	0.24 aB	0.12 bB	0.18 bB	0.21 aB	0.14 bB	0.15 bB
C 20:2 n11, n14	raw	12.77 aA	0.58 b	0.39 b	12.3 aA	0.46 b	0.39 b
	cooked	11.59 B	0	0	10.97 B	0	0
	frozen	11.76 B	0	0	10.66 B	0	0
C 20:3 n3	raw	0	0.26 a	0.22 a	0	0.26 a	0.24 a
	cooked	0	0	0	0	0	0
	frozen	0	0	0	0	0	0
C 20:3 n6 n9	raw	1.96 aA	6.93 bA	7.06 bA	1.73 aA	5.7 bA	7.37 bA
	cooked	1.6 aB	6.12 bB	5.81 bB	1.51 aB	3.37 bB	5.34 bB
	frozen	1.58 aB	6.0 bB*	5.24 bB	1.5 aB	3.22 bB	5.48 bB
C 20:4	raw	1.02 aA	0.3 bA	0	1.32 aA	0.2 bA	0
	cooked	0.32 aB	0	0	0.5 aB	0	0
	frozen	0.29 aB	0	0	0.52 aB	0	0
C 20:5 n3	raw	2.9 aA	0.15 bA*	0.14 bA*	2.46 aA	1.53 bA	1.25 bA
	cooked	1.68 aB	0.07 bB*	0.06 bB*	1.32 aB	0.67 bB	0.5 bB
	frozen	1.68 aB	0.06 bB*	0.06 bB*	1.27 aB	0.65 bB	0.48 bB
C 22:2	raw	0.26 aA	0.19 a	0.55 b	0.22 aA	0.25 a	0.53 b
	cooked	0.16 aB	0	0	0.12 aB	0	0
	frozen	0.13 aB	0	0	0.12 aB	0	0
Σ PUFA	raw	39.68	44.58	46.65	38.78	39.81	41.3
	cooked	34.14	38.58	40.11	32.63	31.54	33.99
	frozen	32.11	38.0	39.34	30.89	31.57	33.09

a, b – the mean values for each fatty acid differ significantly within Farm A or B at $P \leq 0.01$ horizontally; A, B – the mean values differ significantly within each fatty acid at $P \leq 0.01$ vertically
* – significant differences between sites of snail collection

The CAA fat contained eight polyunsaturated fatty acids, and similarly to CAM fat, the main components were C18:2 n6 and C20:3 n6,9 acids. The presence of arachidonic acid (C20:4) was not detected in CAA fat.

Heat treatment of the meat decreased the content of all identified PUFA. However, PUFA contents in frozen meat were comparable to those determined in cooked meat. The CAM and CAA fat extracted from heat-processed and frozen meat evinced no presence of C20:2, C20:3 n3, and C22:2 acids, these occurring only in raw meat. A similar finding related to the C20:4 acid level was recorded in CAM fat.

The material collection site affected PUFA content in snail fat. Significant differences were established in linoleic acid (C18:2 n6) and clupanodonic docosapentaenoic acid (C20:5) in grey snail (CAM and CAA) fat. The fat of both grey snail species obtained from Farm A demonstrated a higher level of C18:2 n6 acid and a lower C20:5 content than the Farm B counterparts. As for other PUFA in grey snail fat, there were no statistically significant differences in their contents between the material obtained from Farms A and B. As regards Roman snails, there were no significant differences in content of particular polyunsaturated fatty acids between the regions A and B.

Table 4. Fatty acid ratio (%) in edible part of *Helix pomatia* (HP), *Cornu aspersa maxima* (CAM), and *Cornu aspersum aspersum* (CAA)

	Stage of snail meat processing	Region/Heliciculture Farm A			Region/Heliciculture Farm B		
		HP	CAM	CAA	HP	CAM	CAA
PUFA/SFA	raw	1.14	1.55	1.59	1.1	1.41	1.4
	cooked	0.9	1.18	1.22	0.85	0.96	1.03
	frozen	0.82	1.13	1.16	0.8	0.93	0.98
∑ n6	raw	21.28	39.9	41.65	21.26	33.61	35.04
	cooked	18.9	30.64	32.08	18.13	25.37	25.79
	frozen	18.61	30.61	31.95	17.95	26.3	25.65
∑ n3	raw	5.37	3.91	4.06	5.0	5.49	5.34
	cooked	3.25	1.89	2.28	2.72	3.47	3.36
	frozen	3.25	1.89	2.28	2.72	3.47	3.36
n6/n3	raw	3.96	10.2	10.26	4.25	6.12	6.56
	cooked	5.82	16.21	14.07	6.67	7.31	7.68
	frozen	5.73	16.2	14.01	6.6	7.58	7.63

Discussion

Snail fat, just like fat of other animal species, contains three types of fatty acids, *i.e.* SFA, MUFA, and PUFA. It is very important to provide adequate dietary intake of the PUFA called essential unsaturated fatty acids. Those of primary importance are linoleic acid (LA), which is a substrate for the synthesis of the n6 fatty acid family, and α-linolenic acid (ALA), the parent fatty acid of the n3 PUFA family. Due to the competition between these two acids for the same enzymes involved in the synthesis of LA and ALA metabolites, dietary intake of a balanced LA:ALA ratio is critical. The recommended ratio between n6 and n3 unsaturated acids should be 4:1, and these acids are expected to make up 1/3 of the daily fat requirement (1, 10, 11, 27). Dietary guidelines recommend that the saturated to unsaturated acid ratio should be 0.45:1 or better, where better is generally agreed to be a lower SFA term (15).

The results summarised in Table 4 indicate that snail meat is rich in unsaturated acids. However, snail fat is characterised by high variation in particular fatty acid contents, including unsaturated acids, and is mostly affected by the feeding regimen (60). However, the present studies have found that the proportions between particular fatty acids groups in HP fat seem to be more stable and comparable to those available in literature (18). The studies on meat of collected wild HP snails showed that the PUFA/SFA ratio was 0.68 and the proportion of n6 to n3 acids – 4.94. As regards CAA and CAM, the proportions between particular fatty acid groups were more varied, which is attributed to additional commercial feed supply that increased the n6 content in snail meat (27). Notably, feeds that include corn, sunflower or soybean rich in n6 acids were shown to increase the content of these acids in meat. The fat of farmed snails of the *Cornu* genus had a higher content of acids of the n6 family than *Helix* genus fat.

The studies performed indicated significant differences in fatty acid content between *Helix* genus and *Cornu* genus snails. The HP fat showed a higher level of SFA than CAM and CAA. The CAM and CAA fat, however, had significantly higher content of MUFA and PUFA acids. Although the literature appears scarce as to data on fatty acid content in edible snail fat (5, 7, 14, 15, 18, 25, 28), the available data serve to confirm the relationship between the SFA, MUFA, and PUFA proportions established in the present studies. The current literature data demonstrate that PUFA acids in CAM and CAA fat can account for from 34.38% up to as high as 57.06% of fatty acid content, MUFA may represent from 20.06% to 23.82%, whereas SFA make up from 22.2% to 28.76% (5, 15, 16). Özogul *et al.* (18) investigating FA content in HP reported a lower unsaturated fatty acid level as compared to the *Cornu* snails where PUFA made up 25.83% and MUFA 19.65%, while SFA were more abundant and constituted 37.87%. A crucially important fact is the highest quantitative differentiation in fatty acid content was observed in the unsaturated fatty acid group which implies the involvement of additional external factors affecting fatty acid profile. The results of the studies by Çağıltay *et al*. (5) and Milinsk *et al*. (15) serve as the basis for comparison of fatty acid contents in the *Cornu aspersa maxima* snails obtained from the heliciculture and those of the same species but living wild. The free-living snails displayed a lower level of UFA and higher SFA, and a similar relationship was found in HP fat (8).

Heat treatment (cooking) of snail meat caused an increase in all SFAs identified. In a group of MUFA, an elevated content of 18:1, 20:1, and 22:1 acids was observed, whereas a decrease in 14:1, 15:1, 16:1, 17:1, and 24:1 (only in HP) acids was recorded. A decline in all the PUFAs determined was also noted. Regarding SFA acids, their concentration increased to a small degree, around 3.5%. The level of MUFAs in raw and frozen meat was comparable, while the decrease in

PUFA content was about 6%. As a rise in SFA content in cooked meat over raw meat pertaining to all SFAs was identified, it was likely to be a result of water content loss during the cooking process (12, 26). A lowered UFA content was caused by autoxidation mechanisms initiated by temperature rise in meat during its cooking (22, 23). UFA are more susceptible to oxidation than SFA (2, 13, 27). The factors known to induce the autoxidation process are primarily temperature, light, and the presence of metals. Cooking also makes muscle cells undergo structural changes that lead to more intensive interaction of fatty acids with the prooxidative factors mentioned above (2). The changes depicted in fatty acid profile were similar to those observed in beef, poultry meat, and muscle tissue of various fish species (9, 17). Contrary to expectations, the frozen meat showed no decline in the level of UFA, neither MUFA nor PUFA. That may derive from the slow speed of oxidation and hydrolysis promoting lipid breakdown due to the limitation on the factors conducive to autoxidation. These factors included storage of meat in plastic bags without oxygen and light exposure, inactivation of tissue enzymes (cyclooxygenase and lipoxygenase), as well as a decreased level of microorganisms after the heat treatment cold storage. It is in line with the reports that highlight the absence of changes in meat fatty acid content during the first three months of cold storage (6, 30).

In conclusion, the fat of edible snails harvested in Poland, primarily the fat of farmed snails of *Cornu* genus, is of high nutritional value in view of its high content of unsaturated acids, beneficial n6:n3 fatty acid ratio, and proper balance between PUFA and MUFA.

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