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Snail meat, a newly discovered old source of protein in the human diet

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Abstract

The aim of this study was to determine the physicochemical parameters, i.e. water, protein, fat, ash, sodium and carbohydrate content and energy value, as well as fatty acid composition and pH of snail meat from two species, Cornu aspersum maximum and Cornu aspersum Müller. The snail meat was found to have relatively high protein content (13.12 g/100 g vs. 16.53 g/100 g), low fat content (0.89 g/100 g vs. 1.21 g/100 g), and low energy value (343.8 kJ vs. 379.2 kJ). The pH of snail meat was very high (8.59 vs. 8.19). On average, snail meat has a favourable fatty acid composition as it contains 27.08 wt. % saturated (SFA), 19.00 wt. % monounsaturated, and 53.92 wt. % polyunsaturated fatty acids (PUFA). It has a favourable PUFA/SFA ratio (1.99), but an unfavourable n-6/n-3 ratio (20.33) and a relatively high proportion of trans fatty acids (3.93 wt. %). The fatty acid profile of snail meat is dominated by linoleic acid (20.89 wt. %), arachidonic acid (13.27 wt. %), oleic acid (12.67 wt. %), nonadecanoic acid (10.23 wt. %), and stearic acid (10.08 wt.%). The aim of our study was also to verify the culinary value of snail meat. For this purpose, two snail meat pâtés of acceptable sensory quality were prepared. The panel evaluated the sensory quality of the pâté made from the meat (foot and liver) of the snail Cornu aspersum Müller significantly worse than the pâté made from the meat of the snail Cornu aspersum maximum, mainly due to the unpleasant aroma, in which the soapy, sweet and spicy components predominated, as well as the absence of the snail meat aroma.

Keywords: snails; snail meat; physicochemical parameters; protein; fatty acid composition; sensory properties

Introduction

Snails are widespread throughout Europe and maintain the balance of the natural environment. In snail farming, there are mainly two edible snail species, the large garden snail (*Helix pomatia*) and the European brown snail (*Cornu aspersum*) (Rygało-Galewska et al., 2022). Both species are equally valued, but differ in that the large garden snail does better in cooler climates, while the brown garden snail prefers warmer climates and coastal regions. In practice, snail meat has always been used in human nutrition (Ećimović and Velkovrh, 1992). The first evidence of consumption of land snails in human diet dates from 31300 to 26900 years BC. The discovery of snail shell remains together with the remains of animal skeletons and stone tools in a cave in Spain is one of the first

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evidences of the use of land snails in human diet. Interestingly, the best available data from the late Pleistocene/early Holocene come from the Pupićina cave in Istria, where land snails were definitely part of the diet, along with red deer, roe deer, wild boar, a variety of medium-sized and small ungulates, and some marine shellfish (Miracle et al., 2000). Even the ancient Greeks and Romans frequently consumed snail meat as a tasty and medicinal component of a meal. The history of snail farming can be traced back to ancient Rome, where snails were raised for luxurious feasts. In the Middle Ages, snails were almost the only food for starving people. Snail meat occupies an important place in the human diet, especially in France, Germany, Switzerland, and Italy, where snail consumption is highest (Ećimović and Velkovrh, 1992).

Snail meat is particularly interesting from a nutritional point of view because it is rich in proteins and can contain up to 18 g/100 g, depending on the snail species (Özogul et al., 2005; Kougiagka et al., 2022). *Cornu aspersum* snail meat in 100 g contains 78.46 g water, 14.56 g protein, 0.69 g fat, 1.42 g ash, and has 82.70 kcal/100 g (Ećimović and Velkovrh, 1992). In more recent studies, authors give slightly different values, in 100 g were 81.8-83.3 g water, 11.0 g protein, 0.4-0.7 g fat, 1.5 g ash, depending on whether it was farmed or wild snail meat (Kougiagka et al., 2022). However, Helix pomatia meat is also extremely rich in elements; Ca content is up to 750 mg/100 g, P, K, Mg and Na content are 104.52, 82.17, 54.05 and 90.50 mg/100 g, respectively, while Fe, Mn and Zn content are less than 2 mg/100 g (Özogul et al., 2005). Thus, snails are rich in proteins and minerals but have low fat content. However, the ratios of n-6/n-3 and saturated/polyunsaturated fatty acids (PUFA/SFA) were in a good range according to Simopoulos (2004), who indicated that a favourable n-6/n-3 ratio should preferably be between 1/1 and 4/1. The ratio of n-6 and n-3 fatty acids was 4.94 in *Helix pomatia* (Özogul et al., 2005), 5.7 in *Cornu aspersa* fed with different vegetable oils (Milinsk et al., 2003), and 7.8, 6.9, and 5.2 in *Helix* species, *Haplotrema sportella*, and *Vespericola columbiana*, respectively (Zue et al., 1994). The PUFA/SFA ratio was found to be 0.68 in *Helix pomatia* (Özogul et al., 2005).

The consumed snails may be contaminated with Salmonella. The microbial population of microorganisms in the intestine is significantly larger than in the meat of snails, so cleaning the digestive tract of snails before harvesting and preparation for human consumption is one of the most important steps to ensure safe food (Parlapani et al., 2013; Murphy, 2001). They are also indicators of environmental contamination by heavy metals (Iwegbue et al., 2008).

Only live snails may be used for processing. Snails can be preserved for a shorter or longer period of time by freezing (previously de-sliming for 45 minutes in water with 7.5 % salt and 10 % vinegar) or canning (Mašić, 2004; Mezquita et al., 2007). In contrast to France, Germany, and Switzerland, where snails are mostly sold canned, in Italy live snails are sold in 80 % of cases. In international cuisine, there are various preparation methods and recipes for snail meat. Snails are used in very different forms as appetizers (Escargots de Bourgogne), soups (cream soup with snails), main dishes (snail caviar, Italian snails, snails with herb butter), in sauces, salads and even desserts (Willan, 1989; Rygało-Galewska, 2022).

In our study, we evaluate for the first time the quality properties of snail meat of different commercial species, farmed in Slovenia. The main objective was to study the physicochemical parameters, namely water, protein, fat, ash, sodium, carbohydrate content and energy value, as well as fatty acid composition and pH value of snail meat. In addition, the culinary usefulness of snail meat was verified. For this purpose, two pâtés were prepared from snail meat and evaluated sensory.

Material and methods

Sampling and preparation of samples for analysis

As mentioned above, the aim of this study was to determine the physicochemical parameters (proximate composition and pH). For this purpose, samples of snail meat were obtained from the company Vegralda d.o.o. (Komenda). Two different types of snail meat, *Cornu aspersum* maxima snail meat (foot) and *Cornu aspersum* Müller snail meat (foot with liver) were taken. Samples were vacuum packed and frozen and brought to the laboratory in a cooler bag, where they were immediately transferred to the freezer. Samples were kept at a temperature of -20 °C until they were analysed or processed into pâté.

Frozen samples of snail meat were homogenized (Grindomix 200, Retch, Germany) before physicochemical analyses. All analyses were performed in parallel in pairs or threes (in the case of protein and fat determination) and expressed as arithmetic mean values. The content of water, fat, protein, ash and Na was expressed as a percentage of the initial mass. After obtaining the results of the basic chemical composition of the snail meat, the carbohydrate content and energy value of the meat were calculated. The conversion factors used to calculate the energy value of food are 17 kJ/g for carbohydrates and proteins and 37 kJ/g for fats.

In the second part of the experiment, pâtés were prepared from snail meat and sensory evaluation was performed the next day after preparation.

Both snail meat samples were used to make the pâtés, resulting in two types of pâtés, although the process was the same for both. The following recipe was used for the production (Demšar and Polak, 2010): snail meat (33.8 %), pork (29.0 %), sunflower oil (16.4 %), water (17.4%), nitrite salt (1.4 %), phosphate mixture (0.5 %), spices (0.5 %), and fried onions (1.0 %). The process for making the pâté was slightly adapted and is briefly described below. Minced meat, oil and water were treated with moist heat to a mass temperature of 80 °C. Hot mass, phosphate mixture (Aroma UK, Prava Aroma, d.o.o.), nitrite salt (mixture of NaCl and additives: salt, preservative (E 250) 0.5 % to 0.6%, Prava Aroma, d.o.o.), and spices (spice mixture for poultry pâté, Droga d.o.o.) were transferred into a preheated (60 °C) Stephan UMC 5 electronic (Stephan Nahrungsmittel und Verfahrenstechnik, Germany) and homogenized for 10 minutes at a speed of 2400 × rpm. Then the container of chopper was cooled with ice and homogenization continued until the temperature of the mass reached 40 °C. The pâté emulsion was filled into glass jars and then heat treated (pasteurized) in a combi oven (Rational FRIMA SCC61, Landsberg am Lech, Germany). The heat treatment of the pâtés was performed for 90 minutes, at a steam temperature of 40 °C for the first 30 minutes, at a steam temperature of 60 °C for the next 30 minutes, and at a steam temperature of 72 °C for the last 30 minutes. After completion of the heat treatment, the pâtés were cooled to refrigerator temperature and stored in the refrigerator at 4 °C until sensory analysis.

Methods

Determination of pH values, proximate composition and sodium content: The pH values were measured in an aqueous extract obtained by filtration of 5 g of homogenized sample in 50 ml of distilled water using a combined glass-gel spear electrode (Type 03, Testo Pty Ltd, Australia). The accuracy of the measurement was 0.01 units. The pH meter was calibrated to pH 4.00 and pH 7.00 with buffer. Water content was determined as the mass loss of 5 g of the homogenized sample dried to constant mass at 105 °C by the AOAC Official Method 950.46 for Moisture in meat (Official Methods of Analysis, 1997). Fat content was extracted from a homogenised sample of 10 g by the AOAC Official Method 991.36. Fat (crude) in Meat and Meat Products (Official Methods of Analysis, 1997), and total lipids were extracted by hot treatment using petroleum ether as solvent. Total nitrogen content was determined by the Kjeldahl method, AOAC Official Method 928.08 Nitrogen in meat (Official Methods of Analysis, 1997), and total nitrogen results were multiplied by 6.25 to determine protein content. Sodium content (Na) was determined using a sodium ion-selective electrode (DX223; Sodium Analyzer AP214, Mettler Toledo GmbH, Zurich, Switzerland).

The fatty acid composition of the samples was determined by in situ transesterification (Park and Goins, 1994) as modified by Polak et al. (2008). Fatty acid methyl esters (FAMEs) were determined by capillary gas chromatography on GC Agilent Technologies 6890 with a flame ionization detector and HP-88 capillary column (100 m × 0.25 mm × 0.20 µm, Agilent Technologies). The separation and detection conditions are published in Lušnic Polak et al. (2017a). Samples were analysed in duplicate. FAMEs were expressed as weight percent of total FA content.

Sensory evaluation: the evaluation of the sensory profile of pâté made from snail meat was carried out by a panel of six experts in the field of meat products was appointed. The evaluation was carried out under defined, precisely prescribed, controlled and reproducible operating conditions. This included: arrangement of laboratory, samples, accessories and organization of assessment (ISO 8589:2007). The samples were taken from the refrigerator and left at room temperature (the temperature of slices during the analysis was about 15 °C). For the sensory evaluation, the

Table 1 Description of the points in the sensory evaluation of pâté

Attribute / Number of scores	Description
External appearance	
2	Characteristic appearance, shape and colour of the product
1.5	If at most one of the defects occurs to a moderate extent: atypical (too light, too dark) colour, uneven colour, inappropriate size
1.0	If two of the listed defects occur to a greater extent: atypical (too light, too dark) colour, uneven colour, inappropriate size
0.5	If the listed defects are unacceptably pronounced: atypical (too light, too dark) colour, uneven colour, inappropriate size, damaged lid/casings
0	Appearance, shape, colour of the products are completely atypical and unacceptable, severely damaged, give the impression of microbiological spoilage
Cross-section composition	
3	Characteristic mosaic
2.5	Minor individual defects in the mosaic
2.0	Single more pronounced defects in the mosaic, pieces of binder, partially dissolved fat
1.5	Two or more pronounced defects in the mosaic
1.0	Very pronounced two or more defects in the mosaic
0.5	A barely acceptable mosaic with three or more pronounced defects
0	A totally unacceptable mosaic with several defects
Cross-section colour	
3	Characteristic and uniform colour of the product
2.5	A minor defect in one of the colour characteristics of the product
2.0	A more pronounced defect (atypicality, ambiguity, non-uniformity) in one of the colour characteristics of the product
1.0 do 1.5	A significant defect in two of the colour characteristics of the product
0 do 0.5	The colour of the product is completely atypical and unacceptable, discoloration
Texture	
4	The texture is moderately firm, typical spreadable products, without hard parts (tendons, bones)
3.5	Slight defect in one of the texture characteristics (slightly non-spreadable, too soft, too firm, dry, juice and/or fat releasing)
3.0	Marked defect in one of the texture characteristics (non-spreadable, too soft, too firm, dry, juice and/or fat releasing), tendon parts
2.0 do 2.5	Pronounced defect in two or more texture characteristics
1.0 do 1.5	Very pronounced defect in two or more texture characteristics
0 do 0.5	One or more unacceptable texture defects (hard, too soft, falling apart, hard and dry, juice and/or fat releasing)
Smell	
3.0	Typical of snail meat, sufficiently/moderately pronounced
2.5	Minor (barely perceptible) defect in one of the olfactory characteristics
2.0	Two or more expressed defects in smell, rancidity
1.0 do 1.5	Very to unacceptably pronounced smell defects (characteristic, distinctness of smell)
0 do 0.5	Putrid smell (sour, putrid, mouldy), foreign smells
Aroma	
5.0	The aroma is characteristic, consistent and adequately pronounced
4.0 do 4.5	Slight to moderately pronounced defects in aroma
3.0 do 3.5	Pronounced defects in the aroma (atypical, inconsistent, too little or too much)
2.0 do 2.5	Strong defects in the aroma (atypical, inconsistent, too little or too much), rancidity, foreign aromas
0.5 do 1.5	Unacceptably pronounced aroma defects (atypical, inconsistent, too little or too much), rancidity and other foreign aromas
0	Unacceptably pronounced aroma defects and/or spoiled taste (sour), strong foreign aromas

Data analysis: Data were analysed using the SPSS statistical programme (version 23.0, SPSS Inc., Chicago, USA) and expressed as mean ± standard deviation (S.D.). The t-test at 0.05 level of significance was used to compare the data of sensory attributes of pâtés from different snail species.

visual attributes of the samples were evaluated on the whole pâté jar, and 2-mm-thick slices of pâtés were prepared for evaluation of other sensory attributes. To neutralise the taste, the panel used the central dough of white bread.

The panellists evaluated the sensory quality of two pâtés according to an abbreviated analytical test with the sum of the values for all evaluated attributes 20 and a deduction system. External appearance, cross-section composition, cross-section colour, texture, smell and aroma were evaluated. A score of 0 represents a very poorly expressed or inappropriate sensory attribute, while the highest scores (3, 4, or 5) represent optimally to perfectly expressed individual sensory attributes. For each defect found in an attribute, a certain number of points is deducted from the maximum score. If a product defect is scored 0 points, the product is eliminated (Demšar and Polak, 2009). All points are then summed up. Samples that score less than 15 points are considered inferior but still acceptable; products that score less than 13 points are unacceptable. A description of the points for each sensory attribute of any kind of pâté can be found in Table 1.

Results and discussion

Basic chemical composition and pH value of snail meat

Table 2 shows that snail meat is rich in protein and contains very little fat. The meat of the snails *Cornu aspersum* Müller, which had a liver as well as a foot, contains more protein, fat, and ash and less water and carbohydrate than the meat of *Cornu aspersum* maxima snails. The basic chemical composition of snail meat from this study is similar to the results of Ećimović and Velkovrh (1992) for the meat of *Cornu aspersum* snails, which in 100 g contains 78.46 g of water, 14.56 g of protein, 0.69 g of fat, 1.42 g of ash, and 3.87 g of carbohydrates. Snail meat contains less protein than beef (loin, 22.4 g/100 g), pork (loin, 21.2 g/100 g), and poultry (boneless and skinless chicken breast, 22.8 g/100 g), less fat than beef (loin, 2.8 g/100 g), pork (loin, 3.5 g/100 g), and poultry (boneless and skinless chicken breast, 1.5 g/100 g). Cornu aspersum maxima snail meat contains less ash and *Cornu aspersum* Müller meat contains more ash than beef (loin, 1.22 g/100 g). The same is true for pork (loin, 1.06 g/100 g) and poultry meat (boneless and skinless chicken breast, 1.19 g/100 g) (Golob et al., 2006). The sodium content in snail meat ranges from 51.32 to 58.21 mg/100 g (Table 2), which is not in agreement with Çağıltay (2011), who found 91.95 mg sodium in 100 g snail meat. The sodium content in snail meat is lower than in pork (61 mg/100 g), higher than in chicken (33.8 mg/100 g), but the content in beef is higher (94 ± 5 mg/100 g; Rodrigues et al., 2016) or equal (58.8 mg/100 g; Golob et al., 2006).

The pH of snail meat (Table 2) is significantly higher than that of meat from slaughtered animals, e.g. the average final pH of beef 24 hours post mortem is less than 5.7 (Young et al., 2004).

The energy values of the two species of snail meat were 339.6 kJ for *Cornu aspersum* maxima and 374.2 kJ for the *Cornu aspersum* Müller (Table 2). Ećimović and Velkovrh (1992) reported the energy value of the meat of *Cornu aspersum* and *Helix pomatia* snails as 346.0 kJ and 305.2 kJ, respectively. For comparison, the energy value of 100 g of the edible part of beef is 483 kJ, of pork 492 kJ, and of chicken 442 kJ (Golob et al., 2006).

Table 2 Basic chemical composition, pH and energy value of snail meat

	Snail meat of	
Parameter	*Cornu aspersum* maxima, foot	*Cornu aspersum* Müller, foot with liver
Protein (g/100 g)	13.12 ± 0.21	16.53 ± 0.23
Fat (g/100 g)	0.89 ± 0.01	1.21 ± 0.08
Water (g/100 g)	80.34 ± 0.28	78.10 ± 0.04
Ash (g/100 g)	0.74 ± 0.06	1.31 ± 0.01
Carbohydrate (g/100 g)	4.92 ± 0.34	2.85 ± 0.26
Na (mg/100 g)	58.21 ± 0.06	51.32 ± 0.06
pH value	8.59 ± 0.01	8.19 ± 0.01
$EV_{100 g}$ (kJ)	343.8	379.2

$EV_{100 g}$ – Energy value.

Table 3 Fatty acid composition (wt. % of total fatty acids) and calculated nutritional quality indicators of snail meat of two species

FA (wt.% of total FA)	Snail meat of *Cornu aspersum* maxima, foot	Snail meat of *Cornu aspersum* Müller, foot with liver	P_s	Average across species
C12:1	0.03 ± 0.04	< 0.01	Ns	0.01 ± 0.03
C14:0	0.14 ± 0.03^{b}	0.26 ± 0.01^{a}	*	0.20 ± 0.07
C15:1t	2.49 ± 0.02	2.11 ± 0.19	Ns	2.30 ± 0.25
C15:1c	0.30 ± 0.02	0.28 ± 0.01	Ns	0.29 ± 0.02
C16:0	5.66 ± 0.05	5.67 ± 0.06	Ns	5.67 ± 0.04
C16:1t	< 0.01b	0.35 ± 0.05^{a}	*	0.17 ± 0.20
iso-C17:0	0.22 ± 0.00^{b}	0.46 ± 0.01^{a}	***	0.34 ± 0.14
C17:0	0.52 ± 0.01	0.61 ± 0.05	Ns	0.57 ± 0.06
C17:1t	1.04 ± 0.05	1.04 ± 0.03	Ns	1.04 ± 0.03
C18:0	10.67 ± 0.02^{a}	9.49 ± 0.13^{b}	*	10.08 ± 0.69
C18:1t-9	0.47 ± 0.04	0.36 ± 0.05	Ns	0.41 ± 0.07
C18:1c-9	11.89 ± 0.06	13.45 ± 0.52	Ns	12.67 ± 0.95
C18:1c-11	< 0.01^{b}	0.49 ± 0.11^{a}	*	0.25 ± 0.29
C19:0	10.80 ± 0.10	9.66 ± 0.54	Ns	10.23 ± 0.73
C18:2n-6	19.98 ± 0.14	21.80 ± 0.68	Ns	20.89 ± 1.12
C18:3n-3	1.24 ± 0.01^{b}	1.83 ± 0.06^{a}	**	1.53 ± 0.34
C20:1n-9	1.39 ± 0.15	1.15 ± 0.02	Ns	1.27 ± 0.17
C20:1n-12	0.69 ± 0.11	0.46 ± 0.06	Ns	0.58 ± 0.15
C20:2n-6	9.37 ± 0.23	8.87 ± 0.01	Ns	9.12 ± 0.32
C20:3n-6	1.06 ± 0.10	1.41 ± 0.29	Ns	1.23 ± 0.27
C20:4n-6	13.54 ± 1.14	12.99 ± 0.07	Ns	13.27 ± 0.73
C22:2n-6	2.25 ± 0.04^{a}	1.25 ± 0.13^{b}	**	1.75 ± 0.59
C22:3n-6	1.31 ± 0.07^{b}	1.59 ± 0.01^{a}	*	1.45 ± 0.16
C22:4n-6	3.94 ± 0.11	3.36 ± 0.31	Ns	3.65 ± 0.39
C22:5n-3	1.00 ± 0.01	1.08 ± 0.24	Ns	1.04 ± 0.14
SFA	28.01 ± 0.14^{a}	26.15 ± 0.41^{b}	*	27.08 ± 1.11
MUFA	18.30 ± 0.40	19.69 ± 0.49	Ns	19.00 ± 0.88
PUFA	53.69 ± 0.55	54.16 ± 0.07	Ns	53.92 ± 0.42
PUFA/SFA	1.92 ± 0,03^{b}	2.07 ± 0,03^{a}	*	1.99 ± 0,09
n-3	2.24 ± 0.01^{b}	2.90 ± 0.18^{a}	*	2.57 ± 0.40
n-6	51.45 ± 0.54	51.26 ± 0.11	Ns	51.35 ± 0.34
n-6/n-3	22.98 ± 0.16^{a}	17.69 ± 1.14^{b}	*	20.33 ± 3.12
trans FA	4.00 ± 0.03	3.85 ± 0.17	Ns	3.93 ± 0.13

*FA – fatty acid, SFA – saturated fatty acid, MUFA – monounsaturated fatty acid, PUFA – polyunsaturated fatty acid. PS, statistical probability of species effect. *** P ≤0.001 statistically very highly significant; ** P ≤0.01 statistically highly significant; * P ≤0.05 statistically significant; Ns – P >0.05 statistically not significant. Data with different superscript letters within a row differ significantly (P <0.05, a-b differences between species).*

A total of 42 fatty acids (> 0.01 wt. % FA) were detected in snail meat; 25 of them are listed in Table 3. The major FA was linoleic fatty acid (C18:2n-6, 20.89 wt. % FA), followed by arachidonic acid (C20:4n-6; 13.27 wt. % FA), oleic acid (C18:1c-9; 12.67 wt. % FA), nonadecanoic acid (C19:0; 10.23 wt. % FA), and stearic acid (C18:0; 10.08 wt. % FA). In proportions below 10 wt. % FA were eicosadienoic acid (C20:2n-6; 9.12 wt. % FA), palmitic acid (C16:0; 5.67 wt. % FA), docosatetraenoic acid (C22:4n-6; 3.65 wt. % FA), and all others were below 5 wt. % FA.

On average, in 100 g of total fatty acids, snail meat contains 53.92 ± 0.42 g of polyunsaturated fatty acids (PUFA), 27.08 ± 1.11 g of SFA, and 19.00 ± 0.88 g of monounsaturated fatty acids (MUFA). From the above composition, there is also a very high PUFA/SFA ratio, namely 2.0 ± 0.09. The results of this study do not fully agree with those of Çağıltay et al. (2011), who found more MUFA (20.66 wt. %), less PUFA (34.38 wt. %), a lower PUFA/SFA ratio (1.20), more n-3 FA (7.92 wt. %) and less n-6 FA (29.65 wt. %).

Lušnic Polak et al. (2017b) determined a PUFA/SFA ratio of 0.5 for horse meat, Golob et al. (2006) reported 0.31 and 0.36 for *longissimus dorsi* and *biceps femoris* muscles in pig, and 0.25 for *triceps brachii* muscle in cattle. Meat with a ratio higher than 0.5 is nutritionally more favourable (Enser et al., 2001), which means that snail meat can be classified as a meat with a very favourable PUFA/SFA ratio (Çağıltay, 2011; Rygało-Galewska et al., 2022).

The ratio between n-6 and n-3 fatty acids is significantly higher than the recommended limit (20:1; recommendation n-6/n-3 = 5:1); other researchers have determined lower ratios for the meat of *Cornu aspersum* aspersum, *Cornu aspersum* maxima and *Helix pomatia* snails, namely 6.33, 7.79, and 5.87, respectively (Milinsk, 2003; Milinsk et al., 2006; Çağıltay, 2011; Rygało-Galewska et al., 2022). The ratio is also much higher than the values reported by Golob et al. (2006) for the *longissimus dorsi* and *biceps femoris* muscles in pig (13.7 and 12.4, respectively) and *triceps brachii* muscle in cattle (2.9), and by Lušnic Polak et al. (2017b) for horse meat (3.6).

The requirements for dietary fat intake are as follows: Total fat intake should be less than 30 % of daily energy intake, with SFA less than 10 % (even less than 7 %), MUFA more than 10 % of daily energy intake, and *trans* FA less than 1 % (Referenčne vrednosti..., 2003). There is scientific evidence that the intake of trans FA is associated with cardiovascular diseases in different ways (Monguchi et al., 2017). Therefore, the recommendation for the intake of trans FA in the human body is limited to 1 % of energy (EFSA, 2010). Table 3 shows that the content of trans FA in snail meat is relatively high (3.93 % ± 0.13 %), but due to of the very low fat content of snail meat, it probably does not pose a real risk to consumer health.

The meat of *Cornu aspersa* maxima snails and the meat with liver of *Cornu aspersa* Müller snails differ in fatty acid profile by SFA and n-3 content and consequently by two nutritional fat indices, PUFA/SFA and n-6/n-3 ratio. From a nutritional point of view, the meat of *Cornu aspersa* Müller snails with liver is more favourable (Table 3).

Sensory properties

Table 4 shows the results of the evaluation of the sensory properties of pâtés prepared from the meat of snails of two different species (in the case of *Cornu aspersum* Müller snails, we used the whole foot with the liver). In terms of appearance, colour and texture, the panellists could not detect any significant differences between the pâtés. In terms of taste and smell, they estimated that the pâtés were significantly different from each other. *Cornu aspersum* maxima snail meat pâté (value 17.2) was rated significantly better than *Cornu aspersum* Müller snail meat pâté (value 15.8). *Cornu aspersum* maxima snail meat pâté was described by panellists as slightly unstable, with a distinct greyish colour, a strong sandy texture, and a burning sensation in the mouth, with no snail meat aroma, only spices. *Cornu aspersum* Müller snail meat pâté was described as slightly unstable and porous, with a crumbly texture and an unpleasant

Table 4 Sensory attributes of pâtés made from snail meat from different species

	Pâtés from snail meat from different species		
Attribute (value)	*Cornu aspersum* maxima, foot	*Cornu aspersum* Müller, foot with liver	P_S
External appearance (0-2)	1.8 ± 0.3	1.8 ± 0.3	*Ns*
Cross-section composition (0-3)	2.5 ± <0.1	2.5 ± <0.1	-
Cross-section colour (0-3)	2.8 ± 0.3	2.6 ± 0.2	*Ns*
Texture (0-4)	3.3 ± 0.3	3.1 ± 0.2	*Ns*
Smell (0-3)	2.6 ± 0.2^a	2.2 ± 0.3^b	***
Aroma (0-5)	4.3 ± 0.3^a	3.7 ± 0.4^b	***
Total score (0-20)	17.2 ± 0.9^a	15.8 ± 0.8^b	***

*PS, statistical probability of species effect. *** P ≤0.001 statistically very highly significant; ** P ≤0.01 statistically highly significant; * P ≤0.05 statistically significant; Ns – P >0.05 statistically not significant. Data with different superscript letters within a row differ significantly (P <0.05, a-b differences between species).*

aroma dominated by a soapy aftertaste, a sweet and spicy component, characterized by a lack of snail meat aroma.

Conclusion

Due to its favourable nutritional value and its potential in gastronomy, the importance of snail meat in Slovenia will certainly increase in the future, as it is already the case in other parts of the world. The number of snail breeders is increasing, so this type of meat will probably soon be found on our shelves and plates, and most importantly, consumers will be aware that they are eating one of the more nutritious meats. The study presents the content of various nutrients and especially one less studied nutrient in snail meat, namely fat and its fatty acid profile. Further and more in-depth studies on the above nutrients for the development of molluscs in closed farms, for the evaluation of health security, as well as nutritional and technological properties of snail meat are needed. At a time when the world population is growing and demand for new sources of protein increasing, the production of pâtés from edible land snails represents a remarkable culinary experiment, considering that the smell and aroma of snail meat are not exactly first class.

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References

[1] **Çağıltay, F., N. Erkan, D. Tosun, A. Selçuk (2011):** Amino acid, fatty acid, vitamin and mineral contents of the edible garden snail (Cornu aspersum). J fish sci 5 (4), 354-363, DOI: 10.3153/jfscom.2011040.
[2] **Demšar L., T. Polak (2009):** Tehnologije predelave animalnih živil: vaje za predmet Tehnologije predelave animalnih živil za študente prve stopnje Živilstva in prehrane: 1. del Meso (Animal food processing technologies: exercises for the course named Animal food processing technologies for students of the first level of Food and Nutrition: Part 1 Meat). Ljubljana, Biotehniška fakulteta, Oddelek za Živilstvo, pp. 36-37
[3] **Ećimović, T., B. Velkovrh (1992):** Polž in polžereja (snail and snail farming). Ljubljana, ČZP Kmečki glas, 1992.
[4] **EFSA (2010):** Scientific opinion on dietary reference values for fats, including saturated fatty acids, polyunsaturated fatty acids, monounsaturated fatty acids, trans fatty acids, and cholesterol EFSA J 8 (3), 1461. DOI: 10.2903/j.efsa.2010.1461.
[5] **Enser, M., N. Scollan, S. Gulati, I. Richardson, G. Nute, J. Wood (2001):** The effects of ruminally-protected dietary lipid on the lipid composition and quality of beef muscle. Proceedings of the 47th International Congress of Meat Science and Technology, Kraków, Poland, 26-31.6.2001, pp. 186-187.
[6] **Fernández-López de Pablo, J., E. Badal, C. Ferrer García, A. Martínez-Ortí, A. Sanchis Serra (2014):** Land snails as a diet diversification proxy during the early upper palaeolithic in Europe. PLoS ONE 9, 8: e104898. DOI: 10.1371/journal.pone.0104898.
[7] **Golob T., V. Stibilj, B. Žlender, U. Doberšek, M. Jamnik, T. Polak, J. Salobir, M. Čandek-Potokar (2006):** Slovenske prehranske tabele - meso in mesni izdelki (Slovenian nutritional tables - meat and meat products). Golob T., U. Doberšek, M. Jamnik, B. Koroušić-Seljak, J. Bertoncelj (Eds.). Ljubljana, Biotehniška fakulteta, Oddelek za Živilstvo 127 pp.
[8] **ISO 8589:2007 (2007):** Sensory analysis – General guidance for the design of test rooms: Geneva, International Organization for Standardization: 16 pp.
[9] **Iwegbue C.M.A., F.O. Arimoro, G.E. Nwajei, O. Eguavoen (2008):** Heavy metal content in the african giant snail Archachatina Marginata (Swainson, 1821) (Gastropoda: Pulmonata: Achatinidae) in southern Nigeria. Folia Malacologica 16 (1), 31-34. DOI: 10.12657/folmal.016.005.
[10] **Kougiagka, E., C. Apostologamvrou, P. Giannouli, M. Hatziioannou (2022):** Quality factors of commercial snail fillets as affected by species. Food Sci Biotechnol 60 (3), 330-337. DOI: 10.17113/ftb.60.03.22.7403.
[11] **Lušnic Polak, M., L. Demšar, U. Luzar, T. Polak (2017a):** Can long chain n-3 fatty acids from feed be converted into very long chain n-3 fatty acids in fillets from farmed rainbow trout (Oncorhynchus mykiss)? IOP Conf Ser: Earth Environ Sci 85, 012008. DOI: 10.1088/1755-1315/85/1/012008.
[12] **Lušnic Polak M., U. Mervič, L. Demšar (2017b):** Nutritional value of horse meat and products on the Slovenian market. Meso 19 (1), 38-47, 73-81. DOI: 10.31727/m.19.1.1.
[13] **Mašić, M. (2004):** Meso puža u ljudskoj prehrani. Meso VI (3), 53-57.
[14] **Mezquita, P.C., P.E. Madariaga, Y.M. Segovia (2007):** A practical approach to preparation and meat preservation by refrigeration or freezing of the land snail (Helix aspersa Müller). J Muscle Foods 20 (4), 401-419. DOI: 10.1111/j.1745-4573.2009.00156.x
[15] **Milinsk, M.C., R. das Graças Padre, C. Hayashi, C.C. de Oliveira, J.V. Visentainer, N.E. de Souza, M. Matsushita (2006):** Effects of feed protein and lipid contents on fatty acid profile of snail (Helix aspersa maxima) meat. J Food Compos Anal 19 (2-3), 212-216. DOI: 10.1016/j.jfca.2004.09.011.
[16] **Milinsk, M.C., R. das Graças Padre, C. Hayashi, N.E. de Souza, M. Matsushita (2003):** Influence of diets enriched with different vegetable oils on the fatty acid profiles of snail Helix aspersa maxima. Food Chem 82 (4), 553-558. DOI: https://doi.org/10.1016/S0308-8146(03)00010-4.
[17] **Miracle P., N. Galanidou, S. Forenbaher (2000):** Pioneers in the hills: early Mesolithic foragers at Šebrn Abri (Istria, Croatia). Euro-

pean Journal of Archaeology 3 (3), 293-329. DOI: 10.1177/146195710000300.
[18] **Monguchi, T., T. Hara, M. Hasokawa, H. Nakajima, K. Mori, R. Toh, Y. Irino, T. Ishida T, K.-I. Hirata, M. Shinohara (2017):** Excessive intake of trans fatty acid accelerates atherosclerosis through promoting inflammation and oxidative stress in a mouse model of hyperlipidemia. J Cardiol 70 (2), 121-127. DOI: 10.1016/j.jjcc.2016.12.012.
[19] **Murphy, B. (2001):** Breeding and growing snails commercially in Australia. Barton, Rural Industries Research and Development Corporation: 39 pp.
[20] **Official Methods of Analysis (1997):** (16th ed.). Washington, DC: Association of Official Analytical Chemists.
[21] **Özogul, Y., F. Özogul, A.I. Olgunoglu (2005):** Fatty acid profile and mineral content of the wild snail (Helix pomatia) from the region of the south of the Turkey. Eur Food Res Technol 221, 547-549. DOI: 10.1007/s00217-005-1191-7.
[22] **Park P.W., R.E. Goins (1994):** In situ preparation of fatty acid methyl esters for analysis of fatty acid composition in foods. J. Food Sc 59 (6), 1262-1266. DOI: 10.1111/j.1365-2621. 1994.tb14691. x.
[23] **Parlapani, F.F., C. Neofitou, J.S. Boziaris (2013):** Microbiological quality of raw and processed wild and cultured edible snails. J Sci Food Agric 94, 768-772. DOI: 10.1002/jsfa.6438.
[24] **Polak T., A. Rajar, L. Demšar, B. Žlender (2008):** Cholesterol concentration and fatty acid profile of red deer (Cervus elaphus) meat. Meat Sci 80 (3), 864-869. DOI: 10.1016/j.meatsci.2008.04.005.
[25] **Referenčne vrednosti za vnos hranil (Reference values for nutrient intake) (2003):** 1st ed. Ljubljana, Ministry of Health of the Republic of Slovenia, pp. 27-30
[26] **Rodrigues, I., M.A. Trindade, F.R. Caramit, K. Candoğan, P.R. Pokhrel, G.V. Barbosa-Cánovas (2016):** Effect of high-pressure processing on physicochemical and microbiological properties of marinated beef with reduced sodium content. Innov Food Sci Emerg Technol 38(B), 328-333. DOI: 10.1016/j.ifset.2016.09.020.
[27] **Rygało-Galewska, A., K. Zglińska, T. Niemiec (2022):** Edible Snail Production in Europe. Animals 12 (20), 2732. DOI: 10.3390/ani12202732.
[28] **Simopoulos, A.P. (2004):** Omega-6/omega-3 essential fatty acid ratio and chronic diseases. Food Rev Int 20 (1), 77-90. DOI: 10.1081/FRI-120028831.
[29] **Willan, A. (1989):** Complete guide to cookery. 1st ed. London, Dorling Kindersley Limited: 165-165 pp.
[30] **Young, O.A., R.D. Thomson, V.G. Merhtens, M.P.F. Loeffen (2004):** Industrial application to cattle of a method for the early determination of meat ultimate pH. Meat Sci 67 (1), 107-112. DOI: 10.1016/j.meatsci.2003.09.014.
[31] **Zhu, N., X. Dai, D.S. Lin, W.E. Connor (1994):** The lipids of slugs and snails: Evolution, diet and biosynthesis. Lipids 29, 869-875. DOI: 10.1007/BF02536255.

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Meso puževa, novotkriveni stari izvor proteina u ljudskoj prehrani

Sažetak

Cilj ovog rada bio je odrediti fizikalno-kemijske parametre, tj. udio vode, bjelančevina, masti, pepela, natrija i ugljikohidrata te energetsku vrijednost, kao i sastav masnih kiselina i pH mesa puževa dviju vrsta, *Cornu aspersum maximum* i *Cornu aspersum Müller*. Utvrđeno je da meso puža ima relativno visok udio proteina (13,12 g/100 g u odnosu na 16,53 g/100 g), nizak udio masti (0,89 g/100 g u odnosu na 1,21 g/100 g) i nisku energetsku vrijednost (343,8 kJ u odnosu na 379,2 kJ). pH mesa puževa bio je vrlo visok (8,59 naspram 8,19). Meso puževa u prosjeku ima povoljan sastav masnih kiselina jer sadrži 27,08 mas. % zasićenih (SFA), 19,00 % mononezasićenih i 53,92 % polinezasićenih masnih kiselina (PUFA). Ima povoljan omjer PUFA/SFA (1,99), ali nepovoljan omjer n-6/n-3 (20,33) i relativno visok udio transmasnih kiselina (3,93 %). Profilom masnih kiselina u mesu puževa dominiraju linolna kiselina (20,89 %), arahidonska kiselina (13,27 %), oleinska kiselina (12,67 %), nonadekanska kiselina (10,23 %) i stearinska kiselina (10,08 %). Cilj našeg istraživanja također je bio provjeriti kulinarsku vrijednost mesa puževa. U tu svrhu pripremljene su dvije paštete od puževog mesa prihvatljive senzorske kvalitete. Panel je značajno lošije ocijenio senzorsku kvalitetu paštete od mesa (stopala i jetra) puža *Cornu aspersum Müller* od paštete od mesa puža *Cornu aspersum maximum*, uglavnom zbog neugodne arome, u kojoj se prevladavaju sapunaste, slatke i ljute komponente, kao i odsustvo arome puževog mesa.

Ključne riječi: puževi, meso puževa, fizikalno-kemijski parametri, protein, sastav masnih kiselina, senzorna svojstva

Schneckenfleisch, eine neu entdeckte alte Eiweissquelle für die Menschliche Ernährung

Zusammenfassung

Ziel dieser Studie war es, die physikalisch-chemischen Parameter, d. h. den Wasser-, Protein-, Fett-, Asche-, Natrium- und Kohlenhydratgehalt und den Energiewert, sowie die Fettsäurezusammensetzung und den pH-Wert von Schneckenfleisch zweier Arten, Cornu aspersum maximum und Cornu aspersum Müller, zu bestimmen. Das Schneckenfleisch wies einen relativ hohen Proteingehalt (13,12 g/100 g gegenüber 16,53 g/100 g), einen niedrigen Fettgehalt (0,89 g/100 g gegenüber 1,21 g/100 g) und einen niedrigen Energiewert (343,8 kJ gegenüber 379,2 kJ) auf. Der pH-Wert von Schneckenfleisch war sehr hoch (8,59 vs. 8,19). Im Durchschnitt hat Schneckenfleisch eine günstige Fettsäurezusammensetzung, da es 27,08 Gew.-% gesättigte (SFA), 19,00 Gew.-% einfach ungesättigte und 53,92 Gew.-% mehrfach ungesättigte Fettsäuren (PUFA) enthält. Es hat ein günstiges PUFA/SFA-Verhältnis (1,99), aber ein ungünstiges n-6/n-3-Verhältnis (20,33) und einen relativ hohen Anteil an trans-Fettsäuren (3,93 Gew.-%). Das Fettsäureprofil von Schneckenfleisch wird dominiert von Linolsäure (20,89 Gew.-%), Arachidonsäure (13,27 Gew.-%), Ölsäure (12,67 Gew.-%), Nonadecansäure (10,23 Gew.-%) und Stearinsäure (10,08 Gew.-%). Das Ziel unserer Studie war es auch, den kulinarischen Wert von Schneckenfleisch zu überprüfen. Zu diesem Zweck wurden zwei Schneckenfleischpasteten von akzeptabler sensorischer Qualität zubereitet. Die Jury bewertete die sensorische Qualität der Pastete aus dem Fleisch (Fuß und Leber) der Schnecke Cornu aspersum Müller deutlich schlechter als die Pastete aus dem Fleisch der Schnecke Cornu aspersum maximum, was vor allem auf das unangenehme Aroma zurückzuführen war, bei dem die seifigen, süßen und würzigen Komponenten überwogen, sowie auf das Fehlen des Schneckenfleischaromas.

Schlüsselwörter: Schnecken; Schneckenfleisch; physikochemische Parameter; Protein; Fettsäurezusammensetzung; sensorische Eigenschaften

Carne de caracol, una vieja fuente de proteína recientemente descubierta en la dieta humana

Resumen

El objetivo de este trabajo fue determinar los parámetros físico-químicos, es decir, la proporción de agua, proteínas, grasas, cenizas, sodio y carbohidratos, así como el valor energético, la composición de ácidos grasos y el pH de la carne de caracoles de dos especies, Cornu aspersum maximum y Cornu aspersum Müller. Se encontró que la carne de caracol tiene un contenido de proteína relativamente alto (13,12 g/100 g frente a 16,53g / 100g), bajo contenido de grasa (0,89g / 100g frente a 1,21g /100g) y bajo valor energético (343,8g / 100g kJ frente a 379,2 kJ). El pH de la carne de caracol era muy alto (8,59 frente a 8,19). En promedio, la carne de caracol tiene una composición de ácidos grasos favorable, ya que contiene 27,08% en peso de saturados (SFA), 19,00% monoinsaturados y 53,92% de ácidos grasos poliinsaturados (PUFA). Tiene una relación PUFA/SFA favorable (1,99), pero una relación n-6/n-3 desfavorable (20,33) y una proporción relativamente alta de ácidos grasos trans (3,93% en peso). El perfil de ácidos grasos en la carne de caracol está dominado por ácido linoleico (20,89 %), ácido araquidónico (13,27 %), ácido oleico (12,67 %), ácido nonadecanoico (10,23 %) y ácido esteárico (10,08 %). El objetivo de nuestra investigación también fue comprobar el valor culinario de la carne de caracol. Para ello fueron preparados dos patés de carne de caracol de aceptable calidad sensorial. El panel calificó la calidad sensorial del paté de carne de caracol Cornu aspersum Müller (patas e hígado) significativamente peor que la carne de paté Cornu aspersum maximum, principalmente debido al aroma desagradable, en el que predominan los componentes jabonosos, dulces y picantes, así como la ausencia de aroma a carne de caracol.

Palabras claves: caracoles, carne de caracol, parámetros fisicoquímicos, proteína,

La carne di chiocciola, un'antica fonte di proteine nella dieta umana

Riassunto

Questo studio aveva lo scopo di determinare i parametri fisico-chimici, cioè il contenuto di acqua, proteine, grassi, ceneri, sodio e carboidrati, nonché il valore energetico, la composizione degli acidi grassi e il pH della carne di chiocciola (impropriamente chiamata lumaca di terra) di due specie, Cornu aspersum maximum e Cornu aspersum Müller. È stato riscontrato che la carne di chiocciola ha un contenuto proteico relativamente elevato (13,12 g/100 g contro 16,53 g/100 g), un basso contenuto di grassi (0,89 g/100 g contro 1,21 g/100 g) e un basso valore energetico (343,8 kJ rispetto a 379,2 kJ). Il pH della carne di chiocciola è risultato molto alto (8,59 contro 8,19). In media, la carne di chiocciola ha una composizione favorevole di acidi grassi, poiché contiene il 27,08 % di acidi grassi saturi (SFA), il 19,00 % di acidi grassi monoinsaturi e il 53,92 % di acidi grassi polinsaturi (PUFA). Ha un rapporto PUFA/SFA favorevole (1,99), ma un rapporto n-6/n-3 sfavorevole (20,33) e una percentuale relativamente alta di acidi grassi trans (3,93%). Il profilo degli acidi grassi nella carne di chiocciola è dominato dall'acido linoleico (20,89%), seguito dall'acido arachidonico (13,27%), dall'acido oleico (12,67%), dall'acido nonadecilico o nonadecanoico (10,23%) e dall'acido stearico (10,08%). L'obiettivo della nostra ricerca era anche quello di verificare il valore culinario della carne di chiocciola. A tale scopo sono stati preparati due pâté di carne di chiocciola di qualità sensoriale accettabile. Il panel ha valutato la qualità sensoriale del pâté di carne di chiocciola Cornu aspersum Müller (zampe e fegato) significativamente peggiore rispetto al pâté di carne Cornu aspersum maximum, principalmente a causa dell'aroma sgradevole, in cui predominano le componenti saponose, dolci e piccanti, nonché per l'assenza dell'aroma della carne di chiocciola.

Parole chiave: chiocciole, carne di chiocciola, parametri fisico-chimici, proteine, composizione degli acidi grassi, proprietà sensoriali