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RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

AMINO ACID, FATTY ACID, VITAMIN AND MINERAL CONTENTS OF THE EDIBLE GARDEN SNAIL (*Helix aspersa*)

Ferhat Çağıltay[*1], Nuray Erkan[2], Deniz Tosun[1], Arif Selçuk[3]

[1]Istanbul University, Faculty of Fisheries, Department of Aquaculture, Laleli/Istanbul -Turkey

[2]Istanbul University, Faculty of Fisheries, Department of the Seafood Processing and Quality Control, Laleli/ Istanbul -Turkey

[3]TÜBİTAK Marmara Research Center, Food Institute, Gebze/ Kocaeli-Turkey

Abstract: The nutritive and market value of meat of edible garden snail from northern Turkey was determined. Protein, fat, ash, water and carbohydrate value of edible garden snail were found 9.87, 0.58, 1.07, 82.50 and 5.99 % wet weight, respectively. The results of this study have showed that garden snails are good sources of amino acid, fatty acid, vitamins and minerals. The lysine, isoleucine and leucine content from essential amino acids were 721, 467.57 and 611.50 mg/100g, respectively. The major amino acids detected were aspartic acid (996.814 mg/100g), glutamic acid (1405.158 mg/100g), alanine (1063.877 mg/100g), serine (1039.248 mg/100g). Total saturated fatty acid, monounsaturated fatty acid and polyunsaturated fatty acid were determined 28, 76, 20.66 and 34.38 %. The vitamin A, vitamin E, vitamin B_1, B_2, B_3 and B_6 of vitamins were 5.462, 0.887, 0.154, 0.065, 3.226 and 0.288 mg/100g wet wt, respectively. Mineral analysis of garden snails showed that they are rich in calcium and potassium (1357 and 1054 mg/kg) and low in iron (5.21 mg/kg).

Keywords: Edible garden snail, *Helix aspersa*, Chemical composition

[*] **Correspondence to:** **Ferhat ÇAĞILTAY**, Istanbul University, Faculty of Fisheries, Department of Aquaculture, Ordu cad. No:200 34470 Laleli/ Istanbul-TÜRKİYE

Tel: (+90 212) 455 57 00-16449 **Fax:** (+90 212) 514 03 79

E-mail: ferfez@istanbul.edu.tr

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Özet: **BAHÇE SALYANGOZUNUN (Helix aspersa) AMİNO ASİT, YAĞ ASİTİ, VİTAMİN VE MİNERAL İÇERİKLERİ**

Türkiye' nin kuzeyinde dağılım gösteren bahçe salyangozu etinin besinsel ve pazar değeri belirlendi. Protein, yağ, kül nem ve karbonhidrat değerleri sırasıyla % 9.87, 0.58, 1.07, 82.50 ve 5.99 olarak bulundu. Bu çalışmadaki sonuçlar göstermiştir ki bahçe salyangozları iyi bir amino asit, yağ asiti, vitamin ve mineral kaynaklarındandır. Esansiyel amino asitlerinden lisin, izolösin ve lösin içeriği sırasıyla 721, 467.57 ve 611.50 mg/100 g' dır. Belirlenen en büyük amino asitleri aspartik asit (996.814 mg/100g), glutamik asit (1405.158 mg/100g), alanin (1063,877 mg/100g), serin (1039.248 mg/100g) dir. Toplam doymuş yağ asitleri, teklidoymuş yağ asitleri ve çoklu doymuş yağ asitleri %28, %76, %20.66 ve %34.38 olarak belirlendi. Vitaminlerden A, E, B1, B2, B3 ve B6 miktarları 5.462, 0.887, 0.154, 0.065 ve 0.288 mg/100 g.' dı. Bahçe salyangozlarının mineral analizleri göstermiştir ki bu canlılar kalsiyum ve potasyum açısından zengin (1357 ve 1054 mg/kg) demir bakımından düşük (5.21 mg/kg) içeriklere sahiptir.

Anahtar Kelimeler: Bahçe salyongozu, *Helix aspersa*, Kimyasal kompozisyon

Introduction

Snails are members of Mollusca phylum, like slugs, oysters, squids and cuttlefish. They live widely spreader across fresh water, seas and land. Land based species prefer moist areas. They can be seen commonly through spring and autumn where rain fall is abundant (Thompson & Cheney, 2008; Robert, 2009). Human beings have eaten snails for thousands of years and nowadays snails are a common food consumed by millions of people worldwide (Jess & Marks, 1995). The market for snails and their products is of great interest in many countries of Europe and America because of their palatability. This mainly herbivorous species has high economic value and is considered to be luxury food. Snails are mainly consumed in France and Italy as well as in Spain, Germany and United Kingdom. For instance, in France, the annual requirement is about five million kilogrammes (kg) and over 60 percent of that is imported. The estimated annual consumption in Italy is 306 million snails. This is an indication that it has potential for export. Snail meat is a delicacy in Asian cuisines, Japanese and Chinese. In the United States and Australia it is consumed as main meal. In Africa, such as Nigeria and South Africa, land snail called giant African snail is also a traditional food (Lubell, 2003; Avagnina, 2006). Snails are handpicked by the collectors and traded as deep frozen or canned in garlic, butter/spice sauce. The most preferred and consumed species of snails is *Helix aspersa* (garden snail) which is found widely in west Europe and north Mediterranean (Bonnet *et al.* 1990; Lubell, 2003; Avagnina, 2006). *Helix pomatia* (Roman or edible snail) is another snail species which is consumed and can be found in mid and southeast Europe. *Archatina fulica* and *Archachatina marginata* are land based species which can commonly be found in Africa (Bonnet *et al.* 1990; Lubell, 2003; Avagnina, 2006; Thompson & Cheney 2008; Susanna, 2010). Snail is reared in commercial farms for its meat and shell. *Helix aspersa*, has been the principal subject of studies related to snail culture methods.

Generally, mollusc meat is considered to be highly nutritious, owing to its content of essential amino acids, proteins, rich vitamins and minerals (Thanonkaew *et al.*, 2006). Studies on the nutritional value of snail have reported that snail is high in protein quality but low in fat contents hence an alternative food for people with high protein quality low fat diet requirements. Although the nutritional composition of a variety of foods has been known for many years, relatively little information has been collected on the nutritional composition of edible snail.

The aim of this study was to evaluate the nutritional properties of garden snails (*Helix aspersa*) handpicked along the Anatolia coast of Istanbul, Turkey. Knowledge of their nutritional properties would help individuate elements useful to their valorisation and promotion on the market.

Materials and Methods

Samples

Three hundred garden snails (*Helix aspersa*) were collected by hand from the region Asian of Istanbul (Figure 1.), Turkey. Collected snails were kept in 70-80˚C water for 30 seconds. The meat was removed from the shell using hooks. After meat colour measurement, specimens were homogenized. Average weights of three hundred snails were 13.44 ± 1.12 g with shell and 12.59 ±1.32 g without shells.

Chemical Analysis

Moisture content was determined by drying an accurately weighed sample of minced samples in an oven at 105 ±2ºC for 3 h (Mattissek *et al.*, 1992). The ash content was obtained by heating the residue for 3 hours at 550ºC (AOAC, 1998a). Fat was extracted according to the acid hydrolysis method described by Weilmeier & Regenstein (2004). The total nitrogen content was determined by the Kjeldahl method and was converted to crude protein content by multiplying by 6.25 (AOAC 1998b). Amino acid analysis was determined using high performance liquid chromatography (HPLC) (Shimadzu, Kyoto, Japan) (Erkan *et al.*, 2010). The IUPAC II D19 method (1980) was used to determine fatty acid composition by Thermo Trace gas chromatography (GC) with auto sampler (Thermo, Milan, Italy) equipped with a flame ionization detector. Vitamin A and E were determined by AOAC (2005a & 2005b) method. Vitamin B_1 and B_2 were determined by acid hydrolysis method of Finglas & Faulks (1984), B_3 and B_6 content of samples were determined by the Ackurt *et al*. (1999) method. Determination of minerals was performed with a Thermo electron X7 inductively coupled plasma mass spectrometry (ICP-MS), model X series; Winsford-Cheshire UK (EPA, 1994). All chemicals used were of analytical grade.

Colour Measurement

The colour of the garden snail samples was determined with the help of a Konica Minolta chromo meter (model CR 400/410; Minolta, Osaka, Japan). L* (brightness), a* (+ a, red; – a, green) and b* (+ b, yellow; – b, blue) values were measured. The colorimeter was calibrated using white references (CR-A44) (Gerdes & Santos Valdez, 1991).

Results and Discussion

The proximate compositions of garden snails are represented in Table 1. According to the results of our study, garden snail consists of 80.50 ± 0.23 % water, 12.87 ± 0.13 % protein, 0.58 ± 0.03 % fat, 1.07 ± 0.05 % ash and 5.99 ± 0.28 % carbohydrate. Özoğul *et al.* (2005) reported these values for wild snail (*Helix pomatia*) from the south region of Turkey as 80.80% moisture, 16.35 % protein, 0.41 % fat and 1.89 % ash. In another study, for snail meat 10.22 % protein, 27.91 % fat and 2.57 % ash were reported (Olgunoğlu & Olgunoğlu 2009). Milinsk *et al.* (2006) reported that *Helix aspersa maxima's* nutritional composition might change with its feeding habits (moisture, 77.47-79.85 %, protein, 9.50-12.56 %; fat, 0.45-2.66 % and ash, 0.65-0.92 %). Özden & Erkan (2011) reports 66.78 % moisture, 21.08 % protein, 1.96 % ash, 2.54 % fat and 8.64 % carbohydrate for sea snail. It has been noted in many studies that nutritional composition may change between species. Factors like collection method and location, season and sexual condition are important factors for the nutritional compositions (Ludorff & Meyer, 1973).

Figure 1. Garden snail (*Helix aspersa*) collected region in Istanbul

Table 1. Proximate composition of garden snail (*Helix aspersa*) (± st.dev.)

Water (%)	82.50±0.23
Protein (%)	12.87±0.13
Fat (%)	0.58±0.03
Ash (%)	1.07±0.05
Carbohydrate (%)	4.99±0.28

Comparative amino acid composition of garden snail *Helix aspersa* used in our study is given in Table 2. Lysine, leucine and valine constituted the highest essential amino acid (EAA) concentration in garden snail (*Helix aspersa*) and land snail (*Helix lucorum*) (Olgunoğlu & Olgunoğlu, 2008), while phenylalanine had the highest concentration of EAA in sea snail (Özden & Erkan 2011). Glutamic acid, alanine and aspartic acid are the major non-essential amino acids in *Helix aspersa*. These amino acids responsible for product-specific taste (Özden, 2005). These data are parallel to the data reported by Adeyeye & Afolabi (2004) on land snails. Table 2 shows that aspartic acid, glutamic acid and glycine had the lowest value of 996.81 mg/100g, 1405.16 mg/100g and 782.04 mg/100g in *Helix aspersa* compared to the other land and sea snail. In the literature, recommended daily amounts for lysine (30 mg/kg body weight), methionine (15 mg/kg body weight), threonine (15 mg/kg body weight), tryptophan (4 mg/kg body weight), isoleucine (20 mg/kg body weight), leucine (39 mg/kg body weight), phenylalanine (25 mg/kg body weight) and valine (26 mg/kg body weight) are suggested (FAO/WHO/UNU 2007). According to these results, when 10 pieces of snail meat is consumed (about 100 grams), %30 of the daily essential amino acid requirements for a 75 kg person will be met. Amino acid composition of garden snail (*Helix aspersa*) shows resemblance to other sea foods as Özden & Erkan (2011) suggested in his findings. Garden snail meat has high nutritional values like shrimp, lobster, squid and similar sea foods and it is cheaper when compared to these protein sources. Cultivation and consumption of this species should be encouraged and promoted to enrich sustainable protein resources.

In the garden snail, a total of 21 fatty acid (FAs) were identified. Milinsk *et al.* (2006) and Özoğul *et al.* (2005) have discussed the fatty acid composition of garden snail and reported a total of 20 and 21 FAs, respectively. Previous studies reported lower FA values for various snail species. In the present study, unsaturated fatty acid contents (UFAs) were found 55.02 % for garden snail, and these ratios were higher compared to those of saturated fatty acids (SFA). In the garden snail, stearic acid (18:0) was the main component of SFA followed by palmitic acid (16:0). Milinsk *et al.* (2006) reported that the content of SFA was 22.20 % and staeric acid (12.32 %) was also the primary SFAs followed by palmitic acid (6.72%). Although in the present study, profiles of the FA in garden snail were dominated by PUFAs and SFAs (Table 3), it has been shown that wild snail *Helix pomatia* muscles may contain much higher SFA (37.87%) and much lower PUFAs (25.83%) (Özoğul *et al.*, 2005). Oleic acid (C18:1 n-9) has been reported as the dominant monounsaturated fatty acid (MUFA) in this species examined. In addition, our results indicated that polyunsaturated fatty acids (PUFAs) were the most abundant FA in the garden snail. PUFAs are separated as n-3 and n-6 FAs due to their well-studied and distinct epidemiological function in humans (Eseceli *et al*., 2006). Among the PUFAs, linoleic acid (n-6), arachidonic acid (n-6), linolenic acid (n-3) and eicosapentaenoic acid (n-3) were the dominant fatty acids in this study.

The n-3: n-6 ratio has been suggested to be a useful indicator for comparing relative nutritional values of food oils. A higher ratio of n-3: n-6 PUFAs has often been cited as an index of better nutritional value (Zhao et al., 2010). According to current WHO recommendations, daily ratio of n-3: n-6 in a balanced human diet should be lower than 1:5 (Vujkovic *et al.*, 1999). Although the n-3: n-6 ratios of both snail species were within the recommended value, n-3: n-6 ratio of garden snail was higher compared to wild snail (Tables 3). These results indicate that snail species contain a balanced lipid composition for nutritional purposes.

A, E, B_1, B_2, B_3 and B_6 vitamins have important roles in human metabolism, immune system and digestive system. It is reported that the human body needs 1.5 mg vitamin A, 17 mg vitamin E, 1.4 mg vitamin B_1, 1.6 mg vitamin B_2, 17 mg B_3 and 1.9 mg vitamin B_6, daily (Belitz *et al*., 2001). Our results indicate that 100 g snail meat contains 5.462 mg vitamin A, which is suf-

ficient. It is also noteworthy that the same amount of snail meat would meet the required amounts of vitamins-, E, B_1, B_2, B_3 and B_6. Our study shows that garden snail *Helix aspersa* is no different from the other animal food sources in terms of vitamin content (Table 4).

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As rich in protein and amino acids, our study shows that garden snails are also rich in minerals (Table 5). Calcium was determined the highest in *Helix aspersa* land snails (Ca, 1357mg/kg), followed by potassium (K 1054 mg/kg), phosphorus (P 967 mg/kg) and sodium (Na 919 mg/kg). In addition 170 mg/kg magnesium (Mg) and 5.21 mg/kg iron (Fe) was measured. The mineral content is known to change by location, biological cycles, season and feeding habits (Özoğul *et al*., 2005). Especially, *Helix aspersa* is comparable with Atlantic bonito with regards to mineral content (Oksuz *et al*., 2008). Similar to other aquatic products, especially fish, snail meat has vitamin content.

When physical parameter "colour" of the land snail is evaluated L* brightness value was calculated 54.67±1.85, a* redness value was -0.03±0.89 and b* value was 19.49±1.53 (Table 6). Comparable data were found in this regard.

Table 2. Amino acid compositions of garden snail (*Helix aspersa*) and different snail species (mg/100g) (± st.dev.)

Amino acids	Garden snail (*Helix aspersa*)	Edible land snail (*Helix lucorum*) Olgunoglu and Olgunoglu (2009a)	Sea snail
Lysine	721.00 ± 2.55	614.90	996.73
Methionine	426.27 ± 2.72	-	375.19
Threonine	450.70 ± 0.01	451.20	509.59
Isoleucine	464.57 ± 4.45	376.80	538.94
Leucine	611.50 ± 1.40	785.10	895.65
Phenylalanine	362.76 ± 2.66	424.70	1480.31
Valine	714.51 ± 14.74	416.60	564.20
Histidin	253.41± 0.81	335.50	188.25
Total essential amino acid	**4004.72**	**3404.80**	**5549.15**
Serine	1039.25 ± 4.11	407.80	532.86
Arginine	674.26 ± 6.88	-	1212.58
Cysteine	391.57 ± 8.38	-	-
Tyrosine	596.88 ± 2.59	442.40	329.73
Alanine	1063.88 ± 6.07	522.30	781.71
Aspartic acid	996.81 ± 10.49	2523.60	1200.52
Glutamic acid	1405.16 ±12.05	1031.00	1776.09
Glycine	782.04 ± 2.10	693.00	1259.13
Proline	319.96 ± 4.78	447.00	3259.90
Total Non essential amino acids	**7269.81**	**6067.10**	**10352.52**

Table 3. Fatty acid composition (%) of garden snail (*Helix aspersa*) and different snail species (± st.dev.)

Fatty acid (%)	Garden snail (*Helix aspersa*)	Wild snail (*Helix pomatia*) Özoğul et al. (2005)	Cultured snail (*Helix aspersa maxima*) Milinsk et al. (2006)
$C_{14:0}$ (myristic acid)	Not determined	0.42	0.42-0.65
$C_{15:0}$ (pentadecanoic acid)	Not determined	0.32	-
$C_{16:0}$ (palmitic acid)	7.28 ± 0.27	10.29	6.72-10.11
$C_{16:1}$ (palmitoleic acid)	Not determined	0.57	0.23-0.37
$C_{17:0}$ (heptadecanoic acid)	Not determined	1.99	0.67-0.77
$C_{18:0}$ (stearic acid)	17.37 ± 0.47	16.38	12.32-14.51
$C_{18:1}$ (oleic acid) n-9	13.57 ± 1.03	14.70	16.73-20.42
$C_{18:2}$ (linolelaidic acid) n-6	1.38 ± 0.17	Not determined	Not determined
$C_{18:2}$ (linoleic acid) n-6	17.53 ± 0.93	13.56	19.37-24.53
$C_{18:3}$ (linolenic acid) n-3	5.63 ± 0.09	1.87	1.04-1.34
$C_{20:0}$ (arachidic acid)	2.80 ± 0.40	0.75	-
$C_{20:1}$ (eicosanoic acid) n-9	3.54 ± 0.09	1.85	1.60-2.54
$C_{20:2}$ (cis 11,14 eicosadienoic acid) n-11	7.54 ±0.36	9.08	Not determined
$C_{20:3}$ (cis 11,14,17 eicosatrienoic acid) n-3	Not determined	0.56	0.33-0.43
20:4 (arachidonic acid) n-6	10.74 ± 0.55	Not determined	9.33-10.61
$C_{20:5}$ (cis 5,8,11,14,17 eicosapentaenoic acid) n-3	2.29 ± 0.05	0.08	1.58-1.95
$C_{22:0}$ (behenic acid)	1.30 ± 0.11	6.27	Not determined
$C_{22:1}$ (erucic acid) n-9	Not determined	0.05	Not determined
$C_{22:6}$ (cis 4,7,10,13,16,19 docosahexaenoic acid) n-3	Not determined	0.23	Not determined
$C_{23:0}$ (tricosanoic acid)	Not determined	0.21	Not determined
$C_{24:1}$ (nervonic acid) n-9	3.54 ± 0.31	2.02	Not determined
Not identified	16.21	16.65	Not determined
Total saturated fatty acid (SFA)	28.76	37.87	22.20-26.26
Monounsaturated fatty acid (MUFA)	20.66	19.65	20.74-23.82
Poly unsaturated fatty acid (PUFA)	34.38	25.83	49.92-57.06
PUFA/SFA	1.20	0.68	
Total unsaturated fatty acid	55.04	63.70	70.66-80.88
Total n-6	29.65	13.56	
Total n-3	7.92	2.51	

Table 4. Comparing the vitamin content of garden snail (*Helix aspersa*) to other animals (± st.dev.)

Vitamin (mg/100g)	Garden snail (*Helix aspersa*)	Fish (Hering) Belitz et al. (2001)	Beef Belitz et al. (2001)
A	5.462 ± 0.05	0.04	0.02
E	0.887 ± 0.07	1.5	0.48
B_1	0.154 ± 0.00	0.04	0.08
B_2	0.065 ± 0.01	0.22	0.26
B_3	3.226 ± 0.04	3.8	7.5
B_6	0.288 ± 0.01	0.5	0.24

Table 5. Comparing the mineral compositions of garden snail (*Helix aspersa)* to other animals (± st.dev.)

Mineral (mg/kg)	Garden snail (*Helix aspersa*)	Wild snail (*Helix pomatia*) Ozogul et al. (2005)	Atlantic bonito Oksuz et al. (2008)
Fe	5.21 ± 0.21	17.1	13-48
Ca	1357.00 ± 0.30	7262.5	104-241
Mg	170.50 ± 0.12	540.5	95-134
P	967.20 ± 0.11	1045.2	853-895
Na	919.50 ± 0.32	905.0	117-197
K	1054.00 ± 0.18	821.7	654-914

Table 6. Colour of garden snail (*Helix aspersa*) (± st.dev.)

Colour	Garden snail
L*	54.67±1.85
a*	-0.03±0.89
b*	19.49±1.53

Conclusion

This study shows that, garden snail meat has similar levels of proteins, amino acids, vitamins, minerals and fatty acid contents as other seafood. It is an important food source to supply daily nutritional needs. Given improved culture techniques it has the potential to become an important culture species providing a rich source of proteins, vitamins and minerals. Turkey has the potential to economically benefit from this species. Snail culture is particularly important in the light of declining natural stocks with the rising demand on snail meat. Seasonal abnormalities and lack of rain is another stress factor on natural occurring snails. Culture techniques for snails must be developed to ensure a continuous and high quality snail meat production.

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