Food Bulletin (2023), *2*(2), 53-60 https://doi.org/10.61326/foodb.v2i2.124

http://foodbulletin.net

FOOD BULLETIN

e-ISSN: 2979-9848

https://prensip.gen.tr

REVIEW ARTICLE

Processing and Nutritional Quality of Sea Snail (*Rapana venosa* Valenciennes, 1846) Meat

Koray Korkmaz • Bahar Tokur

Ordu University, Faculty of Marine Science, Department of Fisheries Technology Engineering, Ordu/Türkiye

ARTICLE INFO

Article History
Received: 04.12.2023
Accepted: 18.12.2023
First Published: 31.12.2023

Keywords
Nutritional quality
Processing
Rapana venosa
Seafood

ABSTRACT

Sea snail, which is considered an invasive species in the Black Sea, has been caught by fishermen who earn their living in this area since the second half of the 1980s, as an alternative to other products, processed in factories and exported to countries with demand abroad. The fishing of sea snails, a highly sought-after delicacy in the Far East, has been limited due to declining stocks in the Sea of Japan caused by overfishing. Consequently, this has created export opportunities for several countries, including Turkey, and its significance has been steadily growing with the increasing export volumes. Due to their low cholesterol and fat content, and significant levels of protein and minerals, snails are among the healthiest foods consumed by humans. The fact that shellfish are sensitive and perishable products increases the sensitivity of the issue on issues such as the processing method, duration, and cold storage of these products. Therefore, ensuring that the quality reaches consumers without deterioration and monitoring it is of great importance in the export of shellfish. It will be possible for countries to reach a higher potential in snail exports and increase their market share in snail trade by obtaining products of appropriate quality. For this, it is necessary to improve the collection conditions in snail hunting, to monitor its transportation under appropriate conditions and to improve the processing stages. The purpose of the article was to provide an overview of the processing and quality of sea snail (*Rapana venosa*) meat.

Please cite this paper as follows:

Korkmaz, K., & Tokur, B. (2023). Processing and nutritional quality of sea snail (*Rapana venosa* Valenciennes, 1846) meat. *Food Bulletin*, *2*(2), 53-60. https://doi.org/10.61326/foodb.v2i2.124

1. Introduction

The native habitat of *Rapana venosa* Valenciennes 1846 (Neogastropoda, Muricidae), often known as sea snails, includes the Sea of Japan, the Yellow Sea, the Bohai Sea, and the areas extending from the East China Sea to Taiwan (Bayraklı et al., 2016). The dissemination occurred globally by maritime vessels during World War II or, more plausibly, through the ballast water of ships when the eggs were in their larval phase. The first place detected in the Black Sea was reported by edde) in Novorossiysky Bay in 1946 (Gönener & Özsandıkçı, 2017). The sea snails, introduced to the Black Sea by ships, quickly established themselves in their new environment. Despite being non-invasive, they rapidly proliferated and were visible throughout the shores of the Caucasus, Crimea, and the Sea of Azov within a decade. Between 1959 and 1972, *Rapana thomasiana* penetrated the northwestern part of the Black Sea and reached the waters of Romania, Bulgaria and Turkey, where it proceeded to reproduce and increase in numbers. The proliferation of sea snails along the entire Black Sea coast and the southern part of the Sea of Azov occurred in only 25 years (Zolotarev, 1996). Since 1984, *Rapana venosa* has been seen migrating from the Black Sea to the Aegean and Mediterranean Seas, subsequently expanding its distribution to other regions, such as France, England, the North Sea, and the German coast (Gönener & Özsandıkçı, 2017).

Correspondence
E-mail address: koraykorkmazodu@gmail.com

The economic significance of sea snails grew as a source of income for small-scale fishermen in the Black Sea area beginning in the 1980s (Sağlam & Düzgüneş, 2016). Fishing communities in the Black Sea have been harvesting sea snails - an invasive species- since the 1980s as a cheap substitute for other products, with the intention of processing and exporting them to areas where they are in high demand. Turkey is one of several countries that have found opportunities to export sea snails, which are highly valued in the Far East but have been severely limited in hunting due to overfishing in the Sea of Japan. As a result, sea snails are becoming increasingly important as exports continue to rise (Meraklı, 2018). Exports of sea snails reached $14,419,013 from January to September 2023, up 67% from $8,627,019 in the same period the previous year. The amount of products exported increased from 1,136 metric tons to 1,326 metric tons (Yıldız, 2023).

The habitats of the sea snail are sandy, muddy, algae environments, and around mussel beds up to a depth of 90 m. The lack of a natural predator in the Black Sea has allowed the fast expansion of a carnivorous sea snail, which is often considered the most active predator of mussels and oysters (Sağlam, 2007). An important factor contributing to the survival of this species is its ability to adjust to significant fluctuations in both salinity and temperature (Kos'yan, 2013). *Rapana venosa* has a high tolerance to varying salinity levels, ranging from 15 to 32‰ (Pirkova, 2020).

Snail meat has been eaten worldwide since ancient times, however it is not often consumed in Turkey like red meat, white meat, and fish (Olgunoğlu & Olgunoğlu, 2008). According to Gökhan and Sağlam (2009), these meals are considered luxury items since they are sourced from nature and exported abroad. Sea snails, which have gained significance as a valuable export commodity in our country, are marketed in several forms including live, fresh meat, frozen, cooked frozen, canned, and pickled. Various preparations of sea snail are more highly regarded in culinary traditions. According to Sürer (2013), it is often enjoyed in North American salads and soups, while in the Far East it is more commonly eaten raw or in canned form.

Sea snails, or "ashtrays," are an important source of revenue in the Black Sea area and the nation as a whole due to their widespread capture, processing, and export. The *Rapana venosa* that is captured in the Eastern Black Sea Region is packed into 50-60 kilogram sacks and transported to processing companies by trucks. Once there, it undergoes a series of processes that are necessary for export (Arslan, 2009).

The manufacturing process for the sea snail involves many steps after the quality check of the raw material obtained via hunting. These steps include steam cooking at a temperature of 100 °C for 10 minutes, separating the shell, removing the internal organs, chilling the snail at a temperature of 4 °C, and washing it thoroughly. During the calibration process, sea snails are measured and categorized based on their size. They are then allowed to rest before being filled and weighed. After that, they are frozen and packed at a temperature of -45°C. Finally, they are kept for future use (İrkin et al., 2007).

Preserving food for a healthy life has grown more important as society's eating habits have evolved from the past to the present, especially with the rise of ready-to-eat meals (Karslı, 2013). According to Özgür (2005), one-third of the protein needed for a balanced diet each day must come from animal sources, and the significance of a healthier and more balanced diet is growing as people get more understanding about the topic. Because it provides for a large portion of people's nutritional requirements, aquaculture is seen as a possible response to the world's growing population and food require.

In addition to its economic importance, snails are a valuable food in terms of nutritional content, as they are rich in mineral salts, copper, zinc, calcium and phosphorus. Snails are beneficial not only for food consumption but also for the treatment of some diseases in the medical fiel (Sağlam et al., 2003). A study on hemocyanin, a protein in invertebrate blood that transports oxygen, discovered that hemocyanins from the snails *Rapana venosa* (RvH) and *Helix vulgaris* (HvH) had specific immuno-adjuvant properties that could be activated by cell-mediated immunity. Guerin acid showed increased resistance to tumor progression in tumor-bearing animals treated with RvH and HvH compared to non-immunized animals and showed a significant immune activation, much higher than that in the Keyhole limpet haemocyanin (KLH)-immunized control group. It showed the highest survival rate in animals treated with HvH, RvH, and KLH compared to unimmunized animals (Iliev et al., 2008).

2. Systematics of the Sea Snail (*Rapana venosa*)

Sea snail, whose Latin name is *Rapana venosa*, belongs to the Muricidae family of the Mollusca (molluscs) phylum and Gastropoda (gastropod) class in the scientific classification (Kıran, 2015) (Figure 1).

Figure 1. *Rapana venosa*.

Regnum: *Animalia*

Phylum: *Mollusca*

Class: *Gastropoda*

Subclass: *Prosobranchi*

Family: *Muricidae*

Genus: *Rapana*

Species: *Rapana venosa* Valenciennes, 1846

3. Frozen Sea Snail (*Rapana venosa*) Meat Processing and Nutritional Quality

3.1. Frozen Sea Snail (*Rapana venosa*) Meat Processing

Sea snails captured in the Black Sea Region and transported to the sea snail processing plant in perforated sacks undergo sensory evaluation at the first step of raw material acceptance, and then samples are taken from the processing stages.

The workflow of the Sea Snail Meat Processing Plant, as described by Korkmaz and Pinal (2022), is shown in Figure 2.

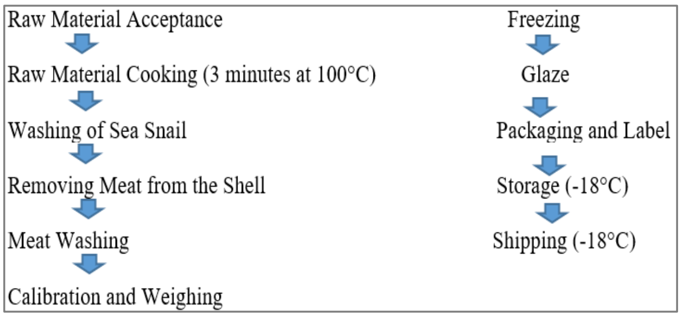

Figure 2. Sea snail processing plant workflow (Korkmaz & Pinal, 2022).

3.1.1. Raw material acceptance

Sea snails are transported to the seafood processing plant using a refrigerated transport vehicle that is stacked to provide for proper air circulation. If the microbial load in the raw material grows along with the rise in temperature over time, resulting in deformations, bruises, and deceased organisms in the sea snail flesh, these abnormalities do not meet the requirements for accepting the raw material. Once assigned a lot number based on their arrival order and weighed, the live sea snails are carefully kept away from any contact with water until they undergo processing. (Figure 3).

Figure 3. The sea snails in perforated sacks.

3.1.2. Raw material cooking

After the product raw material is entered, the cooking process is started. The live snails that have started the cooking process are thrown into the boiling water after the water in the cooking pots boils, and the cooking process is completed in 3 minutes after the water starts to boil again. The baking process is above 100°C (Figure 4.).

Figure 4. Boiling of sea snails.

3.1.3. Washing of sea snails

The output of the cooking boiler is sent to the shell washing machine for water-based cleaning. The sanitized product is put in sterilized plastic containers to purify the water. The water has been fully depleted inside plastic boxes. In this process, the cleaned product is conveyed to the pre-cooling area using plastic containers (Figure 5.).

Figure 5. Washing of sea snails in the washing drum.

3.1.4. Pre-cooling

The product undergoes pre-cooling to a temperature of 0 °C after the washing process. Consequently, the product is stored in a regulated environment to preserve its quality before processing.

3.1.5. Removing meat from the shell

Sea snails are swiftly handled with sharp equipment such as scissors and forks once they get to the product processing benches of the plant. The guts of the snails that are delivered to the booths are cleaned with scissors after they have been pulled off of their shells using a fork (Figure 6).

Figure 6. The process of separating snails from shells and entrails.

3.1.6. Washing of meat

The meat is transferred from plastic crates to washing tanks, where it is cleaned using facility water that satisfies the standards for drinking water. After the washing process is completed, the meat is placed in disinfected plastic cases (Figure 7).

Figure 7. Washing of sea snails meat in pan.

3.1.7. Selecting

The employees start picking out the products from the sanitized plastic containers. The ones that have spoiled and changed color are sorted (Figure 8).

Figure 8. Selecting of meats in bands.

3.1.8. Grading

Following the process of washing, the sea snails are transferred into plastic containers and then inserted into the grading machine. The washed and graded snail meats are then sorted into disinfected plastic cases based on their size (Figure 9).

Figure 9. Grading of sea snail meats.

3.1.9. Weighing and freezing

Following the process of washing and calibrating, the snail meat is weighed in crates and stored in the freezer's shock chamber to undergo freezing prior to packaging. The snail meat is subjected to freezing temperatures in a freezing chamber, specifically ranging between -35 °C and -40 °C. During this process, the internal temperature of the meat reaches -18 °C.

Once taken out of the freezer, the snail meat is coated in a glaze. Glazing involves coating the product's surface with water to prevent ice burns and protect it from the freezing process that follows. The sea snail meat is then packed into polyethylene bags and then into cardboard boxes using blocks. Prior to shipping, the packed and frozen products are kept at a temperature of -18 °C.

3.2. Nutritional Quality of Sea Snail (*Rapana venosa*) Meats

Sea snails are caught, processed and exported to Japan and some European countries. In terms of nutritional value, sea snails, with an average protein content of 12.95% and phosphorus content of 0.65 mg/kg, are a valuable product for healthy nutrition (İrkin et al., 2007). Table 1 shows that snail meat is an essential part of a healthy diet, even if its protein level is lower than that of red meat and much higher than that of milk. According to Kocabaş and Fenercioğlu (1992), snail meat is an excellent alternative for other meats due to its high protein and low fat content.

Table 1. The ratios of dry matter, protein, and lipids in snail meat compared to other foods (%) (Kocabaş & Fenercioğlu, 1992).

Foods	Dry Matter	Protein	Lipid
Snail Meat	21.82	13.74	0.57
Beef	42.7	24.4	15.10
Mutton	36.3	18	17.5
Fish Meat	22.8	19.0	2.5
Egg	26.0	12.8	11.5
Milk	13.0	3.5	3.9

Due to their low cholesterol and fat content and high mineral and protein content, snails are considered one of the healthiest diets for humans (Özoğul et al., 2005). Snail meat has a low calorie count (67 kcal/100 g), more nutrients than even the leanest meat or fish, and is a great diet meal because of all of these things. In terms of microelements, snail meat has ten times more calcium than conventionally consumed meat. Additionally, snail foot muscles are known to be exceptionally rich in iron, copper, zinc, and selenium, an essential antioxidant (Duman, 2015).

According to research by Düzgüneş et al. (1992), sea snail meat generally consists of 72.04% water, 16.29% protein, 2.25% fat, and 1.82% ash. Stoeva et al. (1995) found that the same species had a carbohydrate content of 8.9% (glycogen).

Before and after cooking, Merdzhanova et al. (2018) conducted research on the lipid composition, fatty acid content, fat-soluble vitamin content, and cholesterol content of sea snails. The cooking process resulted in a considerable alteration in the composition of fatty acids, but the temperature had no effect on the fatty acid groups that were present in phospholipids. Palmitic acid (C16: 0) and eicosapentaenoic acid (C20: 5n-3) were the fatty acids that were found in the highest concentrations across all lipid classes in both raw and cooked samples. According to the findings of this research made by Merdzhanova et al. (2018), cooking has an effect on the amount of fat-soluble cholesterol in the flesh.

In a study conducted by Arslan (2009), the alteration in nutritional properties resulting from the use of various processing procedures to sea snails was examined. To boil sea snails, begin by pre-boiling them at a temperature of 105°C for a duration of 15 minutes, followed by a subsequent boiling at 110°C for 40 minutes. Following the boiling phase, the product underwent various processing techniques. These included pasteurization, which involved subjecting the product to a temperature of 90 °C for 15 minutes, canning, which involved subjecting the product to a temperature of 121 °C for 20 minutes, smoking, and marinating at a temperature range of 70-80 °C for 2 hours. Additionally, fresh sea snails were examined separately, and the analysis results were provided. The moisture content of fresh sea snail, boiled at 105 °C for 15 minutes, boiled at 110 °C for 40 minutes, was found to be 71.30% ±0.05, 69.74% ±0.21, 70.63 ±0.17%, respectively. The protein result of the fresh sample, boiled for 15 minutes at 105 °C and boiled for 40 minutes at 110 °C was determined as 19.55±0.45%, 20.18±0.00%, 21.98±0.00%, respectively. Based on the results of the lipid oil analysis, the fresh sample had a lipid content of 0.45 ±0.10%, the sea snail cooked for 15 minutes at 105 °C had a lipid content of 0.24±0.03%, and the sea snail boiled for 40 minutes at 110 °C had a lipid content of 0.31±0.04%. The lipid content of sea snails boiled for 15 minutes at 105 °C and 40 minutes at 110 °C was found to be significantly lower than that of fresh snails, although there was no statistically significant difference between the two.

Table 2 displays the results of the nutritional evaluation of sea snail products processed using various methods.

Table 2. The nutritional content of sea snail products made using various processing methods (%) (Arslan, 2009).

	Pasteurized Snail	Canned Snail	Smoked Snail	Marinated Snail
Moisture	72.46 ± 0.28^{a}	66.75 ± 0.49^{b}	51.54 ± 0.77^{c}	69.37 ± 0.37^{d}
Protein	19.64 ± 0.20^{a}	23.54 ± 0.10^{b}	31.35 ± 0.37^{c}	19.55 ± 0.06^{a}
Lipid	0.21 ± 0.06^{a}	0.51 ± 0.02^{b}	0.93 ± 0.08^{c}	0.26 ± 0.02^{a}
Ash	2.56 ± 0.04^{a}	2.50 ± 0.03^{a}	7.44 ± 0.04^{b}	3.50 ± 0.05^{c}

In his 2015 research, Kıran investigated the impact and variations of sea snails collected from 12 distinct locations in the Eastern Black Sea (Giresun, Trabzon, Rize, and Artvin provinces) using scuba and free diving techniques. The study focused on analyzing the dry matter, ash values, crude protein, and crude lipid levels of sea snail meats throughout various seasons. Despite the fact that the characteristics that have been studied differ from one location to another, the overall average values of the seasons were as follows: dry matter (%), ash values (%), crude protein (%), and crude lipid (%) quantity have been found to be 24.69%, 2.29%, 16.43%, and 0.58%, respectively.

Popova et al. (2017) examined the variations in the characteristics and lipid composition of snail meat (*Rapana venosa*) during different seasons. The snails used in the research were collected by divers from the Bulgaria (Bay of Varna) area, located one mile away from the coastline, at a depth ranging from 10 to 15 meters, starting from late spring (June-October). The snails that were gathered were measured using a digital scale. Furthermore, the tissue, operculum, and intestines were extracted from the shell, and the weight of the flesh was documented. During the months of June, July, and October, the researchers discovered that the snail's live weight ranged from 56.44 to 110.02 grams, and that the meat content was compatible, ranging from 11.98 to 23.27 grams. Analysis revealed that the meat output reached its minimum in June and thereafter exhibited a rise in July. However, in the subsequent samples obtained, the meat yield gradually declined until October. Research on the quality of snail (*Rapana venosa*) meat found that chemical analyses revealed a moisture content ranging from 70.89% to 76.24%, with the greatest value recorded in July and the lowest value recorded in October. July had the lowest protein value and October had the highest, with a range of 18.62% to 24.09%. Lipid analysis shows that it has modest levels, ranging from 0.58% to 0.85%.

Kocabaş and Fenercioğlu (1992) investigated the alterations detected in land snails (*Helix pomatia*) obtained from different areas of Adana, which were then stored and operated on at a commercial company. The land snails that were gathered and brought in throughout the months of April, May, and June in 1989 were maintained in a living state for durations of 0, 1, 2, and 3 days. The results revealed that the total dry matter content exhibited variation based on the months during which the samples were collected. The relative dry matter content was determined to be 20.84%, 21.54%, and 23.21%. The snail meat had fat contents of 0.61%, 0.34%, and 0.76% correspondingly. Upon protein analysis, snail meat was shown to be a significant source of protein, with an average content of 13.74%. The protein contents varied by month, with values of 13.94%, 14.1%, and 13.18%. The average ash content of snail meat varied by month, with values of 0.26%, 0.28%, 0.24%, and 0.25% recorded for each corresponding month.

Olgunoğlu and Olgunoğlu (2009) examined the chemical composition values of snails (*Helix lucorum* Linnaeus, 1758), collected from different geographies of Turkey and brought to the snail processing factory, as they were prepared for consumption by weighing them. The analyzes of the research were carried out after thawing and homogenizing the snail samples in butter sauce prepared by adding parsley and garlic, frozen at -40 °C, in the refrigerator. As a result of the study, the moisture, ash, crude protein, lipid, saturated fat and unsaturated fat of snail meat, ready for consumption, were found to be 54.77%, 2.57%, 10.22%, 27.91%, 16.77%, and 8.86%, respectively.

The nutritional value of sea snail (*Rapana venosa*) meats was evaluated at each step of processing by Korkmaz and Pinal (2022) using a fisheries processing facility. Each stage included scalding, washing, skin removal, calibrating, freezing at -40 ºC after 1 hour, and storage at -18 ºC after 1 week. Based on the study, the raw moisture contents throughout the several phases of processing were determined to be as follows: Besides, the raw ash content contents were determined as 73.32±0.90% (scalding), 70.53±0.17% (washing), 72.67±0.27% (skin removal), 75.51±0.57 (calibration), 76.79±0.14% (freezing), and 76.01±0.10% (frozen storage). In addition, the following raw ash content contents were found: 2.49±0.03% for scalding, 2.31%±0.27% for washing, 2.74±0.50% for skin removal, 1.25±0.14% for calibration, 1.08%±0.16% for freezing, and 1.09±0.14% for frozen storage. Moreover, crude protein and lipid contents were calculated as 19.44±0.07% and 0.83±0.52% (scalding), 21.46±0.70% and 1.65%±0.65% (washing), 20.07±0.08% and 0.53±0.0% (skin removal), 18.92±0.72% and 0.53±0.00% (calibration), 19.28±0.57% and 1.08±0.16 (freezing) and, 18.17% ±0.41 and 1.09±0.14% (frozen storage), respectively.

4. Conclusion

Sea snails meats are an important source of income for the people of the Black Sea region and are an important export product as they are in demand abroad. It provides a source of income for tens of thousands of people, from hunting by boats and divers to its transportation from processing factories. It will be possible for Turkey to reach a higher potential in snail exports and increase its market share in snail trade by obtaining suitable quality products. In snail hunting, collection conditions need to be improved, transportation under appropriate conditions must be monitored, and processing processes must be improved. It is important to reveal the processing process and changes in nutritional and quality parameters of sea snail, which is an important export product for the Black Sea.

Conflict of Interest

The authors have no conflict of interest to declare.

References

Arslan, G. (2009). *Farklı işleme tekniklerinin deniz salyangozunun (Rapana venosa, Valenciennes, 1846) besin bileşimi üzerine etkisi* (Master's thesis, Istanbul University). (In Turkish)

Bayraklı, B., Özdemir, S., & Birinci-Özdemir, Z. (2016). Yakakent bölgesindeki (Güney Karadeniz) deniz salyangozlarının (*Rapana venosa* Valenciennes, 1846) boy-ağırlık ilişkileri, kondisyon indeksleri ve et verimleri. *Alınteri Journal of Agricultural Sciences*, *31*(2), 65-71. (In Turkish)

Duman, M. B. (2015). *Sinop ilindeki kara salyangozlarından Helix aspersa ve Helix lucorum` un biyokimyasal kompozisyonu, et verimi ve üreme periyodunun belirlenmesi* (Master's thesis, Sinop University). (In Turkish)

Düzgüneş, E., Ünsal, S., & Feyzioğlu, M. (1992). *Estimation of periwinkle (Rapana thomasiana Crosse 1861) stocks in the Eastern Black Sea*. Project No: DEBAG 143/6, Karadeniz Technical University, Sürmene Faculty of Marine Sciences, Trabzon.

Gökhan, H. B., & Sağlam, N. (2009). Elazığ, Keban yöresinde yaşayan salyangoz (*Helix lucorum*, Linnaeus,1758) 'da vitamin A ve β-karotenin araştırılması. *Fırat Üniversitesi Fen Bilimleri Dergisi*, *21*(1), 45-52. (In Turkish)

Gönener, S., & Özsandıkçı, U. (2017). Density distribution and some biological properties of veined rapa whelk *Rapana venosa* (Valenciennes, 1846) populations in south central Black Sea. *Cahiers de Biologie Marine*, *58*, 199-206. https://doi.org/10.21411/CBM.A.8355944F

Iliev, I., Toshkova, R., Dolashka-Angelova, P., Yossifova, L., Hristova, R., Yaneva, J., & Zacharieva, S. (2008). Haemocyanins from *Rapana venosa* and *Helix vulgaris* display an antitumour activity via specific activation of spleen lymphocytes. *Reports from the Bulgarian Academy of Sciences*, *61*(2), 203-210. https://doi.org/10.3109/08820139.2010.513408

İrkin, R., Korukluoğlu, M., & Tavşanlı, H. (2007). İhracata yönelik hazırlanan bazı deniz ürünlerinin mikrobiyal özellikleri. *Türk Hijyen ve Deneysel Biyoloji Dergisi*, *64*(1), 26-30. (In Turkish)

Karslı, B. (2013). *Akivades (Ruditapes decussatus, Linnaesus, 1758)'te farklı işleme tekniklerinin kalite kriterlerine etkisinin araştırılması* (Master's thesis, Recep Tayyip Erdoğan University). (In Turkish)

Kıran, A. (2015). *Doğu Karadeniz Bölgesi`ndeki deniz salyangozunun (Rapana venosa, Valenciennes, 1846) mevsimsel biyokimyasal kompozisyonu ve et kalitesi değişiminin belirlenmesi* (Master's thesis, Recep Tayyip Erdoğan University).

Kocabaş, G., & Fenercioğlu, H. (1992). Adana'da işlenen kara salyangozlarının özelliklerinde bekletme ve işletme sırasında görülen değişmeler ile kimyasal bileşiminin belirlenmesi üzerine bir araştırma. *Gıda*, *17*(1), 67-71. (In Turkish)

Korkmaz, K., & Pinal, F. (2022). Deniz salyangozu (Rapana venosa) işlem basamaklarında besin kompozisyonu analizleri ve toplam uçucu bazik azot (TVB-N) düzeylerinin belirlenmesi. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, *25*(6), 1479-1488. https://doi.org/10.18016/ksutarimdoga.vi.1006399 (In Turkish)

Kos'yan, A. R. (2013). Comparative analysis of *Rapana venosa* (Valenciennes, 1846) from different biotopes of the Black Sea based on its morphological characteristics.

Oceanology, *53*, 47-53. https://doi.org/10.1134/S0001437013010074

Meraklı, N. (2018). *Doğu Karadeniz'de deniz salyangozu (Rapana venosa Valenciennes, 1846) populasyonunda imposeks durumunun araştırılması* (Master's thesis, Karadeniz Technical University). (In Turkish)

Merdzhanova, A., Panayotova, V., Dobreva, D. A., Stancheva, R., & Peycheva, K. (2018). Lipid composition of raw and cooked *Rapana venosa* from the Black Sea. *Ovidius University Annals of Chemistry*, *29*(2), 48-54. https://doi.org/10.2478/auoc-2018-0007

Olgunoğlu, İ. A., & Olgunoğlu, M. P. (2008). Yenilebilir kara salyangozu (*Helix lucorum* Linneaus, 1758) etinin amino asit kompozisyonu. *Uludağ University Faculty of Veterinary Medicine Journal*, *27*(1-2), 35-39. (In Turkish)

Olgunoğlu, İ. A., & Olgunoglu, M. P. (2009). Dondurulmuş tereyağlı salyangoz (*Helix lucorum* Linnaeus, 1758) etinin hazırlanması ve besin etiketi analizleri. *Biyoloji Bilimleri Araştırma Dergisi*, *2*(1), 35-39. (In Turkish)

Özgür, N. M. (2005). *Kurbağa (Rana spp.) bacağının füme olarak değerlendirilmesi* (Master's thesis, İstanbul University). (In Turkish)

Özoğul, Y., Özoğul, F., & Olgunoğlu, A. İ. (2005). Fatty acid profile and mineral content of the wild snail (*Helix pomatia*) from the region of the south of the Turkey. *European Food Research and Technology*, *221*, 547-549. https://doi.org/10.1007/s00217-005-1191-7

Pirkova, A. V. (2020). Characteristics of mitotic chromosomes of *Rapana venosa* (Valenciennes, 1846) (Gastropoda, Muricidae). *Russian Journal of Biological Invasions*, *11*, 66-73. https://doi.org/10.1134/S2075111720010099

Popova, T., Stratev, D., Vashin, I., Zhelyazkov, G., Valkova, E., & Dospatliev, L. (2017). Seasonal changes in the quality and fatty acid composition of meat in rapa whelk *(Rapana venosa)* from the Bulgarian Black Sea coast. *Turkish Journal of Agriculture and Natural Sciences*, *4*(3), 277–283.

Sağlam, H. (2007). Son 20 yılda salyangoz avcılığı. *SÜMAE YUNUS Araştırma Bülteni*, *7*(1), 8-9. (In Turkish)

Sağlam, H., & Düzgüneş, E. (2016). *Ecological and socio-economic effects of invasive species Rapana venosa in the Black Sea Ecosystem*. II. International Conference on Environmental Science and Technology. Belgrade.

Sağlam, N., Harlıoğlu, A., Tuna, G., & Gökhan, H. B. (2003). *Semi-controlled production of snail (Helix lucorum)*. XII. National Aquaculture Symposium. Elazığ.

Stoeva, S., Rachev, R., Severov, S., Voelter, W., & Genov, N. (1995). Carbohydrate content and monosaccharide composition of *Rapana thomasiana grosse* (Gastropoda) hemocyanin and its structural subunits. Comparison with gastropodan hemocyanins. *Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology*, *110*(4), 761-765. https://doi.org/10.1016/0305-0491(94)00201-5

Sürer, U. Y. (2013). *Karadeniz'de deniz salyangozu (Rapana venosa) populasyonunun incelenmesi* (Master's thesis, Karadeniz Technical University). (In Turkish)

Yıldız, İ. (2023). *Sea snail exports increased by 67% compared to last year and reached $14 million 419 thousand 13*. Bazaar Times. https://bazaartimes.com/sea-snail-exports-increased-by-67-compared-to-last-year-and-reached-14-million-419-thousand-13/

Zolotarev, V. (1996). The black sea ecosystem changes related to the introduction of new mollusc species. *Marine Ecology*, *17*(1-3), 227-236. https://doi.org/10.1111/j.1439-0485.1996.tb00504.x