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SEASONAL IMPACT OF HARVESTING ON THE FRESHNESS AND QUALITY OF GILTHEAD SEABREAM MEAT (*Sparus aurata* Linnaeus, 1758)

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Original scientific paper

Summary

In order to determine the impact of seasonal and stunning ways to maintain the freshness and quality of the gilthead seabream meat for consumption, 50 samples in two seasons (summer and winter) were randomly caught in the Bay of Neum using two stunning ways: using ice/sea water mixture (group I) and using anesthetic (group II). After stunning, number of muscle contractions, blood lactate concentration, temperature and pH of fish meat were measured. During laboratory analysis, trend values of pH and temperature were continued. The analysis also included the measurement of morphometric values, determination of the chemical composition of fish meat and carrying out the sensory analysis (QIM – Quality Index Method). The results showed that analyzed specimens were with uniform morphometric measures, without statistically significant differences between groups and seasons. According to a determined chemical composition, protein content was 17.7% (in summer period) and 18.5% (in winter period), moisture content was 70.2% (summer) and 78.0% (winter), and crude fat was 3.98% (summer) and 1.17% (winter). A statistically significant difference between seasons occurred at the moisture content, and especially for fat content. Temperatures are slightly down during the analysis with statistical difference between seasons every day, except day 11th. Readings of pH during analysis were 6.41 to 7.12 with a statistically significant difference between seasons at day 7 and 9. Based on the lactate content, it can be concluded that the fish group I (anesthetic) from the winter season survived stress levels higher than all other groups. Higher average number of muscle contraction after stunning was recorded in the fishes from group II (2.0) than in fish from group I (0.54). QIM values, as expected, had constant increase during testing (from 0.0 to 12.0), with significant differences between seasons for days 3, 7 and 11. Stunning methods, therefore, do not have an impact on maintaining the freshness and quality of gilthead seabream meat during storage, but the season of harvest has.

Key words: *Gilthead seabream, Freshness, Meat quality, Seasonal impact, Stunning methods*

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INTRODUCTION

Perch-like fish (order Perciformes) are fish that belong to the ray-finned fish superorder (Acanthopterygii). About 40% of all bony fish belong to this order, and thus they form the most numerous order of all vertebrates. Along with the fish from Cipriniformes order, the perch-like fish are the most numerous order of ichthyofauna and the order with the most developmental diversity in terms of the number of species. About 75% of the species from this order live in the coastal part of the sea, and the other species in the oceans and fresh water (Bogut *et al.*, 2006). According to Berg (1947), the perch-like fish order includes 8.000 species classified into 180 to 200 families, while Nelson (1994) lists 18 suborders, 148 families and 9.293 species.

Gilthead seabream is a representative of the sea breams and porgies family (Sparidae), and the body of fish from this family is tall, more or less laterally flattened, covered with ctenoid scales. Their dorsal fin is long and composed of a front spiny and rear soft part. The dorsal fin is relatively long and contains several strong spines. The ventral fins are located on the chest, below or in front of the pectoral fins. They have strong teeth on their jaws (Sofradžija, 2009).

The body of the gilthead seabream is elongated, oval high and strong, laterally flattened. The upper body profile is more rounded. The head is short and massive. The mouth is terminal, low, and the lips are fleshy and thick. The scales are large and ctenoid. The lateral line follows the upper body profile. Gilthead seabream have one dorsal fin, long, with spiny and soft rays. The pectoral fins are long, pointed, and the ventral fins are much shorter than the pectoral fins. The caudal fin is forked. The back is bluish-greenish gray with a metallic luster, the sides are silvery gray with longitudinal brown or brownish greenish stripes. A golden-yellow bridge bordered by dark zones extends between the eyes. Another scarlet (crimson) spot is sometimes found on the edge of the gill cover (operculum). At the beginning of the lateral line there is a larger black spot that covers the corner of the operculum. A blackish stripe runs along the middle of the dorsal fin. Gilthead seabream can grow to a length of 70 cm (about 10 kg), but usually grows from 20 to 50 cm (Jardas, 1997).

The gilthead seabream most often lives along the coast, in bays and harbors, regardless of the bottom. It is most abundant near the mouths of rivers (brackish waters). It prefers quiet coves with a stony-sandy substrate and in meadows of sea grass (Posidonia), from the coast to a depth of 50 m (most often 5 to 10 m). We rarely find it along the coasts that collapse into the sea under a steep slope, and on reefs far from the coast. In the spring, it enters the brackish waters in large numbers, where it stays all summer, and in the autumn it returns to the sea for spawning. This pecies is a protandric hermaphrodite. It first matures as a male (about 20 to 30 cm long, 1 to 2 years old) and later as a female (about 33 to 40 cm long, 2 to 3 years old). It spawns in the sea at the end of autumn and the beginning of winter. It feeds on all kinds of bivalves, snails and smaller crustaceans. Sometimes the gilthead seabream exceptionally looks for worms and then very quickly and deftly turns stones over with his head. It also feeds on some sea plants. It has been noticed that in shallow areas it whips the sand with its tail and digs out shellfish and snails from it. The gilthead seabream is also using his teeth to tear off the shellfish attached to the stones. Its presence in oyster and mussel farms is not desirable, because it causes great damage by crushing young shellfish. It also feeds on human food waste, cephalopods and discarded fish (Grubišić, 1988).

It is widespread in the Mediterranean Sea, less often in the Black Sea and the Atlantic Ocean, from the British Isles to the Canary Islands. It is quite common in the Adriatic Sea, where it mostly stays in the coastal area from where it enters the lower reaches of tributaries. In Bosnia and Herzegovina, it is relatively common in the lower course of the Neretva river (the area around the mouth of the Krupa river and downstream) (Sofradžija, 2009).

Traditionally, the gilthead seabream was farmed extensively in coastal lagoons and sea ponds until the beginning of the 1980s, when the conditions for intensive farming were developed. Italian "vallicoltura" or Egyptian "hosha" are extensive fish farming systems that act as natural fish traps, taking advantage of the natural trophic migration of fry from the sea to coastal lagoons. The gilthead seabream is a very suitable species for extensive aquaculture in the Mediterranean because of its good market price, high survival rate and feeding habits (which are relatively low in cage farming). Artificial spawning in Italy was successfully carried out at the beginning of the eighties of the last century. The production of fry develops at the end of the same decade in Spain, Italy and Greece. This species adapts very easily to conditions of intensive breeding, both in ponds and in cages (FAO Yearbook, 2006).

The gilthead seabream belongs to the group of the highest quality Adriatic fish species (Sofradžija, 2009). The annual world production of the gilthead seabream is gradually increasing from year to year. Most of the production takes place in the Mediterranean, primarily in Greece (49%), followed by Turkey (15%), Spain (14%) and Italy (6%). In addition, significant production occurs in Croatia, Cyprus, Egypt, France, Malta, Morocco, Portugal and Tunisia. It is also farmed in the Red Sea, the Persian Gulf and the Arabian Sea, where the main producer is Israel (3%), while there are smaller productions in Kuwait and Oman. Considering that mariculture is the youngest branch of human food production in Bosnia and Herzegovina and that all production is located in Neum on only 0.36 hectares of land, our country still managed to achieve positive results in the gilthead seabream breeding. The total annual production is growing year by year (FAO Yearbook, 2011).

Fish meat is one of the most nutritionally valuable foods. Fish meat is similar to the meat of warm-blooded animals (with a high content of phosphorus and iodine or protein digestibility), but it exceeds it in many of its characteristics. The main carrier of the nutritional value of fish meat is the high protein content, with a favorable ratio of protein and fat, as well as a wealth of minerals and vitamins (Lambaša-Belak, 2006).

Proteins are the most valuable ingredients of fish meat, which, along with fats and carbohydrates, form the basis of proper nutrition diet. The amount and composition of protein in fish varies from 12 to 24% (Šoša, 1989). Their distinct value lies in easy digestibility (on average 2 to 3 hours), better utilization, and suitable amino acid

composition of fish meat. Fish proteins contain all essential amino acids. When we talk about quality, we usually associate it with aesthetic appearance or the degree of deterioration, but we evaluate quality differently and very often subjectively. The fish quality as a food can include aspects of healthy food that must be free from harmful bacteria, parasites or chemical compounds. Thus, today there are many different methods of quality assessment, which are not always applicable, because we need to know what, how and why to assess. Assessment methods can roughly be divided into sensory and instrumental, but since the consumer is the ultimate quality assessor, most instrumental methods must be correlated with sensory assessments before their application. Likewise, sensory methods must be scientifically conducted and controlled to minimize the influence of environment and subjectivity (Huss, 1995).
If the fish is not fresh, its eyes are cloudy, the gills are grayish-white, the scales come off easily, the meat is inelastic, and the smell is unpleasant. If the fish is cut, its freshness can also be checked by the color of the meat – the fish meat that is no longer usable is yellowish or blue. If the ribs separate from the sides when cleaning the fish, then this is a good reason to seriously check whether the fish is fresh (Karahmet, 2013).

MATERIALS AND METHODS

Examination of the seasonal impact of harvesting on the freshness and quality of gilthead seabream meat were performed on consumption size samples. A total of 100 fish samples were caught from one cage during two different seasons – summer and winter. In each of the seasons, 50 samples of randomly selected specimens were sampled and they were distributed in two groups:
- the first group of fish (n=25) stunned by freezing/shocking (in a solution of sea water and ice),
- the second group of fish (n=25) stunned with anesthetic (in a solution of sea water and anesthetic).

Before sampling the individuals, the basic physico-chemical parameters of the sea water were measured using a digital measuring instrument – water temperature, water pH, and the concentration of dissolved oxygen in the water. The gilthead seabream samples were collected at the fish farm in the bay of Neum. Immediately after harvesting and stunning the required individuals, the temperature and pH of the meat of each fish were measured, as well as the lactate content in the blood.
After the fieldwork measurements, each fish was marked using special stapler, then they were placed to ice boxes and transported to the laboratory of the Center for Aquaculture and Fisheries at the Faculty of Agriculture and Food Sciences University of Sarajevo for further analysis.
During the next 14 days of laboratory analysis, the samples were stored in a dark and cool place. On the first day of laboratory analysis, basic morphometric characteristics (standard body length and total weight) were measured on all samples. Physico-chemical analyzes included: determination of chemical composition (moisture, protein and fat), measurement of temperature and pH of meat, and sensory analysis (QIM –

Quality Index Method) was carried out to evaluate freshness of fish. Laboratory analyzes were performed in five repetitions, each day that was designated for the analysis meant taking 5 fish from each group (10 fish per repetition).

RESULTS AND DISCUSSION

At the beginning of the laboratory analyses, the basic morphometric measurements of gilthead seabream were measured (body mass and standard body length), and the condition factor was calculated based on them. The condition factor values were calculated using the following formula:

$$K = W \cdot L^{-3} \cdot 100,$$

where W is the weight of the fish in grams, and L is the standard length of the fish in centimeters.
The average values of basic morphometric characteristics and condition factor are presented in table 1.

Table 1. The average values ± SD of morphometric characteristics and condition factor by season

Parameter	Season			
	Summer (n=50)		Winter (n=50)	
	Group I	Group II	Group I	Group II
Weight (g)	**287.6 ± 81.24**	**295.4 ± 58.29**	**245.61 ± 63.85**	**242.04 ± 57.72**
	291.5 ± 70.09		**243.83 ± 60.27**	
Standard length (cm)	**22.44 ± 2.01**	**22.58 ± 1.49**	**21.46 ± 1.59**	**21.42 ± 1.78**
	22.51 ± 1.76		**21.44 ± 1.67**	
Condition factor	**2.51**		**2.43**	

The obtained results of the basic morphometric characteristics of gilthead seabream indicate that it is a uniform population with no statistically significant difference ($P>0.05$) whether it is between groups within a season or between seasons. The condition factor shows a slightly higher average value for the summer season (2.51) than for the winter season (2.43).
Table 2., shows the average values of the chemical composition of gilthead seabream meat – the average percentage of protein, fat and moisture in the meat of fish harvested during the summer and winter period.

Table 2. The average percentage ± SEM of protein, fat and moisture in gilthead seabream meat

Parameter	Season	
	Summer	Winter
Protein (%)	**17.67 ± 0.28**	**18.54 ± 1.18**
Fat (%)	**3.98 ± 0.34**	**1.17 ± 0.15**
Moisture (%)	**70.17 ± 0.62**	**78.01 ± 0.3**

The presented data indicate that the average protein content in fish meat ranged from 17.7% in the summer season to 18.5% in the winter season, so there was no statistically significant difference ($P>0.05$). Moisture content in fish meat has statistically significantly higher values ($P<0.05$) for winter samples (78.0%) than for those from the summer season (70.2%). Even greater statistically significant differences between seasons ($P<0.05$) were noted for the average values of fat content in fish meat, because in summer samples about 4% of crude fat was found, and in winter samples only 1.2%. These values of fat content are far less than those by Grigorakis (2007), who determined an average amount of even 20.4% of fat in gilthead seabream samples from fish farms, but they are therefore much closer to the findings of Popović (2011), who found an average crude fat content of 9.06% in gilthead seabream samples from a fish farm, and the values are quite similar in terms of protein content (16.39%) and water content (72.03% on average).
Table 3. shows the average values of the basic physico-chemical parameters measured immediately after fish stunning on day zero for both seasons and groups of fish.

Table 3. The average values ± SEM of basic physico-chemical parameters of gilthead seabream meat

Parameter	Season			
	Summer		Winter	
	Group I	Group II	Group I	Group II
Temperature of meat (˚C)	**11.27 ± 0.37**	**23.07 ± 0.55**	**2.07 ± 0.15**	**12.4 ± 0.05**
pH of meat	**7.08 ± 0.04**	**7.02 ± 0.04**	**7.12 ± 0.04**	**7.06 ± 0.04**
Lactate level (mmol/l)	**2.14 ± 0.39**	**2.65 ± 0.22**	**1.93 ± 0.3**	**3.92 ± 0.23**

For the blood lactate concentration values, it can be concluded that there are no statistically significant differences between seasons, nor between groups within seasons ($P>0.05$). However, it is observed that fish from group II (stunned with anesthetic) experienced higher levels of stress than fish from group I (stunned with ice) in both seasons. This especially refers to fish from group II during the winter season, which survived the highest level of stress of all groups, considering that they had a slightly higher concentration of lactate in their blood (3.92 mmol/l) compared to group I (1.93), but also in relation to the samples of both groups of the summer season (average 2.41 mmol/l).

The obtained pH value results of the fish meat do not show a statistically significant difference between the examined groups and between the seasons ($P>0.05$), because for the summer period the average pH value ranged from 7.02 to 7.08, while for the winter period the average pH value ranged from 7.06 to 7.12. This leads to the conclusion that harvested gilthead seabream individuals experienced almost the same level of stress.

Figure 1. shows the movement of the pH value of fish meat during the days of analysis – storage in ice.

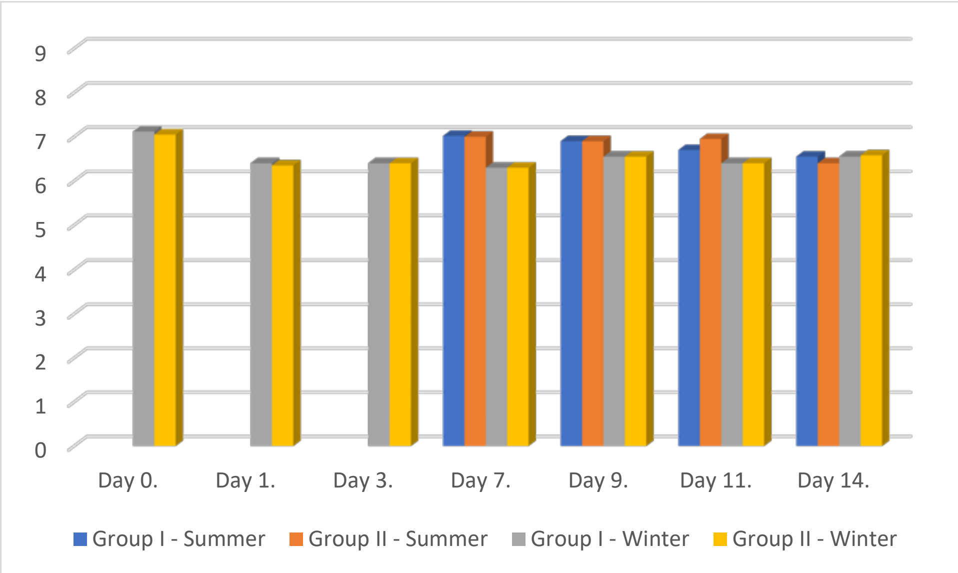

Figure 1. Average pH values of fish meat by seasons and groups during the days of analysis

The pH values of the fish meat ranged from neutral (maximum 7.12) to slightly acidic (minimum 6.41), with a total average value of 6.66. As can be seen from the figure, there are no statistically significant differences between the groups within the seasons for any day ($P>0.05$). Significant differences exist between the seasons on the 7th and 9th day of analysis, for both groups ($P<0.05$).

Figure 2. shows the movement of the average fish meat temperature for both groups of fish during storage in ice – during the days of the experiment.

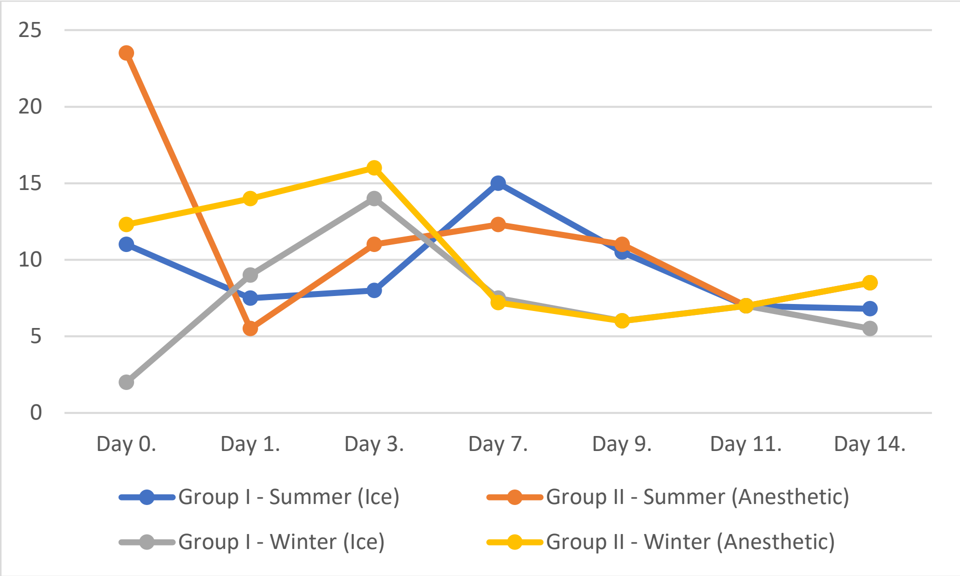

Figure 2. Average temperature values of fish meat by seasons and groups during the experiment

After the fish manipulation during the fieldwork measurements, all the samples were placed in ice boxes and stored, and the very next day it led to the equalization of fish temperatures between groups and also between seasons. However, statistically significant differences between seasons are observed every day of the analysis ($P<0.05$), except for the 11th day.

The figure shows that the average temperature value of both fish groups during storage shows an irregular trend. On average, for all groups, a temperature drop in can be noted after being placed in ice (the 1st day) from 12.2 to 9.1 °C, then there is a slight increase on the 3rd day (to an average of 12.4 °C), and since then a slight but permanent decline continued until the end of the analysis.

The next two tables show the average scores from the QIM test (by season) for each of the parameters according to the assessment days and groups, and figure 3. shows the average summary values of the QIM scores for all groups of fish according to the assessment days.

Table 4. Average QIM values according to parameters by days and fish groups in the summer season

Quality parameter		Day 3.		Day 7.		Day 9.		Day 11.		Day 14.	
		Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II
		Summer									
Appearance	Skin	1	1	0.8	0.8	1	1	1.1	1	1	1
	Mucus	0	0	1	1	1	1	0.7	1	1	1
Flesh	Elasticity	0	0	0.6	0	0.8	0.5	0.9	1.2	1	1
Odor	Odor	1	1	1.5	1.5	2	2	2	2	2	2
Eyes	Brightness	0.2	1	1	1	1	1	1.2	1.3	1.6	1.4
	Concavity	0.8	0	0.8	1	0.8	1	1.6	1.3	2	2
Gills	Color	0	0	0.6	0.5	1	1	0.3	0.5	1.1	1.1
	Odor	1	1	1.9	1.7	2	2	2	2	2	2
Quality Index		**4**	**4**	**8.2**	**7.5**	**9.6**	**9.5**	**9.8**	**10.3**	**11.7**	**11.5**

Table 5. Average QIM values according to parameters by days and fish groups in the winter season

Quality parameter		Day 3.		Day 7.		Day 9.		Day 11.		Day 14.	
		Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II	Group I	Group II
		Winter									
Appearance	Skin	0	0	0.5	0.5	1	1	2	2	2	2
	Mucus	0	0	0	0	1	1	1	1	1	1
Flesh	Elasticity	0	0	0.5	0.5	0.4	0.4	1	1	1	1
Odor	Odor	0	0	0	0	1.5	1.5	2	2	2	2
Eyes	Brightness	0	0	0.5	0.5	1	1	1	1	1	1
	Concavity	0	0	0.5	0.5	1	1	1.5	1.5	2	2
Gills	Color	0	0	0.5	0.5	0.8	0.8	1	1	1	1
	Odor	0	0	1	1	1.5	1.5	2	2	2	2
Quality Index		**0**	**0**	**3.5**	**3.5**	**8.2**	**8.2**	**11.5**	**11.5**	**12**	**12**

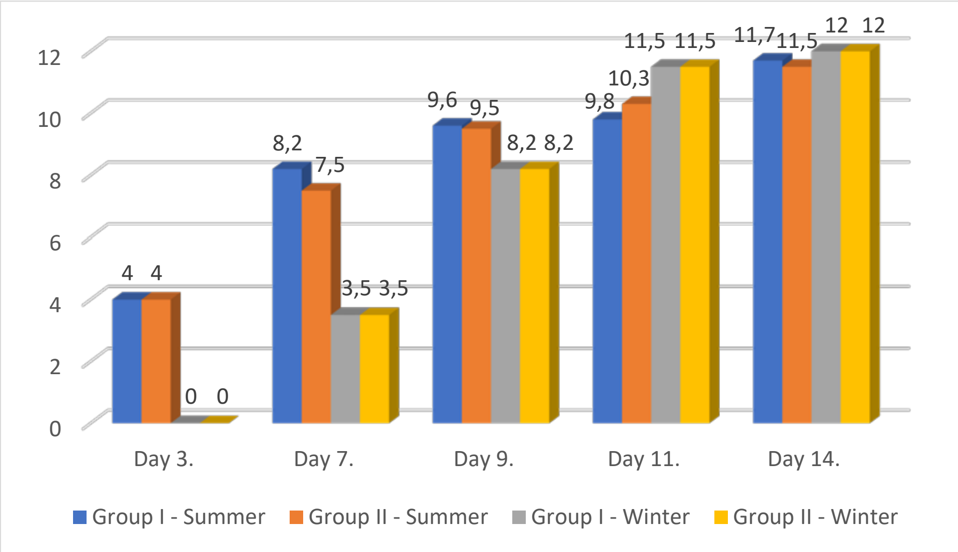

Figure 3. Movement of QIM values for all groups of fish during the assessment period

The obtained QIM values have a constant increase during the duration of the analyses. Observed by days of analysis, QIM values start to increase sharply from the 7th day of storage for samples from the summer season and from the 9th day for winter samples. Therefore, the lowest QIM value was assessed on the 3rd day of analysis (the 1st day of assessment) of the winter season for both groups (the total score was 0.0), and the highest on the 14th day of the same season (the total score was 12.0), also for both groups. The values do not show significant differences ($P>0.05$) between the groups by days of analysis in any of the seasons, but statistically significant differences occur ($P<0.05$) between the seasons for 3rd, 7th and 11th day.

It is observed that the values of both groups from the winter season are completely matching on each of the evaluation days, so all this leads to the conclusion that the freshness of the fish is certainly more influenced by the ambient conditions (the winter sample values are on average about 1.5 points lower than in the samples from summer season), than harvesting method.

CONCLUSION

The freshness and quality of gilthead seabream intended for the final consumer can be improved by applying the best harvesting method – the method of harvesting and stunning that will cause the least stress to the fish, which will certainly affect the freshness and quality of the final product. The general conclusion is that in our ecological conditions (Bay of Neum), the method of harvesting has no effect on maintaining the freshness and quality of the gilthead seabream meat, but that the harvesting season does, considering that statistically significant differences between seasons were observed ($P<0.05$). Significant differences between harvesting seasons were observed in most monitored parameters: sensory evaluation of meat, chemical composition of meat (especially fat content), temperature and pH of meat, and lactate content. For some subsequent research, the question remains whether this general conclusion will be valid when all this is also observed from a microbiological aspect, or not.

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SEZONALNI UTICAJ IZLOVLJAVANJA NA SVJEŽINU I KVALITET MESA ORADE (*Sparus aurata* Linnaeus, 1758)

Rezime

U cilju određivanja uticaja godišnjeg doba i načina izlovljavanja na održavanje svježine i kvaliteta mesa konzumne orade nasumično je u Neumskom zaljevu izlovljeno po 50 uzoraka u dva godišnja doba (Ijeto i zima) na dva načina: omamljivanje podleđavanjem i anestetikom. Prilikom izlova na terenu očitan je broj mišićnih kontrakcija, izmjerena koncentracija laktata u krvi, temperatura i pH mesa ribe, a kretanje vrijednosti pH i temperature nastavljeno je i tokom laboratorijskih analiza. Rad je obuhvatio i mjerenje morfometrijskih vrijednosti, utvrđivanje hemijskog sastava ribljeg mesa i provođenje senzorne analize (QIM – Quality Index Method). Rezultati su pokazali da su analizirane jedinke ujednačenih morfometrijskih mjera, bez statistički značajnih razlika između grupa i godišnjeg doba. Prema određenom hemijskom sastavu, udio proteina je iznosio 17,7% (ljeti), odnosno 18,5% (zimi), sadržaj vlage 70,2% (ljeto) i 78,0% (zima), a sirove masti 3,98% (ljeto), odnosno 1,17% (zima). Statistički značajna razlika između godišnjih doba se ispoljila kod sadržaja vlage, a naročito kod sadržaja masti. Vrijednosti temperatura su u blagom padu tokom trajanja analiza uz statističku razliku između godišnjih doba tokom svih dana, osim 11-og. Očitane pH vrijednosti mesa tokom dana analiza su bile od 6,41 do 7,12 uz statistički značajne razlike između godišnjih doba za dane 7 i 9. Na osnovu sadržaja laktata može se zaključiti da su ribe grupe II (anestetik) iz zimskog perioda preživjele najveći nivo stresa od svih grupa. Veći prosječni broj mišićnih kontrakcija nakon omamljivanja je zabilježen kod riba grupe II (2,0), nego kod riba iz grupe I (0,54). Vrijednosti QIM-a očekivano imaju konstantan porast tokom trajanja ogleda (od 0,0 do 12,0), uz značajne razlike između godišnjih doba za dane 3, 7 i 11. Način izlovijavanja, dakle, nema uticaj na održavanje svježine i kvalitet mesa konzumne orade tokom skladištenja, ali period izlova ima.

Ključne riječi: *orada, svježina, kvalitet mesa, sezonalni uticaj, načini omamljivanja*