

INFLUENCE OF STUNNING METHODS ON THE FRESHNESS OF RAINBOW TROUT MEAT (*Oncorhynchus mykiss* Walbaum, 1792)

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Summary

The method of fish harvesting, which largely causes stress in fish and a number of other changes in the postmortem phase, reflects on the freshness and quality of the fish meat. The main goal of this research is to determine the impact of stunning methods on the incidence of stress and other postmortem processes that take place on the freshness and quality of fish meat during storage and conservation, since the fish, due to their chemical composition of meat and increased water content, is a perishable food. The research included a number of tasks: determining the chemical composition of fish meat, the implementation of sensory analysis (QIM) of fish meat, monitoring the degree of rigor mortis in fish, color shift tracking of fish meat and fillets, and a number of other non-core analyses and measurement. The trial included working with three different groups of stunned fish: by dull thud (hammer) in the head, stunning in ice/freshwater mixture and in CO₂ solution. From the third group (CO₂) have been prepared fillets, 10 fresh and 10 vacuum. The pH measurements of fish and the concentration of lactate in the blood, after harvesting and stunning showed no statistically significant difference between the groups, which means that they have almost the same level of stress. The obtained values of rigor mortis during the analysis showed constant decline for both groups, and that there are no statistically significant differences between two fish groups. QIM grades showed no significant differences between groups.

Keywords: *Meat freshness, Stunning methods, Rainbow trout, Sensory analysis, Quality*

INTRODUCTION

The rainbow trout (*Oncorhynchus mykiss*) originates from the west of North America, where it inhabits coastal areas from Alaska to the southern coast of California, and the popular term rainbow trout has been domesticated. This species is a typical representative of the Salmonidae family, and it is distinguished from other members of this family by a clearly defined lateral line of rainbow colors, which is why it got the name rainbow trout (Aganović, 1979).

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Thanks to its positive biological characteristics, which differ in many ways from other salmonids, rainbow trout has become the most economically important species of freshwater fisheries. Among these characteristics, the following can be distinguished: they are less demanding than other salmonids in relation to water quality, they tolerate adverse environmental conditions very well, with a satisfactory oxygen content they can withstand water temperatures between 20 and 22 °C, they can be intensively farmed in brackish and salty water, they tolerate the presence of other fish species in their vicinity which allows keeping a large number of individuals in a limited space (intensive production), they consume dry, artificial food well, with good food conversion, juvenile individuals easily get used to artificial food, they are characterized by rapid growth, and are significantly more resistant than other salmonids in all stages of development (Muhamedagić, 2002).

Fresh fish is a highly perishable product (Ashie *et al.*, 1996; Gram and Husse, 1996). Preservation of fish quality is a big problem for processors and consumers. The loss of fish quality largely depends on the fish species, but also on the conditions of preservation and storage (Whittle *et al.*, 1990). Microbiological and biochemical processes, which are observed during the sensory assessment of fish meat quality, affect the reduction of fish quality during preservation and storage (Ehira and Uchiyama, 1986). Fish stress caused by the harvesting method also affects the quality of fish meat. The reason for this is increased activity, i.e. the fish's attempt to resist harvesting, which leads to muscle fatigue (depletion of phosphogenic reserves and transition to the glycolytic phase to adenosine triphosphate – ATP), compared to rested fish that were not treated (Robb and Warriss, 1997; Roth *et al.*, 2002).

According to Fletcher *et al.* (2002) a low level of pH value in meat (6.13) can lead to a shorter shelf life of fish quality, compared to the optimal pH value. Conducted research on the assessment of sensory quality confirms that a high pH value in fish packages resulted in slowed bacterial growth and less protein denaturation during cooking. The rainbow trout is a good model for monitoring meat color changes, due to the expressive pigmentation of the meat. Increased activity (stress) during stunning causes in fish significant brightness, reduced red color and increased saturation in addition to reduced significant card value of Roche color (Robb *et al.*, 2000). According to Antunnes *et al.* (1971) rainbow trout (*Oncorhynchus mykiss*) has an acceptable shelf life of 14 days, if frozen immediately after harvesting or stored for a maximum of 6 hours at a temperature below 10 °C before freezing. Even if the fish is stored at a temperature of 30 °C for a period of 6 hours, the quality is acceptable for 4 days during storage in ice.

MATERIALS AND METHODS

Tests on the influence of stunning methods on the quality of fish meat were carried out on samples of market size rainbow trout. A total of 60 fish samples were harvested from one cage. The samples were divided into three groups, according to the stunning method: group I (n=20) was stunned by a blunt blow (hammer) to the head, group II

(n=20) was stunned by submersion in liquid ice and group III (n=20) was stunned in CO₂ solution and filleted (10 fresh and 10 vacuum fillets). Fish from group I and group II (n=40) were marked with animal marking pliers, and fillets (n=20) were marked with plastic tags.

During fish sampling, basic morphometric measurements (body mass and standard length) and basic meat quality parameters (temperature, pH, lactate level and number of muscle contractions) were performed. After all samples were measured (fish and fillets), they were transported in ice boxes to the Center for Aquaculture and Fisheries at the Faculty of Agriculture and Food Sciences in Sarajevo, where further measurements and analyses were performed.

Laboratory analyses were performed at predetermined time intervals for 10 or 20 samples for that day, i.e. for 5 fish samples from group I and for 5 fish samples from group II, as well as on fillets from the third group – 5 fresh and 5 vacuum packed samples. During each laboratory analysis (day 1, day 3, day 7, day 9, day 11 and day 14), fish and fillet pieces were taken to determine the chemical composition of the meat (fat, protein and moisture content), temperature and pH of the meat, degree of rigor mortis (postmortem rigidity), and sensory analysis using the QIM (Quality Index Method), in order to determine the freshness of the fish.

RESULTS AND DISCUSSION

Immediately after fish harvesting from the cage, and after stunning, the basic morphometric characteristics of rainbow trout were measured. The average values of the basic morphometric characteristics of rainbow trout are shown in Table 1.

Table 1. The average values \pm SD of morphometric characteristics measured on day zero during the fieldwork

Parameter	Group I (n=20)	Group II (n=20)	Group III (n=20)
Weight (g)	366.0 \pm 75.0	357.0 \pm 48.3	357.0 \pm 46.8
Standard length (cm)	29.3 \pm 2.3	29.4 \pm 1.4	29.5 \pm 1.7

The obtained results of the basic morphometric characteristics of rainbow trout indicate that it is a uniform population without statistically significant differences. The average fish weight (mass) in the first group (stunned with a hammer) was 366 grams, with an average length of 29.3 cm. Fish from group II (stunned in liquid ice) were approximately the same average length (29.4 cm), but slightly lighter (357 grams on average). The third group of fish (stunned with CO₂) weighed 357 grams, with an average length of 29.5 cm.

The average values of the chemical composition of rainbow trout meat are presented in Table 2.

Table 2. The Average values \pm SD of chemical composition for all three groups

Parameter	Group I (n=20)	Group II (n=20)	Group III (n=20)
Protein (%)	18.5 \pm 1.6	17.9 \pm 1.3	20.0 \pm 0.3
Fat (%)	2.5 \pm 1.0	3.2 \pm 2.3	2.4 \pm 0.2
Moisture (%)	72.9 \pm 3.5	74.3 \pm 3.1	73.4 \pm 0.3

The obtained results show that the average protein content in rainbow trout meat ranged from 17.9% (group II) to 20.0% (group III). At the same time, the highest average content of fat in the meat was recorded in fish from group II and was 3.2%, while the percentage in other two groups was almost equal. The moisture content ranged from 72.9% (group I) to 74.3% (group II).

The influence of stunning method on the stress level in rainbow trout can be determined based on the monitoring of some physico-chemical parameters, such as pH value, temperature value and lactate level (concentration) in the blood.

Table 3. shows the average values of the basic physico-chemical parameters measured immediately after fish stunning on day zero for all 3 groups.

Table 3. The average values \pm SD of physico-chemical parameters measured on the fieldwork

Parameter	Group I (n=20)	Group II (n=20)	Group III (n=20)
pH of meat	7.1 \pm 0.1	6.8 \pm 0.2	6.8 \pm 0.1
Temperature of meat (°C)	18.5 \pm 0.1	17.0 \pm 0.2	8.8 \pm 0.4
Lactate level (mmol/l)	7.1 \pm 0.4	4.0 \pm 0.8	3.4 \pm 0.2

The obtained pH value results of the meat do not show a statistically significant difference between the examined groups, because the average pH value ranged from 6.8 to 7.1. This leads to the conclusion that harvested rainbow trout individuals had almost the same stress level.

A similar conclusion can be drawn for the lactate level in the blood, with the exception of group I, where a slightly higher concentration (7.1 mmol/l) was recorded compared to other two groups (3.4 and 4.0), by which it can be concluded that fish from group I had a slightly higher stress level.

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

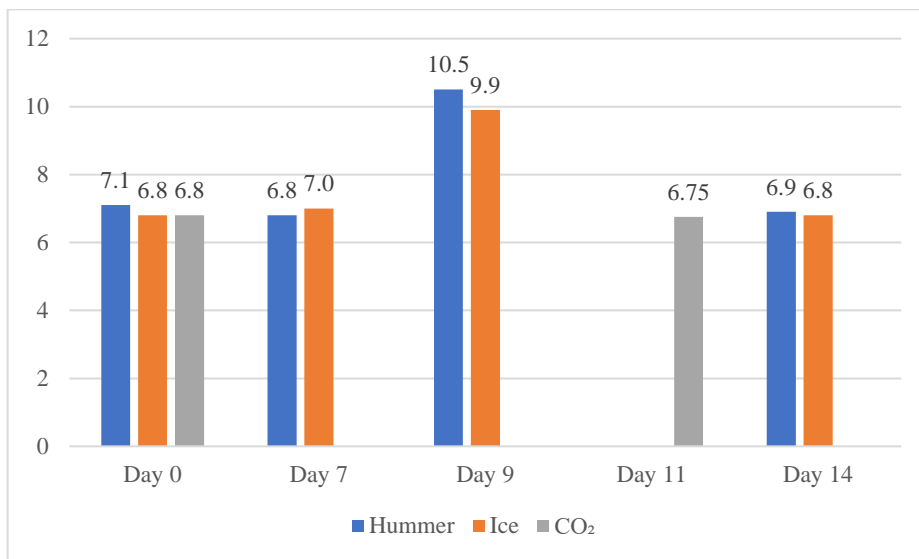


Figure 1. The average pH values of fish meat by groups during storage

The pH values of fish meat ranged from neutrality (7.1) in the first group to weak acidity (6.75) in the third group. Although on the ninth day of analyses the pH value was higher than the average value (9.9-10.5), there is no statistically significant difference between the groups.

The average temperature values of fish meat from group I and group II on day zero are quite approximate. This value is slightly lower for group II, which is understandable, considering that the fish were stunned in liquid ice.

The average temperature of fish meat was significantly lower for group III (8.8 °C). Such a low average value is conditioned by the fish manipulation, which was transported, after harvesting, to the processing plant, where the temperature is much lower.

Figure 2 shows the average value movement of fish meat temperature for group I and group II during storage.

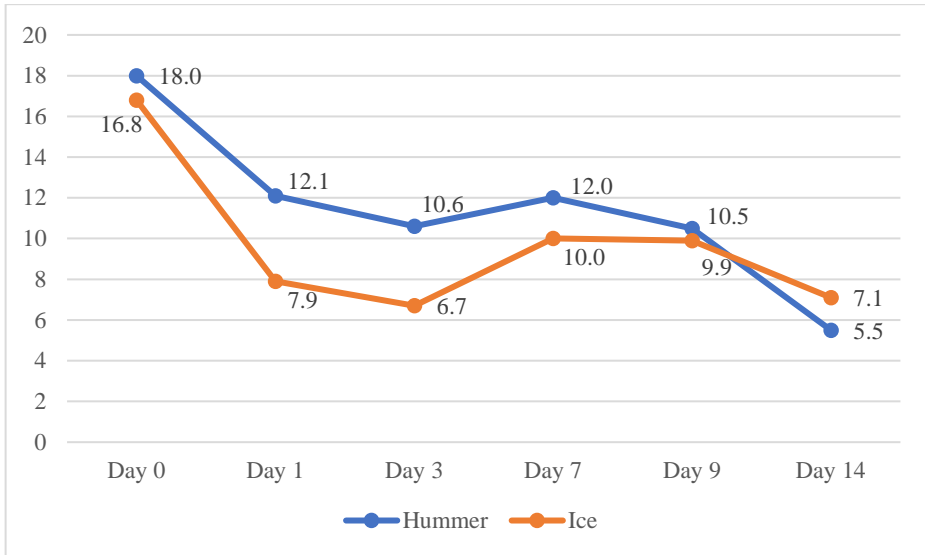


Figure 2. The average values of fish meat temperature by groups during storage days

The average value of the meat temperature for both groups during storage days shows a permanent decrease, and the temperature dropped from a maximum of 18.0 °C, which was the average meat temperature for group I on the day zero (sampling), to a minimum of 5.5 °C, which was on the last day of analyses for the same group. Similar values were recorded for group II, where the average temperature value on the day zero was a maximum of 16.8 °C, and on the last day of analyses, a minimum of 7.1 °C.

Table 4 shows the number of fish muscle contractions in average, manifested during harvesting (on the day zero).

Table 4. The average values ± SD of contractions measured on day zero during the fieldwork

Parameter	Group I (n=20)	Group II (n=20)	Group III (n=20)
Contractions	2.2 ± 0.1	2.7 ± 0.2	3.4 ± 0.2

The highest average number of contractions was recorded for fish group III and it amounted to 3.4. A slightly lower number (2.7 on average) was recorded for group II, and the smallest number of contractions was recorded for group I, with an average of 2.2.

Different procedures are used to evaluate the freshness of fish, including the use of appropriate scoring systems, which refer to the evaluation of the eyes, gills, skin, musculature and abdomen. For some fish species (as in this case for the rainbow trout) the Quality Index Method (QIM) is used. Therefore, QIM is adapted only for a specific fish species and cannot be used for any other species.

Figure 3 shows the average QIM values obtained during the analysis for group I and group II.

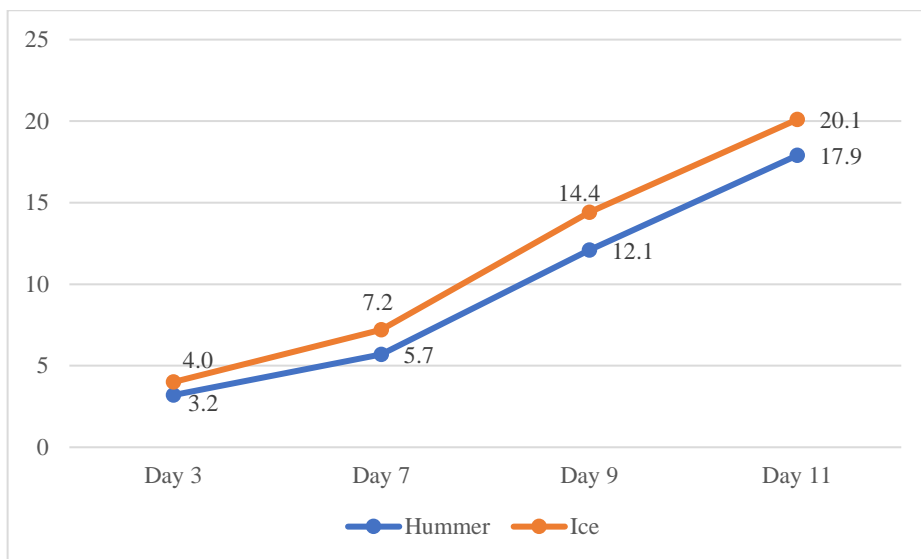


Figure 3. The movement of QIM values for the first and second fish group during the analyses

Monitoring of QIM values does not show major differences between groups, and the obtained values have a constant increase during the analyses. Observed by days of analysis, QIM values start to increase sharply from 7th day of storage. The lowest QIM value was on the 3rd day (3.2 for group I and 4.0 for group II), and the highest on the 11th day (17.9 for group I and 20.1 for group II).

Figure 4 shows the average values of rigor mortis for group I and group II during storage.

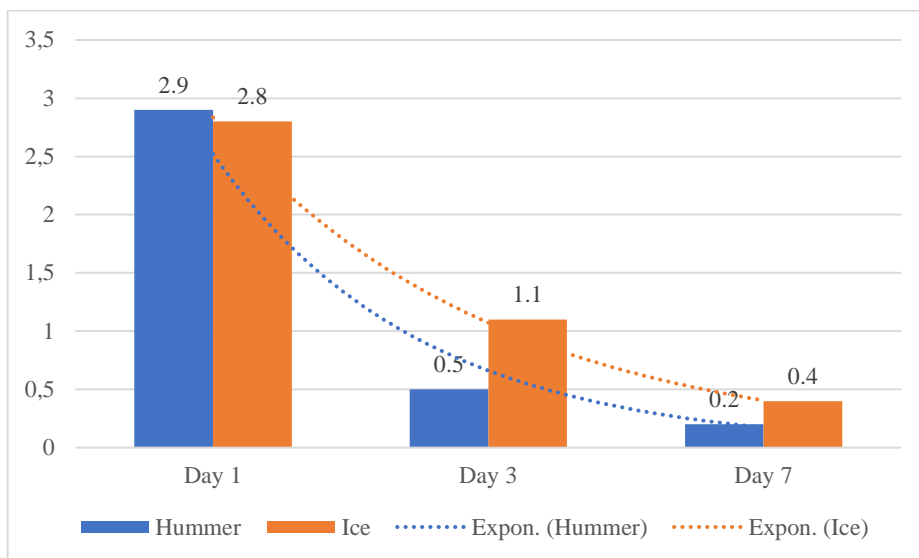


Figure 4. The average values of rigor mortis during analyses for group I and group II along with displayed trend lines

The values obtained during the analysis shows that the postmortem rigidity is in constant decline for group I and group II. Thus, for group I (fish stunned with hummer), rigor mortis value of 2.9, which was determined on the 1st day, dropped to only 0.2 on the 7th day of analyses. Within these limit values are the values for group II (fish stunned with liquid ice), which ranged from 2.8 on the 1st day to 0.4 on the 7th day. Analysis of variance showed that there are no statistically significant differences between group I and group II.

CONCLUSION

The stunning method during fish harvesting has no influence on the freshness and quality of rainbow trout meat in our environmental conditions. The stunning method does not lead to significant differences neither when it comes to the degree of experienced rigor mortis, nor the sensory evaluation of the meat. Also, all other secondary analyses and measurements (temperature, pH, lactate, contractions, chemical composition) did not show a statistically significant difference.

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UTJECAJ NAČINA OMAMLJIVANJA NA SVJEŽINU MESA KALIFORNIJSKE PASTRMKE (*Oncorhynchus mykiss* Walbaum, 1792)

Rezime

Način izlova, koji u velikoj mjeri izaziva stres kod riba i niz drugih promjena u postmortalnoj fazi, se odražava na svježinu i kvalitet ribljeg mesa. Osnovni cilj ovog istraživanja je utvrđivanje utjecaja načina omamljivanja na pojavu stresa i drugih postmortalnih procesa koji se odražavaju na svježinu i kvalitet ribljeg mesa tokom skladištenja i čuvanja, obzirom da je riba, zbog svog hemijskog sastava mesa i povećanog sadržaja vode, lako kvarljiva namirnica. Istraživanje je obuhvatilo čitav niz

zadataka: utvrđivanje hemijskog sastava ribljeg mesa, provođenje senzorne analize (QIM) ribljeg mesa, praćenje stepena rigor mortis-a kod riba, praćenje promjene boje ribljeg mesa i fileta, te niz ostalih sporednih analiza i mjerenja. Ogled je proveden sa tri grupe različito omamljenih riba: tupim udarcem (čekićem) u glavu, podležavanjem i u rastvoru CO₂. Od treće grupe (CO₂) pripremljeni su fileti, 10 svježih i 10 vakuum. Izmjerene pH vrijednosti i vrijednosti laktata u krvi riba nakon izlova i omamljivanja ne pokazuju statistički značajnu razliku između ispitivanih grupa, što znači da su imale skoro isti nivo stresa. Dobijene vrijednosti rigor mortis-a tokom analize pokazale su da je u konstantnom padu za obje grupe riba, te da ne postoje statistički značajne razlike između ove dvije grupe riba. Ocjene senzorne analize (QIM) nisu pokazale veće razlike između grupa.

Ključne riječi: *svježina mesa, načini omamljivanja, kalifornijska pastrmka, senzorna analiza, kvalitet*