Biotechnology in Animal Husbandry 37 (3), 213-222, 2021
Publisher: Institute for Animal Husbandry, Belgrade-Zemun
ISSN 1450-9156
UDC 637.05'639.215
https://doi.org/10.2298/BAH2103213B

CHANGES OF SENSORY ATRIBUTES OF CHILLED VACUUM-PACKAGED COLD-SMOKED COMMON CARP (*CYPRINUS CARPIO*) AND COLD-SMOKED BIGHEAD CARP (*HYPOPHTHALMICHTHYS NOBILIS*) FILLETS

Jelena Babić Milijašević, Milan Milijašević, Slobodan Lilić, Jasna Đinović-Stojanović, Branka Borović, Jelena Jovanović, Aleksandra Nikolić

Institute of Meat Hygiene and Technology, Kaćanskog 13, 11000 Belgrade, Republic of Serbia
Corresponding author: Jelena A. Babić Milijašević, jelena.babic@inmes.rs
Original scientific paper

Abstract: The aim of this research was to monitor changes of selected sensory properties and instrumental colour parameters (L*, a*, b*) of vacuum-packaged cold-smoked common carp (*Cyprinus carpio*) and cold-smoked bighead carp (*Hypophthalmichthys nobilis*) fillets during storage at 3 ± 0.5 °C and to determine the shelf life of the products. Sensory tests and instrumental color determination were performed on days 1, 7, 10, 12, 14, 15, and 16 of storage. All estimated sensory characteristics of common carp samples received significantly lower ($P < 0.05$) score on day 15. "Musty" odour of common carp samples detected on day 16 caused that odour score was below the acceptability limit of 2. On the last day of experiment, reduced intensity of pink cream colouring of carp muscle was observed together with softened texture and surface slime. A decrease of scores of the sensory attributes of cold-smoked bighead carp fillets was observed throughout the storage period. However, all estimated sensory characteristics were within the acceptability level. Significant increase ($p < 0.05$) of L* value was noted in both group of samples, while redness (a*) and yellowness (b*) remaid quit stable during the storage. Based on the sensory results, it was concluded that vacuum-packaged cold-smoked common carp samples remained acceptable for up to 15 days of storage, whereas vacuum packaged cold-smoked bighead carp samples remained unchanged until the end of the experiment.

Key words: cold-smoked fish, overall acceptability, shelf life, instrumental colour parameters

Introduction

Most of the wild fish and fish from aquaculture consumed in Serbia are marketed for human consumption as fresh or frozen. However, smoked products have seen a considerable surge in popularity. Smoking is one of most acceptable fish-processing method, because it does not require expensive equipment, the production period is short, acceptability on the Serbian market is very good, considering that the local population is accustomed to eat mostly smoked pork (*Kilibarda et al., 2009*). Modern consumers demand high quality food that retains the sensory characteristics and nutritive value of the raw material from which it is produced; also, it is expected to satisfy very demanding safety standards. This requirement is largely met by packaging the products in vacuum or modified atmosphere. The efficiency of vacuum in extending the shelf life of fish depends on several factors, such as the fish species, fat content, initial microbial cell count and most importantly, the storage temperature (*Babić Milijašević, 2017*). The most common reason for spoilage of smoked fish products is microbial activity. Microbial growth and the creation of products of their metabolic activity can lead to undesirable odour and taste, and the appearance of discoloration (*Leroi et al., 2001*).

Cyprinid species (common carp, bighead carp, and grass carp) are most commonly bred in Serbia (*Statistical Yearbook, 2020*). The aim of this research was to monitor changes of selected sensory properties and instrumental colour parameters (L*, a*, b*) of vacuum-packaged cold-smoked common carp (*Cyprinus carpio*) and cold-smoked bighead carp (*Hypophthalmichthys nobilis*) fillets during storage at 3 ± 0.5 °C and to determine the shelf life of the products.

Materials and Methods

Sampling

Samples from eleven common carp and eleven bighead carp of 2.5 ± 0.3 kg and 2.7 ± 0.5 kg live weight, respectively, were obtained from a fishpond where a semi-intensive rearing system was used. Fish were processed at freshwater fish processing plant using a standard procedure (killing by electrocution, descaling, evisceration, and filleting). Two fillets from each carp were made, and each fillet was divided into 2 portions, i.e. a total of 4 portions were obtained from 1 fish. After primary treatment, fish portions were washed and soaked in brine containing 25 g/L NaCl for 24 h at 5 °C and then pressed, laid on the grid in chambers for 1 h

at 12 °C. Smoking was performed on an automated smokehouse for 8 h at the temperature of 28 °C.

The 42 portions of cold-smoked common carp as well as the 42 portions of cold-smoked bighead carp were vacuum-packaged using the machine Variovac (Variovac Primus, Zarrentin, Germany), and a polyethylene-polyamide film (Suomen Union Verpackungs, Helsinki, Finland) with an oxygen permeability of 29–45 ml O_2 /m_2/24 h/atm (23 °C, 50% relative humidity, RH) and a water vapour permeability of 10–15 g/m2/24 h (38 °C, 90% RH) (1 atm = 101 325 Pa). All samples were stored under the same conditions, at the temperature of 3 ± 0.5 °C, and on days 1, 7, 10, 12, 14, 15, and 16 of storage, sensory tests and instrumental color determination were performed.

Sensory evaluation

The sensory evaluation was performed by six trained panelists. Panelists were trained according to international procedure (*EN ISO 8586, 2014*) and sensory assessment was carry out in test room who meet requirements of *EN ISO 8589, 2010*. Prior the sensory evaluation, samples were taken out from refrigerator to remain at room temperature for 30 min. For each day of examination, each assessor was provided with portion of fillet. The samples were evaluated for overall acceptability, with regard to odour, flesh colour, and texture using 1–5 intensity scale, with 5 corresponding to the most liked sample, and 1 corresponding to the least liked sample. The product was defined as unacceptable with a score of less than 2 points recorded by at least of 50% of the judges.

Instrumental colour determination

Colour of fish fillets was evaluated using colorimeter (Minolta Chroma Meter RC-400). The CIE system color profile of L*, a*, b* was measured by reflectance colorimeter using illuminant source D65, 8-mm aperture and 10° observation angle. The L* value represents lightness (L*= 0 for black, L*= 100 for white), while a* scale represents the red/green dimension, with positive values for red and negative ones for green. The b* scale represents the yellow/ blue dimension, with positive values for yellow and negative ones for blue (*CIE, 1976*). The colorimeter was calibrated throughout the experiment using a standard white ceramic tile (Y = 87.2; x = 0.3173; y = 0.3348). At each day of examination three measurement was carried out on surface of two portion.

Statistical analysis

The mean values and standard deviations were calculated by using column statistics with the processing of 6 values for each analyzed group. Significant

differences between groups were calculated using one-way ANOVA analysis by Tukey comparative test, Pearson's correlation analyses were performed on means of the values in the program Microsoft Office Excel (2010). Differences were evaluated as significant at $P < 0.05$.

Results and Discussion

The results of the sensory evaluation of cold-smoked common carp fillets and cold-smoked bighead carp fillets are presented in Table 1 (mean value ± standard deviation).

Table 1. Sensory evaluation of cold-smoked common carp fillets and cold-smoked bighead carp fillets stored under vacuum conditions at +3 ± 0.5°C.

Sensory parameter	Group	Storage time (days)						
		1	7	10	12	14	15	16
Odour	I	4.25±0.30^{a}	3.75±0.40^{b}	3.5±0.30^{b}	3.5±0.00^{b}	3.3±0.20^{b}	2.6±0.40^{c}	1.2±0.20^{d}
	II	5.0±0.00^{a}	5.0±0.00^{a}	4.8±0.25^{a}	4.0±0.40^{b}	3.8±0.50^{b}	3.5±0.40^{b}	2.8±0.50^{c}
Flesh texture	I	4.1±0.20^{a}	4.0±0.00^{a}	4.0±0.00^{a}	3.7±0.20^{a}	3.6±0.40^{a}	2.7±0.40^{b}	2.2±0.40^{b}
	II	5.0±0.00^{a}	5.0±0.00^{a}	4.8±0.25^{a}	4.6±0.50^{a}	4.4±0.40^{a}	3.7±0.50^{a}	3.1±0.20^{a}
Flesh colour	I	4.2±0.30^{a}	3.7±0.40^{b}	3.7±0.40^{b}	3.6±0.40^{b}	3.3±0.40^{b}	2.6±0.40^{c}	2.1±0.20^{d}
	II	5.0±0.00^{a}	5.0±0.00^{a}	4.8±0.25^{a}	4.1±0.60^{b}	4.1±0.60^{b}	3.6±0.50^{b}	3.4±0.60^{b}
Overall acceptability	I	4.2±0.30^{a}	3.7±0.40^{a}	3.5±0.40^{a}	3.6±0.20^{a}	3.5±0.40^{a}	2.6±0.40^{b}	1.2±0.20^{c}
	II	5.0±0.00^{a}	5.0±0.00^{a}	4.8±0.25^{a}	4.2±0.60^{a}	4.1±0.60^{a}	3.6±0.40^{a}	2.7±0.60^{b}

Group I: cold-smoked common carp samples; Group II: cold-smoked bighead carp samples; Same lowercase letters in a row indicate no significant differences ($p>0.05$)

At the beginning of storage period, colour, flesh texture, odour as well as overall acceptability were evaluated with very high scores in both group of samples. First day, color of common carp and bighead carp fillets was graded with high scores (4.2±0.30 and 5.0±0.00 respectively). Average grade of colour acceptability of cold smoked common carp and bighead carp fillets decreased during the storage. On the last day of experiment, reduced intensity of pink cream colouring of carp muscle was observed and it was evaluated as barely acceptable (2.1±0.20). The color of cold-smoked bighead carp muscle remained acceptable throughout the storage period (16. day it was evaluated as "acceptable" 3.4±0.60). In their research, *Kolodziejska et al. (2002)* and *Leroi et al. (2001)* found that colour intensity of vacuum packaged cold-smoked fish did not significantly change during three weeks of storage at 4°C. Likewise, *Bugueno et al. (2003)* did not reveal changes of smoked salmon colour packaged in vacuum and modified atmosphere during the storage at different temperature conditions. Numerous

studies in the European Union showed that the colour of smoked food products, specially smoked fish, is a main parameter that influence consumer decision to buy a particular type of food (*Espe et al., 2004*). *Johnston et al. (2000)* suggested that undesirable colour, as one of the most important cold-smoked salmon quality parameters, greatly reduces the cost of this product on the market.

In our research, textural changes was detected in common carp muscle during the storage. On day 16, softened texture and surface slime was discovered, and this sensory attribute were evaluated as "barely acceptable" (2.2±0.40). On the other hand, average scores of flesh texture of bighead carp muscle during the storage remained essentially unchanged. It was estimated as "very acceptable" at the beginning (5.0±0.00) and "acceptable" (3.1±0.20) at the end of storage period. The texture of cold-smoked fish has great importance for the quality of fish meat (*Lakshmanan et al., 2005*). During the storage, autolytic processes can cause changes in fish meat structure and consequently undesirable fish softening, even when the microbiota which usually causes spoilage is still not sufficiently developed to do so (*Olafsdottir et al., 2005; Dondero et al., 2004*).

During the experiment it was observed decrease of average grade of odour acceptability of cold smoked common carp fillets. On day 16 "musty" odour caused that odour score of common carp samples was below the acceptability limit of 2 (1.2±0.20). However, average scores of odor of bighead carp muscle during the storage period remained within the acceptability limit. It was estimated as "excellent" at the beginning (5.0±0.00) and "acceptable" (2.8±0.50) at the end of experiment. The high average odour score of bighead carp muscle in the present study had a positive impact on the overall acceptability of these fillets. *Truelstrup Hansen and Huss (1998)* and *Leroi et al. (1998)* in their examination of vacuum packaged cold-smoked trout, also found that during storage, the odour and taste of smoke intensity decreased, and became milder or almost neutral. Volatile substances that are usually produced by bacteria are the cause of undesirable odours in smoked fish (*Olafsdottir et al., 2005; Dondero et al., 2004*). These substances include trimethylamine, the volatile sulphur compounds, aldehydes, ketones, esters, hypoxanthine, and other low molecular weight substances. Trimethylamine is responsible for the typical "fishy" odour, indicator of spoilage.

As the results show, all estimated sensory characteristics of common carp samples received significantly lower ($P < 0.05$) score on day 15. A decrease of scores of the sensory attributes of cold-smoked bighead carp fillets was observed throughout the storage period. However, all estimated sensory characteristics were within the acceptability level.

Changes in fish meat begin at the moment fish dies, or already at the time of the catch and are the result of the activities of their own enzymes, the metabolism of microorganisms and the oxidation of lipids. Changes in the sensory characteristics of the fish usually result from the microbiological development. The decomposition of food ingredients and the growth of microorganisms cause an

unpleasant smell and taste as well as the production of visible pigmented or unpigmented colonies. The synthesis of polysaccharide extracellular materials and diffuse pigments results in sensory changes in the form of mucus formation and discoloration (*Fletcher et al., 2002*). On the other hand, chemical changes such as auto oxidation or enzymatic hydrolysis of fats may cause the rise of unpleasant smell and taste or, in the latter case, the activity of tissue enzymes may lead to unacceptable softening of the fish meat.

Changes in instrumental colour parameters of cold-smoked common carp fillets and cold-smoked bighead carp fillets are presented in Table 2. (mean value ± standard deviation).

Table 2. Instrumental determination of colour of cold-smoked common carp and cold-smoked bighead carp filets during the storage, CIE Lab system

	Group	Storage time (days)						
		1	7	10	12	14	15	16
L*	I	42.35±1.60^{a}	44.40±1.10^{a}	44.34±0.90^{a}	44.11±1.7^{a}	50.05±1.10^{b}	49.63±2.60^{b}	57.88±1.50^{c}
	II	50.26±0.20^{a}	49.10±1.90^{a}	50.80±0.25^{a}	52.15±3.3^{ba}	53.80±1.80^{a}	56.23±1.80^{b}	59.55±1.10^{c}
a*	I	4.70±0.47	4.14±0.30	4.67±0.28	3.94±0.50	4.60±2.32	4.00±0.38	4.52±0.45
	II	1,29±0.25	0.93±0.72	2.24±0.91	1.25±0.60	1.67±0.26	1.42±0.35	1.95±0.29
b*	I	5.92±0.71	7.01±0.25	5.54±2.27	7.18±1.94	7.54±1.87	5.93±0.54	6.76±1.08
	II	1.88±0.27	1.63±0.30	0.89±1.23	0.72±1.06	1.31±1.68	1.28±1.41	0.43±0.67

Group I : cold-smoked common carp samples; Group II: cold-smoked bighead carp samples; Same lowercase letters in a row indicate no significant differences ($p>0.05$)

In our research, from 1. to 12. day of experiment lightness (L*) of common carp samples did not change significantly ($P > 0.05$). After that period of time to the end of experiment lightness (L*) increased significantly ($P < 0.05$) by 24%. Lightness (L*) of bighead carp muscle was quite stable during the first fourteen days of storage. From that on L* value contineusly increase by the end of storage by 14.70%.Value for redness (a*) and yellowness (b*) remaid quit stable during the storage in both group of samples. Our results are in agreement with *Choubert et al. (2005)* who reported increase in L* value of vacuum packaged sliced smoked rainbow trout stored at chilled temperature. They concluded that during storage slices became paler, while changes in a* and b* parameters was not significant. During 40 days of storage at 4 °C *Rizo et al. (2015)* detected significantly increase of L*, a*, b* values of smoke-flavoured salmon packaged in water vapour permeable bags. The increase in lightness is explained by the water loss produced during storage which lead to greater water deposits on the fish surface. On the other hand, *Bugueno et al. (2003)* did not find any significant differences in L*, a*, b* values of smoked salmon packaged under vacuum and in modified atmosphere as a function on storage time. They suggested there was good colour stability of the examined product.

Table 3. Coefficients of correlation (r) of meat color (L*, a*, b*) and sensory attributes of cold-smoked common carp and cold-smoked bighead carp fillets

	Group	Odour	Flesh colour	Flesh texture	Overall acceptability
L*	I	-0.34	-0.54	-0.49	-0.51
	II	-0.37	-0.52	-0.40	-0.47
a*	I	0.25	0.15	0.09	0.21
	II	0.053	-0.023	0.120	0.007
b*	I	0.21	0.20	-0.25	-0.32
	II	0.27	0.24	0.26	0.25
Overall acceptability	I	0.98	0.91	0.87	-
	II	0.96	0.93	0.93	-

Group I : cold-smoked common carp samples; Group II: cold-smoked bighead carp samples

In our research moderate negative correlation between lightness (L*) and flesh colour as well as flesh texture and overall acceptability of cold-smoked common carp and cold-smoked bighead carp fillets was detected. Weak negative correlation between lightness (L*) and odour of cold-smoked common carp and bighead carp samples was determined.

Strong positive correlation between overall acceptability and odour, flesh colour and flesh texture of cold-smoked common carp and cold-smoked bighead carp samples was recorded.

Conclusion

Based on the sensory results, it was concluded that vacuum-packaged cold-smoked common carp samples remained acceptable for up to 15 days of storage, whereas vacuum packaged cold-smoked bighead carp samples remained unchanged until the end of the experiment.

Promena senzorskih svojstava ohlađenih hladno dimljenih fileta šarana (*Cyprinus carpio*) i hladno dimljenih fileta tolstolobika (*Hypophthalmichthys nobilis*) pakovanih u vakuumu

Jelena Babić Milijašević, Milan Milijašević, Slobodan Lilić, Jasna Đinović-Stojanović, Branka Borović, Jelena Jovanović, Aleksandra Nikolić

Rezime

Cilj ovog istraživanja bio je da se ispitaju promene senzorskih svojstava i instrumentalnih vrednosti boje (L*, a*, b*) hladno dimljenih fileta šarana (*Cyprinus carpio*) i hladno dimljenih fileta tolstolobika (*Hypophthalmichthys nobilis*) pakovanih u vakuum koji su čuvani na temperaturi od 3 ± 0.5 °C, kao i da se odredi održivost proizvoda. Senzorska analiza i instrumentalno određivanje boje rađeni su 1, 7, 10, 12, 14, 15 i 16 dana. Petnaestog dana eksperimenta, sva ispitivana senzorska svojstva hladno dimljenih fileta šarana ocenjena su statistički značajno nižim ocenama ($P < 0.05$). Poslednjeg dana eksperimenta ustanovljen je užegao miris koji je ocenjen kao neprihvatljiv, dok je boja fileta šarana bila slabije izražena i bila je na granici prihvatljivosti. Tekstura mesa šarana bila je meka, a na površini fileta je utvrđeno prisustvo sluzi. Iako je ustanovljen pad vrednosti ocena senzorskih svojstava dimljenih fileta tolstolobika, sva senzorska svojstva su bila prihvatljiva tokom eksperimenta. Značajno povećanje L* vrednosti ($p < 0.05$) tokom ispitivanja utvrđeno je kod obe grupe uzoraka, dok su vrednosti za udeo crvene (a*) i žute (b*) boje bile stabilne. Na osnovu ispitanih senzorskih svojstava može se zaključiti da su hladno dimljeni fileti šarana pakovani u vakuumu bili prihvatljivi 15 dana, dok su hladno dimljeni fileti tolstolobika pakovani u vakuumu bili prihvatljivi do kraja ispitivanja.

Ključne reči: hladno dimljena riba, opšta prihvatljivost, rok trajanja, instrumentalni parametri boje

Acknowledgement

Research was financed by Ministry of Education, Science and Technological Development of the Republic of Serbia, Agreement on the realization and financing of scientific research work in 2021. No. 451-03-9/2021-14/200050 from 05.02.2021.

References

BABIĆ MILIJAŠEVIĆ J. (2017): Pakovanje ribe u modifikovanu atmosferu-uticaj na održivost i bezbednost. Zadužbina Andrejević, Posebna izdanja, Beograd, pp. 47.

BUGUENO G., ESCRICHE I., MARTINEZ-NAVARRETE N., CAMACHO M., CHIRALT A. (2003): Influence of storage conditions on some physical and chemical properties of smoked salmon (*Salmo salar*) processed by vacuum impregnation techniques. Food Chemistry 81, 85−90.

CHOUBERT G., DENTELLA A.E., ATGIE´ C., BACCAUNAUD M. (2005): Effect of light on colour stability of sliced smoked rainbow trout Oncorhynchus mykiss fed astaxanthin. Food Research International 38, 949–952.
CIE (1976): Commission Internationale de l Eclairage, Colorimetry, 2nd ed., Vienna.
DONDERO M., CISTERNAS F., CARVAJAL L., SIMPSON R. (2004): Changes in quality of vacuum-packed coldsmoked salmon (*Salmo salar*) as a function of storage temperature. Food Chemistry 87, 543−550.
EN ISO 8586 (2014): Sensory analysis - General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors.
EN ISO 8589 (2010): Sensory analysis - General guidance for the design of test rooms.
ESPE M., KIESSLING A., LUNESTAT B., TORRISSEN O., RØRA, A. B. (2004): Quality of cold smoked salmon collected in one French hypermarket during a period of 1 year. Lebensmittel-Wissenschaft & Technologie 37, 627−638.
FLETCHER G.C., SUMMERS G., CORRIGAN V., CUMAARSAMY S., DUFOUR J.P. (2002): Spoilage of king salmon (*Oncorhynchus tshawytscha*) fillets stored under different atmospheres. Journal of Food Science, 67, 6, 2362-2374.
JOHNSTON I.A., ALDERSON R., SANDHAM C., DINGWALL A., MITCHELL D., SELKIRK C., NICKELL D., BAKER R., ROBERTSON B., WHYTE D., SPRINGATE J. (2000): Muscle fibre density in relation to the colour and texture of smoked Atlantic salmon (*Salmo salar L.*). Aquaculture 189, 335–349.
KILIBARDA N., BALTIĆ M., DIMITRIJEVIĆ M., KARABASIL N., TEODOROVIĆ V. (2009): The smoked fish-producing and quality. Proceedings of the 4th International Conference „Fishery", May 27-29, Belgrade, 296-306.
KOLODZIEJSKA I., NIECIKOWSKA C., JANUSZEWSKA E., SIKORSKI Z. E. (2002): The Microbial and Sensory Quality of Mackerel Hot Smoked in Mild Conditions. Lebensmittel- Wissenschaft & Technologie 35, 87−92.
LAKSHMANAN R., MISKIN D., PIGGOTT J. R. (2005): Quality of vacuum packed cold-smoked salmon during refrigerated storage as aff ected by high-pressure processing. Journal of the Science of Food and Agriculture 85, 655–661.
LEROI F., JOFFRAUD J., CHEVALIER F., CARDINAL M. (1998): Study of the microbial ecology of cold-smoked salmon during storage at 8 °C. International Journal of Food Microbiology 39, 111−121.
LEROI F., JOFFRAUD J., CHEVALIER F., CARDINAL M. (2001): Research of quality indices for cold-smoked salmon using a stepwise multiple regression of microbiological counts and physics-chemical parameters. Journal of Applied Microbiology 90, 578−588.
OLAFSDOTTIR G., CHANIE E., WESTAD F., JONSDOTTIR R., THALMANN C. R., BAZZO S., LABRECHE S., MARCQ P., LUNDBY F., HAUGEN J.E.

(2005): Prediction of microbial and sensory quality of cold smoked Atlantic salmon (*Salmo salar*) by electric nose. Journal of Food Science 70, 9, 563−574.
RIZO A., MANES V., FUENTES A., FERNANDEZ-SEGOVIA I., BARAT J.M. (2015): Physicochemical and microbial changes during storage of smoke-flavoured salmon obtained by a new method. Food Control 56, 195-201.
STATISTICAL YEARBOOK OF THE REPUBLIC OF SERBIA (2020): Belgrade, pp 224.
TRUELSTRUP HANSEN L., HUSS H. H. (1998): Comparison of the microflora isolated from spoiled cold-smoked salmon from three smokehouses. Food Research International 31, 10, 703−711.

Received 17 May 2021; accepted for publication 28 July 2021