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Effect of modified atmosphere pakaging on the shelf-life of common carp (*Cyprinus carpio*) steaks

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Abstract

The effect of modified atmosphere packaging (MAP 1: 40%CO_2+60%N_2 and MAP 2: 100%CO_2) on the shelf-life of carp steaks was studied. Carp steaks were stored at +3±0.5˚C and on days 1, 3, 6, 9, 13 and 15, microbiological, chemical and sensory testing was performed. Based primarily on odour scores it was observed that carp steaks packaged in MAP1 remained acceptable up to 13 days of storage, while carp steaks packaged in MAP2 remained unchanged until the end of the study. By using MAP, especially 100% CO_2, products shelf-life can be significantly prolonged.

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Keywords: Fish; shelf-life; total viable count (TVC); *Enterobacteriaceae*; pH; total volatile base nitrogen (TVB-N); sensory assesment

1. Introduction

The fish and fish products market is growing rapidly worldwide. One of the consumer demands is that fish entering the retail chain is deboned and ready for fast cooking[1]. Shelf-life of fresh chilled fish can be extended by

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packaging in vacuum or in modified atmosphere (MAP). Modified atmosphere packaging is achieved by removing air from the packaging unit and filling with a single gas or mixture of gasses. Gasseous mixtures with high carbon dioxide (CO_2) and nitrogen (N_2) concentrations were the most commonly studied by numerous researchers in the field of fish packaging in the last decade. However, modified atmosphere packaging of fish is not present on the Serbian market. The aim of this research was to monitor the changes in microbiological, chemical and sensory parameters in common carp (*Cyprinus carpio*) steaks packed in modified atmosphere during the 15 days of storage.

2. Materials and methods

In this study, two year old marketable carp (*Cyprinus carpio*) of average body weight of 2.5 kg were used. Carp originated from a fishpond where semi-intensive farming was used. Carp were transported live to the fish slaughtering and processing facility, where they were stunned, slaughtered, scaled, and carcasses were cut into steaks 2 cm thick. Two sample groups of carp steaks were formed and packaged in modified atmospheres with different gas ratios: MAP1: 40%CO_2+60%N_2 (I group) and MAP2: 100%CO_2 (II group). The machine used for packaging the carp steaks was Variovac (Variovac Primus, Zarrentin, Germany), and the packaging material was foil OPA/EVOH/PE (oriented polyamide/ethylene vinyl alcohol/polyethylene, Dynopack, Polimoon, Kristiansand, Norway) with low gas permeability (degree of permeability for O_2 – 3.2 cm^3/m^2/day at 23˚C, for N_2 - 1 cm3/m2/day at 23˚C, for CO_2 – 14 cm^3/m^2/day at 23˚C and for steam 15 g/m^2/day at 38˚C). The ratio gas : fish steak in the package was 2:1. All samples were stored in the same conditions at 3±0.5˚C and on days 1, 3, 6, 9, 13 and 15 of storage, microbiological, chemical and sensory testing was performed.

2.1. Microbiological analyses

Total viable count (TVC) was determined according to ISO 4833 -2:2003 (PCA Merck, Germany). Number of bacteria of the family *Enterobacteriaceae* was determined according to ISO 21528 -2:2004 (VRBD Merck, Germany). All plates were exsamined visually for typical colony types and morphological characteristics associated with each growth medium. Microbiological data were transformed into logarithms of the number of colony-forming units: $\log_{10}$ cfu/g.

2.2. Chemical analysis

Muscle pH was measured by Cyber Scan pH-510 digital pH-meter (EUTECH Instruments, Netherlands). The total volatile basic nitrogen (TVB-N) was determined using official steam distillation method according to Commission Regulation (EC) 2074/2005 and expressed as mg TVB-N/100 g.

2.3. Sensory evaluation

The sensory evaluation was performed by six trained panellists prior to the chemical analyses. 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. Product was defined as unacceptable if it achieved a score less than 2 points by at least of 50% of the judges.

2.4. Statistical evaluation

Results of the analyses were statistically evaluated using one-factor analysis in the ANOVA programme (Microsoft Office Excel 2007).

3. Results and discussion

Fig. 1 shows the effect of storage on growth rate of total viable count (a) and *Enterobacteriaceae* count (b) in carp steaks stored under modified atmosphere at +3±0.5˚C.

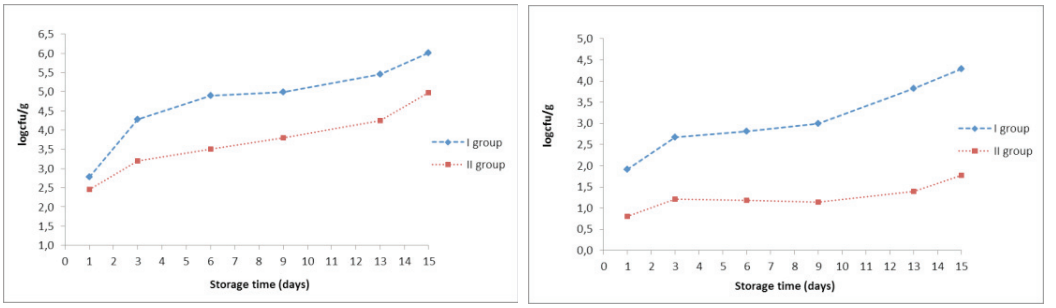

Fig. 1. (a) Changes in total viable count; (b) Changes in Enterobacteriaceae count.

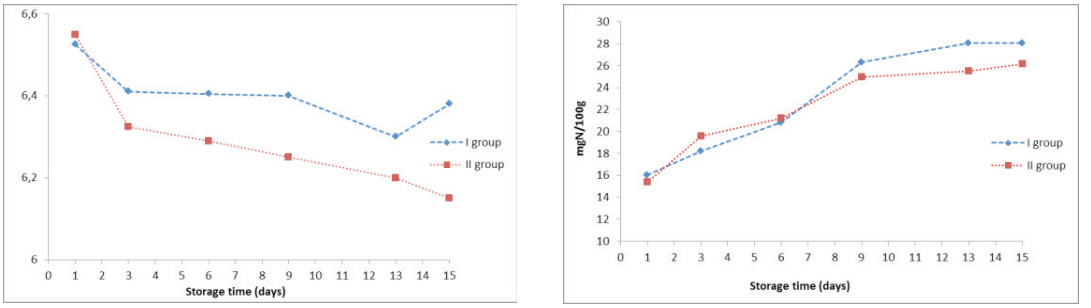

Fig. 2. (a) Changes in pH value; (b) Changes in TVB-N value.

The initial TVC values indicated good fish quality and good manufacturing practice. During the storage, TVC values increased in both groups of samples and on last day of the study had not reached value of 7 $\log_{10}$ cfu/g, which is considered as the upper acceptability limit for fresh fish[2]. The bacteriostatic effect of CO_2 was observed in our study, as these microorganisms showed slower growth, particularly in II group (100% CO_2; Fig. 1a). Studies on herring fillets[3] and filleted sardines[4] also showed that refrigerated storage under 100% CO_2 prolonged the microbiological shelf-life of these fish. Aerobic micro-organisms are generally sensitive to CO_2, therefore MAP delays the spoilage of fish.

In our study, the influence of MAP on reduction of *Enterobacteriaceae* growth rate was observed. The counts of *Enterobacteriaceae* in II group were significantly lower ($p < 0.01$) compared to I group (Fig. 1b). This can be explained by the higher concentration of CO_2 in II group of samples, as well as by fact that CO_2 has inhibitory effects primarily on gram-negative bacteria, such as microorganisms of the family *Enterobacteriaceae*. Arashisar *et al.*[5] established that growth-rate of aerobic mesophilic and psychrotropic bacteria, as well as enterobacteria, was the lowest in trout fillets packaged in atmosphere containing 100% CO_2 during their entire storage period.

Fig. 2 shows pH values (a) and TVB-N values (b) in carp steaks stored under modified atmosphere at +3±0.5˚C throughout the storage period.

We observed a decrease of pH value in both packaging groups during the storage period (Fig. 2a). The lower pH value in fish packaged in MAP with higher CO_2 rate was recorded by other authors[4,6,7] which is in accordance with the results of the present study. It is well known that CO_2 can be absorbed into the surface of fish muscle, acidifying it via the formation of carbonic acid[8]. Also, decreasing pH values can be explained by acid metabolic products created by different kinds of bacteria, primarily lactobacilli[9]. Moderate growth of the pH value at the end of storage

period of carp steaks from I group may be attributed to the higher quantity of basic compounds produced at this time by activity of fish spoilage bacteria[10], such as aerobic Gram-negative bacteria.

As shown in Fig. 2b, TVB-N values of carp steaks were affected by the atmosphere used and increased progressively with time of storage. Throughout the study, carp steaks in the gas mixture with lower content of CO_2 contained higher values of TVB-N. This can be explained by higher numbers of TVC in this group of samples, since TVB-N is produced mainly during bacterial decomposition of fish meat. According to Masniyom et al.[5], sea bass samples kept under a higher content of CO_2 showed lower TVB-N values and generally, the air packaged sea bass had higher TVB-N values compared with CO_2 enriched atmosphere sea bass throughout their storage period. The same observations were reported by Ordonez et al.[11] for hake stored under MAP which support the results of the present study.

All estimated sensory characteristics of carp steaks from I group received significantly lower ($p < 0.01$) scores on day 15. A "musty" odor of carp steaks from I group detected on day 15 caused the odor score to be lower then the acceptability limit of 2. By the last day of the study, a reduced intensity of pink cream colouring of carp muscle was observed as well as softened texture and surface slime among I group fish. No sensory changes of carp steaks samples from II group were detected throughout the storage period. (results not shown).

4. Conclusion

Based primarily on odour scores, it was concluded that fresh carp packaged in an atmosphere containing 40% CO_2 and 60% N_2 remained acceptable up to 13 days of storage, while fresh carp packaged in an atmosphere containing 100% CO_2 remained unchanged until the end of the study. By using MAP, especially 100% CO_2, products shelf-life can be significantly prolonged.

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