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Effect of vacuum packaging on the shelf-life of silver carp (*Hypophthalmichthys molitrix*) fillets stored at 4 °C

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ABSTRACT

This study was carried out to evaluate the chemical changes, microbial load and sensory attributes of silver carp (*Hypophthalmichthys molitrix*) fillets when packaged at two vacuum levels (30 and 50 kPa) and stored at 4 °C for 14 days. The fillets packaged at 30 kPa had significantly lower pH values and total volatile basic nitrogen (TVBN) contents than those packaged at 50 kPa and normal atmospheric pressure (control). The increase in viable bacterial population was significantly lower in samples packed at 30 kPa and the control. The results of sensory evaluation and electronic nose (E-nose) analyses showed good agreement with the results obtained from chemical and microbial analyses. Both vacuum levels combined with refrigerated storage resulted in an extension of the shelf-life of fillets; up to 11 days at 30 kPa, 9 days at 50 kPa compared to 6 days in control samples. The headspace vacuum level of 30 kPa combined with storage at 4 °C was found to significantly slow down the undesirable chemical changes, retard the lipid oxidation, improve the sensory attributes and extend the shelf-life of silver carp fillets.

1. Introduction

Carp is one of the most widely cultured and traded species all over the world due to its fast growth rate, easy cultivation, high feed efficiency ratio and high nutritional value. In China, the silver carp (*Hypophthalmicthys molitrix*) species is extensively cultured. Statistical data show that 3,713,900 tons of silver carp were caught in China in 2011 which accounted for 30.9% of the harvested fish (Li, Hu et al., 2012; Li, Li et al., 2012; Li, Sinclair & Li 2011; Shi, Cui, Yin, Luo, & Zhou, 2014).

Freshness is one of the main quality attributes for processing, marketing and consumption of fish. Fish is increasingly becoming the favored food of people in many countries as it is rich in proteins. However, the disadvantage associated with broader consumption of fish products is their comparatively short shelf-life (Morsy et al., 2016). The inherent susceptibility to deterioration of fish and fish products makes them more susceptible to food-borne hazards. Therefore, effective methods for extending shelf-life and improving quality of fresh silver carp fillets are necessary. Fresh fish is highly perishable due to its biological composition. The short shelf-life of fresh fish and fish products is brought about biological reactions such as lipid oxidation, enzymatic and microbial activities (He & Xiao, 2016; Ojagh, Rezaei, Razavi, & Hosseini, 2010). The spoilage of fish is a complicated process in which activities of the fish's own enzymes and chemical reactions are usually responsible for the initial loss of freshness, whereas the metabolic activities of microorganisms are involved in the whole spoilage (Ramezani, Zarei, & Raminnejad, 2015). It has also been documented that freshness is difficult to be clearly defined and accurately measured because it involves many factors (Huang, Zhao, Chen, & Zhang, 2014). The freshness quality features include a series of parameters related to safety, nutritional quality, and edibility, all of which can be affected by handling, processing and storage procedures from the catch to the consumers (Cheng, Sun, Zeng, & Pu, 2014).

A number of methods have been used to assess fish freshness. Sensory evaluation and chemical methods including evaluation of total volatile basic nitrogen and microbial assay are three key methods of assessing freshness in fish. Researchers have been studying the potential of using the electronic nose (E-nose) as a non-destructive method for evaluating the freshness of pork

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(Huang et al., 2014). E-noses refer to gas sensors that measure the ambient gas atmosphere based on the general principle that changes in the gaseous atmosphere alter the sensor properties in a characteristic way (Papadopoulou, Panagou, Mohareb, & Nychas, 2013). In recent years, E-Nose comprised of metal oxide semiconductor (MOS) gas sensors or biosensors has been widely studied in different research fields such as air contaminant detection, food analysis, medical diagnosis, and explosion detection (Zhang, Tian, & Pei, 2014).

It is looking more likely that human beings are going to face worldwide food shortage in future. Food waste is one of the important causes of this crisis. Therefore, preserving food for longer time is very important from food security perspective. In this regard, vacuum storage has gained considerable attention due to its effectiveness in preserving freshness of foods. Vacuum packaging is widely used in the food industry because of its relatively low cost and effectiveness in reducing oxidative reactions in the products (Mbarki, Ben Miloud., Selmi, Dhib, & Sadok, 2009). Vacuuming process removes oxygen from the headspace of a product and reduces the oxidation reaction thereby contributes to the freshness of oxidation sensitive products such as fish fillet (Zaragozá et al., 2012).

The aim of this study was to evaluate and understand the effect of different vacuum treatments (30 Kpa and 50 Kpa) on the quality of silver carp fillets in order to establish an effective vacuum storage. The effects of different vacuum treatments on the quality of silver carp fillets were studied by evaluating the physiochemical and microbial changes as well as determining total volatile basic nitrogen (TVB-N) of fillets during vacuum refrigerated storage.

2. Materials and methods

2.1. Sample preparation

Fresh silver carp was purchased from a local fish market. The fish was kept in ice throughout transportation to the laboratory. The fish was hand-filleted using knives and cut into 2–3 cm cubes. The cutting boards were cleaned using dish washing detergent and then rinsed with 1% chlorinated water (sterile water). These fillets were packed under 2 vacuum (50 kPa and 30 kPa) in fresh keeping boxes and refrigerated at 4 °C for 2 weeks. The control sample was placed in the same refrigeration condition (4 °C) without vacuuming. Sensory, chemical and microbiological analyses were carried out at 0, 2, 4, 6, 8, 10, 12, and 14 days. After image acquisition, microbiological tests were implemented immediately to determine the total viable counts in each sample using standard plate count method.

2.2. Measurement of pH

Approximately 5 g of grounded fish muscle samples was homogenized in 90 mL of 7.4% KCl solution and pH value of the homogenate was measured using a laboratory pH meter (PB-11, Satorius) standardized at pH 4.01 and 6.86. pH tests were carried out every two day of the experiment from day zero to day 14.

2.3. Determination of color parameters

The color parameters of the fillet samples were determined in triplicate on the medial surface (bone side) of fillets. The bone side was used to avoid discolorations of the fillet surface. L* (lightness), a* (green to red) and b* (blue to yellow) of CIELAB color space system were measured with a portable colorimeter (Minolta Chroma Meter Model CR-300) using a D65 standard illuminant and a 10° standard observer according to (O'Sullivan & Kerry, 2013). These tests were carried out in triplicate.

2.4. Determination of total volatile base nitrogen (TVB-N)

TVB-N content in the sample was measured by a stream distillation method (http://www.sciencedirect.com/science/article/pii/S0308814609011844Goulas & Kontominas, 2005). The surface fat was removed from the sample, and then each sample was ground using a meat grinder with 4 mm diameter holes. The ground fish muscle (10 g) was transferred into a beaker, blended with 100 mL distilled water, and held still for 30 min. The beaker was shaken briefly at every 10 min during holding. This blend was centrifuged at 3000 rpm for 10 min. The supernatant was filtered through a filter paper. About 5 mL of the filtrate was taken out and mixed with 5 mL of 10 g/L magnesium oxide (MgO). Steam distillation was performed using Kjeldahl distillation unit (Shanghai Jianqiang glass Co., China) for 5 min. The distillate was absorbed by 10 mL of 20 g/L boric acid, and then titrated with 0.1 mol/L HCl. Results were expressed as TVB-N mg N/100 g, respectively.

2.5. Sensory evaluation

The sensory evaluation of the fillet samples was carried out by a 7 semi-trained member panel. Sensory assessment included the color, odor and texture using a 5-point scale (5 = the best and 1 = the worst). The specifications for each quality parameter were defined according to Michalczyk et al. (2008) developed for grading fishery products (Howgate et al., 1992). Prior to the analysis, the panel was trained according to Polish Standard (1996). The panel scores for each quality attribute were averaged. The mean value for each attribute is reported as an overall sensory score. The lowest limit of acceptability was 3.5.

2.6. Total viable count (TVC)

Microbiological tests were carried out at storage days of 0, 2, 4, 6, 7, 8, 10, 12, and 14. One fillet sample was removed from the package on each specified day and cut aseptically. These prepared samples were transferred into individual sterile Petri dishes in order to avoid contamination during image acquisition. The total viable cell count of each sample was measured using the standard spread plate method (Yao-Ze Feng, 2013). Each fish sample was put into 90 mL buffered peptone water (BPW). This mixture was then homogenized to produce initial dilution. Serial dilutions were also made by adding 1 mL of suspension into 9 mL BPW. Subsequently, 0.1 ml aliquots of appropriate dilution were inoculated onto prepared plate count agar and spread homogeneously on the agar surface. After setting, the plates were inverted and incubated at 37 °C for 48 h. All the colonies appearing on the plates were counted. The reported colony count data only involved plates where the number of colonies was between 25 to and 250. The microbial load is reported as $\log_{10}$ CFU per gram sample (http://www.sciencedirect.com/science/article/pii/S0308814609011844Arashisara, Hisara, Kayab, & Yanik, 2004; Khalid, 2007). These experiments were performed in triplicate.

2.7. E-nose analysis of volatile compounds

The aromas profiles of fish fillet samples stored under different vacuum conditions were measured using an E-nose instrument (ISENSO INTELLIGENT., China). Many metal oxide semiconductor sensors combined with pattern recognition algorithms were used to construct the intelligent bionic olfactory (E-nose) system. This E-nose instrument was comprised of three components: (1) gas injection and sampling system (2) sensor array (3) intelligent pattern