Innovative Food Science and Emerging Technologies 12 (2011) 104–110

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

journal homepage: www.elsevier.com/locate/ifset

The effect of different high pressure conditions on the quality and shelf life of cold smoked fish

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ARTICLE INFO

Article history:
Received 12 April 2010
Accepted 9 December 2010

Editor Proof Receive Date 07 January 2011

Keywords:
Cold smoked salmon
High pressure treatment
Quality
Shelf life

ABSTRACT

Cold smoked salmon were HP treated at 220, 250 and 330 MPa, at 3, 7, 15 and 25 °C for 5 and 10 min. The influences of such treatments on some quality parameters (the changes of colour, TBA and TMA values) were studied. These parameters were determined for cold smoked salmon suitable combinations (at 220–250 MPa, 3 °C for 5 min, at 330 MPa, 15 °C for 5 min and at 250 MPa, 25 °C for 10 min). In the second stage the shelf life of cold smoked salmon HP treated at 250 MPa, 3 °C for 5 min and at 250 MPa, 25 °C for 10 min and stored at 2 °C was investigated by measurement of sensory, chemical and microbiological analyses. Based on the sensory and microbiological results, the control samples were acceptable only up to 6 weeks, compared to 8 weeks in HP treatment cold smoked salmon samples, extending the shelf-life by 2 weeks.

Industrial relevance: Little information exists on the effects on physical and biochemical characteristics and shelf life of HP-treated cold smoked samples, compared to other preserved methods. This paper illustrates the changes induced in cold smoked salmon flesh by pressurization at different conditions. HP treatment significantly changed the sensory, chemical and microbiological properties of cold smoked salmons, and in combination with adequate chilled storage, can improve the shelf-life and safety of cold smoked salmons.

1. Introduction

Smoking is one of the oldest means of preserving fish and meat. The preservative effect is due to the presence of some antimicrobial compounds in smoke such as phenols and formaldehyde (Tülsner, 1994). Cold-smoked fish is of considerable economic importance worldwide particularly in Europe. This foodstuff is produced by a light salting and smoking process and is typically consumed as ready-to-eat with no heat treatment. Information on quality and shelf life of cold smoked fish stored in refrigerator is available in literature. Cold smoked fish, usually stored at chilled temperature, is very sensitive to deterioration and, based on sensory evaluation, has a limited shelf life often 2–4 weeks, though it may be up to 6 weeks (Rorvik, Yndestad, & Skjerve, 1991; Kolsarıcı & Özkaya, 1998; Dondero, Cisternas, Carvajal, & Simpson, 2004).

In recent years, studies have focussed on new preservation methods aimed at extending the shelf-life and improving the quality of smoked fish products. High pressure (HP) technology is relatively new to food industry and is more and more considered as an alternative to traditional preservation methods like heat processing. Inactivation of bacteria, spores, and virus has been demonstrated (Thakur & Nelson, 1998; Yuste, Capellas, Pla, Fung, & Mor-Mur, 2001). However, in complex matrices like food the desired effect of e.g. microbial inactivation may also produce physical and biochemical changes which may affect the product properties in a negative manner. Undesirable physicochemical changes can be monitored by colour, texture and thiobarbituric acid analysis (Erkan & Üretener, 2010; Erkan, Üretener, & Alpas, 2010). The suitable selection of the processing parameters temperature, time and pressure can ensure that the processing goal is reached without extensive detrimental effects (Heinz & Bukow, 2010). High pressures have been employed of late to preserve various smoked fish species (Lakshmanan, Miskin, & Piggot, 2005; Gómez-Estace, Gómez-Guillén, & Montero, 2007). Nevertheless, application of high pressures to smoked fish is a recent development, and as a consequence the literature is limited.

This study was conducted in two stages. First, the effects of a variety of treatments (different pressure levels, hold times and temperature combinations) on cold-smoked salmon were evaluated in order to determine the conditions which give optimum quality attributes in terms of colour, trimethylamine nitrogen (TMA-N) and thiobarbituric acid (TBA) values, relative to controls. Two combinations were selected for further

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doi:10.1016/j.ifset.2010.12.004

study. Quality attributes, based on sensory, chemical and microbiological changes, were evaluated during storage of the salmon for 8 weeks at 2 °C.

2. Materials and methods

2.1. Samples

Cold smoked salmon fillets were purchased from Alarko-Leröy, Company in Kocaeli (Turkey). Samples in ice boxes were transported to the laboratory within 6 h. This study took place in two stages. Three kilograms of samples (15 fillets) was used for the experiment in the first stage. The fish were divided into portions of equal weight (15 g). The samples were covered with flexible plastic films to avoid direct contact between the samples and pressure transmitting fluid. Then they were pressurized at 220, 250 and 330 MPa at 3, 7, 15 and 25 °C for 5 and 10 min. Colour (L*, a* and b* value) was measured in all samples. Samples were frozen to −30 °C until use for TMA-N and TBA value measurement. Colour and TBA analysis results that were considered collectively (control sample close to the value L*, a*, b* and control sample close to the value or lower TBA values based) for cold smoked salmon HP application for the best combination were determined.

Two batches were prepared to study the behaviour of both the pressurized and the unpressurized cold smoked salmon during chilled storage (second experiment). Six kilograms of samples (30 fillets) was used for the second experiment. Samples was pressurized at 250 MPa, 3 °C, for 5 min and at 250 MPa, 25 °C for 10 min and then stored at 2 °C, and the other batch (No HP) was stored directly at 2 °C without undergoing high pressure treatment. After treatment, samples were stored for 8 weeks at 2 °C. Samples were placed into oxygen permeable bags for the storage study.

2.2. HHP treatment

HHP treatments were performed in a designed and constructed laboratory-scale unit (capacity: 30 cm^3, maximum pressure: 500 MPa). Water was used as the pressure-transmitting medium. The equipment consists of a pressure chamber of cylindrical design, two end closures, a means for restraining the end closures, a pressure pump and a hydraulic unit to generate high pressure for system compression, and also a temperature control device. The pressure vessel was made of hot galvanized carbon steel and piston was hard chrome-plated and polished to mirror finish (steel-type heat-treated special K) which was processed into the required sizes at the Electrical and Electronic Engineering Department of Middle East Technical University (Ankara, Turkey). The liquid was heated prior to pressurization to the desired temperature by an electrical heating system surrounding the chamber. Time to reach the desired pressure and also for decomposition was approximately 5–10 s for the system.

2.3. Analyses

2.3.1. Physical analyses

2.3.1.1. Colour analyses. The colour of the fish samples was determined with the help of a Konica Minolta chromo meter (model CR 400/410; Minolta, Osaka, Japan). L^* (brightness), a^* (+a, red; −a, green) and b^* (+b, yellow; −b, blue) values were measured. The colourimeter was calibrated using white references (CR-A44). The colour was measured on homogenates prepared from ten fish fillets. The homogenate was placed in plastic petri dishes and the colour measurement was repeated 10 times. Averages and standard deviations of L^*, a^* and b^* values were calculated as the total colour differences. The total colour difference (ΔE), as calculated below, was also used for evaluation, $\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2}$ where ΔL^*, Δa^* and Δb^* are the differences of the L^*, a^* and b^* values between the treated samples and control (Gerdes & Santos Valdez, 1991).

2.3.2. Chemical analysis

2.3.2.1. Measurement of pH. One gram of each sample was blended with 10 mL distilled water. The pH of the fish homogenate was measured using a digital pH meter Hanna pH 211 Microprocessor pH meter (HANNA Instruments, Michigan, USA), standardized at pH 4.0 and 7.0 (Erkan, 2007).

2.3.2.2. Measurement of thiobarbituric acid value (TBA). The thiobarbituric acid value (TBA) was determined colourimetric by the method of Erkan and Özden (2008). A portion (500 mg) of sample was weighed into a 50 mL volumetric flask. An aliquot (45 mL) of a 5% (w/v) solution of TCA and 100 μL butylated hydroxytoluene was added and in an Ultra-Turrax, homogenised at high speed for 2 min. The mixture was filtered through a Whatman No. 1 filter paper. A portion (5.0 mL) of the mixture that was pipetted into a dry stoppered test tube 5 mL of TBA reagent (0.02 M of the solution of 2-thiobarbituric acid in 90% acetic acid) was added. The test tubes were stoppered, vortexed and placed in a water bath at 80 °C for 30 min, then cooled. Absorbance was measured at 532 nm against water blank. The concentration of MDA was calculated from a standard curve using 1,1,3,3-tetraethoxy-propane (TEP) as the standard compound. TBA values were expressed as mg of malondialdehyde (MDA)/kg of sample.

2.3.2.3. Measurement of trimethylamine nitrogen (TMA-N). TMA-N was determined by the method of AOAC (1998). Homogenised samples (10 g) were weighed, blended with 90 mL of 7.5% trichloroacetic acid (TCA) solution and filtrated. Blended solution was fixed with formaldehyde (20%). Four millilitres of extract was transferred into test tubes and 1 mL formaldehyde, 10 mL anhydrous toluene and 3 mL KOH (20 %) solutions were added. The tubes were shaken and 5 mL toluene layer was pipetted. Five millilitres of picric acid working solution (0.02%) was added. The contents were mixed and transferred to a spectrophotometric cell. Absorbance at 410 nm against the blank was measured. The concentration of TMA-N was calculated from a standard curve using trimethylamine hydrochloride as the standard compound. Results of TMA-N were expressed as mg per 100 g of muscle.

2.3.2.4. Measurement of total volatile basic nitrogen (TVB-N). Total volatile basic nitrogen (mg TVB-N/100 g) was determined according to the method of Antonacopoulos and Vyncke (1989). For total volatile basic nitrogen (TVB-N), fish muscle (10 g) was homogenised with 6% perchloric acid (90 mL) for 1 min in an Ultra-Turrax. The homogenates were filtered through a filter paper (Whatman no 1) and filtrates alkalized by NaOH (20%) before distillation duplicate filtrates were distilled in a Velp Marka (Model UDK 140, Milan, Italy)

Table 1
Sensory scale.

Attributes/quality	7–9 = very good	6–6.9 = good quality	5–5.9 = acceptable quality	4.9–1.0 = spoiled
Appearance	Pink, translucent	Pink, moist, translucent	Pale pink or orange	Many pale pink or orange
Odour	Pungent smoky, salty	Smoky salty	Metallic	Rancid
Taste	Pungent smoky, salty	Smoky salty	Metallic	Rancid
Texture	Soft	Mild soft	Neutral	Loose