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Quality assessment of *Scomber colias japonicus* under modified atmosphere and vacuum packaging

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Abstract

The effect of initial head-spaces of atmospheric air, vacuum and modified atmospheres packaging (50% CO_2/50% N_2) on microbiological, physicochemical and sensory changes of chub mackerel (*Scomber colias japonicus*) was studied at 3 and 6 °C. The microbial flora of chub mackerel comprised mainly lactic acid bacteria, *Brochothrix thermosphacta* (Gram-positive flora) and secondly pseudomonads, *Shewanella putrefaciens*, *Enterobacteriaceae* (Gram-negative bacteria). The spoilage of chub mackerel stored under modified atmosphere was delayed compared with those samples stored under vacuum or air. The concentrations of moisture, ash, protein, fat and polyunsaturated fatty acids were not affected during the storage period compared to the pH values and the concentrations of lactate and ammonia that showed significant differences.

Keywords: Spoilage indicators; Microbial flora; Chemical parameters; PUFA; Mediterranean chub mackerel

1. Introduction

Coyne, as early as 1933, had stated that high CO_2 concentrations can reduce microbial growth and may therefore extend the shelf-life of food products. Regularly, fish stored in aerobic conditions have been spoiled by Gram-negative organisms, primarily *Shewanella putrefaciens* (SP). Technological aspects of modified atmosphere packaging (MAP) have since been studied (Dainty & Mackey, 1992). In CO_2-packed fish, the growth of SP is strongly inhibited. In contrast, the Gram-negative organism *Photobacterium phosphoreum* has been identified as the organism responsible for spoilage (Dalgaard, Mejlholm, Christiansen, & Huss, 1997). MAP in combination with refrigeration has proved to be an effective preservation method for the extension of shelf-life and quality retention of a large variety of fresh chilled food products like red meat, poultry, fruits, vegetables, bakery products, fresh pasta, fish and fish products (Brody & Marsh, 1997; Davies, 1997). Seafood, unlike other muscle foods, is very susceptible to both microbiological and chemical deterioration (Pastoriza, Sampedroo, Hherrera, & Cabo, 1996). Spoilage begins as soon as the fish dies or is caught. It is the result of a series of complicated changes brought about in the dead fish mainly by bacteria and enzymes. The shelf-life of fish products in MAP can be extended depending on raw material, temperature, gas mixtures and packaging materials (Davies, 1997). In the literature, there are numerous studies on the effect of MAP on fish and fish products (Bak, Andersen, Andersen, & Bertelsen, 1999; Goulas, Chouliara, Nessi, Kontominas, & Savvaidis, 2005; Hoz, Lopez-Galez, Fernandez, Hierro, & Ordonez, 2000; Lopez-Caballero, Goncalves, & Nunes, 2002; Ozogul, Polat, & Ozogul, 2004; Ruiz-Capillas & Moral, 2001).

Chub mackerel demonstrates an exceptional nutritional value in the human diet being rich in minerals, vitamins and polyunsaturated fatty acids (PUFA) (Karakoltsidis, Zotos, & Constantinides, 1995). These fatty acids are

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biologically important and have been associated with a decreased risk of cardiovascular disease (Kromhout, Bosschiter, & Lezenne, 1985). In Greece, chub mackerel is usually marketed as fresh chilled in ice or as processed, i.e. salted-smoked or canned. The annual quantities of fresh (1215 and 376 tons) and processed (1413 and 408 tons) chub mackerel consumed in Greece in the years 1998 and 2003 respectively, classify it as one of the most popular seafood species (Stamatis, Monios, Stergiou, Petrou, & Kallianiotis, 2005). Moreover the shelf-life of refrigerated chub mackerel is estimated as approximately 7 days, thus research on new preservation methods focusing on shelf-life extension is required. In the literature, there is very limited information on the effect of MAP on chub mackerel preservation. Therefore, the objective of the present work was to study the effect of MAP and vacuum packaging (VP) on the shelf-life and quality retention of chub mackerel stored at 3 and 6 °C, using microbiological, physicochemical and sensory parameters as quality indicators.

2. Materials and methods

2.1. Preparation and storage of samples

Fresh chub mackerel was obtained from the local fish pier in Kavala, Greece and transported to the laboratory within 15 min in ice. In the laboratory, fish were filleted and packed under a modified atmosphere (50% CO_2/50% N_2) in Suprovac polyamide laminate bags (thickness 90 μm, gas permeability cm^3/m^2 d bar at 20 °C, 50% RH ca. 25, 90 and 6 for CO_2, O_2 and N_2 respectively; Flexopack, Koropi, Athens, Greece), with a vacuum packaging machine (Henkovac 1502, The Netherlands). Also identical fish samples were vacuum and air (control) packaged. All pouches were heat-sealed. The average weight of the fillets was 60 g and the gas volume in the bag was ca. 300 cm^3. The samples of all treatments were stored at 3 ± 0.5 and 6 ± 0.5 °C for 15 days. Two replicated experiments were conducted and two pouches were analyzed on each sampling occasion. Thus each number in figures and tables is the average of four values.

2.2. Microbiological analysis

Fish fillets (25 g) were aseptically placed into a sterile stomacher bag containing 225 ml of sterile 1/4 Ringer's solution with NaCl (0.85%, w/v) and homogenized for 1 min in a Seward 400 Stomacher (Seward Medical UAC House, London, UK). Samples (0.1 ml) of decimal serial dilutions of fish homogenate were spread on the surface of the appropriate dried media in Petri dishes for enumeration of: total viable count (TVC) on plate count agar (PCA, Oxoid code CM 325) incubated at 20 °C for 4 days; pseudomonads (Ps) on cetrimide fusidin cephaloridine agar (CFC, Oxoid code CM 559, supplemented with SR 103) incubated at 20 °C for 2 days; *Brochothrix thermosphacta* (BrT) on streptomycin sulphate thallous acetate cycloheximide (actidione) agar (STAA, Oxoid CM 881, supplemented with SR 151), incubated at 20 °C for 3 days. For *Enterobacteriaceae* (Ent), lactic acid bacteria (LAB) and hydrogen sulphide-producing bacteria (HSB) enumeration, samples (1.0 ml) of decimal serial dilutions were inoculated into 10 ml of molten (45 °C) violet red bile glucose agar (VRBGA, Oxoid code CM 485), MRS medium Lactobacillus de Man Rogosa Sharpe agar, Oxoid code CM 361 and iron agar (IA, Oxoid code CM 867), respectively. After setting, a 10 ml overlay of molten media was added and plates were incubated at: 30 °C for 24 h for VRBGA plates; 25 °C for 5 days for MRS plates; 20 °C for 4 days for iron agar plates.

Three replicates of at least three appropriate dilutions were enumerated. All plates were examined 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 (CFU g^{-1}).

2.3. Chemical analysis

The pH value was determined with a pH meter (WTW 526, Germany), the glass electrode being applied directly to the flesh. Crude protein ($N \times 6.25$)-, total lipid-, moisture-, and ash-content were determined by the methods described in the AOAC manual (AOAC, 1975). For ammonia and lactic acid analysis 10 g fish flesh was treated as described by Drosinos, Lambropoulou, Mitre, and Nychas (1997). Lactic acid was assayed enzymatically by the method described by Gawehn (1984) and ammonia was determined colorimetrically by the method of Chaney and Marbach (1962). For fatty acid analysis, lipids were extracted from the homogenized fresh edible portion by the Bligh and Dyer (1959) method and were further prepared for fatty acid analysis according to the procedure of Kates (1972). Methyl esters were prepared by saponification with 0.5 N NaOH and methylation with 14% boron trifluoride-methanol (Metcalfe, Schmitz, & Pelka, 1966). Fatty acid methyl esters were analyzed by a Hewlett Packard (5890-Series II) gas chromatograph, separating at 177 °C, 18 min hold time and 2.3 °C/min to 210 °C and equipped with a flame ionization detector. The capillary column SGE-BPX 70 (50 m × 0.22 mm × 0.25 μm) was used with helium as carrier gas and nitrogen (auxiliary gas) flow rate at 36 ml/min, hydrogen at 30 ml/min and compressed air at 330 ml/min. For peak identification, solutions of reference substances were analyzed under the same conditions and their retention times (RT) and chromatograms were compared to those of samples. The contribution of each identified compound was expressed as the percentage (%) of its peak area to the total area of all peaks eluted in each chromatogram. The precision of the results was always better than ±5%. For statistics on chromatograms the HP GC-Chem Station, Rev. A. 06.03 [509], 1990–1998 software was used.