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Retention of shelf life and microbial quality of seer fish stored in modified atmosphere packaging and sodium acetate pretreatment

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ABSTRACT

Preliminary shelf life tests were performed to select the best gas composition and the best sodium acetate concentrations in the modified atmosphere. Bacterial quality assessment was carried out by the monitoring of total aerobic bacteria, H_2S producing bacteria, lactic acid bacteria, pseudomonads, Enterobacteriaceae, *Staphylococcus aureus*, streptococci, sulphite reducing clostridia and botulinum toxin by mouse bioassay. Bacteria grew most quickly in seer fish stored in air, followed by those in MAP and the lowest counts were with MAP pre-treated with sodium acetate. The application of sodium acetate treatment to seer fish steaks resulted in a bacteriostatic effect, contributing to the improvement of the microbiological quality of seer fish steaks. There was less trimethylamine in the modified atmosphere packed samples pretreated with sodium acetate than in air packed samples by the factor of seven, at the end of the shelf life. Modified atmosphere packaging alone increased the shelf life from 8 (air pack) to 22 days; however, addition of sodium acetate further extended the shelf life to 28 days. The results showed that the combined effect of MAP (70 vol.% CO_2:30 vol.% O_2) and sodium acetate (1%, w/v) is a valuable tool to allow an effective extension of the shelf life of raw fish products.

1. Introduction

Fresh fish and many fishery products are highly perishable food items and the shelf life of such food is restricted in the presence of oxygen and the growth of aerobic spoilage microorganisms (Ozogul, Polat, & Ozogul, 2004). MAP technique could offer enhancement in fish and fishery products shelf life with minimal quality defect (Mendes, Pestana, & Goncales, 2008). Modified atmosphere containing CO_2 with refrigeration are effective in extending the shelf life of many foods (Fernandez, Aspe, & Roeckel, 2009; Ioannis et al., 2011; Yesudhason, Srinivasa Gopal, Ravishankar, Lalitha, & Ashok Kumar, 2009; Zakrys-Waliwander, O'Sullivan, O'Neill, & Kerry, 2012). However, one major concern is the inhibition of aerobic spoilage micro flora and the possible growth of psychrotropic food pathogens,

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which may result in food becoming unsafe for consumption before it appears to be organoleptically unacceptable (Sivertsvik, Jeksrud, & Rosnes, 2002).

CO_2 atmospheres extend the lag phase and generation time of aerobic bacteria decreasing the growth rate and extending shelf life (Mastromatteo, Danza, Conte, Muratore, & Nobile, 2010; Sivertsvik et al., 2002; Yesudhason, Srinivasa Gopal, Ravishankar, Lalitha, & Ashok Kumar, 2010). The inhibition of bacterial growth in food packaged with CO_2 increases as the storage temperature decreases (Reddy, Armstrong, Rhodehamel, & Kautter, 1992). It has been found that it exhibits an inhibitory effect, mainly against Gram negative micro organisms (Blixt & Borch, 2002). Generally, spoilage flora is replaced probably to a large extent, by CO_2 resistant organisms, e.g. lactic acid bacteria and *Brochotrix thermophacta* (Dalgaard, Munoz, & Mejlholm, 1998; Stamatis & Arkoudelos, 2007). The use of gas packaging, specifically elevated CO_2 levels have been shown to inhibit normal spoilage bacteria such as pseudomonads, *Alteromonas, Shweanella, Moraxella* and *Acinetobactor* in fish from cold and temperate waters (Hubbs, 1991) and thus double or triple shelf life (Arkoudelos, Stamatis, & Samaras, 2007; Fernandez, Aspe, & Roeckel, 2010; Mohan, Ravishankar, Srinivasa Gopal, Lalitha, & Asok Kumar, 2010; Ozogul, Ozyurt, Ozogul, Kuley, & Polat, 2005).

The preservation of all foods in industrialized and developing countries is based on combinations of several factors that secure microbial safety, stability and sensory quality. The hurdle concept is widely accepted as a food preservation strategy, its potential, using MAP has still to be fully realized (Devlieghere, Vermeiren, & Debevere, 2004). Besides the modified atmosphere packaging effect, the extension of shelflife can also achieved by the addition of diverse additives to fish. Recent years there has been increasing interest using additives such as sodium acetate and sodium lactate. Sodium acetate is an approved (USFDA) flavoring and pH control agent for foods. Previous studies reported the antimicrobial ability of different percentages of sodium acetate in various meat and seafood (Blom et al., 1997; Manju, Jose, Srinivasa Gopal, Ravishankar, & Lalitha, 2007; Muhlisin et al., 2013; Rajesh, Ravishankar, Sriniasa Gopal, & Varma, 2002). Combination of MAP and sodium acetate have improved the shelf life and quality of fish. Manju et al. (2007) reported that vacuum-packaging in combination with sodium acetate, was found to delay the spoilage and extended the shelf life of Pearl spot at refrigeration temperatures. Sallam (2007) and Mohan et al. (2010) reported that sodium acetate significantly lowers the population of aerobic microorganisms and effective in controlling growth of major spoilage bacteria. Studies on the effect of MAP in combination with sodium acetate on the quality of seafood are still limited. Therefore, this study was conducted to evaluate the combined effect of modified atmosphere packaging and sodium acetate on the retention of shelf life and microbial quality of seer fish steaks stored at 0–2 °C.

2. Materials and methods

2.1. Sodium acetate treatment and packaging of seer fish

Fresh seer fish (*Scomberomorus commerson*) were purchased from the fish landing center in Cochin, Kerala, India. The fish samples were then washed with water and transported to the laboratory in ice (0–2 °C). With in 30 min of arrival, seer fish were beheaded, gutted and cut into steaks weighing 100–110 g using a sterile stainless steel knife. The treatment solution of (1%, w/v) sodium acetate (Merck, Darmstadt, Germany) was prepared in pre-chilled (4 °C) water.

2.2. Experimental design

The whole seer fish steaks were then divided into three batches and packaged as follows: Batch I air pack, Batches II and III were packed under the modified atmosphere with high-density polyethylene thermoformed trays (Dimension of 540 mm × 400 mm × 430 mm and thickness of 0.5 mm). Trays were sealed in a Dyno 500 VG packaging machine (Dynopack, Kristiansan, Norway) with a flexible packaging film of low-density polyester (12 μm) laminated with low-density polyethylene (75 μm). The final gas/fish ratio in all trays was about 2:1 (v/w) for MA packaging conditions. A MAP Gas Mix 9000 (PBI Dansensor, Ringsted, Denmark) was used to adjust the gas compositions. The gas composition of 70% CO_2/30% O_2 was selected to pack the seer fish steeks based on our initial study and the gas mixtures evaluated were 40–70% CO_2, 30–60% O_2 and 30% N_2 along with a control. Sensory evaluations was conducted by an untrained panel ($n = 7$). Seer fish steaks with a gas mix of 70% CO_2/30% O_2 showed a better shelf life based on the sensory evaluation; and thus, it was selected for the modified atmosphere packaging of seer fish. The concentration of 1.0% (w/v) sodium acetate was optimized for the treatment based on our initial study. Seer fish steaks were dipped in aqueous solutions of sodium acetate (0.5, 1.0, 1.5 and 2.0%, w/v) for 30 min. After dipping, steaks were allowed to drain for 10 min and packed under 70% CO_2/30% O_2 atmosphere. Sensory evaluation was conducted by an untrained panel ($n = 7$). Samples dipped in 1% sodium acetate solution showed better correlation with the shelf life for fresh fish than the other samples and therefore, it was selected for the dip treatment. Samples were coded as; control air pack: CAP; control modified atmosphere pack: CMAP; sodium acetate treated modified atmosphere pack: SAMAP.

All samples were stored in chill room, where the temperature was maintained 0–2 °C until the end of the storage. Analyses were conducted immediately after packing, and periodic sampling was carriedout (0 day, 4th day, 8th day, 12th day, 15th day, 18th day, 21st day, 23rd day, 27th day, 31st day and 32nd day) for microbiological and chemical analyses. On each sampling occasion, three fish samples from each batch were evaluated.

2.3. Microbiological analysis

Seer fish steaks (25 g) were transferred aseptically to a stomacher bag (Seward Medical, London, UK), 225 ml of saline (NaCl, 0.85%, w/v) was added, and the mixture was homogenized for 60 s with a stomacher (Lab blender 400; Seward Medical, London, UK). Successive 10-fold dilutions were made as required. Total aerobic plate counts (TPC, 20 °C, 4–5 days) were determined by spread plate technique using plate count agar (AOAC, 2002, chap. 17). Pseudomonads were determined on cetrimide fusidin cephaloridine agar (CFC, Oxoid, supplemented