Food Chemistry 121 (2010) 29–38

Contents lists available at ScienceDirect

Food Chemistry

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

Synergistic effect of tannic acid and modified atmospheric packaging on the prevention of lipid oxidation and quality losses of refrigerated striped catfish slices

Sajid Maqsood, Soottawat Benjakul *

Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand

ARTICLE INFO

Article history:
Received 12 June 2009
Received in revised form 16 November 2009
Accepted 27 November 2009

Keywords:
Tannic acid
MAP
Striped catfish
Lipid oxidation
Microbial count

ABSTRACT

Chemical, microbiological and sensorial changes of striped catfish (*Pangasius hypophthalmus*) slices treated without and with tannic acid (100 and 200 mg/kg) were determined during 15 days of storage at 4 °C in air and under modified atmospheric packaging (MAP, 60% N_2/35% CO_2/5% O_2). The slices consisted of 9.2 g lipid/100 g and the lipid contained 64.55% unsaturated fatty acids and 33.87% saturated fatty acids. During the storage, the sample treated with 200 mg/kg tannic acid and stored under MAP (M_2) had the lowest peroxide value (PV) and thiobarbituric acid-reactive substances (TBARS) with the coincidental lowest non-haem iron content, indicating the retarded lipid oxidation. Fourier transform infrared (FTIR) spectra indicated the formation of primary oxidation products and free fatty acids in M_2 sample after 15 days. Conversely, these compounds were found at lower contents in the control samples kept in air without tannic acid treatment (A_0), suggesting that the deterioration was more advanced. Myosin heavy chain of A_0 was degraded by 17.85% after 15 days of storage, whereas no change was noticeable in M_2, compared with the fresh sample (F). Based on microbiological acceptability limit (10^7 cfu/g), the shelf-life of A_0 and M_2 was estimated to be 3 and 15 days, respectively. M_2 had the acceptable scores for all sensory attributes up to 15 days, while A_0 was acceptable when stored for 9 days. Therefore, tannic acid exhibited a synergistic effect with MAP on retarding lipid oxidation and microbial growth, thereby increasing the shelf-life of striped catfish slices during refrigerated storage.

1. Introduction

Fresh fish are highly perishable products and their deterioration is mainly from the biological reactions such as oxidation of lipids, protein degradation or decomposition mediated by endogenous or microbial enzymes. These activities lead to a short shelf-life of fish and other seafood products (Gobantes, Choubert, & Gomez, 1998). Fish contain a high amount of n-3 polyunsaturated fatty acid, especially eicosapentaenoic acid (20: 5 n-3) and docosahexaenoic acid (22: 6 n-3), which have been shown to have potential benefits for human health (Lee & Lip, 2003). Nevertheless, they are susceptible to oxidation, which is associated with the rancidity and loss in nutritive value (Frankel, 1998a). To alleviate the spoilage caused by microorganisms, frozen storage has been used widely. However, freezing and frozen storage are not able to terminate the chemical reactions, especially lipid oxidation and protein denaturation (Benjakul, Visessanguan, Thongkaew, & Tanaka, 2005). These reactions result in the decrease in functional properties, quality and consumer acceptability.

Modified atmosphere packaging (MAP) in combination with refrigeration has been proved to be an effective preservation method, in which the shelf-life extension and quality retention of a large variety of fresh chilled food products e.g. red meat, poultry, fruits, vegetables, etc. have been achieved (Brody & Marsh, 1997). MAP was also used to extend the shelf-life of fish and fish products (Masniyom, Benjakul, & Visessanguan, 2002; Ozogul, Polat, & Ozogul, 2004; Pastoriza, Sampedro, Herrera, & Cabo, 1998; Ruiz-Capillas & Moral, 2001, 2005). However, Masniyom et al. (2002) reported that the use of MAP with 60% and 80% CO_2 resulted in the increase in lipid oxidation of seabass slices during refrigerated storage. To lower the lipid oxidation, the treatment of fish with potential antioxidants is required. Phenolic compounds have been used as the natural antioxidant to retard lipid oxidation in foods. Tannins from *Osbeckia chinensis* were found to have potential antioxidative efficiency in the linoleic acid-thiocyanate system (Su, Osawa, Kawakishi, & Namiki, 1998). Recently, Maqsood and Benjakul (2010) found that tannic acid exhibited the highest antioxidative activity by different *in vitro* assays as well as in fish oil-in-water emulsion and fish mince. Tannic acid is affirmed as Generally Recognised as Safe (GRAS) by the Food and Drug Administration (FDA) for the use as a direct additive in some food

* Corresponding author. Tel.: + 66 7428 6334; fax: +66 7421 2889.
E-mail address: soottawat.b@psu.ac.th (S. Benjakul).

0308-8146/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2009.11.086

products such as baked goods and baking mixes, alcoholic and non-alcoholic beverages, frozen dairy desserts and mixes, hard candy and cough drop as well as meat products (21 CFR184. 1097, US Code of Federal Regulation, 2006). Therefore, the use of tannic acid in combination with MAP could be a promising means to lower lipid oxidation and extend the shelf-life of striped catfish slices, containing a high amount of fat, which has become an economically important species in Thailand.

To our knowledge, no information on synergistic effect of phenolic compound and MAP on lipid oxidation and shelf-life extension of refrigerated striped catfish slices have been reported. Thus, the objective of present work was to study the combined effect of tannic acid and MAP on the changes in chemical, microbiological as well as sensory properties of striped catfish slices during refrigerated storage at 4 °C.

2. Material and methods

2.1. Chemicals

Tannic acid, thioglycolic acid, cumene hydroperoxide, β-mercaptoethanol and bathophenanthroline disulfonic acid were purchased from Sigma Chemical Co. (St. Louis, MO, USA). Sodium chloride, anhydrous sodium sulphate, potassium iodide, trichloroacetic acid, iron standard solution, ethanol and methanol were obtained from Merck (Damstadt, Germany). Disodium hydrogen phosphate, 2-thiobarbituric acid, ammonium thiocyanate, ferrous chloride, sodium nitrite and saturated sodium acetate were purchased from Fluka Chemical Co. (Buchs, Switzerland). Plate count agar was obtained from Hi-media (Mumbia, India). Chloroform was procured from Lab-Scan (Bangkok, Thailand). All chemicals for electrophoresis were obtained from Bio-Rad (Richmond, CA, USA).

2.2. Fish preparation

Striped catfish (*Pangasius hypophthalmus*) weighing 10–11 kg, off-loaded 24 h after capture and stored in ice, were purchased from the fish market in Hat Yai, Songkhla, Thailand. The fish were kept in ice during transportation to the Department of Food Technology, Prince of Songkla University. Upon arrival, fish were washed with tap water, filleted, deskinned and cut into slices with a thickness of 1–2 cm. The slices were placed in polyethylene bags and kept in ice until use. A portion of slices was taken for lipid extraction and analysis.

2.3. Lipid extraction and analysis

Lipid was extracted by the method of Bligh and Dyer (1959). Ground sample (25 g) was homogenised with 200 ml of chloroform:methanol:distilled water mixture (1:2:1) at the speed of 9500 rpm for 2 min at 4 °C using an Ultra-Turrax T25 homogeniser (Janke & Kunkel, Staufen, Germany). The homogenate was then added with 50 ml of chloroform and homogenised at 9500 rpm for 1 min. Subsequently 25 ml of distilled water was added and the mixture was homogenised again for 30 s. The homogenate was centrifuged at 14,500*g* at 4 °C for 15 min using a RC-5B plus centrifuge (Beckman, JE-AVANTI, Fullerton, CA, USA), and transferred into a separating flask. The chloroform phase was drained off into a 125 ml-Erlenmeyer flask containing about 2–5 g of anhydrous sodium sulphate, shaken very well, and decanted into a round-bottom flask through a Whatman No. 4 filter paper (Whatman International, Ltd., Maidstone, England). The solvent was evaporated at 25 °C, using an EYELA rotary evaporator N-100 (Tokyo, Japan), and the residual solvent was removed by flushing with nitrogen gas.

2.4. Determination of fatty acid profile

Fatty acid profile of lipid from fish slices was determined as fatty acid methyl esters (FAMEs). The FAMEs were prepared according to the method of AOAC (2000). The prepared methyl esters were quantified by gas chromatography (GC). GC (Shimadzu, Kyoto, Japan) equipped with a flame ionisation detector (FID, at a split ratio of 1:20) was used. A fused silica capillary column (30 m × 0.25 mm), coated with bonded polyglycol liquid phase, was used. The analytical conditions were: injection port temperature of 250 °C and detector temperature of 270 °C. The injection volume was 2 μl. The oven was programed from 170 to 225 °C at a rate of 1 °C/min (no initial or final hold). Retention times of FAME standards were used to identify chromatographic peaks of the samples. Fatty acid content was calculated, based on the peak area ratio and expressed as gram fatty acid/100 g of lipid.

2.5. Tannic acid treatment and modified atmosphere packaging (MAP) of striped catfish slices

Striped catfish slices (50 g) were placed on the polystyrene trays (20 × 12 cm^2). Tannic acid (5 and 10 mg) was dissolved separately in 1 ml of distilled water and applied uniformly to prepared slices (50 g) to obtain a final concentration of 100 and 200 mg/kg, respectively. A tray containing fish slices was inserted in nylon/LLDPE bag (30 × 16 cm^2) (Asian Foams, Hat Yai, Thailand) with the thickness of 0.08 mm and gas permeability (CO_2, N_2 and O_2: 1.7×10^{-10}, 0.1×10^{-10} and 0.4×10^{-10} m^3 mm/cm^2 s cmHg at 25 °C, 1 atm pressure, respectively) and was packed with a fish/gas ratio of 1:3 (w/v) using a Henkovac type 1000 (Tecnovac, Italy). Prior to filling the gas, the bag was evacuated fully. Gas mixture containing 60% CO_2/35% N_2/5% O_2 with a pressure of 5 kg/cm^2 was filled in the bag. Fish slices treated without and with tannic acid (100 and 200 mg/kg) and packed in air were prepared and designated as A_0, A_1 and A_2, respectively. Those packed under MAP were designated as M_0, M_1 and M_2, respectively. For the control samples (A_0 and M_0), same quantity (1 ml) of distilled water was added to the slices. All samples were stored at 4 °C and taken for chemical, microbiological and sensory analysis every 3 days for 15 days, except sensory analysis was omitted at day 12.

2.6. Chemical analysis

2.6.1. Peroxide value

Peroxide value was determined as per the method of Richards and Hultin (2002) with a slight modification. Ground sample (1 g) was homogenised at a speed of 13,500 rpm for 2 min in 11 ml of chloroform/methanol (2:1, v/v). Homogenate was then filtered using Whatman No. 1 filter paper. Two millilitre of 0.5% NaCl was then added to 7 ml of the filtrate. The mixture was vortexed at a moderate speed for 30 s and then centrifuged at 3000*g* for 3 min to separate the sample into two phases. Two millilitre of cold chloroform/methanol (2:1) were added to 3 ml of the lower phase. Twenty-five microlitre of ammonium thiocyanate and 25 μl of iron (II) chloride were added to the mixture (Shantha & Decker, 1994). Reaction mixture was allowed to stand for 20 min at room temperature prior to reading the absorbance at 500 nm. A standard curve was prepared using cumene hydroperoxide at a concentration range of 0.5–2 ppm.

2.6.2. Thiobarbituric acid-reactive substances (TBARS)

Thiobarbituric acid-reactive substances (TBARS) were determined as described by Buege and Aust (1978). Ground sample