Food Chemistry 130 (2012) 408–416

Contents lists available at ScienceDirect

Food Chemistry

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

Effect of tannic acid and kiam wood extract on lipid oxidation and textural properties of fish emulsion sausages during refrigerated storage

Sajid Maqsood [a], Soottawat Benjakul [b,*], Amjad Khansaheb Balange [c]

[a] Department of Food Science, Faculty of Food and Agriculture, United Arab Emirates University, Al-Ain 17551, United Arab Emirates
[b] Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, Hat Yai, Songkhla 90112, Thailand
[c] Department of Fish Processing Technology and Microbiology, College of Fisheries, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India

ARTICLE INFO

Article history:
Received 20 November 2010
Received in revised form 30 April 2011
Accepted 18 July 2011
Available online 22 July 2011

Keywords:
Striped catfish
Emulsion sausages
Tannic acid
Kiam extract
Lipid oxidation

ABSTRACT

Effect of tannic acid (0.02% and 0.04%) and ethanolic kiam wood extract (EKWE) (0.04% and 0.08%) on lipid oxidation and textural properties of fish emulsion sausages during 20 days of refrigerated storage was investigated. Control samples (C) had the highest peroxide value (PV) and thiobarbituric acid-reactive substances (TBARS) value up to day 16 and 8 of storage, respectively. With the addition of tannic acid and EKWE, PV and TBARS values in the sausages were retarded effectively, compared to the control ($P < 0.05$), especially when the tannic acid and EKWE at higher level were used. At the same level, EKWE showed the lower ability in retarding the lipid oxidation, in comparison with tannic acid. Tannic acid at both levels (0.02% and 0.04%) was also effective in retarding the formation of fishy odour in the samples throughout the storage, compared to the control and EKWE treated samples ($P < 0.05$). Both tannic acid and EKWE had no detrimental effect on the sensory attributes of sausages. However, EKWE treated sample had lower L^* and higher a^* and ΔE^* values, compared to the control samples ($P < 0.05$). After 20 days of storage, the sample added with 0.04% tannic acid had higher hardness, gumminess and chewiness, compared with others ($P < 0.05$). Samples added with 0.04% tannic acid also displayed more compact structure with no visible voids. Furthermore, oil droplets with smaller size were dispersed more uniformly, compared to others. Thus, tannic acid (0.02% and 0.04%) and EKWE (0.08%) were effective in retarding lipid oxidation and fishy odour development as well as could maintain the textural properties of fish emulsion sausages during the refrigerated storage of 20 days.

1. Introduction

Emulsion sausages, such as frankfurter, are widely consumed in both Western and Asian countries. A product is typically made of beef, pork, or chicken and contains the fat by 25–30%. Fish mince and surimi have recently been used as a raw material for emulsion sausage production, particularly in Asian countries (Konno, 2005). Marine fish are generally a rich source of $n-3$ polyunsaturated fatty acids (PUFA) containing approximately 14–30% of total fatty acids, whereas PUFA in freshwater fish was only 1–11% of total fatty acids (Rahman, Huah, Hassan, & Daud, 1995; Steffens, 1997). Biological importance of $n-3$ PUFA, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), on brain and retina development, has been realized (Simopoulos, 1997). An increase in consumption of $n-3$ PUFA has been reported to reduce the risk of coronary heart disease, decrease mild hypertension and prevent certain cardiac arrhythmias (Garg, Wood, Singh, & Moughan, 2006). Fish oil is actually the main dietary source of $n-3$ PUFA. The World Health Organization (WHO Study Group, 2003) recommends regular fish consumption to provide approximately 200–500 mg per week of EPA and DHA and replacement of saturated fat by monounsaturated counterpart.

Fortification of marine fish oil rich in $n-3$ PUFA to the fresh water fish sausage could be an alternative means to improve its fat quality and to increase $n-3$ PUFA consumption. However, marine fish oil is susceptible to lipid oxidation, thereby negatively affecting flavour, odour, colour, texture, and the nutritional value of fish products (Frankel, 1998). To retard such a quality loss, synthetic antioxidants have been used to decrease lipid oxidation during the processing and storage of fish and fish products (Boyd, Green, Giesbrecht, & King, 1993). However, the use of synthetic antioxidants has raised questions regarding safety and toxicity (Chang, Ostric-Matijasevic, Hsieh, & Chang, 1977). The use of natural antioxidants is emerging as an effective means for controlling lipid oxidation and limiting its deleterious consequences. Recently, Maqsood and Benjakul (2010a, 2010b, 2010c) reported that tannic acid exhibited the superior radical scavenging activities as well as reducing power and effectively inhibited the lipid oxidation in fish

* Corresponding author. Tel.: +66 7428 6334; fax: +66 7455 8866.
E-mail addresses: sajid.m@uaeu.ac.ae (S. Maqsood), soottawat.b@psu.ac.th (S. Benjakul).

0308-8146/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodchem.2011.07.065

mince, fish oil-in-water emulsion, fish slices and ground beef. Haemoglobin mediated lipid oxidation in washed Asian seabass mince was also impeded by incorporation of tannic acid (Maqsood & Benjakul, 2011a). Tannic acid is also affirmed as Generally Recognised As Safe (GRAS) by the Food and Drug Administration (FDA) at a level of 10–400 ppm for the use as an ingredient in some food products including meat products (Chung, Steven, Lin, & Wei, 1993; US Code of Federal Regulation, 2006).

Tannic acid or tannins are polyphenolic compounds commonly occurring in the barks, woods and fruits of many kinds of plants (Yazaki & Collins, 1994). Kiam (*Cotylelobium lanceotatum craih*) trees are very common in the southern part of Thailand. Pieces of wood from the kiam tree have been traditionally submerged in sugar palm sap to prevent or retard microbial fermentation (Chanthachum & Beuchat, 1997). Balange and Benjakul (2009) reported that tannic acid (456.3 mg/kg) was found as the major component of the kiam wood extract. Therefore, the objective of the present study was to evaluate the effect of tannic acid and ethanolic kiam wood extract (EKWE) on the lipid oxidation and textural properties of emulsion sausages prepared from the meat of striped catfish, a fatty fish, during refrigerated storage.

2. Materials and methods

2.1. Chemicals

Menhaden oil, tannic acid (99.5% purity), cumene hydroperoxide and osmium were purchased from Sigma Chemical Co. (St. Louis, MO, USA). Sodium chloride, sodium bicarbonate, potassium iodide, trichloroacetic acid and glutaraldehyde were obtained from Merck (Damstadt, Germany). Disodium hydrogen phosphate, sodium tripolyphosphate, soy protein isolate, 2-thiobarbituric acid, ammonium thiocyanate and ferrous chloride were purchased from Fluka Chemical Co. (Buchs, Switzerland). All chemicals used were of analytical grade.

2.2. Preparation of kiam wood extract

2.2.1. Collection and preparation of kiam wood

The kiam wood was obtained from the forest of the Phattalung province in the Southern Thailand. The tree was about 15–20 years old and harvested in May, 2010. The tree was cut by using a sawing machine; the leaves and branches were separated manually by cutting and the trunk was kept for sun drying for 3 months. The trunk was chopped into smaller flakes of wood and then dried in an oven at 70 °C for 8 h and cut into pieces with an average size of $1.5 \times 1.5\ cm^2$, until the moisture content reached 4–5% (wet weight basis). Those pieces were ground using a portable grinding machine (Spong-90, Leeds, UK) and sieved with a sieve size of 6 mm and was then subjected to size reduction using a blender (National Model MKK77, Tokyo, Japan) and finally sieved using a stainless steel sieve of 80 mesh size (with the diameter of 0.177 mm). The obtained powder was placed in a polythene bag, sealed and kept at room temperature until use.

2.2.2. Extraction of phenolic compounds from kiam wood

Kiam wood powder was subjected to extraction according to the method of Santoso, Yoshie-stark, and Suzuki (2004) with slight modifications. The powder (10 g) was mixed with 150 ml of absolute ethanol. The mixture was stirred at room temperature (28–30 °C) using a magnetic stirrer (IKA-Werke, Staufen, Germany) for 6 h. The mixture was then centrifuged at 5000*g* for 10 min at room temperature using a RC-5B plus centrifuge (Beckman, JE-AVANTI, Fullerton, CA, USA). The supernatant was filtered using a Whatman filter paper No. 1 (Whatman International, Ltd., Maidstone, England). The filtrate was then evaporated at 40 °C using an Eyela rotary evaporator (Tokyo Rikakikai, Co. Ltd., Tokyo, Japan). To remove the residual ethanol, the extract was purged with nitrogen gas. The extract was then dried using a freeze dryer to obtain the dry extract. Dried extract was powdered using a mortar and pestle and was kept in an amber bottle and stored in a desiccator until use. The dried powderised extract was referred to as "ethanolic kiam wood extract; EKWE". EKWE had the total phenolic content of 602.61 mg tannic acid equivalent/g and consisted of tannic acid at a concentration of 545.57 mg/g (Maqsood & Benjakul, 2011b).

2.3. Preparation of fish emulsion sausages containing tannic acid and EKWE

Striped catfish (*Pangasius hypophthalamus*) weighing 3–4 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 minced using a mincer with a hole diameter of 5 mm. Moisture content of the mince was adjusted to 86%. Fish emulsion sausages were prepared following the method described by Panpipat and Yongsawatdigul (2008) with slight modifications. Fish mince (85 g) was added with sodium chloride (2 g), sodium tripolyphosphate (1.5 g) and soy protein isolate (1.5 g) and menhaden oil (10 g). The mixture was ground for 3 min using a Panasonic Food Processor (MK, 5087M, Selangor Darul Ehsan, Malaysia).

To study the effect of tannic acid or EKWE on lipid oxidation and textural properties of emulsion sausages, tannic acid and EKWE with total phenolic content of 602.6 mg tannic acid equivalent/g dry powder and tannic acid content of 545.57 mg/g dry powder was added to obtain the designated final concentration. Tannic acid (0.02% and 0.04% w/w) or EKWE (0.04% and 0.08% w/w) dissolved in distilled water were added to the mixture along with menhaden oil (10% v/w). Subsequently, the mixture was further ground thoroughly for 5 min in order to obtain a homogenous paste. The paste was stuffed into a cellophane casing (diameter of 22 mm) and pre-incubated at 55 °C for 40 min prior to cooking at 80 °C for 15 min (Panpipat & Yongsawatdigul, 2008) in a temperature controlled water bath (Memmert, D-91126, Schwabach, Germany). The samples added with tannic acid at a level of 0.02% and 0.04% were referred to as 'TA-0.02' and 'TA-0.04' respectively and those added with EKWE at a level of 0.04% and 0.08% were referred to as 'EKWE-0.04' and 'EKWE-0.08', respectively. The control samples (C) were prepared in the similar manner but distilled water was added instead of tannic acid or EKWE solution. Samples were cooled for about 30 min in iced water and stored at 4 °C. Samples were randomly taken at day 0, 4, 8, 12, 16 and 20 of storage for analysis of lipid oxidation products. Sensory analysis was conducted at day 0, 12 and 20, while samples were subjected to textural analysis at day 0 and 20.

2.4. Analyses

2.4.1. Determination of peroxide value

Peroxide value (PV) was determined as per the method of Richards and Hultin (2002) with a slight modification. Samples (1 g) were mixed with 11 ml of chloroform/methanol (2:1, v/v). The mixtures were homogenised at a speed of 13,500 rpm for 2 min. Homogenates were then filtered using a Whatman No. 1 filter paper. Two millilitres of 0.5% NaCl were then added to 7 ml of the filtrate. The mixtures were vortexed at a moderate speed for 30 s using a Vortex-Genie2 mixer 4 (Bohemia, NY, USA) and then centrifuged at 3000*g* for 3 min to separate the sample into two phases.