Food Research International 99 (2017) 630–640

Contents lists available at ScienceDirect

Food Research International

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

Changes provoked by boiling, steaming and *sous-vide* cooking in the lipid and volatile profile of European sea bass

Bárbara Nieva-Echevarría, María J. Manzanos, Encarnación Goicoechea, María D. Guillén*

Food Technology, Faculty of Pharmacy, Lascaray Research Center, University of the Basque Country (UPV/EHU), Paseo de la Universidad n° 7, 01006 Vitoria-Gasteiz, Spain

ARTICLE INFO

Chemical compounds studied in this article:
Docosahexaenoic acid (PubChem CID: 445580)
Eicosapentaenoic acid (PubChem CID: 446284)
Cholesterol (PubChem CID: 5997)
Retinyl palmitate (PubChem CID: 5280531)
Trimethylamine (PubChem CID: 1146)
2,6-Di-*tert*-butyl-4-methylphenol (PubChem CID: 31404)
(*E,E*)-2,4-Heptadienal (PubChem CID: 5283321)
Methional (PubChem CID: 18635)
2-Ethylfuran (PubChem CID: 18554)
2-(1-Pentenyl)furan (PubChem CID: 5369956)

Keywords:
Fish
Omega-3
Cooking
Lipids
Volatile components

ABSTRACT

This study aims to shed light on the changes provoked by boiling, steaming and *sous-vide* cooking on the lipids and volatile profile of farmed and wild European sea bass meat. None of the cooking techniques provoked changes due to hydrolytic or oxidation processes detectable by ^{1}H NMR on sea bass lipids. The lipid profile of main and minor lipidic components was maintained after cooking. However, study by SPME-GC/MS evidenced that steaming and *sous-vide* cooking modified the volatile profile of sea bass meat, especially in farmed specimens. The compounds generated came from the occurrence, to a very small extent, of lipid and protein degradation. By contrast, boiling scarcely modified the initial characteristics of raw sea bass. Thus, from a sensory point of view and considering the odour-active compounds generated, steaming and *sous-vide* cooking provoked more noticeable changes than boiling, especially in farmed sea bass meat.

1. Introduction

Fish consumption is highly recommended in the context of a healthy diet due, among other things, to its high content in long-chain polyunsaturated omega-3 acyl groups, including eicosapentaenoic (EPA, 20:5n-3) and docosahexaenoic (DHA, 22:6n-3) groups. Indeed, in recent years their intake has been associated with potential health benefits. However, it has to be considered that several factors like fish species, growing conditions and also post-harvest technological processing, including culinary treatment, can greatly influence fish composition, especially regarding its lipids (Grigorakis, 2007; Nieva-Echevarría, Goicoechea, Manzanos, & Guillén, 2016; Orban, Nevigato, Di Lena, Casini, & Marzetti, 2003; Vidal, Manzanos, Goicoechea, & Guillén, 2012).

Several processes take place during cooking, mainly intended for the improvement of fish safety, digestibility and sensory characteristics. Among other reasons, lipid oxidation may occur due to the exposure to heat, to oxygen and to endogenous pro-oxidant species present in fish muscle tissue that can be released as a result of protein denaturation (Hsieh & Kinsella, 1989). In consequence, the potential oxidation of polyunsaturated acyl groups during fish cooking has received special attention and several studies addressing this topic have been published. Nevertheless, with the exception of frying, inconclusive results have been reported regarding the effect of other cooking methods (Al-Saghir et al., 2004; Bakar, Rahimabadi, & Che Man, 2008; Gladyshev, Sushchik, Gubanenko, Demirchieva, & Kalachova, 2006, 2007; Larsen, Quek, & Eyres, 2010; Nieva-Echevarría et al., 2016; Regulska-Ilow & Ilow, 2002; Weber, Bochi, Ribeiro, Victório, & Emanuelli, 2008).

The discrepancies observed among the different studies could be attributed not only to the different fish species studied or to the cooking experimental conditions (*i.e.* time and temperature), but also to the low specificity and reliability of the methodologies employed to assess lipid oxidation extent (measurement of conjugated dienes by ultraviolet-visible spectrophotometry, peroxide and/or anisidine values,

* Corresponding author.
E-mail address: mariadolores.guillen@ehu.eus (M.D. Guillén).

http://dx.doi.org/10.1016/j.foodres.2017.06.043
Received 3 January 2017; Received in revised form 14 June 2017; Accepted 17 June 2017
Available online 19 June 2017

thiobarbituric acid reactive substances test). In fact, the drawbacks and limitations of the above-mentioned classical methodologies employed to assess lipid oxidation level are well-known (Frankel, 2005). Therefore, further research is required on the effect of common household cooking techniques on fish lipid oxidation, but using more specific and sound techniques.

In addition, further knowledge about the changes provoked by cooking in fish volatile profile might be of great interest because of their relevance for cooked fish aroma, an attribute of paramount importance for consumer preference and acceptance (Sampels, 2015; Whitfield, 1992). To date, little is known about the potential differences among cooking methods regarding the formation of odour and flavour-contributing volatile compounds in fish. A few studies, which focused on just one cooking method, have been published to date (Chung, Choi, Cho, & Kim, 2011; Frank, Poole, Kirchhoff, & Forde, 2009; Hallier, Prost, & Serot, 2005; Liu, Zhao, Xiong, & Zhang, 2009; Milo & Grosch, 1996; Moreira, Valente, Castro-Cunha, Cunha, & Guedes de Pinho, 2013; Prost, Serot, & Demaimay, 1998).

In this context, the effect of mild culinary treatments, like boiling, steaming and *sous-vide* cooking, on the lipids and on the volatile components of farmed and wild European sea bass (*Dicentrarchus labrax*) were subject of study. This fish species was selected because it is highly appreciated and consumed in the Mediterranean area. Moreover, differences reported between farmed and wild specimens, regarding lipid composition (Grigorakis, 2007; Orban et al., 2003; Vidal, Goicoechea, Manzanos, & Guillén, 2014; Vidal et al., 2012) and volatile profile (Vidal, Manzanos, Goicoechea, & Guillén, 2016a), could influence the changes provoked by cooking in both kinds of sea bass, allowing also their discrimination after cooking. The techniques employed were Proton Nuclear Magnetic Resonance (^{1}H NMR) to study the changes occurring in fish lipids during cooking, and Solid Phase-Microextraction followed by Gas Chromatography/Mass Spectrometry (SPME-GC/MS), to study those taking place in sea bass volatile profile.

2. Materials and methods

2.1. Fish samples

Fresh specimens of farmed (F, $n = 6$) and wild (W, $n = 6$) European sea bass (*Dicentrarchus labrax*) were acquired at the end of January from a local supplier within 48 h of their catch. The fish specimens were kept refrigerated with flake ice inside polystyrene boxes provided with a lid and holes for drainage, and transported to the laboratory within 1 h of purchase. Afterwards, and just before cooking, fish specimens were gutted, cleaned, filleted and skinned. Average weight of farmed and wild sea bass fillets was 251.5 ± 21.0 ($n = 12$) and 281.5 ± 40.6 g ($n = 12$), respectively. Average length, width and thickness of farmed and wild sea bass fillets were 25.4 ± 2.1 cm ($n = 24$), 10.1 ± 1.5 cm ($n = 24$) and 12.3 ± 0.4 mm ($n = 24$), respectively.

All the fish fillets were kept at 2 °C until further analysis. From each specimen, one fillet was kept raw (R) as a control, and the other one was submitted to cooking. Raw fillets of farmed sea bass were named $\mathbf{F_R}$ ($n = 6$) and those of wild sea bass $\mathbf{W_R}$ ($n = 6$). For the study of the volatile profile of the starting samples by SPME-GC/MS, raw fillets were minced independently in a grinder before sampling. The remaining ground meat of each fillet was vacuum-packed immediately and stored at − 80 °C for up to 24 h for the subsequent extraction of their lipids and study by ^{1}H NMR.

2.2. Cooking methods

Within 2 h of purchase, sea bass fillets were cooked using three different culinary treatments: boiling, steaming or *sous-vide* cooking. These techniques were selected because: i) boiling and steaming are widely used conventional methods, in which water (liquid or steam respectively) is employed to transfer heat to food; ii) *sous-vide* cooking involves lower temperatures and longer times than those employed in traditional cooking methods; iii) *sous-vide* cooking is currently considered by the food industry as an interesting alternative for the manufacture of high quality *ready-to-eat* foods (Sampels, 2015) because of the improved sensory (texture and flavour) and nutritional (lower loss of temperature-labile nutrients) properties reported.

Cooking times and temperatures of the three cooking methods were decided in line with real household conditions. For this purpose, preliminary tests were performed in our laboratory with sea bass fillets of similar size, and the most suitable conditions for ensuring their satisfactory cooking were selected. Each fish fillet was cooked independently and cooking experiments were carried out in duplicate for consistency of results. Thus, 4 sea bass fillets were cooked by each kind of method, 2 of them farmed specimens and the other 2 wild. After cooking, the core temperatures of the fillets were checked with a thermometer (104-IR, Testo instruments, Lenzkirch, Germany).

2.2.1. Boiling (BO)

This was performed using a domestic stainless steel casserole (24 cm internal diameter) over an electric heating unit; each fillet was immersed in 2 L of boiling water (100 °C) for 10 min. After boiling, farmed ($\mathbf{F_{BO}}$ $n = 2$) and wild ($\mathbf{W_{BO}}$ $n = 2$) fillets core temperature was 88 ± 2 °C.

2.2.2. Steaming (ST)

This was carried out using a steaming casserole set (24 cm internal diameter); 2 L of boiling water (100 °C) were placed in the bottom of the casserole and the fillet was placed on the perforated middle layer (covered with the lid) and submitted to steaming for 10 min. After steaming, farmed ($\mathbf{F_{ST}}$ $n = 2$) and wild ($\mathbf{W_{ST}}$ $n = 2$) fillets core temperature was 91 ± 0 °C.

2.2.3. Sous-vide cooking (SV)

Each fillet was vacuum-packed in a polypropylene (PP) heat-resistant (up to 120 °C) bag designed for this culinary technique, using a vacuum sealer (VAC-20S model, Edesa, Mondragon, Spain). Then, plastic bags were submerged for 20 min in 20 L of water pre-heated at 85 °C, using a thermostatic water bath (Precisdig model, Selecta, Barcelona, Spain). Afterwards, the plastic bag was opened and the core temperature of farmed ($\mathbf{F_{SV}}$ $n = 2$) and wild ($\mathbf{W_{SV}}$ $n = 2$) fillets measured (83 ± 2 °C).

Immediately after cooking, each fish fillet was minced in a grinder and the volatile profile of the minced sea bass meat was studied by Solid Phase Microextraction followed by Gas Chromatography/Mass Spectrometry (SPME-GC/MS). The remaining ground meat of each fillet was vacuum-packed immediately and stored at − 80 °C for up to 24 h for the subsequent extraction of their lipids and study by Proton Nuclear Magnetic Resonance (^{1}H NMR).

2.3. Lipid extraction

Lipids of sea bass fillets before and after cooking were extracted using dichloromethane as solvent (CH_2Cl_2, HPLC grade, Sigma-Aldrich, St. Louis, MO, USA), as in a previous study (Nieva-Echevarría, Goicoechea, Manzanos, & Guillén, 2017). Different extraction conditions and solvents had previously been tested in our laboratory to ensure an exhaustive extraction of fish lipids. Finally, dichloromethane was selected because of its ability to extract lipids, its suitable polarity for an exhaustive extraction and its high volatility. Minced fish meat and dichloromethane were mixed in a proportion of 1:2 (w/v) using an Ultra-Turrax T25 basic mixer (IKA-Werke GmbH & Co, Staufen, Germany) at 11000 rpm/min for 2 min. Afterwards, the mixture was kept for 1 h at a 40 kHz frequency in an ultrasonic bath (JP Selecta Ultrasons, Barcelona, Spain), in order to favor the extraction of bounded lipids. The temperature of the ultrasonic bath was controlled and kept at 0–5 °C along this hour. Subsequently, the mixture was filtered