“Effects of frozen storage on sensory characteristics, on lipids and fatty acid composition of gilthead sea bream, *Sparus aurata* skin-on fillets”

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Abstract

Gilthead sea bream (*Sparus aurata*) skin-on fillets, prepared from 48-hour post-harvest iced fish, were individually quick-frozen in an Armfield FT 34-MKII plate freezer, wrapped in a single layer of polyethylene film and stored at -18 °C. Quality changes of the fillets were assessed by sensory evaluation, lipid profile analyses, rancidity development assays and colour measurements of the raw and cooked flesh, over a period of three months.

Rancidity development, assessed by measurements of thiobarbituric acid-reactive substances (TBA-RS), proceeded slowly during storage and correlated significantly ($r = 0.955$, $P < 0.05$) with the observed decline in sensory score for cooked fish flavour. Unlike fillet lightness (L^*), which remained practically unchanged ($P < 0.05$) during storage, changes in a^* and b^* values were quite pronounced, indicating a shift towards reddish/bluish colorations in the cooked flesh.

Lipids in fresh *Sparus aurata* skin-on fillets were composed of triglycerides and phospholipids as major constituents. Small amounts of cholesterol, free fatty acids and diglycerides were noticeable. During frozen storage, both triglyceride (TG) and phospholipid (PhL) contents decreased, while the free fatty acid (FFA), diglycerides (DG), monoglycerides (MG) and lyso-phosphatidylcholine (l-PC) contents increased, particularly with increasing storage time ($P<0.05$). This suggested that TG and PhL were hydrolysed into FFA, DG, MG and l-PC during extended storage. Furthermore, the result at the end of the storage period (3 months) indicated that the decreasing rate of TG was comparatively higher than that of PhL. This was possibly due to the greater activity of lipase in farmed sea bream than phospholipase activity.

The major saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) identified in all studied samples, whether raw or frozen, were palmitic (C16:0), oleic (C18:1 ω-9) and linoleic (C18:2 ω-6) acids, respectively. Frozen storage significantly affected the fatty acid composition of *Sparus aurata* fillets. Since triglycerides and phospholipids underwent hydrolysis into FFA during storage, free PUFA and MUFA could have undergone oxidation, which is supported by the increasing TBA values. This result was evidenced by the significant decrease in PUFA and MUFA during storage. As SFA increase and PUFA decrease synchronously following frozen storage of fish fillets, PUFA/SFA ratio decreased ($P<0.05$) compared to raw samples. Marked decreases in ω-3 PUFA, especially eicosapentaenoic acid (EPA; C20:5 ω-3) and docosahexaenoic acid (DHA; C22:6 ω-3) were observed as the frozen storage time

Materials and Methods

Sensory analyses were performed by a panel of five experienced assessors, using the Torry sensory scheme for cooked white fish fillets (Whittle et al., 1990). Total lipid was determined by the chloroform-methanol extraction procedure (Hanson & Olley, 1963). Thiobarbituric acid-reactive substances (TBA-RS) were monitored by the method of Witte et al. (1970). Colour measurements were conducted on three points along the dorsal muscle (bone-side) of raw and steam-cooked fillets, using a ColorTecTM-PCM analyzer (ColorTec Associates, Clinton, N.J.). Data were expressed as CIE $L^*a^*b^*$ coordinates. TLC–FID analysis of neutral and polar lipids was performed by an Iatroscan thin-layer chromatograph (Model MK-6 TLC/FID - FPD Analyser, Iatron Laboratories, Japan), equipped with a flame ionization detector (Sinanoglou et al., 2011). Both quantitative and qualitative analyses of fatty acids methyl esters of total lipids were performed on an Agilent 6890 Series Gas Chromatograph equipped with a flame ionization detector. DB-23 capillary column (60m × 0.25mm i.d., 0.15μm film) was used (Sinanoglou et al., 2011). All data were analysed with the SPSS 10 statistical software, with one-way ANOVA post hoc tests.

Results and Discussion

Mean scores for cooked flavour declined almost linearly during storage (y = -0.026x + 9.28, r = 0.970). Slight rancid, cod liver oil-like off-flavours were evident by the end of the trial.

Rancidity development proceeded slowly during storage (3.4 mg malondialdehyde at the end of the trial) and correlated significantly ($r = 0.955$, $P < 0.05$) with the observed decline in sensory score for cooked fish flavour. Fillet lightness remained practically unchanged during storage. Upon cooking, L^* values increased dramatically, reflecting the change in flesh colour from light creamy (raw fish) to white (cooked fish). The changes observed in a^* and b^* values were probably associated with products of carbonyl-amino reactions and changes in haem proteins (Lougovois & Kyrana, 2005).

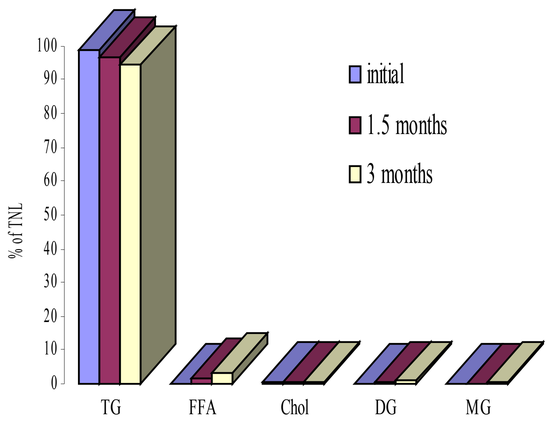

Figure 1: Neutral lipids profile (% of TNL) of the fish fillet total lipids.

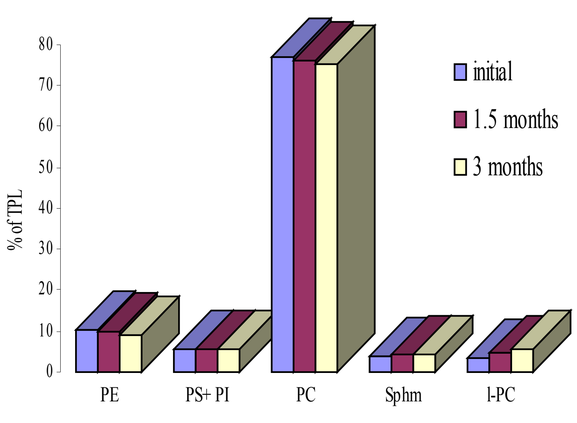

Figure 2: Polar lipids profile (% of TPL) of the fish fillet total lipids.

Fat content was significantly ($P<0.05$) reduced during frozen storage (initial, 12.00%; 3 months of storage, 10.47%). The major lipid class in skin-on fillets of sea bream *S. aurata* were neutral lipids (NL) (>91%), mainly triglycerides (TG). Frozen storage caused significant ($P<0.05$) decomposition in TG that was reflected in more than fifteen fold increase in FFA and appreciable increase in DG and MG (Fig. 1).

PL mainly consisted of phosphatidylcholine (PC) followed by phosphatidylethanolamine (PE), phosphatidylserine + phosphatidylinositol (PS+PI), sphingomyelin (Sphm) and lyso-phosphatidylcholine (l-PC) (Fig. 2). Frozen storage appeared to cause significant ($P<0.05$) degradations in the above PhL into FFA and l-PC, which can be considered a degradation product of PC.

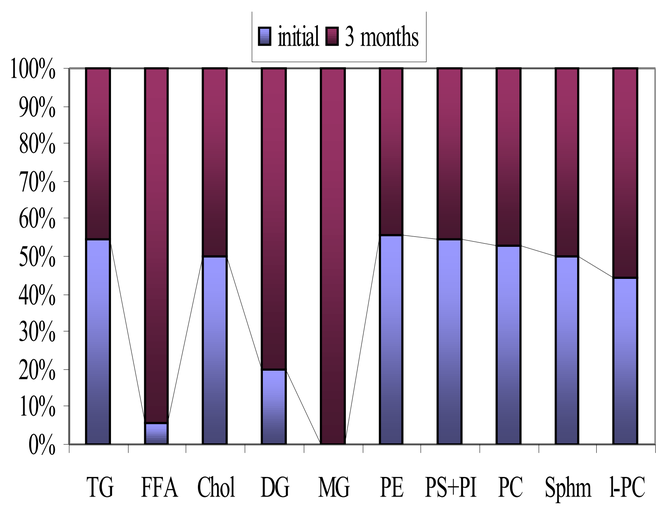

Figure 3 Neutral and polar lipids content expressed as g/100 g on a wet weight basis of fresh and frozen fillets.

From a nutritional perspective, cholesterol content remained unchanged ($P>0.05$) at 0.07 g per 100 g of fish fillets. *S. aurata* on-skin fillets are an excellent source of dietary PC, providing 790mg of PC per 100 g of fillet. In spite of the significantly ($P<0.05$) PC content decrease (from 0.97 g/100 g of edible portion in initial sample to 0.70 g/100 g in the 3 months frozen storage sample), its concentration was found to exceed the PC recommended daily intake (RDI) in the human diet (550 mg for men and 450 mg for women) (Fig. 3).

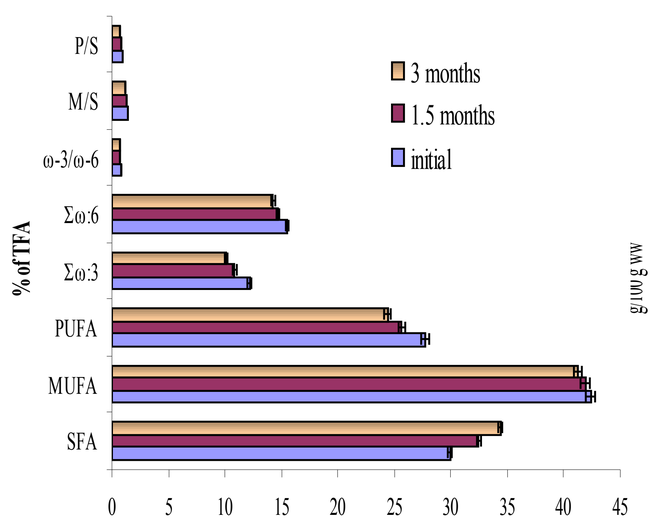

Figure 4: Fatty acid sums composition [% (w/w)] in total lipids of fresh and frozen fillets.

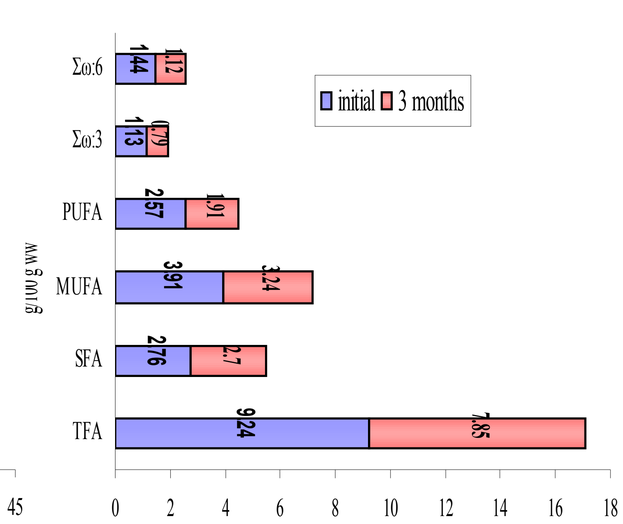

Figure 5: Fatty acid sums composition [% (w/w)] in total lipids of fresh and frozen fillets.

At the beginning of storage at -18 C the total lipids of the fish fillets showed a predominance of MUFA, followed by SFA and lastly PUFA as the minority component. These results give a PUFA/SFA (P/S) ratio of 0.93. MUFA, PUFA, P/S, M/S and ω-3/ω-6 fatty acids ratios decreased as frozen storage period increased (Fig. 4). With regard to the frozen storage, the P/S and ω-3/ω-6 ratio values observed in the present study for fish fillets remained favourable. On a weight basis, it was observed that the increase of frozen storage period resulted in an insignificant SFA content change and a significant ($P<0.05$) MUFA and PUFA content decrease (Fig. 5).

References

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