# Quality enhancement and shelf life extension of fresh Mediterranean fish by nonthermal and minimal processing

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## Introduction

The short shelf life and perishability of fish products is a commercial drawback and methods of extension are being investigated. New minimal and nonthermal food processing methods are sought by the industry in the pursuit of producing better quality fish products with extended shelf life with retention of nutritional and sensory properties (Tsironi et al., 2014 and 2019; Tsironi and Taoukis, 2019). Several studies have been conducted recently on the efficacy of washing and sanitizing treatments in reducing microbial populations on food products. Limited work on fish has been published and no industrial scaling-up has been reported (Thi et al., 2015).

The objective of the study was to investigate the effect of nonthermal, i.e. osmotic dehydration (OD), pulsed electric fields (PEF) and minimal processing (i.e. surface decontamination) on the quality and shelf life of farmed gilthead seabream and European sea bass during refrigerated storage.

## Materials & Methods

Gilthead seabream (*Sparus aurata*) and European sea bass (*Dicentrarchus labrax*) fillets were treated using, OD (glycerol/NaCl solutions) and PEF (250-1000 pulses , 15 μs, 20 Hz, 1,7 kV/cm- Elcrack-5kW, DIL, Quakenbruck, Germany) as alternative approaches to the conventional post-harvest fish processing methods. The incorporation of natural organic acids (0-200 ppm, 0-10 min-lactic acid or citric acid, 0-150 ppm, 0-4 min-peracetic acid) at different concentrations in the washing water during gutting was also tested for its efficacy to reduce initial microbial load and prolong shelf life. Samples were stored under controlled isothermal conditions (0-10°C). Quality assessment was based on microbiological analysis (total viable count, *Pseudomonas* spp., *Enterobacteriaceae* spp.), pH, colour , texture measurement and sensory scoring. A sensory score of 5 was taken as the average score for minimum acceptability. Temperature in the incubators was constantly monitored with electronic, programmable miniature data-loggers (COX TRACER ®, Belmont, NC).

## Results

### ***Effect of washing with organic acids on fish***

Initial surface decontamination (up to 2 logcfu/g for total viable count, *Pseudomonas* spp. and *Enterobacteriaceae* spp.) by the addition of organic acids in the washing water was observed (Figure 1). Microbial load reduction was increased for higher washing solution concentrations and longer treatment. Higher reduction of the initial microbial load was observed after treatment with citric acid for TVC, *Pseudomonas* spp. and $H_2S$-producing bacteria and with lactic acid solution for *Enterobacteriaceae* spp.

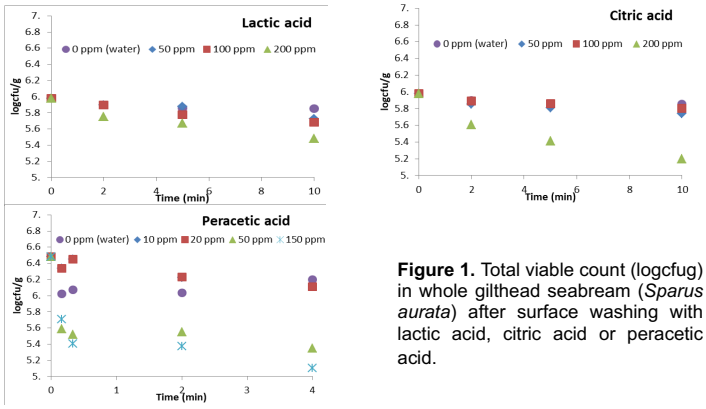


**Figure 1.** Total viable count (logcfug) in whole gilthead seabream (*Sparus aurata*) after surface washing with lactic acid, citric acid or peracetic acid.

Mathematical models were developed for the inactivation of spoilage bacteria as a function of treatment conditions and the concentration of acid in the washing water. The experimental data were adequately described by Equation (1):

$$\log\left(\frac{N}{N_o}\right) = a * \sqrt{C - b} * e^{-d*t}$$

where $N_o$ and $N$ are the initial and final (after treatment) microbial load, $C$ is % (w/v) washing solution concentration, $t$ is treatment (min) and *α, b, d* are constants. Limit of sensory shelf life of gutted fish (score 5 by the sensory panel for overall impression) coincided with a *Pseudomonas* spp. level of $10^7$ cfu/g at all tested storage temperatures (0-10°C). The shelf life of gutted gilthead seabream for different treatment conditions is presented in Table 1.

**Table 1.** Shelf life (days) of gutted gilthead seabream for different processing and storage conditions

| Processing / storage conditions | Control | Citric acid (100ppm/5 min) | Citric acid (200 ppm/10 min) |
|---|---|---|---|
| 0°C | 12 | 13 | 16 |
| 5°C | 6 | 7 | 8 |
| 10°C | 4 | 5 | 6 |

*Effect of OD treatment on fish*

Osmotic dehydration caused substantial $a_w$ decrease with higher solution concentrations showing the strongest effect. $A_w$ was initially 0.99 and reached final values between 0.87, 0.83 and 0.82 after 240 min of osmotic treatment at 40, 50 and 60% glycerol, respectively. The effective diffusion coefficients of water ($D_{ew}$) and solids ($D_{es}$) were calculated by applying Fick's law on the experimental data (Table 1).

**Table 1.** Effective diffusion coefficients of water ($D_{ew}$) and solids ($D_{es}$) during osmotic dehydation of sea bass fillets

| Treatment | $D_{ew}$ ($m^2 \cdot s^{-1}$) | $D_{es}$ ($m^2 \cdot s^{-1}$) |
|---|---|---|
| **40% glycerol** | 1,90 (± 0,15) ·$10^{-9}$ | 1,82 (± 0,12) ·$10^{-9}$ |
| **50% glycerol** | 2,77 (± 0,15) ·$10^{-9}$ | 2,50 (± 0,21) ·$10^{-9}$ |
| **60% glycerol** | 3,62 (± 0,27) ·$10^{-9}$ | 4,12 (± 0,55) ·$10^{-9}$ |
| **PEF/50% glycerol** | 4,03 (± 0,32) ·$10^{-9}$ | 4,14 (± 0,38) ·$10^{-9}$ |

OD resulted in significant shelf life extension of fish fillets (6 days and up to 10 days for untreated and osmo-treated samples at 5°C, respectively).

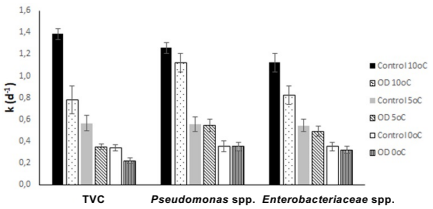


**Figure 2.** Microbial growth rates in OD treated sea bass fillets during isothermal storage at 0-10°C.

*Combined effect of OD and PEF on fish*

PEF enhanced the mass transfer phenomena during osmotic treatment but did not affect significantly the quality and shelf life of fish fillets. PEF pretreatment further increased $D_{ew}$ and $D_{es}$ values up to 50% and 66% respectively (for 1500 pulses) and the number of pulses correlated with the calculated $D_{ew}$ and $D_{es}$ values, following a logistic mathematical model (Table 1).

## Conclusions

The results of the study indicated that the application of nonthermal and minimal processing led to improved quality stability during subsequent refrigerated storage and significant shelf life extension, in terms of microbial growth, physicochemical and organoleptic degradation of the fillets. Minimal processing of fish could open new distant markets currently inaccessible to fresh fish products and allow the use of higher temperatures (5ºC) in the cold chain of seafood which would significantly reduce energy and food waste. The application of surface sanitization by washing with organic acids proved comparatively effective to the alternative minimal and nonthermal processes studied.

## References

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