Nonthermal and minimal processing of fresh Mediterranean marine cultured fish for quality improvement and shelf life extension

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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 non-thermal food processing methods are sought by the industry in the pursuit of producing better quality foods with extended shelf life. The advantages of nonthermal processing over classical thermal methods include the better retention of nutritional and sensory properties (Tsironi et al., 2014 and 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 the effect of nonthermal and minimal treatments on fish has been published and no industrial scaling-up has been reported (Fidalgo et al., 2011). The objective of the study was to investigate the effect of nonthermal i.e. high pressure (HP), osmotic dehydration (OD), pulsed electric fields (PEF) and minimal processing methods (i.e. surface decontamination of fish) 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 HP (600 MPa, 5 min, 25ºC - FPU 1.01, Resato International BV, Roden, Holland), OD (40-60% glycerol, 5% NaCl, 15°C, 0-240 min) 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, citric 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 HP processing on fish

HP resulted in more than a 5 logcfu/g reduction in the initial TVC. *Pseudomonas* (reported food spoilers) persisted in HP fillets. The shelf life of the untreated samples was 10 days and for the HP-treated fillets exceeded 2 months (based on a minimum score of 5 for overall acceptability scoring in a 1 to 9 hedonic sensory scale). However, it affected significantly the texture and colour of the fish flesh (Picture 1, Figure 1).

Picture 1. HP (600 MPa, 5 min, 25°C) treated sea bass fillets after 67 days of isothermal storage at 2°C.

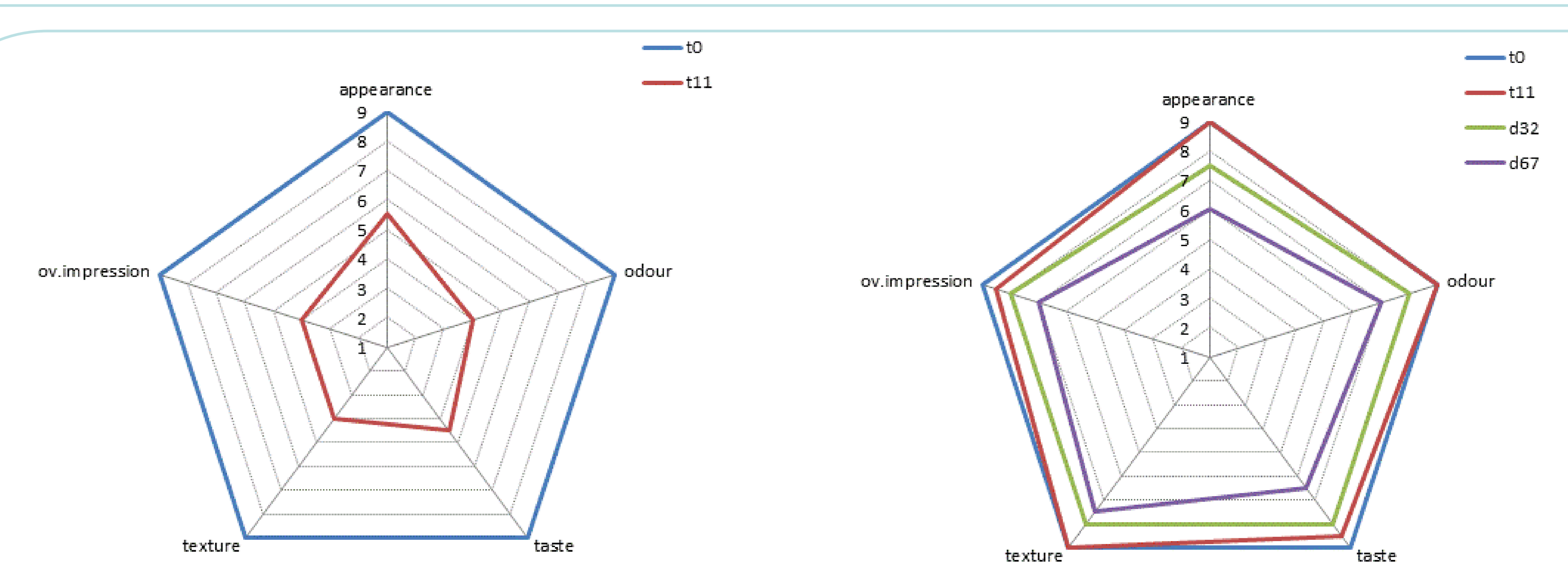

Figure 1. Sensory profile of untreated (Control) and HP (600 MPa, 5 min, 25°C) treated sea bass fillets during isothermal storage at 2°C.

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) $\cdot 10^{-9}$	1,82 (± 0,12) $\cdot 10^{-9}$
50% glycerol	2,77 (± 0,15) $\cdot 10^{-9}$	2,50 (± 0,21) $\cdot 10^{-9}$
60% glycerol	3,62 (± 0,27) $\cdot 10^{-9}$	4,12 (± 0,55) $\cdot 10^{-9}$
PEF/50% glycerol	4,03 (± 0,32) $\cdot 10^{-9}$	4,14 (± 0,38) $\cdot 10^{-9}$

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).

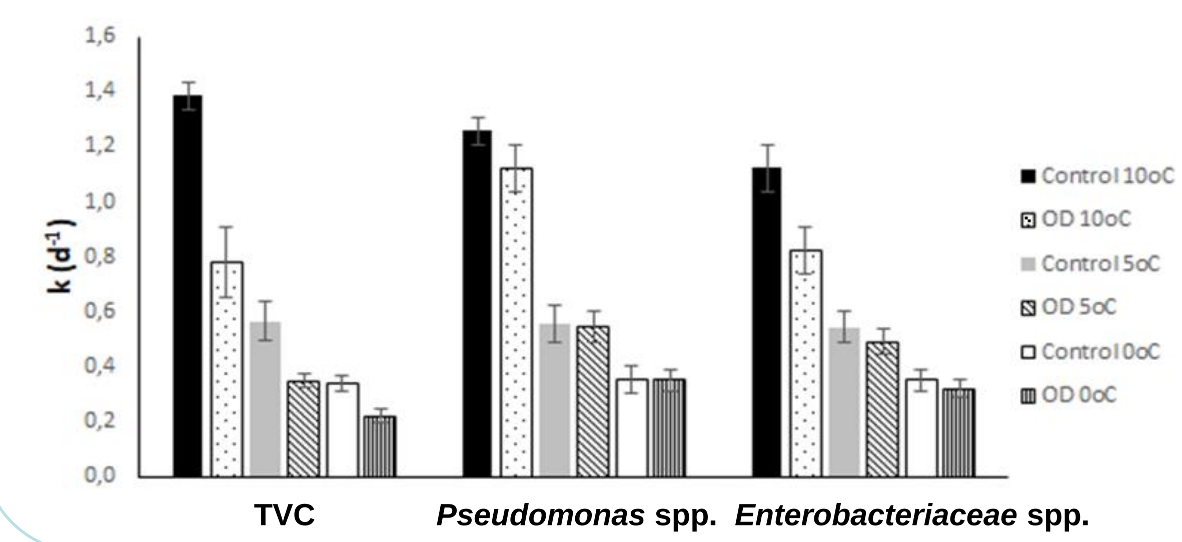

Figure 2. Microbial growth rates in OD (50% glycerol, 30 min) treated sea bass fillets during isothermal storage at 0-10°C.

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.

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, which may result in 2-4 days shelf life extension of fish fillets at 0°C.

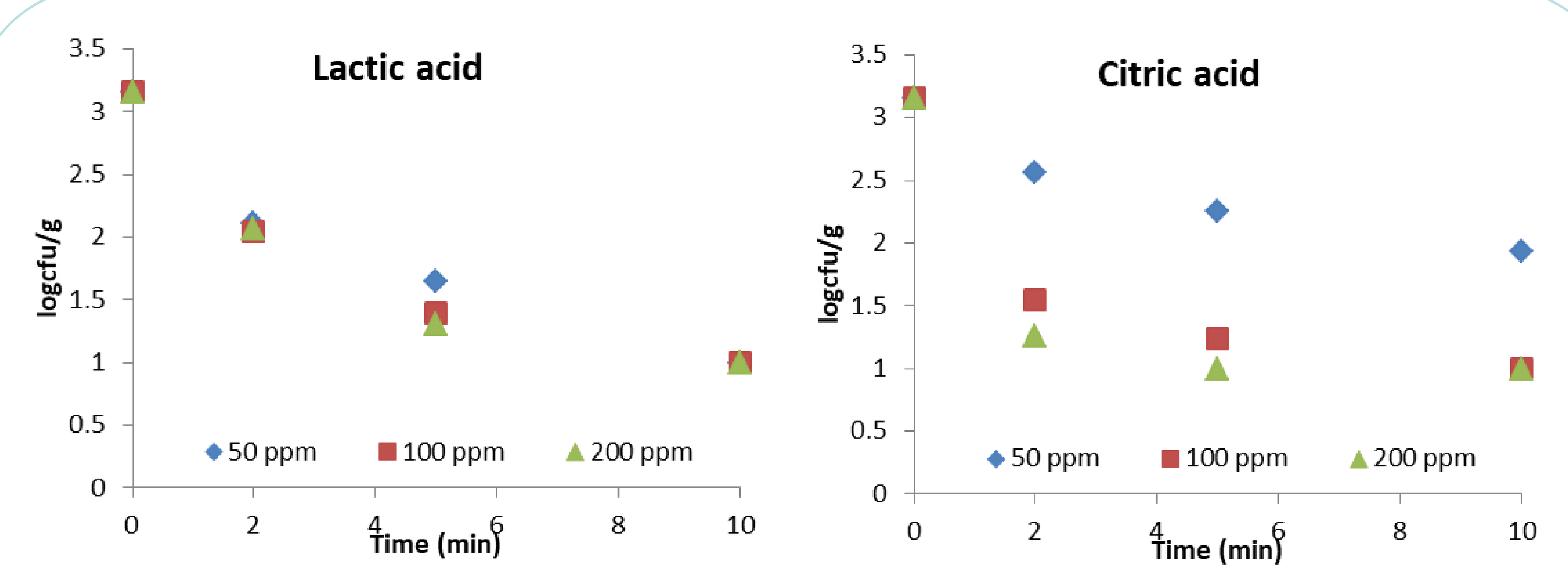

Figure 3. *Enterobacteriaceae* spp. load in whole gilthead seabream after washing during gutting with lactic acid or citric acid at concentrations 0-200 ppm and 0-10 min.

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.

References

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