Mathematical modelling of the fish surface microbial inactivation by alternative washing media

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EFFoST 2019 INTERNATIONAL CONFERENCE
12-14 November Rotterdam, The Netherlands
www.effostconference.com

Introduction

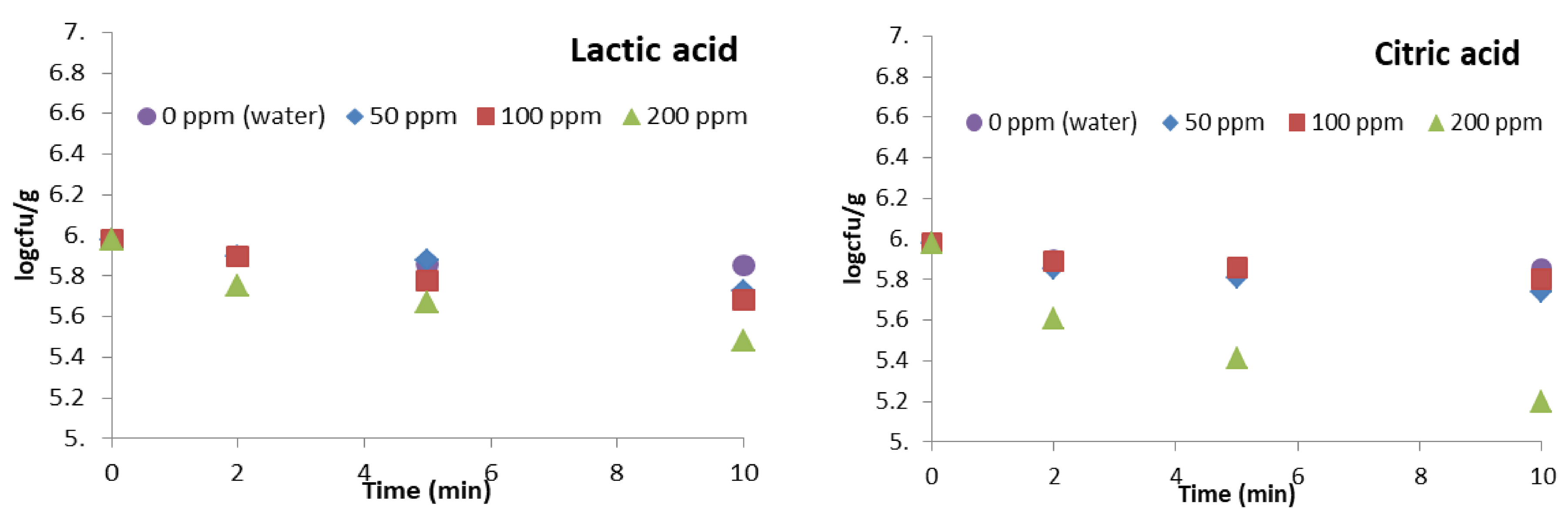
The short shelf life and perishability of fish products is a commercial drawback and methods of extension are being investigated. New minimal and nonthermal food processing methods are sought by the industry in the pursuit of producing better quality fish products with extended shelf life with retention of nutritional and sensory properties (Tsironi et al., 2015 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 the effect 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 and mathematically model the effect of surface decontamination of fresh fish using alternative organic acids on the quality and shelf life during refrigerated storage.

Materials & Methods

Marine cultured gilthead seabream (*Sparus aurata*) were stored isothermally at 0°C for 6 days after harvesting. Fish was gutted manually and immersed in water for 0-10 min. The incorporation of natural organic acids (lactic acid, citric acid, peracetic acid) at different concentrations (0-200 ppm) for times 0-10 min during gutting was tested for its efficacy to reduce initial microbial load and prolong shelf life.
Control (treated with water) and organic acid treated samples were afterwards stored under controlled isothermal conditions (0-10°C) for shelf life testing. Quality assessment was based on microbiological analysis (total viable count, *Pseudomonas* spp., *Enterobacteriaceae* spp., lactic acid bacteria, H_2S-producing bacteria, etc), pH, colour, texture measurement and sensory scoring (1-9 scale). A sensory score of 5 was taken as the average score for minimum acceptability.

Results

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). Increased microbial load reduction was achieved 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.



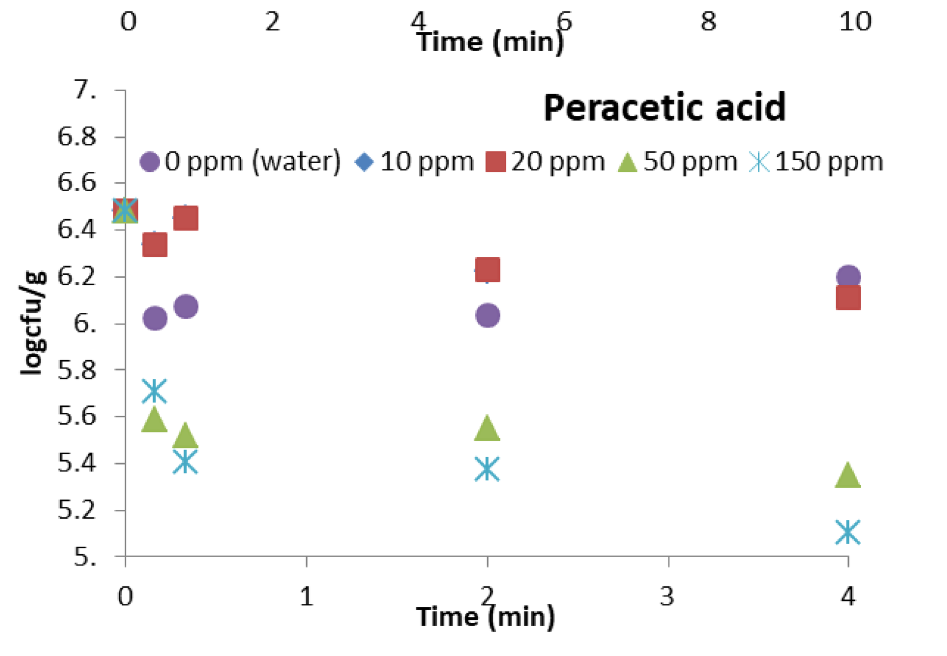


Figure 1. Total viable count (logcfug) in whole gilthead seabream (*Sparus aurata*) after surface washing with lactic acid, citric acid or peracetic acid

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):

$$log\left(\frac{N}{N_o}\right) = \alpha \cdot \sqrt{C+b} \cdot e^{-d \cdot t} \qquad (1)$$

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.

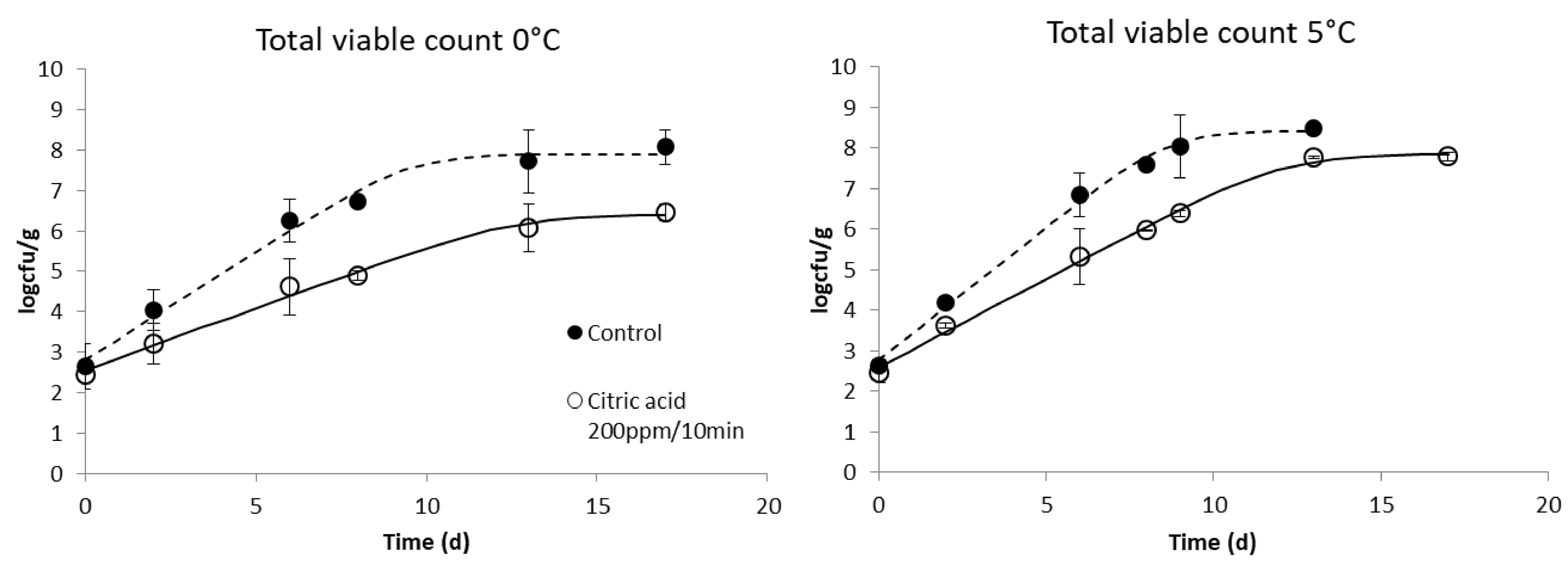
	Lactic acid	Citric acid
a	-0.015	-0.022
b	2.574	2.151
d	-0.137	-0.096

Table 1. Constants of Eq.1 for the inactivation of *Pseudomonas* spp. as a function of washing parameters

Microbial growth during subsequent refrigerated storage of untreated (Control) and treated fish was modeled using the Baranyi Growth Model (Figure 2). 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). Based on the values at the end of the shelf life of the studied indices and the temperature dependence of their rate constants expressed by the Arrhenius kinetics, simple equations for shelf life calculation can be used (Equation 2).

$$t_{SL} = \frac{logN_l - logN_o}{k_{ref} \cdot exp\left[\frac{-E_a}{R} \cdot \left(\frac{1}{T} - \frac{1}{T_{ref}}\right)\right]} \qquad (2)$$

where t_{SL} is the shelf life (d) of gilthead seabream, $logN_l$ is the limit *Pseudomonas* spp. load (7 log cfu/g), $logN_o$ is the initial *Pseudomonas* spp. load, k_{ref} is the rate constant of *Pseudomonas* spp. growth at a reference temperature T_{ref} (4°C), E_a is the activation energy of *Pseudomonas* spp. growth (60-70 kJ/mol for the different treatments), R is the universal gas constant.
Based on these calculations, the shelf life of gutted gilthead seabream for different treatment conditions is presented in Table 2.



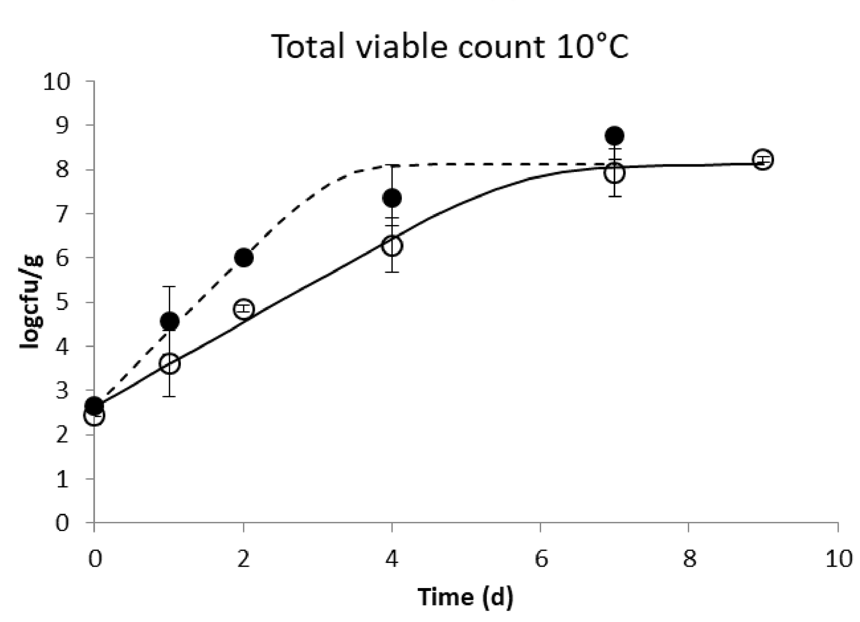


Figure 2. Total viable count (logcfug) in whole gilthead seabream (*Sparus aurata*) after surface washing with citric acid (200ppm for 10min) or water (Control) during isothermal storage at 5°C

Table 2. 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

Conclusions

The results of the study indicated that the application of washing treatment led to improved quality stability during subsequent refrigerated storage and shelf life extension. Initial surface decontamination up to 2.0 logcfu/g by the addition of organic acids in the washing water may result in 2-4 days shelf life extension of gutted fish at 0°C storage. Shelf life extension of fish could open new distant markets currently inaccessible to fresh fish products and allow the use of higher temperatures (e.g. 5°C) in the cold chain of seafood which would significantly reduce energy and food waste.

References

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Acknowledgment
This study was supported by the Greek Operational Programme for Fisheries, Priority Axis "Innovation in Aquaculture", Project title: "Development and application of novel methods at harvesting and processing of fish for quality improvement and shelf life extension" (2018-2021) website: slurryfish.chemeng.ntua.gr