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ABSTRACTS

MODELLING THE PRESERVATIVE EFFECT OF MODIFIED ATMOSPHERE PACKAGING ON FRESH FISH QUALITY AND SHELF LIFE

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Introduction

The limited and variable shelf life of chilled fish, mainly due to bacterial activity, is a major problem for their quality assurance and commercial viability. Modified atmosphere packaging (MAP) can effectively alter and delay the spoilage process and extend the shelf life of fresh fish (Tsironi and Taoukis, 2018). CO_2 inhibits the development of the respiratory organisms like *Pseudomonas* spp. and *Shewanella putrefaciens*. Despite the increasing importance of MAP technology in fish industry and the several studies evaluating the effect of MAP on fish products, a limited number of predictive models for quality deterioration and shelf life have been proposed, including the combined effect of temperature and gas concentration in the packaging environment (Koutsoumanis et al., 2000). An Arrhenius-type model has been developed by Tsironi et al. (2011) as an effective tool for predicting gilthead seabream (*Sparus aurata*) fillet quality and shelf life under different chilled storage temperatures (0-15°C) and modified atmospheres (20-80% CO_2) and its applicability has been validated in the real cold chain. On the other hand, a disadvantage of ordinary MAP is its demand for high gas to product volume ratio. Increased concentration of CO_2 in the headspace and high gas to product volume ratio may result in increased dissolution of CO_2 in the fish flesh, due to a higher partial pressure of CO_2 (Devlieghere et al., 1998). Optimal gas mixture depends on the type of the packed food.

The objective of the study was to select appropriate MAP parameters for farmed gilthead seabream and European sea bass and to develop predictive models for quality deterioration and shelf life of chilled MAP fish

Materials and methods

Whole, gutted, gilthead sea bream (*Sparus aurata*) and European sea bass (*Dicentrarchus labrax)* packed under modified atmospheres ($40\%CO_2/40\%N_2/20\%O_2$) were provided by Selonda S.A. Two alternative packaging types were tested, i.e. 1-3 specimens/package, corresponding to different levels of gas to product volume ratio in the package headspace. Samples were stored at controlled isothermal conditions in the refrigerated range (0-10°C) in high-precision (±0.2°C) low-temperature incubators (Sanyo MIR 153, Sanyo Electric, Ora-Gun, Gunma, Japan) for shelf life evaluation. Temperature in the incubators was constantly monitored with electronic, programmable miniature data-loggers (COX TRACER®, Belmont, NC). The composition of the headspace of package was measured using CheckMate 9900 O_2/CO_2 (PBI Dansensor, Ringsted, Denmark) gas analyzer. Quality assessment of fish was based on microbiological analysis (total viable count, *Pseudomonas* spp., lactobacilli, *Enterobacteriaceae* spp. and H_2S-producing bacteria), pH and sensory scoring. Samples were taken at appropriate time intervals to allow for efficient kinetic analysis of quality deterioration. Values of the different measured indices were plotted versus time for all temperatures studied and the apparent order of quality loss was determined based on the least square statistical fit. The experimental data for microbial growth were fitted to the Baranyi model (Baranyi and Roberts, 1995), using DMfit software of IFR (Institute of Food Research, Reading, UK), and the kinetic parameters of microbial growth were estimated (maximal growth rate, k and lag phase duration, lag). Temperature dependence of the deterioration rate constants, k, was modelled by the Arrhenius equation (Taoukis et al., 1997).

Results

CO_2 concentration in the package headspace decreased during the initial hours of storage (up to final CO_2 level of 20%), which was related to CO_2 dissolution in the fish flesh, especially at the lower gas to product volume ratios. Afterwards, $\%CO_2$ level increased, due to metabolic activity of spoilage bacteria, reaching highest levels at the end of storage period. With regards to O_2 concentration, it showed a descending trend, while at the end of shelf life O_2 concentration exhibited zero levels, which was related to increased microbial population of total viable counts. Shelf life estimation of MAP fish was performed based on the correlation of microbial load of total viable counts and the sensory evaluation of the samples. At all studied conditions, the time of sensory rejection coincided with an average total viable count of 10^7 cfu/g. The developed mathematical models were adapted into user friendly worksheets that allow the prediction of microbial

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growth and shelf life of gutted gilthead sea bream and European sea bass packed in MA and stored under different time-temperature conditions. It is apparent that the selection of optimal MAP parameters (i.e. initial headspace gas composition and gas to product volume ratio) is a complex issue and is a very important step in the design of MAP systems for fish products. Selection depends on the effect on microbial growth, desired food quality and shelf life, as well as the appearance of a package. CO_2 emitters, which produce CO_2 in contact with water that is obtained from liquid leaking from the fish flesh may enable reduced gas to product volume ratios in MAP fish and further increase shelf life.

Discussion and conclusion

Since shelf life extension of MAP fish requires in pack CO_2 concentration maintenance, a smart label monitoring CO_2 levels in package headspace would ensure this. The combined use of the developed shelf life models with an indicator with function of CO_2 detection and a Time Temperature Indicator (TTI) would provide useful information on the probability of the quality deterioration of packed fish, allowing better management and optimization of the cold chain from manufacture to consumption.

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