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Food Improved by Research, Science, & Technology

Effect of active packaging on microbial growth and shelf life kinetics of gutted sea bass and sea bass fillet

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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) has been established as an efficient method to preserve fresh fish products. Additionally, carbon dioxide emitters have been proposed as materials that utilize the O_2 in the package headspace so as to form CO_2 in contact with liquid leaking from the fish flesh and enhance the concentration of a CO_2/N_2 headspace in the package without requiring an additional insertion of gas, thus serving as active packaging tools (Tsironi et al., 2019).

AIM

The aim of the study was the evaluation and mathematical modeling of the effect of active modified atmosphere packaging (MAP) by the incorporation of CO_2 emitters in the package, on the microbial stability and shelf life of gutted sea bass and sea bass fillet during refrigerated storage.

METHOD

Gutted sea bass and sea bass fillet samples (*Dicentrarchus labrax*) were provided by Selonda S.A. and packaged in MAP (50% CO_2–40% N_2–10% O_2) with and without CO_2 emitters (Gutted fish: 90x255mm, 300 ml CO_2, Fillets: 80x130mm, 120 ml CO_2) kindly offered by McAirlaid's, Berlingerode, Germany (MAP-PAD, MAP samples) (gas/product volume ratio 3:1) and stored at 0-10 °C. Gas concentration (%CO_2, %O_2) was evaluated using the CheckMate9900 O_2/CO_2 device (PBI Dansensor, Ringsted, Denmark) and microbial growth (total viable count (TVC), *Pseudomonas* spp., *Enterobacteriaceae* spp., and H_2S-producing bacteria (mainly *Shewanella putrefaciens*) was monitored during storage (Fig. 3 and 4). Microbial growth was modelled using the Baranyi Growth Model and the growth rates (k) at each temperature were estimated (Fig. 5 and 6). The temperature-dependence of growth rates was modelled via the E_a of Arrhenius equation.

Picture 1. Packaged gutted sea bass and sea bass fillets with CO_2 emitters (MAP-PAD).

RESULTS

CO_2 concentration in the package headspace of the MAP samples decreased from 62% and 60% for the whole fish and the fillets, respectively, to the value of 45% approximately. This was attributed to the CO_2 dissolution in the fish flesh. Then CO_2 was increased up to 50% reaching the maximum values due to the metabolic activity of the spoilage bacteria. MAP-PAD samples resulted in higher CO_2 concentration compared to MAP samples both for gutted fish and seabass fillets because of the incorporation of CO_2 emitters in the package (Fig. 1 and 2). O_2 concentration showed a descending trend with time and exhibited zero levels at the end of the storage period.

The MAP-PAD gutted sea bass reached the acceptability limit of 7 log CFU g^{-1} for TVC (ICMSF 1986) on days 31, 20, 17, and 10 at 0, 2.5, 5, and 10°C, respectively (Fig. 3). The MAP gutted sea bass samples reached the same value quicker on days 18, 10, and 6 at 0, 5, and 10°C, respectively. The shelf life of MAP gutted sea bass at 5°C (based on the final TVC : 7 log CFU g^{-1}) was extended by 41% (7 days extension). The E_a for TVC growth rates ranged from 52 to 67 kJ mol^{-1}, for MAP-PAD and MAP samples, respectively (Table 1).

Table 1. Kinetic parameters of TVC growth in MAP-PAD gutted sea bass during isothermal storage at 0, 2.5, 5 and 10ºC.

		Growth rate, k (d^{-1})				E_a (kJ mol^{-1})
		0°C	2.5°C	5°C	10°C	
Gutted sea bass	MAP	0.175	-	0.337	0.496	67.2
	MAP-PAD	0.138	0.184	0.277	0.308	52.0

In the case of sea bass fillet, the shelf life based on the final TVC was marginally extended by the use of CO_2 emitters, for example at 5 °C shelf life was extended from 5 to 6 days.

Significant inhibitory effect of CO_2 emitters was observed for *Pseudomonas* spp. in all MAP-PAD sea bass fillet samples, that contribute to sensory quality and acceptability due to reduced off odors formed.

Table 2. Kinetic parameters of TVC growth in MAP-PAD sea bass fillet during isothermal storage at 0, 2.5, 5 and 10ºC.

		Growth rate, k (d^{-1})				E_a (kJ mol^{-1})
		0°C	2.5°C	5°C	10°C	
Sea bass fillet	MAP-PAD	0.130	0.185	0.375	0.955	131.9

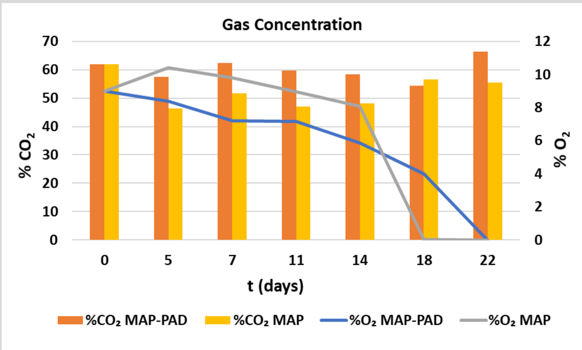

Figure 1. CO_2 and O_2 concentration in the gutted sea bass (MAP-PAD, MAP) package headspace during the isothermal storage at 5 °C. MAP: modified atmosphere packaging, MAP-PAD: active modified atmosphere packaging with CO_2 emitters.

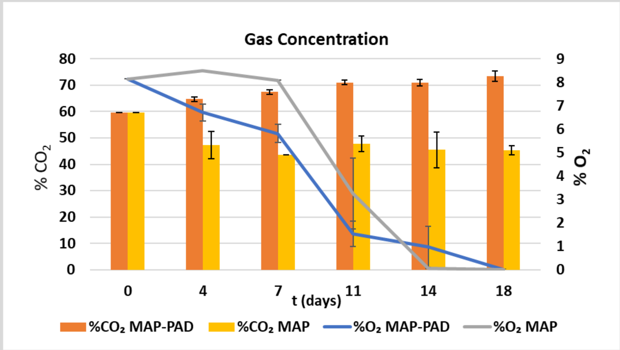

Figure 2. CO_2 and O_2 concentration in the sea bass fillet (MAP-PAD, MAP) package headspace during the isothermal storage at 5 °C. MAP: modified atmosphere packaging, MAP-PAD: active modified atmosphere packaging with CO_2 emitters.

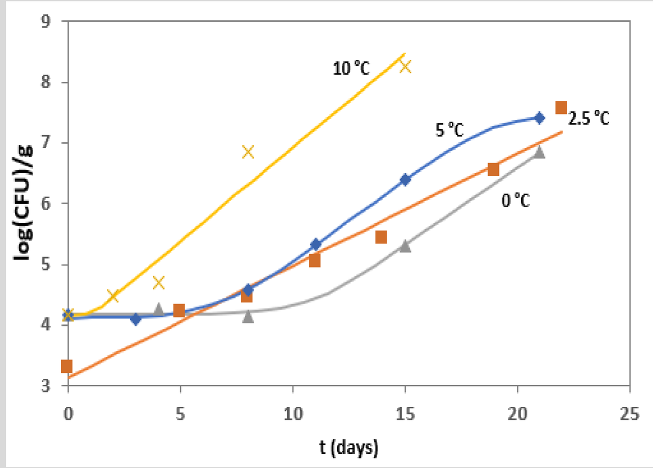

Figure 3. Total viable counts growth in MAP-PAD gutted sea bass during the isothermal storage at 0, 2.5, 5 and 10°C.

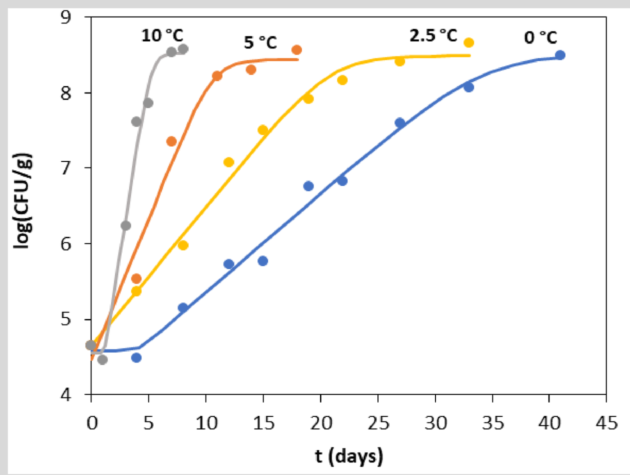

Figure 4. Total viable counts growth in MAP-PAD sea bass fillet during the isothermal storage at 0, 2.5, 5 and 10°C

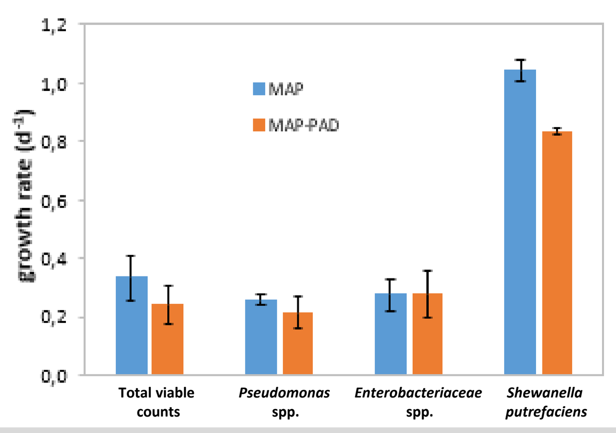

Figure 5. Growth rate (d^{-1}) for the total viable count, *Pseudomonas* spp., *Enterobacteriaceae* spp. and *Shewanella putrefaciens* in gutted sea bass during the isothermal storage at 5°C.

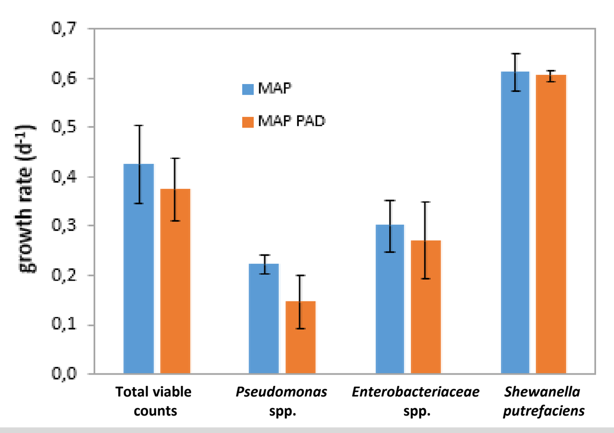

Figure 6. Growth rate (d^{-1}) for the total viable count, *Pseudomonas* spp., *Enterobacteriaceae* spp. and *Shewanella putrefaciens* in sea bass fillet during the isothermal storage at 5°C.

CONCLUSIONS

The results of the study indicated that the use of CO_2 emitters serving as active packaging materials in combination with modified atmosphere packaging inhibited dominant spoilage microorganisms in seabass (gutted fish and fillets) leading to shelf life extension during refrigerated storage.

New active packaging tools can contribute to increased shelf life, improved quality and reduced food waste along the cold chain in the case of highly perishable food such as fresh fish product.

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