THE EFFECT OF THE COMBINATION OF CLEAN LABEL INGREDIENTS AND PACKAGING CONDITIONS ON THE SHELF-LIFE AND MICROBIOLOGY OF MEAT

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Meat has a relatively short shelf-life (9 days maximum) with microbial spoilage being the main limiting factor. The aim of this study was to investigate the antimicrobial effect and potential for shelf-life extension of essential oil component (EOC) solutions, citral (CIT), carvacrol (CAR), thymol (THY) and eugenol (EUG) and organic acid (OA) solutions, citric acid (CA), lactic acid (LA) and ascorbic acid (AA), on samples. Solutions were applied using an immersion method with EOCs of 1% (v/v) and OAs of 5% (v/v). Packaging technologies, modified atmosphere packaging (MAP) and skin pack, were tested in combination with the above solutions and stored at 2°C. Microbial analysis was carried out including total viable count (TVC), total Enterobacteriaceae count (TEC), Pseudomonads and other spoilage bacteria on day 0, 9 and 18. TVC values indicated spoilage in aerobic samples by day 9, with MAP and skin pack extending the shelf-life beyond day 18.

Key Words – Clean label ingredients, Packaging technologies, Shelf-life extension of meat

I. INTRODUCTION

The consumption of meat and protein sources is increasing worldwide, for example fish consumption has increased from 9.9kg per person in 1960 to 19.2kg in 2012 [2], with demand leading to wider transport networks. Post-harvest loss of meat due to spoilage is estimated to be at least 10% worldwide, with microbial degradation the main contributor to this loss [1].The short shelf-life (9 days maximum) and increasing consumer demand has led to a need for technologies to increase shelf-life while maintaining quality. EOCs are obtained from natural plant sources and are considered to be an alternative to common chemically synthesised food preservatives [2]. With their natural antimicrobial properties, which are attributed to their phenolic compounds, they possess the potential to extend the shelf-life of meat and fish [3]. OAs, such as CA and LA, have also been effective in prolonging the shelf-life of fresh fish [4]. There has been a rise in the use of vacuum packing and MAP in processing raw fish. Skin packing inhibits aerobic bacterial growth by removing air from the pack, while MAP replaces air with a fixed gas mixture, using CO_2 to inhibit bacterial growth [5]. In this study, the antimicrobial effects of the EOC and OA treatments were monitored to assess the shelf-life extension on cod samples, aerobically stored and in MAP and skin packs. The proposed preservation technologies could also be applied to other protein sources, such as red meat.

II. MATERIALS AND METHODS

Samples (cod fillets) were obtained from a local fish monger and transported on ice to Teagasc Food Research Centre, Ashtown, within one hour. Exactly 10g samples were immersed in EOC solutions of CIT (1% v/v), CAR (1% v/v), THY (1% w/v) and EUG (1% v/v) and OA solutions of CA (5% w/v), LA (5% v/v) and AA (5% w/v) for 30 seconds. Samples were then rinsed with a 30 second immersion in sterile distilled water. Samples were transported to a nearby packaging facility to be skin packed and MAP (40% CO_2, 40% N_2, 20% O_2) using a Multivac T250 semi-automatic tray-sealer. All samples were stored at 2°C for 18 days. On day 0, 9 and 18, samples were homogenised and serial dilutions prepared. Bacterial counts were enumerated for TVC (mesophilic and psychrotrophic), TEC, *Pseudomonas sp*., *Clostridium sp*., *Brochothrix thermosphacta*, *Listeria spp*., *Photobacterium phosphoreum*, lactic acid bacteria and H_2S bacteria using ISO or peer reviewed methods. Statistical analysis was performed using a student-t test to identify significant reduction in growth ($p<0.05$).

III. RESULTS AND DISCUSSION

The results are presented in Tables 1-3. The aerobically stored samples passed the sensory rejection point of 7 $\log_{10}$ cfu/cm^{-2} by day 9 (Table 1), with the immersion of samples in EOCs and OAs showing no significant ($p>0.005$) reduction when analysed using a student t-test. This, however, was not the case with the packaging technologies, which suggested an extended shelf-life (TVC) with the end-of-shelf-life rejection point not reached in any of the MAP (Table 2) or skin packed (Table 3) samples by day 18. *Pseudomonas* and *S. putrefaciens* are the spoilage organisms associated with aerobically stored fish. This is reflected in the results with Pseudomonas growth above 7 $\log_{10}$ cfu/cm^{-2} on day 9 for

all treatments, while MAP and skin pack remain below 5 $\log_{10}$ cfu/cm^{-2} (data not shown). *S. putrefaciens* follows a similar trend. The spoilage organisms in MAP and skin pack (*P. phosphoreum* and LAB) remain lower than in aerobic samples throughout storage.

Table 1: Microbial counts ($\log_{10}$ cfu/cm-^{2}) of TVC (mesophilic) from cod (*Gadus morhua*) samples treated with essential oil components (1%) and organic acids (5%), stored aerobically for 18 days at 2°C

Day	Treatment							
	SDW[1]	CA[2]	LA[3]	AA[4]	CIT[5]	CAR[6]	THY[7]	EUG[8]
0	3.42^{A}	3.21^{A}	3.02^{A}	3.26^{A}	3.18^{A}	2.91^{A}	3.38^{A}	2.91^{A}
9	8.00^{B}	7.54^{AB}	7.32^{AB}	7.33^{AB}	7.51^{AB}	7.34^{AB}	7.03^{A}	7.70^{AB}
18	7.83^{AB}	8.55^{B}	7.44^{A}	7.81^{AB}	7.77^{AB}	8.06^{AB}	7.83^{AB}	8.36^{B}

[1]SDW= Sterile distilled water [2]CA=Citric acid [3]LA=Lactic acid [4]AA= Ascorbic acid [5]CIT=Citral [6]CAR=Carvacrol [7]THY=Thymol [8]EUG=Eugenol. Statistical analysis:[A]The same letter indicates the treatment is not statistically different at the 5% level (P>0.05)

Table 2: Microbial counts ($\log_{10}$ cfu/cm-^{2}) of TVC (mesophilic) from cod (*Gadus morhua*) samples treated with essential oil components (1%) and organic acids (5%), stored under modified atmosphere packaging (CO_2:40%, N_2:40%, O_2:20%) conditions for 18 days at 2°C

Day	Treatment							
	SDW[1]	CA[2]	LA[3]	AA[4]	CIT[5]	CAR[6]	THY[7]	EUG[8]
0	3.35^{A}	3.34^{A}	3.07^{A}	3.58^{A}	2.86^{A}	2.72^{A}	3.05^{A}	3.20^{A}
9	4.72^{B}	4.50^{AB}	4.40^{AB}	4.22^{AB}	4.28^{AB}	3.59^{A}	4.98^{B}	4.94^{B}
18	6.22^{B}	5.17^{AB}	5.46^{AB}	4.84^{A}	5.54^{AB}	5.55^{AB}	6.11^{B}	5.97^{B}

[1]SDW= Sterile distilled water [2]CA=Citric acid [3]LA=Lactic acid [4]AA= Ascorbic acid [5]CIT=Citral [6]CAR=Carvacrol [7]THY=Thymol [8]EUG=Eugenol. Statistical analysis:[A]The same letter indicates the treatment is not statistically different at the 5% level (P>0.05)

Table 3: Microbial counts ($\log_{10}$ cfu/cm-^{2}) of TVC (mesophilic) from cod (*Gadus morhua*) samples treated with essential oil components (1%) and organic acids (5%), stored in a skin pack for 18 days at 2°C

Day	Treatment							
	SDW[1]	CA[2]	LA[3]	AA[4]	CIT[5]	CAR[6]	THY[7]	EUG[8]
0	3.64^{A}	3.32^{A}	3.51^{A}	3.70^{A}	2.69^{A}	2.71^{A}	3.21^{A}	3.30^{A}
9	4.52^{AB}	4.43^{AB}	3.67^{A}	4.64^{AB}	4.50^{AB}	4.41^{AB}	5.07^{B}	5.39^{B}
18	5.73^{B}	4.73^{AB}	4.36^{A}	4.99^{AB}	5.60^{AB}	5.17^{AB}	5.51^{B}	5.45^{B}

[1]SDW= Sterile distilled water [2]CA=Citric acid [3]LA=Lactic acid [4]AA= Ascorbic acid [5]CIT=Citral [6]CAR=Carvacrol [7]THY=Thymol [8]EUG=Eugenol. Statistical analysis:[A]The same letter indicates the treatment is not statistically different at the 5% level (P>0.05)

IV. CONCLUSION

The application of EOCs and OAs alone had no significant impact on the TVCs of cod over a period of 18 days. However, the use of packaging technologies indicated an increased shelf-life of cod with TVC values not exceeding the end-of-shelf-life rejection point of 7 log10 cfu/cm-^{2} by day 18. Similar techniques may be applied to other meat species to increase shelf-life.

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