

**Title** A novel packaging method with a dissolving CO<sub>2</sub> headspace combined with organic acids prolongs the shelf life of fresh salmon

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### Abstract

The aim of this study was to evaluate a novel packaging method for fresh fish and to determine its effect on the bacterial growth in fresh salmon. Fresh salmon was packed with a small amount of 100% CO<sub>2</sub> (gas/product ratio 0.2/1.0 v/v) and a brine solution containing various combinations of citric acid (3% w/w, pH 5), acetic acid (1% w/w, pH 5) and cinnamaldehyde (200 µg/ml). Total bacterial counts, counts of sulphur reducing bacteria, lactic acid bacteria and Enterobacteriaceae as well as the bacterial composition in the product after storage were determined. The combination of CO<sub>2</sub> and organic acids completely inhibited bacterial growth during 14 days of storage at 4 °C both in inoculation experiments and in experiments on salmon with natural background flora. CO<sub>2</sub>, acetic acid and citric acid alone each inhibited the growth of total bacterial counts, lactic acid bacteria, sulphur reducing bacteria and Enterobacteriaceae, but effects were enhanced in combinations. The addition of cinnamaldehyde did not influence bacterial growth. Analysis of the bacterial flora of salmon inoculated with different spoilage bacteria showed that *Photobacterium phosphoreum* and *Carnobacterium maltaromaticum* remained the dominating species after inoculation while *Yersinia aldovae*, *Aeromonas salmonicida* and *Shewanella putrefaciens* were outcompeted by other species. In addition, lactic acid bacteria from the natural background flora grew to high numbers. Combinations of CO<sub>2</sub> and acetic acid reduced the relative abundance of *P. phosphoreum*. All CO<sub>2</sub> dissolved in the product, thereby creating a product with the outer appearance of a vacuum package. Further work is needed to determine consumer acceptability of acid concentrations and to implement the packaging method for industrial purposes. However, implication of this packaging method in the industry may lead to a new packaging technology, combining the advantages of vacuum packaging (low space requirement) and modified atmosphere packaging (antimicrobial effect of CO<sub>2</sub>).