SHELF-LIFE OF FRESH SALMON (SALMO SALAR) WITH LEMON JUICE STORED AT NORMAL AND ABUSIVE TEMPERATURES

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Introduction

Fish is an important constituent of human diet, being an important source of chemical constituents, such as liposoluble vitamins, microelements, essential amino acids and polyunsaturated fatty acids (Sallam, 2007; Vinagre *et al*., 2011).

Fish has a relatively short shelf-life due to several mechanisms involved in the process of fish deterioration, such as physical and chemical changes and microbiological activity (Hozbor *et al*., 2006). During storage, processing and distribution, changes in protein and lipid fractions occur, resulting in a significant degradation of sensory quality and nutrition.

Fish microbiota is quite influenced by capture location and fish handling during distribution and storage (Briones *et al*., 2010).

Modified atmosphere packaging (MAP) with refrigeration and active packaging are increasingly used to extend the shelf-life of food products. Consumers have a preference for using natural antimicrobials components in their foods and the extract of citrus fruits has been shown to decrease the growth of specific spoilage bacteria on fish (Corbo *et al*., 2008).

Freshness of fish can be established by various indicators, including microbial enumeration methods, such as total viable counts (TVC), measurement of lipid oxidation and sensory evaluation (Hozbor *et al*., 2006).

The aim of this work was to estimate the onset of spoilage of fresh Atlantic salmon (Salmo salar) fillets stored at 3 and 8°C, under different atmospheres with addiction of lemon juice.

Materials and Methods

Salmon specimens were obtained in the local market (Portugal) and were immediately transported on ice in refrigerated Styrofoam boxes to the laboratory. There was headed, deskinned and filleted in 3x4x1 cm^3 samples, weighing about 30 g, and individually packed, in duplicate, in three different conditions: air packaging (AP), and modified atmosphere packaging consisted of 50%O_2/40%CO_2/10%N_2 (Praxair, Portugal) without (MAP) and with lemon juice addition (MAPL).

Air packaging salmon fillets were tray-packed overwrapped with polyethylene film. MAP and MAPL samples were individually placed in plastic bags (COMBITHERM XX, WIPAK Walsrode, HAFRI) 0.115 mm thick, having an O_2 transmission rate of 1cm^3 m^{-2} d^{-1}atm^{-1} at 23 °C and 0% RH and WVT of 1g m^{-2} d^{-1} at 23 °C and 85% RH. Air was first removed from the bags and then flushed with the gas mixture using a vacuum equipment (SAMMIC V-420 SGA, Spain). The final ratio gas to sample volume was approximately 3:1. For MAPL samples, 0.5 mL of LJ was distributed on a 6x7 cm^2 No.42 Whatman paper and paper was placed within the container using a procedure identical to Skandamis and Nychas (2002).

After packaging, the samples were stored at 3 and 8° C and analyzed at intervals of 24, 72, 144, 216 and 312h for the two temperatures. One sample was immediately analyzed, corresponding to t0.

The aim of this study was to evaluate the effect of lemon juice in combination with MAP on microbial (TVC, Psychrotrophics, LAB, *Brochothrix thermosphacta*, *Enterobacteriaceae*, H_2S producers and *Pseudomonas* spp.), physical-chemical (pH, colour L* a* b*, Total Volatile Base-N) and sensory parameters (colour, viscosity, odour and overall assessment of freshness (OAF) using a non-structured scale of 0 to 15cm) of salmon fillets.

The relation between the studied parameters and spoilage of fresh Salmon fillets was calculated using principal component analysis (PCA) and discriminant analysis (DA). Pearson's and Spearman's correlations between physical-chemical, microbiological, sensory analysis and OAF were calculated. Data analysis was carried out using XLStat V2006.06 package (Addinsoft, Inc, New York, U.S.A.).

Results and discussion

For lactic acid bacteria, yeasts and moulds, Enterobacteriaceae, total viable counts and H_2S producers an effect of lemon juice (MAPL) was observed, with less growth rate, particularly evident in the final stage of storage. Lemon juice combined with MAP showed a more pronounced effect in the reduction of *Brochothrix thermosphacta* and H_2S producer counts.

Colour is an importance parameter to consumer's choice due to the direct association between this characteristic and fish freshness (Santos et al., 2013). This kind of fish has a natural orange or pink colour which is considered a positive attribute, and during the spoilage processes a loss of salmon fillets colour occur.

As expected, positive correlations were obtained between the sensory colour attributes, *sui generis* odour and OAF. A slightly significant correlation between L* and OAF revealed that for assessors associate the increase of luminosity values (L*) with a whiteness, then classified salmon fillets with less OAF. The values of a* and b* parameters, more related to the colour perceived by the human eye, confirmed that fillets did not undergo a significant variation of b* parameter ($p>0.05$) during storage. On the other hand, fillets packaged under AP became darker (L* values decreased).

Santos et al. (2013) also noted that the L*values of fillets in MAP, increased over the storage time, which may be due to the acidification of the muscle due to dissolution of CO_2 and denaturation of proteins that whitens fillets (Ruff et al., 2002).

The viscosity, sour, putrid, ammoniacal off-odours were responsible for the sensory rejection of the fillet

samples and ultimately these attributes contribute to decrease the OAF value, determining the sensory salmon shelf-life.

The discriminant analysis technique revealed to be very useful, providing a clear separation between the fresh salmon fillets packaged in AP and those stored in MAP and MAPL, preserving high levels of accuracy.

Conclusions

It was established that the viscosity, off-odours and OAF were the best sensory attributes for evaluation of freshness. In conclusion, lemon juice with MAP applied to salmon fillets had a positive effect, retarding the growth of microorganisms thereby increasing the shelf-life of the salmon.

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