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Effects of glazing and chitosan-based coating application on frozen salmon preservation during six-month storage in industrial freezing chambers

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ABSTRACT

Freezing and glazing are techniques commonly used to reduce the incidence of fish deterioration processes. In order to find an alternative to complement freezing and replace water glazing, the present work aimed at evaluating the effect of water glazing and edible coatings of 0.5% w/v and 1.5% w/v chitosan on quality parameters of frozen fish. Both types of coatings – water glazing and chitosan coatings – were applied directly on frozen Atlantic salmon (*Salmo salar*) and stored for 9 months at −22 °C. Several parameters such as coating/glazing loss, weight loss, drip loss, Total Viable Counts (TVC), Total Volatile Basic-Nitrogen (TVB-N), K-value, pH and color coordinates $L^*a^*b^*$ were periodically evaluated in order to compare glazing with the chitosan-based coatings and uncoated control samples. Samples coated with 1.5% w/v chitosan performed better in maintaining the color of the salmon and controlling microbial contamination of frozen and thawed samples.

1. Introduction

The demand for food that promotes health and well-being has increased in recent years (FAO, 2012). The populations of many industrialized countries are becoming older, richer, more educated and more health conscious (FAO, 2012). Freezing is the main method of processing fish for human consumption and the most used to control and/or reduce biochemical changes that occur during storage (Fan et al., 2009; Kilincceker, Dogan, & Kucukoner, 2009; Rodriguez-Turienzo et al., 2011; Sathivel, Liu, Huang, & Prinyawiwatkul, 2007). However, there are reports of progressive loss of intrinsic and sensory quality of frozen fish during storage (Vanhaecke, Verbeke, & eBrabander, 2010). In fact, if on one hand, the use of temperatures below −12 °C inhibits microbial growth and slows down enzymatic activity (Jiang & Lee, 2004 cited in Rodriguez-Turienzo et al., 2011), on the other hand, freezing is not able to completely inhibit microbial and chemical reactions, such as lipid oxidation, protein denaturation and surface dehydration (due to sublimation and recrystallization of ice crystals) leading to deterioration of fish quality during prolonged storage. These reactions result in off-flavors, rancidity, dehydration, weight loss, loss of juiciness, drip loss and toughening, as well as microbial spoilage and autolysis (Fan et al., 2009; Gonçalves & Gindri Junior, 2009; Rodriguez-Turienzo et al., 2011 Sathivel et al., 2007).

The application of a thin layer of ice on the surface of the frozen products by spraying or dipping into a water bath is a common practice in frozen fish industry, in a process termed glazing (Gonçalves & Gindri Junior, 2009; Vanhaecke et al., 2010). This technique aims at minimizing the impact of undesirable changes on the quality of frozen products during storage (Gonçalves & Gindri Junior, 2009; Vanhaecke et al., 2010). This water glaze excludes air from the surface of the product, thus reducing the rate of oxidation and also serves as a protective barrier to temperature fluctuations, allowing the glaze to evaporate in the place of tissue water, when an increase of temperature occurs (Fossan & Jacobsen, 2001 cited in Gonçalves & Gindri Junior, 2009). New technologies are being used to ensure the conformity of frozen fish during storage trying to satisfy the growing demand for this product (Sathivel et al., 2007; Souza et al., 2010). Edible films and coatings have become a promising alternative to protect food products against mechanical damage, physical, chemical and microbiological activities (Falguera, Quintero, Jimenez, Munoz, & Ibarz, 2011; Pinheiro et al., 2010). Chitosan is a natural amino-cationic hetero-

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polymer composed of β-1.4 D-glucosamine units, linked to N-acetylglucosamine residues, which can be obtained by chitin deacetylation. Chitosan attracts much attention in the food industry because it is non-toxic, bioactive (anti-microbial, anti-oxidant), biodegradable, biocompatible and has also a very interesting reactivity, selective permeability, polyelectrolytic action, adsorption capacity and ability to form gels and films, a consequence of its visco-elastic properties once in solution (Fan et al., 2009; Pinheiro et al., 2010; Sathivel et al., 2007).

Monitoring and controlling the quality of frozen fish is one of the fundamental worries of the seafood industry. Many parameters are involved in the definition of quality, including safety, nutritional and sensory properties, price, convenience and constancy, packaging color, availability and freshness (Ólafsdóttir et al., 1997; Souza et al., 2010). The change of one of these parameters affects largely the product acceptability by the consumers and consequently also its commercial value (Rodriguez-Turienzo et al., 2011). Freshness is one of the most important parameters for the quality of the final product (Ólafsdóttir et al., 1997).

2. Materials and methods

2.1. Fish preparation

Frozen and packaged Atlantic salmon (*Salmo salar*) fillet was obtained from a local company (Vanibru – Comércio de Produtos Alimentares, Braga, Portugal). After unpacking, the salmon fillets were cut into slices (samples) with the dimensions 10 cm × 5 cm × 2–3 cm (Fig. 1) and an average weight of 113.4 ± 7.4 g, using a vertical bone sawing machine (FK 32, BIZERBA, Germany). This process was carried out in a refrigerated (5–8 °C) room to minimize heat uptake. For each treatment, salmon samples ($n = 3$) were individually packed in zip-lock polyethylene freezer bags and stored in an industrial freezing chamber maintained at −21.4 ± 1.6 °C, for 9 months.

2.2. Preparation of coating solutions

Chitosan from Golden-shell Biochemical Co. Ltd. (China) with a 91% degree of deacetylation was used. The coating solutions were prepared by dissolving chitosan (0.5% and 1.5% w/v) in a 1% (v/v) lactic acid solution with agitation, using a magnetic stirrer, at a temperature of 45 °C, until complete dissolution.

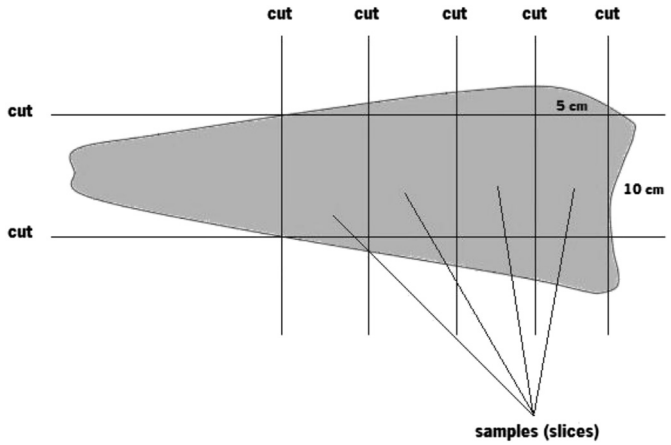

Fig. 1. Illustration of the salmon fillet, exemplifying the scheme of cuts used.

2.3. Sample preparation

2.3.1. Samples coated with chitosan

Frozen salmon samples at −21.4 ± 1.6 °C were weighed (W_1) and divided in two groups: one group of samples was immersed in a 0.5% w/v chitosan solution at 5.18 ± 0.49 °C during 35 s and another group of samples was immersed in 1.5% w/v chitosan solution at 8.10 ± 0.57 °C during 10 s. The solution temperature was monitored by an infrared Pronto Plus thermometer (HANNA Instruments, HI765PW and HI99556-10, Romania). Samples were subsequently drained for 2 min and weighed again (W_2). The temperatures and dipping times of the different coating solutions are different because they were adjusted to achieve a similar coating uptake in all samples. These experiments were performed in a pilot-scale glazing tank with the help of a stainless steel mesh, used to collect the samples from inside the tank in order to minimize the interference with the amount of coating applied. Following Equation (1), the coating uptake was calculated, where W_1 and W_2 indicate the weight of the salmon sample before and after the coating application, respectively. An average of 9.6 ± 0.1% and 10.0 ± 0.2% of coating uptake (wt%) was obtained for chitosan solutions (w/v) of 0.5% and 1.5%, respectively.

$$\text{Coating uptake}(\%) = \frac{W_2 - W_1}{W_2} \times 100 \quad (1)$$

2.3.2. Samples glazed with water

A similar process was followed for water glazed salmon samples. These samples were weighed (W_3), dipped in water at 0.28 ± 0.08 °C for 40 s, drained for 1 min and weighted again (W_4). Glazing uptake was calculated using Equation (2), where W_3 and W_4 indicate the weight before and after glazing is applied in the samples, respectively. An average of glazing uptake of 8.4 ± 0.3% was obtained.

$$\text{Glazing uptake}(\%) = \frac{W_4 - W_3}{W_4} \times 100 \quad (2)$$

2.3.3. Control samples

Samples from the control group were left untreated. These non-coated samples were used for comparison with the remaining groups of samples.

2.4. Samples storage and transport

All salmon samples were individually packed in ziplock polyethylene freezer bags, inside corrugated boxes, and stored in an industrial freezing chamber maintained at −21.4 ± 1.6 °C, for 6 months. This temperature was monitored using a data logger (DS7922 1Wire® Thermochrom® iButton®, Dallas Semiconductor Inc., U.S.A.). All analyses were done in triplicate.

2.5. Samples analyses

2.5.1. Coating loss

After the storage period, coated samples were weighed again (W_5) and the coating loss was calculated using Equation (3).

$$\text{Coating loss}(\%) = \frac{W_5 - W_2}{W_2 - W_1} \times 100 \quad (3)$$