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Microbial and sensory changes during refrigerated storage of desalted cod (*Gadus morhua*) preserved by combined methods

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Abstract

Water blanching and the use of additives (potassium sorbate and citric acid) combined with different types of packaging (air, vacuum "VP" and modified atmosphere packaging "MAP": 60% CO_2, 30% N_2 and 10% O_2), were studied as new methods of preservation of chilled desalted cod. Microbial counts and total volatile basic nitrogen (TVB-N) analyses were carried out during a period of 42 days on all samples stored at 4 °C. No *Aeromonas* or sulphite-reducing *Clostridium* were isolated from any of the analysed samples. The lowest microbial counts of mesophilic, psychrotrophic, *Pseudomonas*, moulds and yeasts, were found in samples with additives in all kinds of packaging. These samples in VP or MAP maintained an excellent microbial quality throughout the 42 days of storage, with mesophilic and psychrotrophic counts always below 4 log CFU/g. Counts of the four microorganisms above-mentioned in blanched samples packaged with air, exceeded 5 log CFU/g on days 21–28, so it became necessary to use VP or MAP to maintain these microorganisms at an acceptable level for the entire storage period. TVB-N contents were low in samples with additives, regardless of the kind of packaging, as well as in blanched samples packaged in VP and MAP, never reaching 25 mg/100 g. Since there were no significant differences either in microbial growth or in TVB-N between samples in VP and MAP, a sensory analysis was performed only in desalted cod submitted to the two treatments (blanching and additives) combined with VP, both in raw and cooked samples. The results of this analysis showed that the addition of potassium sorbate and citric acid did not alter the typical organoleptic features of desalted cod. The sensory characteristics of both blanched samples and those with additives in VP showed no change during the period of the study.

Keywords: Desalted cod; Additives; Blanching; Vacuum packaging; Modified atmosphere

1. Introduction

Salt-cured cod (*Gadus morhua*), frequently referred to by its Spanish name "bacalao", is an important product obtained mainly from the Icelandic and Norwegian fisheries (Bjornsson, 2000; Gallart-Jornet et al., 2003). It is principally consumed in the Mediterranean countries such as Spain and Portugal, and also in Latin America (Thorarinsdottir et al., 2002; Bjϕrkevoll et al., 2003). The high salt concentration of this product (approximately 20% w/w) requires rehydration for 24 h before consumption. Current trends indicate consumer demand for products that are as consumer-ready as possible, which means that the development of new ready-to-use desalted cod products would be a welcome addition to the market (Rodríguez-Barona et al., 2000). The main problem involved is its limited shelf life in refrigeration, due to the rapid growth of microbiota as well as sensory spoilage (Akse and Joensen, 1996; Skjerdal et al., 1997; Fernández-Segovia et al., 2000).

Several studies have dealt with the cod desalting process (Martínez-Álvarez, 2002; Rodríguez-Barona et al., 2003; Barat et al., 2004a,b,c, 2006; Erikson et al., 2004; Andres et al., 2005); however, there is very little information on the preservation of cold desalted cod. Some of the studies carried out have investigated the application of oxygen peroxide, which was found to be unsuitable since it could involve unpleasant changes in the sensory characteristics, such as color or texture. Previous studies carried out in our laboratory

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demonstrated that the combination of citric acid with potassium sorbate (GRAS – generally recognized as safe-compounds approved for use in seafood), would be an acceptable alternative for the preservation of desalted cod (Fernández-Segovia et al., 2003a, 2006).

Mild thermal treatments (water and steam blanching, and microwave radiation) have also been applied in previous studies on desalted cod. The results showed a significant reduction in microbial growth (Fernández-Segovia et al., 2000, 2003b), although the heat caused changes in the original texture, color and other important characteristics as compared to untreated desalted cod (Fernández-Segovia et al., 2003c). Nevertheless, a sensory study (Escriche et al., 2001) demonstrated that after cooking there were no differences in the organoleptic characteristics between the thermally treated product and the untreated samples. Mild thermal treatments could therefore be used for prolonging the shelf life of desalted cod as a means of offering consumers pre-cooked ready-to-use desalted cod. In this way, the thermal treatments would not only preserve the fish but would also contribute added value to the desalted cod.

Hurdle preservation technology requires the combination of techniques that establish a series of preservative factors that will slow down microbial growth, increasing shelf life and safety. Some of these hurdles may be low storage temperatures, thermal treatments, water activity, pH, preservatives and other techniques including modified atmosphere packaging (MAP), bioconservation, bacteriocins, etc. (Leistner and Gorris, 1995). Potassium sorbate has been used in combination with MAP, giving additional shelf life to fish products (Fey and Regenstein, 1982; Reddy et al., 1992). However, other reports did not show additional effect (Barnett et al., 1987) on the extension of the shelf life. Dalgaard et al. (1998) demonstrated that potassium sorbate markedly reduced growth of *Photobacterium phosphoreum*, identified as the specific spoilage organism in modified-atmosphere-packed cod fillets (Dalgaard, 1995; Dalgaard et al., 1997) and salmon (Emborg et al., 2002) stored at chill temperatures.

The aim of this work was to study the effects of water blanching treatment and the incorporation of additives (potassium sorbate and citric acid), combined with different types of packaging (air, vacuum and modified atmosphere), on the microbial growth, TVB-N evolution and sensory quality of desalted cod stored at 4 °C.

2. Materials and methods

2.1. Sample preparation

The raw material consisted of whole Spanish salted cod (*Gadus morhua*) supplied by a local factory (Valencia, Spain). All the tests were carried out with cod from the same batch and with a similar size (weight from 1.200 to 1.500 kg approximately).

The tail was removed from each piece and the sides were trimmed to form a rectangular shape. The rectangle was cut into portions of 6.5×2.5 cm, randomly divided into 3 batches (C=Control samples, B=Blanching and A=Additives) and were subsequently desalted and/or subjected to different treatments (Table 1). In all cases, the desalting process was carried out for 48 h submerging the samples in distilled water (weight/volume [w/v] ratio 1:6) at 4 °C, with water changes at 2, 7, 24 and 36 h. The water in the third and fourth changes had 7% of NaCl to ensure that all the portions of desalted samples had a salt concentration previously established (5%). This level of salt was selected in order to contribute to the inhibition of *Clostridium botulinum* type E (Graham et al., 1996) and because the effectiveness of this concentration combined with additives on the extension of the shelf life of desalted cod, had been previously demonstrated (Fernández-Segovia et al., 2003a).

The samples in batch C were desalted without additives and were used as control samples.

After desalting as previously described, the portions in batch B were submitted to blanching treatment by introducing the samples into boiling water for 1 min. The thermal treatment conditions chosen were based on previous studies (Fernández-Segovia et al., 2000).

In the desalting process of samples in batch A, NaCl (7% in solution) and citric acid (CA) (0.2% in solution) were incorporated in the third change, and NaCl (7% in solution) and potassium sorbate (KS) (0.45% in solution) in the fourth change (Table 1). The CA, KS and NaCl concentrations were based on those of previous experiments (Fernández-Segovia et al., 2003a). NaCl, potassium sorbate and citric acid were supplied by Panreac Química, S.A. (Barcelona, Spain).

Immediately after desalting, the samples of the three batches were each randomly divided into three new groups that were packaged in three different ways, one group with air, the second in vacuum (VP) and the third in modified atmosphere (60% CO_2, 30% N_2, 10% O_2). All samples were packaged in Polyamide/

Table 1
Experimental design of the treatments carried out with the raw material

Treatment	Desalting process						Kind of packaging
	2 h	7 h	24 h	36 h	48 h		
Control	Water change	Water change	Water change+NaCl (7%)	Water change+NaCl (7%)	End process		Air vacuum MAP
Blanching	Water change	Water change	Water change+NaCl (7%)	Water change+NaCl (7%)	End process	Water blanching (1 min)	Air vacuum MAP
Additives	Water change	Water change	Water change+NaCl (7%)+CA (0.2%)	Water change+NaCl (7%)+KS (0.45%)	End process		Air vacuum MAP

CA: citric acid; KS: potassium sorbate; MAP: modified atmosphere.