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# Use of citric and lactic acids in ice to enhance quality of two fish species during on-board chilled storage

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ABSTRACT

This work focused on the on-board chilled storage of European hake (*Merluccius merluccius*) and megrim (*Lepidorhombus whiffiagonis*). To enhance fish quality, an aqueous solution including citric (1.25 g $l^{-1}$) and lactic (0.50 g $l^{-1}$) acids was prepared, frozen, ground and employed as icing medium. Its effect on sensory, microbiological and chemical changes was monitored after 9, 12 and 15 days of on-board storage. Lower ($p < 0.05$) bacterial growth was detected according to microbiological (aerobe, anaerobe, psychrotrophe, proteolytic, and Enterobacteriaceae counts) and chemical (trimethylamine content) assessments. An inhibitory effect ($p < 0.05$) on autolysis development (K value assessment) in hake was also detected. Finally, an enhancement of sensory scores (eyes, external odour and gills) in both species was obtained. Results described allow to conclude that on-board employment of such acid-mixture icing system can provide a profitable strategy to obtain higher quality and safe products while unloading.



# Utilisation d'acides lactiques et citriques dans la glace afin d'améliorer la qualité de deux espèces de poissons pendant l'entreposage frigorifique à bord des navires de pêche

*Mots clés :* *Merluccius* ; *Lepidorhombus whiffiagonis* ; Refroidissement à bord des bateaux de pêche ; Acide citrique ; Durée d'entreposage ; Acide lactique

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## 1. Introduction

Deterioration of marine species begins immediately upon capture or harvest, and the degree to which it continues depends directly on storage conditions. Flake ice has been the most employed method to cool and store fish products and partially inhibit detrimental effects on the commercial value. However, significant deterioration of sensory quality and nutritional value has been detected in chilled fish as a result of microbial and biochemical degradation mechanisms (Whittle et al., 1990; Beaufort et al., 2009). To retard fish damage as long as possible and accordingly extend shelf life, a wide number of preservative strategies to be combined with flake ice chilling have been tested satisfactorily such as previous chemical treatment (Manju et al., 2007), employment of preservative packaging (Ruiz-Capillas et al., 2001) and presence of preservative compounds (ozone) (Pastoriza et al., 2008) or plant extracts (thyme hydrosol, rosemary extract) (Oral et al., 2008; Özyurt et al., 2012) in the icing medium.

Among previous chemical treatments used during chilling storage, natural low molecular weight organic acids and their sodium salts represent a relevant choice because of their easy availability, low commercial cost and wide range of permitted concentrations for use. Thus, citric acid (CA) is widely known for its role as a chelator and an acidulant in biological systems; its presence has resulted in a profitable effect on fish fillet (Badii and Howell, 2002; Kilinc et al., 2009) and whole fish (Aubourg et al., 2004) quality. Further, lactic acid (LA) has been reported to be effective in preserving and extending shelf-life for fish fillets (Kim et al., 1995; Metin et al., 2001) and coated fish (Gogus et al., 2006).

Unlike other muscle food, fish are usually harvested in remote locations. Among them, the Grand Sole North Atlantic fishing bank has been exploited by a wide number of European countries. Due to the fast post-mortem deterioration of fish species, most problems are encountered because the time elapsed between catching in these locations, and arrival at the ultimate destination can reach a 14–17-day period. Consequently, the threat of having fish condemned, withdrawn from sale, or sold at low prices at harbour, may limit the length of the voyage (Aubourg et al., 2006; Barros-Velázquez et al., 2008). As a result, substantial efforts are needed for the optimisation of the refrigeration systems employed on-board to meet the increasing consumer demand for high quality and safe, fresh products.

The present work is focused on the on-board storage and commercialisation of two abundant fish species (European hake, *Merluccius merluccius*; megrim, *Lepidorhombus whiffiagonis*.) from the Grand Sole bank. Its basic objective was the quality enhancement of fish captured during the first period of the trawler trip. Previous research carried out at laboratory level showed that quality loss could be inhibited in both species when applying ice prepared from an aqueous solution of CA and LA (García-Soto et al., 2013, 2014). With the aim of attaining a quality enhancement, an aqueous solution including both acids was prepared and employed on-board as an icing medium. Its effect on sensory, chemical and microbiological changes was monitored at different catching times during a trawler trip.

## 2. Material and methods

### 2.1. Icing systems

An aqueous solution containing 1.25 g $l^{-1}$ of CA and 0.50 g $l^{-1}$ of LA was prepared, packed in polythene bags and kept frozen at −20 °C until use. Traditional ice was prepared starting only from tap water that was packed and kept frozen in the same way as the ice including both acids. Before addition to individual fishes, the two ices were ground to obtain common flakes. Organic acids encountered in the present research are regarded as safe (GRAS) for use in foods according to European and American administrations (Madrid et al., 1994; Giese, 1996).

Previous research was conducted onshore to assess a convenient concentration of CA and LA to prepare the ice (García-Soto et al., 2013, 2014). Thus, solutions combining the two acids in the 0.05–2.50 g $l^{-1}$ concentration range were preliminary tested. According to the evaluation of sensory, microbiological and chemical indices related to quality loss, the above-mentioned combination of both acids (1.25 g $l^{-1}$ of CA and 0.50 g $l^{-1}$) of LA was chosen.

### 2.2. Fish material, processing and sampling

European hake (*Merluccius merluccius*; length 32–35 cm, weight 180–210 g), and megrim (*Lepidorhombus whiffiagonis*; length 20–23 cm, weight 95–120 g) were captured in the Grand Sole North Atlantic fishing bank throughout a single trip (May–June 2012). All fish were gutted immediately after catching, but none were beheaded. For each fish species, individuals were distributed on-board into acid (treated batch, T) or traditional (control batch, C) icing treatments. Individuals were surrounded by ice at a fish/ice ratio of 1/1 (w/w) and stored on-board in a refrigerated room at 0–1 °C. Each fish species was captured at three different times of the trip. At each sampling time, and for both C and T batches, individuals were separated into three groups (three individuals per group) in order to be analysed separately ($n = 3$).

Once the fishing boat arrived at Vigo harbour, fish specimens were transported to the laboratory to be analysed. Consequently, sensory, microbiological and chemical analyses were performed after 9, 12 and 15 days of on-board chilled storage from catching time. Sensory analysis was conducted on the whole fish, while microbiological and chemical analyses were done on the white muscle.

### 2.3. Sensory analysis

Sensory analysis was conducted by a sensory panel consisting of five experienced judges (three male and two female with an age in the 30–55 yr range), according to traditional guidelines concerning fresh and refrigerated fish adapted to the species under study (Council Regulations, 1996). Before starting the present experiment, the panel was trained on chilled hake and megrim. In this training, evaluation of chilled specimens belonging to the two species and corresponding to different chilling times (from starting material until the time the fish was no more acceptable) and quality degrees were tested. These preliminary chilled experiments were carried out several times,