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Postmortem changes in the adductor muscle of Pacific lions-paw scallop (*Nodipecten subnodosus*) during ice storage

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Abstract

Postmortem biochemical, chemical, and physical changes of the adductor muscle of Pacific lions-paw scallop were studied during a 15-day storage period at 0 °C (ice). Content of ATP and breakdown products, K value, pH, trimethylamine, total volatile bases, water-holding capacity, colour, and texture changes were examined. K value increased logarithmically ($r^2 = 0.95$) from an initial value of 40.3–79.7% on day 15. The spoilage indicators trimethylamine and total volatile bases increased from 15.6 to 30.7 and 1.3 to 6.8 mg N/100 g of sample, respectively, which indicated spoilage at the end of the storage period. Texture, colour, and pH were not affected; however, water-holding capacity decreased significantly, from 96.0% on day 1 to 86.0% on day 15. Overall results indicated that quality of Pacific lions-paw scallop adductor muscle was maintained during at least 12 days of ice storage.

Keywords: Pacific lions-paw scallop; Adductor muscle; Postmortem changes; K value; Freshness; Quality

1. Introduction

Pacific lions-paw scallop (*Nodipecten subnodosus*) is a bivalve mollusk exploited on the Pacific coast of the Baja California Peninsula, Mexico, where it is an important marine resource. This scallop is prized for the flavour and weight of the adductor muscle meat, which can reach 150 g and a price of US $16/kg in the international market. The only commercial fishery occurs in the Laguna Ojo de Liebre in the state of Baja California Sur, where the scallop is harvested by Hooka divers. Yearly production of adductor muscle has increased from 5 mt (metric tonnes) in 1991 to a peak of 157 mt in 1999 (Instituto Nacional de Pesca, 2002). Even though, this scallop fishery is underdeveloped, and it is a good candidate for production through aquaculture because of its high economic value and rapid growth. From 2001 to 2002, several Mexican companies have cultivated and produced $\sim 3.2 \times 10^6$ specimens in the Laguna Manuela. The scallop can reach commercial size (7 cm) in eight months. In spite of high demand, good flavour, and high price of the adductor muscle, studies of postmortem changes and their impact on quality are scarce. Results from those studies can be used to evaluate methodologies for primary processing and development of value-added products.

As in fish, after death scallops pass through the following stages: rigor mortis, dissolution of rigor mortis, autolysis, and bacterial spoilage. The autolytic process occurs as a result of endogenous enzymatic changes within the muscle, while spoilage is a product of bacterial growth. Ehira and Uchiyama (1987) reported that biochemical, chemical, and sensory changes are associated with fish quality during handling and storage. These changes are affected mainly by the storage temperature's influence on

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freshness, which determines the quality of the fishery products. Freshness of fishery products is rapidly lost if temperature abuse is involved.

Methods for evaluating freshness and quality of different marine species are based on measurements of postmortem changes associated with sensory quality, chemical and physical changes, and microbiological growth (Ohashi, Okamoto, Ozawa, & Fujita, 1991). Indices of quality based on nucleotide degradation (hypoxantine and K value) have received special attention for monitoring freshness of fishery products during handling and processing. The concentration of major adenine nucleotides and their related compounds in postmortem muscle correlates well with the loss of freshness in a wide range of fish. Total molar concentration (TMC) of ATP and related compounds in muscle, as well as the rates and patterns of changes in their levels during storage are species-dependent and muscle-dependent. Regardless of the species and muscle type, ATP decreases rapidly within the first 24 h postmortem. In fish muscle, ATP is metabolized as ATP → ADP → AMP → IMP → HxR (inosine) → Hx (hypoxantine). In marine invertebrates, degradation of ATP has not been thoroughly investigated. Hatae et al. (1995) reported that ATP degradation in invertebrates proceeds via adenosine in lieu of IMP; however, several reports show accumulation of IMP in postmortem muscle of mollusks (Nakamura, Fujii, & Ishikawa, 1976; Suwetja, Hori, Miyazawa, & Ito, 1989). Yokohama, Sakaguchi, Kawai, and Kanamori (1994) state that squid muscle (*Doryteuthis bleekeri*) ATP was degraded through the IMP and adenosine (Ado) pathways. Similar results have been reported for muscle of other mollusks, such as abalone (*Haliotis diversicolour*) (Arai, 1966) and scallop (*Patinopecten yessoenssis*) (Kawashima & Yamanaka, 1992), where the activities of AMP deaminase and adenosine deaminase were low (Hatae et al., 1995). Even though the K value is widely accepted as a freshness index for many fish species because it has linear correlation, a behaviour not observed in shellfish.

In Mexico, Pacific lions-paw is one of the most important scallop species. However, studies about the postmortem changes of the its adductor muscle during handling and storage are still lacking. This study reports information on postmortem changes in the adductor muscle of Pacific lions-paw scallop under proper post-catch handling operations (0 °C), and their effects on the quality of the adductor muscle. This data will be used for comparisons with scallops handled under commercial conditions. Appropriate applications of the findings could generate higher profit margins for producers and improve development of this fishery.

2. Materials and methods

2.1. Collection and handling of sample

Pacific lions-paw scallops were harvested in Laguna Ojo de Liebre, Baja California Sur (BCS), Mexico. Recently caught Pacific lions-paw scallops were covered with ice and transported immediately to the processing plant in nearby Guerrero Negro, BCS. Shucking, washing, chilling, and bagging operations were supervised to assure that handling and temperature control procedures were consistently applied. Elapsed time between collection and shucking was approximately 1 h. Adductor muscles were packed in polyethylene bags weighing about 1.6 kg each and stored in alternate layers with ice in a portable cooler and transported to the laboratory in Hermosillo, Mexico. Elapsed time from capture to arrival at the laboratory did not exceeded 24 h. At the laboratory, the bags were emptied and meat washed with fresh water and ice. The meat was drained for 5 min and 30 adductor muscles were weighed and measured. The meat was separated into eight batches weighing 500 g and repacked in new polyethylene bags. The freshly repacked meat was kept between alternate beds of ice in a hermetically-sealed ice box and stored in a cool room at 0 °C for 15 days. Two experimental runs were carried out; each run consisting of 5 kg of adductor muscle.

ATP and related compounds, K value, total volatile bases (TVB-N), trimethylamine (TMA-N), pH, texture (puncture and shear force), water-holding capacity (WHC), and colour were carried out to evaluate postmortem changes in Pacific lions-paw scallop adductor muscle. All analytical determinations were done in duplicate on days 1, 2, 3, 5, 7, 9, 12, and 15, for a total of eight sampling times. A batch was used to perform the analyses on each one of the test days. Proximate analysis was carried out only on day 1. When necessary, during storage, the cooler was drained and fresh ice was added. For each sampling day, a portion of the adductor muscle from about five specimens was homogenized in a homogenizer (model Cusinart 8 Plus, Cuisinart Inc., Greenwich, CT). The homogenized sample was divided into appropriate subsamples and stored at −20 °C until analysis.

2.2. Analyses

2.2.1. Chemical analyses and pH

Moisture, protein, fat, and ash were determined according to standard methods (AOAC, 1990). Non-protein nitrogen (NPN) was determined by mixing a 50-g homogenate with 100 ml 10% trichloroacetic acid (TCA) solution. Precipitated protein was separated by centrifugation at 2000*g* (4 °C for 15 min). The supernatant was filtered through fibreglass and NPN determined by the micro-Kjeldhal method (AOAC, 1990). TMA-N, TVB-N, and pH were determined following previously described methods (Woyewoda, Shaw, Ke, & Burns, 1986).

2.2.2. ATP, related compounds, and K value

Determinations of nucleotides and related compounds were performed by a reverse phase high performance liquid chromatography procedure (Ryder, 1985). The identification of nucleotides, nucleosides, and bases was made by comparing retention times with those of commercially