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

Ramón Pacheco-Aguilar [a], Enrique Marquez-Ríos [a], María Elena Lugo-Sánchez [a], Guillermina García-Sanchez [a], Alfonso N. Maeda-Martínez [b], Víctor M. Ocaño-Higuera [c,*]

[a] *Centro de Investigación en Alimentación y Desarrollo, P.O. Box 1735, Hermosillo, Sonora 83000, Mexico*
[b] *Centro de Investigaciones Biológicas del Noroeste, Mar Bermejo 195, La Paz, BCS 23090, Mexico*
[c] *Departamento de Ciencias Químico Biológicas, Universidad de Sonora, Encinas y Rosales s/n, Hermosillo, Sonora 83000, Mexico*

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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

* Corresponding author. Tel./fax: +52 662 259 2163.
E-mail address: ocano@guayacan.uson.mx (V.M. Ocaño-Higuera).

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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

obtained standards and by adding or spiking of standards. The K value was calculated as the percent ratio of HxR and Hx to the sum of ATP and degradation products as follows:

$$\text{K value}(\%) = [(\text{HxR} + \text{Hx})/(\text{ATP} + \text{ADP} + \text{AMP} + \text{IMP} + \text{HxR} + \text{Hx})] \times 100.$$

2.2.3. Texture

Shear force and puncture measurements were used to evaluate texture in the adductor muscle. Shear force was measured in the muscle using a Warner–Bratzler blade in a universal testing machine (Model 1130, Instron Corp., Canton, MA) equipped with a 50-kg cell. The speed was set at 20 cm/min and the shearing force was applied transversally to the direction of the muscle fibres. Standardized cuts ($10 \times 10 \times 20$ mm) were used and force (kg_f) necessary to shear the muscle was recorded.

The puncture test was carried out with a 5-mm diameter ball probe in a texture analyzer (Model TA.XT2i, Texture Technology, Scarsdale, NY). Standardized cubic cuts of 10 mm edge and a penetration force of 90% were used. Puncture was applied parallel to the direction of muscle fibres.

2.2.4. WHC

Water-holding capacity was measured using a standard methodology (Cheng, Hamann, Webb, & Sidwell, 1979). WHC was expressed as "water loss", which was the percentage of weight loss in the sample compared to the initial weight.

2.2.5. Colour

Colour changes of the adductor muscle were determined with a tristimulus colourimeter (Model CR-300, Minolta Co., New York, NY). Measurements were taken at the surface of adductor muscles. From the colour data, the whiteness index was calculated by a standard procedure (Ocaño-Higuera, 1999).

2.2.6. Statistical analysis

Analyses were performed with the NCSS 2000 statistical software (NCSS, Kaysville, UT). Descriptive statistics (mean, standard deviation, and coefficient of variation), one-way ANOVA, multiple comparison with the Tukey test, linear regression analysis, and a matrix of linear correlation were applied. Significance level was set at 5%.

3. Results and discussion

3.1. Size and muscle composition

The adductor muscle had an average weight of 83.2 ± 2.5 g and an average height of 5.0 ± 0.2 cm with a 4.6 ± 0.2 cm diameter. Its proximate composition was $75.5 \pm 0.3\%$ moisture, $17.5 \pm 0.5\%$ protein, $0.1 \pm 0.0\%$ lipids, $1.3 \pm 0.0\%$ ash, and $0.9 \pm 0.0\%$ NPN. Similar results were reported for catarina scallop (*Argopecten ventricosus*) (Ocaño-Higuera, Maeda-Martínez, Lugo-Sánchez, & Pacheco-Aguilar, 2006). Our results indicated that the adductor muscle of Pacific lions-paw scallops is high in protein and low in fat. The sum of the analyses was about 94.4%, implying by the difference that adductor muscles are high in carbohydrates (5.6%). In one report, glycogen in the adductor muscle of *Chlamys tehuelchus* was 5.3% (De Vido, Paredi, & Crupkin, 2001).

3.2. Nucleotide catabolism and K value

Variation of ATP content and related compounds in the adductor muscle of lions-paw scallop during the 15-day storage period at 0 °C is shown in Fig. 1. The TMC for ATP and derivatives was 5.9 μmol/g. This value is similar to the 6.6 μmol/g reported in adductor muscle of catarina scallop (Ocaño-Higuera et al., 2006), but was lower than the 10.2 μmol/g in the adductor muscle of Japanese baking scallop (*Pecten albicans*) (Wongso & Yamanaka, 1998). The variations in TMC are due to species, season, physiological condition, feeding, etc. (Ocaño-Higuera, Pacheco-Aguilar, & Maeda-Martínez, 2001).

In this study, the ATP content at day 1 was 0.08 μmol/g of muscle, while the AMP was the nucleotide that accumulated (2.8 μmol/g) in the same period. Higher 24 h postmortem AMP molar concentrations are reported in the adductor muscle of several scallop species and other mollusks. Hiltz, Bishop, and Dyer (1974) and Ocaño-Higuera et al. (2006) reported 3.8 μmol/g and 4.6 μmol/g in adductor muscle of the scallop *Placopecten magellanicus* and catarina scallop (*A. ventricosus*), respectively, while Yokohama et al. (1994) reported 4.0 μmol/g in the mantle muscle of spear squid (*D. bleekeri*).

Mendes, Quinta, and Nunes (2001) reported that AMP is one of the dominant nucleotides of mollusks and crustaceans and that its accumulation is the result of a highly reduced or non-existent AMP deaminase activity. This fact is in accordance with the low concentration of IMP found

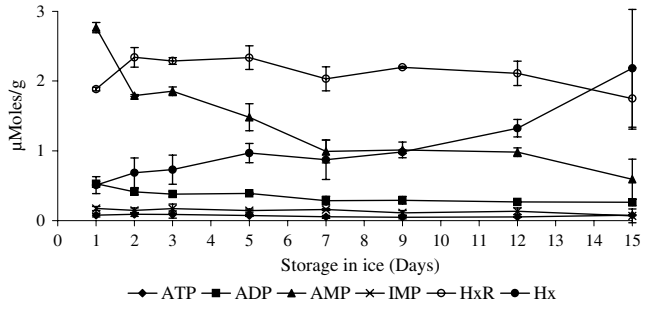

Fig. 1. ATP and related endogenous degradation products in adductor muscle of Pacific lions-paw scallop (*Nodipecten subnodosus*) stored at 0 °C for 15 days. Data point are the mean of $n = 2$ for each sampling day. Bars represent the standard deviation. ATP = Adenosine 5′triphosphate, ADP = adenosine 5′diphosphate, AMP = adenosine 5′mophosphate, IMP = inosine 5′mophosphate, HxR = inosine and Hx = hypoxantine.

in this study (0.2 μmol/g). AMP content declined logarithmically [$y = -0.72\,\mathrm{Ln}(x) + 2.6$, $r^2 = 0.94$, $p < 0.001$] from 2.8 ± 0.1 μmol/g on day 1 to 0.6 ± 0.3 μmol/g at day 15, whereas in spite of the fact that the concentration of HxR was the same to the beginning and at the end of the storage period (1.9 ± 0.0 y 1.8 ± 0.4 μmol/g, respectively), a significant increase in this compound at day 2 (2.3 ± 0.1 μmol/g, $p < 0.05$) and a subsequent but no significant ($p \geqslant 0.05$) decrease was observed. Hx gradually increased from 0.51 ± 0.11 μmol/g to 2.18 ± 0.84 μmol/g in the same period ($y = 0.096x + 0.38$; $r^2 = 0.84$, $p < 0.001$). Similar results were reported by Hiltz et al. (1974) for the adductor muscle of the sea scallop (*P. magellanicus*). This author reported that the absence of adenosine, the probable intermediate in the degradation pathway of AMP to HxR in scallop muscle, is indicative of a strong adenosine deaminase activity. In this study, adenosine was not detected, suggesting a rapid conversion of AMP to HxR and Hx via adenosine. Further studies are required to elucidate the AMP enzymatic degradation pathway in the adductor muscle of Pacific lions-paw scallop.

Literature reported that IMP and AMP are responsible for the sweetness characteristic of fresh fish muscle (Church, 1998), while the production of HxR and Hx is correlated with a loss of freshness and flavour (bitterness) in some fish species (Cox & Karahadian, 1998). In this study, the Hx accumulation in adductor muscle after day 12 (1.3 ± 0.1 μmol/g) reflects the initial phase of autolytic deterioration as well as bacterial spoilage (Woyewoda et al., 1986).

The K value defined as the ratio (×100) of non-phosphorylated ATP breakdown products to the total ATP breakdown products has been used as a freshness measure in many species (Ehira & Uchiyama, 1987). Fig. 2 shows a significant and logarithmic increase [$y = 12.6\,\mathrm{Ln}(x) + 42.0$, $r^2 = 0.95$, $p < 0.05$], in the K value of the adductor muscle of Pacific lions-paw scallop during the storage period, from a value (not adjusted) of $40.3 \pm 2.50\%$ (day 1) to a final value of $79.7 \pm 8.5\%$ (day 15). K value at time zero cannot be calculated from the equation due to its logarithmic nature, however, the K value at 1 h post-catch under our experimental condition was predicted giving an initial value of 1.4%. Derived from this fact, it is necessary to generate experimental data at time zero to determine if the K value concept, as a freshness indicator for Pacific lions-paw scallop, really follows a natural logarithmic relationship with time. A similar logarithmic relationship of K value with time had been reported for catarina scallop (Ocaño-Higuera et al., 2006).

Saito, Arai, and Matsuyoshi (1959) described fishery products with K values less than 20% as very fresh, less than 50% as moderately fresh, and greater than 70% as not fresh. Based on these K value categories, the adductor muscle of Pacific lions-paw scallop under the experimental conditions of this study could be considered as moderately fresh up to day 2 (K value = $55.25 \pm 2.51\%$) and not fresh

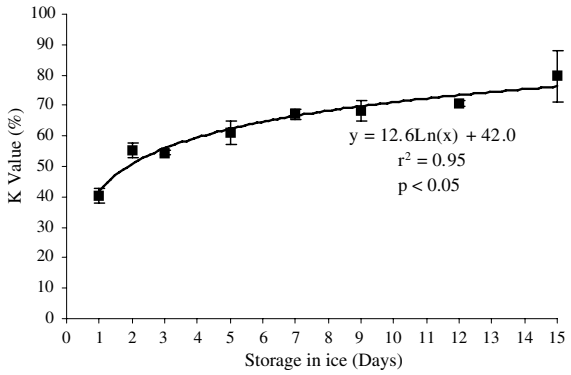

Fig. 2. K value in adductor muscle of Pacific lions-paw scallop (*Nodipecten subnodosus*) stored at 0 °C for 15 days. Data points shown are the mean at least of three replicates of two repetitions for each sampling day. Bars represent SD.

at day 12 (K value = $70.63 \pm 0.91\%$). K values of 83% was reported by Wongso and Yamanaka (1998) for the adductor muscle of the Japanese baking scallop (*P. albicans*) stored 11 days in ice, while Ocaño-Higuera et al. (2006) reported for the catarina scallop a K value of 68.5% at day 15.

No spoilage-related odors were detected even at day 15; however, starting at day 12 (K value = 70.6%), a change in the characteristic initial fresh odor was detected. Ehira and Uchiyama (1987) pointed out that spoilage odor in fish kept at 0 °C did not appear before day 17, where the viable bacterial count was on the order of 10^5 g^{-1}, the minimum of the range considered to be the threshold for spoilage.

3.3. Changes in pH

Changes in pH of the adductor muscle of Pacific lions-paw scallop during 15 days of storage are shown in Fig. 3. The pH on day 1 was 6.3 ± 0.05 with no significant changes ($p \geqslant 0.05$) after storage for 15 days. De Vido et al. (2001) reported a pH of 6.8 in the adductor muscle of scallop *C. tehuelchus* immediately after death and 6.2

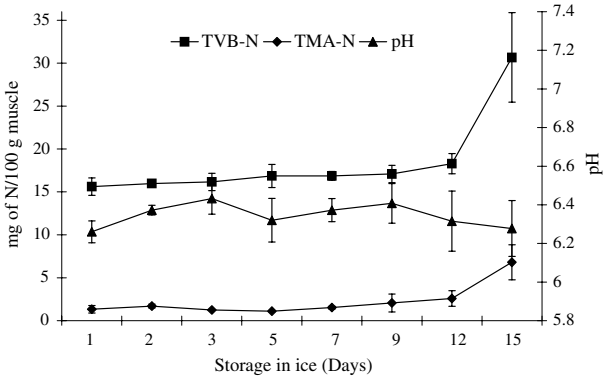

Fig. 3. Postmortem changes in pH, TMA-N, and TVB-N in adductor muscle of Pacific lions-paw scallop (*Nodipecten subnodosus*) stored at 0 °C during 15 days. Data points shown are the mean at least of three replicates of two repetitions for each sampling day. Bars represent SD.

on day 1 and 4 after death, respectively. The rapid decline in pH could be the result of the accumulation of lactic acid and octopine, as mentioned by Hiltz and Dyer (1971), because of the stress suffered during transportation from the site of capture to the laboratory. This information suggests that in our study a decline of pH could also occur from its initial value to 6.3 in the first 24 h postmortem.

Riaz and Qadri (1985) evaluating quality changes in lobster muscle (*Panulirus poliphagus*) stored on ice, reported that increments during storage lower than or equal to 0.1 pH units represented a first quality muscle. Pronounced pH increase indicates the accumulation of alkaline metabolites from bacterial accumulation over time. Our results suggest a low bacterial count and no spoilage in muscle after 15 days of storage in ice.

3.4. Changes in TMA-N and TVB-N

TMA-N and TVB-N analyses have been traditionally used as indicators of quality in the fisheries products stored in ice. In this study, the amount of TVB-N and TMA-N in adductor muscle of Pacific lions-paw scallop increased ($p < 0.05$) with time (Fig. 3). Initial TVB-N content on day 1 was 15.6 ± 1.0 mg/100 g. Lower levels were reported by Ocaño-Higuera et al. (2006) for the adductor muscle of catarina scallop (13.5 mg/100 g) and by Ruiz-Capillas, Horner, and Gillyon (2001) for the adductor muscle of king scallop (*Pecten maximus*) (11 mg/100 g). On the other hand, a similar value was reported by Ruiz Capillas, Moral, Morales, and Montero (2002) for squid (15.6 mg/100 g). No significant changes ($p \geqslant 0.05$) in TBV-N was observed during the first 12 days of storage in ice, however a strong significant increase ($p < 0.05$) was detected after this day, reaching a value of 30.7 ± 5.2 mg of TVB-N on day 15. A similar behaviour was observed by Ocaño-Higuera et al. (2006) for catarina scallop (*A. ventricosus*), where a significant increase from 17.3 to 21.4 mg of TVB-N/100 g was detected from day 12 to day 15, respectively. Similar levels were reported by Murata and Sakaguchi (1986) for the adductor muscle of oyster (*Crassostrea gigas*) and by Ohashi et al. (1991) for squid (*Todarodes pacificus*). A limit of 30 mg TVB-N/100 g of muscle has been considered acceptable in fishery products for human consumption (Riaz & Qadri, 1985).

The pungent odor of spoiling fish has often been correlated with tissue TMA levels, as well as with the number of spoilage organisms present in many marine fish species. The rejection limit is usually from 5 to 10 mg TMA-N/100 g muscle. In this study, the production of TMA-N followed a similar pattern to TVB-N during storage in ice, where a significant increase was observed ($p < 0.05$) with time. TMA-N content on day 1 was 1.3 ± 0.4 mg TMA-N/100 g muscle, while 6.8 ± 2.0 mg of TMA-N was detected on day 15. Results agreed with those in the literature. Ruiz-Capillas et al. (2001) reported for adductor muscle of king scallop (*P. maximus*) values of <6 mg/100 g at 16 days at 0 °C. Because levels of TMA-N and TVB-N exceeded the rejection limits cited in the literature on day 15, our results suggested that the adductor muscle of Pacific lions-paw scallop was maintained at an edible quality during al least 12 days of storage.

3.5. Texture and WHC

Texture loss during the storage of fish products has been reported in the literature (Sato, Ohashi, Ohtuki, & Kawabata, 1991). Several investigators have associated low muscle pH with tough texture and high drip loss (De Vido et al., 2001), while other authors suggest involvement of several enzymes in texture deterioration during storage (Sato et al., 1991). In our study, no significant ($p \geqslant 0.05$) differences were obtained for texture measurement, shear force (SF), and puncture (P) in the adductor muscle during the 15-day storage period (Fig. 4). The initial values were 0.3 ± 0.05 and 0.19 ± 0.02 kg_f for SF and P, respectively.

On the other hand, a significant ($p < 0.05$) difference was observed for WHC during the storage period, which decreased from 96% at day 1 to 86% at day 15. Usually fish muscle becomes tougher accompanied by a progressive loss of fluid and reduction of water-holding capacity. Nevertheless the WHC has been reported to be a good indicator for fish quality evaluation since its decrease has been shown to result in texture loss (Hsing-Chen, Moody, & Shann-Tzong, 1990). Our results indicated that the denaturation (aggregation and/or hydrolysis) that could occur in the myofibrillar protein of adductor muscle during the storage period affected its WHC, but did not affect its texture in accordance with the SF and P data. Further investigations are required to evaluate the nature of the possible conformational changes in the protein structure of adductor muscle of this species during its chilled storage.

3.6. Colour

The colour is one of the most important parameters used to evaluate the quality of fisheries products. Haard

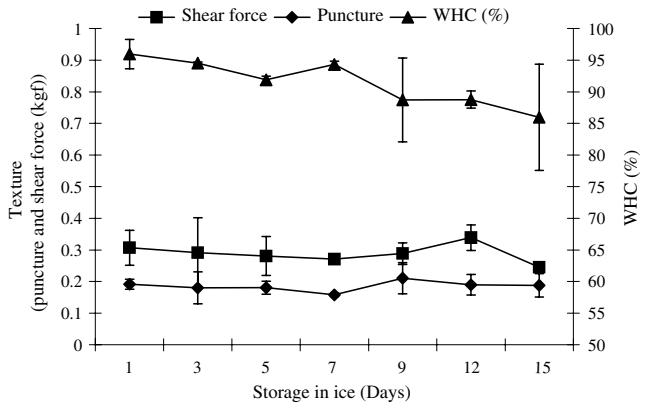

Fig. 4. Postmortem changes in texture (shear force and puncture) and water-holding capacity (WHC) in adductor muscle of Pacific lions-paw scallop (*Nodipecten subnodosus*) stored at 0 °C for 15 days. Data points shown are the mean at least of three replicates of two repetitions for each sampling day. Bars represent SD.

(1992) reported that the initial colour of fish products change during the storage in ice, affecting the quality. Surface colour parameters for the adductor muscle are shown in Table 1. The colour parameters did not show significant differences ($p \geqslant 0.05$) during the 15-day storage period; hence, colour was not affected. The average composite values for "*L*", "*a*", "*b*", and whiteness were 51.4 ± 0.0, -3.4 ± 0.0, 6.0 ± 0.0, and 50.9, respectively. Similar to our results Ocaño-Higuera et al. (2006) found no significant difference ($p \geqslant 0.05$) in colour parameters for the adductor muscle of catarina scallop (*A. ventricosus*) during storage in ice for 15 days. The consistent negative values of "*a*" indicate a yellow–green hue for the samples. In addition, the combined effect of low "*a*" and "*b*" values indicates an opaque product. Subjectively, the colour of the adductor muscle was defined as slightly yellowish-obscure.

Table 1
Postmortem changes in colour parameters in adductor muscle of Pacific lions-paw scallops *(Nodipecten subnodosus)* stored at 0 °C for 15 days

Storage in ice (Days)	*L*	*a*	*b*	Whiteness index
1	51.4 ± 0.0^a	-3.4 ± 0.0^a	6.0 ± 0.0^a	50.9^a
2	49.4 ± 0.8^a	-2.1 ± 1.8^a	4.8 ± 2.9^a	49.2^a
3	46.7 ± 4.7^a	-1.7 ± 2.3^a	2.6 ± 3.3^a	46.6^a
5	49.0 ± 0.6^a	-3.8 ± 0.0^a	3.6 ± 1.0^a	48.7^a
7	51.0 ± 0.1^a	-3.6 ± 0.3^a	6.5 ± 2.9^a	50.5^a
9	49.2 ± 0.1^a	-3.3 ± 0.3^a	5.2 ± 1.0^a	48.8^a
12	50.0 ± 2.1^a	-3.0 ± 0.5^a	5.6 ± 2.6^a	49.6^a
15	50.0 ± 1.2^a	-3.5 ± 0.7^a	5.6 ± 2.3^a	49.6^a

Data represent the mean and standard deviation of $n = 6$ for each sampling day. Means in a column with the same letter are not significantly different ($p \geqslant 0.05$).

3.7. Degree of association among the different quality parameters

The matrix of linear correlation among the quality parameters used to evaluate postmortem changes in the adductor muscle is shown in Table 2. Data indicate highly significant ($p < 0.000$) correlations of AMP and Hx with K value ($r = -0.985$ and $r = 0.825$, respectively), as well as of K value and AMP with time ($r = 0.906$ and $r = -0.874$, respectively). Data suggested that the decrease in muscle AMP content and the increase in Hx could be used together with the K value for monitoring freshness in the adductor muscle of Pacific lions-paw scallop during ice storage.

4. Conclusions

Postmortem behaviour of adductor muscle of Pacific lions-paw scallop indicated that both endogenous and microbial processes could be controlled with appropriate post-catch handling practices. The biochemical, chemical, and physical parameters used in this study proved their usefulness in assessing the quality of the adductor muscle of Pacific lions-paw scallop. In contrast with fish species, a high initial K value was obtained and AMP was the most abundant nucleotide at day 1. K value as well as AMP,

Table 2
Matrix of linear correlation for the quality parameters applied to adductor muscle of Pacific lions-paw scallop

	Storage in ice (Days)	AMP	HxR	Hx	K value	pH	TVB-N	TMA-N	WHC	SF	P	L
Storage in ice (Days)	1.000 (0.000)											
AMP	−0.874 (0.000)	1.000 (0.000)										
HxR	−0.398 (0.126)	0.181 (0.503)	1.000 (0.000)									
Hx	0.823 0.000	−0.723 (0.002)	−0.534 (0.033)	1.000 (0.000)								
K value	0.906 (0.000)	−0.984 (0.000)	−0.259 (0.333)	0.825 (0.000)	1.000 (0.000)							
pH	−0.144 0.595	−0.125 (0.643)	0.024 (0.929)	−0.046 (0.865)	0.101 (0.709)	1.000 (0.000)						
TVB-N	0.745 0.000	−0.542 (0.030)	−0.391 (0.134)	0.724 (0.002)	0.606 (0.013)	−0.349 (0.159)	1.000 (0.000)					
TMA-N	0.750 0.000	−0.574 (0.019)	−0.626 (0.009)	0.894 (0.000)	0.670 (0.004)	−0.254 (0.342)	0.810 (0.000)	1.000 (0.000)				
WHC	−0.722 0.001	−0.653 (0.006)	−0.459 (0.074)	−0.789 (0.000)	−0.708 (0.002)	−0.002 (0.994)	−0.419 (0.106)	−0.744 (0.001)	1.000 (0.000)			
SF	−0.290 0.275	−0.279 (0.295)	0.322 (0.225)	−0.224 (0.404)	−0.250 (0.351)	0.335 (0.205)	−0.316 (0.233)	−0.336 (0.203)	0.323 (0.223)	1.000 (0.000)		
P	0.167 0.535	−0.020 (0.941)	0.051 (0.849)	−0.041 (0.880)	0.019 (0.946)	0.193 (0.473)	0.215 (0.422)	−0.073 (0.788)	0.080 (0.769)	0.393 (0.131)	1.000 (0.000)	
L	0.199 0.477	−0.153 (0.587)	−0.393 (0.146)	0.269 (0.332)	0.188 (0.503)	−0.002 (0.993)	0.138 (0.625)	0.173 (0.537)	−0.198 (0.477)	0.305 (0.269)	0.292 (0.290)	1.000 (0.000)

( ) = probability, HxR = inosine, Hx = hypoxanthine, TVB-N = nitrogen of total volatile bases, TMA-N = nitrogen of trimethylamine, SF = shear force, P = puncture, L = lightness.

could be used as good indicators for monitoring loss of freshness during the shelf life of Pacific lions-paw scallop. Overall results indicated a 12-day minimum shelf life for the adductor muscle of Pacific lions-paw scallop handled under the experimental conditions, with no effect on texture characteristics. On the basis of this information, it is highly recommended to modify commercial handling operations by Mexican producers because their current procedures are reducing the shelf life of their products.

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