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Effect of Storage Temperature on the Microbiological and pH Changes of Mackerel, Croaker, and Saury During Storage

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저장온도가 고등어, 조기, 꽁치의 저장중 미생물 및 pH의 변화에 미치는 영향

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Abstract

To examine the quality changes of three typical fishes under usual storage conditions during marketing, we determined the total bacterial counts and pH values during storage of mackerel, croaker, and saury. Mackerels were stored at 0℃ and on ice at 19℃, which is the usual storage condition in a local market, and croakers and saury were stored at 0℃ and 4℃. Total bacterial counts of mackerel, croaker, and saury were 3.2×10^3, 2.9×10^3, and 2.8 x 10^4 CFU/g at the time of storage, respectively. Total bacterial counts of mackerel stored on ice at 19℃ increased during storage and reached to 8.4 x 10^6 CFU/g at day 6, while those stored at 0℃ decreased up to 2 days of storage and increased to 5.6 x 10^4 CFU/g. For croaker and saury, total bacterial counts at 0℃ were 2.5 x 10^5 and 2.1 x 10^5 CFU/g at day 6, respectively, while those stored at 4℃ had 3.6 x 10^6 and 2.6 x 10^5 CFU/g. The pH value of mackerel was 5.56 at the time of storage, yet it increased to 6.04. The pH changes of croaker and saury had a similar pattern with that of mackerel, which increased with time of storage. These results suggest that storage of fishes at 0℃ should be better than those at 4℃ or on ice at 19℃ in terms of microbial safety as well as quality and shelf-life of fishes.

Key words : bacterial counts, marketing, quality change, storage

Introduction

Fish quality can be assessed by sensory methods such as color, odor, appearance, and texture, yet its reliability is mostly based on judgement by trained people (1). To make an objective evaluation on fish quality, measurement of total bacterial count and pH can be a useful tool. Chemical tests can be also used for the assessment of fish quality by measuring the amounts of breakdown products.

In Korea, consumption of fish is steadily increasing. Typical fishes for public preference are mackerels (*Scomber japonicus*), croakers (*Larimichthys polyactis*), and sauries (*Cololabis saira*). However, microbial safety of fish is usually concerned because of poor storage condition during marketing. In particular, considering that small markets which sell fish on ice at room temperature are the major place for dealing fish, hazard analysis critical control point (HACCP) on fish is needed. Regarding storage condition for maintaining fish quality, storage characteristics and quality changes during chilled sea water storage have been reported (2).

Sensory attributes of quality and the shelf-life of fish are affected mainly by the initial microbial contamination and storage temperature (3). Therefore, in this study, to examine the effect of storage temperature on the microbiological and pH changes of fishes and to improve the quality and safety of fishes during marketing, three typical fishes were examined during storage at various temperatures including on ice at room temperature, which is the usual marketing condition of fish in Korea.

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Materials and Methods

Materials

Mackerels (*Scomber japonicus*) and sauries (*Cololabis saira*)

were purchased in Daejeon, and croakers (*Larimichthys polyactis*) was purchased in Seoul. Fishes were kept on ice after purchase and immediately used for storage experiment.

Storage conditions

Croakers and sauries were stored at 0℃ and 4℃ and mackerels were stored at 0℃ and on ice at 19℃.

Total bacterial counts

Ten grams of fish samples were collected aseptically and placed in a sterile corning tube with 90 ml of saline solution (0.85% NaCl, w/v). After grinding for 2 min and filtration, dilution was performed with saline solution and poured on plate count agar (PCA), and incubated at 35℃ for 48 hr. Total bacterial counts were determined as colony forming units (CFU) per gram of samples.

Measurement of pH value

After grinding and filtering samples with 90 ml of distilled water, pH value of the samples were measured using a pH meter.

Results and Discussion

Microbiological change during storage

The most important factor of fish quality is the number of viable bacteria on the surface of fish. For mackerels, the initial microbial load was 3.2 x 10^3 CFU/g (Fig. 1). This result is in good agreement with other report where Kolodziejska *et al* (3) reported the initial number of aerobic bacteria of raw mackerel was in the range of 1.1 x 10^2-4.5 x 10^4 CFU/g. During storage of mackerels stored on ice at 19℃, total bacterial number increased sharply after 2 days and reached to 1.3 x 10^5 CFU/g, which is above the number indicating initial decay. At day 6, it increased to 8.4 x 10^6 CFU/g. On the contrary, for mackerels stored at 0℃, total bacterial number had a different pattern. It decreased up to day 2, and after that increased slowly. This initial decrease of total bacterial count was attributed to the death of bacteria sensitive to low temperature and lag phase for the growth of psychrophilic bacteria. During storage at 0℃, it appeared to be microbiologically acceptable until day 6, assuming that total bacterial count below 10^5 CFU/g indicates sanitary condition of fish. For mackerels stored under two different storage conditions, total bacterial count was significantly different by 2.5 log cycles at day 6. Similar results were observed in other report (3) where 2℃ and 8℃ were used as storage temperature. This indicated that fresh fish should be stored at 0℃ during entire marketing period. These results also suggest that microbiological change during storage of mackerels should be examined for quality assessment.

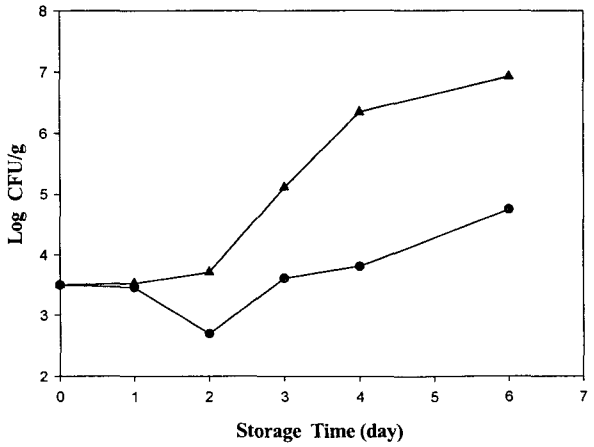

Fig. 1. Microbial changes of mackerels during storage at 0 ℃ (●) and on ice at 19℃ (▲).

There have been reports on quality control of mackerels during storage (3-6). Deteriorative changes during ice storage of irradiated mackerel was reported by determining histamine content and volatile basic nitrogen (6), and Oh *et al* (4) reported the ATP bioluminescence assay for a rapid estimation of microbial levels in mackerel. Lee *et al* (5) also studied quality changes during storage of salted mackerel fillet and reported the shelf-life at 5℃, based on panel scores of color and rancidity. Kolodziejska *et al* (3) studied the microbial and sensory quality of hot-smoked mackerel and reported that hot smoking reduced the bacterial count on the fish surface by 1.9 log cycle.

For croakers, initial microbial load was 2.9 x 10^3 CFU/g (Fig. 2A). When they were stored at 0℃, total bacterial number decreased at day 1, similar to mackerels. However, it increased slowly and reached 2.5 x 10^5 CFU/g at day 6, which was two log cycle increase. In the case of storage temperature of 4℃, it continued to increase up to 3.6 x 10^6 CFU/g at day 6, which was one log cycle more than that of 0℃. Based on the total bacterial count and sensory evaluation, croakers stored at 4℃ reached initial decay at day 5 and those stored at 0℃ had a longer shelf-life. Recently, as a way of processing for extension of shelf-life of croakers, preparation of dried croaker fillet after addition of seasoning was reported (7).

For sauries, in contrast to mackerels and croakers, initial microbial load was higher by one log cycle, 2.8 x 10^4 CFU/g (Fig. 2B). Up to two days, both saury samples stored at 0℃ and 4℃ had a decrease in number of total bacterial count. However, it increased drastically for saury samples stored at 4℃ and reached 2.6 x 10^5 CFU/g at day 4, while those stored at 0℃ reached 2.1 x 10^5 CFU/g at day 6. These results clearly indicate that sauries stored at 0℃ had a longer shelf-life by two days.

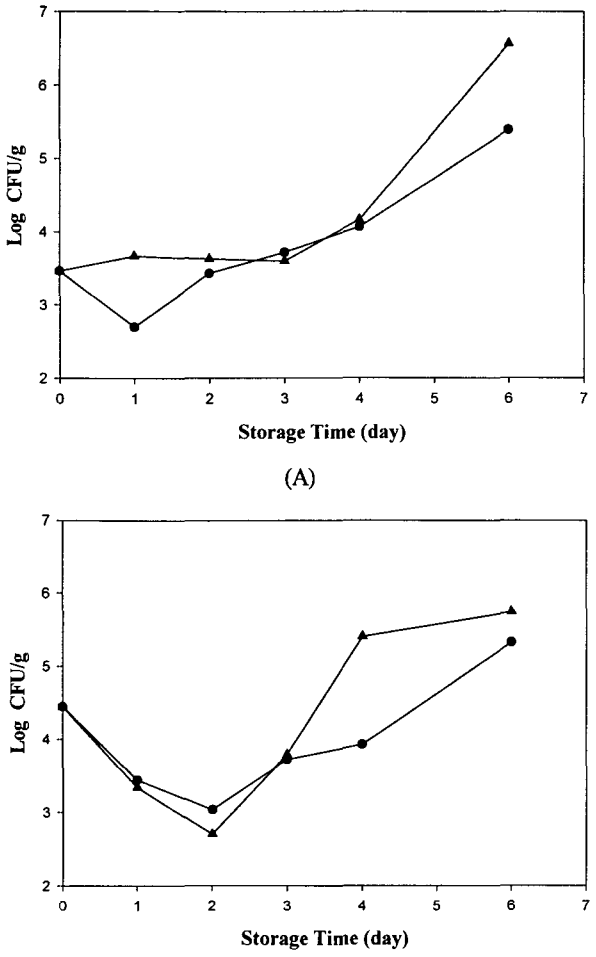

Fig. 2. Microbial changes of croakers (A) and sauries (B) during storage at 0 ℃ (●) and at 4℃ (▲).

The pH change during storage

The pH of live fish muscle is close to 7.0; however, postmortem pH can vary from 5.5 to 8.0 depending on season, species, and other factors (8). The pH value of fish usually decreases after death, mainly due to degradation of ATP and production of lactic acid. And after it decreases to pH 5.5, it increases up to 8.0 because of increase of basic components produced by decay. The pH change of mackerels during storage is shown in Fig. 3. Initial pH value for mackerels was 5.56. For mackerels, both samples stored at 0℃ and on ice at 19℃ had a increase in pH values during storage. This is basically due to the production of basic components induced by growth of bacteria during storage. Similar results were reported for sardine (9). Mackerels stored at 0℃ had a pH value of 6.03 at day 6, in contrast to 5.56 of initial pH. On the contrary, those stored on ice at 19℃ had a pH value of 6.04 at day 4, indicating initial decay began at day 4. Sensory evaluation also indicated that surface of fish was dehydrated and eyes of fish were cloudy at day 4. With microbial analysis, these results suggest that fresh fish should be washed with sea water and stored at cold temperature like 0℃.

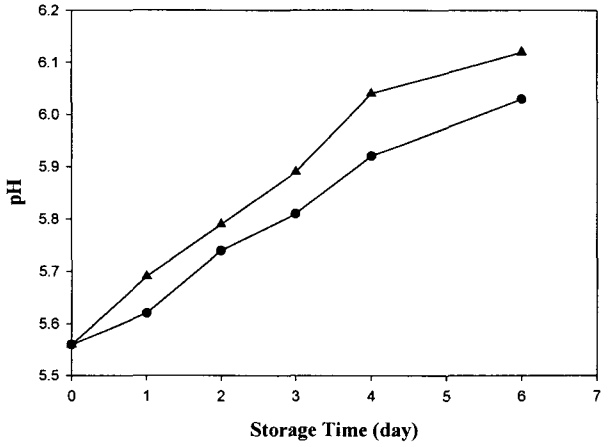

Fig. 3. Changes of pH in mackerel during storage at 0 ℃ (●) and on ice at 19℃ (▲).

For croaker and saury samples, pH change had a similar pattern, which increases with time of storage (data not shown). Regarding the pH change of fish during storage, Simeonidou *et al* (1) reported that it should not be considered as a significant indicator of quality assessment. However, our results clearly indicated that pH change can be a useful criteria for quality assessment.

Fish is susceptible to histamine formation due to high levels of histidine in the muscle (10). Formation of histamine in fish is regulated by the FDA and can be a potential health hazard (11). Silva *et al* (11) reported that a low refrigeration storage temperature is critical for reducing the histamine during storage since histamine is produced mainly by bacteria. Therefore, storage temperature is the most important factor in maintaining quality of fish, regarding microbial safety as well as histamine formation.

In summary, storage of fishes at 0℃ was better than that at

4℃ in terms of microbial safety as well as quality and shelf-life of fishes. Considering the marketing conditions of fish in Korea, storage temperature of fresh fish is very important to keep the quality and to extend the shelf-life.

요 약

일반적으로 실제 저장 유통되는 조건 하에서 생선의 품질 변화를 예측하기 위하여 대표적 생선인 고등어, 조기, 꽁치를 대상으로 미생물과 pH의 변화를 측정하였다. 고등어의 저장조건으로는 실제 유통되고 있는 조건인 실온 얼음상과 0℃에 저장하면서 그 변화를 관찰하였으며 조기와 꽁치는 0℃와 4℃에 각각 저장하면서 저장온도에 따른 변화를 관찰하였다. 고등어의 초기 총균수는 3.2×10^3 CFU/g 이었으며 실온 얼음상에서는 저장 6일 후 8.4×10^6까지 증가하였다. 반면, 0℃에서 저장한 고등어의 경우 저장 2일까지 총균수가 일시적으로 감소하는 경향을 보였다가 점차 증가하여 6일째 5.6×10^4 CFU/g을 나타냈다. 조기와 꽁치의 초기 총균수는 각각 2.9×10^3, 2.8×10^4 CFU/g 이었으며 0℃에서 6일간 저장하는 동안 점차 증가하여 각각 2.5×10^5과 2.1×10^5 CFU/g 으로 나타났다. 또한, 4℃에서 저장한 조기와 꽁치의 총균수는 3.6×10^6과 2.6×10^5 CFU/g으로 나타났으며 이러한 결과는 생선의 저장에 있어 0℃가 미생물의 번식을 억제하는데 보다 효과적인 것으로 나타났다. 또한, pH의 경우 실험구 모두에서 저장 시간이 증가함에 따라 점차적으로 증가하는 경향을 보였다. 본 연구 결과는 0℃에서의 저장이 4℃나 실온 얼음상보다 미생물학적 안전성, 품질 변화 및 저장기간 연장 측면에서 보다 바람직하다는 것을 보였다.

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