Short Paper

Effect of inhabited sea area on chub mackerel meat texture and possible degradation of type V collagen during chilled storage

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Chub mackerel Scomber japonicus shows rapid deterioration after death, and in general, lacks a tough texture that is enough to allow raw consumption. Chub mackerel meat from Bungo Channel, Oita Prefecture, Japan, however, retains a tough texture after death. Whereas, Bungo Channel chub mackerel are caught by line-fishing and killed individually using a knife before being shipped to market, other chub mackerels are generally caught using a net and killed by asphyxiation. Mochizuki et al. reported that differences in the killing procedure, described above, affect the postmortem biochemical changes in meat and Bungo Channel chub mackerel meat can maintain a firmer texture than other chub mackerels, after death.1 It has been reported that struggling while dying promotes weakening of endomysium, which is one of the causes of postmortem softening of fish meat.2 Additionally, struggling while dying also promotes degradation of type V collagen, which constitutes the endomysium.3,4

The sea area where Bungo Channel chub mackerel are caught is especially narrow and results in a very fast current velocity (maximum 9 km/h).5 Meanwhile, chub mackerel living in slower current sea areas have softer meat and show earlier softening during chilled storage compared to the Bungo channel chub mackerel.6

The objective of this study was to research the influence of current velocity in chub mackerel inhabited sea areas with regards to changes in type V collagen content of the mackerel, which corresponds to postmortem softening of the meat during chilled storage.

Chub mackerel caught from the Genkainada sea, Fukuoka Prefecture, Japan, in May 2001 (28–30 cm; approximately 334 g; three individuals) and from Bungo Channel, Oita Prefecture, Japan, in August 2001 (30–32 cm; approximately 475 g; three individuals), were killed instantly by decapitation and stored at 4°C for 24 h. The breaking strength of the meat was measured at 0 h and 24 h by using a rheometer (RT-1002 A, Fudoh, Tokyo, Japan) as previously reported.2 The current velocity of Genkainada sea is about 1.8 km/h.7

Collagen was prepared from dorsal meat at 0 h and 24 h after death according to the method of Sato et al.8 Dorsal ordinary muscle was minced and stirred in 0.1 M NaOH overnight at 5°C. After centrifugation (10,000 ¥ g, 20 min), 10 volume of 0.1 M NaOH (v/w) was added to the precipitate and stirred overnight again. The NaOH washing was done once again, and the precipitate was washed by distilled water and centrifuged (10,000 ¥ g, 20 min). To the precipitate, 0.5 M acetic acid with pepsin (Wako, Tokyo, Japan) was added to the precipitate at enzyme substrate ratio of 1 : 20 (w/w), and it was stirred for 2 days at 5°C. The solution was dialyzed against 50 mM Na₂HPO₄ (pH 7.5), and suspension of pepsin-prepared collagen was obtained. The suspensions were hydrolyzed in 6 M HCl at 150°C for 1 h and the hydroxyproline content was determined using an amino acid analyzer (L-8500, Hitachi, Tokyo, Japan). The whole collagen amount was calculated from the hydroxyproline content.9 The content of type V collagen in the collagen suspensions was determined using the method of Sato et al.10 Significance was tested by one-way ANOVA.

The changes in breaking strength are shown in Fig. 1. After 0 h and 24 h storage, the values of Bungo Channel chub mackerel showed a 2.6 and
1.5-fold high value against Genkainada sea chub mackerel, respectively (Fig. 1a). In the case of relative breaking strength, a decreasing ratio of 54.1% in Bungo Channel chub mackerel after 24 h storage was found, compared with only 20.1% in Genkainada sea chub mackerel. These results correspond to the previous report that showed the decreasing ratio was larger in chub mackerel meat from the Bungo Channel than from the Kumanonada sea, where the current velocity is slower than in the Bungo Channel.6

The contents of the meat collagens are shown in Fig. 2. No significant changes were observed in the whole meat collagen between the stored samples (Fig. 2a), whereas, the type V collagen content of the Bungo Channel chub mackerel decreased from 1.4 to 0.6 (mg/100 g) after 24 h death (Fig. 2b) with a decreasing rate of 56% (Fig. 2c). In the case of the Genkainada sea chub mackerel, the type V collagen content was 9.6 (mg/100 g) immediately after death and 6.5 (mg/100 g) after 24 h after death (Fig. 2b) and had a decreasing ratio lower than the Bungo Channel chub mackerel (33%, Fig. 2c). In the present study, we determined the content of 0.1 M NaOH-insoluble collagen. In other words, the content represents the solubility of collagen against 0.1 M NaOH. Therefore, the results indicate that relatively higher content of type V collagen of Bungo Channel chub mackerel turned to be soluble for 0.1 M NaOH during chilled storage than the Genkainada sea mackerel. From these results, it was speculated that the higher decreasing ratio of the breaking strength in Bungo Channel chub mackerel most probably correlates to the decreasing rate of type V collagen, as previously reported for other fish.11

The decrease in type V collagen content in the muscle could, speculatively, correspond to proteolytic action. Saito et al. cloned matrix metalloproteinase-2, derived from the fibroblast of rainbow trout, and detected its proteolytic activity towards human type V collagen.12 It has also been reported that meat softening is accelerated when bleeding is omitted during the killing of fish.13 Therefore, the influence of proteases existing in the blood is probable. The difference in decreasing ratio of type V collagen shown in the present study may be due to variations in the amount and activity of such collagenolytic proteases between their inhabitants.

Fig. 1  Change in breaking strength during chilled storage at 4°C. (a) Raw data; (b) relative values calculated from raw data. ■, immediately after death; □, 24 h after death. Each value is expressed by mean ± SE (n = 3). *, significantly different between 0 h and 24 h after death (P < 0.05).

Fig. 2  Comparison of collagen contents between two mackerels. (a) Contents of meat collagen; (b) contents of type V collagen; and (c) relative contents of type V collagen calculated from raw data. ■, immediately after death; □, 24 h after death. Each value is expressed by mean ± SE (n = 3). *, significantly different between 0 h and 24 h after death (P < 0.05).
Chub mackerel living in faster current velocity waters have firmer meat than similar mackerel living in slower current velocity waters. Collagen contents have been found to be much higher in the body parts of fish which are vigorously involved in swimming. Also, fish meat containing greater amounts of collagen is considerably firmer than fish meat containing less collagen. From these reports, it has been hypothesized that chub mackerel living in faster current velocity waters move more and, therefore, have firmer meat with abundant collagen. However, from the present study, the collagen content of Bungo Channel chub mackerel was half that of Genkainada sea chub mackerel (Fig 2a). Therefore, such differences in meat texture could be due to differences in physical strength of myofibrils, rather than collagen. Tachibana et al. reported that exercising could elevate the physical strength of myofibrils resulting in an improved tougher meat texture in red sea bream. Bungo Channel chub mackerel may, therefore, have elevated the physical strength of myofibrils due to extensive exercise and which thereby results in firmer meat.

Present results also showed the relative content of type V collagen in whole meat collagen. The relative contents of Genkainada sea chub mackerel and of Bungo Channel chub mackerel were 1.92%, and 0.57% immediately after death, respectively (Figs 2a,b). Virtanen et al. reported that synthesis of human type I collagen was promoted by exercising, while synthesis of the type III collagen was not promoted. This result suggests that exercising could induce type-specific synthesis of collagen. Additionally, fish muscle has type I and V collagens. Together with these results, the lower proportion of type V collagen in Bungo Channel chub mackerel might be due to relatively promoted synthesis of type I collagen by exercising. The relative content of type V collagen was extremely low in Bungo Channel chub mackerel compared with other fish that have already been reported, and it is interesting that exercising has a possibility for type-specific synthesis of collagen.

REFERENCES