Short Paper

Enhanced Protease Activity in Muscle of Chum Salmon *Oncorhynchus keta* during Spawning Migration*¹

A remarkable decrease in the fat and protein contents and increase in moisture have previously been observed in the muscle tissue of some Pacific salmon while ascending the river to spawn.^{1,2)} Occasionally, very whitish and very soft meat is found in chum salmon *Oncorhynchus keta* trapped by a set-net at the coastal sea off northern Japan. In extreme cases, the meat is slimy and sticky, paste-like both in appearance and to the touch. The paste-like condition of meat is rather common in salmon after naturally spawning and those kept in fresh water for a relatively long time before artificial breeding.³⁾ From commercial point of view, the intrinsic properties of the meat of salmon caught during spawning migration, such as low fat and low protein, high moisture and soft texture must be disadvantageous.

This study was begun to elucidate the cause of the abnormal softening of the meat of chum salmon caught by coastal set-net fishery. Three groups of chum salmon were obtained in the frozen state below -30°C : Group 1, consisting of salmon during feeding migration caught in the Northern Pacific in July 1980; Group 2, consisting of salmon during spawning migration in the sea trapped by a set-net off the Pacific coast of Sanriku at the end of December 1980; and Group 3, consisting of salmon during river migration caught at a point about 3 km up the Yoichi river in Hokkaido at the end of November 1980. A sample of salmon with paste-like meat was found in the same catch as Group 2. A histological observation of the tissue of the paste-like meat revealed that the muscle fibers were broken down into irregular fragments and amorphous granules which appeared to be lysed. No parasites of any type nor foreign bodies was detected. Autolytic (protease) activity in the meat of salmon in different migratory stages was therefore examined as a preliminary study.

The dorsal ordinary muscle was tested for autolytic activity. The activity was determined by incubating the mixture of one volume of the muscle homogenate (muscle: water = 1:3) and an equal volume of 0.2 M citric acid-phosphate buffer (pH 2~8) at 37°C for one hour. The reaction was stopped by adding two volumes of 10% trichloroacetic acid (TCA). Blanks were not incubated, but the homogenate, TCA and the buffer were mixed in this order. The TCA-soluble products in the filtrate were determined by FOLIN's phenol reagent.⁴⁾

The pH-autolytic activity curves of muscle homogenates are shown in Fig. 1. Every curve shows an optimum autolytic activity at around pH 3.5. The autolytic activity at pH 3.5 of salmon during spawning migration and river migration is about 4 times higher, and that of the paste-like meat is about 6 times higher

Fig. 1. Autolytic activity of muscle homogenate of salmon in different migratory stages. $\triangle$ — $\triangle$: Salmon during feeding migration, $\circ$ — $\circ$: Salmon during spawning migration in the sea, $\bullet$ — $\bullet$: Salmon during river migration, $\bullet$ — $\bullet$: Paste-like salmon.

than that of salmon during feeding migration. By comparing the hydrolysis rates of proteins in the homogenate and its supernatant, it was found that both myofibrillar and sarcoplasmic proteins were hydrolyzed to about the same extent in the homogenate. No attempts at enzyme purification or characterization was made. The autolytic activity at pH 3.5 was inhibited up to 30~40% by 1 mM pepstatin, 60~70% by 1 mM leupeptin, about 25% by 1 mM sodium iodoacetate, not inhibited by 4 mM diisopropylphosphofluoride and increased up to 10~20% by 1 mM cysteine. Little protease activity was detected in the slightly alkaline region even in the presence of 1 mM Ca^{2+} and 2 mM cysteine, and accordingly the amount of calcium-activated protease was negligible even if present.

From these findings, it can be concluded that enhanced protease activity which may possibly be attributable to cathepsins in salmon muscle during spawning migration is directly responsible for the softening or lysing phenomenon of salmon muscle tissue both when the fish is still alive and after death, resulting paste-like meat if the activity is very high. The protease activity enhancement may possibly be related to the expenditure of body protein for energy required to make the long trip and concurrently to develop mature gonads. Details will be published elsewhere.

Shiro KONAGAYA*²

Tokai Reg. Fish. Res. Lab., Kachidoki-5, Chuo, Tokyo 104, Japan.

References

- 1) H. IGARASHI and K. ZAMA: *Bull. Japan. Soc. Sci. Fish.*, **18**, 618-622 (1953).
- 2) C. E. THURSTON and H. W. NEWMAN: *Fish. Ind. Res.*, **2**, 15-22 (1962).
- 3) T. UNO, T. TOKUNAGA, and M. NAKAMURA: *Bull. Hokkaido Reg. Fish. Res. Lab.*, No. 14, 89-95 (1956).
- 4) S. KONAGAYA and K. AMANO: *Bull. Japan. Soc. Sci. Fish.*, **39**, 1169-1178 (1973).

(Received March 23, 1982)

*¹ 産卵回帰中のシロザケ筋肉における高プロテアーゼ活性, 東海区産研究所業績B第715号.

*² 小長谷史郎: 東海区水産研究所.