Studies on the comparison of fish meat qualities between two mackerel species, spotted mackerel Scomber australasicus and Pacific mackerel S. japonicus

［課程博士・論文博士共通］

博士学位論文内容要旨
Abstract

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論文題目 Title	Studies on the comparison of fish meat qualities between two mackerel species, spotted mackerel *Scomber australasicus* and Pacific mackerel *S. japonicus* （ゴマサバおよびマサバ筋肉の品質の比較に関する研究）		

It is necessary to characterize deterioration in the quality of fish muscle to prevent post-mortem muscle softening and to develop frozen sashimi products from mackerels. In Chiba Prefecture, two mackerel species, namely spotted mackerel Scomber australasicus and Pacific mackerel S. japonicus, are produced. Muscle softening is often observed in spotted mackerel, especially in frozen-thawed fish, and reduces the commercial value of fish products. Muscle softening is considered to be related to an increase in protease activity and post-mortem proteolytic degradation of muscle proteins. In this research, the effects of freshness, freezing temperature, species, and season on the quality of muscle were examined.

Chapter 1 describes the effects of freezing and thawing on the meat quality of spotted mackerel. First, the quality of mackerel meat was characterized in fish under various chilled and freezing conditions. The spotted mackerel meat was kept at 4 °C for different time intervals before it was frozen at -20 °C, -30°C and -60 °C. The frozen meat of fresh fish 3 h after death showed only small ice crystals in muscle fibers. In contrast, in fish with low freshness and high freezing temperatures, large ice crystals were observed between muscle fibers, and a large amount of drip was produced. These findings indicate that the quality of frozen fish meat was determined by both the freshness of fish before freezing and the freezing temperature. Muscle cellular structure of spotted mackerel was observed by scanning electron microscopy (SEM). The ice crystals in the muscle tissue of pre-rigor fish stored for 3 h before freezing were small and were distributed mainly in intracellular spaces, whereas those of fish kept at 4 °C for 96 h before freezing were large and were distributed mostly around connective tissues. These findings suggest that the degradation of connective tissues along with the decline in freshness might result in large ice crystals and thus a large amount of thawing drip. This phenomenon was considered to be the major cause of quality deterioration in frozen spotted mackerel. In addition, in an analysis of the meat color of frozen-thawed fish, the a* value of pre-rigor fish after storage at -60 °C was higher than that of fish after cold storage for 51 h. These findings indicate that the meat color of frozen products was affected by the freshness of fish before freezing.

In Chapter 2, meat quality was compared between spotted mackerel and Pacific mackerel. These two species are genetically closely related, but show differences in meat quality. In unfrozen fresh fish, spotted mackerel meat was softer than Pacific mackerel meat. In frozen fish, ice crystals were larger in spotted mackerel meat than in Pacific mackerel meat. After thawing frozen meat, spotted mackerel meat was softer than Pacific mackerel meat. Based on SEM, the connective tissue structure of unfrozen muscle of the spotted mackerel was thinner. In additon, the quantity of collagen in the spotted mackerel was lower than those of the Pacific mackerel. These findings suggest that muscle structure and biochemical components before freezing may influence ice crystal formation, and meat toughness can decrease during the thawing process. In addition, to compare the meat color quality of spotted mackerel and Pacific mackerel, the unfrozen and frozen-thawed muscle color and total selenium content were determined. The total selenium content, which affects antioxidant function, and meat color values were greater in the muscle of spotted mackerel than in Pacific mackerel.

Chapter 3 describes seasonal variation in the chemical composition of mackerel muscle tissues. Information about the deterioration in fish meat quality can provide a basis for improvements in fish quality

and commercial value. Accordingly, post-mortem changes in pH and breaking strength were characterized in spotted mackerel and Pacific mackerel. The muscle pH ranged from 5.5 to 6.1 in spotted mackerel and from 5.6 to 6.2 in Pacific mackerel. Seasonal variation in meat quality and chemical composition, toughness of unfrozen and frozen-thawed muscle, drip rate of frozen-thawed muscle, pH of unfrozen and frozen-thawed muscle, gonadosomatic index, cathepsins B and L activity, water content, and crude lipids were compared between the two mackerel species. In spotted mackerel, unfrozen muscles were soft in May and September. Furthermore, in both species, gonadosomatic indexes were high in April and May, muscle water content was high and crude lipid content was low in February, and cathepsins B and L activity was high from April to June. In unfrozen muscle, a significant positive correlation between breaking strength and pH and a significant negative correlation between breaking strength and gonadosomatic index were detected in spotted mackerel. A positive correlation between breaking strength and pH and negative correlation between breaking strength and cathepsins B and L activity were detected in Pacific mackerel. In frozen-thawed muscle, a significant positive correlation between drip rate and water content and a significant negative correlation between drip rate and lipid content and pH were detected in both species. A significant positive correlation between breaking strength and pH was detected in both species. In both spotted mackerel and Pacific mackerel meat, toughness was strongly influenced by the pH value and cathepsin L activity in muscle tissues.

Chapter 4 includes a comprehensive discussion synthesizing these results. Freshness before freezing and freezing temperature influenced ice crystal formation during frozen storage and the drip rate after thawing. Based on a comparison of meat quality and biochemical composition between the two mackerel species, the connective tissue structure and its proteolytic degradation might be responsible for ice crystal formation during frozen storage and a decrease in muscle toughness after thawing. The mechanism by which meat quality deteriorates might be influenced by pH and cathepsins B and L activity levels.