Changes in quality properties of fish meat as affected by salting and subsequent freezing

Doctoral Dissertation

Changes in quality properties of fish meat as affected by salting and subsequent freezing
（塩漬とその後の凍結に伴う魚肉の性状変化）

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Graduate School of Marine Science and Technology

Tokyo University of Marine Science and Technology

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JIANG QINGQING

学位論文の要約

Summary

Salting is a conventional method used to maintain the quality and extend the shelf-life of foods, especially in the application of preserving highly perishable fish. With the transformation of lifestyle and urgent demands of healthy, fast, and tasty foods, lightly salted fish products are gaining popularity. Salt is now primarily used for unique mouthfeel, juiciness, flavor enhancement, and high yield rather than as a primary preservative. Freezing, an effective preservation method for fresh fish, can be conveniently and extensively applied, and numerous studies have been conducted on the effects of freezing and frozen storage on the quality properties of fish meat. However, there is limited information on the quality changes of pre-salted fish meat as affected by freezing and frozen storage. Therefore, the objectives of this study were (1) to investigate the effects of salting condition on the quality properties of frozen-thawed fish meat, (2) to study the freeze-thaw stability of pre-salted fish meat, and (3) to find out the appropriate storage conditions for lightly salted fish products to minimize the quality deterioration during frozen storage.

To achieve these objectives, effects of salt concentration and salting time on the physicochemical and histological properties of tuna meat were investigated. Then, the susceptibility of tuna meat salted with various salting conditions was studied in terms of quality attributes and histological properties, when subjected to freezing, frozen storage, and repeated freeze-thaw cycles at −20°C. Finally, the effects of different frozen storage temperatures (−20°C, −30°C, −40°C, and −60°C) on the quality properties of lightly salted tuna meat were investigated during frozen storage.

The main conclusions are listed as follows:

(1) Effects of salt concentration Modifications in the tissue histology and ice crystal morphology were dependent on salt concentration. At a low concentration of salt, muscle tissues could absorb water from the salting medium but the samples had a weak water-holding capacity when subjected to freezing-thawing or centrifugation. When a high salt concentration was applied, large ice crystals formed and extracellular spaces enlarged, resulting in decreased water-holding capacity. This decrease might be caused by the changes in protein properties, as indicated by the insolubilization of water-soluble protein and decreased stability of myofibrillar proteins. Salting using optimal salt concentrations (around 1 M) contributed to the recovery of microstructure and formation of numerous spherical or ellipsoidal ice crystals rather than ice columns. After freezing-thawing, high water holding capacity can be maintained in the pre-salted meat with optimal salting conditions.

(2) Effects of salting time With the extension of salting in 1 M NaCl solution, the tissue microstructure evolved in three stages: shrinking, swelling, and falling apart. Lightly salted tuna meat was characteristic of increased water-holding capacity and unique textural properties with the "recovery" of intracellular microstructure from frozen damages in the materials, and after frozen storage these positive effects could be maintained with optimized salting time. Instead of the ice columns in the unsalted samples, numerous spherical ice crystals were found in the samples with proper salting time. With an extended salting time, enlarged extracellular spaces caused decreased water-holding capacity and loose and mushy texture. In these samples, large ice crystals were also found during frozen storage. The samples with salting time of 1 h had higher stability when subjected to frozen storage.

(3) Effects of freeze-thaw cycles Enhanced water-holding capacity and springiness were obtained in the salted samples, which was attributed to the modified morphology and distribution of ice crystals in frozen tissues and improved microstructural recovery after thawing. Instead of the distorted myofibers and large extracellular ice crystals found in the unsalted samples, the salted samples were characteristic of regular and plump myofibers and intracellular ice crystals even after multiple freeze-thaw cycles. Protein cross-linking by hydrophobic interactions was promoted significantly in the frozen salted samples, presumably due to the unfolding of proteins and increased steric accessibility by salting. The accelerated discoloration in the salted samples after freezing-thawing was ascribed to the decreased oxidative stability of meat by salt as indicated by the exacerbated oxidation of myoglobin and lipid. The overall quality of lightly salted tuna meat was better preserved during freezing-thawing, but to improve the oxidative stability is imperative for frozen salted meat products.

(4) Effects of frozen storage temperature Lightly salted tuna meat was better preserved when stored at –40°C or lower temperatures. The enhanced water-holding capacity, appealing appearance, and improved textural properties could be maintained, with the suppressed oxidation of myoglobin and lipid. The insolubilization of water-soluble protein was also minimized by applying a low storage temperature. The lightly salted tuna meat should be stored at −40°C or lower to minimize the quality deterioration during frozen storage.

Frozen lightly salted fish products with unique quality characteristics can be obtained by applying optimal salting conditions and a low and constant storage temperature. Although further studies are needed, the present findings have great implications for the processing and storage of lightly salted fish products.