Research on the utilization of fish oil into surimi and surimi-based products（すり身ならびに練り製品への魚油の混合利用に関する研究）

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博士学位論文内容要旨
Abstract

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論文題目 Title	Research on the utilization of fish oil into surimi and surimi-based products (すり身ならびに練り製品への魚油の混合利用に関する研究)		

Surimi, as an intermediate product, plays an important role in seafood production. Addition of fish oil to surimi to generate various new products is increasingly becoming a trend. Kamaboko is the most typical surimi-based product in Japan, and its textural properties affect the consumer attitudes; therefore, it is necessary to provide a scientific basis for the development of surimi-based products with preferred texture properties. Freezing is an effective method for preservation of surimi-based products. In some cases, kamaboko was founded easily deteriorated after freezing, which makes it necessary to improve technology to minimize frozen damage. Previously, emulsifying fish oil was reported to have a positive effect on the gel properties and water-holding capacity (WHC) of heat-induced surimi gels, which may be related to fish oil droplets becoming smaller by emulsification. It was also considered that emulsification of fish oil into surimi may have some effect on improving the quality of frozen gels. However, adequate information was not available. Therefore, the objectives of this research were as follows 1) to evaluate the effect of emulsifying fish oil on the textural properties of heat-induced surimi gels using physical, physiological, and psychophysical approaches; 2) to investigate on the effects of emulsifying fish oil, the quality changes in frozen surimi gels; 3) to understand the mechanisms of emulsification of fish oil on the quality changes of emulsified surimi gels, and the effect of compositions and different emulsification conditions on physical and rheological properties, and WHC of emulsified surimi gels; 4) to apply this technology to commercial surimi-based products, and to confirm the potential implications of fish oil emulsification on the quality changes in Sasa-kamboko (local products of Miyagi Prefecture) during frozen storage.

In Chapter 1, it provides an introduction to the human health and the function of fish oil, development of frozen surimi and emulsified surimi products, previous research on the investigation of utilization of fish oil into surimi and surimi-based products; texture assessment of surimi-based products using different instrumental and sensory methods, introduction of electrography (EMG), and frozen damage on surimi-based products after freezing and frozen storage.

In Chapter 2, the effects of emulsifying fish oil in improving gel properties of heat-induced surimi gels, four types surimi gels with varied lipid composition (0%, 2.5%, 5.0%, and 10.0%) were evaluated and prepared at a constant protein concentration (10% w/w). The dynamic rheological results showed that the higher storage modulus (G') and loss modulus (G'') during heating were consistent with the increased content of fish oil. The surimi gels were cut and their textural properties were compared using instrumental measurements (puncture test and texture profile analysis (TPA)) and fragment tests. On increasing fish oil contents, surimi gel fragments showed larger equivalent fragment diameters after ten times chews, which corresponds to higher breaking strength. The enhanced rheological properties were consistent with the texture changes, as shown by instrumental and fragment tests. A similar tendency was observed by dynamic rheology,

mechanical, and fragment tests.

In Chapter 3, the textural properties of heat-induced surimi gels emulsified with fish oil were comprehensively evaluated using EMG test approaches. Our aim was to investigate the texture characteristics of the surimi seafood model-emulsified surimi gels based on physical, physiological, and psychophysical approaches, and to analyze the correlations among these methods. Four types of prepared heat-induced surimi gels (3 g) were provided to eight subjects in duplicate and the subjects were allowed to freely consume them for the EMG recording, sensory evaluation and fragment tests; emulsified fish oil distribution was observed microscopically. Overall, these results were compared with those of instrumental evaluation, TPA and puncture test. It was found that in emulsified samples (containing 10.0% fish oil), stronger emulsification conditions resulted in larger EMG variables, and significantly affected gel fragments ($p < 0.05$). For control gels (without fish oil), same tendency existed. Moreover, a similar tendency was obtained among instrumental, EMG recording, and fragment test. The effect of stronger emulsification conditions on the textural properties of emulsified surimi gels is reflected by instrumental results and mastication effort.

In Chapter 4, the effect of emulsifying fish oil on the WHC and ice crystal formation of frozen surimi gels was determined. Emulsified surimi gels containing 5% fish oil were frozen by quick and slow freezing methods, and the gel quality was evaluated. Emulsified surimi gels showed lower thawing drip and expressible drip compared to the control gel. Microscopic observation revealed that the ice crystals sizes in the emulsified surimi gel stored for 3 months after freezing by quick and slow freezing methods were smaller than those of the control gels. Thus, emulsification of fish oil into surimi was shown to have some positive effects on the WHC of heat-induced surimi gels during frozen storage. Ice crystal formation seemed to be different between the emulsified and control samples, which may be related to the difference in WHC. Four types of samples were prepared, after slow freezing and frozen storage, the quality was evaluated. Emulsified surimi gels with stronger emulsification conditions showed higher storage modulus and WHC compared to the weak emulsification conditions samples. Because of the smaller size of ice crystals after frozen storage, less frozen damage to microstructure after thawing, and higher WHC were observed in the stronger emulsification conditions gels. Small and regular fish oil particles caused by the stronger emulsification conditions improved the stability of the gel structure before and after frozen storage. These results may indicate that the improved WHC of the vigorous mixing gel by emulsification restricts the growth of nuclei and ice crystals, and the smaller oil particles surrounded by the protein membrane form a compact gel structure network, limiting ice crystal growth through physical action.

In Chapter 5, we describe new type of commercial surimi-based products, with 0% (control), 2.5%, or 5% fish oil-supplemented Sasa-kamaboko were frozen and stored at −20°C for 4 weeks. Compared to the control, emulsification of fish oil into Sasa-kamaboko significantly ($p < 0.05$) improved the WHC, whiteness, and breaking strength before freezing and after thawing followed frozen storage. Microscopic observation revealed that the fish oil particles in thawed sample were well-distributed even after frozen storage, and that there was only slight structural damage. It was indicated that fish oil supplementation affected the formation and distribution of ice crystals, which had positive effects on the quality of thawed Sasa-kamaboko. Also, sensory evaluation results of the emulsified Sasa-kamaboko showed that the acceptable texture was obtained. After frozen storage, the texture properties of thawed samples were decreased to some extent. However, no significant difference in texture was observed compared with unfrozen Sasa-kamaboko ($p < 0.05$). These findings may be used to improve the manufacturing process of high-quality frozen surimi-based products.

In Chapter 6, the conclusions and future prospects are presented. A similar tendency was observed in the dynamic rheology, mechanical, and fragment test on emulsified surimi gels. The effect of stronger emulsification conditions on the textural properties of emulsified surimi gels is reflected by instrumental results and mastication effort. Emulsification of fish oil into surimi has some positive effects on the WHC of

heat-induced surimi gels before freezing and after frozen storage. Small and regular fish oil particles caused by stronger emulsification conditions improved the stability of the gel structure before and after frozen storage. Emulsification of fish oil into Sasa-kamaboko significantly ($p < 0.05$) improved the WHC, whiteness, and breaking strength before freezing and after frozen storage. The above results indicate that emulsification with fish oil, in addition to being, used to fortify the nutritive value and functionality, is also an effective method to minimize frozen damage of frozen Sasa-kamaboko.

We expect that this detailed research will help future studies in applying emulsification technology to surimi-based product manufacturing. Emulsified fish oil enhances nutrition and adds values to surimi and surimi-based products, by contributing to the improvement of WHC and, texture without affecting sensory characteristics.