Study on the development of non-fish meal and non-fish oil diet for red seabream Pagrus major using with microalgae(微細藻類によるマダイ用無魚粉・無魚油飼料の開発に関する研究)

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博士学位論文内容要旨
Abstract

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論文題目 Title	**Study on ohmic heating processing of surimi-based products**		

Ohmic heating is a heating process in which alternating electric current passes through electrically conducting food products. Heat is internally generated due to the electrical resistance of the food materials and conducts within the samples. For this reason, heat is readily transferred within the sample, resulting in a rapid heating rate and uniform heat distribution. This is a striking contrast to conventional heating methods in which the temperature of the product increases relatively slow because heat penetrates from the external heating medium.

Ohmic heating has been applied to surimi for the last 30 years. Surimi is washed minced fish muscle mixed with cryoprotectants such as sucrose and sorbitol. The fish muscle consists of salt soluble myofibrillar proteins and has unique gelling properties that make it useful as a food base in seafood analogs. Ohmic cooking method has been utilized to evaluate the gel-forming ability of various forms of surimi and surimi seafood. However, further study is still needed to utilize more effectively this heating method in the production of surimi-based products.

This dissertation will review various features of ohmic heating in surimi and surimi seafood as affected by processing and quality parameters.

In Chapter 1, the research motivation and the academic information that are necessary to understand the content of this study were summarized and provided. Which are introduction and literature review, respectively.

In Chapter 2, in order to clarify how ohmic heating affects the physical properties of surimi gel under OH, gels from croaker surimi (SA grade) were obtained using different heating conditions (heating speed, heating time, or salt concentration - electrical conductivity). Furthermore, the gels heated by ohmic heating were compared with the gel obtained by conventional water-bath heating. At the same heating rates, higher salt concentration generated better surimi gels for croaker surimi. Gels cooked ohmically at a slow heating rate performed significantly better than those cooked at a fast heating rate or heated conventionally in a water

bath. The results also indicated that holding time at target temperature showed no effect on the gel properties.

In chapter 3, frozen Alaska pollock surimi (FA, A, and RA grade) were used to clarify how heating methods (OH and WB) and heating rate affect the physical properties of heat-induced gels. Textural properties of every grade of surimi were significantly influenced by heating method and heating rate. Slow heating enhanced gel strength of high-grade surimi more effectively than low-grade surimi. The quality of the gels prepared by WB and OH differed even if the heating time to the final temperature was the same, probably due to the difference in linear and nonlinear temperature patterns among two heating methods. From the results using the gels with progressed setting (2-steps heating) and the gels with the suppressed setting (EDTA addition), it was confirmed that the slow heating rate enhanced the gel strength by setting phenomenon but also influenced by modori and that the level of the effect is different depending on the surimi grades.

Chapter 4, frozen Alaska pollock surimi (RA grade) was chopped with salt (1.5%) and ice water and then mixed with refined fish oil (10%) at four different mixing conditions (hand mixing, mild mixing (300rpm/min; 900rpm/min), and vigorous mixing) to prepare different levels of emulsified surimi paste. The prepared surimi pastes were heated in a water bath (90^{o}C for 30min) and ohmic heater (applied two different heating speeds: 3^{o}C/min- slow and 80^{o}C/min - fast) to 90^{o}C to obtain the emulsified heat-induced gels. Physical properties, water-holding capacity (WHC), color, microstructural, and rheological properties were conducted to evaluate the effects of oil particle distribution and electrical parameters on the gel properties. The well-emulsification of fish oil into surimi promoted gel properties both in water-bath heating and ohmic heating. Vigorous mixing decreased the size of oil droplets and generated uniform and stable emulsified surimi paste and contributed to the higher gel strength. The heating rate also influenced the gel properties and significantly improved gel-forming ability and WHC of emulsified surimi paste. The highest breaking strength and lowest drip loss of emulsified gels were obtained by the slow heating rate (3^{o}C/min) in comparison with the other conditions ($p < 0.05$). Rheological and color measurement also showed coincident results.

In Chapter 5, frozen croaker surimi (SA grade) and refined fish oil (0, 2, 5, and 10%) were mixed at different mixing conditions to prepare different levels of emulsified surimi paste and measured the electrical conductivity (EC). Two methods obtained the heat-induced gel: OH (applied two different heating speeds: 3°C/min and 80°C/min) and water bath heating (heat samples to 90°C for 30min). The EC of emulsified surimi paste decreased slightly with not only the increase of oil content but also oil particle size. Vigorous mixing decreased the size of oil droplets and generated uniform and stable emulsified surimi paste and contributed to the higher gel strength both in water-bath heating and OH. Oil concentration had a significant effect on emulsified gel properties ($p<0.05$). The heating rate also influenced the gel properties of emulsified surimi paste by OH. The highest breaking strength and lowest drip loss of emulsified gels were obtained by the slow heating rate (3°C/min) in comparison with the other conditions ($p<0.05$).

Overall results were concluded in the last chapter. This research revealed that the electrical conductivity of surimi paste varied with the added components (salt, fish oil) and temperature. Changes in electrical conductivity affected the heating conditions of ohmic heating. Slow heating rate was more suitable for heating a high-grade of surimi that contains less or no protease enzymes. The heating rate also influenced the gel properties of emulsified surimi paste by OH. These findings in this study will provide a useful reference for the industry to apply ohmic heating to the manufacturing of high-quality surimi-based products.