

Effects of Triglycerides on the Thermally Induced Gel-Forming Ability of Salt-Ground Fish Meat

Erlinda B. PANGGAT^{*1}, Jo SHINDO^{*2} and Hisashi ICHIKAWA^{*3}

Abstract The gel-forming ability of the lean-fish (white croaker) surimi on the addition of vegetable oils or triglycerides were investigated. Addition of oils to fish surimi alter the softness of fish paste. However, effects of the adding varying levels of rice, soybean and olive oils were not only in decreasing, but also in increasing the gel strength of white croaker surimi after the addition of a few %(W/W) of the oils. Breaking strengths (BS) of these heat-induced gels significantly increased to 1.12 times when rice oil was mixed at 2% concentration of the surimi, 1.19 times when soybean oil was mixed at 2%, and 1.20 times when olive oil was mixed at 4%. BS of each heat-induced gel declined with increasing levels of vegetable oils, i.e. 4%, 6% and 8%. A similar study was also employed using the triglycerides, trilinolein, triolein and tristearin. Effects of these triglycerides were evidently relative to the concentrations in the gels. The addition of less than 4~5% of three types of triglyceride except tripalmitin gave a significantly higher BS value than that of the control white croaker surimi gel, but excessive addition decreased the BS value. Only tripalmitin showed decreasing effect on the BS value of the gel at all concentrations tested. These results suggest that some triglycerides (trilinolein, triolein and tristearin) in vegetable oils show reinforcing and obstructing (softening) effects on the thermally induced gel-forming ability of the lean-fish surimi.

Key words : gel-forming ability, surimi, vegetable oil, triglyceride

Introduction

Since the gel strength of fish pastes is inversely proportional to moisture content, an increase in moisture content dilutes the myofibrillar protein concentration. Increasing only a few %(W/W) of moisture, results in the myofibrillar protein network becoming sparse [1]. However, the effect of oils on the gel-strength of heat-induced surimi gel is not clarified yet. Ikeuchi *et al.* reported that oil additives decrease the gel-forming ability of fish surimi gel [2]. Generally, small amounts of vegetable oil is often added in molded fish paste products. This makes the cooked gel less rubbery [3]. However, the method of oil-addition that improved the gel-forming ability by using a high-speed mixer was reported recently [4].

In this study, the effect of oils and triglycerides on the heat-induced gel-forming ability of white croaker surimi was investigated. It was found that the addition

of a few %(W/W) of rice oil, soybean oil or olive oil enhanced the gel strength of this lean-fish surimi. The effect appeared to be dependent of the oil-concentration. The gel strength of heat-induced surimi gel declined with the addition of 4% and higher proportions of rice oil, 6% and higher soybean oil, and 8% and higher olive oil. Also, it was found that trilinolein, triolein and tristearin had the same effect on the gel-forming ability. However, tripalmitin simply decreased the gel-forming ability of white croaker surimi. Therefore, triglycerides were classified into the following two groups according to their influence on the heat-induced gel formation of white croaker surimi: 1), exerting both reinforcement and obstruction of the heat-set gel formation, and 2), exerting only obstruction of the gel formation.

In Japanese fish paste (Kamaboko) manufacturing, enhancement of the gel-forming ability has been an important aspect in obtaining valuable products. However, recent consumer's markets require relatively

* 1 College of Fisheries and Ocean Sciences, University of the Philippines in the Visayas, Miag-ao, Iloilo 5023, Philippines

* 2 Faculty of Fisheries, Kagoshima University, Kagoshima 890-0056, Japan

* 3 Graduate School of Fisheries Science and Environmental Studies, Nagasaki University, Nagasaki 852-8521, Japan

soft-textured foods. One intention is the improvement of the QOL (Quality of Life) of elderly people. Today, both techniques for the reinforcement and obstruction of the gel-forming ability are necessary for the expanding of the fish pastes processing. The addition of oil will be an important technique to modify the gel-forming ability of surimi. The finding in this study is applicable to the texture controlling method of the fish paste processing.

Materials and Methods

White croaker surimi was obtained from white croaker (*Pennahia argentata*) dorsal muscle following the procedure described elsewhere [5]. After checking moisture content using a water content analyzer (SARTORIUS MA 45), the moisture content of the surimi was adjusted to 83%. Then, the surimi was ground with 3% NaCl (W/W), and mixed with vegetable oils or triglycerides in separate preparation at varying levels of concentrations (1~16% for oils or 1~8% for triglycerides). Commercial grade vegetable oils used were olive (Ajinomoto Co., Inc.), soybean (Riken Nosankako Co., Ltd.), and rice (The Nisshin Oillio Group Ltd.) oils. Reagent grade triglycerides, i.e. trilinolein, triolein, tristearin and tripalmitin were obtained from Wako Pure Chemical Industries. Ltd. The salt-ground meat paste was stuffed into a stainless steel case (ϕ 13mm \times height 10mm), then wrapped with a film and heated at 80°C for 60min. The gel was formed after cooling in iced water for 10min. Effects of adding oils or triglycerides on the rheological properties and on the water holding capacity (WHC) of heat-set gels were determined. Rheological properties of heat-set surimi were measured based on breaking strengths (BS). BS values of heat-set gels were measured 5 times for each condition by using a rheometer (FUDOH NRM-2010J with a ϕ 2mm cylindrical stainless plunger; and with a compressing speed of 60mm/min) under room temperature (25°C). The size of cylindrical-shape sample was ϕ 13mm \times height 10mm. Dixon's Q-test [6] was used to reject outliers among obtained data. For each sample, the mean BS value and confidence interval (determined by the 95% of confidence level, $t=2.776$) of five data were calculated. WHC of the gel was calculated from its moisture and unexpressed water contents after pressing the sample under 2 Kg/cm² for 2min [7].

Results and Discussion

Effects of added oils on BS values of white croaker heat-set surimi gels are shown in Fig. 1. The BS value of white

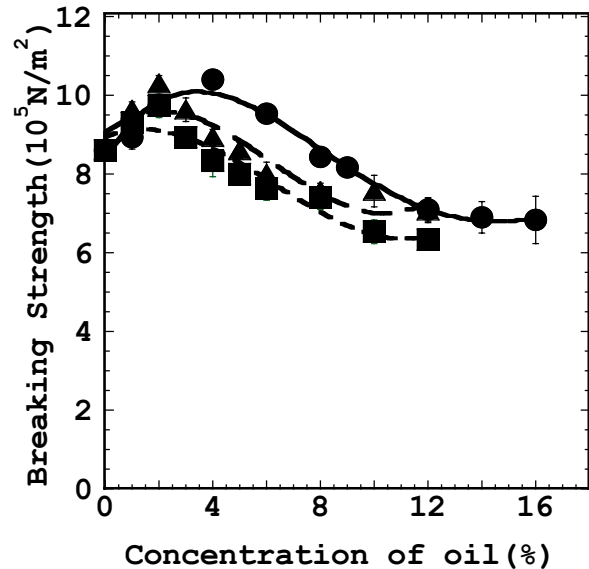


Fig. 1 Effect of adding oil on the gel forming ability of the white croaker surimi

Salt-ground surimi obtained from white croaker ordinary muscle was adjusted to 83% of moisture content, mixed with varying amounts of vegetable oils, then heated at 80°C for 1hr and gelled at 5°C. BS value of a gel sample was measured using a rheometer attached a cylindrical stainless plunger (ϕ 2mm). Symbols show BS values of heat-set surimi gels containing olive oil (●), soybean oil (▲) and rice oil (■), respectively. BS value of the control was $8.6 \pm 0.2 \times 10^5 \text{N/m}^2$.

croaker surimi gel without the oil (control) was $8.6 \pm 0.2 \times 10^5 \text{N/m}^2$. BS values were lower than the control in surimi gels containing 4% and higher proportion of rice oil (■), 6% and higher soybean oil (▲), and 8% and higher olive oil (●). Increasing the amount of oils in the fish paste altered texture and increased softness. On the other hand, when less than 4%, 6% and 8% in proportions were added for rice, soybean and olive oils, respectively, BS values of heat-set gels increased above the level of the control, increasing with the amount of oil added. However, reinforcement effects of rice, soybean and olive oils on the gel-forming ability of white croaker surimi were different at varying levels. From polynomial curves fitted to data points shown in Fig. 1, maximum BS values obtained were, as compared to the control surimi gels, 1.12, 1.19 and 1.20 times higher for 2% rice oil, 2% soybean oil and 4% olive oil, respectively. WHC levels of heat-set gels were 84~58, depending on the amount of added oils, and showed a good correlation with their BS values (Data is not shown).

Influences of chemical components of vegetable oils on the gel-forming ability of the surimi were examined. Three kind of vegetable oils thus studied were composed of different triglycerides. Standard tables of food compositions in Japan [8] show that for olive oil at least 75% of its fatty acid composition is oleic acid (Numerical symbol is 18:1), while the composition is 52.7% linoleic acid (18:2) and 24.3% oleic acid in soybean oil. In rice oil, it is 42% oleic acid and 36.6% linoleic acid. Palmitic acid (16:0) contents of olive, soybean and rice oils are 9.9, 10.3 and 16.4%, respectively. Also, the three vegetable oils contain relatively small amounts of stearic acid (18:0), and are contained 3.2, 3.8 and 1.7% for olive, soybean and rice oils, respectively. So, the influence of four triglycerides such as trilinolein, triolein, tristearin and tripalmitin on the gel-forming abilities of white croaker surimi were examined. For results, effects of added triglycerides on BS of the white croaker heat-set surimi gel are shown in Fig. 2. In this experiment, the BS value

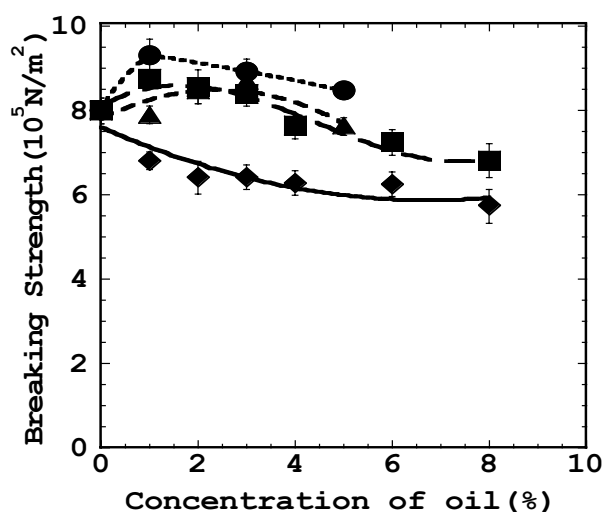


Fig. 2 Effect of adding triglyceride on the gel forming ability of the white croaker surimi

Salt-ground surimi obtained from white croaker ordinary muscle was adjusted to 85% of moisture content, mixed with varying amounts of triglycerides, and then gelled under heat-setting temperature at 80°C as in Fig. 1. BS value of gel sample was measured as in Fig. 1. Symbols show BS values of heat-set surimi gels containing tripalmitin (◆), tristearin (■), triolein (▲), and trilinolein (●), respectively. BS value of the control was $8.0 \pm 0.3 \times 10^5 \text{ N/m}^2$.

of the control white croaker surimi gel (without triglyceride) was $8.0 \pm 0.3 \times 10^5 \text{ N/m}^2$. Polynomial curves fitted to data points are shown in Fig. 2. Result for trilinolein (●), triolein (▲) and tristearin (■) showed that BS values of the heat-induced triglyceride-containing gels significantly increased to about 1.15, 1.05 and 1.09 times for 1% trilinolein, 2% triolein and 1% tristearin, respectively. BS of heat-induced gels declined

with increasing levels of triglyceride i.e. >5%, 5% and 4%. The addition of less than 4~5% of each triglyceride gave a significantly higher BS value than that of the control white croaker surimi gel, but excessive additions decreased the BS value. Only tripalmitin (◆) showed decreasing effect on the BS value of the gel at all concentrations tested.

To compare the effects of vegetable oils (Fig. 1) and triglycerides (Fig. 2) on the surimi gel strength, reinforcement and softening effects obtained at specific concentrations of the oils are summarized in Table 1. For

Table 1 Modulation of the gel-forming ability of white croaker surimi by addition of vegetable oils and triglycerides

Oil added	Reinforcement effect		Softening effect
	Most effective Conc. for increasing BS (%)	BS-elevated (times*)	Minimum Conc. for decreasing BS (%)
Olive oil	4	1.20	8
Soybean oil	2	1.19	6
Rice oil	2	1.12	4
Tripalmitin	(BS value decreased at all concentrations of oil added)		
Tristearin	1	1.09	4
Triolein	2	1.05	5
Trilinolein	1	1.15	>5

*: The value against the Breaking Strength of the controlsurimigel without oil

the reinforcement effect, the most effective concentrations of trilinolein and tristearin required to increase the BS values were lower than those of the vegetable oils. For the softening effect, minimum concentrations of tristearin and triolein required to decrease the BS values were lower than those of the vegetable oils. The reinforcement effect of olive oil was effective (BS-elevated ratio; 1.20) at a relatively high concentration of 4%, and this seemed to be the influence of triolein, which had a reinforcement effect (BS-elevated ratio; 1.05) at a relatively high concentration of 2%. On the other hand, the reinforcement effect of soybean oil was effective (BS-elevated ratio; 1.19) at a relatively low concentration of 2%, and this seemed to be combined influences of trilinolein, which had a relatively high reinforcement effect (BS-elevated ratio; 1.15) at a relatively low concentration of 1% and of triolein, which was as described above. Also, the reinforcement effect of rice oil (BS-elevated ratio; 1.12) was less than the other vegetable oils as shown in Table 1. Rice oil showed the lowest minimum concentration (4%) among three vegetable oils for decreasing BS. It was suggested that rice oil may contain more palmitic acid than the other vegetable oils [8]. This seemed to be from combined influences of triolein, trilinolein and tripalmitin. Here, tripalmitin was a unique triglyceride, and addition of it, regardless of concentrations, resulted in the reduction of BS as is

shown in Fig. 2. Therefore, these results suggest that effects of vegetable oils on the gel-forming ability of surimi (Fig. 1) can be attributed to the presence of these triglycerides in these oils. Thus, the ratio of tripalmitin to the other three types of triglycerides in each of the vegetable oil might attribute to the difference in the reinforcement and/or softening effect among the three vegetable oils tested.

Oil-added fish paste is considered an emulsion gel that contains oils in a gel consisting of muscular proteins such as myosin and actin. Vliet reported that the minute size of oil droplets in a protein gel elevate a shear modulus corresponding to the surface tension when an interaction is formed between the gel-matrix of proteins and dispersed minute oil droplets [9]. This phenomenon is called the "active filler effect". It is suggested that a small amount of added-triglyceride dispersed in the surimi reinforced the shear modulus of the heat-set muscle protein gel. In this case, oil droplets showed the filler effect, and the gel strength of muscle protein may have been reinforced. However, by adding more oil into the surimi, the excess oil disturbs this phenomenon. Also, increasing the oil dilutes the myofibrillar protein concentration, thus supposedly making a part of the myofibrillar protein network rough. The reason why tripalmitin did not show the filler effect in this study was also considered. Many kinds of triglycerides are contained in croaker muscle itself. It is well known that fresh croaker meat is rich in palmitic acid. The level of palmitic acid content in its meat is 22 mg/100g of meat [8]. The content of palmitic acid is more than 10 times in excess against contents of other fatty acids. The tripalmitin effect brought about by its addition into the surimi may have been influenced by the tripalmitin that was originally in the white croaker muscle. As a result, the amount of tripalmitin required to induce an active filler effect may have already been reached by the amount of tripalmitin that was contained originally in the fish meat.

In this study, it was apparent that the addition of vegetable oil into fish surimi altered the texture of the fish paste, making it either harder or softer, depending on the amount of the oil added. The triglyceride composition of vegetable oil was supposed to be the factor affecting the gel strength. The mechanism behind the changing of the surimi gel formation as a result of oil additives need to be studied further. It's well known that main component of the gel network in fish paste is myosin [10]. For further studies, investigating the influence of triglycerides on the fish myosin gel formation and clarifying the interaction between the

myosin gel-matrix and dispersed minute oil droplets are required.

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塩摺魚肉の熱ゲル形成能に及ぼすトリグリセリドの効果

リンダ パンガット, 進藤 穰, 市川 寿

長寿高齢化社会への移行に伴い、咀嚼嚥下の容易な魚肉練り製品が求められている。魚肉練り製品を柔らかく、しかも食塊形成し易い性状にするために植物油の添加が有効である。本報告は、この植物油の効果がトリグリセリドの種類と量によって生じる事を示した。シログチの塩すり身にトリパルミチン、トリステアリン、トリオレイン、トリリノレインをそれぞれ最大で魚肉の8%まで添加し加熱ゲルを形成させたところ、トリパルミチンは添加濃度に依存しすり身ゲルの強度を25%まで低下させたが、他のトリグリセリドは、極少量添加（トリステアリンとトリリノレインでは1%、トリオレインでは2%）で一旦ゲル強度の増強効果を示した後、それ以上の添加で軟化効果を発現した。これらの結果から、すり身への種々の植物油添加が魚肉ゲルを軟化させる効果は、植物油中トリグリセリド成分の種類と量により決定されると考えられた。