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Image Analysis of Surimi Sol and Gel in Composite System

– Research note –

Byoung-Seung Yoo[†] and Chong M. Lee[*]

Dept. of Food Technology, Dongguk University, Seoul 100-715, Korea
[*]Dept. of Food Science and Nutrition, University of Rhode Island, Kingston, RI 02881, USA

Abstract

Surimi sol and gel were prepared by mixing egg albumin, starch, oil and carrageenan, which are used as representative ingredients in the surimi composite, at different ratio. Structural properties in surimi composite were investigated by examining the phase changes and dispersion pattern (average particle size, size range and the average number of particle) of the particulate ingredients in sol and gel with an image analyzer. A staining technique of the specimen containing egg albumin in surimi gel was developed by adjusting pH of a toluidine staining solution. Image analysis revealed that size and density of ingredient particles were function of the level and dispersion of ingredients except for starch incorporated surimi gel which showed maximum particle size at 6%

Key words: surimi, structural property, sol, gel, egg albumin

INTRODUCTION

Composite systems consisting of solid particulates dispersed in a polymeric matrix are frequently applied to the plastics industry in order to enhance the mechanical and thermal properties of the finished product. Food systems can be also considered as complex mixtures of many components, namely, composites in which particulate ingredients are dispersed in a continuous matrix (1). Structural principles for polymer composites have been applied in explaining food composite characteristics (2-4). In a few studies, the surimi composite characteristics were varied by dispersing various amounts of biopolymeric ingredients in a surimi sol, as well as by altering the physical state of the dispersed phase through heating (2,4,5). However, no comprehensive studies have been reported regarding the effects of ingredients on structural properties in surimi composite with an image analyzer. Especially, the structural properties of egg albumin in surimi compoiste has not been examined because there was not any staining technique for differentiating the egg albumin protein from the fish protein (5). The objectives of this study were : 1) to assess the composite characteristics by examining the microstructure under a light microscope and the phase changes and dispersion pattern of the particulate ingredients in surimi sol and gel with an image analyzer, 2) to develop a staining technique for the specimen containing egg albumin in surimi sol and gel.

MATERIALS AND METHODS

Spary-dried egg albumin (Monark Egg Products, Kansas City, MO, USA), corn starch (40% Melojel and 60% Fregex, National Starch, Bridgewater, NJ, USA), corn oil (Best Foods, Englewood Cliffs, NJ, USA), iota-carrageenan without synergist (SD389) and with cation-donating synergist (mixture of K_2CO_3, Na_2CO_3 and $CaSO_4$) (XP8009) (FMC, Philadelphia, PA, USA) were used as representative ingredients in the surimi composite. Melojel is composed of unmodified 25% amylose and 75% amylopectin corn starch, while Fregex is composed of hydroxypropylated modified 18~28% amylose and 72~82% amylopectin tapioca starch. The levels of each ingredient (egg albumin, 1~3%; starch, 4~8%; oil, 2~6%; Carrageenan-SD, 0.1~0.3%; Carrageenan-XP, 0.2~0.6%) are selected on the basis of the commercial usage. Surimi prepared from Alaska pollock (*Theragra chalcogramma*) was supplied by the Profish International (Seattle, WA, USA).

Preparation of surimi sol and gel

Half-thawed surimi (-2°C) was chopped for 2 min with 1.5% salt in a silent cutter, followed by additional chopping for 8 min with ingredients. Calculated amount of water was added to adjust the final moisture level of all formulas to 78%. Heat-induced surimi gel were prepared by stuffing the remaining surimi sol into casing and heating at 90°C in a steam cooker for 20 min (1).

Analysis of composite characteristic

Composite characteristics were assessed by examining the microstructure under a light microscope and a Java image analysis system (Jandel Scientific, Corte Madera, CA, USA) for measuring the density and size of ingredient particles. Specimens for the microstructure analysis were prepared from both uncooked sol and cooked gel following the procedure described by Lee (6). The specimens containing carrageenan, starch and oil were stained with a toluidine blue, a toluidine blue-iodne mixture, and hematoxylin and Oil Red O, respectively.

[†]Corresponding author

RESULTS AND DISCUSSION

Staining technique for the specimen containing egg albumin

A staining technique for the specimen containing egg albumin in surimi gel was developed by adjusting pH of a toluidine staining solution. A good contrast was obtained between surimi and egg albumin protein, by adjusting pH of toluidine solution to a point (pH=5.0) where fish protein (pI=6.0) is positively charged but egg albumin (pI=4.6) is not and then by adjusting pH of toluidine solution to a point (pH=3.5) where fish protein and egg albumin are both positively charged, showing different location. The positively charged protein reacts with the staining solution since there is an electrostatic interaction between positively charged groups of amino acids and the negatively charged dye molecules. However, this staining technique was not applied to the specimen containing egg albumin in surimi sol. The measurement of the partile size and denity was not performed of oil whose some particle size was too small to differentiate.

Structure analysis

The image analysis on changes in particles size and density of ingredients in surimi sol (before cooking) and gel (after cooking) were shown in Table 1 and 2. According to image analysis, there was a wide range of particle size distribution in each level of ingredients. Image analysis measured average particle size, size range and the average number of particle in a given area of the composite surimi sol and gel section. All of these values were changed with the level of ingredient. Dispersion of ingredients in the surimi exhibited a pattern which the particle size increased as the levle of ingredient increased. The particles at the low level of ingredient appeared to be well dispersed in small sizes while the particles at the high level of ingredient appeared to be dense in large sizes due to insufficient dispersion.

Table 1. Average particle size (x), smallest (min) and largest (max) particle size and particle density (d) of composite surimi gel with starch and egg albumin

(Starch)

State	Level (%)	x	Min[1)]	Max[1)]	d_a
Sol	4	0.904	0.021	3.476	4.31
	6	0.910	0.022	4.272	6.25
	8	0.913	0.024	4.610	7.24
Gel	4	3.442	0.024	19.913	1.88
	6	4.595	0.026	38.306	2.82
	8	4.172	0.048	31.547	4.42

(Egg albumin)

State	Level (%)	x	Min[1)]	Max[1)]	d_b
Gel	1	21.433	5.209	54.767	9.5
	2	31.076	6.846	104.176	13.9
	3	73.913	5.655	627.738	19.1

[1)]Measured in a field of 10^{-4} mm^2

d_a: No$\times 10^2/mm^2$, d_b: No/mm^2

Table 2. Average particle size (x), smallest (min) and largest (max) particle size and particle density (d) of composite surimi gel with carrageenan

(Carrageenan SD)

State	Level (%)	x	Min[1)]	Max[1)]	d
Sol	0.1	1.268	0.024	4.393	0.94
	0.2	2.086	0.025	11.707	1.67
	0.3	2.908	0.027	27.927	3.29
Gel	0.1	1.276	0.027	4.586	0.84
	0.2	2.480	0.034	11.028	1.41
	0.3	3.291	0.048	26.920	2.51

(Carrageenan XP)

State	Level (%)	x	Min[1)]	Max[1)]	d
Sol	0.2	1.639	0.021	5.262	1.17
	0.4	1.807	0.024	11.296	1.74
	0.6	2.522	0.028	11.296	2.26
Gel	0.2	2.146	0.034	6.855	0.61
	0.4	2.423	0.064	11.426	1.17
	0.6	3.154	0.121	20.975	2.00

[1)]Measured in a field of 10^{-4} mm^2

d : No$\times 10^2/mm^2$

Therefore, the distribution (density) and size of ingredient particles were affected by the level and dispersion of ingredients except for starch. In sol state the particle size of starch granules remained unchanged while in gel state maximum particle size resulted at 6%. Beyond 6% level, there seems to be an incomplete swelling due to competition for water between starch granules. Therefore, a level of starch greater than 6% caused a decrease in the particle size. After cooking, starch and carrageenan particles expanded as a result of swelling or hydodynamic activity (Fig. 1) (7,8). This process activated starch and carrageenan as composite-reinforcing ingredients. Image analysis revealed that size and density of ingredient particles were a function of the level and dispersion of ingredients except for starch.

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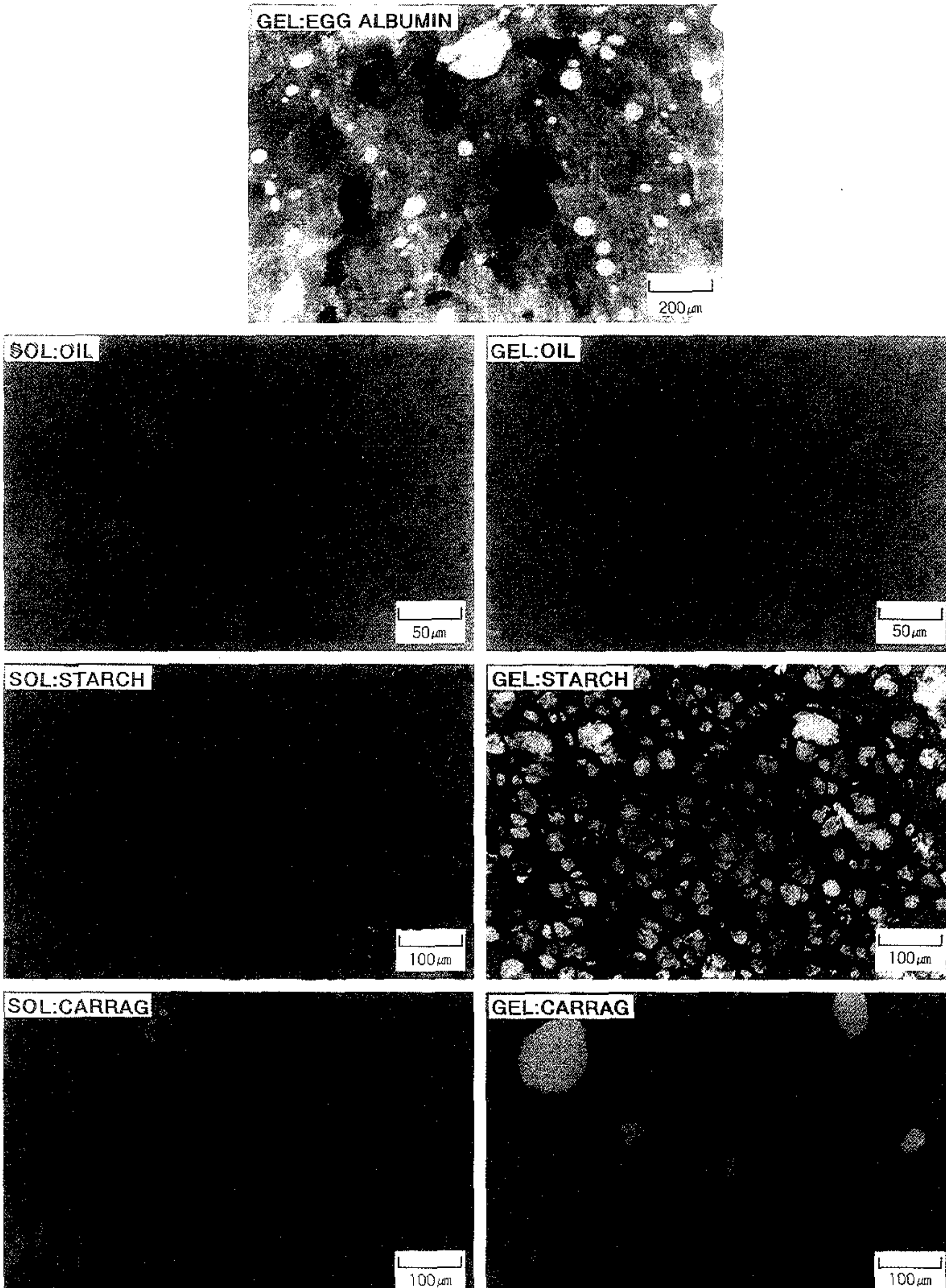

Fig. 1. Photomicrographs of surimi sols and gels incorporated with various ingredients.

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