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Evaluation of Wheat Gluten and Modified Starches for Their Texture-modifying and Freeze-thaw Stabilizing Effects on Surimi Based-products

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Abstract

Texture-modifying and freeze-thaw stabilizing effects of different wheat gluten and modified starches on surimi based-product were evaluated. The different incorporation manners of wheat gluten and modified wheat starch in surimi gel were also examined to evaluate their effects of textural properties on surimi gel. The addition of wheat gluten reduced the gel strength of surimi, but after freeze-thaw cycle it significantly improved freeze-thaw stability by reducing freeze-thaw expressible moisture and also by preventing rubbery texture development. Gluten-1 incorporated surimi gel showed higher functionality in forming cohesive gel determined by compressive and penetration force as well as expressible moisture after freeze-thaw cycle. Surimi gel containing modified wheat starch showed better freeze-thaw stability than that of modified potato starch. When a preblended mixture of wheat gluten and starch are incorporated into surimi gel, it made gel texture significantly softer as so in high sensory score. The competition for moisture between gluten and starch is a main reason to show different way of textural modification.

Key words: wheat gluten, modified starch, texture-modifying and freeze-thaw stabilizing effect in surimi gel

INTRODUCTION

The major use of vital wheat gluten has traditionally been, and continues to be in bakery product application. However, the unique adhesive, cohesive and film-forming characteristics of hydrated vital wheat gluten and its thermosetting properties serve the basis of various types of application in meat, fisheries and poultry products such as frankfurters and bologna as a protein extender and binder(1-4). Proteins from blood, cottonseed, eggs, peanuts and sunflower and wheat gluten have been incorporated into communited meat product to enhance some functional properties(5,6). Siegel et al.(7) used beef semi-tendinous pieces to test the adhesion properties of various nonmeat proteins and found egg white to exert the strongest binding force in presence of 8% sodium chloride and 2% sodium tripolyphosphate. Chung and Lee(8,9) demonstrated the texture-modifying effect of nonfish protein in surimi gel. Because of its being less expensive and comparable to texture-modifying properties of egg white, wheat gluten is currently one of the main protein ingredients used in surimi-based analog products as well as meat based gel products.

In this study, three different wheat glutens were evaluated along with modified wheat starch for their texture-modifying and freeze-thaw stabilizing properties in surimi-based products. The effect of different incorporation techniques of gluten and modified starch was also evaluated.

MATERIALS AND METHODS

Frozen Alaska pollock(*Theragra chalogramma*) surimi obtained from the Alaska Fisheries Development Foundation(Anchorage, AK) was used in this study. Partially thawed surimi block was chopped in a silent cutter for 10 min with addition of 1.5% salt, ingredients(wheat gluten and starch) and an appropriate amount of water to adjust the moisture level to 78%. All ingredients were added on a surimi weight basis. Ingredients used were three different gluten and starches. They included Gluten-1(IWGA composite gluten) from Ogilvie Mill (Minnetonka, MN. USA), and modified potato starch

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from Avebe(Princeton, NJ., USA), Gluten-2(Flash-Dried gluten) and Gluten-3(Flovor Pro-200 gluten) and modified wheat starch from the Midwest Grain Products(Atchison, KS., USA). Some part of resulting paste was extrude into a sheet and partially heat-set for 2min at 100°C, and fiberized to run sensory evaluation and shear test. The rest of the paste was stuffed into a 25mm diameter cellulose casing. Fiberized and casing-molded samples were cooked at 90°C for 15min and 20min, respectively, in a steam cooker. The fiberized sample was cooled and kept in a refrigerator, while the casing-molded sample was cooled down in the running cold water for 10min and kept overnight at room temperature prior to the evaluation of the textural properties.

Measurement of textural properties of samples

For the casing-molded sample, compressive force, penetration force and expressible moisture were evaluated as textural parameters using an Instron testing machine(Model 1122, Instron Corp., Canton, MA, USA) following the procedure proposed by Lee and Chung (10). For all tests, cylindrical samples(25mm width, 25 mm length) were used. Compressive force was measured as an index of gel cohesiveness at 90% deformation with failure using a 10cm diameter compression head. At the same time, the amount of moisture expressed upon compression was measured by collecting the fluid on three layers of filter paper. The amount of expressible moisture(5) of gel was then calculated by comparing the amount of water absorbed by the filter paper and total moisture content of gel. Penetration force at 90% deformation was measured as an index of firmness using a 5mm diameter plunger with spherical end.

For the fiberized sample, shear test was conducted. In the shear test a fiberized sample was sheared longitudinally by descending flat blade(1mm thickness) while the sample rested on a stationary plate.

Sensory evaluation of fiberized products

Sensory evaluation of the textural properties of the fiberized surimi gel product was conducted by a group of 12 panelists. The textural characteristics evaluated were firmness, rubberiness, chewiness, moistness and overall texture acceptability. The panel was composed of graduate students and faculty of the department who had a prior experience in evaluating the quality of surimi gel products. The panelists were asked to score the intensity and desirability of textural characteristics on a 9-point scale.

Microscopic analysis of the dispersion pattern

The morphological changes(size and shape) and dispersion patterns of gluten and modified starch in the surimi gel were examined under a light microscope.

To examine the structure, a 4mm thick specimen was frozen in liquid nitrogen and cut into 16μm thick sections using a microtome cryostat(Model 3398, Damon/Ice Minotom, Needham Heights, MA., USA). The specimen was stained with hematoxyline for 20 min after hydrating the sample with 60% isopropanol for few seconds, and excess stain were rinsed off with water. Stained samples containing starch were placed at the chamber saturated with iodine vapor. The stained and dried samples were examined under a light microscope.

Analysis of data

The Statistical Analysis System(11) was used to determine the significance of variations in the textural properties of various ingredients in the surimi gel system. Correlation coefficients were used to determine relationship among textural parameter.

RESULTS AND DISCUSSION

Comparison of three different wheat gluten for their texture-modifying effect in surimi gel

The addition of wheat gluten significantly reduced the gel strength(compressive and penetration force) and expressible moisture(increased water binding) of molded surimi gel products(Table 1). The decreased gel strength of gluten-incorporated surimi gel is believed to be due to the combination of a reduced amount of myofibrillar protein and interference of gluten in gelation of myofibrillar protein(8,9). Between gluten-incorporated gels, the gels containing Gluten-2(Flash-dried) and Gluten-3(Flavor pro-200) showed slightly lower gel strength(significant for compressive force; insignificant for penetration force) than the one with Gluten-1(Ogilvie), except that the gel with Gluten-3 showed significantly lower penetration force than the one with Gluten-1. After 2 freeze-thaw cycles, penetration, shear force and expressible moisture of gels increased due to freeze syneresis. The increased ex-

Table 1. Comparison of textural properties among different gluten(2%)-incorporated surimi gel products(molded) determined by Instron testing machine

Glutens	Compressive force(kg)		Penetration force(g)		Shear force(g)		Expressible moisture(%)	
	Freeze-thaw cycle							
	0	2	0	2	0	2	0	2
Control	62.6[a]	42.3[a]	370[a]	383.3[a]	643[a]	900[a]	0.65[a]	1.29[a]
Gluten-1	37.3[b]	30.8[b]	313[b]	346.3[b]	560[b]	620[b]	0.62[a]	1.08[a]
Gluten-2	31.3[c]	31.0[b]	303[b]	326.7[c]	470[c]	680[b]	0.45[b]	1.38[b]
Gluten-3	32.3[c]	26.7[c]	273[c]	303.3[d]	450[c]	633[b]	0.46[b]	1.54[b]

Gluten-1: Iwga composite, Gluten-2: Flash-dried, Gluten-3: Flavor Pro-200
Means with different superscripts within the same column are significantly different($p<0.05$)

Table 2. Comparison of textural properties among different gluten-incorporated surimi gel products(fiberized) determined by sensory evaluation

Glutens	Firmness	Chewiness	Rubberness	Moistness	Overall texture
	Freeze-thaw cycle				
Intensity (desirability)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	(0/2)
Control	7.3/7.6 (8.0/5.3)	7.3/7.6 (8.0/5.3)	7.3/7.8 (7.5/5.3)	5.8/5.3 (7.3/6.5)	(7.8[a]/5.0[a])
Gluten-1	6.5/6.8 (7.0/7.0)	6.0/6.8 (6.6/7.0)	6.5/6.8 (7.1/6.5)	5.5/5.8 (6.9/7.0)	(7.0[a]/6.8[b])
Gluten-2	6.0/5.8 (7.4/6.5)	6.1/5.8 (7.1/6.5)	6 3/5.8 (7.1/6.6)	6.0/6.0 (7.3/7.0)	(7.0[a]/6.8[b])
Gluten-3	5.6/4.5 (6.5/5.1)	5.6/4.8 (6.5/5.1)	5.8/4.5 (6.5/5.0)	6.7/5.3 (7.5/5.8)	(6.5[b]/5.1[a])

Gluten-1: Iwga composite, Gluten-2: Flash-dried, Gluten-3: Flavor Pro-200
Means with different superscripts within the same column are significantly different($p<0.05$)

Table 3. Effect of modified starches on textural properties and freeze-thaw stability of surimi gel products(molded) determined by Instron testing machine

Starches	Compressive force(kg)		Penetration force(g)		Shear force(g)		Expressible moisture(%)	
	Freeze-thaw cycle							
	0	2	0	2	0	2	0	2
Control	63.7[a]	27.0[a]	397[a]	353[a]	550[a]	1007[a]	0.56[a]	1.25[a]
Potato	57.7[b]	36.0[b]	330[b]	333[b]	530[b]	670[b]	0.45[b]	0.87[b]
Wheat	40.0[c]	32.3[b]	303[c]	277[c]	463[c]	500[c]	0.45[b]	0.73[c]

Modified starches were added at 6% level
Means with different superscripts within the same column are significantly different($p<0.05$)

pressible moisture after freezing reflected the increase in shear force as an indication of a tough, rubbery texture development. However, the extent of such increase in expressible moisture and shear force was significantly less with gels prepared with wheat gluten than that without gluten. This explains why the gluten-incorporated gels received significantly higher score than the one without gluten(Table 2). The sensory analysis of fiberized samples revealed that Gluten-1 and 2 samples received higher desirability scores than Gluten-3 sample because the Gluten-3 sample was softer and less elastic than Gluten-1 and 2 samples.

Freeze-thaw stabilizing and texture-modifying effect of modified starches in surimi-based products

Table 3 showed the textural properties and freeze-thaw stability of molded and fiberized products which were measured with an Instron testing machine. The

Table 4. Effect of modified starches on textural properties and freeze-thaw stability of surimi gel products(fiberized) determined by sensory evaluation

Starchs	Firmness	Chewiness	Rubberiness	Moistness	Overall texture
	Freeze-thaw cycle				
Intensity (desirability)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	(0/2)
Control	6.3/7.3 (6.8/6.5)	6.3/7.7 (6.8/6.3)	6.0/7.7 (7.3/6.0)	5.5/5.7 (6.8/7.0)	($7.0^a/6.3^a$)
Mod-potato	6.5/6.3 (6.9/6.7)	6.8/6.3 (6.9/6.7)	6.0/6.2 (7.3/6.7)	5.0/6.7 (6.6/7.3)	($6.8^a/6.7^A$)
Mod-wheat	6.3/6.8 (6.5/7.5)	6.0/6.8 (6.5/7.5)	5.6/6.7 (7.0/7.3)	5.5/6.3 (6.6/7.3)	($6.6^a/7.3^b$)

Modified starches were added at 6% level
Means with different superscripts within the same column are significantly diffferent($p<0.05$)

Table 5. Comparison of modified starches(4%) for their effect on textural properties of 2% wheat gluten-incorporated surimi gel products(molded)

Samples	Compressive force(kg)		Penetration force(g)		Shear force(g) (fiberized)		Expressible moisture(%)	
	Freeze-thaw cycle							
	0	2	0	2	0	2	0	2
Control	63.7	27.0	397	353	550	1007	0.56	1.15
G-mp-1	50.4	35.3	337	370	510	700	0.57	1.10
G-mp-2	41.7	27.7	327	340	407	477	0.5	1.09
G-mw	32.7	20.7	297	263	347	530	0.6	0.76

G-mp-1: Iwga composite, G-mp-2: Flavor Pro-200 gluten+modified potato starch, G-mw: Flavor Pro-200 gluten+modified wheat starch

addition of modified starch at a 6% level significantly reduced gel strength(compressive and penetration force). However, after 2 freeze-thaw cycles, the samples prepared with modified starch remained more cohesive and less rubbery than the control as shown by higher compressive force. The lower shear force and expressible moisture indicate that modified starch effectively improved freeze-thaw stability, where modified wheat starch(hydroxypropylated) performed slightly better than modified potato starch(hydroxypropylated). A similar result was observed by Kim and Lee(12). The above Instron data support the result of the sensory analysis that after 2 freeze-thaw cycles, the overall texture desirability of fiberized samples with modified starch was better than that of the control, where the sample with modified wheat starch received the highest desirability score because of its being moderately firm and elastic (Table 4).

Comparison of modified starches for their effects on the textural properties and freeze-thaw stability of gluten-incorporated surimi gel products

When Gluten-3 was compared with Gluten-1 for their texture-modifying and freeze-thaw stabilizing effects in the presence of 4% modified potato starch, it produced a weaker gel(reduced compressive and penetration force, Table 5), but after 2 freeze-thaw cycles, it received the same desirability score as the Gluten-1(Table 6). On the other hand, when modified wheat starch was used in place of modified potato starch, the texture became soft and thus the overall desirability decreased although the freeze-thaw stability of the gel was significantly better than those with modified potato starch.

Effect of different incorporation techniques of wheat gluten and modified wheat starch

G-MW-1 is our conventional chopping method in which surimi is chopped for 3min with 1.5% of salt, followed by the addition of gluten and starch with an 1min interval. G-mw-2 is a method in which gluten and starch are incorporated together after being preblended. Results revealed that incorporation of preblended gluten and starch significantly reduced gel strength(Table 7). Modified wheat starch contributed to a good freeze-thaw stability in gluten-incorporated surimi-based product

Table 6. Comparison of modified starches(4%) for their effect on textural properties of 2% wheat gluten-incorporated surimi gel products(molded)

Samples	Firmness	Chewiness	Rubberiness	Moistness	Overall texture
	Freeze-thaw cycle				
Intensity (desirability)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)
Control	6.7/7.7 (7.8/6.2)	6.7/7.7 (7.8/6.2)	6.7/7.7 (7.8/6.0)	5.6/5.7 (7.3/7.0)	(7.7/6.0)
G-mp-1	6.3/6.5 (7.0/7.2)	6.3/5.8 (6.8/7.0)	6.3/6.5 (6.8/7.0)	5.3/5.7 (6.7/7.0)	(7.0/7.0)
G-mp-2	6.2/6.7 (6.8/7.0)	5.8/6.0 (5.8/6.8)	5.3/6.0 (6.7/6.8)	5.5/5.7 (6.8/7.0)	(6.7/7.0)
G-mw	5.5/5.5 (6.3/6.5)	5.3/5.2 (6.0/6.5)	4.8/5.5 (6.0/6.5)	5.5/6.0 (6.8/7.3)	(6.1/6.5)

G-mp-1: Iwga composite, G-mp-2: Flavor Pro-200 gluten+modified potato starch, G-mw: Flavor Pro-200 gluten+modified wheat starch.

Table 7. Effect of the manner of incorporation of wheat gluten and modified wheat starch on textural properties of surimi gel products(molded) determined by Instron testing machine

Mixing techniques	Compressive force(kg)		Penetration force(g)		Shear force(g)		Expressible moisture(%)	
	Freeze-thaw cycle							
	0	2	0	2	0	2	0	2
Control	62.6	42.3	370	383	643	900	0.65	1.29
Gluten-1	49.3	30.7	373	376	500	627	0.47	1.47
G-mw-1	50.3	30.0	413	273	380	500	0.49	0.62
G-mw-2	33.0	22.7	333	243	320	367	0.46	0.59
Mw-g	49.2		407		395		0.56	

Gluten-1: Flavor Pro-200 gluten, G-mw-1: Flavor gluten+modified wheat starch(conventional method), G-mw-2: Flavor Pro-200 gluten+modified wheat starch.(preblend), Mw-g: Modified wheat starch+Flavor Pro-200

Table 8. Effect of the manner of incorporation of wheat gluten and modified wheat starch textural properties of surimi gel products(fiberized) determined by sensory evaluation

Mixing techniques	Firmness	Chewiness	Rubberiness	Moistness	Overall texture
	Freeze-thaw cycle				
Intensity (desirability)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	0/2 (0/2)	(0/2)
Control	7.0/8.0 (8 0/5.3)	7.0/8.0 (8.0/5.3)	7.0/8.0 (8.0/5.3)	5.7/6.0 (7.7/7.3)	(7.7/4.7)
Gluten	6.2/6.2 (7 7/7.5)	6.2/6.3 (7.5/7 5)	6.2/6.2 (7.7/7.5)	5.7/6.0 (7.7/7.3)	(6.5/7.3)
G-mw-1	5.3/6.5 (6.7/7.2)	5.3/6.5 (6.7/7.2)	5.3/6.5 (6.7/7 2)	5.7/6.0 (6.7/7.2)	(6.7/7.2)
G-mw-2	4.0/6.0 (5.5/7.7)	4.0/6.0 (5.5/7.7)	4.0/6.0 (5.5/7.6)	5.7/6.0 (7.3/7.3)	(5.5/7.5)
Mw-g	5.2 (5.5)	5.3 (5.8)	5.2 (5.8)	5.8 (7.3)	(5.8)

Gluten-1: Flavor Pro-200 gluten, G-mw-1: Flavor Pro-200 gluten+modified wheat starch(conventional method), G-mw-2: Flavor Pro-200 gluten+modified wheat starch(preblend), Mw-g: Modified wheat starch+Flavor Pro-200

regardless of incorporation techniques as indicated by insignificant changes in amount of expressible moisture of samples prepared by G-MW-1 and G-MW-2 techniques after 2 freeze-thaw cycles. This can be partly

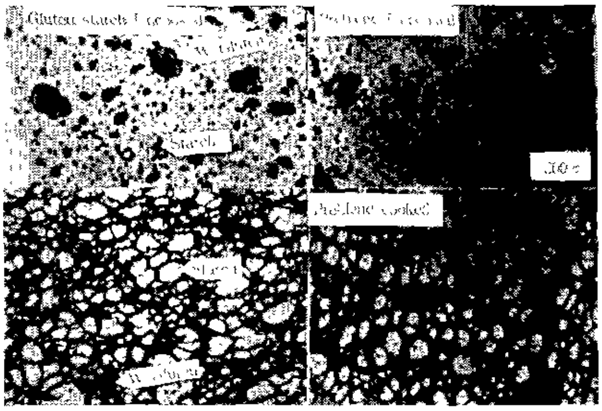

Fig. 1. Comparison of incorporation method on dispersion and development of wheat gluten and starch swelling.

explained by the difference in the extent of starch swelling shown in Fig. 1 where the swelling of starch was relatively restricted when added together with wheat gluten than when added separately. The greater gel strength resulting from G-MW-1 could be due to initial dispersion and favorable interaction of wheat gluten with myofibrillar protein in surimi before starch being incorporated. After 2 freeze-thaw cycles, however, there were no significant differences in sensory properties and the overall desirability between incorporation after preblending(G-MW-2) and conventional technique(G-MW-1)(Table 8). It was interesting to note that the result was not affected by reversing the order of incorporation(MW-G-1) so long as they were incorporated apart(Table 7).

CONCLUSIONS

The addition of wheat gluten reduced the gel strength of surimi, but after freeze-thaw it significantly improved freeze-thaw stability by reducing freeze-thaw expressible moisture and also by preventing rubbery texture development.

Surimi gel which is incorporated with Gluten-2 yielded a gel with a firmer, chewier and elastic texture and higher desirability score than that with Gluten-3 both before and after frozen storage.

When compared to Gluten-1, both Gluten-2 and 3 appear to be less functional in forming a cohesive gel as indicated by lower compressive and penetration force and higher expressible moisture after 2 freeze-thaw cycles.

Surimi gel prepared with modified wheat starch made a gel softer, but better performed in keeping freeze-thaw wheat starch made a gel softer, but better performed in keeping freeze-thaw expressible moisture low, and received a significantly higher desirability score than the one with modified potato starch.

The incorporation of preblended mixture of wheat gluten and starch resulted in a significantly softer texture as so in desirability score. This was a result of the competition for moisture between gluten and starch which limited the moisture available for starch swelling.

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