EFFECTS OF SUBSTITUTION OF SPENT LAYING HEN MEAT ON THE QUALITY CHARACTERISTICS OF IMITATION CRAB STICKS DURING STORAGE

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Abstract— **Imitation crab stick (ICS) samples were divided into four treatments, a control (C) prepared with Alaska Pollack as a commercial ICS, T1, which consisted of Alaska Pollack with spent laying hen surimi collected by the pH adjust method, T2, which was composed of Alaska Pollack with spent laying hen surimi collected by the filter cake method, and T3, which consisted of Alaska Pollack with whole spent laying hen meat batter collected by the cutting method. The lightness (L*) and whiteness (W) was higher in the control than in the other ICS samples at 0 days of storage, whereas the yellowness (b*) was significantly higher in T3 than in the other ICS samples. Additionally, the pH increased with storage time in the spent laying hen substituted samples (T1, T2 and T3), with T1 showing a significantly higher pH during storage. The TBARS value increased with storage time in all ICS samples, with T2 showing a significantly lower TBARS value than the other ICS samples at the beginning and end of the storage periods. There was no significant difference in any sensory evaluation items among the ICS samples during storage.**

Index Terms— **Imitation crab stick; Spent laying hen; Alaska Pollack; Gel characteristics**

I. INTRODUCTION

Surimi, which is the stabilized myofibrillar protein that is obtained from mechanically deboned fish flesh, is washed, mixed with cryoprotectans, and stored frozen until used as a raw material for production of a great variety of products (Sanchez-Gonzalez et al., 2008). Usually, surimi based foods are the primary ingredient used to create imitation crab meat and surimi is primarily composed of myofibrillar proteins. Therefore, imitation crab meat can be made using a myofibrillar protein of other species such as pork, beef or chicken (Jin et al., 2009). To date, several studies have been conducted to evaluate the development of surimi based products made from beef, pork, sheep and chicken. The application of surimi technology in the production of surimi based products from other species could provide a new approach toward increasing its value and utilization. For example, spent laying hens may be a good source of surimi base product because their meat is very cheap and the use of spent laying hens would improve the utilization of this waste resource. Thus, this study was conducted to develop ICS containing spent laying hens breast meat and to investigate the effects of substitution of spent laying hens for Alaska Pollack on quality characteristics of ICS during storage.

II. MATERIALS AND METHODS

ICS samples were divided into four treatments, a control (C) composed of commercial ICS containing no spent laying hen meat, T1, which consisted of ICS containing 7.92% spent laying hen myofibrilla protein collected by the pH adjust method, T2, which consisted of ICS containing 7.92% spent laying hen myofibrilla protein collected by the filter cake method and T3, which was ICS containing 7.92% whole spent laying hen meat batter collected by the cutting method.

III. RESULTS AND DISCUSSION

Meat color: The lightness (L*) and whiteness (W) were higher in the control than the other ICS samples at 0 days of storage, whereas the yellowness (b*) was significantly higher in T3 than in the other ICS samples until 4 weeks of storage. However, the myoglobin (Mb) did not differ among the ICS samples during storage periods. Ochiai et al. (2001) suggested that high-quality surimi with higher whiteness can be obtained when as much dark muscle is removed as possible, and that a low myoglobin content was better than a high myoglobin content for surimi quality. Thus, the washing process is necessary for color improvement and gel strengthening of surimi produced from whole muscle (Chaijan et al., 2004). In the present study, T3 showed significantly lower lightness and whiteness during storage, although the Mb content did not differ significantly among ICS samples during storage. These findings may have occurred because the T3 sample contained fine minced whole chicken breast meat batter and there was no washing step during the preparation of T3.

Table 1. Changes of color in imitation crab stick during cold storage

Items	Treatments[1)]	Storage (weeks)			
		0	2	4	6
L^*	C	79.00±0.83^{Aa}	77.55±0.14^{b}	77.12±0.72^{b}	79.36±0.22^{Aa}
	T1	77.07±0.71^{B}	77.28±0.28	77.28±0.13	77.47±0.14^{B}
	T2	76.95±0.49^{B}	76.77±0.51	77.08±0.62	78.01±0.54^{B}
	T3	77.30±0.26^{B}	77.35±0.49	77.06±0.49	77.85±0.26^{B}
a^*	C	-1.51±0.11^{b}	-1.34±0.06^{Ba}	-1.21±0.12^{a}	-1.60±0.05^{Bb}
	T1	-0.40±1.54	-0.62±0.43^{A}	-1.03±0.22	-0.70±0.30^{A}
	T2	-1.44±0.23^{b}	-1.23±0.02^{Bab}	-1.19±0.05^{a}	-1.70±0.10^{Bc}
	T3	-0.45±1.51	-1.00±0.12^{AB}	-1.03±0.17	-1.46±0.09^{B}
b^*	C	8.07±0.17^{Bb}	7.37±0.18^{Cc}	7.46±0.17^{BCc}	9.53±0.09^{Aa}
	T1	8.32±0.04^{Ba}	7.73±0.07^{Bb}	7.71±0.07^{Bb}	7.87±0.23^{Cb}
	T2	7.56±0.18^{Ca}	7.10±0.15^{Db}	7.06±0.18^{Cb}	7.53±0.08^{Ca}
	T3	8.59±0.12^{A}	8.25±0.07^{A}	8.37±0.42^{A}	8.59±0.26^{B}
W	C	54.80±0.32^{Aa}	55.43±0.42^{Aa}	54.73±0.66^{Ba}	50.76±0.31^{Db}
	T1	52.11±0.78^{Bb}	54.08±0.50^{Ba}	54.15±0.31^{Ba}	53.85±0.72^{Ba}
	T2	54.27±0.29^{Ab}	55.46±0.73^{Aa}	55.89±0.32^{Aa}	55.41±0.46^{Aa}
	T3	51.53±0.29^{B}	52.59±0.40^{C}	51.94±0.77^{C}	52.09±0.79^{C}
Mb (mg/g)	C	0.39±0.01	0.40±0.01	0.39±0.00	0.39±0.01
	T1	0.39±0.01	0.39±0.01	0.39±0.00	0.39±0.01
	T2	0.39±0.00	0.39±0.01	0.39±0.01	0.38±0.01
	T3	0.39±0.00	0.38±0.02	0.39±0.00	0.39±0.00

$^{A\text{-}C}$ Means with different superscript in the same column significantly differ at $p<0.05$. $^{a\text{-}c}$ Means with different superscript in the same row significantly differ at $p<0.05$.

Gel characteristics: The gel characteristics did not differ significantly among the ICS samples at the beginning of the storage period and there were consistent trends in these characteristics observed among ICS samples. Usually, high pH, high protein content and low water content are closely related to the high water-holding capacity and shear force in meats (Jin et al., 2007). However, gel characteristics were not influenced by substitution of spent laying hens for Alaska Pollack in the present study.

Table 2. Changes of gel characteristics in imitation crab stick during cold storage

Items	Treatments[1)]	Storage (weeks)			
		0	2	4	6
Breaking force (g)	C	137.33±8.74^{b}	187.33±4.04^{a}	160.67±14.01^{Bab}	169.67±22.50^{a}
	T1	155.67±12.90	178.00±13.89	174.67±2.52^{AB}	158.67±20.82
	T2	140.00±5.00^{c}	170.00±15.00^{b}	192.00±10.00^{Aa}	175.00±5.00^{ab}
	T3	143.00±5.29^{b}	171.33±9.02^{a}	159.67±15.04^{Bab}	155.33±7.64^{ab}
Deformation (mm)	C	9.59±1.45^{b}	6.51±0.35^{Cc}	6.52±0.21^{Dc}	13.18±0.46^{Aa}
	T1	8.74±1.78	10.79±0.26^{A}	10.22±0.45^{C}	9.79±0.65^{C}
	T2	10.34±1.65^{a}	8.64±0.36^{Bb}	11.71±0.51^{Ba}	10.87±0.28^{Ba}
	T3	9.37±0.88^{b}	10.24±0.20^{Ab}	13.01±0.23^{Aa}	5.32±0.08^{Dc}
Gel strength (g/cm^2)	C	700.68±44.57^{b}	955.78±20.62^{a}	819.73±71.49^{Bab}	865.65±114.80^{a}
	T1	794.22±65.80	908.16±70.88	891.16±12.84^{AB}	809.52±106.21
	T2	714.29±25.51^{c}	867.35±76.53^{b}	979.59±51.02^{Aa}	892.86±25.51^{ab}
	T3	729.59±27.00^{b}	874.15±46.01^{a}	814.63±76.76^{Bab}	792.52±38.97^{ab}
Jelly strength (g*mm)	C	130.88±11.99^{b}	121.87±6.66^{Cb}	106.22±8.14^{Cb}	223.33±25.56^{Aa}
	T1	134.57±18.19^{c}	192.00±14.66^{Aa}	178.53±7.01^{Bab}	154.47±10.29^{Cbc}
	T2	145.23±27.13^{c}	147.13±17.50^{Bc}	224.79±4.83^{Aa}	190.33±8.94^{Bb}
	T3	133.74±7.71^{c}	175.51±11.39^{Ab}	207.80±21.89^{Aa}	82.72±5.02^{Dd}
Shear force (kg/cm^2)	C	1.04±0.01^{c}	1.21±0.10^{Cb}	1.79±0.13^{Aa}	1.11±0.02^{Bbc}
	T1	1.20±0.10^{c}	1.68±0.16^{Aa}	1.43±0.04^{BCb}	1.11±0.02^{Bc}
	T2	1.19±0.05^{b}	1.28±0.02^{BCa}	1.32±0.03^{Ca}	1.12±0.02^{Bc}
	T3	1.17±0.06^{b}	1.45±0.08^{Ba}	1.50±0.02^{Ba}	1.46±0.03^{Aa}

$^{A\text{-}D}$ Means with different superscript in the same column significantly differ at $p<0.05$. $^{a\text{-}d}$ Means with different superscript in the same row significantly differ at $p<0.05$.

pH, TBARS and VBN: The pH increased with storage periods in T1, T2 and T3, with T1 having a significantly higher pH during storage and C having a significantly pH. Usually, a high pH is closely related to a high shear force or gel strength in meat products. However, pH was found to have no effect on the shear force and gel strength in any ICS samples in the present study. Thus, we assumed that the changes in pH may have been influenced by substitution methods, but that they were likely not influenced by physico-chemical characteristics in the ICS samples. The TBARS value increased with storage periods in all ICS samples, with T2 showing a significantly lower TBARS value than the other ICS samples at the beginning and end of the storage periods. The VBN value was not significantly different during storage in all ICS samples. Lipid oxidation induces the formation of an array of products, which leads to a direct or indirect decrease in the sensory quality of the meat products. Ahn et al. (1993) reported that the differences in fat content, fatty acid compositions and the classes of lipids had significant effects on lipid oxidation only when oxygen had free access to the stored meat products. However, the lipid oxidation value (TBARS) was not influenced by lipid contents and fatty acid compositions in the present study. Moreover, the protein degradation value (VBN) was not influenced by the substitution methods or storage periods. These findings indicate that the shelf-life of the ICS samples is not influenced by substitution of spent laying hen meat for Alaska Pollack.

Table 3. Changes of pH, TBARS and VBN in imitation crab stick during cold storage

Items	Treatments[1)]	Storage (weeks)			
		0	2	4	6
pH	C	7.28±0.03^{C}	7.42±0.07^{B}	7.33±0.07^{C}	7.13±0.30^{C}
	T1	7.68±0.02^{Ac}	7.82±0.03^{Ab}	7.89±0.03^{Aa}	7.93±0.03^{Aa}
	T2	7.35±0.01^{Bd}	7.44±0.01^{Bc}	7.50±0.02^{Bb}	7.54±0.03^{Ba}
	T3	7.36±0.01^{Bd}	7.39±0.00^{Bc}	7.44±0.01^{Bb}	7.50±0.03^{Ba}
TBARS (mg/100g)	C	0.64±0.02^{Ac}	0.58±0.01^{c}	0.73±0.05^{b}	1.60±0.13^{a}
	T1	0.55±0.03^{Bc}	0.59±0.05^{c}	0.72±0.04^{b}	1.61±0.12^{a}
	T2	0.64±0.04^{Ac}	0.58±0.01^{c}	0.78±0.02^{b}	1.56±0.06^{a}
	T3	0.61±0.01^{Ac}	0.58±0.02^{c}	0.72±0.04^{b}	1.50±0.05^{a}
VBN (mg%)	C	2.38±0.59	5.79±1.69	5.09±1.82	8.31±3.15
	T1	3.45±1.59	4.76±0.99	6.39±2.10	9.45±3.46
	T2	3.73±0.43^{c}	3.87±0.86^{c}	5.95±0.89^{b}	8.72±1.38^{a}
	T3	4.01±0.32^{b}	4.57±1.70^{b}	7.65±0.89^{a}	7.42±0.28^{a}

$^{A\text{-}D}$ Means with different superscript in the same column significantly differ at $p<0.05$. $^{a\text{-}d}$ Means with different superscript in the same row significantly differ at $p<0.05$.

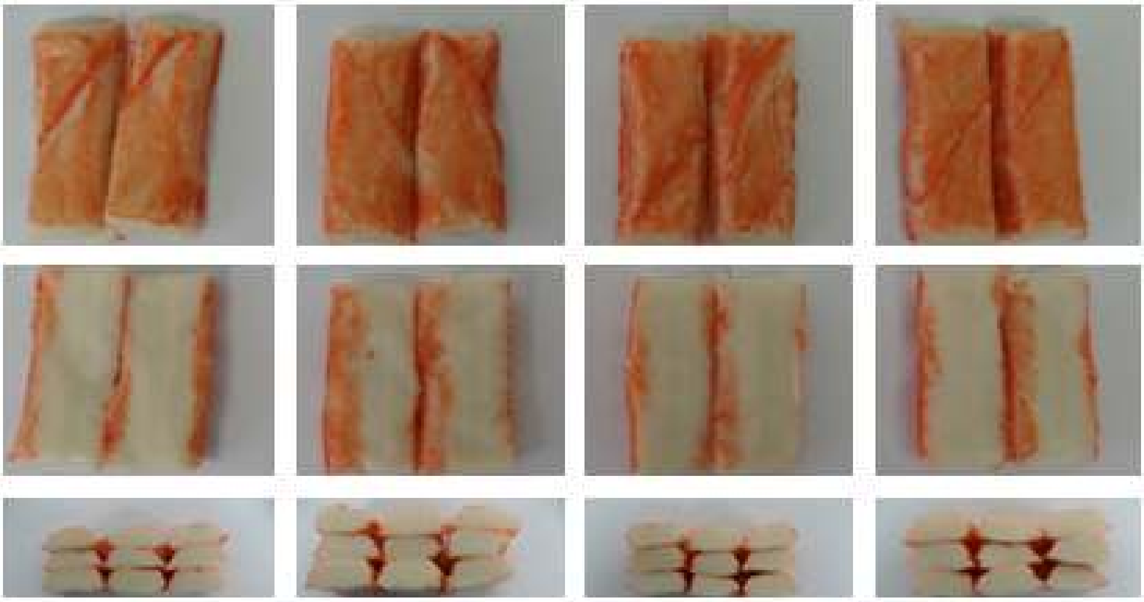
Sensory evaluation: The color, aroma, tenderness and juiciness decreased after 2 weeks of storage; however, none of the sensory evaluation items differed significantly among the ICS samples during storage. Especially, the overall acceptability did not differ significantly among ICS samples. In the present study, we found that the color determined by the sensory panels was not different among the ICS samples moreover color of final products (Figure 1) also seems to be the same although mechanical color was different among the ICS samples. These results indicated that the substitution of laying hen meat batter (T3) for Alaska Pollack is a very useful method for production of ICS because it enables a simple production process that does not require myofibrilla protein recovery steps such as washing or pH adjustments. Thus, the substitution of spent laying hen meat batter for Alaska Pollack would be useful from the point of view of the ICS manufacturing procedure or reduction of the waste water.

Table 4. Changes of sensory evaluation in imitation crab stick during cold storage

Items	Treatments[1)]	Storage (weeks)			
		0	2	4	6
Color	C	8.14[2)]±0.38^{a}	7.14±0.38^{b}	6.71±0.70^{b}	7.20±0.27^{b}
	T1	8.07±0.35^{a}	6.79±0.49^{b}	6.71±1.22^{b}	6.90±0.55^{b}
	T2	8.00±0.00^{a}	6.86±0.56^{b}	6.64±0.99^{b}	7.20±0.27^{b}
	T3	8.00±0.00^{a}	6.43±0.73^{b}	6.64±0.90^{b}	6.70±0.45^{b}
Aroma	C	7.86±0.38^{a}	6.71±0.91^{b}	6.36±1.41^{b}	6.90±0.22^{ab}
	T1	7.79±0.27^{a}	6.64±0.90^{b}	6.36±1.14^{b}	6.90±0.55^{ab}
	T2	8.07±0.61^{a}	6.71±1.04^{b}	6.86±0.99^{b}	7.00±0.50^{b}
	T3	7.86±0.24^{a}	6.86±0.75^{ab}	6.21±1.55^{b}	7.00±0.71^{ab}
Flavor	C	8.07±0.19^{a}	7.43±0.98^{ab}	6.64±1.21^{b}	7.00±0.61^{b}
	T1	7.93±0.35^{a}	7.43±0.93^{ab}	6.71±0.81^{b}	6.80±0.76^{b}
	T2	8.00±0.50	7.21±0.70	6.86±1.31	7.10±0.74
	T3	7.86±0.48	7.29±0.57	6.86±1.31	6.90±0.74
Tenderness	C	8.00±0.50^{a}	7.21±0.64^{ab}	6.43±1.24^{b}	7.50±0.35^{a}

	T1	7.93 ± 0.53^{a}	7.29 ± 0.39^{ab}	6.93 ± 0.89^{b}	7.00 ± 0.35^{b}
	T2	8.21 ± 0.49^{a}	7.00 ± 0.29^{b}	6.86 ± 0.94^{b}	7.20 ± 0.45^{b}
	T3	7.79 ± 0.57^{a}	7.00 ± 0.71^{ab}	6.64 ± 0.85^{b}	7.10 ± 0.42^{ab}
Juiciness	C	8.00 ± 0.50^{a}	6.93 ± 0.53^{b}	6.43 ± 1.17^{b}	7.00 ± 0.50^{b}
	T1	8.00 ± 0.50^{a}	7.14 ± 0.38^{b}	6.64 ± 0.85^{b}	6.80 ± 0.67^{b}
	T2	8.07 ± 0.53^{a}	7.21 ± 0.57^{b}	6.86 ± 0.90^{b}	6.90 ± 0.65^{b}
	T3	7.93 ± 0.53^{a}	7.14 ± 0.38^{b}	6.71 ± 0.81^{b}	6.80 ± 0.57^{b}
Overall acceptability	C	7.86±0.69	7.29±1.22	6.64±1.25	7.20±0.45
	T1	7.64±0.75	7.21±0.81	6.79±0.81	6.90±0.42
	T2	8.00±0.58	7.21±0.49	6.93±1.43	7.20±0.57
	T3	7.64±0.63	7.00±0.41	6.79±1.38	7.00±0.35

[a-c] Means with different superscript in the same row significantly differ at $p<0.05$. [2)] Color (9 = very good and 1 = very bad), aroma (9 = very intense and 1 = very weak), flavor (9 = very good and 1 = very bad), tenderness (9 = very tender and 1 = very though), juiciness (9 = very juiciness and 1 = very dry), overall acceptability (9 = very good and 1 = very bad).



C T1 T2 T3

Figure 1. The picture of the final products

IV. CONCLUSION

In the present study, myofibrilla protein collected from spent laying hens and spent laying hen meat batter were substituted for Alaska Pollack to make an ICS. The results revealed that the quality characteristics were not heavily influenced by substitution of the spent laying hen myofibrilla proteins and spent laying hen meat batter for Alaska Pollack. These findings indicate that ICS can be made by the substitution of spent laying hen myofibrilla protein and spent laying hen meat, regardless of the substitution methods employed.

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