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Full Length Research Paper

Effect of soy protein isolate on quality of light pork sausages containing konjac flour

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The effect of soy protein isolate (SPI) on quality characteristics of light pork sausages (10% fat) containing konjac flour was investigated. Three formulations which replaced for pork meat with SPI ranging 1 to 2% levels were studied for their physical and sensory properties. Incorporation of 2% SPI level significantly increased ($p < 0.05$) moisture content and cooking yield, while decreased purge loss of the sausages in relation to the control. Also, the sausages were less red and more yellow when the addition of SPI was not less than 1.5% level. Sensory results indicated that some quality attributes of light sausages such as juiciness and firmness can be improved by the addition of SPI. Both 2% SPI and control light sausages were darker and firmer and microbiologically safe after storage at 4-5°C for 4 weeks.

Key words: Sausage, Soy protein isolate, low-fat meat products, konjac flour.

INTRODUCTION

With the growing need for products with less fat or calorie content, it becomes necessary to develop meat products that are pertinent to consumer demand. Several studies have demonstrated possible use of food hydrocolloids such as carrageenan, cellulose gum, konjac flour, guar gum and xanthan gum as fat replacements or the use of poultry meat as replacement for red meat in reduced-fat meat products (Troutt, 1992; Chin et al., 1998; Andrès et al., 2006; Bhattacharyya et al., 2007). Konjac flour, a glucomannan polysaccharide gum, has been used as a fat replacer in low-fat prerigor fresh pork sausages (Osburn and Keeton, 1994), low-fat bolognas (Chin et al., 1998), reduced-fat pork sausages (Akesowan, 2002a) and Thai traditional minced and preserved pork products (Moo Yo) (Akesowan, 2002b). Previous study in my laboratory showed the possibility of using 1.5% konjac gel in the production of light pork sausages (10% fat), which retained sensory attributes similar to those of full-fat sausages (28% fat), except for firmness attribute that tended to obtain lower scores (Akesowan, 2002a). This result implied that the textural quality, a key attribute, needed to be improved for better eating quality of the products.

Soy proteins, one of non meat proteins, are widely used as meat binders because of their several functionalities such as water-holding, binding and emulsifying properties (Arrese et al., 1991). They have been incorporated into comminuted meat to improve physical and chemical properties of processed meat products such as frankfurters and ground meat patties (Alvarez et al., 1990). Ahn et al. (1999) has shown that addition of soy proteins resulted in better binding and texturization of sausages. However, beany flavour of soy proteins also limits their expanded applications in foods (Ho et al., 1997). Of all soy protein products, soy protein isolate (SPI) has the mildest flavour and higher protein content (≥ 90%); consequently, it can be used as a meat binder and good soy protein source. In addition, isoflavones, which can be found naturally in soy proteins, has been shown to possess natural antioxidant activity that may combat oxidative degradation that could lead to disease inside the body (Conforti and Davis, 2006). Therefore, the purpose of this study was to determine the effect of SPI on physicochemical and sensory properties of light pork sausages (10% fat) containing konjac flour.

MATERIALS AND METHODS

Materials

Fresh pork meat and fat were obtained from local processors. SPI containing ≥ 90% protein (Vichi Consolidate Co., Thailand), konjac flour and xanthan gum (Thai Food and Chemical Co., Thailand) and analytical grade NaCl, $NaNO_2$ and sodium tripolyphosphate were used. Dry ingredients such as corn flour, sodium caseinate, sugar, pepper and monosodium glutamate were purchased from a local supermarket.

Konjac gel preparation

A 3:1 ratio konjac flour/xanthan gum was used for fat replacement. The 1.5% konjac/xanthan gum solution was heated at 80-85°C until the volume was reduced to 2/3 of origin. The konjac gel was ground through 0.4-cm plate and chilled at 4-5°C for 1 h before processing.

Pork sausages processing

Initially, visible fat was trimmed to provide > 96% lean meat. The 1-kg lean pork meat (2 x 2 x 2 cm^3 cut) was cured with 24 g of nitrite salts ($NaCl:NaNO_2$ = 99.4:0.6) and kept at 4°C for 24 h. The fat was ground once through a 1.7-cm plate and then through a 0.4-cm plate before keeping at -18°C for 24 h.

The processing of light pork sausages made with konjac gel was produced by the method of Akesowan (2002a). The 1-kg cured lean meat was ground through 1.7 and 0.4-cm plates, respectively. The 196 g of pork fat, 349 g of konjac gel and dry ingredients including 50 g of corn flour, 33.25 g of sodium caseinate, 14.5 g of sugar, 12.5 g of pepper, 6.25 g of sodium tripolyphosphate, 2 g of monosodium glutamate and 2.75 g of spice mix were gradually added to ground meat while chopping for 10 min in a meat chopper (Scharfen type Cutter, Witten, West Germany). The batter was allowed to stand at -18°C for 20 min, and then chopped again for 10 min. Cellulose casings (20 mm diameter) were stuffed with meat batter by using a hand-operated stuffer (F. Dick, Edelstahl, Germany) and hand-linked into 10-cm length. After boiling at 80°C for 15 min, the products were cooled down to 10°C and let stand in ambient temperature for 10 min. These links were vacuum packaged (Lapack Model 430, Dlblpack group, Italy) in nylon-polyethylene bags (4 links/bag) and stored at 4-5°C until further analysis.

In SPI added formulation processing, the SPI was replaced for pork meat at the level of 1, 1.5 and 2% based on control formula weight. The SPI was hydrated with distilled water (1:4) for 30 min prior to use.

Proximate analysis

All sausages were homogenized to make the samples for analysis. Moisture, protein and fat were determined according to AOAC (1995) procedures.

Cooking yield

The weight of each sausage was measured before and after cooking to determine cooking yield, which was defined as the cooked weight divided by the uncooked weight then multipied by 100% (Khalil, 2000).

Purge loss

Sausages were determined for the purge loss after storage at 4-5°C for a week. Purge loss was reported as a percentage of content weight according to the method reported by Yang et al. (2001).

Colour

Internal colour of cooked sausages was determined by using a Hunterlab colourimeter (Model D25M, Hunter Associates Laboratory, Reston, VA). Values for L* (lightness), a* (redness) and b* (yellowness) were recorded for 3 samples per batch using a 25 mm aperture.

Texture analysis

The Lloyd texture analyser (Model LRX, Lloyd Instruments, Hampshire, UK) with 25 N load cell and crosshead speed 250 mm/min was used for texture determination. Peak force (N) was determined by shearing cooked sausage samples (2 cm diameter x 10 cm length).

Sensory evaluation

A total of ten judges drawn from the University of the Thai Chamber of Commerce based on participant's interest and discriminative ability was used for the evaluation. Panelists were semitrained before initiation in the experiment. Sensory attributes tested included for internal colour, flavour, juiciness and firmness were evaluated by using a 13-cm unstructured line scale test (Lawless and Heymann, 1998).

Microbiological analysis

After each week (0 to 4 weeks) of storage at 4-5°C, the sausages were analysed for total aerobic plate counts according to procedures outlined in Rehberger et al. (1984).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using Statistical SPSS for Window version 14.0. When ANOVA showed a significant effect at a level of 5%, treatment means were compared using the Duncan's New Multiple Range Test (Cochran and Cox, 1992).

RESULTS AND DISCUSSION

Physicochemical analysis

Physicochemical analysis for light pork sausages with SPI as replacement for pork meat is shown in Table 1. Increasing SPI levels resulted in higher ($p < 0.05$) moisture content, but no differences ($p > 0.05$) were found for protein and fat content among all formulations. In sausage processing, SPI was hydrated in water (1:4) before adding in meat patties, possibly causing high water content in the sausages. The moisture content of formulations was dependent on added SPI levels. There was no significant difference ($p > 0.05$) in pH among all formulations.

When the SPI level used did not exceed 1.5%, there was no significant difference ($p > 0.05$) in cooking yield between added SPI and control sausages (Table 1). As the 2% SPI was incorporated, the sausage showed significantly higher cooking yield ($p < 0.05$). This was probably because of water holding capacity of SPI. Chin et al. (1998) reported that textural modifying ingredients, such as non meat proteins (e.g. SPI) or gums would be added

Table 1. Physicochemical analysis of light pork sausages containing SPI.

Parameter	Light pork sausages			
	0% SPI	1% SPI	1.5% SPI	2% SPI
Chemical composition (%)				
Moisture content	64.49^d	65.24^c	66.54^b	68.18^a
Protein^{ns}	16.69	16.41	16.47	16.19
Fat^{ns}	9.87	10.11	9.03	9.75
pH^{ns}	6.12	6.13	6.24	6.21
Cooking yield (%)	95.31^b	94.86^b	96.13^b	98.74^a
Purge loss (%)	14.43^a	12.18^b	12.59^b	11.82^b
CIE colour scales				
L*^{ns}	45.84	45.96	45.83	45.44
A*	3.98^a	3.73^a	3.22^b	3.01^b
B*	5.94^b	6.32^b	6.91^a	6.83^a
Peak force (N)	**16.98^b**	**16.05^b**	**16.27^b**	**18.03^a**

Means in the same row with different superscripts are different ($p < 0.05$).
CIE colour scales: L* = lightness (0 = black, 100 = white); a* = redness/greenness (+ = red, – = green); b* = yellowness/blueness (+ = yellow , – = blue).
ns = Non significant.

in low-fat meat products to retain added water not to loss during cooking. With respect to purge loss, the 1% SPI sausages showed a decrease in purge loss in relation to the control, but no significant changes (p > 0.05) were found among SPI added formulations. The beneficial effect of SPI on reducing purge loss was similar to that reported by Chin et al. (2000) who found that low-fat bolognas containing 1% SPI had reduced purge loss after processing and during refrigerated storage.

Instrumental (CIE-L*a*b* values) colour determination data are shown in Table 1. No significant difference (p > 0.05) was found for lightness (L* values) in all formulations. The addition of 1.5 and 2% SPI levels significantly decreased (p < 0.05) a* values and increased (p < 0.05) b* values, causing the light sausages to be less red and more yellow in internal colour, while no significant difference (p > 0.05) was found as 1% SPI level used with respect to the control sausage. In related study of Ahn et al. (1999) showed that addition of 1.5% SPI had no effect on L-values, but a decrease in a-values of sausages was occurred. This was probably because of the colour difference of pork meat (red) which would be replaced by SPI (cream). In addition, heat causes the red pigment of the meat to darken due to increased concentration of pigments and surface dehydration (Ahn et al., 1999). However, the 1.5% SPI sausage showed no significant differences (p < 0.05) for redness (a* value) and yellowness (b* value) in relation to those with 2% SPI used.

Results from texture determination, expressed as peak force, indicated that the firmness of the sausages was increased when SPI was added at the 2% level, although 1% SPI, 1.5% SPI and control sausages had similar peak force values. Andrès et al. (2006) found that increasing of whey protein concentration increased cohesiveness of chicken sausages. Similar results were reported by Sofos et al. (1977) working with wiener-type sausages with added texturized soy protein and by Li et al. (1998) when wheat protein was added to the formulation. This was probably due to the water binding property of SPI with liquid component to form a gel-like network to modify the texture of the sausages (Yao et al., 1988).

Sensory evaluation

The results of sensory evaluation in Table 2 shows that there were no significant differences (p > 0.05) for all attributes among 1% SPI, 1.5% SPI and control sausages. When 2% SPI was incorporated, the sausage was significantly darker, juicier and firmer than other formulations, but no significant difference in colour was found between 1.5 and 2% SPI formulations. The addition of SPI may help to improve water binding in light sausages by increasing protein-protein and protein-water interactions (Gregg et al., 1993). Khalil (2000) noted that the inability of meat proteins to bind increased amount of water may decrease textural qualities associated with high added water, low-fat meat products. Thus, fat replacement with konjac gel (high water content) and with an ingredient as SPI led to light pork sausages with improved sensory quality.

Shelf life of products

The changes of colour values were observed in both control (0% SPI) and 2% SPI light pork sausages over storage time, as evidence in Table 3. There was a decline

Table 2. Sensory evaluation of light pork sausages containing SPI.

Sensory attributes	Light pork sausages			
	0% SPI	1% SPI	1.5% SPI	2% SPI
Colour	4.84[b]	5.39[b]	5.95[ab]	6.18[a]
Flavour[ns]	5.73	5.44	5.35	5.06
Juiciness	5.12[b]	4.97[b]	5.45[b]	6.07[a]
Firmness	6.47[b]	6.66[b]	6.78[b]	7.04[a]

Means in the same row with different superscripts are different ($p < 0.05$).
Based on a 13-cm unstructured line scale test (1 = extremely low, 10 = extremely strong).

Table 3. Colour values and peak forces of light pork sausages containing SPI during storage at 4 - 5°C for 4 weeks.

Characteristics	Storage time (week)				
	0	1	2	3	4
0% SPI light pork sausage					
CIE colour scales					
L*	45.85[a]	45.88[a]	45.76[a]	44.72[b]	43.12[b]
a*	2.93[c]	3.58[b]	3.85[ab]	4.38[a]	3.88[ab]
b*	6.54[a]	6.59[a]	6.53[a]	5.46[a]	5.11[b]
Peak force (N)	15.36[b]	15.72[b]	17.74[ab]	18.52[a]	18.93[a]
Total aerobic count (log CFU/g)	1.85[d]	2.32[cd]	3.41[c]	5.75[b]	6.74[a]
2% SPI light pork sausage					
CIE colour scales					
L*	45.80[a]	46.18[a]	46.03[a]	44.81[b]	44.27[b]
a*	2.85[c]	3.09[b]	3.09[b]	3.23[ab]	3.74[a]
b*	7.03[a]	7.14[a]	7.06[a]	6.29[b]	5.81[c]
Peak force (N)	14.59[b]	15.74[ab]	16.92[a]	17.67[a]	17.89[a]
Total aerobic count (log CFU/g)	1.63[c]	1.86[c]	2.10[c]	5.15[b]	5.88[a]

Means in the same row with different superscripts are different ($p < 0.05$).
CIE colour scales: L* = lightness (0 = black, 100 = white); a* = redness/greenness (+ = red, – = green); b* = yellowness/blueness (+ = yellow , – = blue).

($p < 0.05$) in L* and b* values, but increase ($p < 0.05$) in a* values of both formulations, indicating that internal colour of the sausages became darker. This could be attributed to the lipid oxidation, which produces a malonaldehyde that enhances meat discoloration (Park et al., 1993). In addition, the brown pigment occurred may result from light and oxygen, due to the light splits the nitric oxide from the heme of the myoglobin and it is oxidized by the air to cause the brown pigment (Gregg et al., 1993). With respect to lower meat content, internal colour of 2% SPI sausage was lighter than that of the control after the fourth week of storage.

There was significant increase ($p < 0.05$) in peak forces of both sausages as shown in Table 3, indicating that firmer textures were obtained after storage. This trend was attributed to the change of the gel/emulsion matrix which increases in binding strength of the protein-protein and protein-water interactions, resulting in releasing of some water from the matrix (Berlitz and Grosch, 1986). However, the 2% SPI sausages had lower increased in peak forces than that of the control, possibly due to the water binding of SPI which retarded water release in the sausages.

As shown in Table 3, total aerobic plate counts in both formulations tended to increase during refrigerated storage. The total number of microorganism of control and 2% SPI sausages at the fourth week of storage were 6.74 and 5.88 log CFU/g; respectively, which were below the typical spoilage level of ~ 7.0 log CFU/g (Osburn and Keeton, 1994). It can be seen that the microbial growth of 2% SPI sausage was lower than that of the control on each week. This was probably due to water binding of SPI.

Conclusion

The quality of light pork sausage containing konjac gel was improved by incorporating 2% SPI levels, which produced a juicy and firm texture. The lower total aerobic counts were also observed for 2% SPI sausages. Better understanding of how the SPI improves textural characteristics of the sausages is required and should be investigated.

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