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QUALITY OF LIGHT PORK SAUSAGES CONTAINING KONJAC FLOUR IMPROVED BY TEXTURIZING INGREDIENTS

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ABSTRACT

Texturizing ingredients including κ-carrageenan, polydextrose, oat bran and corn flour, at 0.5 and 1% addition level, were investigated for quality improvement of light pork sausages made with konjac flour. The addition of polydextrose and oat bran showed significant decreases ($p<0.05$) in cooking loss of the sausages with respect to the control sausage. Whilst, all texturizing ingredients at least 0.5% significantly increased ($p<0.05$) the sausage firmness, in exception of that with 0.5% oat bran. The lowest values for lightness (L^*) and redness (a^*) were observed for the sausage with 1% oat bran; on the contrary, the sausage with 1% κ-carrageenan displayed the highest lightness and yellowness (b^*). Higher sensory scores for firmness and cohesiveness were evident when all texturizing ingredients were applied. The lowest juiciness score was obtained in the light sausage with 1% κ-carrageenan whereas that with polydextrose showed the lowest flavor. However, color scores obtained in all light sausages with texturizing ingredients were significantly lower ($p<0.05$) than the control.

Key words: Konjac flour, sausage processing, low-calorie foods, texturizing ingredient.

INTRODUCTION

Fat in processed meat products performs several functionalities depending on product types. For emulsion-type sausages, fat is in part related to emulsion participation/stability which supports to product texture characteristics and sensory perception. Nevertheless, several studies have been reported on the disadvantage of saturated fat, namely people who consume more largely saturated fat-rich food products usually take a chance to be coronary disease, high blood pressure, obesity and other health problems (Lee and Chin, 2009). With a recommendation for less than 30% calories intake from fat per total calories a day, low-fat meat products have been extensively studied to meet consumer demand (Andrès *et al*., 2006). In the manufacture of low-fat meat products, water, non-meat ingredients, hydrocolloids or gums and dietary fibers are used as fat replacers (Choi *et al.*, 2008). However, the fat reduction in meat products usually causes unpleasant characteristics such as softer or harder texture than the regular, which reduces consumer acceptance. It is therefore a challenge to develop low-fat meat products with retaining good characteristics.

Konjac flour, a neutral polysaccharide consisting of glucose and mannose (2:3) units with β–(1,4)–linkages, has been extensively used as gelling or thickening agents in food processing and as a fat replacer in low-fat meat products (Osburn and Keeton, 1994; Thomas, 1997; Takigami, 2000). In low-fat meat processing, a heat-induced konjac/gellan mixed gel prepared as fat analogue can be used to partially replace for fat, but some sensory characteristics such as texture and juiciness need to be improved for better eating quality (Akesowan, 2010). The use of secondary fat replacers or additional texturizing ingredients like hydrocolloids, modified starch, dietary fiber and soy/whey proteins may present some advantages in the light pork sausage containing konjac. Since these ingredients display technological properties by binding a high amount of water, thus solving the sausage texture problem (Tabarestani and Tehrani, 2012). κ-Carrageenan, an anionic polysaccharide extracted from red seaweeds (e.g. *Chondrus crispus*), has an ability to bind water and form a gel after heat treatment. This would be beneficial to increase the water holding capacity of meat batter, which is subjected to cooking loss reduction and texture modification of the light product. In addition, it has been reported that konjac can react with κ-carrageenan to produce a gel; although, the konjac alone does not form a heat-induced gel (Morris, 1998; Takigami, 2000. Oat bran has been extensively used in low-fat products as it provides water holding capacity, dietary fiber, protein, vitamins and minerals required for human health (Kerr *et al*., 2005). It is also of interest for its beneficial to control obesity, hypertension, heart disease and constipation relief (Feng and Xiong, 2002). Polydextrose is a low-calorie, low glycaemic, special carbohydrate with prebiotic properties. It is widely recognized as a dietary fiber which has a low calorie content (1 kcal/g) (Martinez-Cervera *et al.*, 2012). As a premium bulking agent, polydextrose has a clean neutral taste that allows for the appreciation of true flavors. At the same time, corn flour which served as a binding agent can help to hold together components and thicken the meat batter, as such, it resulted in moisture retention and firmer texture in meat products.

Therefore, this work was aimed to enhance physical and sensory characteristics of light pork sausages containing konjac flour by adding various types and levels of texturizing ingredients such as κ-carrageenan, polydextrose, oat bran and corn flour.

MATERIALS AND METHODS

Materials: Fresh pork meat and fat were obtained from local processors in a Huai Kwang market, Bangkok. Konjac flour (Chengdu Qiteng Trading Co., Ltd., Chengdu, China) and xanthan gum (KELTROL®, CP Kelco, San Diego, CA, USA), analytical grade sodium chloride (NaCl), sodium nitrite ($NaNO_2$) and sodium tripolyphosphate and texturizing ingredients including κ-carrageenan (MSC5744, MSC Ltd., USA), polydextrose (Litesse®, Danisco A/S, Copenhagen, Denmark), oat bran (Quaker®, Quaker Oats Company, Chicago, USA) and corn flour (KS, New Siam Foods, Thailand) were used. Other ingredients such as sodium caseinate, sugar, pepper and monosodium glutamate were purchased from a local supermarket.

Konjac gel preparation: Konjac gel (fat analogue) was prepared by heating 1.5% konjac/xanthan (3:1) blend solution at 80-85°C until reducing to 2/3 of total volume. The konjac gel was ground through 0.4-cm plate and chilled at 4-5°C for 1 h before use.

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 sausage made with konjac gel was produced by the method of Akesowan (2008). The control and light sausages with various texturizing ingredients were identified as C (control) and T1-T8, as shown in Table 1. The 1-kg cured lean meat was ground through 1.7-cm 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 at 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.

Physicochemical analysis

Cooking loss: The meat batter stuffed into cellulose casing was weighed and then boiled at 80°C for 15 min. After cooling down to room temperature, cooked sausage was weighed and a percentage of cooking loss was calculated as [(weight of uncooked batter – weight of cooked sausage)/weight of uncooked batter] ×100.

Color: Internal color of cooked sausages were determined using a Hunterlab colorimeter (ColorFlex, Hunter Associates Laboratory, Reston, VA), equipped with a 25 mm aperture. Values for L* (lightness), a* (redness) and b* (yellowness) were recorded.

Firmness: 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. Firmness was expressed as a peak force (N) used for 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 semi-trained before initiation in the experiment. Sensory attributes included firmness, cohesiveness, juiciness, springiness, flavor and internal color were evaluated by an unstructured line scale test (Lawless and Heymann, 1998).

Statistical analysis: Sausage processing and all analyses of each treatment were carried out in triplicate. Data were analyzed statistically by analysis of variance (ANOVA) using SPSS for Window version 16.0. Means with a significant difference ($p < 0.05$) were compared by Duncan's new multiple range test (Cochran and Cox, 1992).

RESULTS AND DISCUSSION

Physical properties: Fig.1a shows the results for cooking loss of light pork sausages added with various types and levels of texturizing ingredients. The addition of κ-carrageenan and corn flour up to 1% used level presented no significant effects ($p>0.05$) for reducing cooking loss in relation to the control. At the same time, the addition of polydextrose and oat bran at least 0.5% demonstrated a significant lower ($p<0.05$) in cooking loss than the control, indicating that these two substances are suitable choices used for light product improvement. This was in agreement with Choi *et al.* (2010) who showed that chestnut peel powder, one of dietary fiber that is likely to be the major contributor to water holding capacity, can be used to decrease cooking loss by improving water and fat binding properties of chicken sausages. Pszczola (1991) reported that oat bran or fiber has the ability to retain moisture and prevent meats from drying out when cooked. In addition, Yang *et al.* (2010) revealed that the addition of oat meal caused decreasing cooking loss in sausages made from beef, pork or chicken. Similar results were also obtained by Choi *et al*. (2008) for low-fat tteokgalbi with rice bran fiber, Akesowan (2010) for light pork sausage fortified with soy protein isolate and Mahmoud and Badr (2011) for reduced-fat beef burger with wheat bran.

The different types and levels of texturizing ingredients affected the firmness of light pork sausages, as shown in Fig. 1b. The firmness, which defines as 'peak force' used for shearing the sausage, were significantly higher ($p<0.05$) in the sausages added with all texturizing ingredients than the control, except for that with 0.5% oat bran, which was similar to the control. These ingredients effectively enhanced firmness of the light sausage in the following: κ-carrageenan > corn flour > polydextrose > oat bran. The results also indicated a minimum level of these ingredients at 0.5% level was sufficient to improve firmness of the light products. Akesowan (2010) demonstrated that the moist and soft texture of the light pork sausage containing konjac could be improved by addition of soy protein isolate. This ingredient displays its role on gel/emulsion matrix which increases in binding strength of the protein–protein and protein–water interactions, allowing in a firmer texture (Chin *et al*., 2006). The highest peak force obtained in the product added with κ-carrageenan may come from a gelling ability of this gum alone to form a heat-induced gel with firm and brittle texture upon its cooling (Morris, 1998). In addition, in the presence of konjac, the synergistic interaction between these two structurally different gums can cause the formation of a physical hydrogel with increased gel texture. The mechanism of intermolecular interactions has not been fully elucidated; however, the interactions may occur, only when the carrageenan is in its ordered helical form, by the molecules associate through hydrogen bonding once the ordered structure has formed (Baeza *et al.,* 2002; Thomas, 1997; Williams, 2009). Kim *et al.* (2010) and Confrades *et al.* (2008) obtained similar results of increasing hardness and decreasing springiness by the addition of sea tangle powder, which contains alginate, a kind of hydrocolloids classified as 'dietary fiber'. The significant increases in hardness or firmness found in meat products containing dietary fiber were due to the fact that the samples with added dietary fiber had stronger water binding ability than those without dietary fiber (Choi *et al.,* 2009). Highly soluble fibers from various sources such as wheat fiber, oat fiber, sea tangle fiber, lemon albedo fiber and pumpkin fiber are generally used to modify texture, control water migration and improve the marketability of the meat products (Choi *et al.*, 2012).

In terms of instrumental color as shown in Fig. 2, internal color measured for $L^*a^*b^*$ of the sausages were affected by texturizing ingredients based on their originated color. The lowest lightness or L^* was observed for the light sausage with oat bran whereas that with κ-carrageenan showed the highest. This suggests that oat bran made the sausage darker; especially as 1% oat bran (T6) was applied, which was in good agreement with sensory evaluation (Table 2), namely panelists rated in the lowest score with regard to color attribute, representing an undesirable sense. Similar result was obtained by Choi *et al*. (2008) who showed that the lightness (L^*) of low-fat Tteokagalbi decreased with increasing levels of rice bran fiber. Besides, the addition of oat bran lowered a^* or red color of the products. Comparatively, the light sausage with 0.5% corn flour had internal color similar to the control.

Sensory evaluation: Sensory results of light pork sausages under various texturizing agents shown in Table 2 reveal a better trend for panelists' preference, especially firmness, cohesiveness and juiciness in relation to those of the control sausage. Higher firmness were observed ($p<0.05$) for all sausages with texturizing ingredients as compared with the control, indicating that panelists sensed a desirable texture. This was in consonance with the result of instrumental peak force determination where higher peak force values were obtained in most sausages with added texturizing ingredients. At the same time, the addition of texturizing ingredients increased cohesiveness scores, and all the treatments received significantly higher ($p<0.05$) scores than the control, except for that with 0.5% κ-carrageenan. Because cohesiveness defines the degree of difficulty in breaking down the internal structure of the sausage, a higher cohesiveness represents a better combination of all components. This was associated with the effective role of these ingredients for increasing water holding in meat batter. In addition, texturizing ingredient islands can be formed within the meat protein gel, appearing to help in moisture binding as well as act as reinforcement components to strengthen the gel structure. This result also implied a direct relationship to the level of texturizing ingredients used, namely cohesiveness score was increased with increasing level of these ingredients. When the correlation coefficients between sensory attributes were statistically analyzed, the only firmness correlated with cohesiveness ($r = 0.911$) (data not shown), which indicated that the relationship was highly positive ($p<0.05$).

As can be seen in Table 2, juiciness score of the sausage with 1% κ-carrageenan was the lowest, followed by that with 0.5% polydextrose and 1% oat bran, respectively, while other treatments were similar to the control. The remarkably undesirable juiciness by adding 1% κ-carrageenan, which was found to result in a 'gel-like' texture of the light sausage, could be explained by the gelation process of this gum which influenced and modified by many factors, one of which is the concentration of the gum (Baeza *et al*., 2002). At the same time, springiness scores of light pork sausages with 1% polydextrose or 0.5% oat bran were significantly lower ($p<0.05$) than the control, whereas the addition of 1% oat bran or 0.5% corn flour significantly increased ($p<0.05$) the springiness. This finding also implied that increasing level of these ingredients decreased springiness of the products apart from oat bran that presented a contrary result, namely higher springiness was found with 1% addition level.

The flavor scores of light pork sausages with κ-carrageenan and corn flour were similar to the control, as evidence in Table 2. Whilst, the low score achieved by added polydextrose was remarkable, possibly due to a strange flavor and bland taste information given by panelists. It was interesting to note that the sausage with added oat bran was more appreciated in flavor, even than the control, which was attributed to oat bran contains polyunsaturated fatty acids and oils that would probably be contributed to savory flavor and taste in the product (Beccerica *et al*., 2011). This was in agreement with Yang *et al*. (2010) who showed that flavor scores were improved by the addition of hydrated oatmeal, especially in pork and chicken sausages. However, all sausages with these texturizing ingredients were rated in color scores lower ($p<0.05$) than the control.

As the above results, it can be seen that each texturizing ingredient showed both advantage and disadvantage on sensory attributes of the light pork sausage. According to a 'sausage product ideal' consideration, the major criterion is based on firmness and cohesiveness whereas flavor and color could be of minor importance, it is feasible to use 0.5% oat bran to enhance quality characteristics of the light sausage so as to obtain a product with better eating quality.

Table 1. Formulations for light sausages with texturizing ingredients

Treatment	Texturizing ingredients added
C	No added
T1	0.5% κ-carrageenan
T2	1% κ-carrageenan
T3	0.5% polydextrose
T4	1% polydextrose
T5	0.5% oat bran
T6	1% oat bran
T7	0.5% corn flour
T8	1% corn flour

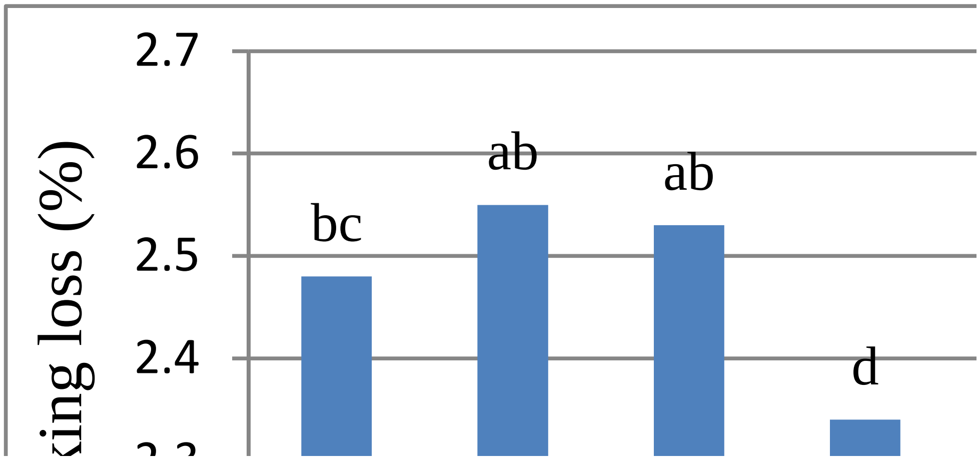
Table 2. Sensory evaluation of light pork sausages with texturizing ingredients

Treatment*	Sensory scores**					
	Firmness	Cohesiveness	Juiciness	Springiness	Flavor	Color
C	$1.34{\pm}0.42^{e}$	$1.85{\pm}0.25^{e}$	$2.78{\pm}0.20^{a}$	$2.73{\pm}0.35^{bc}$	$2.20{\pm}0.34^{bc}$	$3.25{\pm}0.30^{a}$
T1	$2.21{\pm}0.15^{d}$	$1.90{\pm}0.47^{e}$	$2.62{\pm}0.09^{ab}$	$2.91{\pm}0.16^{ab}$	$2.41{\pm}0.16^{b}$	$2.79{\pm}0.21^{cd}$
T2	$3.70{\pm}0.08^{a}$	$3.44{\pm}0.03^{a}$	$1.99{\pm}0.27^{d}$	$2.61{\pm}0.23^{c}$	$2.29{\pm}0.11^{b}$	$2.98{\pm}0.15^{bc}$
T3	$3.11{\pm}0.09^{b}$	$2.85{\pm}0.06^{b}$	$2.25{\pm}0.06^{c}$	$2.92{\pm}0.09^{ab}$	$1.70{\pm}0.08^{e}$	$2.47{\pm}0.32^{e}$
T4	$2.87{\pm}0.05^{c}$	$2.56{\pm}0.08^{c}$	$2.73{\pm}0.14^{a}$	$2.22{\pm}0.12^{d}$	$1.85{\pm}0.11^{de}$	$2.51{\pm}0.11^{e}$
T5	$2.82{\pm}0.13^{c}$	$2.25{\pm}0.24^{d}$	$2.75{\pm}0.09^{a}$	$2.06{\pm}0.06^{d}$	$2.64{\pm}0.12^{a}$	$2.80{\pm}0.12^{cd}$
T6	$3.03{\pm}0.05^{bc}$	$2.61{\pm}0.36^{c}$	$2.47{\pm}0.07^{b}$	$3.07{\pm}0.14^{a}$	$2.80{\pm}0.32^{a}$	$2.03{\pm}0.08^{f}$
T7	$3.14{\pm}0.09^{b}$	$3.12{\pm}0.14^{ab}$	$2.76{\pm}0.11^{a}$	$3.03{\pm}0.11^{a}$	$2.28{\pm}0.24^{b}$	$2.67{\pm}0.08^{de}$
T8	$3.67{\pm}0.08^{a}$	$3.26{\pm}0.12^{a}$	$2.69{\pm}0.17^{ab}$	$2.78{\pm}0.09^{bc}$	$2.11{\pm}0.27^{cd}$	$3.03{\pm}0.11^{b}$

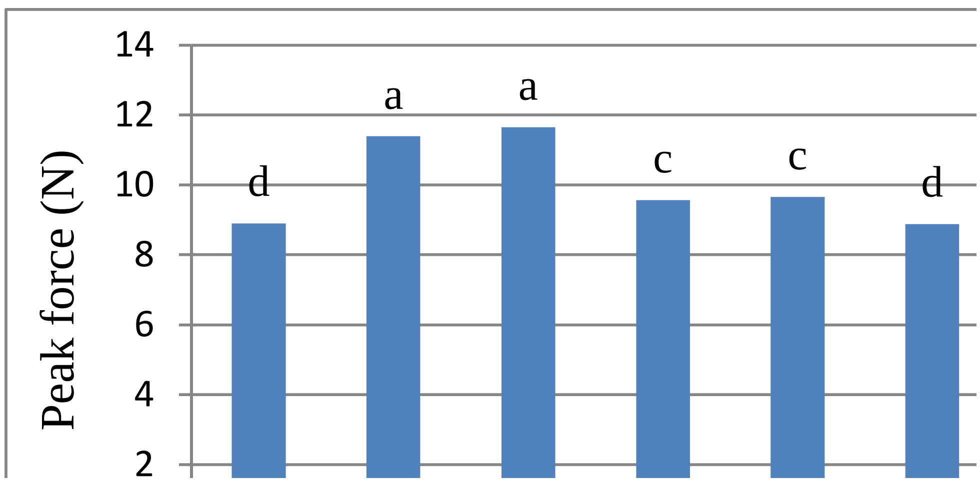
Means in the same column with different superscripts are different ($p < 0.05$).

*C and T1–T8 refer to treatment codes on Table 1.

** Based on an unstructured line scale test (1 = extremely undesirable, 5 = extremely desirable).



(a) Cooking loss



(b) Firmness

Fig. 1. Cooking loss and firmness of light sausages under various types and levels of texturizing ingredients. Equal lowercase letters are not significantly different (p<0.05). C and T21-T8 refer to treatment codes on Table 1

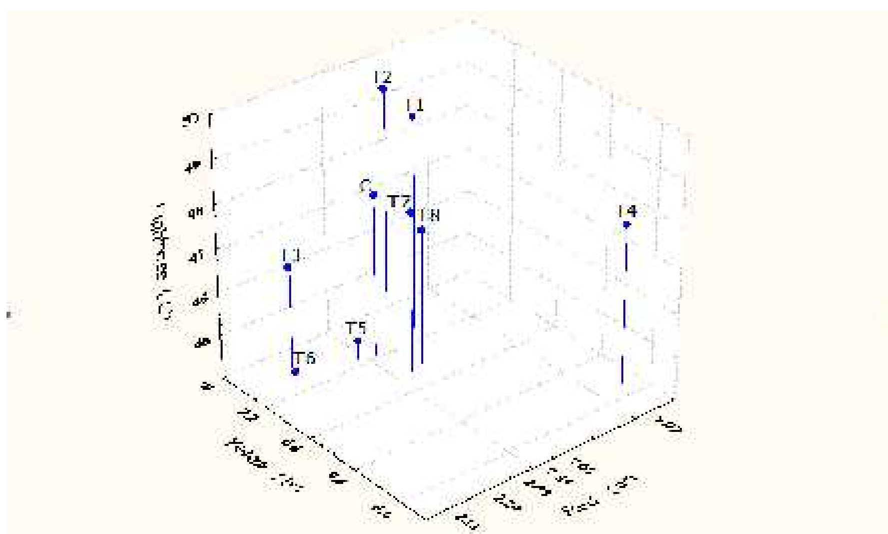


Fig. 2. L*a*b* color scales of light sausages under various types and levels of texturizing ingredients. C and T21-T8 refer to treatment codes on Table 1.

Conclusion: The addition of polydextrose or oat bran up to 1% level in a light pork sausage containing konjac flour was effective for decreasing cooking loss whereas the increment of peak force was pronounced when 0.5 or 1% κ-carrageenan were applied. The sausage with oat bran was darker than the others by instrumental color determination. Overall, the light sausage showing better eating quality can be produced by incorporating 0.5% oat bran to the formulation. Storage stability of this product is needed to be investigated for further study.

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