Effects of sodium chloride replacement with potassium chloride and flavor enhancers on the physico-chemical and sensorial qualities of low-fat chicken frankfurter sausage

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Abstract: The effects of sodium chloride (NaCl) replacement with potassium chloride (KCl) and flavor enhancer on the physico-chemical and sensorial qualities of low-fat chicken frankfurter sausage was studied to reduce sodium content in the product. Three independent replications of low-fat chicken frankfurters were manufactured to compare seven treatments: control (1.2% NaCl), replacing NaCl by 25% 50% 75% KCl with 1% lysine (25KL, 50KL and 75KL, respectively) and replacing NaCl by 25% 50% 75% KCl with 1% yeast extract (25KY, 50KY and 75KY, respectively). The results showed that NaCl replacement by KCl together with both flavor enhancers did not affect to pH of batter, pH of sausage, and emulsion stability (P>0.05). Replacement of NaCl by KCl with both flavor enhancers in the product resulted in lower values of hardness, gumminess, and chewiness as increased the percentage of KCl (P<0.05). Moreover, the addition of yeast extract in replacing NaCl by KCl showed a lower lightness with higher yellowness than control and lysine groups (P<0.05). The flavor of 50KY and 75KY were lower sensorial liking score than control. Liking scores of taste, texture, and overall acceptability of 75KL, 50KY, and 75KY were lower than control. However, the lysine addition of 25KL and 50KL showed similar flavor, taste, and overall acceptability scores as compared with control. In conclusion, the use of 50% replacement of NaCl by KCl and with 1% lysine (50 KL) was optimum formulation to reduce the sodium content in low-fat chicken frankfurter sausages while maintaining quality characteristics of low-fat frankfurters.

Keywords: Sodium chloride replacement, Potassium chloride, flavor enhancer, low-fat frankfurter

Introduction

Chronic diseases and high level of sodium intake are related to hypertension and subsequently an increased risk of cardiovascular disease (Vollmer *et al*., 2001). The World Health Organization (WHO) stated that the consumption of salt in form of sodium chloride (NaCl) more than 6 gram of NaCl /person/day is associated with an increase in hypertension. As reviewed by Weiss *et al.* (2010), the reduced salt intake to 5 gram of NaCl/person/day (accounted for 2 gram sodium content, Na) is recommended to decrease health risks.

NaCl is one of the common ingredients in emulsion-type sausage. It activates the extraction of myofibrillar protein and enhances emulsification. In addition, NaCl has crucial role in texture, taste and shelf-life of frankfurter (Yotsuyanagi *et al.*, 2016).

To reduce the sodium content in meat products, the replacing the NaCl by other salt are one of favorable strategy. Among of altermative salts, potassium chloride (KCl) was widely used to replace NaCl. It can replace NaCl with the equal content, because it has similar chemical properties including molecular composition and the ionic strength (Stanley *et al.*, 2017). However, in some meat procut, high amonts of KCl (30-40%) result in a bitter, metallic taste and astringent taste, leading to decreasing sensory liking score of replacement product. There are some ingredients which can reduce the detrimental impacts caused by KCl. Flavour enhancer are reported as the good masking agent for salt substitutes including lysine and yest extract (Horita *et al.*, 2014).

Regarding the decreased sodium content in meat product, Campagnol *et al.* (2011) reported that lysine can reduce the sensory defects caused by high KCl levels in low-fat Bologna-type sausages. On the other hand, Campagnol *et al.* (2011) showed that yeast extract can be used as masking agent in fermented sausage when NaCl was replaced by high level of KCl. However, there are no comparative studies among lysine and yeast extract for bitterness-masking agents in sodium replacer by KCl in meat product, especially for low-fat chicken frankfurter sausages. Thus, the objective of this study was to determine the influences of NaCl replacement with KCl and flavor enhancer including lysine and yeast extract on the physico-chemical and sensorial qualities of low-fat chicken frankfurter sausage.

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Materials and Methods

Formulations and processing of low-fat chicken frankfurter sausage

Skinless boneless breast (SBB) from chicken meat and chicken skin were purchased from modern trade, Ladkrabang, Thailand. Lean materials and chicken skin were ground through an 8 mm plate. Seven formulation frankfurters were shown in Table 1 including 1.2%NaCl (control), replacing NaCl by 25%KCL with lysine (25KL), replacing NaCl by 50%KCL with lysine (50KL), replacing NaCl by 75%KCL with lysine (75KL), replacing NaCl by 25%KCL with yeast extract (25KY), replacing NaCl by 50%KCL with yeast extract (50KY) and replacing NaCl by 75%KCL with yeast extract (75KY). The detail of meat and other ingredients was presented in Table 1. The sausage manufacturing was followed by Sorapukdee *et al.* (2013) with some modification. Briefly, the salts (NaCl, KCl, STPP, sodium nitrite, and sodium erythorbate) and the half of ice were added to the ground meat. The mixture was chopped in 5-liters of stainless steel cutter mixer (Universal Fritter-brane QS-505A, Champ, China) for 120s. Thereafter, ground skin chicken, soy protein, and the rest of ice were added and chopped for 90 s. The frankfurter premix and lysine and/or yeast extract was added and continuously chopped for 90 s. Finally, the meat batter was stuffed into 21-mm diameter collagen casing, handlinked at 6 inch intervals and cooked in a sausage smoke oven (100 BUDGET, Red Arrow Equipment, USA) until a core temperature of 75°C. Thereafter, frankfurters were chilled overnight at 4°C.

Table 1. low-fat chicken frankfurter formulations with various NaCl, KCl, and flavor enhancer (units: g/kg)

Ingredients	Control	25KL	50KL	75KL	25KY	50KY	75KY
Chicken meat	670	670	670	670	670	670	670
Skin chicken	100	100	100	100	100	100	100
Water/Ice	180	180	180	180	180	180	180
Soy protein isolate	14	14	14	14	14	14	14
Sodium nitrite	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium erythorbate	1	1	1	1	1	1	1
Sodium tripolyphosphate	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Frankfurter premix	20	20	20	20	20	20	20
NaCl	12	9	6	3	9	6	3
KCl	-	3	6	9	3	6	9
Lysine	-	10	10	10	-	-	-
Yeast extract	-	-	-	-	10	10	10

Physical and chemical analysis

Cooking loss

Cooking loss was evaluated according to the method of Hughes *et al.* (1997). Cooking loss was estimated from weight loss after processing of the uncooked frankfurters until a core temperature of 75°C in a sausage smoke oven and expressed as the percentage (%) of initial sample weight.

pH values

The pH was evaluated by direct measurement into batter and frankfurter sausage using pH meter after overnight chilling (Mettler Toledo, Greifensee, Switzerland). pH value were masured at triplicate determination for each sample.

Emulsion stability

Emulsion stability was performed according to the method of Colmenero *et al.* (2005). Meat batter was placed in to 50-mL centrifuge tube (six tubes per treatment) and then heated to 70°C for 30 min. After centrifuge for 3 min at 4000 rpm (Sigma2-16KL, Sigma, Germany), samples were opened and left to stand upside-down at room temperature (32±2 °C) for 50 min to release the exudates onto a plate. Total fluid released (TFR) was expressed as percentage (%) of initial sample weight. Water released (WR) was calculated from weight loss after heating the TFR at 105°C in a convection oven (FD115, BINDER, Germany) for 16 h and expressed as percentage (%) of initial sample weight. The difference between TRF and WR was calculated as fat released (FR).

Texture profile analysis (TPA)

TPA was tested using a texture analyser (Instron Model 3344, Illinois Tool Works Inc., USA) with cylindrical probe. Seven peices of each treatment (21 mm diameter and 20 mm height) were prepared and placed on the instrument's base. TPA parameters as described by Bourne (1978) including hardness (N), cohesiveness (ratio), gumminess (N), chewiness (N) and springiness (ratio) were recoreded from the force-time curves generated by the Bluehill 2 software.

Color

The central part of the internal surface color of six cylinder-shaped samples (21 mm diameter and 20 mm height) was recorded in the L*a*b* mode of CIE by Hunter Lab colorimeter (Hunter Associates Laboratory Inc., USA). The average values were expressed as L*, a*, and b* for lightness, redness, and yellowness, respectively.

Sensory evaluation

Sensory evaluation was carried out for cooked low-fat chicken frankfurter sausages with the method as described by Wheeler *et al.* (2016). The sausages were examined for their appearance, flavor, taste, texture, and overall acceptability. The treatments were code with three digits random number. There were 20 semi-trained panelists in all sensory evaluation tests. Sensory attributes were evaluated using a seven points hedonic scale from 1= dislike extremely, 2= dislike very much, 3= dislike, 4= neither like nor dislike, 5=like, 6= like very much and 7= like extremely.

Statistical analyses

The experiment was conducted as Randomized Complete Block Design. Three independent batches were conducted. Significant effects were performed by One-way ANOVA and mean comparison were compared by the Duncan's multiple range test. Data were analyzed using SPSS (v.19, IBM SPSS Inc.).

Results

Cooking loss, pH values, and emulsion stability

Cooking loss of low-fat chicken frankfurter sausage was shown in Table 2. The replacement of NaCl by KCl and flavor enhancer of low-fat chicken frankfurter sausages were not affected on cooking loss ($P>0.05$). For all treatments, cooking loss varied from 6.05% to 7.94%.

The emulsion stability of low-fat chicken frankfurter sausages was analyzed by TFR, FR, and WR, as shown in Table 2. TFR ranged from 1.24% to 1.68%, FR varied from 0.10 to 0.13 and WR ranged from 1.14 to 1.55. There were not observed significant differences among treatments ($P>0.05$).

There were no significant differences among treatments for pH of batter and sausage ($P>0.05$) (Table 2). For all treatments, the batter pH values ranged from 6.17 to 6.23 and the sausage pH values ranged from 6.09 to 6.13.

TPA

The instrumental TPA was shown in Table 3. It was found that the low-fat chicken frankfurter sausages showed different value of hardness ($P<0.05$). The treatment 25KL had the highest of hardness, gumminess, and chewiness compared to other treatments. However, the higher addition of KCl, especially for 50KL, 75KL, 50KY, and 75KY seem to be decreased hardness, gumminess, and chewiness as compared with control. Cohesiveness and springiness for each treatment did not shown significant difference ($P>0.05$).

Table 2. Cooking loss, pH value and emulsion stability of low-fat chicken frankfurter sausage

Sample	Cooking loss (%)	pH values		Emulsion stability		
		batter	sausage	TFR (%)	FR (%)	WR (%)
Control	6.73±0.01[a,1,2]	6.23±0.01[a]	6.10±0.02[a]	1.68±0.43[a]	0.13±0.04[a]	1.55±0.02[a]
25KL	7.48±0.01[a]	6.22±0.01[a]	6.13±0.01[a]	1.39±0.19[a]	0.13±0.03[a]	1.26±0.02[a]
50KL	6.05±0.01[a]	6.20±0.01[a]	6.12±0.01[a]	1.24±0.16[a]	0.10±0.01[a]	1.14±0.03[a]
75KL	7.94±0.01[a]	6.21±0.01[a]	6.09±0.01[a]	1.54±0.70[a]	0.13±0.07[a]	1.41±0.01[a]
25KY	6.70±0.01[a]	6.17±0.01[a]	6.10±0.02[a]	1.32±0.70[a]	0.11±0.06[a]	1.21±0.01[a]
50KY	7.52±0.01[a]	6.20±0.01[a]	6.09±0.01[a]	1.41±0.27[a]	0.11±0.03[a]	1.30±0.02[a]
75KY	7.13±0.01[a]	6.23±0.01[a]	6.13±0.01[a]	1.37±0.11[a]	0.11±0.01[a]	1.26±0.04[a]

[1] Mean values ± SD obtained from three independent batches.
[2] Different letters in the same column indicate significant difference (P<0.05).

Table 3. TPA of low-fat chicken frankfurter sausage

Sample	Texture profile analysis				
	Hardness (N)	Cohesiveness (ratio)	Gumminess (N)	Chewiness (N)	Springiness (ratio)
Control	22.76±0.27[ab,1,2]	0.79±0.01[a]	17.99±0.21[ab]	15.75±0.56[b]	0.88±0.02[a]
25KL	23.50±0.48[a]	0.79±0.01[a]	18.67±0.52[a]	17.20±0.15[a]	0.90±0.02[a]
50KL	20.15±0.20[c]	0.79±0.01[a]	15.93±0.26[c]	14.05±0.20[c]	0.88±0.01[a]
75KL	18.29±0.22[d]	0.78±0.01[a]	14.32±0.10[d]	12.51±0.15[d]	0.87±0.01[a]
25KY	21.75±1.45[b]	0.80±0.01[a]	17.34±1.34[ab]	15.18±1.38[bc]	0.88±0.01[a]
50KY	21.73±0.52[b]	0.79±0.01[a]	17.12±0.63[bc]	15.31±0.88[bc]	0.89±0.02[a]
75KY	19.93±1.46[c]	0.80±0.01[a]	15.89±1.15[c]	14.20±0.70[c]	0.89±0.02[a]

[1] Mean values ± SD obtained from three independent batches; [2] Different letters in the same column indicate significant difference (P<0.05).

Color

The partial substitution of NaCl by KCl impacted to color of low-fat chicken frankfurter sausages (Table 4). The replacement of NaCl by KCl together with 1% yeast extract addition (25KY, 50KY and 75KY) decreased lightness with increased yellowness (P<0.05), especially as compared with control. A similar relationship was found in lysine group (25KL, 50KL and 75KL), but smaller impact as compared with yeast extract. However, all treatment of low-fat frankfurters were not significant differences in redness (P>0.05).

Sensory analysis

The appearance evaluated by panelists demonstrated that there were no significant differences among treatments (P>0.05) (Table 5). The flavor liking scores of 50KY and 75KY were lower than control (P<0.05). The taste and overall acceptability liking scores of 75KL, 50KY and 75KY were also lower than control (P<0.05). Among the sodium chloride replacement formulation, 25KL showed the highest texture score than other treatment and tended to decrease as increased KCl.

Table 4. Color (CIE L*, a*, b*) of low-fat chicken frankfurter sausage

Sample	Color parameter		
	Lightness (L*)	Redness (a*)	Yellowness (b*)
Control	68.43±0.32 [a,1,2]	7.83±0.35[a]	20.67±0.68[c]
25KL	67.04±0.49[b]	7.78±0.17[a]	20.92±0.30[bc]
50KL	67.49±0.29[b]	7.81±0.20[a]	20.67±0.45[c]
75KL	66.47±0.44[c]	7.98±0.17[a]	21.40±0.15[b]
25KY	66.03±0.43[c]	7.80±0.36[a]	22.25±0.62[a]
50KY	66.49±0.63[c]	7.93±0.51[a]	22.44±0.79[a]
75KY	66.51±0.36[c]	7.76±0.22[a]	22.28±0.34[a]

[1] Mean values ± SD obtained from three independent batches;[2] Different letters in the same column indicate significant difference (P<0.05).

Table 5. Sensory evaluation (7-point hedonic scale) of low-fat chicken frankfurter sausage

Sample	Appearance	Flavor	Taste	Texture	Overall acceptability
Control	6.22±0.28 [a,1,2]	6.78±0.20[a]	6.14±0.46[a]	5.21±0.57[ab]	5.86±0.29[a]
25KL	6.43±0.20[a]	6.28±0.39[ab]	5.64±0.33[ab]	5.79±0.36[a]	5.93±0.32[a]
50KL	6.65±0.20[a]	6.06±0.36[ab]	5.07±0.20[ab]	5.50±0.34[ab]	5.43±0.15[a]
75KL	6.58±0.40[a]	6.21±0.59[ab]	3.50±0.65[c]	4.29±0.97[b]	3.86±0.51[b]
25KY	6.72±0.26[a]	5.85±0.35[ab]	4.93±0.07[b]	5.07±0.43[ab]	5.00±0.24[a]
50KY	6.01±0.58[a]	5.21±0.78[b]	3.43±0.50[c]	4.21±0.71[b]	3.64±0.39[b]
75KY	6.43±0.81[a]	5.21±0.98[b]	3.36±0.64[c]	4.14±1.07[b]	3.50±0.50[b]

[1] Mean values ± SD obtained from three independent batches.
[2] Different letters in the same column indicate significant difference (P<0.05).

Discussion

The reformulation of chicken frankfurter sausage to be the low-sodium product in present study was not influenced on cooking loss, emulsion stability, and pH value. According to Dos Santos Alves *et al.* (2017), the significant differences in cooking loss and emulsion stability between low-fat bolona-type sausages with sodium replacement by KCl and control were not found. Similary, Choi *et al.* (2014) found that there was no significant impact of KCl for sodium replacer on cooking loss of frankfurter sausages when compared with control. These informations suggested that the type of ion not affect to protein extraction capacity as well as moisture retention ability, but depend on ionic strength of the system (Pietrasik and Gaudette, 2015). Furthermore, NaCl and KCl were similarly effective in protein extraction of tumbled hams (Trout and Schmidt, 1986). In present study, it was noted that cooking loss was not difference between treatments might be due to the use of soy protein isolate in our formulation, which could increase the gel forming and water-binding capacity in final product. Concerning pH, Campagnol *et al.* (2012) also reported that pH values of fermented sausage between KCl added product and NaCl group at begin of production were not significantly observed. The other report also found that NaCl content did not influence the pH of frankfurter (Puolanne *et al.,* 2001).

Regarding textural characteristics, hardness, gumminess, and chewiness of products were decreased as increased KCl content. According to Campagnol *et al.* (2012), they also reported that replacing NaCl by KCl in low-sodium fermented sausages decreased hardness value when compared with control. The sodium replacer by using KCl in combination with yeast extract was impacted on color of our low-fat chicken frankfurter sausages. Generally, yeast extract is creamy yellow coloured powder. Therefore, the decreased lightness and increased yellowness could be observed in treatment formulated with yeast extract. Similarly to Campagnol *et al.* (2011), the replacing NaCl by KCl with added yeast extract in fermented sausages also decreased lightness of resulting product.

In present study, the sodium replacer by 50% KCl with added lysine were not contributed the detrimental impact on sensory score as compared with control. Dos Santos Alves *et al.* (2017) reported that consumers did not identify differences in color, aroma, flavor, texture, and overall acceptability among samples between replacing NaCl by 50% KCl with 1% lysine addition and control. In addition, Gou *et al.* (1996) reported that the textural characteristics of ferment sausages between replacement of NaCl by KCl and control groups were similar profiles, but a bitter taste was detected when a 30% substitution level was used.

In conclusion, the replacement of NaCl by 50% KCl with 1 % lysine addition were not negatively impacted on physico-chemical and sensorial properties of low-fat chicken frankfurter sausages. Therefore, this product reformulation could be used to produce a healthier low-fat chicken frankfurter sausage for the consumers who are concerning the high calories and high sodium intake.

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