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# Effect of sodium chloride and sugar reduction on the quality of ready-to-eat- healthy chinese fish sausage

**Theprugsa, P.[1,2*] and Pakasap, C.[1]**

[1]Department of Food Science and Technology, Thammasat University, Pathum Thani, Thailand; [2]Thammasat University Center of Excellence in Food Science and Innovation, Pathum Thani, Thailand.

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**Abstract** The replacement of sodium chloride with potassium chloride in the ratio of 50:50 was not affected the physical properties in the term of hardness and toughness but significantly reduced the free water content of product. The acceptability sensorial score of 50% sodium chloride replaced with potassium chloride was 7.41±0.84. For the replacement of sugar by using sweeteners, it was found that using maltitol and adjustment the sweetness by sucralose that replaced 100 % of sugar and showed the most comparable quality to the control without affected the sensorial quality. For the final product, total microorganism found was to be <10 CFU/g for *Staphylococcus aureus*, < 10 CFU/g for *Salmonella* spp. and *Esherichia coli* were not found. The microbiological quality of product had met Thai community product standard of dried fish sausage product (TPCS107/2555). The ready-to-eat- healthy chinese fish sausage is presented to be 25.24% which lower sodium content than control formula, and sugar content was not detected.

**Keywords:** Fish sausage, Potassium chloride, Sodium chloride, Sweetener

## Introduction

Chinese fish sausage is a type of sausage from fish and fat such as lard, fish fat or shortening and mixed with seasonings such as sugar, salt and other ingredients such as spices and herbs, then forming and drying. Packed in clean and dry packaging to prevent contamination from external impurities (Sloyjalung, 2017). Processed foods in the market are rich in sugars and sodium that make its taste delicious. Consumer recieves too much sugar and sodium each day, which is the main cause of kidney disease, high blood pressure and cardiovascular disease. In addition, processed meat or ready-to-eat foods generally contain sodium as an ingredient in various forms, including salt, nitrite salt, phosphate salt, fish sauce, soy sauce, and MSG. The World Health Organization (WHO) recommends that the maximum daily intake of

[*]**Corresponding Author:** Theprugsa, P.; **Email:** prapasritheprugsa@gmail.com

sodium is 2 g/day or only 1 tsp/day of salt intake (Härtl, 2013; Vidal *et al*., 2020). Researchers reported that using of potassium chloride instead of using sodium chloride can lowere blood pressure and reducing risk of cardiovascular diseases (Mahannopkul and Yossaksri, 2018).

Sweeteners are one of the food additives used as sugar substitutes. tSweeteners are may sweeter than sucrose, but does not give energy or give less energy which is commonly used in food and beverages for the purpose of reducing energy and maintaining the taste of sweetness (Tanaviyutpakdee and Srianujata, 2018). Sugar alcohols are commonly used as an ingredient in many food products such as sweets, diet food and ready-to-eat processed food. Sugar alcohols that are regularly used as sweeteners such as maltitol, sorbital, isomalt and erythritol (Phukasmas, 2013).

Nowadays, consumer behavior is more focused on choosing healthy food because consumers can quickly recognize and access health-related information through a variety of channels. There is also a wide variety of products in the competitive market. As a result, the product presentation must meet the exact needs. of consumers as much as possible

Therefore, the research was aimed to develop the chinese fish sausage with a new form that can be consumed immediately without reheating, using a salt substitute and sugar substitutes to develop product into ready-to-eat healthy chinese fish sausage products that are beneficial to consumers.

## Materials and methods

### *Materials*

Catfish, salt, sugar, glycerol were purchased from local market near Thammasat University, Thailand. Rice bran oil shortening was purchased from Thai Edible Oil Co., Ltd., Thailand. Potassium chloride, isomalt, maltitol powder and erythritol were obtained from Chemipan Corporation Co., Ltd., Thailand.

### *Preparation of chinese fish sausage*

The catfish was cut into pieces. Then wash with clean water, salt, tapioca starch and vinegar to deodorize the fishy smell. The pieces of Catfish then cut to separate the fillet from the skin and bones. The fillets were ground with a 5-mm flange grinder and then 58% of grinded fillet was mixed with 0.72% salt and 9% sugar. After that the mixture was mixing and then added 14% rice brand oil shortening and mixing for 2 minutes. 13% of glycerol and 4% of water were mixed with the mixture for 2 minutes. The mixture was packed into a 3x4 cm square mold and then baked at 85$^{o}$C for 3 hours and dry at 65 $^{o}$C for 12 hours. For developed chinese fish sausage studies, five level of NaCl was replaced with KCL in the ratio of NaCl : KCl (100: 0, 75:25, 50:50, 25:75 and 0:100) and sugar was completely replaced with isomalt, maltitol powder and erythritol. The sample witout potassium chloride and sweeteners replacement were used as a control sample.

### *Statistical analysis*

Analysis of variance (ANOVA) was used to determine the effects of factors (the ratio of NaCl: KCl and the sweeteners instead of sugar) on the qualities of Chinese fish sausages. Significant effects were verified using Duncan's multiple range test with a 95% confidence level.

### *Qaulity determination*

Water activity: Chinese fish sausage samples were cut into 2 mm cube and measured using water activity meter.

pH values: the pH values of all sample were determined using pH meter (PB-20, Satorius, Germany).

Hardness and toughness: hardness and toughness were measured using texture analyzer (plus-upgrade, Stable Micro System, USA). The hardness was determined by the maximum compressive force using guillotine blade probe (HDP/BS) with speed of 1 mm/sec. The toughness is determined by the maximum cutting force with a cutting speed of 1 mm/s (Sa-adchom and Swasdisevi, 2014).

Chemical composition: moisture, protein, ash, sugar and sodium were measured according to In-house method based on AOAC (2019) by National Food Institute, Thailand.

Microorganism: total plate count (FDA-BAM, 2001), *Staphylococcus aureus* (ISO6888-1:1999), *Salmonella* spp. (ISO6579-1:2017), Yeast and Molds count (AOAC, 2019) were analyzed by Asia Medical and Agricultural Laboratory and Research Center Public Co., Ltd., Thailand.

## Results

### *Replacement of sodium chloride with potassium chloride*

The water activity and pH of chinese fish sausage replacement of sodium chloride with potassium chloride are shown in Table 1. Water activity of chinese fish sausage decreased with the increase of potassium chloride proportion. The lowest pH was found in sample replace with 100% potassium chloride, which was 0.605± 0.01. pH of all samples was in the range of 6.33-6.38.

**Table 1.** Water activity and pH of chinese fish sausage replacement of sodium chloride with potassium chloride

| NaCl : KCl | $a_w$ | $pH^{ns/2}$ |
|---|---|---|
| 100:0 | $0.620^{a1/}$± 0.01 | 0.05 ± 6.38 |
| 75:25 | $0.617^{b}$± 0.01 | 0.07 ± 6.35 |
| 50:50 | $0.617^{b}$± 0.02 | 0.04 ± 6.37 |
| 25:75 | $0.610^{c}$± 0.02 | 0.10 ± 6.33 |
| 0:100 | $0.605^{d}$± 0.01 | 0.09 ± 6.34 |

[1/] Different letters in the same column indicate significant differences ($p < 0.05$).
[2/] non-significant ($p \geq 0.05$).

Result showed that hardness and toughness of chinese fish sausage replacement of sodium chloride with potassium chloride (Table 2). It was found that the control sample without potassium chloride replacement had shown to be the lowest hardness and toughness. Hardness and toughmess tended to increase with the increased potassium chloride replacement.

**Table 2.** Hardness and toughness of chinese fish sausage replacement of sodium chloride with potassium chloride

| NaCl : KCl | hardness ($kg_{force}$) | toughness ($kg_{force}$.sec) |
|---|---|---|
| 100:0 | $7.28^{d1/}$ ± 0.21 | $40.66^{b}$ ± 1.35 |
| 75:25 | $7.55^{c}$ ± 0.17 | $42.54^{ab}$ ± 1.87 |
| 50:50 | $7.83^{b}$ ± 0.25 | $41.33^{ab}$ ± 0.98 |
| 25:75 | $8.05^{a}$ ± 0.08 | $43.57^{a}$ ± 2.05 |
| 0:100 | $8.17^{a}$ ± 0.11 | $43.76^{a}$ ± 1.46 |

[1/] Different letters in the same column indicate significant differences ($p < 0.05$).

The sensorial score of chinese fish sausage replacement of sodium chloride with potassium chloride is shown in Table 3. It was found that replacing salt with potassium chloride at a 50:50 ratio did not affect consumer acceptance, but when potassium chloride ratio was increased to 75, the overall taste preference score and overall preference score were decreased. Sodium chloride replaced with potassium chloride at the ratio of 50:50 had sensorial score in the term of moderately like (7.41±0.84), which refer that customer accepted the product.

**Table 3.** Sensorial score of chinese fish sausage replacement of sodium chloride with potassium chloride

| NaCl : KCl | Appearancens/2 | Colorns | Flavorns | Texturens | Taste | Overall acceptability |
|---|---|---|---|---|---|---|
| 100:0 | 7.51+0.85 | 7.28+1.02 | 7.47+0.76 | +7.641.11 | 7.32a+0.42 | 7.67a1/+0.67 |
| 75:25 | 7.33+1.02 | 7.76+1.15 | 7.62+0.83 | +7.530.84 | 7.28a+0.58 | 7.53a+0.53 |
| 50:50 | 7.54+0.88 | 7.34+0.95 | 7.35+1.14 | +7.660.56 | 7.36a+0.82 | 7.41a+0.84 |
| 25:75 | 7.31+0.74 | 7.49+0.87 | 6.33+0.53 | +7.540.77 | 6.87ab+0.54 | 6.53b+0.61 |
| 0:100 | 7.42+0.92 | 7.56+0.73 | 6.04+0.75 | +7.591.09 | 6.64b+0.33 | 6.14b+0.62 |

[1/] Different letters in the same column indicate significant differences ($p < 0.05$).
[2/] non-significant ($p \geq 0.05$).

### *Replacement of sugar by sweeteners*

Water activity and pH of chinese fish sausage replacement of sugar by sweeteners are presented in Table 4. Control sample using sugar had the highest water activity, while sample using isomalt had the lowest. pH of all sample was ranged of 6.27-6.33.

**Table 4.** Water activity and pH of chinese fish sausage replacement of sugar by sweeteners

| Sweeteners | $a_w$ | $pH^{ns}$ |
|---|---|---|
| Sugar (control) | $0.620^{a1/} \pm 0.002$ | 0.10±6.30 |
| Isomalt | $0.612^{c} \pm 0.001$ | 0.12±6.28 |
| Maltitol powder | $0.615^{b} \pm 0.003$ | 0.07±6.33 |
| Erythritol | $0.619^{a} \pm 0.002$ | 0.15±6.27 |

[1/] Different letters in the same column indicate significant differences ($p < 0.05$).

The hardness and toughness of chinese fish sausage replacement of sugar by sweeteners is presented in Table 5. It was found that sample using erythritol had the highest hardness and toughness, wich was $8.05\pm0.33$ kg $_{force}$ and $44.64\pm0.47$ kg $_{force}$.sec, respectively.

**Table 5.** Hardness and toughness of chinese fish sausage replacement of sugar by sweeteners

| Sweeteners | Hardness (kg $_{force}$) | Toughness (kg $_{force}$.sec) |
|---|---|---|
| Sugar (control) | $7.78^{ab1/}\pm0.66$ | $42.01^{b}\pm0.72$ |
| Isomalt | $7.50^{b}\pm0.48$ | $41.98^{b}\pm1.35$ |
| Maltitol powder | $7.69^{b}\pm0.71$ | $42.35^{b}\pm0.85$ |
| Erythritol | $8.05^{a}\pm0.33$ | $44.64^{a}\pm0.47$ |

[1/] Different letters in the same column indicate significant differences ($p < 0.05$).

Sensorial score of chinese fish sausage replacement of sugar by sweeteners are presented in Table 6. It was found that the completely replacement sugar with sweeters did not affect cusromer acceptance. Sensorial score of all samples were in the range of 6.40-7.53, which indicate that customer slightly liked to moderately like the product.

**Table 6.** Sensorial score of chinese fish sausage replacement of sugar by sweeteners

| Sweeteners | Appearance$^{ns1/}$ | Color$^{ns}$ | Flavor$^{ns}$ | Texture$^{ns}$ | Taste$^{ns}$ | Overall acceptability$^{ns}$ |
|---|---|---|---|---|---|---|
| Sugar (control) | $7.60\pm0.89$ | $7.53\pm1.11$ | $7.73\pm0.69$ | $7.03\pm1.22$ | $7.07\pm1.05$ | $7.50\pm0.86$ |
| Isomalt | $7.57\pm0.86$ | $7.00\pm1.58$ | $7.35\pm0.24$ | $7.00\pm0.67$ | $7.12\pm0.74$ | $7.40\pm0.57$ |
| Maltitol | $7.35\pm0.52$ | $7.65\pm0.41$ | $7.26\pm0.33$ | $7.09\pm0.83$ | $7.10\pm1.65$ | $7.53\pm0.68$ |
| Erythritol | $7.40\pm0.14$ | $7.34\pm0.86$ | $7.13\pm0.67$ | $6.40\pm0.82$ | $6.89\pm0.74$ | $7.00\pm0.97$ |

[1/] non-significant ($p \geq 0.05$).

### *Chemical composition*

The sodium and sugar content of the control sample was 511 mg/100 g and 11.60 g/100g, respectively, while reduce sodium and sugar sample using

KCl instead of 50% NaCl revealed the sodium content of 382.00 mg/100 g and sugar content was not detected.

**Table 7.** The comparison of control and developed chinese fish sausage

| Chemical composition | Control sample | Reduce sodium and sugar sample |
|---|---|---|
| Moisture (g/100g) | 34.35 | 29.03 |
| Carbohydrate (g/100g) | 25.00 | 28.90 |
| Protein (g/100g) | 14.10 | 19.40 |
| Sodium (mg/100g) | 511.00 | 382.00 |
| Sugar (g/100g) | 11.60 | Not detected |
| Ash (g/100g) | 2.02 | 1.74 |

### *Microorganisms*

Microorganisms of ready-to-eat- healthy chinese fish sausage are showed in Table 8. The results showed that total plate count, yeast and mold, *Staphylococcus aureus*, *Escherichia coli* and *Salmonella* spp. were not found in ready-to-eat- healthy chinese fish sausage

**Table 8.** Microorganisms of ready-to-eat- healthy chinese fish sausage

| Microorganism | Count |
|---|---|
| Total plate count (CFU/g) | <10 |
| Yeast and Mold (CFU/g) WHICH SPECIES ??? | <10 |
| *Staphylococcus aureus* (CFU/g) | <10 |
| *Escherichia coli* (MPN/g) | < 3 |
| *Salmonella* spp. (CFU/25g) | Not detected |

## Discussion

### *Replacement of sodium chloride with potassium chloride*

The replacement of salt with potassium chloride resulted in a decrease of free water content. It was due to salt or sodium chloride had more water holding properties than potassium chloride, so free water content is reduced when sodium chloride is reduced (Thumthanaruk and Teerapornkittikul, 2018). According to the research of Wilailux and Sriwattana (2010), the replacement of sodium chloride with potassium chloride resulted in a reduction in moisture content of Frankfurter sausage products. For the hardness and toughness values, the results showed that the replacement of sodium chloride salt with potassium chloride resulted in a significant increase of the hardness of the product due to the use of potassium chloride results in a decrease of the water holding capacity of the product. Decreasing moisture content of the product affects the texture and increases the hardness of the product (Wilailux and Sriwattana, 2010).

In conclusion, the replacing salt with potassium chloride at a 50:50 ratio did not affect consumer acceptance. However, when the potassium chloride ratio was increased to 75%, the overall taste preference score and overall preference score were decreased. It was due to potassium chloride had a bitter taste, so excessive substitution can affect consumer acceptance. Therefore, a 50:50 salt replacement with potassium chloride was selected as it was the highest substitute and still accepted by consumers to study the type and quantity of the sweetener substitute. The replacement of 100% sugar with sweeteners resulted in a significant reduction in the free content of the product ($p \leq 0.05$) due to the small molecule of the sweetener and the ability to bind to free water. There was no significant difference in the pH of the control sample and products using the sweetener substitute. It indicated that the use of sweeteners had no effect on the pH of chinese fish sausage products. Erythritol used as a sweetener instead of sugar had the highest hardness and toughness. This because erythritol is a sweetener that crystallizes upon cooling, which may affect the texture of the product. The using of isomalt and maltitol does not affect the texture of the product. The use of sweeteners instead of sugar had no effect on consumer acceptance. This is because the use of sweeteners such as Isomalt, Maltitol powder and Erythritol is less sweet than sugar. Therefore, consumers can not be detected of the change in taste. Unlike the use of non-energy sweeteners such as stevia and sucralose, which are 600 times sweeter than sugar and can be perceived by consumers and may have a bitter aftertaste in the mouth. However, maltitol is the lowest cost sugar substitute compared to Isomalt and Erythritol, so maltitol was selected as a sweetener for the benefit of commercialization. Comparison of sodium and sugar content of control sample using 100% sodium chloride and 100% sugar with developed sample using 50% potassium chloride and 100% maltitol, it was found that the sodium content of control formula was 511 mg/100 g. while developed sample using potassium chloride instead of 50% sodium chloride had sodium content of 382 mg/100 g. This indicated that the use of potassium chloride can reduce the sodium content of the product. The sugar content found in the control product using sugar was 11.6 g/100 g. In contrast, developed sample using 100% maltitol substitute for sugar did not detect the sugar content. It has been shown that maltitol, a widely used sugar substitute in food products can be applied to ready-to-eat- healthy chinese fish sausage. The results showed that the product contained all microorganisms, yeast and *Staphylococcus aureus* was less than 3 CFU/g, *Escherichia coli* was less than 3 MPN/g, and *Salmonella* spp. was not found in 25 g samples, which was in accordance with Thai community product standard of dried fish sausage product (TPCS107/2555), which stipulates that all microorganisms must be less than 106 CFU/g, *S. aureus* and yeast fungi must be less than 100 CFU/g, *E. coli* must be less than 3 MPN/g, and *Salmonella* spp. is not found in the 25 g sample.

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