

Properties of Frankfurter-type Sausages with Pork Back-fat Replaced with Bovine Heart Surimi-like Materials

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Abstract

This study investigates the effect of bovine heart surimi-like material (BHSM) used as a back fat replacer, on the physicochemical and sensory characteristics of frankfurter-type sausages. Frankfurter-type sausage with added BHSM had a higher moisture content and lower fat content than the control. In addition, the samples with added BHSM had higher pH, cooking loss and 2-thiobarbituric acid-reactive substance (TBARS) value and lower water exudation than the control. The sausage formulation with 40% BHSM was more effective in delaying lipid oxidation without affecting cooking loss compared to the 60% BHSM treatment sample. Results showed that hardness values increased upon replacement with BHSM, and sausages manufactured with 40% BHSM had higher lightness and lower redness values. Panelists found there were no differences in color, odor, and tenderness scores and the overall acceptability score found that treatment samples containing 20% and 40% BHSM were preferable to the control after storage for 14 d. These results indicate that fat replacement with BHSM was beneficial to the quality of frankfurter-type sausages, and acceptable reduced-fat products can be produced when back fat is replaced with up to 40% BHSM.

Keywords: frankfurter-type sausage, surimi-like material, bovine heart, fat replacer, quality properties

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Introduction

Meat and meat products are important sources of many essential nutrients such as high-quality protein, high available iron, essential fatty acids and B-group vitamins, and contribute a considerable proportion of the dietary intake of nutrients that are essential for optimal growth and development (López-López *et al.*, 2011). However, recent studies have established a likely link between meat and meat products consumption and a higher risk of major chronic diseases (Ferguson, 2010). Furthermore, many consumers believe that excessive consumption of meat and meat products is associated with obesity and various diseases due to their high fat content (Biesalski, 2005). Frankfurter-type sausages are still consumed worldwide despite their bad image (high animal fat content) in terms of their impact on consumer health.

Fat is an important ingredient of processed meat products. Fat stabilizes the solubilized protein gel network and interacts with other ingredients to develop texture, and also helps to prevent shrinkage of the protein during cooking (Brewer, 2012). In addition, fat also plays an important role in development taste and aroma, thus contributing to the sensory quality (Keeton, 1994; Webb and O'Neill, 2008), while some low-fat versions of sausage may be perceived as having a less acceptable texture. Miles (1996) reported that the reduction of fat content in meats to less than 20% can lead to unacceptable product texture, flavor and appearance. The total substitution of fat by water produces an unacceptably soft product with reduced cooking yield and increased purge loss (Claus and Hunt, 1991; Keeton, 1994). The production of low-fat meat products without loss of quality can be achieved through the use of various technologies and ingredients such as proteins (Campbell *et al.*, 1996; Johnson, 2000), vegetable oils (Youssef and Barbut, 2011), carbohydrates (Tomasik, 2004), and gums (Mittal and Barbut, 1994). When using fat replacers, a careful approach is needed in order to achieve the appearance and technological, rheological and sen-

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sory properties required (Tye, 1991).

Surimi is defined as a concentrate of myofibrillar protein obtained after mincing and water washing fresh meat (Park and Morrissey, 2000). Surimi is considered as an intermediate product as it is usually further processed into various other products. Surimi has been added to meat products in an attempt to reduce the fat level (Cavestany *et al.*, 1994). Recently, the manufacturing surimi-like material has increased (Jin *et al.*, 2008). Surimi-like material can be a useful ingredient in the development of low-fat meat products (Choi *et al.*, 2012; Murphy *et al.*, 2004). The slaughter of animals produces a considerable amount of high biological value by-products. The potential exists for the surimi process to be used to upgrade meat by-products for further processing (Whitehead *et al.*, 1993). Surimi-like ingredients from bovine heart can be added to meat products to enhance texture and flavor, and as a result have been used extensively to reduce animal fat content in meat products (Desmond and Kenny, 1998). Some literature citations on the influence of fat substitutes in low-fat meat products have been reported, but only a small amount of research into the utilization of surimi-like materials has been performed, and little information exists on how to increase the maximum allowable level to prepare acceptable meat products, particularly emulsion-type sausages.

Therefore, the objectives of our study were to evaluate the effects of differing levels of bovine heart surimi-like material (BHSM) on the preparation of frankfurter-type sausages, and to determine the replacement level of BHSM that produced the highest consumer acceptability.

Materials and Methods

Preparation of bovine heart surimi-like materials

The bovine heart surimi-like material (BHSM) was manufactured using three washing steps. Fresh bovine hearts (24-h *postmortem*) were obtained from a commercial slaughterhouse. The bovine heart was trimmed to visible fat and connective tissues with knife, and the lean muscle was cut into approximately 2-cm cubes. The lean muscle was ground through a 3-mm-diameter orifice using a mincer. The minced samples were combined with 5 volumes distilled water and homogenized using a Polytron homogenizer (T25-B, IKA Sdn. Bhd., Malaysia) at 8,000 rpm for 30 s. The resulting slurry was filtered through a metal sieve with a 2-mm mesh to remove the connective tissue and re-filtered through cheese cloth. The filtrate was centrifuged at 2,000 g for 20 min, and the super-

natant containing fat and water-soluble proteins was discarded. The residue was washed with 5 volumes distilled water and subjected to final centrifugation at 2,000 g for 10 min and the supernatant was discarded. The final residue used in the experiment.

Sausage formulation and processing

Three independent replicates of each batch were prepared in same ways. Fresh beef, pork lean and pork back-fat were obtained from a local meat processing plant. The beef and pork lean meat was trimmed of any visible fat and connective tissue, and each replicate was ground separately through a 3-mm plate in twice. Prior to incorporation into the sausage batter, the moisture content of BHSM was presented to 85%, and different amounts of BHSM were added with water to provide four different formulations. Four different formulations of frankfurter-type sausages were processed in a pilot plant: 1) without BHSM (control); 2) containing 20% BHSM; 3) containing 40% BHSM; and 4) containing 60% BHSM. In the formulation of frankfurter-type sausages manufactured with 20%, 40%, and 60% BHSM of the pork back-fat were replaced. The ingredient composition of the frankfurter-type sausages is presented in Table 1.

For each batch of frankfurter-type sausages, all ingredients were mixed and homogenized in a silent cutter (AS-30, Ramon, Spain). All added ingredients were mixed for 5 min and maintained at a final temperature below 15°C. The emulsified sausage batter was stuffed into cellulose casings (approximate diameter of 40 mm) using a stuffer (H15, TALSA, Spain). The sausages were then held for 24 h at 4°C to allow the ingredients to equilibrate. Sausage samples were then cooked for 60 min at 80°C to an internal temperature of 75°C in a chamber (750-TH-11 Cook & Hold oven, Alto-Shaam, USA). After cooking, sausage samples were cooled to 4°C, packaged in oxygen-permeable bags (polyethylene, 26.8×27.9 cm, 2 mm, Thai Griptech Co. Ltd., Thailand), and stored at 4°C for 1 or 14 d. Proximate composition, cooking loss, emulsion stability, pH, color, texture profile analysis, and TBARS were determined after storage for 1 d, and sensory characteristics were analyzed after 1 and 14 d.

Proximate composition measurement

The proximate composition analysis of the frankfurter-type sausage, including moisture, crude protein, crude fat and crude ash, was performed according to AOAC methods 950.46 (oven air-drying), 992.15 (Kjeldahl nitrogen), 985.15 (ether-extractable component), and 920.153 (muf-

Table 1. The basic formulation of sausage batter

Ingredient (%)	Treatments ¹⁾			
	Control	T1	T2	T3
Pork lean	49.00	49.00	49.00	49.00
Beef lean	21.00	21.00	21.00	21.00
BHSM ²⁾	0.00	3.00	6.00	9.00
Moisture in BHSM	0.00	2.55	5.10	7.65
Water (Ice)	12.30	9.75	7.20	4.65
Pork fat	15.00	12.00	9.00	6.00
Salt	1.50	1.50	1.50	1.50
Phosphate	0.20	0.20	0.20	0.20
Sugar	0.50	0.50	0.50	0.50
Pepper	0.10	0.10	0.10	0.10
Garlic powder	0.40	0.40	0.40	0.40
Total	100.00	100.00	100.00	100.00

¹⁾Control: without BHSM; T1: sausage batter added with BHSM at 20% level; T2: sausage batter added with BHSM at 40% level; T3: sausage batter added with BHSM at 60% level. ²⁾BHSM: bovine heart surimi-like materials.

fle furnace) for sausage (AOAC, 2000).

pH measurement

The pH was measured using a digital pH meter (MP 230, Mettler Toledo, Switzerland). Approximately 3 g of cooked sausage sample was added to distilled water (27 mL). A slurry was then made using a polytron homogenizer (T25-B, IKA, Malaysia) and the pH measured. The pH meter was calibrated daily using standard buffers of pH 4.0, 7.0 and 9.0 at 25°C.

Cooking loss measurement

The yield due to cooking was determined for each treatment-replication combination. Weight of uncooked and cooked sausages was recorded (Boles and Swan, 1996). The cooking loss was calculated as follows:

$$\text{Cooking loss (\%)} = \frac{[\text{uncooked weight (g)} - \text{cooked weight (g)}] / \text{uncooked weight (g)} \times 100$$

Emulsion stability measurement

Emulsion stability was determined using the methodology proposed by Jiménez-Colmenero *et al.* (2005) with some modifications. Raw batter (25 g) was transferred into a centrifuge tube. The samples were heated in a boiling water bath for 30 min at 70°C followed by centrifugation at 1,000 rpm for 10 min. The total amount of fluid released was expressed as a percentage of the original weight. The content of released fat was determined from the difference in the total liquid released after drying at 105°C for 16 h.

Color measurement

Color was assessed on the cut surface of the cooked sausages using a Minolta Chromameter CR-300 (Minolta Co., Japan) standardized with a white plate ($Y=93.5$, $X=0.3132$, $y=0.3198$). Five replicate measurements were taken and results were expressed as CIE (Commission International de l'Eclairage) L^* , a^* , and b^* .

Lipid oxidation measurement

Thiobarbituric acid-reactive substances (TBARS) content of the sausage samples from each treatment was determined using the TBARS method (Buege and Aust, 1978). The sausage sample homogenate (2 mL) was transferred to a disposable test tube (13×100 mm), and Dibutyl hydroxyl toluene (10%, 50 μ L) and thiobarbituric acid/trichloroacetic acid (TBA/TCA) solution (4 mL) were added. The sample was mixed using a vortex mixer, and then incubated in a boiling water bath for 15 min to develop the color. The sample was analyzed at 531 nm against a blank containing 2 mL of deionized distilled water and 4 mL of TBA/TCA solution. The amounts of TBA were expressed as mg of malondialdehyde (MDA) per kg of sample.

Texture profile analysis (TPA)

TPA was performed using an Instron Universal Testing Machine (Model 3343, Instron, MA). Three cooked sausage cores (diameter 2.5 cm, height 2.0 cm) per treatment were axially compressed to 70% of their original height. Force versus time curves were obtained using a 98-N load cell applied at a crosshead speed of 100 mm/min. The textural attributes of hardness, cohesiveness, springiness,

gumminess and chewiness were calculated from the curve (Bourne, 1978).

Sensory evaluation

Sausage samples from each treatment were evaluated by an 8-member trained, expert descriptive attribute sensory panel at Gyeongsang National University. The panelists were selected and trained according to the procedures of Jung *et al.* (2012) as modified by Meilgaard *et al.* (1999). Panelists were given samples representing anchor points for each attribute, and training sessions using emulsion-type sausages with or without BHSM in the meat lab. The panelists were trained using a 5-point scale (“5=extremely intense” and “1=slightly intense”) for emulsion-type sausage color, cooked sausage flavor, and texture attributes (hardness and juiciness). Final anchor point ratings were decided upon by the training panel after initial evaluation and discussion. They were trained with emulsion-type sausage products for 2 wk on the product characteristics to be evaluated. Cold water was also provided for rinsing their mouths before each sample was tested.

Panelists evaluated the samples in terms of color, flavor, odor, juiciness, tenderness and overall acceptability using a 9-point hedonic scale, where 1=“dislike extremely” and 9=“like extremely,” as described by Meilgaard *et al.* (1999). The samples were placed in glass containers (Pyrex®, Charleroi, PA) with plastic covers before the sensory test. Each panelist received at least 2 cubes per sample and evaluated 8 randomly ordered samples (with/without BHSM) per day (day 1 or day 14).

Statistical analysis

The experiment had to three replications. Data was analyzed by the procedures of generalized linear model (GLM) of SAS (2014) Tukey’s multiple range test was used to compare the mean values of treatments. Mean values and standard error of the means (SEM) were reported. In case

of sensory data was analyzed by the two-way analysis of variance (GLM) was used to evaluate the significance of differences of the obtained data, mean values and standard deviations were reported. Statistical significance for all comparisons was made at $p<0.05$.

Results and Discussion

Proximate composition and pH

The proximate compositions and pH of frankfurter-type sausage are presented in Table 2. The ash contents showed no significant differences among the sausage samples. However, as expected, the treatments differed significantly with respect to their levels of moisture, protein, and fat. The moisture content was higher in the samples with 40% BHSM (T2) and 60% BHSM (T3) than the control ($p<0.05$). Compared to the control, 40% BHSM (T3) had a significantly lower protein content due to the added BHSM ($p<0.05$). The fat content was also lower in the samples with 40% BHSM (T2) and 60% BHSM (T3) than the control ($p<0.05$). The replacement of animal back-fat with BHSM was expected to decrease the total fat content in the sausage batters. Desmond and Kerry (1998) reported that a decrease in the protein content of frankfurter sausages from the addition of surimi-like extracts from bovine heart. However, Choi *et al.* (2012) obtained similar results in pork patties, with the addition of surimi-like materials from porcine muscle leading to increased protein content and reduced total fat content. Similar results were also found in ham pâté with added isolated plasma and globin (Viana *et al.*, 2005).

The pH values of frankfurter-type sausages were higher in the samples with added 40% BHSM (T2) and 60% BHSM (T3) than the control ($p<0.05$). Seo *et al.* (2015) obtained similar results in pork sausages, where pork was replaced with chicken breast and surimi levels increased pH values. Myofibrillar tissues such as myosin and actomyosin are dramatically influenced by pH and an increase

Table 2. Proximate composition (%) and pH of frankfurter-type sausages in added bovine heart surimi-like materials

	Treatments ¹⁾				SEM ²⁾
	C	T1	T2	T3	
Moisture	57.34 ^B	55.74 ^B	61.23 ^A	61.22 ^A	0.75
Fat	17.64 ^A	16.96 ^A	12.97 ^B	12.35 ^B	0.72
Protein	19.79 ^A	19.73 ^A	19.38 ^A	18.45 ^B	0.21
Ash	2.62	2.63	2.54	2.66	0.02
pH	6.24 ^B	6.29 ^{AB}	6.32 ^A	6.30 ^A	0.01

^{A,B}Means with different superscript in the same row significantly differ at $p<0.05$.

¹⁾Control: without BHSM; T1: sausage added with BHSM at 20% level; T2: sausage added with BHSM at 40% level; T3: sausage added with BHSM at 60% level. ²⁾Standard error of the means ($n=3$).

in gel pH led to an increase in water-holding capacity (Kristinsson and Hultin, 2003).

Physicochemical properties

The physicochemical properties of frankfurter-type sausages are presented in Table 3. The lightness and redness values were not significantly different among all sausage samples ($p>0.05$). However, frankfurter-type sausages in T2 had a higher lightness value than the other samples, and the measured redness and yellowness were also lower in the T2 sample. Jin *et al.* (2007) suggested that surimi-like material has high whiteness and lightness due to the removal of pigments, including myoglobin. Desmond and Kerry (1998) also reported a decrease in the lightness and redness values of frankfurter sausages due to the addition of surimi-like material. Therefore, manufactured frankfurter-type sausages containing 40% BHSM showed increased lightness and decreased redness value in the present study.

The T3 treatment sausage exhibited a higher cooking loss than the control ($p>0.05$), whereas no significant differences were detected among the control, T1, and T2 frankfurter-type sausages ($p<0.05$). In general, cooking loss was used to measure of the lost juices amount during cooking. Desmond and Kerry (1998) reported that up to 15% of a surimi-like material from bovine heart may be employed in the preparation of frankfurter sausage formulations without increasing cooking loss. Based on the results of our study, 40% BHSM may be used in sausage formulations without affecting cooking loss.

Lipid oxidation is closely related to fat level and the higher the amount of fat and unsaturated fatty acids present, the greater the TBARS value obtained (Tang *et al.*, 2001). The TBARS value was higher in the treatment with 60% BHSM (T3) than the control ($p<0.05$). However, no significant difference was observed between the 20%

BHSM (T1) and 40% BHSM (T2), when compared to the control. Ahmad and Srivastava (2007) observed that the TBARS value was not significantly affected by the addition of heart. On the other hand, pork sausages in which the pork is replaced with chicken breast and surimi displayed increased TBARS values (Seo *et al.*, 2015). TBARS values were usually below 0.7-1.0 mg malondialdehyde/kg meat, and taste with fat oxidation of acid deterioration would be affected in sensory evaluation tests when reaching levels above 1.0 mg malondialdehyde/kg meat (Ockerman and Kesh, 1982).

Table 3 shows the effects of adding BHSM on the emulsion stability of frankfurter-type sausages. Fat exudation showed no significant differences among the sausage samples. However, T2 and T3 sample groups had the lowest water exudation, and therefore, the highest emulsion stability. Faria *et al.* (2015) obtained similar results in bologna-type sausages, where the replacement of pork back-fat with pork skin and amorphous cellulose increased emulsion stability, and the higher emulsion stability observed in treatment samples can be attributed to the high amorphous cellulose content. Therefore, a high amount of BHSM has the ability to interact with proteins, forming a more gel-like matrix, and preventing the exudation of water (Anderson and Berry, 2001). These results were expected since proteins are used as fat replacers due to their ability to bind water and emulsify fat droplets.

Texture profile analysis

The texture profile analysis of frankfurter-type sausages are presented in Table 4. The hardness value was higher in the treatment samples T2 and T3 than the control ($p<0.05$), and the hardness of the frankfurter-type sausages gradually increased with the increasing amount of BHSM. The cohesiveness value was higher in T1 than the control sample ($p<0.05$). In comparison to the control, all treat-

Table 3. Physicochemical properties of frankfurter-type sausages in added bovine heart surimi-like materials

	Treatments ¹⁾				SEM ²⁾	
	C	T1	T2	T3		
Lightness (L^*)	68.56 ^A	67.43 ^A	69.69 ^A	67.37 ^A	0.35	
Redness (a^*)	7.08 ^A	7.26 ^A	6.81 ^A	7.52 ^A	0.11	
Yellowness (b^*)	12.51 ^{AB}	12.98 ^A	12.20 ^B	12.61 ^{AB}	0.09	
Cooking yield (%)	13.69 ^B	13.86 ^B	14.09 ^{AB}	15.26 ^A	0.21	
TBARS (mgMDA/kg)	0.13 ^B	0.14 ^B	0.17 ^B	0.22 ^A	0.02	
Emulsion stability	Water exudation (%)	7.45 ^A	6.77 ^A	4.54 ^B	3.78 ^B	0.58
	Fat exudation (%)	0.50	0.39	0.32	0.27	0.06

^{A,B}Means with different superscript in the same row significantly differ at $p<0.05$.

¹⁾Control: without BHSM; T1: sausage added with BHSM at 20% level; T2: sausage added with BHSM at 40% level; T3: sausage added with BHSM at 60% level. ²⁾Standard error of the means ($n=3$).

Table 4. Texture profile analysis of frankfurter-type sausages in added bovine heart surimi-like materials

	Treatment ¹⁾				SEM ²⁾
	C	T1	T2	T3	
Hardness (kg)	0.29 ^B	0.30 ^B	0.34 ^A	0.35 ^A	0.00
Cohesiveness	0.54 ^B	0.60 ^A	0.58 ^{AB}	0.57 ^{AB}	0.01
Springiness	1.04 ^{AB}	1.08 ^A	1.05 ^{AB}	1.02 ^B	0.01
Gumminess	0.16 ^C	0.18 ^B	0.20 ^A	0.20 ^A	0.00
Chewiness	0.17 ^B	0.19 ^A	0.21 ^A	0.20 ^A	0.00
Adhesiveness	0.12 ^B	0.13 ^B	0.14 ^A	0.14 ^{AB}	0.00

^{A,B}Means with different superscript in the same row significantly differ at $p < 0.05$.

¹⁾Control: without BHSM; T1: sausage added with BHSM at 20% level; T2: sausage added with BHSM at 40% level; T3: sausage added with BHSM at 60% level. ²⁾Standard error of the means ($n=3$).

ment samples had a significantly higher gumminess value due to BHSM addition ($p < 0.05$), and the chewiness value was higher in T2 and T3 than the control ($p < 0.05$).

Fat positively influences the water-binding capacity and textural properties of meat products. The reduction of fat can lead to unacceptable textures and sensory properties (Keeton, 1994). In the present study, the replacement of back-fat with BHSM could explain the observed harder texture properties of the frankfurter-type sausages. However, Viana *et al.* (2005) reported a decrease in the hardness of ham pâté from the addition of globin and plasma as fat replacers. Yang *et al.* (2007) also reported that pork sausage containing hydrated oatmeal and tofu displayed a reduced hardness when compared to the low-fat control. The use of surimi-like material as a protein additive in an emulsion sausage formulation led to a reduction in hardness (Desmond and Kerry, 1998). In another study, the presence of texture-modifying extenders may reduce binding among proteins rather than the water-binding property of the extenders (Kerry *et al.*, 2005).

Sensory evaluations

The changes in sensory evaluation in frankfurter-type sausages with added BHSM during storage at 4°C are presented in Table 5. The odor scores increased during storage for 14 d in the T2 and T3 samples, and the juiciness score decreased after 14 d in the control sample ($p < 0.05$). On day 1, there was no difference in color, flavor, odor and tenderness score between the control and treatment samples ($p < 0.05$). However, the juiciness and overall acceptability scores of the frankfurter-type sausages with 60% BHSM (T3) were lower than those of other samples. On day 14, the flavor score was lower in the treatment samples T2 and T3 than the control ($p < 0.05$). The T3 sample displayed a lower juiciness score compared to the control ($p < 0.05$). There was no difference in the overall acceptability, but control was high score than other

Table 5. Changes in sensory evaluations in added bovine heart surimi-like materials of frankfurter-type sausage during storage period at 4°C

Treatments ¹⁾	Storage periods (d)		
	1	14	
Color	C	4.40±0.89	4.50±1.00
	T1	5.00±0.71	4.25±1.26
	T2	5.40±1.23	5.00±0.82
	T3	5.20±0.84	4.70±1.00
Flavor	C	5.00±1.83	5.00±0.87 ^A
	T1	5.25±0.96	4.80±1.10 ^{AB}
	T2	5.25±0.50	4.20±0.30 ^B
	T3	4.75±0.50	3.60±0.89 ^B
Odor	C	2.40±1.52	3.75±1.22
	T1	2.60±1.14	3.25±1.06
	T2	2.20±0.84 ^b	4.25±0.71 ^a
	T3	2.40±0.55 ^b	4.50±0.92 ^a
Juiciness	C	6.80±1.14 ^{Aa}	5.00±1.16 ^{Ab}
	T1	5.20±1.10 ^{AB}	4.85±0.82 ^{AB}
	T2	5.40±1.52 ^{AB}	4.25±0.89 ^{AB}
	T3	4.40±0.55 ^B	3.50±0.58 ^B
Tenderness	C	5.40±1.82	5.00±1.83
	T1	4.60±0.89	4.75±1.50
	T2	5.60±1.14	4.25±1.26
	T3	4.80±1.30	4.25±1.71
Overall acceptability	C	6.60±0.89 ^A	5.75±1.50
	T1	6.20±0.84 ^{AB}	5.00±0.82
	T2	5.75±0.50 ^{AB}	4.60±0.58
	T3	4.40±0.55 ^B	4.00±0.86

^{A,B}Means with different superscript in the same column significantly differ at $p < 0.05$. ($n=8$)

^{a,b}Means with different superscript in the same row significantly differ at $p < 0.05$. ($n=8$)

¹⁾Control: without BHSM; T1: sausage added with BHSM at 20% level; T2: sausage added with BHSM at 40% level; T3: sausage added with BHSM at 60% level.

Based on a 9-point intensity scale (1=dislike extremely or extremely light/bland/tough/dry; and 9=like extremely or extremely dark/intense/tender/juice).

treatments. Choi *et al.* (2012) reported that sensory characteristics are increased by the addition of 10% or 20%

surimi-like material from pork muscle. Desmond and Kerry (1998) also reported that the addition of 7% or 10% surimi-like material from bovine heart significantly affected product tenderness and overall acceptability. However, several studies have found similar results for low- and reduced-fat products, with these leading to unacceptable product palatability. There were no significant differences in sensory acceptability between pork sausage with 30% fat and low-fat pork sausage with 6.3% fat and 25.3% surimi (Murphy *et al.*, 2004).

In present study, a slight reduction in flavor scores was observed in the samples that had back-fat replaced with BHSM. Furthermore, a significant reduction in overall acceptability scores was observed in the T3 where back-fat was replaced with BHSM. Because BHSM was odor, but all treatments did not significantly differ from the results of overall acceptability obtained after 14 d ($p < 0.05$). Therefore, our study demonstrated that acceptable frankfurter-type sausages can be produced when back-fat is replaced with up to 40% BHSM.

Conclusion

From the results of this study, we found that BHSM can be used as a fat replacer, similar the quality characteristics of reduced-fat frankfurter-type sausages. Because sausages with added BHSM had a higher moisture content and lower fat content compared to the control. Replacement with BHSM resulted in higher pH and lower water exudation values. In particular, frankfurter-type sausages with 40% BHSM had a lower fat content, cooking loss, water exudation and lipid oxidation than sausages with 15% back fat. Additionally, manufactured frankfurter-type sausages with 40% BHSM added displayed increased lightness and decreased redness values. A slight reduction in sensory characteristics was observed in the treatments where back-fat was replaced with BHSM, but no change in the juiciness and overall acceptability scores was found in frankfurter-type sausages with 40% BHSM added. These results indicate that fat replacement with BHSM was beneficial to the quality of frankfurter-type sausages, and acceptable reduced-fat products can be produced when back fat is replaced with up to 40% BHSM.

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