

## Physical and Sensory Properties of Low Fat Sausage Amended with Hydrated Oatmeal and Various Meats

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### Abstract

Low-fat sausages were prepared with various meats to investigate the effect of the addition of oatmeal at 10% as a fat substitute. The sausages were made with beef, pork and chicken after trimming the visible fat, and the physical and sensory properties of the sausages were evaluated. Beef sausage had the lowest cooking yield and the highest hardness, while chicken sausage showed the opposite properties. The addition of oatmeal resulted in sausage products with less cooking loss and softer texture for all types of meat sausages. Such changes were more pronounced for beef low-fat sausage than for the other types of sausages. The results of moisture absorption suggested that the difference in cooking yield and hardness among sausage products was due to the water-retention properties of different meats and the substitute in response to heat treatment. Sensory evaluation indicated that the greatest overall acceptability of the sausage products were obtained from 10% oatmeal-added pork sausage and that the addition of oatmeal led to better acceptability for all types meat sausages.

**Key words:** low-fat sausage, sausage quality, fat substitute, oatmeal

### Introduction

Fat in processed meat products contributes functional and organoleptic characteristics, and plays an important role in the formation of stable meat emulsions (Hughes *et al.*, 1996). In manufacturing low-fat meat products, reducing the fat content to a certain level without any other alterations results in an increase in toughness of the product (Barbut and Mittal, 1989; Hong *et al.*, 2004). The reduction of fat content in finely ground meats to <20% can lead to unacceptable product texture, flavor and appearance (Miles, 1996). In addition, removal of fat from meat products can result in greater cooking loss and lower water holding capacity (Chin *et al.*, 2004a) with a subsequent decrease in product yield and lower profitability (Yoo *et al.*, 2007).

Fat replacements or substitutes are ingredients that contribute a minimum of calories to formulated meats and alter flavor, tenderness, mouth feel, viscosity and other

sensory and processing properties (Cengiz and Gokoglu, 2007). The direct replacement of fat with ingredients is an attractive alternative to fat reduction due to the functional and nutritional properties that the ingredients may impart. Many substitutes are used for partial replacement of the fat and may include the use of leaner meats, added water (Chin *et al.*, 2004b; Sylvia *et al.*, 1994), protein-based substitutes (Riisom, 1991), carbohydrate substitutes (Giese, 1992), vegetable and plant oils (Paneras and Bloukas, 1994), synthetic compounds (Keeton, 1994) and oat fibre/products (Chang and Carpenter, 1997; Yang *et al.*, 2007).

Oat and oat constituents have received increased consideration for use in low-fat products due to their functional and nutritional qualities. Oat grains contain 39-55% starch, 20-38%  $\beta$ -glucan and other dietary fiber and 8-16% protein (Lasztity, 1998). Fat replacers and substitutes achieve their texture function mainly by stabilizing substantial quantities of water in a gel-like matrix, resulting in lubricant and flow properties similar to those of fats. Both protein and starch can serve as water binding agents and, as such, can help retain moisture and juiciness that decline when the fat level is increased (Kerr *et al.*, 2005). Many of the characteristics of oat products such as

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water absorption could potentially benefit products like fat-free frankfurters and low-fat bologna. For example, improved cooking yields from the addition of oats to frankfurters have been reported (Hughes *et al.*, 1996). Also, sensory evaluations have indicated that the greatest overall acceptability in a low fat pork sausage is attained when hydrated oatmeal is included at 15% (Yang *et al.*, 2007). Oats are considered an excellent source of soluble fiber that has shown to be effective in reducing dietary cholesterol. In addition, oats are of particular interest as an ingredient since they may help to control obesity, hypertension, diabetes and heart disease (Feng and Xiong, 2002). Specifically, foods containing  $\beta$ -glucan and other soluble oat fibers may qualify under Food and Drug Administration healthy heart claims.

Numerous studies have evaluated meat products that are manufactured using meat from several species, including beef, pork, and poultry. The objectives of this research were to evaluate the characteristics of low-fat sausages prepared with beef, pork, and chicken, and to investigate the relationship between water binding properties of fat substitutes and changes in physical and sensory properties of low-fat sausages. The physical and sensory properties of sausage formulated with 10% added hydrated oatmeal containing fat levels were investigated. In addition, the influence of these factors on texture and water-holding attributes were assessed.

## Materials and Methods

### Sausage preparations

Fresh lean beef, pork, and chicken (initial pH 5.5-5.8 $\pm$ 1) were obtained at 48 h post-slaughter from a local market. Excess fat and connective tissue were trimmed

from the meats and the meats were minced through a 5 mm plate using a model MGB-32 grinder (Hankookfuji, Korea) in a cold room at 4°C. Prior to incorporation into the sausage batter, the moisture content of each all meat type was adjusted to 65%, and oatmeal was added with water to provide a final moisture content of 65%. These steps were taken to ensure that any differences observed for the added oatmeal would not be biased by different moisture contents. Three replicates were produced at each factor/level. Oatmeal (1,000 g) was mixed with distilled water (2,300 g) and soaked for 24 h prior to use. Finely minced sausage batches were prepared in a cold room at 4°C; the formulation of each batch is summarized in Table 1. Hydrated oatmeal (10% w/w) was added to the treatment sausages; control sausages not amended with oatmeal were prepared from each batch. For each batch of sausage, meat, oatmeal, and other ingredients were mixed and homogenized in a model AS-30 cutter (Ramon, Spain), with the final temperature maintained below +13°C. After cutting, the sausages were stuffed into synthetic cellulose casings (30 mm approximate diameter) using a model H15 stuffer (TALSA, Spain). The sausages were held for 24 h at 4°C to allow for the ingredients to equilibrate. Samples were then cooked for 30 min in a model SAA10 steam chamber (Absury, Germany) until the center temperature of the sausages reached 80°C.

### Proximate analysis and cooking yield

Moisture (AOAC 950.46), crude protein (AOAC 992.15), and crude fat (AOAC 985.15) contents were determined according to AOAC methods (AOAC, 2000). The moisture, protein, and fat parameters of minced sausage samples were determined in triplicate. The weight of each sausage was recorded before and after cooking to deter-

**Table 1. Formulations of sausage blends with different meat species, hydrated oatmeal, and other ingredients**

Ingredients	Treatments <sup>1)</sup>					
	B (g)	P (g)	C (g)	BO (g)	PO (g)	CO (g)
Lean beef <sup>2)</sup>	2,000	-	-	1,800	-	-
Lean pork	-	2,000	-	-	1,800	-
Lean chicken	-	-	2,000	-	-	1,800
Hydrated oatmeal				200	200	200
Salt	34	34	34	34	34	34
Con syrup solids	30	30	30	30	30	30
Sodium tripolyphosphate	6	6	6	6	6	6
Spice/seasoning	7.5	7.5	7.5	7.5	7.5	7.5
Sodium erthorbate	0.8	0.8	0.8	0.8	0.8	0.8
Sodium nitrite	0.1	0.1	0.1	0.1	0.1	0.1

<sup>1)</sup>B, beef sausage batch; P, pork sausage batch; C, chicken sausage batch; BO, beef sausage batch added with oatmeal at 10% level; PO, pork sausage batch added with oatmeal at 10% level; CO, chicken sausage batch added with oatmeal at 10% level.

mine cooking yield, which was defined as (cooked weight  $\div$  uncooked weight)  $\times$  100.

### Color

Color (CIE  $L^*$ ,  $a^*$ ,  $b^*$ ) was measured using a Minolta CR-400 colorimeter (Minolta, Japan), with measurements standardized with respect to the white calibration plate. Five readings were made from the surface of the cooked samples (CIE, 1986).

### Texture profile analysis (TPA)

TPA was performed in a model 3343 Instron Universal Testing Machine (Model 3343) with a 10 kg load cell. Prior to testing, pre-cooked sausage samples were equilibrated to room temperature for 30 min and were cut into 2.0 cm-thick sections and cored into a 2.5 cm diameter cylinder. The samples were compressed twice at a cross-head speed of 100 mm/min to 70% of their original height using the 3 inch diameter cylindrical plate. From the resulting force/deformation curves, the textural parameters of hardness, cohesiveness, springiness, gumminess and chewiness were calculated (Bourne, 1978). Five specimens each treatments were measured.

### Moisture adsorption capacity (MAC)

MAC values of the meat and oatmeal were determined as previously described (Yang *et al.*, 2007). MAC measurements were conducted using dehydrated beef, pork, chicken, and oatmeal. Prior to dehydration, the samples were prepared with or without heat treatment at 80°C for 30 min. All samples were then frozen at -70°C in a Clean vac 8 apparatus (Biotron, Korea) and freeze-dried over 3-5 d. Dried samples (approximately 1 g each) were placed into polystyrene weighting dishes (2 $\times$ 2 inches, Fisher Scientific, USA) and further dehydrated in a vacuum desiccator over phosphorus pentoxide ( $P_2O_5$ ) for 5-7 d until constant weight was attained. The dehydrated samples were equilibrated at 25°C in sealed chambers over various saturated salt solutions with known relative vapor pressures (RVP):  $P_2O_5$  (0), LiCl (0.11),  $KCH_3$  (0.23),  $MgCl_2$  (0.33),  $K_2CO_3$  (0.43),  $Mg(NO_3)_2$  (0.53), KI (0.69),  $(NH_4)_2SO_4$  (0.81), and  $KNO_3$  (0.93). Equilibrium moisture content (g  $H_2O$ /g solid) was calculated from the weight gain after no further change in weight occurred; triplicate samples from each treatment were measured.

### Sensory evaluations

The sensory panel consisting of students, faculty, and staff of Gyeongsang National University were used to

evaluate the sensory characteristics of the low-fat sausages. Recruitment, selection, and training of panelists were performed according to previously described sensory evaluation procedures (Meilgaard *et al.*, 1999). Eight panelists were screened from 13 potential panelists using a basic taste identification test and were trained using commercial sausage products for 2 wk (30 min sessions per week) to familiarize each individual with the product characteristics to be evaluated. Sausage samples were cooked in an oven as previously described, sliced into pieces, and served warm to the panelists. The panelists evaluated each characteristic of the sample using a 9-point hedonic scale, where one (1) was “dislike extremely” and nine (9) was “like extremely.” To avoid fatigue, the panel was separated into two groups of four with each group evaluating one-half of the samples.

### Statistical analysis

The data were analyzed by analysis of variance (ANOVA) using Statistical Analysis Systems software (SAS, USA). Duncan's multiple range test was used to determine the statistical significance among the means (SAS, 1997) at a 95% significance level. At least three low-fat sausages from each group were analyzed and each sample was tested at least in triplicate.

## RESULTS AND DISCUSSION

### Proximate analysis

Proximate analysis of the sausage batters with/without 10% hydrated oatmeal are shown in Table 2. Moisture contents of the sausage batters ranged from 64.95-66.73%, with no significant difference evident among sausage samples ( $p>0.05$ ). Since moisture content can affect color, texture, and sensory properties of sausage (Ahmed *et al.*, 1990), it was important to ensure that all sausage formulations had the same initial moisture content to ensure that any differences in the physical properties and sensory ratings observed for hydrated oatmeal added low fat sausages would not be biased by different moisture contents. The chicken low-fat sausage was slightly ( $p<0.05$ ) lower in protein content than beef and pork low-fat sausages. Also, the addition of hydrated oatmeal to chicken, beef, and pork low-fat sausages decreased the protein content, resulting in 20.87/100 g, 20.40/100 g, and 20.55/100 g oatmeal added sausages, respectively. After trimming, the fat content of the beef, pork and chicken were about 3.66/100 g, 4.22/100 g, and 3.07/100 g, respectively. Fat content was not changed significantly

**Table 2. Proximate analysis and cooking yield of low fat sausage raw batter with/without hydrated oatmeal**

Treatments	Moisture (%)	Protein (%)	Fat (%)	Cooking yield (%)
Beef <sup>1)</sup>	65.51±1.23	26.47±0.64 <sup>a</sup>	3.66±0.58	88.00±1.01 <sup>c</sup>
Pork <sup>1)</sup>	65.20±1.38	25.76±0.27 <sup>a</sup>	4.22±1.11	90.52±2.58 <sup>bc</sup>
Chicken <sup>1)</sup>	66.73±0.39	24.02±0.26 <sup>b</sup>	3.07±0.50	92.59±2.36 <sup>b</sup>
Beef+10% hydrated oatmeal	64.95±1.44	20.87±0.09 <sup>c</sup>	3.94±0.25	94.45±0.31 <sup>ab</sup>
Pork+10% hydrated oatmeal	66.30±1.12	20.40±0.27 <sup>c</sup>	3.83±0.45	94.13±1.01 <sup>ab</sup>
Chicken+10% hydrated oatmeal	65.95±0.63	20.55±0.31 <sup>c</sup>	2.94±0.60	95.07±0.41 <sup>a</sup>

<sup>a,b,c</sup>Means in the same column with different superscript letters are significantly different ( $p<0.05$ ).

<sup>1)</sup>Control, without hydrated oatmeal.

by the addition of hydrated oatmeal, and fat values ranged from 3.07-4.22 g/100 g and from 2.94-3.94 g/100 g at a 10% addition level. It should be emphasized that the purpose of adding hydrated oatmeal was not to reduce the fat level, but to improve the properties of a reduced fat formulation. Yang *et al.* (2007) reported that fat and protein contents for low-fat pork sausage raw batters are reduced slightly by the addition of oatmeal, and that a higher level of hydrated oatmeal can decrease fat and protein content in sausage raw batter. Also, low-fat sausages display higher moisture and protein contents, and lower fat content of water added than regular-fat sausage (Chin *et al.*, 2004b). One important attribute of emulsion-type sausages and other meat products are the inability to hold moisture and other juices in the product both before and after cooling.

### Cooking yield and color

In this study, cooking yield was used to determine how well juices were retained in the cooked product. The results of cooking yield (Table 2), indicated significant differences among sausage batter samples ( $p<0.05$ ). The chicken low-fat sausage had the highest cooking yield, while beef sausage had the lowest. The addition of oatmeal produced sausage products with less cooking loss for all types of meat sausages. The addition of 10% hydrated oatmeal increased the cooking yield by 6.83%, 3.48%, and 2.61% (over the controls) for the beef, pork,

and chicken low-fat sausages, respectively. The addition of 10% oatmeal to beef sausages increased the cooking yield more when compared with pork and chicken. In a previous study, low-fat pork sausages prepared with 3% oat bran and 7% water had greater cook yields than full-fat varieties (Keeton, 1994). Berry (1997) reported that beef patties containing 8% modified potato starch produce a better cooking yield than control. Hughes *et al.* (1996) obtained similar results in frankfurters with carrageenan or oat fiber added to reduce cooking losses. Pszczola (1991) reported that oat bran or fiber has the ability to retain moisture and prevent meats from drying out when cooked. At higher oat levels and longer cooking times, one would expect an increase in gelatinization of oat starch (Kerr *et al.*, 2005). Although gelatinization results in hydration of the starch, this, apparently, does provide increased resistance to loss of moisture during cooking. In this case, gelatinization takes place during cooking of the starch, and provides more resistance to cooking loss.

Color values of the low-fat sausages with/without 10% hydrated oatmeal are shown in Table 3. Beef low-fat sausage showed lower lightness ( $L^*$ ) and higher redness ( $a^*$ ) values compared to chicken or pork sausage ( $p<0.05$ ). However, with addition of hydrated oatmeal, the  $L^*$  value increased but redness value decreased significantly, compared to controls ( $p<0.05$ ). It has been suggested that grain powders such as rice powder, oatmeal powder, and

**Table 3. Lab color values of low fat sausages with/without hydrated oatmeal**

Treatments	Lightness ( $L^*$ )	Redness ( $a^*$ )	Yellowness ( $b^*$ )
Beef <sup>1)</sup>	50.54±0.70 <sup>f</sup>	17.11±2.71 <sup>a</sup>	9.09±0.18 <sup>d</sup>
Pork <sup>1)</sup>	64.86±0.81 <sup>d</sup>	14.48±1.19 <sup>b</sup>	8.01±0.43 <sup>c</sup>
Chicken <sup>1)</sup>	73.73±0.58 <sup>b</sup>	8.43±0.71 <sup>d</sup>	11.21±0.42 <sup>ab</sup>
Beef+10% hydrated oatmeal	53.23±0.43 <sup>e</sup>	12.57±0.19 <sup>c</sup>	10.98±0.25 <sup>b</sup>
Pork+10% hydrated oatmeal	66.68±0.80 <sup>c</sup>	12.57±0.83 <sup>c</sup>	9.90±0.53 <sup>c</sup>
Chicken+10% hydrated oatmeal	74.91±0.19 <sup>a</sup>	6.54±0.39 <sup>e</sup>	11.51±0.59 <sup>a</sup>

<sup>a,b,c,d,e,f</sup>Means in the same column with different superscript letters are significantly different ( $p<0.05$ ).

<sup>1)</sup>Control, without hydrated oatmeal.

whey powder affect the color of low fat products (Chang and Carpenter, 1997; Hughes *et al.*, 1996; Serdaroğlu, 2006). The latter study reported that whey power can produce a lighter colored low-fat meatball. Also, Hughes *et al.* (1996) suggested that addition of oat fibre can increase lightness and decrease redness of low-fat sausage. The internal color of the cooked products was affected by the oat fibre level. This suggests a slightly lighter product at intermediate oatmeal. In combination, this indicates a shift to a slightly less red and more yellow cooked product at intermediate 10% hydrated oatmeal.

### TPA

The TPA texture attributes for the controls and hydrated oatmeal-added made with different meat species sausages are shown in Table 4. Generally, there were significant differences in texture attributes among all sausage samples with different meat types ( $p<0.05$ ). For example, sausages made with beef showed higher values for hardness, gumminess, and chewiness, while chicken showed the lowest values. On the other hand, hardness, gumminess, and chewiness for beef low-fat sausage with oatmeal decreased while cohesiveness increased. The textural properties of the sausage prepared with beef were most affected by addition of oatmeal.

As expected, beef low-fat sausage had a higher hardness compared to chicken and pork sausages. The control sausages had higher hardness ratings among the sausage samples and the hardness of the sausage samples gradually decreased with the addition of hydrated oatmeal ( $p<0.05$ ). These results indicate that the addition of hydrated oatmeal can be useful in preparing a low-fat sausage with softer textural properties. Cohesiveness is a measure of the degree of difficulty in breaking down the internal structure of the sausages. The addition of hydrated oatmeal produced slight to no difference in cohesiveness. Chicken low-fat sausage had lower cohesiveness compared to beef and pork sausages. Springiness of the sau-

sage samples did differ significantly among the samples but the numerical difference was slight. All types of meat sausage samples were higher in springiness with the addition of oatmeal ( $p<0.05$ ). The chicken low-fat sausage was lowest in gumminess and chewiness than beef or pork sausages. Both gumminess and chewiness decreased significantly with the addition of hydrated oatmeal to the all-meat sausages ( $p<0.05$ ). Such decreases were greater in the hydrated oatmeal-amended sausage than in all types of meat sausages. These results are consistent with previous reports that the addition of oat bran, soy protein, or starch improves the textural properties by decreasing product hardness (Pszczola, 1991; Dawkins *et al.*, (2001). Desmond and Troy (1998) reported that beef burgers containing oat fiber have decreased hardness values when compared to the low-fat control. Troutt *et al.* (1992) suggested that a decrease in the hardness of sausage by the addition of texture-modifying ingredients, such as oat bran and starch, maybe due to the ingredients that help absorb and retain moisture. Kerr *et al.* (2005) suggested that the presence of texture-modifying extenders may reduce the binding ability among proteins rather than the water binding property of the extenders. The influence of texture-modifying agents on hardness associated with the water binding property of the agents is complicated and remains in dispute.

### MAC

To further investigate why different meat types and the addition of oatmeal to sausage mixtures produced lower hardness and higher cooking yield, MAC measurements were taken on dehydrated meat types and oatmeal. The dehydrated samples were prepared with and without heat treatment at 80°C for 30 min. Fig. 1 displays the MAC of dehydrated powdered meat types and oatmeal samples without heat treatment, and prior to dehydration. All samples showed an increase in equilibrium moisture content (EMC) as  $a_w$  values increased from 0.11-0.93; at a low  $a_w$

**Table 4. TPA texture attributes of cooed low fat sausages with/without hydrated oatmeal**

Treatments	Hardness (kg)	Cohesiveness (%)	Springiness (mm)	Gumminess (kg)	Chewiness (kg*mm)
Beef <sup>1)</sup>	0.63±0.08 <sup>a</sup>	56.79±3.93 <sup>b</sup>	14.00±0.10 <sup>d</sup>	35.64±5.04 <sup>a</sup>	498.66±68.63 <sup>a</sup>
Pork <sup>1)</sup>	0.51±0.06 <sup>b</sup>	55.96±2.64 <sup>b</sup>	14.17±0.06 <sup>c</sup>	28.59±2.46 <sup>b</sup>	406.77±31.86 <sup>b</sup>
Chicken <sup>1)</sup>	0.40±0.03 <sup>c</sup>	49.69±3.18 <sup>c</sup>	13.99±0.13 <sup>d</sup>	20.09±2.09 <sup>c</sup>	281.09±28.68 <sup>c</sup>
Beef+10% hydrated oatmeal	0.31±0.04 <sup>d</sup>	61.77±2.24 <sup>a</sup>	14.52±0.06 <sup>a</sup>	14.51±1.93 <sup>d</sup>	233.04±39.20 <sup>d</sup>
Pork+10% hydrated oatmeal	0.28±0.02 <sup>d</sup>	57.77±3.61 <sup>b</sup>	14.41±0.33 <sup>b</sup>	16.12±1.85 <sup>d</sup>	232.16±23.02 <sup>d</sup>
Chicken+10% hydrated oatmeal	0.27±0.02 <sup>d</sup>	49.33±7.15 <sup>c</sup>	14.10±0.45 <sup>c</sup>	15.74±1.63 <sup>d</sup>	221.76±32.87 <sup>d</sup>

<sup>a,b,c,d</sup>Means in the same column with different superscript letters are significantly different ( $p<0.05$ ).

<sup>1)</sup>Control: without hydrated oatmeal.

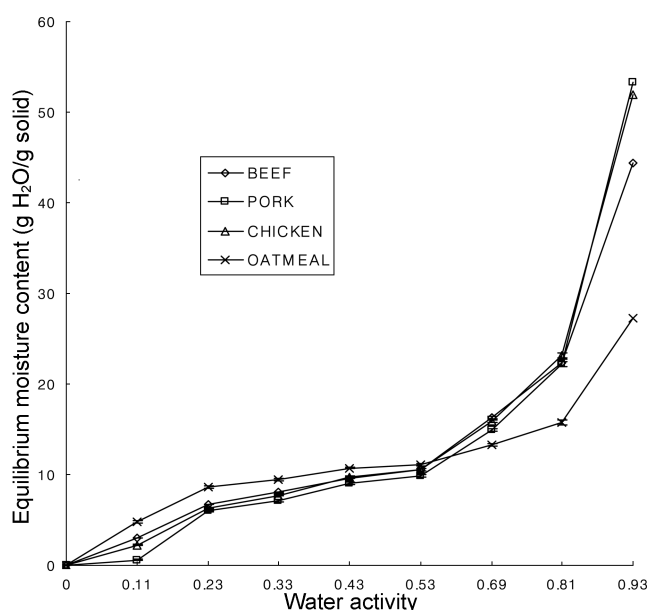


Fig. 1. MAC of dehydrated meat types and oatmeal samples without heat treatment prior to dehydration.

range ( $a_w < 0.69$ ) the equilibrium moisture content (EMC) was in the order of meat types and oatmeal. At a high  $a_w$  range ( $a_w > 0.69$ ), oatmeal showed the lowest EMC. For example, EMC at 0.93  $a_w$  was 0.53 g H<sub>2</sub>O/g solid, 0.52 g H<sub>2</sub>O/g solid, 0.44 g H<sub>2</sub>O/g solid and 0.27 g H<sub>2</sub>O/g solid for pork, chicken, beef, and oatmeal, respectively. This indicates that pork has a higher water binding capacity before heat treatment.

Fig. 2. depicts the MAC of dehydrated powdered meat types and oatmeal samples with heat treatment at 80°C for 30 min prior to dehydration. At a low  $a_w$  range ( $a_w < 0.69$ ), oatmeal had the highest EMC among the samples, while chicken displayed the highest EMC at a high  $a_w$  (0.93). It is of interest that at 0.93  $a_w$ , the EMC of the pork, chicken, and beef by heat treatment decreased from 0.53 g H<sub>2</sub>O/g solid, 0.52 g H<sub>2</sub>O/g solid and 0.44 g H<sub>2</sub>O/g solid to 0.39 g H<sub>2</sub>O/g solid, 0.37 g H<sub>2</sub>O/g solid and 0.35 g H<sub>2</sub>O/g solid, respectively, whereas the EMC of oatmeal retained from 0.27 g H<sub>2</sub>O/g solid to 0.26 g H<sub>2</sub>O/g solid. These results imply that the moisture absorption of different meat types depends on the condition of animal proteins that may be denatured by heating. Therefore, these results suggest that a decrease in hardness by the addition of oatmeal is due to the water binding or water retention property of oatmeal in response to heat treatment. Also, as seen in Fig. 2, at a high  $a_w$  (0.93), chicken had the highest EMC among the meat types, while beef had the lowest EMC. These results suggest that a higher hardness and lower cooking yield in beef low fat sausage is not

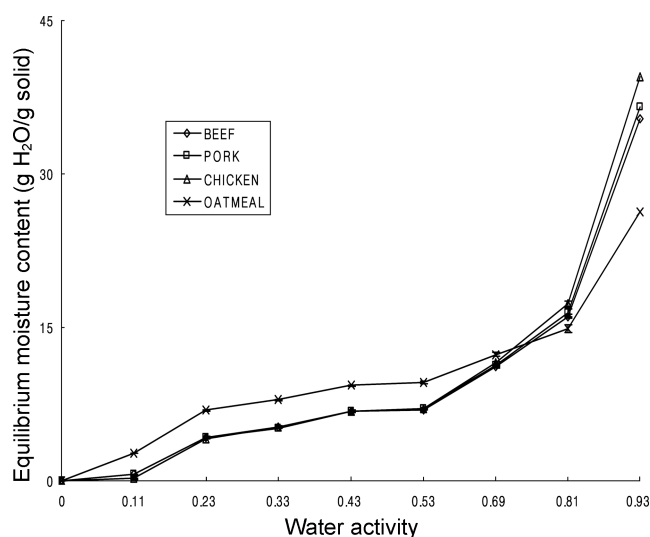


Fig. 2. MAC of dehydrated meat types and oatmeal samples with heat treatment at 80°C for 30 min prior to dehydration.

associated with its water binding property compared to chicken or pork low-fat sausages.

### Sensory evaluation

The sensory panels were convened to assess the effects of the different types of meat and addition of hydrated oatmeal and quantity of these extenders on the color, flavor, texture, and overall acceptability in low fat sausages (Table 5). There were significant differences in color, flavor, tenderness, and acceptability among sausages prepared with different types of meats ( $p < 0.05$ ). The beef sausage had a higher color score compared to chicken and pork sausages. The color of the sausage samples decreased with the addition of hydrated oatmeal, as compared to controls ( $p < 0.05$ ). Flavor scores were improved by the addition of hydrated oatmeal, especially in pork and chicken meat. Tenderness in the sausage products were improved by the addition of hydrated oatmeal, but juiciness was not significantly affected. The overall acceptability scores ranged from 4.03-6.63, with maximum acceptability obtained by addition of hydrated oatmeal in chicken meat. Also, all hydrated oatmeal sausages had higher 1 acceptability scores than the control sausage because of the better flavor and texture characteristics. Several studies have shown that the addition of starch or non-meat proteins (including oat bran) in ground muscle based food products can lead to acceptable products. Huffman *et al.* (1992) demonstrated that lean-pork sausage with 1.5% carageenan can yield better sensory scores for juiciness and tenderness when compared to either low-fat or full-fat controls. Chang and Carpenter

**Table 5. Sensory evaluation of cooked low fat sausages with/without hydrated oatmeal**

Treatments	Color	Flavor	Juiciness	Tenderness	Overall acceptability
Beef <sup>1)</sup>	8.65±1.11 <sup>a</sup>	6.78±2.39 <sup>a</sup>	3.93±1.21	1.98±0.71 <sup>b</sup>	4.03±1.38 <sup>c</sup>
Pork <sup>1)</sup>	6.30±0.57 <sup>b</sup>	5.10±0.86 <sup>ab</sup>	4.63±1.48	1.95±1.09 <sup>b</sup>	4.60±0.96 <sup>bc</sup>
Chicken <sup>1)</sup>	4.20±0.70 <sup>cd</sup>	4.10±1.21 <sup>b</sup>	5.38±1.22	2.15±1.44 <sup>b</sup>	5.28±1.44 <sup>abc</sup>
Beef+10% hydrated oatmeal	7.13±1.93 <sup>ab</sup>	6.53±2.81 <sup>a</sup>	5.98±1.58	4.68±0.44 <sup>a</sup>	5.70±1.12 <sup>ab</sup>
Pork+10% hydrated oatmeal	5.55±0.67 <sup>bc</sup>	5.78±1.44 <sup>ab</sup>	5.60±2.56	4.45±0.67 <sup>a</sup>	5.80±0.71 <sup>ab</sup>
Chicken+10% hydrated oatmeal	3.70±0.98 <sup>d</sup>	5.23±2.35 <sup>ab</sup>	5.58±2.48	4.78±1.57 <sup>a</sup>	6.63±0.53 <sup>a</sup>

<sup>a,b,c</sup> Means in the same column with different superscript letters are significantly different ( $p < 0.05$ ).

<sup>1)</sup> Control, without hydrated oatmeal.

(1997) reported that the addition of water and oat bran enhances product hardness, juiciness, and graininess. The optimum frankfurter formulation was one with 2% added oat bran. Beggs *et al.* (1997) showed that reduced-fat turkey frankfurters prepared with 2.3% starch yield optimum sensory and physical attributes.

The physical and sensory properties of the low-fat sausages manufactured from beef, pork, and poultry were evaluated. Also, the addition of hydrated oatmeal at a level of 10% was also investigated as a fat substitute. Fat and protein contents of trimmed low fat sausages were reduced by the addition of oatmeal. The low-fat sausage from beef showed a lower cooking yield than any other meats. Beef low-fat sausage showed lower  $L^*$  and higher  $a^*$  values compared to chicken or pork sausage. The addition of 10% oatmeal was more effective for increasing cooking yield and decreasing hardness of beef as compared to pork or chicken. The addition of 10% hydrated oatmeal as a fat substitute was more effective for decreasing hardness and increasing cooking yield of beef meat than pork and chicken. Cooking yield and textural properties of a low fat sausage could be improved by addition of oatmeal as a fat substitute. Addition of oatmeal increased tenderness of a low-fat sausage. The oatmeal added low fat sausages improved textural properties such as tenderness compared to different type of meat sausages.

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### References

1. Ahmed, P. O., Miller, M. F., Lyon, C. E., Vaughters, H. M.,

and Reagan, J. O. (1990) Physical and sensory characteristics of low-fat fresh pork sausage processed with various levels of added water. *J. Food Sci.* **55**, 625-628.

2. AOAC (2000) Official methods of analysis. 17th ed. Association of Official Analytical Chemists, Arlington, VA.
3. Barbut, S., and Mittal, G. S. (1989) Influence of  $K^+$  and  $Ca^{++}$  on the rheological properties of reduced-fat sausages containing carrageenan. *LWT-Food Sci. Technol.* **22**, 124-132.
4. Beggs, K. L. H., Bowers J. A., and Brown, D. (1997) Sensory and physical characteristics of reduced-fat turkey frankfurters with modified corn starch and water. *J. Food Sci.* **62**, 1240-1244.
5. Berry, B. W. (1997) Sodium alginate plus modified tapioca starch improves properties of low-fat beef patties. *J. Food Sci.* **62**, 1245-1249.
6. Bourne, M. C. (1978) Texture profile analysis. *Food Technol.* **32**, 62-66, 72.
7. Cengiz, E., and Gokoglu, N. (2007) Effects of fat reduction and fat replacer addition on some quality characteristics of frankfurter-type sausages. *Int. J. Food Sci. Technol.* **42**, 366-372.
8. Chang, H. C., and Carpenter, J. A. (1997) Optimizing quality of frankfurters containing oat bran and added water. *J. Food Sci.* **62**, 194-197.
9. Chin, K. B., Lee, H. L., and Chun, S. S. (2004a) Product characteristics of comminuted sausages as affected by various fat and moisture combinations. *Asian-Aust. J. Anim. Sci.* **17**, 538-542.
10. Chin, K. B., Lee, H. L., Kook, S. H., Yoo, S. S., and Chun, S. S. (2004b) Evaluation of various combinations of pork lean and water added on the physicochemical, textural and sensory characteristics of low-fat sausages. *Food Sci. Biotechnol.* **13**, 481-485.
11. CIE. (1986) Colorimetry. 2nd ed. Commission International del' Eclairage, Publication CIE 15.2. Vienna.
12. Dawkins, N. L., Gagar, J., Cornillon, J. P., Kim, Y., Howard, H., and Phelps, O. (2001) Comparative studies on the physicochemical properties and hydration behavior of oat gum and oat trim in meat-based patties. *J. Food Sci.* **66**, 1276-1282.
13. Desmond, E. and Troy, D. J. (1998) Comparative studies of non-meat adjuncts used in the manufacture of low-fat beef burgers. *J. Muscle Foods* **9**, 221-241.

14. Feng, J. and Xiong, Y. L. (2002) Interaction of myofibrillar and preheated soy proteins. *J. Food Sci.* **67**, 2851-2856.
15. Giese, J. (1992) Development low-fat meat products. *Food Technol.* **4**, 100-108.
16. Hong, G. P., Lee, S., and Min, S. G. (2004) Effects of substitutes level of added water for fat on the quality characteristics of spreadable liver sausage. *Food Sci. Biotechnol.* **13**, 397-402.
17. Huffman, D. L., Mikel, W. B., Egbert, W. R., Chen, C., and Smith, K. L. (1992) Development of lean pork sausage products. *Cereal Food Worlds* **37**, 439-442.
18. Hughes, E., Confrades, S., and Troy, D. J. (1996) Effects of fat level, oat fibre and carrageenan on frankfurters formulated with 5, 12 and 30% fat. *Meat Sci.* **45**, 273-281.
19. Keeton, J. T. (1994) Low-fat meat products. Technological problems with processing. *Meat Sci.* **36**, 261-276.
20. Kerr, W. L., Wang, X., and Choi, S. G. (2005) Physical and sensory characteristics of low-fat Italian sausage prepared with hydrated oat. *J. Food Qual.* **28**, 62-77.
21. Lasztity, R. (1998) Oat grain-A wonderful reservoir of natural nutrients and biologically active substances. *Food Rev. Int.* **14**, 99-119.
22. Meilgaard, M., Civille, G. V., and Carr, B. T. (1999) Sensory evaluation techniques. 3rd ed. CRC Press, Boca Raton, FL. pp. 354.
23. Miles, R. S. (1996) Processing of low fat meat products. Proc. 49th Recip. Meat Conf., Am. Meat Sci. Assoc., Chicago, IL. p. 17-22.
24. Paneras, E. D., and Bloukas, J. G. (1994) Vegetable oils replace pork backfat for low-fat frankfurters. *J. Food Sci.* **59**, 725-733.
25. Pszczola, D. E. (1991) Oat-bran based ingredient blend replaces fat in ground and pork sausage. *Food Technol.* **45**, 60-66.
26. Riisom, T. (1991) Milk proteins as fat replacers. *Scandinavian Dairy Info.* **4**, 28-31.
27. SAS (1997) SAS/STAT Software for PC. SAS Institute Inc., Cary, NC, USA.
28. Serdaroğlu, M. (2006) Improving low fat meatball characteristics by adding whey powder. *Meat Sci.* **72**, 155-163.
29. Sylvia, S. F., Claus, J. R., Marriott, N. G., and Eigel, W. N. (1994) Low-fat, high-moisture frankfurters: effects of temperature and water during extended mixing. *J. Food Sci.* **59**, 937-940.
30. Troutt, E. S., Hunt, M. C., Johnson, D. E., Claus, J. R., Kastner, C. L., and Kroepe, D. H. (1992) Characteristics of low fat ground beef containing texture modifying ingredients. *J. Food Sci.* **57**, 19-24.
31. Yang, H. S., Choi, S. G., Jeon, J. T., Park, G. B., and Joo, S. T. (2007) Textural and sensory properties of low fat pork sausages with added hydrated oatmeal and tofu as texture-modifying agents. *Meat Sci.* **75**, 293-299.
32. Yoo, S. S., Kook, S. H., Park, S. Y., Shim, J. H., and Chin, K. B. (2007) Physicochemical characteristics, textural properties and volatile compounds in comminuted sausages as affected by various fat levels and fat replacers. *Int. J. Food Sci. Technol.* **42**, 1114-1122.

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