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Effects of pork gelatin levels on the physicochemical and textural properties of model sausages at different fat levels

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A B S T R A C T

This study aimed to investigate the effect of various levels of gelatin on physicochemical and textural properties of sausages at two different fat levels. Sausages with two fat levels were manufactured with three levels of pork-skin gelatin powder (0.5, 1.0, and 1.5 g/100 g) and compared to the low-fat control and reference (1.5 g/100 g soy protein isolate). In low-fat sausages, cooking loss (g/100 g) and textural properties increased with increased gelatin level up to 1.5 g/100 g. Expressible moisture (g/100 g) of sausages with 1.5 g/100 g gelatin was lower than those with the control. Regular-fat sausages prepared with 1.5 g/100 g gelatin had lowest cooking loss. However, textural properties were reduced with increased gelatin levels. Sausages prepared with the addition of less than 0.5 g/100 g gelatin powder did not differ from the control in terms of hardness. These results indicated that gelatin might interact with protein and fat in the sausage mixture, depending on the fat levels, resulting in decreases in expressible moisture, and increases in cooking loss and hardness in low-fat sausages, but decreases in cooking loss and textural properties.

1. Introduction

Fat importantly determines major sensory and physicochemical characteristics, such as emulsifying ability and water holding capacity in meat products. Fat contributes to flavor, mouthfeel, appearance, textural properties and increased satiety (Jones, 1996). In addition, it also acts to carry lipophilic flavor compounds and develops the flavor in meat products (Leland, 1997). However, high fat intake can increase the risks of obesity and several cancers. Excess consumption of fat, especially saturated fat, induces high blood pressure and coronary heart disease (McAfee et al., 2010). Thus, the American Heart Association (2006) recommends to limit the intake of saturated fat less than 7 g/100 g of energy for cardiovascular disease risk reduction. Thus, replacement of animal fat by fat-replacer, such as hydrocolloids and non-meat proteins, could produce processed meats with similar characteristics of those of regular-fat products (Chin, Keeton, Longnecker, & Lamkey, 1999). As a fat replacer, hydrocolloids, including carrageenan and konjac flour can be used as a texturizer and for water retention (Jean, 2010; William & Alan, 2010).

Gelatin is a fibrous protein made from collagen. It is an animal by-product extracted from animal bone and hides. It contains a high amount of amino acids, such as glycine, proline and hydroxyproline, which strongly influence the forming of thermos-reversible (Hudson, 1994). Gelatin related hydrocolloid hydrolysates have been used for the manufacture of jelly and various processed foods. The hydrolysate structure changes depends on gelatin concentration, with a low and high gelatin concentration of gelatin resulting in a liquid and a gel, respectively (Brewer, Peterson, Carr, & Mccusker, 2005).

These attributes have prompted the use of gelatin in various food products including meat products. In meat emulsions, gelatin acts as a stabilizer, reducing the loss of fat or water, with an adequate rates of use being 0.5–3.0 g/100 g. In addition, it can produce non-homogenous texture properties during cooking (Stevens, 2010). Doerscher, Briggs, and Lonergan (2003) reported that the inclusion of 10 g/100 g pork collagen (PC) into pork myofibrillar gel resulted in higher water holding capacity and textural firmness as compared to product formed without PC. Pietrasik, Jarmoluk, and Shand (2007) evaluated four non-meat proteins (sodium caseinate, blood protein, soy protein isolate and gelatin) as a water and textural agent. They concluded that the gelation had highest cooking loss and expressible moisture. However, the addition of transglutaminase improved the water

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retension ability of gelatin added pork meat gels. Choe, Kim, Lee, Kim, and Kim (2013) reported that the combination of pork skin, water and wheat fiber at a ratio of 2:2:1 had better emulsion stability in a reduced fat frankfurters (>10 g/100 g fat). The pork skin combination contained 59.07 g/100 g moisture, 11.43 g/100 g protein, 9.56 g/100 g fat and 0.27 g/100 g ash.

The objective of the present study was to investigate the effect of various levels of pork skin gelatin powder on very low-fat sausages (LFSs; <3 g/100 g) and to select the optimum levels of gelatin for the substitution of soy protein isolate (SPI) as a fat replacer. In addition, quality properties of regular-fat sausages (RFSs) as affected by various contents of gelatin powder were also evaluated to derive an optimum the formulation for the manufacture of RFS without quality defects.

2. Materials and methods

2.1. Materials

Fresh pork ham (Landrace x Yorkshire, grade A) and pork back fat were purchased from a local retail meat market (Samho Co., Gwangju, South Korea). The meat was trimmed of all of visible fat and connective tissue, and ground using a grinder (M-12s, Fuji Plant, Busan, Korea) equipped with a 32 mm grind plate. The ground meat was prepared and stored at refrigerator temperature (4 °C ± 1). For the reference (REF), SPI (SUPRO EX45, Solae St. Louise, MO, USA) was hydrated with double distilled water at the ratio of 1:4 using a blender (HM-331, Hanil Electric, Korea) for 1 min. Gelatin powder and extracts from pig skin were provided by Gel-Tech (Model #Gelatin-G, Busan, Korea). The gelatin has a jelly strength of 209 bloom and an 8 mesh particle size.

2.2. Processing the low-fat or regular-fat model sausages

Low-fat model sausages were manufactured with SPI as REF and three levels of pork-skin gelatin powder (0.5, 1.0, and 1.5 g/100 g), and compared to the control (Table 1). The pork meat blocks were mixed with curing and flavoring ingredients using a cutter (HMC-401, Hanil Electric, Korea) for 3 min until completely emulsified, stuffed into 45 mL centrifuge tubes and heated at 75 °C for 30 min in a waterbath (WB-22, Daihan Scientific Co., Ltd., Seoul, Korea) until a temperature of 72 °C was reached in the geometric center. After cooking, sausage samples were chilled in ice water and stored in a refrigerator (4 °C ± 1) until analyzed. RFSs were formulated with approximately 20 g/100 g of pork-back fat with three levels of pork-skin gelatin powder (0.5, 1.0, and 1.5 g/100 g) (Table 2).

Table 1
Low fat sausage formulations (LFSs) containing various levels of gelatin powder.

Ingredients	Amount (g/100 g)				
	REF	CTL1	TRT1	TRT2	TRT3
Meat	60.0	60.0	60.0	60.0	60.0
Water	37.0	37.0	37.0	37.0	37.0
Non-meat ingredients	4.50	3.00	3.50	4.00	4.50
-Salt	1.30	1.30	1.30	1.30	1.30
-Sodium tripolyphosphate	0.40	0.40	0.40	0.40	0.40
-Sodium erythorbate	0.05	0.05	0.05	0.05	0.05
-Cure blend	0.25	0.25	0.25	0.25	0.25
Fat-replacer	2.50	1.00	1.50	2.00	2.50
Konjac + Carrageenan	1.00	1.00	1.00	1.00	1.00
Soy protein isolate	1.50	0.00	0.00	0.00	0.00
Pork skin gelatin	0.00	0.00	0.50	1.00	1.50
Total	101.5	100.0	100.5	101.0	101.5

Treatments: REF, low-fat sausages (LFS) with soy protein isolate (SPI); CTL1, LFS without SPI (1:4); TRT1, LFS with gelatin powder 0.5 g/100 g except the SPI; TRT2, LFS with gelatin powder 1.0 g/100 g except the SPI; TRT3, LFS with gelatin powder 1.5 g/100 g except the SPI.

2.3. pH and color measurements

pH of sausages were measured randomly at five different locations by a direct probe attached to a pH-meter (MP-120, Mettler-Toledo, Greifeense, Switzerland) and average values were calculated. Color values (Hunter Lab) were measured randomly six times internally using a color reader (CR-10, Minolta, Japan), using standard illuminant D65 and 8° observer angle. Before actual measurement, the color value was calibrated with white plate standard (lightness (L) = 95.6, redness (a) = 1.0 and yellowness (b) = 0.2).

2.4. Composition analysis

The proximate composition of samples was measured by dry-oven (moisture content_#950.46), Soxhlet extraction method (fat content_#991.36), and Kjeldahl method (crude protein content_#981.10) according to AOAC (2000).

2.5. Cooking loss (g/100 g)

Cooking loss of sausages in each treatment was determined by weighing chilled samples before and after cooking.

2.6. Expressible moisture (g/100 g)

Approximately 1.5 g of sausage sample was wrapped with three pieces of Whatmann #3 filter paper, and centrifuged at 1660 × g for 15 min (VS-5500, Vision Science Co., Ltd, Korea) according to the modified method of Jauregui, Regenstein, and Baker (1981). Expressible moisture (EM, g/100 g) was calculated by measuring the water escaping to the filter paper wrapping. Results were expressed as the average of four samples for each treatment.

2.7. Texture profile analysis

Sausage samples 13 mm in height and 12.5 mm in diameter were prepared using a puncturing tool. Texture profile analysis was performed using Instron Universal Testing Machine (Model 3344, Canton, MA, USA). Samples were compressed twice to one-quarter of their original height by continuous two-cycle compression. Textural properties of samples were measured with a 500 N load cell for 10 times on randomly selected samples for each treatment. The results were expressed as hardness (N), springiness (mm),

Table 2
Regular fat sausage (RFSs) formulations containing various levels of gelatin powder.

Ingredients	Amount (g/100 g)			
	CTL2	TRT4	TRT5	TRT6
Meat	55.0	55.0	55.0	55.0
Fat	20.0	20.0	20.0	20.0
Water	23.0	23.0	23.0	23.0
Non-meat ingredients	2.00	2.50	3.00	3.50
-Salt	1.30	1.30	1.30	1.30
-Sodium tripolyphosphate	0.40	0.40	0.40	0.40
-Sodium erythorbate	0.05	0.05	0.05	0.05
-Cure blend	0.25	0.25	0.25	0.25
-Pork-skin gelatin	0.00	0.50	1.00	1.50
Total	100.0	100.5	101.0	101.5

Treatments: CTL2, regular-fat sausages (RFS) without gelatin; TRT4, RFS with gelatin powder 0.5 g/100 g; TRT5, RFS with gelatin powder 1.0 g/100 g; TRT6, RFS with gelatin powder 1.5 g/100 g.