EFFECTS OF PORK COLLAGEN AND WHEAT FIBER ON QUALITY PROPERTIES OF REDUCED-FAT SAUSAGE AS A FAT REPLACER

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Abstract – The effect of fat replacing with pre-emulsion of pork collagen and wheat fiber was investigated. The chemical composition, calorie, cooking yield, emulsion stability, texture, and sensory properties of emulsion sausage with pre-emulsion of pork collagen and wheat fiber were measured. Following four treatments were manufactured and analyzed; CON (without pre-emulsion of pork collagen and wheat fiber and has 30% of fat), T1 (10% of fat replaced with pre-emulsion of pork collagen and wheat fiber), T2 (15% of fat replaced with pre-emulsion of pork collagen and wheat fiber), T3 (20% of fat replaced with pre-emulsion of pork collagen and wheat fiber). As a ratio of pre-emulsion of pork collagen and wheat fiber increasing, moisture and protein content increased, while the fat content and calorie of sausages significantly decreased (p<0.05). T2 and T3 had higher cooking yield and more stable emulsion than CON. This study indicates that adding pre-emulsion of pork collagen and wheat fiber as a fat replacer can effectively reduce a fat in emulsion sausage.

Key Words – Collagen, Dietary fiber, Reduced-fat

I. INTRODUCTION

Emulsion sausage has been consumed worldwide since early times as typical processed meat product. Generally, emulsion sausage contains animal fat around 30%. Intake of excessive animal fat, especially, saturated fatty acid, increases risk of obesity, cardiovascular disease, and high blood pressure. However, fat has an important function in meat products such as enhancing the emulsion stability, improving cooking yield, flavor, and tenderness [1, 2]. For these reasons, many studies suggested various kinds of fat replacers which improves the decline of textural and sensory properties of reduced fat sausage [3].

Collagen is known as a ingredient for improving cooking yield and texture of sausage due to their water binding and gelling property [4]. Additionally, dietary fiber can enhance technological properties, such as cooking yield, texture quality [5].

The aim of this study was to evaluate the effect of pre-emulsion formulated with pork collagen and wheat fiber, as a fat replacer, on quality characteristics of reduced-fat sausage.

II. MATERIALS AND METHODS

2.1. *Preparation of pre-emulsion with pork collagen and wheat fiber(PPW)*

The 20% wheat fiber (Central fiber chemical Inc., Seoul, Korea) and 60% ice were homogenized for 1 min in a silent cutter. Then 20% pork collagen powder (Sias., Cheongwon, Korea) was added to the mixture and homogenized for 5 min subsequently.

2.2. *Manufacture of reduced-fat sausage*

The formulation of reduced-fat sausages with pre-emulsion of pork collagen and wheat fiber (PPW) is presented in Table 1. The pork lean meat and back fats were purchased from a local retailer, after 48 h postmortem. All subcutaneous and intramuscular fat and visible connective tissues were removed from the pork lean meat. The pork lean meat and back fat were grinded through a 3 mm plate. The grounded pork lean meat and back fat, PPW, ice, salt, phosphate, and isolated soy protein were emulsified using a silent. After emulsification, the meat batter was stuffed into collagen casings using a stuffer. And the samples were heated at 80 °C for 40 min in a smoker. The cooked sausages were then cooled with cold water and stored at 4 °C until analysis.

2.3. *Chemical compositions*

The chemical compositions of samples were determined using standard AOAC methods [6].

Table 1. Formulations of reduced-fat sausages with different levels of PPW[1)]

(unit, %)

Traits	Treatments			
	CON	T1	T2	T3
Pork meat	50	50	50	50
Pork back fat	30	20	15	10
Pre-emulsion		10	15	20
Ice	20	20(6)[2)]	20(9)	20(12)
Total	100	100	100	100
Pork Collagen	-	(2)	(3)	(4)
Wheat fiber	-	(2)	(3)	(4)
Salt	1.5	1.5	1.5	1.5
ISP[3)]	0.4	0.4	0.4	0.4
Phosphate[4)]	0.2	0.2	0.2	0.2

[1)]PPW : pre-emulsion with pork collagen and wheat fiber
[2)]Figures in bracket means added amount to prepare pre-emulsion
[3)]ISP : isolated soy protein
[4)]Phosphate : sodium tri-polyphosphate

2.4. *Calorie analysis*

Calorie values of cooked sausage samples were determined by measuring the heat of the samples using a Bomb-calorimeter.

2.5. *Cooking yield*

The meat mixture was weighed (80 g) and stuffed into collagen casings and then heat processed at 80 ± 1 °C for 40 min. After cooling for 30 min, the sausages were weighed and the percentage cooking yield was calculated from their weights. The formula was: Cooking yield (%) = [weight of sausage after cooking (g) / weight of sausage before cooking (g)] × 100

2.6. *Emulsion stability*

The meat batters were determined using a modified method adapted from Ensor *et al.* [7]. At the middle of a 15 mesh sieve, pre-weighed graduated glass tubes were filled with batter. The glass tubes were closed and heated for 30 min in a boiling water to a core temperature of 75±1 ºC. They were then cooled to 4 ºC approximately to facilitate the separation of the fat and water layers. The fluid water and fat were measured in milliliters and calculated as percentages of the original weight of the batter.

2.7. *Texture profile analysis (TPA)*

TPA was performed in duplicate on each sample. Samples were cooked as previously described. The cooked sausage was cooled at room temperature for 30 min and the textural properties were measured using a spherical probe (5 diameter), attached to a texture analyzer. The test conditions were as follows: stroke, 20 g; test speed, 2.0 mm/s; and distance, 20.0 mm. Data were collected and analyzed in terms of hardness (N), cohesiveness, springiness, gumminess (N), and chewiness (N).

2.8. *Sensory evaluation*

The cooked sausage samples were evaluated external color, flavor, tenderness, juiciness, warmed-over flavor, and overall acceptability. The samples prepared as previously described were cooled to room temperature at 25±1 ºC and cut and served to the panelists in random order. The sensory evaluation was performed by the panelists under fluorescence lighting. Panelists were instructed to cleanse their palates between samples using water. External color, flavor, tenderness, juiciness, warmed-over flavor, and overall acceptability (1 = extremely undesirable, 10 = extremely desirable) of the samples were evaluated using a 10-point descriptive scale. The trained sensory panel consisted of 12 members from the Konkuk university.

2.9. *Statistical analysis*

An analysis of variance was performed on all the variables measured using the general linear model (GLM) procedure of the SAS statistical package [8]. Duncan's multiple range tests (p<0.05) was used to determine differences between treatment means.

III. RESULTS AND DISCUSSION

Chemical compositions and calorie of emulsion sausages with varying addition level of PPW are presented in Table 2.

As increasing PPW, the moisture and protein contents increased, whereas fat contents and calorie decreased (p<0.05) because pork back fat replaced with PPW. Especially, calorie of T3 is significantly reduced(p<0.05) compared to CON.

Table 2. Chemical compositions and calorie (Kcal/100 g) in reduced-fat sausages with different level of PPW

(unit, %)

Traits	Treatments[1)]			
	CON	T1	T2	T3
Moisture	55.84± 0.55^{D}	60.31± 0.61^{C}	63.87± 0.59^{B}	67.01± 0.71^{A}
Fat	26.46± 0.24^{A}	22.35± 0.31^{B}	16.75± 0.15^{C}	14.06± 0.17^{D}
Protein	13.63± 0.10^{C}	14.64± 0.36^{B}	16.09± 0.15^{A}	16.51± 0.35^{A}
Ash	2.05± 0.11	2.10± 0.12	2.17± 0.14	2.21± 0.17
Calorie	297.93± 0.90^{A}	262.65± 0.73^{B}	220.56± 0.87^{C}	197.85± 0.65^{D}

All values are mean ± SD of the three replicates.
[1)] CON: sausage without PPW (30% back fat), T1: replacement of 10% back fat with PPW, T2: replacement of 15% back fat with PPW, T3: replacement of 20% back fat with PPW.
[A–D]Means sharing different letters in the same row are significantly different (p<0.05).

Table 3. Cooking yield and emulsion stability in reduced-fat sausages with different level of PPW

(unit, %)

Traits	Treatments[1)]			
	CON	T1	T2	T3
Cooking yield	95.15± 0.28^{B}	95.21± 0.13^{B}	95.65± 0.30^{A}	95.34± 0.48^{A}
Fat loss	1.64± 0.02^{A}	1.24± 0.22^{A}	1.31± 0.29^{A}	0.54± 0.15^{B}
Water loss	3.25± 0.04^{AB}	3.99± 0.38^{A}	3.05± 0.25^{AB}	2.58± 0.30^{B}

All values are mean ± SD of the three replicates.
[1)] CON: sausage without PPW (30% back fat), T1: replacement of 10% back fat with PPW, T2: replacement of 15% back fat with PPW, T3: replacement of 20% back fat with PPW.
[A,B]Means sharing different letters in the same row are significantly different (p<0.05).

Cooking yield and emulsion stability of reduced-fat sausages is shown in Table 3. T2 and T3 showed the higher cooking yield than CON, and T3 had the most stable meat emulsion compared with those of the other treatments (p<0.05). This results are might be ascribed with the functional properties of PPW, as an emulsifier, which could improves water and fat binding capacity.

Table 4. Texture profile analysis (TPA) in reduced-fat sausages with different level of PPW

Traits	Treatments[1)]			
	CON	T1	T2	T3
Hardness (N)	50.10± 1.41^{D}	59.89± 0.61^{C}	74.39± 0.59^{B}	87.86± 0.71^{D}
Cohesiveness	0.65± 0.09`	0.54± 0.16	0.54± 0.04	0.52± 0.08
Springiness	0.85± 0.01^{B}	0.88± 0.01^{A}	0.87± 0.02^{A}	0.87± 0.01^{A}
Gumminess (N)	32.55± 4.38^{B}	31.91± 9.07^{B}	40.56± 5.88^{AB}	45.62± 7.62^{A}
Chewiness (N)	27.70± 3.67^{B}	27.99± 8.21^{B}	35.26± 4.70^{AB}	39.73± 6.39^{A}

All values are mean ± SD of the three replicates.
[1)] CON: sausage without PPW (30% back fat), T1: replacement of 10% back fat with PPW, T2: replacement of 15% back fat with PPW, T3: replacement of 20% back fat with PPW.
[A-D]Means sharing different letters in the same row are significantly different (p<0.05).

Table 4 and Table 5 represent respectively TPA and sensory evaluation in reduced-fat sausage with different level of PPW, respectively.

Table 5. Sensory evaluation in reduced-fat sausages with different level of PPW

Traits	Treatments[1)`]			
	CON	T1	T2	T3
Color	8.11± 0.33	8.11± 0.33	8.00± 0.50	7.78± 0.44
Flavor	8.33± 0.50	8.11± 0.60	8.00± 0.71	8.11± 0.78
Tenderness	8.22± 0.44^{A}	7.89± 0.93^{AB}	7.44± 0.88^{AB}	7.33± 0.87^{B}
Juiciness	8,33± 0.50^{A}	7.89± 0.78^{AB}	7.56± 0.88^{AB}	7.11± 1.05^{B}
Warmed-over flavor	9.22± 0.67	8.78± 0.67	8.78± 0.67	8.78± 0.67
Overall acceptability	8,33± 0.50^{A}	8.22± 0.67^{A}	7.56± 0.88^{B}	7.33± 0.50^{B}

All values are mean ± SD of the three replicates.
[1)] CON: sausage without PPW (30% back fat), T1: replacement of 10% back fat with PPW, T2: replacement of 15% back fat with PPW, T3: replacement of 20% back fat with PPW.
[A,B]Means sharing different letters in the same row are significantly different (p<0.05).

The addition of PPW leads to rapid increase in hardness value. Excessive hardness value means decrease of tenderness and it also indicates that PPW holds water strongly in emulsion sausage. Also, decrease in juiciness of samples is related to

preventing exudation of meat juice from sausages to mouth by pre-emulsion. Thus, T3 presented the lowest tenderness and juiciness scores ($p<0.05$).

IV. CONCLUSION

The addition of pre-emulsion of pork collagen and wheat fiber can improve many kinds of nutritional and functional properties. The protein content which is preferable nutrition increased in sausage, whereas fat content and calorie reduced. This means that pre-emulsion of pork collagen and wheat fiber can be utilized as an effective fat replacer. In this study, T2 (replacing 15% of fat with pre-emulsion of pork collagen and wheat fiber) was the best addition level to replace animal fat for satisfying various aspects of quality characteristics.

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