Product Characteristics of Comminuted Sausages as Affected by Various Fat and Moisture Combinations

Koo Bok Chin*, Hye Lan Lee and Soon Sil Chun[1]
Department of Animal Science and Biotechnology Research Institute, Chonnam National University
Gwangju 500-600, Korea

ABSTRACT : Comminuted sausages with reduced fat (25-0%) and increased moisture (19-44%) combinations were manufactured, and their chemical composition, and physico-chemical, textural and sensory properties were determined for the selection of the most palatable sausage treatment. The moisture and fat contents of the comminuted sausages varied from 55-79% and 26.4-2.14%, respectively, whereas, the protein content was relatively constant at 13.5-14.5%. Expressible moisture (EM, %) decreased with increased fat addition, and the high-fat control sausage (~25% fat) had lower EM than those with lower than 15% fat addition. Increased fat level also increased Hunter L values (lightness) of sausage samples taken from the core, and differences in lightness were observed between 15 and 25% fat level at the initial mixture. Sausages without fat addition had different textural characteristics from high-fat control sausages in most texture profile analysis (TPA) values. However, no differences in TPA values were observed among treatments with added fat (<25%) in the formulation. Results of the sensory evaluation showed that the most appropriate fat content of comminuted sausages to have better sensory properties ranged from 15-20% of added fat at the initial mixture. These results also indicated that decreased fat and increased moisture contents produce sausages with higher EM and lower lightness. Comminuted sausages without fat addition had different textural characteristics from the high-fat control. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 4 : 538-542)***

Key Words : Physico-chemical, Textural and Sensory Properties, Comminuted Sausages, Fat Level

INTRODUCTION

In Korea, emulsified sausages, such as frankfurter and bologna, may contain up to 35% fat with lower than 75% moisture in the final products, as regulated by the Korean Food Code (1997). Fat in the diets serves not only as nutrient in the human body, but also as source of essential fatty acids and essential components of cell membrane (Pearson et al., 1987). In addition, dietary fat plays an important role in terms of flavor and texture in meats and meat products. However, consumption of too much dietary fat has been reported to increase the risks of coronary heart disease (CHD) and other related diseases of the circulatory system (AHA, 1978). Previous reports indicated that animal fats, which have high amounts of saturated fatty acids as compared to vegetable oils, should be reduced to prevent consumers from diseases related to fat consumption.

The optimum fat level to have maximum flavor and textural properties in the product should be determined in each type of product. At least 15% of fat should be required for full-fat products to have similar sensory properties (Decker et al., 1986). Bologna which contains 10% fat requires 24.3% added water (AW) to approximate the sensory firmness of bologna with 30% fat and 10% AW (Claus et al., 1989). However, too much reduction of fat down to 5-10% in comminuted sausages may result to darker color, variation in textural properties, and decreased juiciness and cooking yield (Keeton, 1994). To prevent these defects, low-fat comminuted meat products have been reformulated with added fat replacer, which is a food ingredient that emulates the functional and sensory properties of fat without the calories, to reduce the fat content in the formulation. However, Matulis et al. (1995) reported that the combination of 11.25% fat and 1.3% salt was the minimum level required for acceptable sensory attributes in frankfurters with a pH value of 6.0.

Although several studies have evaluated regular-fat or low-fat meat products with or without fat replacers, product characteristics as affected by various fat contents have not been extensively studied. Fat contents might affect the quality of final products in terms of textural and flavor characteristics. Thus, the objectives of this study were to evaluate the physico-chemical, textural and sensory properties of comminuted sausages as affected by reduced fat level (25-0%), and to determine the impact of fat reduction on palatability of sensory characteristics.

MATERIALS AND METHODS

Preparation/processing of comminuted sausages

Fresh pork hams and pork backfats were purchased from a retail meat market in Gwangju, Korea. The procedure for sausage manufacture of Choi and Chin (2003) was followed. Added fat content (%) for sausages was reduced from 25 to 0% with 5% intervals. The formulation

* Corresponding Author: Koo Bok Chin, Tel: +82-62-530-2121, Fax: +82-62-530-2129, E-mail: kbchin@chonanm.ac.kr
[1] Dept. of Food & Nutrition, Sunchon National University, Sunchon 540-742, Korea.
Received May 21, 2003; Accepted November 5, 2003

Table 1. The formulation of comminuted sausage as affected by fat and moisture content

Ingredients	Added fat content (%)					
	0	5	10	15	20	25*
Pork lean (ham)	50	50	50	50	50	50
Pork fat[a]	0	5	10	15	20	25
Added moisture (ice water)	44	39	34	29	24	19
Non-meat ingredients	6	6	6	6	6	6

* 25% fat addition at initial mixture: high-fat control; [a] pork fat= backfat.

Table 2. The composition of non-meat ingredients

Items	Amount (%)	Amount (g)
Salt	1.3	26
Sugar	1.1	22
Non-fat dry milk	1.0	20
Hydrolyzed milk protein	1.0	20
Sodium tripolyphosphate	0.3	6
Prague powder	0.25	5
Spices	1.0	20
Sodium erythorbate	0.05	1
Total	6.00	120

of comminuted sausages and composition of non-meat ingredients are presented in Tables 1 and 2. After the meat batters have been vacuum-packaged, these were stuffed into cellulose casing (26 mm diameter, Yujin Industry Co. GunPo, Korea), smoked, and cooked at an internal temperature of 71.7°C in a smoke chamber (Nu-Vu Food System, ES-13, USA), showered with cold water, and stored in the refrigerator.

Chemical composition and physico-chemical properties

The pH value of the homogenized sausages was measured by using a digital pH meter (Mettler-Toledo, Model 340, Schwarzenbach, Switzerland), and the measurement was randomly repeated five times. Chemical compositions such as moisture, fat and protein contents (%) were determined by the AOAC (1995) method. Water holding capacity (WHC) was determined by the centrifugal method of Jauregui et al. (1981). Approximately 1.5 g of each sausage sample was wrapped with filter paper (Whatman #3) and centrifuged at 3,000 rpm for 20 min. Expressible moisture (EM, %) was calculated as the differences between the total sample and filter paper weight containing the moisture released from the sample during centrifugation. Hunter L, a and b values were measured using a Color Reader (CR-10, Minolta Co., Ltd, Japan). Sausage samples were taken from both core and surface.

Texture profile analysis (TPA)

Texture profile analysis (TPA) of sausage samples cut into cylinder (1.3 cm thick, 1 cm diameter) was performed with the use of a texture meter (TA-XT2, stable micro system, Hasemers, England), which was set to compress sample weight to 75% through a two-cycle compression described by Bourne (1978). The sausage samples laid on a flat plate equipped with 5 kg load cell were measured at a rate of 120 mm/min and the following textural properties were determined: fracturability, hardness, gumminess, springiness, chewiness and cohesiveness.

Sensory evaluation

Sensory evaluation was performed in duplicate and by a seven-member panel at the Meat Science Laboratory, Chonnam National University, Gwangju, Korea. Panelists were provided with sausage samples marked with an 8 point hedonic scale (1=most like; 8=most dislike) for flavor, texture, juiciness, color, saltiness, and overall acceptability.

Statistical analyses

The experiment was performed in triplicate and the data were analyzed through a one-way analysis of variance (ANOVA) using the general linear model (GLM) procedure of the Statistical Analysis System (SAS, 1989). Dunnett's procedure was used to compare the high-fat control (~25% fat) with the mean of each individual treatment in each parameter. If significant treatment effects were observed at p<0.05 level in each parameter tested, Student-Newman-

Table 3. pH, water activity, proximate analysis, and physico-chemical properties of comminuted sausage as affected by various fat contents

Parameters		Added fat content (%)					
		0	5	10	15	20	25
pH	Mean	6.11	6.14	6.19	6.22	6.21	6.16
	SD	0.03	0.02	0.04	0.10	0.05	0.03
Moisture (%)	Mean	78.3[a]*	73.9[b]*	69.3[c]*	64.4[d]*	60.2[e]	55.1[f]
	SD	1.17	0.72	1.88	1.91	3.32	3.11
Fat (%)	Mean	2.14[f]*	6.57[e]*	11.13[d]*	17.16[c]*	21.1[b]*	26.4[a]
	SD	0.79	0.77	1.86	2.78	2.49	2.97
Protein (%)	Mean	14.23	14.53	14.53	13.40	13.70	13.53
	SD	0.45	0.31	0.45	0.98	0.90	0.23
Cooking loss (%)	Mean	16.00	14.30	13.93	12.45	11.74	9.47
	SD	2.78	3.41	3.35	3.26	3.03	1.87
Expressible	Mean	37.83[a]*	34.50[ab]*	28.03[bc]*	21.47[cd]	16.17[de]	11.83[e]
moisture (%)	SD	1.78	0.86	1.86	0.77	0.36	0.25

[a-e] Means with different superscript in a same low are different (p<0.05). * Paired comparison (control vs. treatments) significant at the p<0.05 level.

Table 4. Hunter color values of comminuted sausage as affected by various fat contents

		Added fat content (%)					
		0	5	10	15	20	25
Core							
H L (lightness)	Mean	67.7[b]*	66.6[b]*	66.6[b]*	68.9[b]	70.6[ab]	72.4[a]
	SD	0.45	1.80	0.78	1.66	1.46	2.27
H a (redness)	Mean	10.60	10.21	10.87	10.62	10.03	9.91
	SD	0.20	0.79	0.66	1.37	0.55	0.94
H b (yellowness)	Mean	7.31	7.40	8.75	8.08	8.73	9.36
	SD	1.33	1.33	1.78	0.24	0.63	0.67
Surface							
H L (lightness)	Mean	57.93	59.10	60.20	60.60	57.93	61.17
	SD	0.96	3.20	2.36	1.54	1.79	0.95
H a (redeness)	Mean	15.93	15.40	15.13	15.53	17.06	16.10
	SD	0.90	1.40	1.07	1.31	0.76	0.26
H b (yellowness)	Mean	17.90	18.20	19.77	21.27	22.00	22.47
	SD	1.82	0.66	1.70	1.86	3.15	2.23

[a, b] Means with different superscript in a same low are different (p<0.05). * Paired comparison (control vs. treatments) significant at the p<0.05 level.

Kuels procedure was performed to compare among treatments.

RESULTS AND DISCUSSION

pH, proximate analysis, cooking loss and expressible moisture (%)

The pH values of the high-fat control and the other treatments were 6.16 and 6.11-6.22, respectively, but no significant differences in pH values were observed among all treatments (Table 3). Since moisture content tended to increase from 55.1 to 78.3%, as affected by each 5% reduction of added fat, the total moisture plus fat content added was 44%. Fat content also varied from 2 to 26% and tended to be slightly higher than what was added in the initial mixture due to the cooking loss (CL, %). In the USA, there exists a “40% rule”, in which the amount of fat and added water in processed meats should not exceed 40% (USDA, 1988). This rule suggests that reduced fat is accompanied by increases in moisture content. Thus, the moisture and fat contents differed between the high-fat control and the treatments. However, no differences in protein content were observed between the treatments and the high-fat control. These results indicated that the sausage products had varied moisture and fat contents, but had the same protein content. Although the CLs of the treatments and the control in a smoke chamber were not different due to high variation, expressible moisture (EM, %) for the determination of water holding capacity tended to decrease with increased fat content. Jimenez Colmenero et al. (1996) reported that decreased fat content of about 17% increased the CL. Gregg et al. (1993) also reported that reduced fat and increased moisture content (fat/added water: 30/10 to 10/30%) reduced CL. In this study, however, the values for CL increased with reduced fat and increased moisture contents, but not significantly different at p>0.05 due to high standard deviation among replications. In Dunnett’s-T test, the high-fat control did not have similar EM values when the fat was less than 10% of added fat at the initial mixture.

Hunter color values (L, a, b)

Hunter color values of comminuted sausages either from the core or the surface are listed in Table 4. Since the control had higher fat content (~26%), the core color was higher in lightness (L) values than those of the treatments containing lower than 10% fat in the Dunnett’s T-test. However, lightness values in the surface area were not significantly different (p>0.05). These results indicated that lightness values of the sausage samples were highly affected by fat levels, resulting in lighter color with increased fat level. Claus et al. (1989) reported that the redness values increased and the yellowness values decreased with reduced fat and increased added water, and suggested that fat is the most significant regression variable in predicting the reflection ratio and Hunter L values. Redness (a) and yellowness (b) values were not different (p<0.05) among treatments. This was partially due to the fixed lean contents (55%), even though sausages had varied fat contents. Hand et al. (1987) also observed that when fat content was reduced, “L” and “b” values decreased while “a” values increased. Results of this study showed similar trends with those of previous studies. However, redness and yellowness values were not different (p>0.05) among various fat contents.

Textural profile analysis (TPA)

Although hardness values were not different (p>0.05) among the treatments and the control, decreased fat with increased moisture content tended to decrease TPA values. Sausages without added fat (no-fat sausages) had different TPA values as compared with the high-fat control in the

Table 5. Texture profile analysis values of comminuted sausage as affected by various fat contents

Textural properties		Added fat content (%)					
		0	5	10	15	20	25
Hardness	Mean	5,770	5,213	4,847	5,300	5,299	5,752
	SD	542	730	764	749	922	725
Springiness	Mean	0.29^{a*}	0.27^{ab}	0.24^{ab}	0.24^{ab}	0.22^{b}	0.24^{ab}
	SD	0.02	0.02	0.02	0.02	0.03	0.03
Gumminess	Mean	1,342^{a*}	953^{b}	810^{bc}	774^{bc}	657^{bc}	857^{c}
	SD	57	141	24	35	51	145
Chewiness	Mean	395^{a*}	260^{b}	204^{b}	198^{b}	170^{b}	208^{b}
	SD	47	43	22	20	23	59
Cohesiveness	Mean	0.23^{a*}	0.19^{b*}	0.18^{b}	0.17^{b}	0.16^{b}	0.15^{b}
	SD	0.03	0.02	0.01	0.01	0.01	0.02

$^{a-c}$ Means with different superscript in a same low are different (p<0.05). * Paired comparison (control vs. treatments) significant at the p<0.05 level.

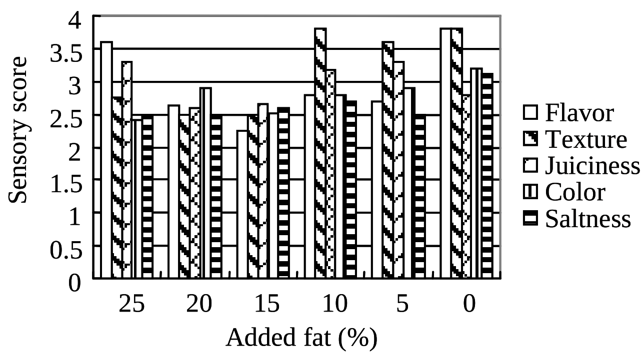

Figure 1. Sensory evaluation of comminuted sausages as affected by various fat addition (Sensory score (8 point scale): lower values toward the "most like", whereas higher value "most dislike").

final products. These results indicated that sausages without added fat (<3%) were not similar in textural characteristics with high-fat control. Fat replacers are ingredients that contribute a minimum of calories to formulated meats and do not dramatically alter flavor, juiciness, mouth-feel, viscosity, or other organoleptic and processing properties (Keeton, 1994). Thus, fat replacer should be added to low-fat meat product to have similar textural characteristics as those of high-fat control. Chin and Lee (2002) reported that the multiple addition of konjac flour, carrageenan, and soy protein isolate at the ratio of 1:1:3 in low-fat meat products resulted to textural characteristics similar to those of regular-fat (19.4%) counterpart. Increases in water content with the same fat level decreased fracturability and hardness, while increases in fat with added water increased cohesiveness in all treatments except for few cases (Claus et al., 1989). Chin and Chung (2003) reported that the addition of microbial transglutaminase to low-fat sausages and restructured meat products improved the textural characteristics and binding capacity without adverse effects.

Sensory evaluation

Sensory evaluation results also revealed that the most appropriate fat content to have better sensory properties was between 15 and 20% of added fat (%) at the initial mixture (Figure 1). The regular-fat sausages containing 11.25% fat and 1.33 salt were observed to be the most palatable among all treatments tested (Matulis et al., 1995). Ahmed et al. (1990) reported that sensory panel rating was affected by fat and added water content, and that replacement of fat with higher amounts of added water resulted in similar sensory characteristics with those of pork sausages. Chang and Carpenter (1997) reported that the optimizing combination of fat, oat bean, and added water was 15%, <2%, and 20%, respectively.

CONCLUSIONS

This study was conducted to evaluate the effect of various fat and moisture combinations at the initial mixture of comminuted sausages on the physico-chemical, textural and sensory characteristics of the final products. The moisture and fat contents of comminuted sausages varied from 55-78% and 26.4-2.16%, respectively, whereas, the protein content ranged from 13.5 to 14.5%. Although cooking losses (CLs) of comminuted sausages were not different among treatments, water holding capacity (WHC) was lower with reduced fat and increased moisture content. Increased lightness values of sausages were observed with increased fat content, regardless of moisture content. Sausages without added fat had higher TPA values, resulting in different textural characteristics as compared with those of high-fat control. Sensory evaluation results indicated that the most appropriate fat content (%) to have better sensory properties was between 15-20%. Further research will be performed to analyze the flavor compounds of these sausages as affected by various fat contents.

ACKNOWLEDGEMENT

This work was supported by No. (R5-2001-000-00706-0) from the Basic Research Program of Korea Science & Engineering Foundation.

REFERENCES

Ahmed, P. O., M. F. Miller, C. E. Lyon, H. M. Vaughter and J. O. Reagan. 1990. Physical and sensory characteristics of low-fat fresh pork sausages processed with various levels of added water. J. Food Sci. 55:625-628.

American Heart Association (AHA). 1978. Diet and coronary heart disease. Circulation 58 (4):762-766.

AOAC. 1995. Official Methods of Analysis. 16th ed. AOAC International, Alington.

Bourne, M. C. 1978. Texture profile analysis. Food Technol. 32(7):62-66, 72.

Chang, H-C. and J. A. Carpenter. 1997. Optimizing quality of frankfurters containing oat bran and added water. J. Food Sci. 62:194-202.

Chin, K. B. and B. K. Chung. 2003. Utilization of transglutaminase for the development of low-fat low-salt sausages and restructured meat products manufactured with pork hams and loins. Asian-Aust. J. Anim. Sci. 16(2):261-265.

Chin, K. B. and H. C. Lee. 2002. Development of low-fat meat processing technology using interaction between meat protein and hydrocolloids-II. Development of low-fat sausages using the results of model study. J. Korean Soc. Food Sci. Nutr. 31(4):629-635.

Choi, S. H. and K. B. Chin. 2003. Evaluation of sodium lactate as a replacement for conventional chemical preservatives in comminuted sausages inoculated with *Listeria monocytogenes.* Meat Sci. 65:531-537.

Claus, J. R., M. C. Hunt and C. L. Kastner. 1989. Effect of substituting added water for fat on the textural, sensory, and processing characteristics of bologna. J. Muscle Foods 1:1-21.

Decker, C. D., C. C. Conley and S. H. Richert. 1986. Use of isolated soy protein in the development of frankfurters with reduced levels of fat, calories, and cholesterol. Proc. European Meeting of Meat Research Workers 7(1):333-349.

Gregg, L. L., J. R. Claus, C. R. Hackeny and N. G. Mariott. 1993. Low-fat, high added water bologna from massage, minced batter. J. Food Sci. 58:259-264.

Jauregui, C. A., J. M. Regenstein and R. C. Baker. 1981. A simple centrifugal method for measuring expressible moisture, a water-binding property of muscle foods. J. Food Sci. 46:1271-1273.

Hand, L. W., C. A. Hollingsworth, C. A. Calkins and R. W. Mandigo. 1987. Effect of preblending, reduced fat and salt level on frankfurter characteristics. J. Food Sci. 58:259-264.

Jimenez Colmenero, F., A. V. Carrascosa, G. Barreto, P. Ferendez and J. Cabballo. 1996. Chopping temperature effects on the characteristics and chilled storage of low- and high-fat pork bologna sausages. Meat Sci. 44:1-9.

Keeton, J. T. 1994. Low-fat meat products-Technological problems with processing. Meat Sci. 36:261-276.

Korean Food Code. 1997. Food standards and criterions: Meat Products. pp. 225-229. Korean Food Industrial Association.

Matulis, R. T., F. K. McKeith, J. W. Sutherland and M. S. Brewer. 1995. Sensory characteristics of frankfurters as affected by fat, salt and pH. J. Food Sci. 60:42-47.

Pearson, A. M., A. Asghar, J. I. Gray and A. M. Booren. 1987. Impact of fat reduction on palatability and consumer accepatance of processed meat. Proc. Recip. Meat Conf. 40:105-114.

SAS Institute Inc. 1989. SAS User's Guide: Statistical Analysis System, Cary, NC.

USDA. 1988. Standards for frankfurters and similar cooked sausages. Fed. Reg. 53:8425-8428.