ROLE OF FAT IN PORK BREAKFAST SAUSAGES

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Summary: Composition, textural, hydration, color, and sensory attributes of reduced fat (5% to 29%) pork breakfast sausages and five commercial Canadian products were investigated. A wide variation in the composition of commercial products was observed. In the reduced fat sausages water holding capacity decreased with the increase in fat content due to lower moisture content. The lower fat (5% to 9%) products provided medium level of hardness. Shear force, springiness, cohesiveness, gumminess, and chewiness decreased in the high fat products. The low fat products (5% and 9%) received lower sensory scores, however, the 13% fat product was as acceptable as the high fat sausages containing 23% and 29% fat which are popular on the market.

Introduction: The objectives of this work were to study the effects of fat reduction on the physical and sensory properties of breakfast sausages produced without gums or binders and to analyze the composition and properties of contemporary commercial pork sausages on the Canadian market.

Materials and methods: Six different pork breakfast sausages were prepared. Fresh pork leg meat and back fat were obtained from the University of Guelph abattoir. The post rigor meat was ground through a 9 mm plate to obtain a homogeneous mass prior to chemical analysis of the raw materials (AOAC, 1990). The meat and fat were frozen, separately, in polyethylene bags and kept frozen for up to two weeks at -20°C prior to use. The products were formulated with certain ratios of lean meat and fat, 1.75% NaC1 and a spice mix (0.21% black pepper, 0.05% nutmeg, 0.02% thyme, 0.02% sage and 0.02% dextrose). In the reduced fat products, water was added to the meat block to come up with the same protein level as in the high fat mixture. The thawed meat (overnight at 4°C) and other ingredients were mixed (Butcher Boy, model 150, Los Angeles, CA) in 6.5 kg batches for 5 min prior to stuffing into moisture-proof casings (6.2 cm dia.).

The textural and sensory properties of the cooked products were evaluated. One cm slices were fried on a preheated electrical skillet (127°C) for a total time of 4.5 min (half time per side). The textural profile analysis (TPA) test (Bourne, 1978) was used to evaluate cooked products on an universal testing machine (model 4204, Instron Corp., Burlington, Ontario, Canada) equipped with an 1 kN load cell. The centre core of five cooked samples per treatment were cut (2.0 cm diameter) and compressed twice to 75% of their original length. Hardness was expressed as N/cm^2. A cross head speed of 200 mm/min and a chart speed of 20 mm/min were used. The TPA parameters, namely hardness (first bite, the force required to produce the first compression), cohesiveness (ratio of the area of the second force-displacement curve to the area of the first curve), springiness (distance the sample recovered in height after the first compression, cm), gumminess (hardness x cohesiveness), and chewiness (gumminess x springiness) were computed. Warner Bratzler shear force was measured on five cores (20 mm dia.) obtained from the cooked samples. The Warner Bratzler cell was attached to the universal testing machine and shearing speed was 100 mm/min. The color of the raw and cooked products was determined by the Pacific Scientific Color System (Silver Spring, MD) and expressed as the Hunter "L" (lightness), "a" (redness), and "b" (yellowness). Water holding capacity (WHC) was determined as the ratio of sample mass after being placed under vacuum of 63.5 kPa at room temperature for 4 h minus the mass of the dried matter, divided by the initial sample mass. Free water was determined by pressing 0.5 g samples at 5520 kPa placed in between filter papers and is expressed as the ratio of the "squeezed water" to the initial moisture content of the sample. Cooking loss was the change in mass during cooking divided by the initial uncooked mass.

Sensory analysis was performed by graduate students and staff in the Food Science Department. The panelists were experienced in sensory evaluation of various food products. The cooked samples were placed on a 29 mm dia. plate and identified by a 3-digit random number. The samples were reheated in a microwave oven for 30 s and served at 45°C. Evaluations of the attributes were recorded by the panelists on scales typical of descriptive sensory analysis (Stone et al., 1974). The semi structured linear scales on ballots were later coded on a nine point basis. Attributes included color (1 = pale, 10 = dark), tenderness (1 = very tender, 10 = very tough), juiciness (1 = very dry, 10 = very juicy) and overall acceptability (1 = dislike, 10 = like).

In addition to the experiment treatments, five commercial breakfast sausages were purchased from a local supermarket and evaluated for their composition, textural characteristics and color.

Results and discussion: Commercial brands: A wide variation in fat, protein and moisture levels were observed. Fat content varied from 17.1% to 28.8%, protein content from 9.5% to 12.6%, and moisture from 51.6% to 60.7%. In low fat sausages, the protein and moisture contents were the highest. Similarly, the higher fat content sausages contained minimum amount of protein. These products also contained unknown amount of various binders.

Effects of Fat Level: Table 1 shows the compositions of six experimental breakfast sausages and their target fat levels (5% to 29%). The protein content was basically kept constant among treatments (16.2% to 16.6%). However, moisture content varied from 52.80% to 77.24%, which was inversely proportional to fat content i.e. moisture content increased with the decrease in fat content. This observation was expected based on the product formulation where fat replaced moisture in high fat sausages. Table 2 tabulates the hydration properties -WHC, free water and cooking loss, and color parameters--L, a, and b. WHC significantly decreased with the increase in fat content. This is due to the higher moisture content in low fat products. Less water was evaporated under vacuum from the products containing lower amounts of water. Indirectly, WHC did not decrease with the decrease in fat level. The low fat products should be more juicy due to the retention of large amount of water. About 13.7% to 16.2% points moisture was evaporated under vacuum from treatments. Thus, fat content has not affected the evaporation of water from the product.

Free or press water is the ratio of "moisture squeezed out" to the initial moisture content. Higher numbers indicate release of more moisture or the decrease in more moisture, or juiciness, from the product. The retained water in the product was lower for the low fat products (5% and 9% fat) and reduced as fat content increased. This is mainly due to less moisture in these products. Cooking loss was not affected by the fat content. Slightly lower shrinkage was noted for sausages with very low (5%) and very high (29%) fat contents.

'L' (lightness) was directly proportional to fat level for raw (uncooked) products which is not surprising since more fat provided a whiter color. However, afer cooking 'L' was inversely proportional to the fat level possibly due to more browning on the product's surface due to the pan frying. For cooked products, the change in 'L' was smaller (4.2) compared to the change in the raw product (15.8). Redness ('a') was not appreciably changed in the raw products due to increase in the fat level. This again was expected since the amount of lean meat, contributing the myoglobin pigment, was constant in all the treatments. Yellowness ('b') was also directly proportional to fat level in raw sausages which is again proportional to the amount of the pork back fat that was not absolute white but yellowish in color. However, in cooked sausages 'b' showed a decreasing trend with increase in fat level. This also probably due to the browning effect.

Table 3 shows the textural properties of breakfast sausages for the various treatments. Hardness was the lowest for the high fat

(23% and 29%) products and the highest for the medium fat (13% and 17%) products. The lower fat (5% and 9%) products showed medium level of hardness. Product hardness, generally, decreases with the increase in fat level and increase in moisture level. In sausages, the moisture level was inversely proportional to fat level, which was responsible for this behavior. Springiness (elasticity) decreased with the increase in the fat level. The minimum springiness was exhibited by high fat products (23% and 29%), and maximum for low fat products (5% and 9%). The increase in moisture content with the decrease in fat has not fully compensated this effect. Similar behavior was noted for shear force, cohesiveness, gumminess and chewiness. All of these properties decreased for the high fat products (23% and 29%) compared to low fat products. Shear force indicates the combination of hardness and elasticity, which was the lowest for 29% fat level and the highest for the low fat products (5%, 9% and 13%). These results are indicative of the fact that fat is much less resistant to shear force than is coagulated protein matrix, and the higher the fat content the lower the shear forces are. Cohesiveness, gumminess and chewiness decreased with the increase in fat level. Chewiness is the energy required to chew the product before swallowing. This was maximum for the low fat (5%) product, and minimum for the high fat (23% and 29%) products. Overall, to manufacture low fat sausages, shear force, cohesiveness, gumminess and chewiness should be decreased to provide the same characteristics as of a high fat product. This can be achieved by adding various non-meat ingredients such as gums and plant proteins. In the five commercial products tested for the textural characteristics, no correlation between fat level and TPA parameters was observed. This may be due to the presence of gums and binders in those commercial products. However, the relationship between fat content and TPA parameters was observed in the experimental formulations where the gum or binder effect was purposely eliminated.

Sensory attributes of the sausages (Table 4) indicated that the visual color scores of the products are in agreement with the objective color measurements (Table 2) where cooked products with higher fat content appear darker in color. As mentioned before, this is probably due to more browning of the high fat products. Tenderness and juiciness were not affected by the fat levels. This was also indicated by objective evaluations (WHC, TPA, shear force, etc.). The reason for this was the increase in moisture level with the decrease in fat level (Table 1). Overall acceptability was higher for the high fat products (17% to 29% fat) which are typically available in the market. However, 17% fat products are not so common. Products with 13% fat were judged to be as acceptable as the high fat products. This product has less than half the fat as the high fat product and represents a significant fat and calorie reduction. Lower scores were given to the lower fat products (5% and 9%).

Overall, production of reduced fat breakfast sausages below 13% fat significantly decreased their acceptability including tenderness, color and juiciness. Thus, production of reduced fat sausages would require modifications in currently used formulations and possibly processes used for their manufacturing so that flavor and texture are acceptable.

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Table 1. Composition of raw breakfast sausages

Treatment		Composition, %			
#	Fat, %	Moisture	Fat	Protein	Ash
1	5	77.24 a	4.62 f	16.37 abc	2.33 d
2	9	72.41 b	8.89 e	16.26 bc	2.41 c
3	13	68.10 c	12.78 d	16.65 a	2.43 bc
4	17	64.26 d	16.86 c	16.51 ab	2.48 a
5	23	58.04 e	23.17 b	16.19 bc	2.45 b
6	29	52.80 f	28.73 a	16.43 abc	2.44 bc

a-f Means followed by the same letter within a column are not significantly different at the 95% level.

Table 2. Effect of fat level in breakfast sausages on hydration properties and color

Treatment		Water holding capacity (%)	Free water (%)	Cooking loss (%)	Raw product color			Cooked product color		
#	Fat (%)				L	a	b	L	a	b
1	5	61.05 a	52.58 a	26.67 b	38.64 e	11.91 ab	12.13 d	51.52 a	3.58[a]	13.[illegible]
2	9	56.98 b	52.84 a	29.16 a	41.98 d	11.91 ab	12.40 d	52.38 a	2.91[c]	12.[illegible]
3	13	53.67 c	44.82 b	29.00 a	42.09 d	12.69 ab	13.01 c	51.85 a	3.09[bc]	12.[illegible]
4	17	48.92 d	46.91 b	28.08 ab	47.16 c	12.07 ab	13.56 b	50.11 b	3.55[a]	11.[illegible]
5	23	44.33 e	44.22 bc	28.59 a	50.06 b	13.39 a	13.81 b	49.06 c	3.21[b]	11.[illegible]
6	29	38.83 f	48.38 ab	27.11 b	54.49 a	9.38 b	14.48 a	48.22 c	3.75[a]	12.[illegible]

a-d Means (n = 10) followed by the same letter within the same column are not significantly different at the 95% level.

Table 3. Effect of fat level on the textural characteristics of breakfast sausages

Treatment		Hardness-I	Springiness	Cohesiveness	Gumminess	Chewiness	Shear force
#	Fat (%)	(N/cm^2)	(cm)	(ratio)	(N/cm^2)	(N/cm)	(N)
1	5	21.75 b	0.49 a	0.34 a	7.48 a	3.62 a	6.29 ab
2	9	21.60 b	0.47 ab	0.31 b	6.62 a	3.08 b	6.79 a
3	13	24.27 a	0.44 b	0.29 bc	7.06 a	3.02 b	6.45 ab
4	17	25.91 a	0.44 b	0.26 cd	6.80 a	2.83 b	5.65 bc
5	23	17.14 c	0.38 c	0.25 d	4.25 b	1.58 c	5.25 c
6	29	17.29 c	0.37 c	0.24 d	4.29 b	1.56 c	3.87 d

a-d Means (n = 10) followed by the same letter within a column are not significantly different at the 95% level.

Table 4. Effect of fat level on the sensory attributes* of breakfast sausages

Treatment		Color	Tenderness	Juiciness	Overall acceptability
#	Fat (%)				
1	5	3.22 d	5.62 a	7.07 ab	6.94 c
2	9	5.02 c	6.33 a	6.22 b	7.48 bc
3	13	6.14 bc	6.72 a	6.99 ab	8.64 ab
4	17	7.03 b	6.26 a	7.40 ab	9.15 a
5	23	8.73 a	6.92 a	8.07 a	9.03 a
6	29	9.17 a	6.14 a	8.58 a	9.79 a

* Scales: Color, 1 = pale, 10 = dark; tenderness, 1 = very tender, 10 = very tough; juiciness, 1 = very dry, 10 = very juicy; overall acceptability, 1 = dislike, 10 = like

a-d Means followed by the same letter within the same column are not significantly different at the 95% level.