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Reduced-Fat Frankfurters with Varying Types of Meat and Fat

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Abstract

This study was conducted to determine sensory and chemical traits of reduced-fat frankfurters made with lean lamb or lean lamb/pork (50%/50%), fat from three different sources (pork fat, lamb fat or high-oleic sunflower oil) and added water products designated as L-P-15, LP-L-15, LP-So-15 and LP-P-15, according to lean meat type, source of added fat and target fat content and to compare such products with a similar reduced-fat product made with lean beef/pork (50%/50%) with pork fat (product designated as BP-P-15) and high-fat products made with lean beef/pork (50%/50%) or lamb/pork (50%/50%) with pork fat (BP-P-30 and LP-P-30). Actual fat contents of reduced-fat and high-fat products formulated for 15% and 30% fat were 17~18% and 28~31%, respectively, after processing. Processing yields were lower for all reduced-fat products than for the high-fat products. Trained sensory panelists rated LP-P-15 less intense in lamb flavor as compared to LP-L-15 and LP-So-15. Off-flavor intensity was positively correlated with lamb-flavor intensity (r=0.80), whereas frankfurter-flavor intensity was negatively correlated with lamb-flavor intensity (r=-0.88) and off-flavor intensity (r=-0.90). According to consumer panelists, LP-P-15 was as desirable in flavor as BP-P-15 or the two high-fat products (BP-P-30 and LP-P-30), while LP-So-15 and LP-L-15 were not. LP-P-15 and BP-P-15 were not notably different from their high-fat counterparts in juiciness and texture desirability and overall palatability. Regardless of fat content, meat type and fat source, there was little lipid oxidation when vacuum-packaged products were refrigerated for 12 weeks.

Key words: frankfurters, reduced-fat, sensory, lamb, beef, pork, fat source

INTRODUCTION

Frankfurters provide convenience for the consumer and are widely consumed. The most popular frankfurters are all-beef or beef/pork products. Traditional (regular-fat) frankfurters, however, are high in total fat content (and calories), saturated fatty acids and cholesterol. The fat content of frankfurters and similar emulsified meats can be reduced by substituting water or other nonmeat additives for fat, providing that the combined total of fat and added water does not exceed 40% by weight of the finished product (with no more than 30% fat), according to the United States Department of Agriculture regulations for cooked sausages (1). Currently, most of the reduced-fat or low-fat frankfurters commercially available in the United States are manufactured with added water. In conformity with the Nutrition Labeling and Education Act of 1990 in the United States, which was implemented in 1994, the fat content of a "reduced"-fat product, when compared to that of the respective reference product, should be at least 25% less (i.e., the fat content must be reduced by 25% or more); for a "low"-fat food, the amount of fat in a serving (and 50 grams of food if serving size is small) should be no more than 3 grams (2).

There have been research efforts to modify fatty acid profiles of frankfurters, specifically to reduce saturated fatty acids by increasing monounsaturated fatty acids (3,4). The fatty acid changes have been achieved either by using meat with an elevated level of monounsaturated fatty acids (3) or by simply replacing trimmable (knife-separable) animal fats with a high-oleic acid vegetable oil (4-6). The impetus of such efforts was the health-related advantages of monounsaturated fatty acids over other fatty acid groups (7). Although the substitution, in diet, of both monounsaturated fat and polyunsaturated fat for saturated fat decreases plasma low density lipoprotein (LDL)-cholesterol in humans, polyunsaturated fat reportedly reduces the level of plasma high density lipoprotein (HDL)-cholesterol as well (8,9). The latter is known to have an inverse relationship with the incidence of coronary heart disease (9). Consumer interest in dietary monounsaturated fat has increased markedly over the past decade, as shown by the tremendous increase in sales/use of canola oil, olive oil, high-oleic sunflower oil and other high-oleic vegetable oils.

Currently, no lamb-based frankfurters are available at supermarkets or large retail stores in the United States. This is not surprising in light of the low annual consumption of lamb in the States (10); the distinct species-related flavor of lamb has been mentioned as one of the main reasons for the low consumption (11). Whether (and to what extent) the "lamby" flavor can be masked by the curing/smoking process and spices used in the manufacture of frankfurters and similar cured meats, or by using other types of meat and/or fat in combination with lamb in such products, has not been documented. The objectives of our study were: (a) to determine

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sensory and chemical properties of reduced-fat frankfurters made with lean lamb or lean lamb/pork (50%/50%) and fat from three different sources (pork fat, lamb fat or high-oleic sunflower oil); (b) to compare such products with a similar reduced-fat product made with lean beef/pork (50%/50%) with pork fat; and (c) to compare all the reduced-fat products with high-fat products made with lean beef/pork plus pork fat or lean lamb/pork plus pork fat.

MATERIALS AND METHODS

Materials

Beef trimmings, lamb legs and shoulders, and pork boston butt and backfat were obtained locally. High-oleic sunflower oil was provided by SVO Enterprises (Columbus, Ohio). Frankfurter seasoning (blend of white pepper, coriander, mustard, ginger, and mace) was obtained from A. C. Legg Packing Co., Inc. (Birmingham, Alabama).

Processing

All processing was done at the Texas A&M University Rosenthal Meat Science and Technology Center. For each species (beef, pork or lamb), the meat was dissected into the lean and fat fractions. The lean and fat parts were separately ground through a grinding plate with 0.95 cm-diameter holes, vacuum-packaged and frozen at -20°C until processing. Immediately before processing the coarse-ground lean and fat were tempered to 2°C and reground through a grinding plate with 0.64 cm-diameter holes. Frankfurter batter preparation (with heat processing/cooking loss estimated at 12%), stuffing and heat processing were done as described by Park et al. (6). Added water levels in the batters prepared for 30% and 15% fat after processing were 10% and 25%, respectively. The proportional amounts of salt, sodium nitrite, sodium erythorbate, dextrose and seasoning were also the same as those used by Park et al. (6). Processing/cooking yields were determined by weighing products before and after heat processing. Products were chilled at 2°C overnight, peeled and vacuum-packaged.

Product designations, along with lean meats used, added fats and product target fat levels, are shown in Table 1. Processing of each product was done in two replications conducted over two days (one replication/day).

Table 1. Frankfurter formulations

Product abbreviation	Lean meat[1)]	Source of added fat	Target fat level (%) of finished product
BP-P-30	50% Beef/50% Pork	Pork	30
LP-P-30	50% Lamb/50% Pork	Pork	30
BP-P-15	50% Beef/50% Pork	Pork	15
LP-P-15	50% Lamb/50% Pork	Pork	15
LP-So-15	50% Lamb/50% Pork	Sunflower oil	15
LP-L-15	50% Lamb/50% Pork	Lamb	15
L-P-15	100% Lamb	Pork	15

[1)]Lean percentages on a fat-free basis.

Determination of composition and lipid oxidation

Total fat was extracted by the procedure of Folch et al. (12) and gravimetrically determined on aliquots of each sample extract after solvent removal. The AOAC (13) oven-drying procedure was used to determine moisture content. Protein percentage was estimated by subtracting total lipid, moisture and ash percentages from 100 (5). All the analyses were done in triplicate.

Lipid oxidation in vacuum-packaged frankfurters stored at 4°C for 0 day and 4~12 weeks was determined by the 2-thibarbituric acid (TBA) procedure modified for cured meat (14). Before the TBA assay of each sample, the amount of residual nitrite in the sample was measured first by the AOAC (13) procedure; then, the amount of sulfanilamide to be added to the blended sample prior to the distillation step was determined on the basis of the residual nitrite (5). Results (TBA-reactive substances; TBARS) were expressed as mg malonaldehyde equivalent/kg sample.

Sensory evaluation

Trained panel evaluation

The sensory panel consisted of 11 panelists who had been selected and trained according to the procedures of Meilgaard et al. (15) and continually retrained and used for evaluation of meat products. Panelists were retrained for 0~15 (0=absent) flavor intensity scales using scale-anchoring reference standards. Various commercial frankfurters were included as training samples. Additionally, cooked ground meat patties (lamb, pork and beef) were used to train the panelists for species-related flavors. The flavor attributes evaluated were frankfurter-flavor, off-flavor and lamb-flavor intensities.

Test products were evaluated in two sessions (1 session/day), with 7 samples (one processing replication of the 7 test products) served in each session. Samples were coded with 3-digit random numbers and served in a random order in each session. Frankfurters were steeped in hot water (95°C) for 7 minutes, sliced into 2.5 cm-long pieces, wrapped in aluminum foil, and held (no more than 15 minutes) in a conventional oven preheated to 80°C until the start of each session. Panelists were seated in individual booths with incandescent lighting, and samples were passed through hooded domes separating the sample preparation and testing areas. Panelists were provided with distilled water at room temperature to cleanse palate between samples and were instructed to expectorate samples in cups provided.

Consumer panel evaluation

Consumer-type (untrained) panelists faculty, staff and students at Texas A&M University also evaluated the products. Samples from each processing replication were evaluated by 50 panelists, with a total of 100 panelists used to evaluate samples from all (two) processing replications. Sample preparation, serving, and test settings were identical to those of the trained panel evaluation. Samples, however, were evaluated on a 9-point hedonic scale (1=dislike extremely, 5=

neither like nor dislike, 9=like extremely) for appearance, flavor, juiciness, texture and overall palatability.

Statistical analysis

The Statistical Analysis System program (16) was used for data analyses. This study was treated as randomized complete block experiments, with 7 products blocked by processing replication. Data were analyzed by the General Linear Models Procedure and Student-Newman-Keuls multiple-range test. The Correlation Procedure was also used where appropriate. Significance was established at $p \leq 0.05$, unless otherwise indicated.

RESULTS AND DISCUSSION

Processing yield and proximate composition

Processing yields and fat, moisture and protein contents of the final products are shown in Table 2. All products were similar in protein content. Analyzed fat percentages for high-fat products (~31% and 28% fat) were close to the target value (30%), whereas those for reduced-fat frankfurters (averaging ~18% fat) were considerably higher than their target value (15%). Yield and moisture percentages were higher for the two high-fat products (BP-P-30 and LP-P-30) than for all the reduced-fat products, indicating that reduced-fat formulations apparently lost more moisture during processing than did the high-fat formulations. The weight loss during heat processing of frankfurter batters occurs primarily through moisture evaporation. The correlation coefficient between yield and product moisture was 0.92 ($p<0.05$) in this study. The moisture (and yield) differences between the high-fat and reduced-fat products may be explained by differences in water content (especially added water) and the ratio of fat-to-protein in their batters. An inverse relationship between the fat-to-protein ratio in frankfurter formulations and the rate of moisture loss during processing has been attributed to the hydrophobic nature of fat that offers resistance to the diffusion of moisture (17). Note that the reduced-fat batters in our study contained more water and were lower in the fat-to-protein ratio (due to their lower fat content) when compared to the high-fat batters. Processing yield was similar ($p>0.05$) for all the reduced-fat products, regardless of the source of added fat. This was consistent with the findings of Park et al. (6). In contrast, Townsend et al. (18) reported a higher shrinkage for vegetable oil-added frankfurter formulations.

Previous studies (3-5) indicated that reduced-fat/high-water frankfurters with elevated levels of monounsaturated fatty acids could be produced without adding water-binding non-meat ingredients. Results of this study have corroborated such findings. In the aforementioned previous studies, the fatty acid modification was achieved either through incorporation of a high-oleic sunflower oil in the processing sequence (5, 6) or by using high-oleic pork (specifically the meat from pigs fed diets with elevated levels of canola oil) in combination with normal beef (3).

Sensory properties

Results from the trained panel flavor evaluation are shown in Table 3. For products with lamb/pork used as lean meat source (LP-P-15, LP-So-15 and LP-L-15), the type of fat added had marked effects on their flavors. Frankfurter-flavor intensity scores were lower when sunflower oil or lamb fat was added (LP-So-15 and LP-L-15, respectively) than when pork fat was added (LP-P-15 and L-P-15). Conversely, LP-So-15 and LP-L-15 were given higher lamb-flavor intensity scores than LP-P-15. Since species-related flavors are associated, either directly or indirectly, with the fat portions of meats

Table 2. Processing yields and proximate composition

	Products[1)]						
	BP-P-30	LP-P-30	BP-P-15	LP-P-15	LP-So-15	LP-L-15	L-P-15
Yield (%)	88.08[a]	86.51[a]	79.90[bc]	82.74[b]	78.26[c]	80.88[bc]	79.11[b]
Fat (%)	31.07[a]	27.82[b]	17.88[c]	17.86[c]	17.57[c]	16.20[c]	16.98[c]
Moisture (%)	47.73[a]	44.36[b]	34.98[c]	34.79[c]	35.12[c]	35.38[c]	35.20[c]
Protein (%)	13.05[a]	12.95[a]	14.45[a]	15.45[a]	14.75[a]	14.50[a]	14.20[a]

[a-d]Means within the same row not bearing a common superscript letter are significantly different ($p<0.05$). Residual standard deviation values were 1.16, 1.25, 0.73 and 0.94 for yield, fat, moisture and protein, respectively.
[1)]See Table 1 for product designations.

Table 3. Trained panel flavor scores for reduced-fat and high-fat frankfurters made with different types of meat and fat

Sensory attributes[1)]	Products[2)]						
	BP-P-30	LP-P-30	BP-P-15	LP-P-15	LP-So-15	LP-L-15	L-P-15
Frankfurter-flavor int.	8.07[ab]	7.86[ab]	8.23[a]	8.33[a]	7.45[b]	7.49[b]	8.24[a]
Lamb-flavor intensity	0.08[b]	0.53[ab]	0.06[b]	0.10[b]	0.90[a]	0.91[a]	0.51[ab]
Off-flavor intensity	0.39[b]	0.35[b]	0.40[b]	0.22[b]	0.80[ab]	1.02[a]	0.30[b]

[a-d]Means within the same row not bearing a common superscript letter are significantly different ($p<0.05$). Residual standard deviation values were 1.13, 0.87 and 0.96 for frankfurter-flavor, lamb-flavor and off-flavor intensity, respectively.
[1)]Scored on a 0~15 scale.
[2)]See Table 1 for product designations.

(11,19), one would expect LP-L-15 (containing both lamb meat and added lamb fat) to be higher in lamb-flavor intensity. As for the lamb/pork franks with sunflower oil (LP-So-15), the species-related flavor of lamb meat (knife-separable lean) might have been stronger than the pork meat flavor and the vegetable oil flavor (not distinct). The ground lean lamb used in this study contained about 4% fat, which might have been sufficient to contribute a lamby flavor to products. Using pork fat (rather than lamb fat or the vegetable oil) with lean lamb/pork combination significantly reduced lamb-flavor intensity. Since the panelists were informed that some test products contained lamb, some of them gave lamb-flavor intensity scores for products containing no lamb (either lean meat or fat). However, the lamb-flavor intensity scores for such products (BP-P-30 and BP-P-15) were extremely low, and of no practical significance, as shown by mean scores of 0.08 and 0.06 on a 0~15 scale (Table 3). Off-flavor intensity scores for reduced-fat products tended to be higher when lamb fat or sunflower oil was added (LP-L-15 and LP-So-15). Products with added pork fat were rated low in off-flavor intensity, regardless of fat content. Correlation analysis revealed the nature of the association between the flavor attributes evaluated. Correlation coefficients were -0.90 ($p<0.01$) for frankfurter-flavor intensity vs off-flavor intensity, -0.88 ($p<0.01$) for frankfurter-flavor intensity vs lamb-flavor intensity, and 0.80 ($p<0.05$) for lamb-flavor intensity vs off-flavor intensity. In other words, as lamb-flavor and off-flavor intensity increased (the two changing in tandem), frankfurter-flavor intensity decreased.

Results from the consumer sensory evaluation are shown in Fig. 1. For flavor desirability, LP-P-15 was rated as high as BP-P-15 and the two high-fat products (BP-P-30 and LP-P-30). LP-So-15, LP-L-15 and L-P-15 received lower flavor desirability scores than the other two reduced-fat products (LP-P-15 and BP-P-15). The two high-fat products (beef/pork and lamb/pork products, both with added pork fat) were rated similar in flavor desirability, reinforcing the positive effect of added pork fat on the flavor of frankfurters containing lamb meat. These consumer panel results on flavor desirability were generally in line with the results from the trained panel evaluation. For both juiciness and texture desirability, two of the reduced-fat products lamb/pork franks with added pork fat (LP-P-15) and beef/pork franks with pork fat (BP-P-15) were rated as high as their high-fat counterparts (LP-P-30 and BP-P-30, respectively). The same trend was observed for overall palatability as well.

Lipid oxidation

All products exhibited very low TBARS values (data not shown). The mean TBARS content according to storage time (0 day and 4, 5 and 12 weeks) ranged from 0.27 to 0.35, with no storage time-dependent trend observed for any of the products. The mean TBARS content according to product was slightly higher for the two high-fat products (means: 0.36 and 0.31) than for all the reduced-fat products (0.23~0.28). However, these small TBARS content differences among all the test products should be of no practical significance. In other words, there essentially was no notable lipid oxidation in the products, regardless of fat content, lean or fat sources, or storage time. Apparently, the nitrite (a well-known antioxidant for meat) in these products and the vacuum-packaged (oxygen-excluded) storage at 4°C were sufficiently effective for inhibition of lipid oxidation.

CONCLUSIONS

When considering results from both consumer panel and

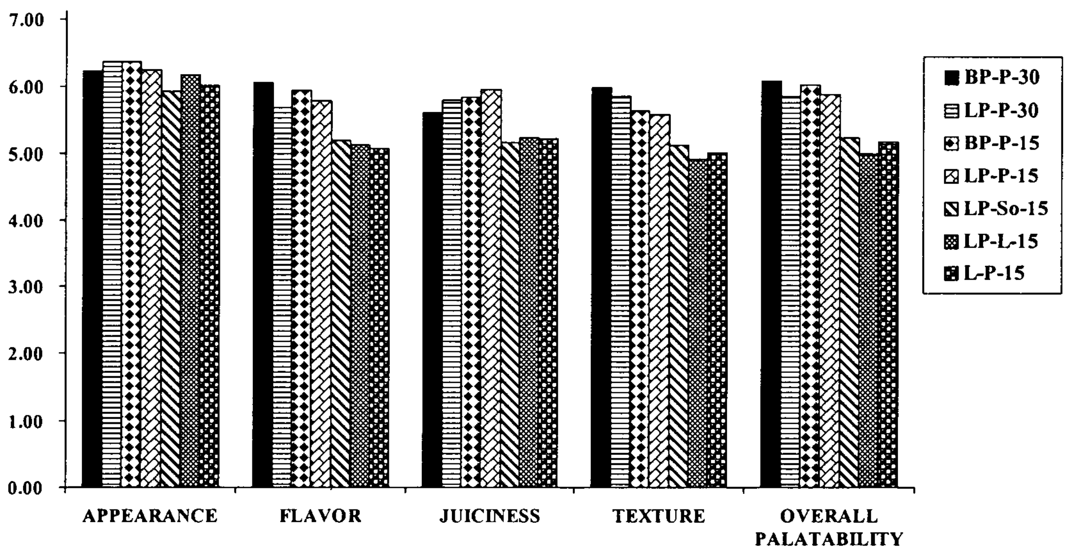

Fig. 1. Consumer panel hedonic scores for reduced-fat and high-fat frankfurters made with different types of meat and fat. Y axis: scores on a 9-point scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely). See Table 1 for product designations.

trained panel evaluations of the test products, flavor seemed to be the most important sensory attribute for lamb-containing frankfurters. The use of frankfurter spice mixture (consisting of several spices) and curing process apparently did not completely mask the species-related lamb flavor in reduced-fat frankfurters made with lean trimmings of lamb/pork (50%/50%) plus lamb fat or high-oleic sunflower oil. Added pork fat had a positive effect on the flavor of products containing lamb meat. Within each fat content category (reduced-fat or high-fat), frankfurters made with lamb/pork meats plus pork fat were as acceptable as the corresponding frankfurters made with beef/pork meats plus pork fat. Using high-oleic sunflower oil, rather than lamb fat, in reduced-fat lamb/pork frankfurters —which may be desirable from a nutritional point of view— did not improve the product flavor and acceptability.

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