Texture and acceptability of goat meat frankfurters processed with 3 different sources of fat

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ABSTRACT: The objective of this research was to evaluate the texture and consumer acceptability of goat meat frankfurter formulations with no added fat (NAF), beef fat (BF), or canola oil (CO). Consumer sensory evaluation, fat, and moisture and texture profile analyses were performed on goat meat frankfurters produced with the fat sources BF, CO, and NAF. For sensory evaluations, NAF was less tender ($P = 0.007$; 4.90 vs. 4.11 and 4.35 for BF and CO, respectively) and the flavor was liked less ($P = 0.004$; 4.59 vs. 3.83 and 4.30 for BF and CO, respectively); BF was scored as the juiciest ($P = 0.003$; 3.86 vs. 4.49 and 4.58 for CO and NAF, respectively); and CO had the least amount of flavor ($P = 0.029$; 3.65 vs. 3.12 and 3.10 for BF and NAF, respectively). Moisture was least ($P < 0.001$) in CO (46.59%), followed by BF (48.57%) and NAF (55.80%). The amount of fat was not different ($P = 0.761$) in BF (24.36%) or CO (24.43%) but was less ($P < 0.001$) in NAF (9.06%), as expected. The NAF had the most protein ($P < 0.001$; 34.14%), followed by CO (27.98%) and BF (26.07%). For texture profile analyses, NAF had the least hardness value ($P = 0.008$; 4.92 vs. 4.48 and 4.40 for BF and CO, respectively) and least chewiness value ($P = 0.026$; 2.89 vs. 3.39 and 3.29 for BF and CO, respectively). Beef fat and CO were not different for hardness ($P = 0.596$) or chewiness ($P = 0.530$). No differences were observed in springiness ($P = 0.954$) or resilience ($P = 0.561$). The sensory panelists tended to prefer BF for overall acceptability. Results from these data revealed that value-added goat meat products received acceptable sensory scores; therefore, continued research and development will greatly expand the knowledge of goat meat and increase the acceptance of value-added products.

Key words: frankfurter, goat meat, sensory evaluation, texture profile analysis, value added

INTRODUCTION

There is a growing demand for goat meat in the United States (Gipson, 1999), with a 329% increase in imports between 1999 and 2006 (Solaiman, 2007). Because the demand for goat meat is increasing, this research seeks to investigate value-added goat frankfurters as an option to add variety to the traditional consumption of goat meat. Goat meat is generally sold as whole carcasses or as bone-in cubes (Kannan et al., 2001) in retail stores that cater to various ethnic groups (Cosenza et al., 2003).

Trends for healthier diets could result in increasing demands for value-added products from nontraditional sources such as goat meat, which could lead to a diet with decreased fat, less cholesterol, or reduced sodium (Dawkins et al., 1999). The USDA Nutrient Database (USDA, 2009) reports that 100 g of raw goat meat has approximately 100 kcal, 5 g of saturated fat, 6 g of MUFA, 0.5 g of PUFA, and 10 mg of cholesterol less than the same portion of ground beef and ground pork. Goat meat also has 0.20 mg more riboflavin than ground beef or ground pork of the same portion size. The reduced calorie and fat content coupled with more riboflavin may be incentives to consume goat meat.

Because recent studies on value added goat meat have focused on cabrito smoked sausage (Cosenza et al., 2003), meat loaves, chili (Rhee et al., 2003), mechanically deboned goat, mutton and pork frankfurters (Marshall et al., 2006), sheep and goat sausage (Chattoraj et al., 2006), and low-fat sausages (Gadiyaram and Kannan, 2004), there is justification for value-added goat meat products, but improvements in emulsification, textural properties, and flavor properties (McMillin and Brock, 2005) have not been studied extensively. It has been reported that melted goat fat

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forms unstable emulsions; therefore, fat from beef or pork may be added to a typically lean meat to increase stability (Chattoraj et al., 2006). Various ethnic groups that typically consume goat meat may have religious objections to consuming fat from other species, so this project explored the addition of canola oil (CO), beef fat (BF), or no added fat (NAF) to goat frankfurters for comparison. Canola was chosen because of its bland flavor (Malcolmson et al., 1994) and because it complements the fatty acid composition of BF (Liu et al., 2009). The objectives were to evaluate the texture and consumer acceptability of goat meat frankfurter formulations with NAF, BF, or CO.

MATERIALS AND METHODS

Institutional Animal Care and Use Committee approval was not obtained for this study because the samples were obtained from federally inspected slaughter facilities.

Frank Processing

Lean goat meat, including goat leg and lean trim, was obtained from and processed at the Auburn University Lambert-Powell Meats Laboratory in Auburn, AL. The animals were intact male Kiko type goats, 6 mo of age, fed a *Sericea lespedeza* alfalfa mix. The carcasses were fabricated 48 h after slaughter, and the meat was frozen at −20 ± 2°C.

Fat sources were 1) BF from commercially grain-fed animals, 2) CO (Wesson, ConAgra Foods Inc., Omaha, NE), and 3) NAF. The ingredients are shown in Table 1 for each formulation. Functional ingredients (soy and starch) were added at quantities common to industry practice. With the CO formulation, soy acted as a stabilizer for the liquid fat, which required a greater amount of protein to coat the fat droplets. For the NAF formulation, it was necessary to increase the moisture content with water as the fat was decreased; therefore, starch was necessary to bind the excess water in the formulation. Each formulation was made twice (2 different processing days).

Goat meat was ground through a Hollemytic 300 Mixer Grinder (Hollematic Corporation, Countryside, IL) with a 3.175-mm plate and a bone eliminator. The grind was then placed in a 22.68-kg-capacity bowl chopper (model SM-40, Koch, Kansas City, MO). The goat meat was chopped for approximately 1 min, curing salts (6.25% sodium nitrite; A. C. Legg, Calara, AL) were added, and the meat was chopped for another minute, followed by the addition of isolated soy protein (Supro 248, Solae, St. Louis, MO) when in the recipe. The seasoning blend was then added. This consisted of salt, dextrose, monosodium glutamate, onion and garlic powder, sodium erythorbate, spice extractives, and tricalcium phosphate as an anticaking agent (A. C. Legg). The seasoning blend was followed by an ice and water mixture and Modified Food Starch PureGel B990 (Grain Processing Corporation, Muscatine, IA) when in the recipe. The source of fat was added last. The emulsion was chopped to a temperature of 12°C. The meat batter was transferred to a twin-screw vacuum stuffer (VeMag Robot 500, VeMag Maschinenbau GmbH, Verden, Germany) and stuffed into 22-mm-diameter cellulose casings (Dewied Int., San Antonio, TX). Frankfurters were thermally processed as follows: 1) wet bulb off, dry bulb 60°C, 30 min with no smoke application; 2) wet bulb off, dry bulb 65.56°C, 20 min with natural smoke; 3) wet bulb 54.44°C, dry bulb 73.89°C for 15 min, natural smoke; 4) wet bulb 67.22°C, dry bulb 79.44°C, cooked to an internal temperature of 69.89°C with natural smoke; and 6) showered with wet and dry bulb off until an internal temperature of 35°C was reached, with smoke off. After thermal processing, casings were removed by hand peeling, and frankfurters were chilled to an internal temperature of 2°C in a cooler for storage of thermally processed meats. They were then vacuum packaged (model UV21C, Ultravac, Kansas City, MO) 6 to 8 per bag (10 × 13 3-mil; 30 to 50 mL of O2/m2/24 h/101325 Pa/23°C; Koch) and stored at 4 ± 2°C for 14 d before analyses were conducted.

Sensory Evaluation

Frankfurters were cut into 2.54-cm-long pieces, placed in aluminum-lined baking pans, covered with aluminum foil, and heated in an oven at 121°C to an internal temperature of 71°C. Samples were assigned random 3-digit numbers, placed into labeled 1-oz (29.57 mL) serving cups, and stored in a warming oven at 71 ± 2°C until they were served to panelists.

Consumer sensory panels were performed at Auburn University using volunteers from Auburn University and Tuskegee University as well as outside volunteers from the community. Volunteers were solicited from an

Table 1. Formulations for goat frankfurters using 3 different fat sources

<table>
<thead>
<tr>
<th>Item</th>
<th>Beef fat, kg</th>
<th>Canola oil, kg</th>
<th>No added fat, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goat meat</td>
<td>7.71</td>
<td>7.99</td>
<td>7.31</td>
</tr>
<tr>
<td>Fat</td>
<td>1.70</td>
<td>1.13</td>
<td>0.00</td>
</tr>
<tr>
<td>Water</td>
<td>0.43</td>
<td>0.45</td>
<td>0.85</td>
</tr>
<tr>
<td>Ice</td>
<td>1.28</td>
<td>1.36</td>
<td>2.55</td>
</tr>
<tr>
<td>Seasoning</td>
<td>0.23</td>
<td>0.23</td>
<td>0.23</td>
</tr>
<tr>
<td>Starch</td>
<td>0.00</td>
<td>0.06</td>
<td>0.34</td>
</tr>
<tr>
<td>Soy</td>
<td>0.00</td>
<td>0.11</td>
<td>0.06</td>
</tr>
<tr>
<td>Curing salts</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
</tbody>
</table>

1 Beef fat from commercially grain-fed animals.
2 Consisting of salt, dextrose, monosodium glutamate, onion and garlic powder, sodium erythorbate, spice extractives, and tricalcium phosphate as an anticaking agent (A. C. Legg). The seasoning blend was followed by an ice and water mixture and Modified Food Starch PureGel B990 (Grain Processing Corporation, Muscatine, IA).
3 Supro 248 (Solae, St. Louis, MO).
4 Modified Food Starch PureGel B990 (Grain Processing Corporation, Muscatine, IA).
5 Curing salts: 6.25% sodium nitrite (A. C. Legg).
Table 2. Least squares means and SE for consumer sensory panel scores, on an 8-point hedonic scale, for goat frankfurters formulated with 3 different sources of fat

<table>
<thead>
<tr>
<th>Item</th>
<th>Tenderness</th>
<th>Juiciness</th>
<th>Flavor</th>
<th>Overall liking of flavor</th>
<th>Overall liking of texture</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef fat</td>
<td>4.11 ± 0.18a</td>
<td>3.86 ± 0.15a</td>
<td>3.12 ± 0.15a</td>
<td>3.62 ± 0.18a</td>
<td>3.83 ± 0.18a</td>
<td>3.78 ± 0.18a</td>
</tr>
<tr>
<td>Canola oil</td>
<td>4.35 ± 0.18a</td>
<td>4.49 ± 0.15b</td>
<td>3.65 ± 0.15b</td>
<td>3.90 ± 0.18a</td>
<td>4.30 ± 0.18b</td>
<td>4.11 ± 0.18b</td>
</tr>
<tr>
<td>No added fat</td>
<td>4.90 ± 0.18a</td>
<td>4.58 ± 0.15b</td>
<td>3.10 ± 0.15a</td>
<td>4.46 ± 0.18a</td>
<td>4.59 ± 0.18a</td>
<td>4.51 ± 0.18a</td>
</tr>
</tbody>
</table>

*Within a column, means without a common superscript differ (*P* < 0.05). Scale: 1 = extremely tender (juicy, flavorful, like, acceptable), 2 = very tender (juicy) and very flavorful (like, acceptable), 3 = moderately tender (juicy, flavorful, like, acceptable), 4 = slightly tender (juicy, flavorful, like, acceptable), 5 = slightly tough (dry, bland, dislike, unacceptable), 6 = moderately tough (dry, bland, dislike, unacceptable), 7 = very tough (dry) and very bland (dislike, unacceptable), 8 = extremely tough (dry, bland, dislike, unacceptable).

The results of consumer sensory panel scaling are shown in Table 2. Panelists were 43% male and 57% female, and 18% of them considered themselves regular consumers of goat meat (more than once per month), with the remainder eating goat meat 1 time or less per year. All 3 treatments were rated by the untrained sensory panel as slightly tender. However, NAF was less tender than BF or CO (*P* = 0.007).

For juiciness, BF was considered moderately to slightly juicy and was juicier than both CO and NAF (*P* = 0.003). Canola oil and NAF were not different and were scored as slightly juicy to slightly dry. This perception of juiciness could be attributed to addition of the BF in that formulation. Animal fat aids in a lubrication effect (Smith and Carpenter, 1974) because fat stimulates the salivary glands to produce more saliva, increasing the sensation of juiciness.

Although all 3 treatments were scored between moderately and slightly flavorful, results revealed that CO was less flavorful (*P* = 0.029) than BF or NAF, which were not different. The CO did have more soy in the

**Objective Measurements**

Percentages of fat and moisture were determined with the CEM SMART system and a SMART Trac Fat and Moisture Analyzer (CEM Corporation, Matthews, NC). Texture profile analysis (TPA) variables were determined using model TA.XT2 (Stable Micro Systems, Texture Technologies Corp., Scarsdale, NY). The following variables were determined: hardness, springiness, cohesiveness, chewiness, and resilience (Bourne, 1978). The TPA test settings used were as follows: pre-test speed of 2.0 mm/s, test and posttest speeds of 5.0 mm/s, samples compressed to 35% of their height, and time between strokes of 0.5 s. The auto-trigger feature was used and set at 0.005 kg.

**Statistical Analysis**

Statistical analyses were performed using the GLM procedure (SAS Inst. Inc., Cary, NC). The experiment was set up as a completely randomized design. Fixed effects in the experiment included fat source and replication for all traits of interest. The interaction between fat source and replication was also included in the model. Least squares means were separated using the PDIF option of SAS for significant main and interaction effects. Differences were detected at the *P* < 0.05 level.

**RESULTS AND DISCUSSION**

**Sensory Evaluation**

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Although all 3 treatments were scored between moderately and slightly flavorful, results revealed that CO was less flavorful (*P* = 0.029) than BF or NAF, which were not different. The CO did have more soy in the
formulation, so this rating could be attributed to a soy flavor; however, the panelists were not asked to comment on off-flavors. This less flavorful rating could also have been a result of the difference in using a tallow compared with an oil for the fat source. However, to justify this assumption, another study would have to be conducted to identify any specific flavor notes in each treatment. Cosenza et al. (2003) reported no flavor differences in cabrito smoked sausage products formulated with 0 or 3.5% soy protein concentrate.

For overall liking of flavor, NAF revealed scores that were slightly liked to slightly disliked. Beef fat and CO were rated better \( (P = 0.004) \) than NAF, between slightly liked and moderately liked. The ratings for overall texture and overall acceptability were moderately liked and moderately acceptable for BF and slightly liked and slightly acceptable for CO and NAF. Although BF was not different from CO, it was different from NAF \( (P = 0.001) \), and CO was not different from NAF. Slight differences were seen within each of the categories for all 3 treatments, but all the means were within an acceptable range, as defined by the scores of the panelists. Using a scale of 1 to 9, with 9 being extremely like and 1 being extremely dislike, Cosenza et al. (2003) reported that consumers rated cabrito smoked sausage products a 6 for texture, flavor, and overall acceptability. The present results are similar in that the panelists rated the product between moderately and slightly like. An opportunity exists for evolution of the recipes to improve the characteristics and overall acceptability of the product.

**Objective Measurements**

Chemical analysis of the goat frankfurters formulated is shown in Table 3. Moisture and protein were different \( (P < 0.001) \) between all 3 treatment groups. The NAF product had the most moisture and CO had the least, whereas NAF had the most protein and BF had the least. As expected, fat was similar between BF and CO, which were both greater \( (P < 0.001) \) than that of NAF.

The TPA values are shown in Table 4. Frankfurters formulated with BF and CO were harder \( (P = 0.008) \) and chewier \( (P = 0.027) \) than NAF. This effect was not seen with the addition of CO because of the chemical differences in tallow and oil. Beef fat is more solid and interacts to form a continuous 3-dimensional solid fat network, which is ultimately responsible for properties such as hardness, whipability, spreadability, graininess formation, brittleness, and aeration properties (Liu et al., 2009). The addition of starch in NAF may have provided protection from hardening. Modified food starch entraps water and forms hydrogen bonds, acting as a water binder. Water increases moisture content and indirectly results in decreased hardness. This was seen in the chemical analysis with the NAF, which contained 0.34 kg of starch in the blend having the greatest moisture content (55.80%; Table 3). These data are consistent with an application study in which no-fat beef hot dogs had the least hardness and the all-beef hot dogs were the hardest (Study 30WB; Texture Technologies Corporation, 1998). Low-fat products with starch and soy protein exhibit sensory properties similar to those of high-fat controls (Resurreccion, 2003). In the current study, NAF had the least values for hardness and chewiness for TPA characteristics. However, the sensory panelists reported that the NAF was less tender, which was opposite the objective results. This could, however, be attributed to the difficulty untrained panelists may have had in separating out the sensation of tenderness.

For cohesiveness, BF and CO were not different and CO and NAF were not different. Beef fat was more cohesive than NAF \( (P = 0.041) \). No difference was observed in springiness (distance the sample recovers between the first and second compression) or resilience (ability of the core sample to resume its original shape) between

**Table 3. Least squares means and SE for chemical analysis of goat frankfurter finished products formulated with 3 different sources of fat**

<table>
<thead>
<tr>
<th>Item</th>
<th>Moisture, %</th>
<th>Fat, %</th>
<th>Protein, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef fat</td>
<td>48.57 ± 0.36a</td>
<td>24.36 ± 0.16a</td>
<td>26.07 ± 0.15a</td>
</tr>
<tr>
<td>Canola oil</td>
<td>46.59 ± 0.36b</td>
<td>24.43 ± 0.16b</td>
<td>27.98 ± 0.15b</td>
</tr>
<tr>
<td>No added fat</td>
<td>55.80 ± 0.36c</td>
<td>9.06 ± 0.16c</td>
<td>34.14 ± 0.15c</td>
</tr>
</tbody>
</table>

*Within a column, means without a common superscript differ \( (P < 0.05) \).

**Table 4. Least squares means and SE for texture profile analysis of goat frankfurters formulated with 3 different sources of fat**

<table>
<thead>
<tr>
<th>Item</th>
<th>Hardness, kg</th>
<th>Springiness, %</th>
<th>Cohesiveness, %</th>
<th>Chewiness, kg</th>
<th>Resilience, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef fat</td>
<td>4.48 ± 0.11a</td>
<td>93.1 ± 0.8</td>
<td>81.9 ± 0.7b</td>
<td>3.39 ± 0.11a</td>
<td>23.0 ± 2.0</td>
</tr>
<tr>
<td>Canola oil</td>
<td>4.40 ± 0.11a</td>
<td>93.4 ± 0.8</td>
<td>79.9 ± 0.7b</td>
<td>3.29 ± 0.11a</td>
<td>20.0 ± 2.0</td>
</tr>
<tr>
<td>No added fat</td>
<td>3.92 ± 0.11b</td>
<td>93.2 ± 0.8</td>
<td>79.5 ± 0.7b</td>
<td>2.89 ± 0.11b</td>
<td>22.0 ± 2.0</td>
</tr>
</tbody>
</table>

*Within a column, means without a common superscript differ \( (P < 0.05) \).
the 3 treatments. Yang et al. (2001) reported that low-fat frankfurters made with modified waxy maize starch and isolated soy protein had textural properties similar to those of high-fat controls. Schilling (2002) reported that modified food starch decreased textural hardness in restructured boneless ham, with no other variables affected. These results are similar to those of Motzer et al. (1998), who reported that the incorporation of modified food starch into water-cooked, restructured hams caused decreased hardness and no other differences. Differences may exist in the behaviors of course-ground products and emulsified products in the way these characteristics perform. Reducing the fat content in frankfurters has been reported to increase toughness (Sofos and Allen, 1977; Paul and Foget, 1983).

The segments involved in producing goat meat are gaining more knowledge of production, marketing, and processing on a daily basis. With continued research into value-added, processed products, a potential exists for products that will appeal to all types of consumers, not only the traditional consumers of goat meat. Although the sensory panel typically preferred the formulation with BF, no major differences were observed in any of the attributes among the treatments. In addition, for textural properties, the NAF frankfurter had reduced hardness, gumminess, and chewiness values while at the same time having less fat than the other 2 formulations; however, consumers scored these as the least tender. In future research, a puncture test should be used to discern between any differences in skin formation. Results from these data reveal that value-added goat meat products received acceptable sensory scores; therefore, continued research and development will greatly expand the knowledge of goat meat and increase the acceptance of value-added products. It appears that a low-fat product may not appeal to sensory panelists compared with a high-fat product, but the textural properties are favorable. With an increased knowledge of the functionality of goat in value-added, processed products, there is potential to enter into a market for these products that has not previously been explored, both with low-fat products and with fat alternatives.

**LITERATURE CITED**


