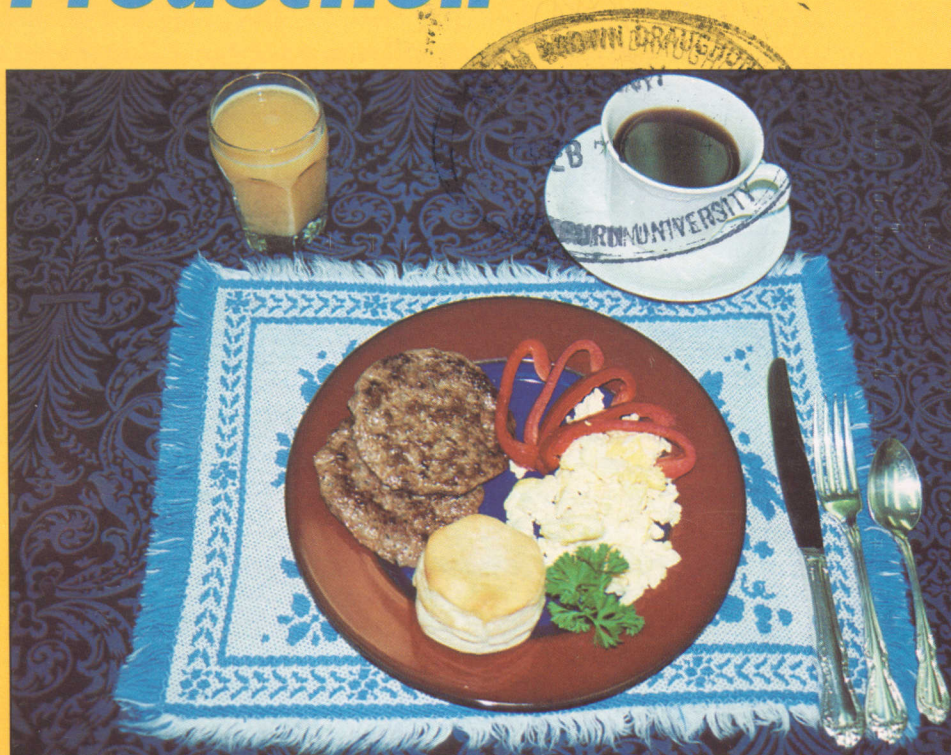


LOW-FAT

Fresh Pork Sausage Production



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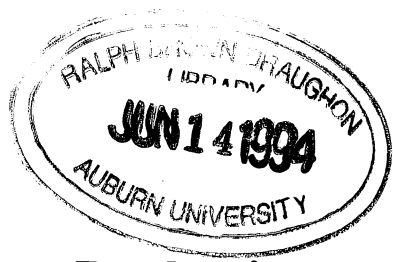
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without regard to race, color, sex, or national origin.*



Low-Fat Fresh Pork Sausage Production

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INTRODUCTION

Over one billion pounds of fresh pork sausage products are consumed annually in the United States. These products generally contain between 35-50 percent fat (*1*). From this information it is clear that as today's consumers continue to become more health conscious, their demand for lean fresh pork sausage products will rapidly expand. The acceptability of pork sausage products is affected by the amount of fat present. Egbert et al. (*1*) reported that the acceptability of fresh pork sausage is closely related to the amount of fat in these products. Simple reduction of the fat level in fresh pork sausage products to less than 10 percent would result in a product with undesirable palatability traits. Therefore, an innovative approach was initiated to develop an acceptable lean fresh pork sausage product.

EXPERIMENTAL DEVELOPMENT

Development of a low-fat fresh pork sausage was approached in a series of logical steps or studies, each building on the results of the previous experiment. The first study explored consumer acceptability of fresh pork sausage containing varying levels of fat. Study II was designed to determine the optimum combination of seasonings, based on consumer ratings. The third study was designed to determine the amount of seasoning from Study II that was desired by consumers. The objective of Study IV was similar to Study III, but the acceptability of varying levels of carrageenan and water was explored. The fifth study was conducted to determine the consumer acceptability of low-fat pork sausage with varying amounts of carrageenan and water. The fifth study confirmed the findings of the earlier studies, which led to development of an acceptable product. Study VI was designed to explore the possibility of further fat reduction of lean pork sausage from 12.5 percent to 7 percent.

¹ Professor and Research Associates of Animal and Dairy Sciences.

² This study was funded in part by the National Live Stock and Meat Board, Chicago, Ill. The contribution of nonmeat ingredients by the Marine Colloids Division of FMC Corporation, Philadelphia, Pa., and A.C. Legg, Inc., Birmingham, Ala., is appreciated. The cooperation of Jason M. Britt and Southern Foods Company, Columbus, Ga., is also acknowledged with appreciation.

DESIGN AND METHODOLOGY

Product Processing Procedure

Fresh boneless pork hams, picnics, and back fat were obtained from a local packer. The raw materials were separated into lean and fat portions and ground separately through a 1/2-inch plate. Representative samples were analyzed for fat content by ether extraction (2). The lean sausage products were formulated using the Pearson square technique to determine the appropriate amount of lean and fat. The lean and fat components were mixed with various ingredient combinations (such as seasoning, carrageenan and/or water) based upon the formulation for each study. After the meat and non-meat ingredients had been mixed for 2 minutes on a speed setting of two (200 rpm) in a Hobart bowl mixer (Model H-120), the products were finely ground through a 3/16-inch plate and made into 2-ounce patties using a Hollymatic (Super 54) patty machine. Sausage patties were stored at 37° F until sensory and chemical analyses were completed.

Methodology for Cooking and Determination of Cooking Loss

Sausage products were griddle broiled on a Model TG-72 Special McDonald's grill (Wolf Range Corporation) at a temperature of 329°F for 5 minutes (1.5 minutes on the first side, 2 minutes on the other side and another 1.5 minutes on the first side) until an internal temperature of 167-172°F was achieved. Percent cooking yields were determined by the difference in weight for three patties from each treatment weighed prior to cooking and after equilibration to room temperature (68°F). Percent cooking loss was determined by subtracting the percent cooking yield from 100 percent.

Moisture, Protein, and Fat Analysis

Raw and cooked samples for each treatment/replication/study were ground three times using a Kitchen Aid Mixer-Grinder (Model K45SS). Moisture and protein (Kjeldahl nitrogen) contents of products were determined in triplicate using the Association of Official Analytical Chemists (2) approved methods. Fat content was determined as described by Folch et al. (3).

Sensory Panel Evaluation

The sensory panels for each study were held within 24-48 hours after processing. The sensory panel (untrained or trained) was composed of students, faculty, and staff of the Department of Animal and Dairy Sciences. Cooked patties were cut into six wedges of approximately equal size and stored in metal pans with lids in a conventional oven until evaluated. Panelists evaluated products for juiciness,

tenderness, cohesiveness, flavor intensity, and overall acceptability on an eight-point hedonic scale (1 = extremely dry, extremely tough, extremely noncohesive, extremely bland, and extremely undesirable; and 8 = extremely juicy, extremely tender, extremely cohesive, extremely intense, and extremely desirable, respectively). Panelists were served one wedge of each treatment in a random order accompanied with unsalted crackers and apple juice at room temperature.

Statistical Analysis

The experimental data for each study were analyzed using a completely random design with three replications. Analysis of variance, means, and standard errors were used for all data (8). When a significant F-value ($P < 0.05$) was found, Fisher's Least Significant Difference (FLSD) mean separation procedure was used to determine differences between treatment means (9).

STUDY I

CONSUMER ACCEPTABILITY OF FRESH PORK SAUSAGE WITH VARYING AMOUNTS OF FAT

DESIGN

Fresh pork sausage patties were formulated to six fat levels (10, 20, 30, 40, 50, and 60 percent). The products were processed as previously described. Sensory evaluation was conducted by 100 untrained consumer-type panelists. Sausage patties were subjected to evaluation for overall acceptability on an eight-point hedonic scale. The study was replicated, and the data were analyzed as previously described.

RESULTS AND DISCUSSION

Proximate Analysis of Raw Product

Proximate analysis data for raw products shown in Table 1 indicate that fat content of products were consistent with formulated fat levels. As the fat level increased in the raw fresh pork sausage patties, the levels of moisture decreased ($P < 0.05$). The results support previous studies (4, 5, 6, 7), which reported that an inverse relationship exists between fat content and moisture content. Protein content was different ($P < 0.01$) for products with different fat levels. An increased fat level in fresh pork sausage patties resulted in a decreased ($P < 0.05$) protein content.

Table 1. Proximate Analysis of Raw Fresh Pork Sausage Patties With Different Amounts of Fat, Study I

| Fat Level ¹ | Moisture ² | Fat ² | Protein ² |
|------------------------|-----------------------|------------------|----------------------|
| <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 10..... | 69.6a | 9.2f | 21.0a |
| 20..... | 62.8b | 17.2e | 18.6b |
| 30..... | 55.6c | 25.9d | 14.9c |
| 40..... | 49.8e | 34.8c | 12.2d |
| 50..... | 40.3e | 43.6b | 10.0e |
| 60..... | 33.3f | 51.8a | 8.9f |

¹"Fat Level" is the projected amount of fat, while "Fat" is the actual fat level found upon analysis.

² Means in the same column followed by different letters are significantly different (P<0.05).

Proximate Analysis of Cooked Product

Proximate analysis results for cooked fresh pork sausage patties presented in Table 2 indicated that composition of the cooked fresh pork sausage patties conform to the same trend as the raw products. Fat content differed (P<0.05) in the cooked pork sausages as formulated fat levels increased, with the exception of products containing 50 or 60 percent fat which did not differ. In general, percent moisture content for the cooked fresh pork sausage patties decreased (P<0.05) as fat increased. Percent protein content varied (P<0.05) among products. This finding is likely due to the change in moisture and fat content.

Cooking Loss

Generally, percent cooking loss increased (P<0.05) as fat increased in the fresh pork sausage patties (Table 2). There was no difference (P>0.05) in cooking loss among products with a fat content below 30 percent or above 40 percent.

Table 2. Proximate Analysis of Cooked Fresh Pork Sausage Patties With Different Amounts of Fat, Study I

| Fat Level | Moisture ¹ | Fat ¹ | Protein ¹ | Cooking Loss ¹ |
|-------------|-----------------------|------------------|----------------------|---------------------------|
| <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 10..... | 63.1a | 11.2e | 23.9b | 34.4b |
| 20..... | 55.8b | 17.6d | 25.6a | 36.7b |
| 30..... | 52.4c | 22.2c | 20.5e | 38.0b |
| 40..... | 45.3d | 27.4b | 23.4b | 44.8a |
| 50..... | 43.1de | 28.7a | 21.7d | 45.7a |
| 60..... | 43.2e | 28.5a | 22.9bc | 46.3a |

¹Means in the same column followed by different letters are significantly different (P<0.05).

Sensory Evaluation

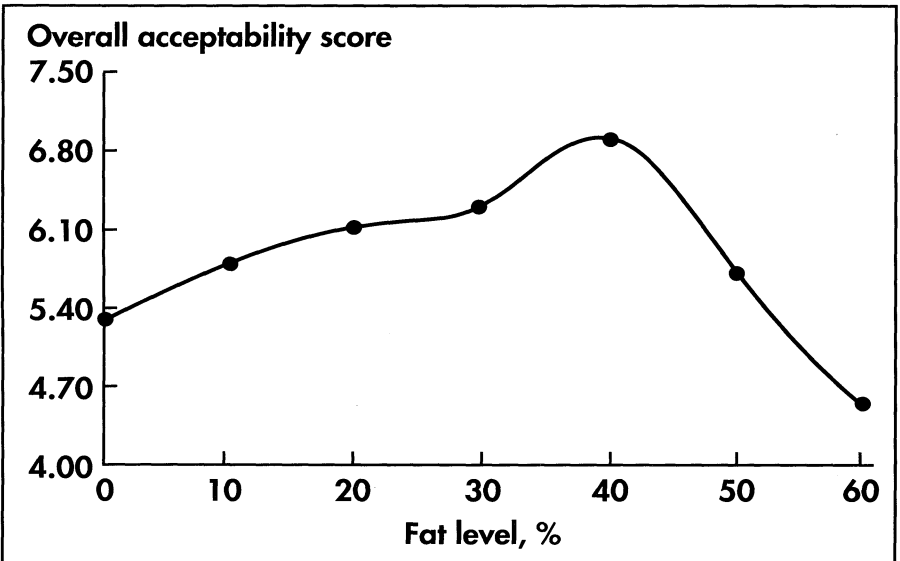
Sensory evaluation data presented in Table 3 and the figure show an increase in overall acceptability scores as fat content increased from 10 percent to 40 percent and a marked decrease at 50 percent and 60 percent fat. When these data are plotted, the curve peaks at an acceptability level of 40 percent. Statistical data (Table 3) show no differences ($P>0.05$) in sensory acceptability scores among products with fat levels of 10 percent, 20 percent, and 30 percent.

Table 3. Overall Acceptability Scores of Fresh Pork Sausage Patties With Different Amounts of Fat, Study I

| Fat Level | Overall Acceptability Scores ^{1,2} |
|-------------|---|
| <i>Pct.</i> | |
| 10..... | 5.8bc |
| 20..... | 6.1bc |
| 30..... | 6.3ab |
| 40..... | 6.9a |
| 50..... | 5.7c |
| 60..... | 4.5d |

¹ Means in the same column followed by different letters are significantly different ($P<0.05$).

² Scale: 1=extremely undesirable; 8=extremely desirable.



CONCLUSION

Since overall acceptability scores from fresh pork sausage patties peaked at a fat content of 40 percent, this fat level was determined to be the standard (control) for future research on the development of low-fat fresh pork sausage products.

STUDY II

CONSUMER ACCEPTABILITY OF FRESH PORK SAUSAGE WITH DIFFERENT SEASONING FORMULATIONS

DESIGN

Fresh pork sausage patties were prepared with three different seasoning formulations (mild, medium, and hot) at 40 percent fat (Table 4). The products were manufactured as described previously. Sensory evaluation was conducted by 100 untrained consumer-type panelists. Sausage patties were subjected to evaluation for overall acceptability on an eight-point hedonic scale. The study was replicated, and the data were analyzed as previously described.

Table 4. Fresh Pork Sausage Seasoning Formulation, Study II

| Treatment | Hot | Medium | Mild |
|-------------------------|-------------|-------------|-------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| Salt..... | 1.630 | 1.630 | 1.630 |
| Dextrose..... | 0.250 | 0.250 | 0.250 |
| Chopped sage..... | 0.220 | 0.160 | 0.100 |
| Black pepper..... | 0.050 | 0.030 | 0.016 |
| Ground red pepper..... | 0.160 | 0.125 | 0.094 |
| Crushed red pepper..... | 0.031 | 0.016 | 0.000 |
| Water..... | 3.000 | 3.000 | 3.000 |

RESULTS AND DISCUSSION

Proximate Analysis

There were no differences ($P>0.05$) for proximate analysis among raw products due to the different seasoning (mild, medium and hot) formulations (Table 5). The same trends also were observed for the cooked products (Table 6).

Table 5. Proximate Analysis of Raw Fresh Pork Sausage Patties With Different Seasoning Formulations, Study II

| Treatment ¹ | Moisture ² | Fat ² | Protein ² |
|------------------------|-----------------------|------------------|----------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| Hot..... | 48.9b | 34.8b | 12.4b |
| Medium..... | 49.5b | 34.7b | 12.3b |
| Mild..... | 49.8b | 34.8b | 12.2b |

¹Description of treatments shown in Table 4.

²Means in the same column followed by different letters are significantly different (P<0.05).

Table 6. Proximate Analysis of Cooked Fresh Sausage Patties With Different Seasoning Formulations, Study II

| Treatment ¹ | Moisture ² | Fat ² | Protein ² | Cooking Loss ² |
|------------------------|-----------------------|------------------|----------------------|---------------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| Hot..... | 45.3b | 27.5b | 22.3b | 44.8b |
| Medium..... | 45.5b | 27.4b | 23.4b | 44.7b |
| Mild..... | 45.3b | 27.5b | 23.5b | 44.8b |

¹Description of treatments shown in Table 4.

²Means in the same column followed by different letters are significantly different (P<0.05).

Cooking Loss

The results of cooking loss determinations (Table 6) indicate no differences (P>0.05) due to different seasoning (mild, medium, and hot) formulations.

Sensory Evaluation

Overall acceptability scores for fresh pork sausage patties with different seasoning formulations are presented in Table 7. Panelists found that product with the mild levels of seasoning ingredients (chopped sage, black pepper, ground red pepper, and crushed red pepper) had lower (P<0.05) overall acceptability than those products with more seasoning. There were no differences (P>0.05) for overall acceptability between products with hot (treatment 1) or medium (treatment 2) seasoning ingredients.

Table 7. Overall Acceptability Scores of Fresh Pork Sausage Patties With Different Seasoning Formulations, Study II

| Treatment ¹ | Overall Acceptability ^{2,3} |
|------------------------|--------------------------------------|
| Hot..... | 7.4b |
| Medium..... | 7.4b |
| Mild..... | 6.6c |

¹ Description of treatments shown in Table 4.

² Means in the same column followed by different letters are significantly different ($P < 0.05$).

³ Scale: 1=extremely undesirable; 8=extremely desirable.

CONCLUSION

Fresh pork sausage patties with a hot or medium seasoning formulation were rated more desirable ($P < 0.05$) than the low seasoning product by panelists. In order to establish a standard seasoning formulation for the development of low-fat sausages, a medium seasoning formulation was chosen as the acceptable standard to prevent the possibility of the hot seasoning masking any off-flavors.

STUDY III

CONSUMER ACCEPTABILITY OF FRESH PORK SAUSAGE WITH DIFFERENT AMOUNTS OF SEASONINGS

DESIGN

Four different amounts of seasoning (1, 1.25, 1.5, and 1.75 times that of the control amounts) were used in the lean sausage products (15 percent fat) to compare regular control (40 percent fat) in order to adjust the flavor intensity due to different fat contents in the sausage products (Table 8). The products were produced as described previously. Sensory evaluation was conducted by 15 trained panelists. Sausage patties were subjected to evaluation for juiciness, tenderness, cohesiveness, flavor intensity and overall acceptability on an eight-point hedonic scale. The study was replicated, and the data were analyzed as previously described.

Table 8. Fresh Pork Sausage Seasoning Formulation, Study III

| Treatment ¹ | 1 | 2 | 3 | 4 | 5 |
|-------------------------|-------------|-------------|-------------|-------------|-------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| Salt..... | 1.625 | 1.625 | 2.031 | 2.438 | 2.844 |
| Dextrose..... | 0.250 | 0.250 | 0.313 | 0.375 | 0.438 |
| Chopped sage..... | 0.160 | 0.160 | 0.200 | 0.240 | 0.280 |
| Black pepper..... | 0.030 | 0.030 | 0.038 | 0.045 | 0.053 |
| Ground red pepper..... | 0.125 | 0.125 | 0.156 | 0.188 | 0.219 |
| Crushed red pepper..... | 0.016 | 0.016 | 0.020 | 0.024 | 0.028 |
| Water..... | 3.000 | 3.000 | 3.000 | 3.000 | 3.000 |

¹ Treatment 1 was formulated to contain 40 pct. fat; all others were formulated to contain 15 pct.

RESULTS AND DISCUSSION

Proximate Analysis

Proximate analysis data for raw products are presented in Table 9. As expected, regular products with 40 percent fat (treatment 1) had higher (P<0.05) fat content and lower (P<0.05) moisture and protein contents than lean products (treatments 2, 3, 4, and 5). The results showed no differences (P>0.05) for moisture, fat, and protein contents among lean products (15 percent fat) with different levels of seasonings. Similar trends were found for cooked products except protein content (Table 10) which was approximately 26 percent for all treatments.

Table 9. Proximate Analysis of Raw Fresh Pork Sausage Patties With Different Amounts of Seasoning, Study III

| Treatment ¹ | Moisture ² | Fat ² | Protein ² |
|------------------------|-----------------------|------------------|----------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 51.5c | 33.2b | 16.8c |
| 2..... | 67.5b | 11.5c | 17.7b |
| 3..... | 67.9b | 11.2c | 17.7b |
| 4..... | 67.6b | 11.9c | 17.6b |
| 5..... | 67.5b | 11.8c | 17.5b |

¹ Description of treatments shown in Table 8.

² Means in the same column followed by different letters are significantly different (P<0.05).

Cooking Loss

Table 10 shows cooking loss data for fresh pork sausage patties. Lean sausage products (treatments 1, 2, 3, 4, and 5) had less ($P<0.05$) cooking loss than regular sausage (40 percent fat). There were no differences ($P>0.05$) for cooking loss among lean (15 percent) sausage patties with different levels of seasonings.

Table 10. Proximate Analysis of Cooked Fresh Pork Sausage Patties With Different Amounts of Seasoning, Study III

| Treatment ¹ | Moisture ² | Fat ² | Protein ² | Cooking Loss ² |
|------------------------|-----------------------|------------------|----------------------|---------------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 50.7c | 25.3b | 25.8b | 37.0b |
| 2..... | 60.2b | 13.8c | 25.6b | 20.5c |
| 3..... | 60.4b | 13.5c | 25.5b | 20.7c |
| 4..... | 60.3b | 13.6c | 25.8b | 20.4c |
| 5..... | 60.0b | 13.8c | 25.6b | 20.6c |

¹Description of treatments shown in Table 8.

²Means in the same column followed by different letters are significantly different ($P<0.05$).

Sensory Evaluation

Sensory evaluation data presented in Table 11 show no differences ($P>0.05$) for sensory characteristics (juiciness, tenderness, flavor intensity, and overall acceptability scores) except product cohesiveness scores. The results showed lean (15 percent fat) products (treatment 2, 3, 4 and 5) had higher ($P<0.05$) cohesiveness scores than regular (40 percent fat) products (treatment 1).

Table 11. Sensory Evaluations of Fresh Pork Sausage Patties With Different Amounts of Seasoning, Study III

| Treatment ¹ | Juiciness ^{2,3} | Tenderness ^{2,3} | Cohesiveness ^{2,3} | Flavor Intensity ^{2,3} | Overall Acceptability ^{2,3} |
|------------------------|--------------------------|---------------------------|-----------------------------|---------------------------------|--------------------------------------|
| 1..... | 5.7b | 6.3b | 5.5c | 5.5b | 5.4b |
| 2..... | 5.4b | 5.7b | 6.5b | 5.9b | 5.5b |
| 3..... | 5.7b | 6.1b | 6.5b | 6.1b | 5.9b |
| 4..... | 5.8b | 5.9b | 6.7b | 6.5b | 5.5b |
| 5..... | 5.8b | 6.0b | 6.4b | 6.6b | 5.1b |

¹Description of treatments shown in Table 8.

²Means in the same column followed by different letters are significantly different ($P<0.05$).

³Scale: 1 = extremely dry, tough, noncohesive, bland, or undesirable, respectively; and 8 = extremely juicy, tender, cohesive, intense, or desirable, respectively.

CONCLUSION

Since no differences were found among lean (<15 percent fat) products for proximate composition, cooking loss and sensory evaluation due to different levels of seasonings, a medium-mild level of seasoning was chosen for further development work.

STUDY IV

CONSUMER ACCEPTABILITY OF FRESH PORK SAUSAGE WITH DIFFERENT LEVELS OF CARRAGEENAN AND WATER

DESIGN

Lean fresh pork sausage patties were prepared with two levels of carrageenan (0 or 0.5 percent) and four levels of added water (3, 10, 20, or 30 percent) as shown in Table 12. The products were produced as described previously. Sensory evaluation was conducted by 15 trained panelists. Sausage patties were subjected to evaluation for juiciness, tenderness, cohesiveness, flavor intensity, and overall acceptability on an eight-point hedonic scale. The study was replicated, and the data were analyzed as previously described.

Table 12. Fresh Pork Sausage Patties With Different Amounts of Carrageenan and Water, Study IV

| Treatment ¹ | 1 | 2 | 3 | 4 | 5 | 6 |
|-------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| Meat..... | 94.66 | 94.24 | 93.74 | 86.74 | 76.74 | 66.74 |
| Salt..... | 1.630 | 2.030 | 2.030 | 2.030 | 2.030 | 2.030 |
| Dextrose..... | 0.250 | 0.313 | 0.313 | 0.313 | 0.313 | 0.313 |
| Chopped sage..... | 0.160 | 0.200 | 0.200 | 0.200 | 0.200 | 0.200 |
| Black pepper..... | 0.030 | 0.038 | 0.038 | 0.038 | 0.038 | 0.038 |
| Ground red pepper..... | 0.125 | 0.156 | 0.156 | 0.156 | 0.156 | 0.156 |
| Crushed red pepper..... | 0.016 | 0.020 | 0.020 | 0.020 | 0.020 | 0.020 |
| Carrageenan..... | 0.000 | 0.000 | 0.500 | 0.500 | 0.500 | 0.500 |
| Water..... | 3.000 | 3.000 | 3.000 | 10.00 | 20.00 | 30.00 |

¹ Treatment 1 was formulated to contain 40 pct. fat; all others were formulated to contain 15 pct.

RESULTS AND DISCUSSION

Proximate Analysis

Proximate analysis data for raw products shown in Table 13 indicated that proximate composition of raw sausages differed ($P<0.05$) with varying levels of carrageenan and water. Moisture content of raw products increased ($P<0.05$) as added water levels increased in the products. The fat content of products decreased ($P<0.05$) when sausages were formulated with 0.5 percent carrageenan. There were no differences ($P>0.05$) for fat content among raw products with different combinations of carrageenan and added water. Sausages with carrageenan and less than 10 percent added water (treatments 3 and 4) had the highest ($P<0.05$) protein content while sausages with carrageenan and more than 20 percent added water (treatments 5 and 6) had the lowest ($P<0.05$) protein content.

Table 13. Proximate Analysis of Raw Fresh Pork Sausage With Different Amounts of Carrageenan and Water, Study IV

| Treatment ¹ | Moisture ² | Fat ² | Protein ² |
|------------------------|-----------------------|------------------|----------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 48.7f | 33.0b | 16.9d |
| 2..... | 67.7e | 11.4c | 17.7c |
| 3..... | 68.3e | 10.5d | 18.5b |
| 4..... | 70.0d | 10.8d | 18.1b |
| 5..... | 73.3c | 10.3d | 15.8e |
| 6..... | 74.6b | 10.7d | 15.4e |

¹Description of treatment shown in Table 12.

²Means in the same column followed by different letters are significantly different ($P<0.05$).

Proximate Analysis of Cooked Products

Proximate composition of cooked products presented in Table 14 show that moisture content of cooked sausages increased ($P<0.05$) when added water increased in the products. The fat content of cooked products was lower ($P<0.05$) for lean products with carrageenan and 10 percent or more added water (treatments 4, 5, and 6) than for other treatments. However, lean sausage patties with carrageenan and 10 percent or more added water (treatments 4, 5, and 6) were not different ($P>0.05$) for fat content. No differences ($P>0.05$) were found among cooked sausage products for protein content.

Table 14. Proximate Analysis of Cooked Fresh Pork Sausage Patties With Different Amounts of Carrageenan and Water, Study IV

| Treatment ¹ | Moisture ² | Fat ² | Protein ² | Cooking Loss ² |
|------------------------|-----------------------|------------------|----------------------|---------------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 50.9g | 25.2b | 25.2b | 37.1b |
| 2..... | 60.0f | 13.8c | 25.7b | 20.6d |
| 3..... | 62.3e | 13.3c | 23.9b | 16.3e |
| 4..... | 65.4c | 12.1d | 23.0b | 18.2de |
| 5..... | 64.2d | 11.9d | 23.8b | 25.7c |
| 6..... | 66.6b | 11.4d | 19.5b | 23.8c |

¹Description of treatments shown in Table 12.

²Means in the same column followed by different letters are significantly different (P<0.05).

Cooking Loss

Cooking loss for sausage products was different (P<0.05) for products containing carrageenan and varying levels of water (Table 14). The data indicate that regular sausage (40 percent fat) had the highest (P>0.05) cooking loss. Lean sausages with 0.5 percent carrageenan and 3 percent added water had the lowest (P<0.05) cooking loss except for lean sausages with 0.5 percent carrageenan and 10 percent added water. No differences (P>0.05) were found for cooking loss of lean sausages with 0.5 percent carrageenan and 20 percent or 30 percent added water. The same result was found between lean sausages with 0.5 percent carrageenan and 3 percent or 10 percent added water.

Sensory Evaluation

Sensory panel data shown in Table 15 indicate that juiciness scores for lean sausages were higher (P<0.05) than regular sausages (treatment 1). Panelists rated sausages with 0.5 percent carrageenan and 30 percent added water (treatment 6) higher (P<0.05) for juiciness scores than others, except sausages with 0.5 percent carrageenan and 20 percent added water (treatment 5). Similar trends were found for tenderness and cohesiveness scores. No differences (P>0.05) were found for flavor intensity scores among products. Panelists found that lean sausage (15 percent fat) with 0.5 percent carrageenan and less than 10 percent water (treatments 3 and 4) had similar (P<0.05) overall acceptability scores as regular sausage (40 percent fat). Lean sausage with 0.5 percent carrageenan and 20 percent or 30 percent added water had higher (P<0.05) overall acceptability scores than regular sausage.

Table 15. Sensory Evaluation of Fresh Pork Sausage Patties With Different Amounts of Carrageenan and Water, Study IV

| Treatment ¹ | Juiciness ^{2,3} | Tenderness ^{2,3} | Cohesiveness ^{2,3} | Flavor Intensity ^{2,3} | Overall Acceptability ^{2,3} |
|------------------------|--------------------------|---------------------------|-----------------------------|---------------------------------|--------------------------------------|
| 1..... | 5.2e | 5.4e | 6.1b | 5.7b | 5.3d |
| 2..... | 5.7d | 5.7de | 6.3b | 6.1b | 5.7bcd |
| 3..... | 5.9d | 6.0d | 5.6c | 5.7b | 5.4cd |
| 4..... | 6.1cd | 6.1d | 5.9bc | 5.9b | 5.6bcd |
| 5..... | 6.4bc | 6.5c | 5.6cd | 6.1b | 5.9bc |
| 6..... | 6.5b | 6.9b | 5.2d | 6.0b | 5.9bc |

¹Description of treatments shown in Table 12.

²Means in the same column followed by different letters are significantly different (P<0. 05).

³Description of scale shown in Table 11.

CONCLUSION

Low-fat sausage patties formulated with 0.5 percent carrageenan and 20 percent or 30 percent water were found to be more juicy, more tender, less cohesive, and have greater overall acceptability characteristics than the control formulation. The treatment containing 10 percent water had some similar sensory properties as the other treatments (20 and 30 percent added water). However, from a practical standpoint the treatment with 20 percent added water and 0.5 percent carrageenan was chosen for further evaluation.

STUDY V

CONSUMER ACCEPTABILITY OF FRESH PORK SAUSAGE WITH DIFFERENT LEVELS OF CARRAGEENAN

DESIGN

Lean fresh pork sausage patties were prepared with four levels of carrageenan (0 percent, 0.2 percent, 0.35 percent, or 0.5 percent) and 20 percent added water, and compared to the control sausage with 3 percent water and 40 percent fat (Table 16). The products were produced as described previously. Sensory evaluation was conducted by 15 trained panelists. Sausage patties were evaluated for juiciness, tenderness, cohesiveness, flavor intensity, and overall acceptability on an eight-point hedonic scale. The study was replicated three times, and the data were analyzed as previously described.

Table 16. Fresh Pork Sausage Patties With Different Amounts of Carrageenan and Water, Study V

| Treatment ¹ | 1 | 2 | 3 | 4 | 5 |
|-------------------------|-------------|-------------|-------------|-------------|-------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| Raw material..... | 94.79 | 94.20 | 77.04 | 76.90 | 76.70 |
| Salt..... | 1.630 | 2.030 | 2.030 | 2.030 | 2.030 |
| Dextrose..... | 0.250 | 0.313 | 0.313 | 0.313 | 0.313 |
| Chopped sage..... | 0.160 | 0.200 | 0.200 | 0.200 | 0.200 |
| Black pepper..... | 0.030 | 0.038 | 0.038 | 0.038 | 0.038 |
| Ground red pepper..... | 0.125 | 0.156 | 0.156 | 0.156 | 0.156 |
| Crushed red pepper..... | 0.016 | 0.020 | 0.020 | 0.020 | 0.202 |
| Carrageenan..... | 0.000 | 0.000 | 0.200 | 0.350 | 0.500 |
| Water..... | 3.000 | 3.000 | 20.000 | 20.00 | 20.00 |

¹Treatment 1 was formulated to contain 40 pct. fat; all others were formulated to contain 15 pct.

RESULTS AND DISCUSSION

Proximate Analysis of Raw Products

Proximate composition of raw sausage patties shown in Table 17 indicates that lean sausage patties had higher ($P<0.05$) moisture content than regular sausage. No differences ($P>0.05$) were found for moisture content among lean sausage treatments containing different levels of carrageenan. Sausage patties with different levels of carrageenan (treatments 3, 4, and 5) contained less ($P<0.05$) fat than other sausage (treatments 1 and 2). Lean sausage with 0.5 percent carrageenan and 20 percent water added (treatment 5) had higher ($P<0.05$) protein content than other treatments except the lean control (treatment 2).

Proximate Analysis of Cooked Products

Proximate composition of cooked sausage patties shown in Table 18 indicate that regular sausage (treatment 1) had the highest ($P<0.05$) fat content and the lowest protein and moisture content. Lean sausage with different levels of carrageenan (treatments 3, 4, and 5) had higher ($P<0.05$) moisture content and lower fat content than other products (treatments 1 and 2). Lean sausage patties with 0.5 percent or 0.35 percent carrageenan (treatments 4 and 5) had higher ($P<0.05$) protein content than other products (treatments 1, 2, and 3).

Table 17. Proximate Analysis of Raw Fresh Pork Sausage Patties With Different Amounts of Carrageenan, Study V

| Treatment ¹ | Moisture ² | Fat ² | Protein ² |
|------------------------|-----------------------|------------------|----------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 47.8c | 38.0b | 13.8d |
| 2..... | 66.8b | 14.5c | 18.2b |
| 3..... | 69.9b | 12.9d | 16.3c |
| 4..... | 69.9b | 12.2e | 16.7c |
| 5..... | 68.1b | 12.7de | 18.3b |

¹Description of treatments shown in Table 16.

²Means in the same column followed by different letters are significantly different (P<0.05).

Table 18. Proximate Analysis of Cooked Fresh Pork Sausage Patties With Different Amounts of Carrageenan, Study V

| Treatment ¹ | Moisture ² | Fat ² | Protein ² | Cooking Loss ² |
|------------------------|-----------------------|------------------|----------------------|---------------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 49.2d | 30.7b | 19.3c | 32.8b |
| 2..... | 56.9c | 19.4c | 22.9b | 18.8d |
| 3..... | 60.3b | 16.7d | 22.2b | 26.8c |
| 4..... | 61.3b | 16.0de | 22.0b | 24.2c |
| 5..... | 64.0b | 14.8e | 21.1b | 24.1c |

¹Description of treatments shown in Table 16.

²Means in the same column followed by different letters are significantly different (P<0.05).

Cooking Loss

Cooking loss data presented in Table 18 indicate that regular sausage (treatment 1) had the highest (P<0.05) cooking loss while lean sausage with no carrageenan (treatment 2) had the lowest (P<0.05) cooking loss. No differences (P>0.05) were found for cooking loss among lean sausage patties with different levels of carrageenan (treatments 3, 4, and 5).

Sensory Evaluation

Sensory panel results (Table 19) show that lean sausage with 0.35 percent or 0.5 percent carrageenan and 20 percent water had better (P<0.05) juiciness, tenderness, and cohesiveness scores than the regular control (treatment 1) and lean control (treatment 2). Lean sausage with 0.2 percent or 0.35 percent carrageenan (treatments

3 and 4) had higher ($P<0.05$) flavor intensity scores than the regular control (treatment 1). Overall acceptability results indicate that all lean sausage formulations (treatments 2, 3, 4, and 5) had higher ($P<0.05$) scores than regular sausage patties containing a higher level of fat (treatment 1).

Table 19. Sensory Evaluations of Fresh Pork Sausage Patties With Different Amounts of Carrageenan, Study V

| Treatment ¹ | Juiciness ^{2,3} | Tenderness ^{2,3} | Cohesiveness ^{2,3} | Flavor Intensity ^{2,3} | Overall Acceptability ^{2,3} |
|------------------------|--------------------------|---------------------------|-----------------------------|---------------------------------|--------------------------------------|
| 1..... | 5.5c | 5.7de | 6.2bc | 5.5c | 5.1c |
| 2..... | 5.4c | 5.5e | 6.6b | 6.8bc | 5.8b |
| 3..... | 5.8bc | 6.0cd | 6.4bc | 6.1b | 6.0b |
| 4..... | 6.0b | 6.2bc | 6.1cd | 6.0b | 6.1b |
| 5..... | 6.3b | 6.5b | 5.8d | 5.8bc | 5.9b |

¹Description of treatments shown in Table 16

²Means in the same column followed by different letters are significantly different ($P<0.05$).

³Description of the scale shown in Table 11.

CONCLUSION

It is evident from these results that low-fat sausage patties formulated with 0.35 percent or 0.50 percent carrageenan and 20 percent water (treatments 4 and 5) provide low-fat fresh pork sausage patties which have sensory properties equal, or superior to control formulations (treatments 1 and 2). Based on this study, it is recommended that the formulation used in treatment 4 (0.35 percent carrageenan) be used for production of lean sausage patties due to its higher numerical scores for overall acceptability.

STUDY VI

ACCEPTABILITY OF FURTHER FAT REDUCTION OF LEAN PORK SAUSAGE

DESIGN

The objective of the final study was to develop a low-fat (less than 7 percent fat) pork sausage product with sensory and physical properties equivalent to the developed product with 12.5 percent fat. The pork sausage products were formulated to contain three fat levels (40 percent = treatment 1; 12.5 percent = treatment 2; and 7 percent = treatment 3) and to comply with U.S.D.A regulations that require low-fat

treatments to contain a maximum of 30 percent fat, water, and added ingredients. Sausage products were evaluated for sensory and compositional properties. The study was replicated three times, and the data were analyzed as previously described.

Table 20. Fresh Pork Sausage Treatments, Study VI

| Treatment | 1 | 2 | 3 |
|-------------------------|-------------|-------------|-------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| Meat..... | 94.60 | 76.90 | 76.90 |
| Salt..... | 1.630 | 2.030 | 2.030 |
| Dextrose..... | 0.250 | 0.313 | 0.313 |
| Chopped sage..... | 0.160 | 0.200 | 0.200 |
| Black pepper..... | 0.030 | 0.038 | 0.038 |
| Ground red pepper..... | 0.125 | 0.156 | 0.156 |
| Crushed red pepper..... | 0.160 | 0.020 | 0.020 |
| Carrageenan..... | 0.000 | 0.350 | 0.350 |
| Water..... | 3.000 | 20.00 | 20.00 |

RESULTS AND DISCUSSION

Proximate Analysis

Low-fat fresh pork sausage with 7 percent fat (treatment 3) was found to be lower in fat and higher in protein than low-fat fresh pork sausage with 12.5 percent fat (treatment 2) or traditional pork sausage with 33 percent fat (treatment 1). Moisture levels were the same for the low-fat treatments, but both were higher than traditional pork sausage. Upon cooking, low-fat fresh pork sausage with 7 percent fat was found to be lower in fat and equivalent to low-fat fresh pork sausage with 12.5 percent fat in both moisture and protein content. Traditional pork sausage with 33 percent fat was lower in moisture, higher in fat and lower in protein than either of the low-fat treatments. See Table 21.

Cooking Loss

Traditional pork sausage (33 percent fat) was highest in cooking loss among the three treatments while low-fat fresh pork sausage with 7 percent fat had greater cooking loss than low-fat fresh pork sausage with 12.5 percent fat (Table 22).

Table 21. Proximate Analysis of Raw Fresh Pork Sausage Patties, Study VI

| Treatment ¹ | Moisture ² | Fat ² | Protein ² |
|------------------------|-----------------------|------------------|----------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 51.1c | 32.7b | 15.3d |
| 2..... | 70.9b | 11.3c | 16.8c |
| 3..... | 73.3b | 6.70d | 19.1b |

¹Description of treatments shown in Table 20.

²Means in the same column followed by different letters are significantly different (P<0.05).

Table 22. Proximate Analysis of Cooked Fresh Pork Sausage Patties, Study VI

| Treatment ¹ | Moisture ² | Fat ² | Protein ² | Cooking Loss ² |
|------------------------|-----------------------|------------------|----------------------|---------------------------|
| | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> | <i>Pct.</i> |
| 1..... | 47.3c | 32.3b | 19.4c | 32.9b |
| 2..... | 63.8b | 14.3c | 20.8b | 13.9d |
| 3..... | 65.9b | 11.0c | 22.1b | 21.3c |

¹Description of treatments shown in Table 20.

²Means in the same column followed by different letters are significantly different (P<0.05).

Sensory Evaluation

Panelists found the traditional pork sausage (33 percent fat) to be less juicy and less tender than either of the low-fat treatments. No differences were found between low-fat treatments for juiciness, tenderness, off-flavor, or flavor intensity. Also, no differences were found among the three treatments for overall acceptability, off-flavors, or flavor intensity (Table 23).

Table 23. Sensory Characteristics of Fresh Pork Sausage Treatments, Study VI

| Treatment ¹ | Juiciness ^{2,3} | Tenderness ^{2,3} | Off-flavor ^{2,3} | Flavor Intensity ^{2,3} | Overall Acceptability ^{2,3} |
|------------------------|--------------------------|---------------------------|---------------------------|---------------------------------|--------------------------------------|
| 1..... | 6.1b | 6.1b | 7.6a | 5.8a | 6.3a |
| 2..... | 7.3a | 7.1a | 7.5a | 6.2a | 6.5a |
| 3..... | 6.9a | 7.3a | 7.3a | 6.3a | 6.4a |

¹ Description of treatments shown in Table 20.

² Means in the same column followed by different letters are significantly different (P<0.05).

³ Description of the scale shown in Table 11.

CONCLUSION

It is evident that the low-fat (AU Lean) sausage formulated with carrageenan and 7 percent fat (treatment 3) has sensory properties equivalent or better than traditional sausage (treatment 1) with a higher fat level. Based on this study, it is recommended that the 12.5 percent fat content of AU Lean sausage could be reduced to 7 percent and still be equivalent to, or better than, the traditional pork sausage.

SUMMARY

The objective upon initiation of this research was to develop a low-fat (<10 percent fat) fresh pork sausage product that had sensory properties equal (or superior) to traditional fresh pork sausage patties. Results from the present studies indicate that the goal of this project was accomplished. Evidence from these studies indicate that low-fat sausages formulated with 0.35 percent carrageenan and 20 percent added water provided sausage patties with significantly less fat, but with more desirable sensory characteristics than the control formulations. The developed low-fat fresh pork sausage patties have a 70 percent reduction in fat and a 46 percent reduction in calories when compared to traditional fresh pork sausage patties.

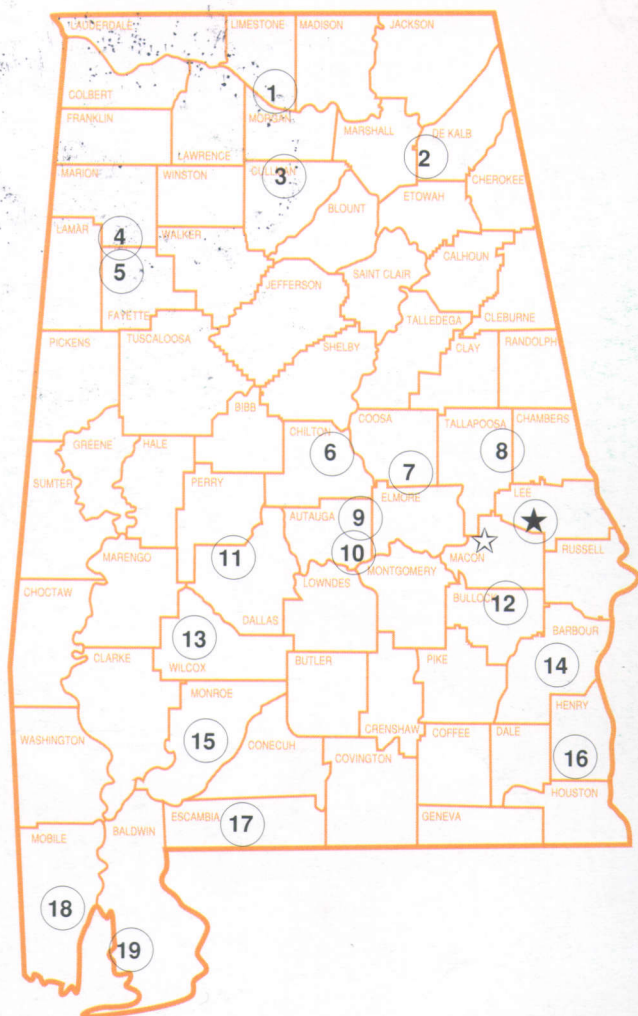
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Alabama's Agricultural Experiment Station System

AUBURN UNIVERSITY

With an agricultural research unit in every major soil area, Auburn University serves the needs of field crop, livestock, forestry, and horticultural producers in each region in Alabama. Every citizen of the state has a stake in this research program, since any advantage from new and more economical ways of producing and handling farm products directly benefits the consuming public.



Research Unit Identification

- ★ Main Agricultural Experiment Station, Auburn.
- ☆ E. V. Smith Research Center, Shorter.

- | | |
|---|---|
| <ul style="list-style-type: none"> 1. Tennessee Valley Substation, Belle Mina. 2. Sand Mountain Substation, Crossville. 3. North Alabama Horticulture Substation, Cullman. 4. Upper Coastal Plain Substation, Winfield. 5. Forestry Unit, Fayette County. 6. Chilton Area Horticulture Substation, Clanton. 7. Forestry Unit, Coosa County. 8. Piedmont Substation, Camp Hill. 9. Forestry Unit, Autauga County. 10. Prattville Experiment Field, Prattville. | <ul style="list-style-type: none"> 11. Black Belt Substation, Marion Junction. 12. The Turnipseed-Ikenberry Place, Union Springs. 13. Lower Coastal Plain Substation, Camden. 14. Forestry Unit, Barbour County. 15. Monroeville Experiment Field, Monroeville. 16. Wiregrass Substation, Headland. 17. Brewton Experiment Field, Brewton. 18. Ornamental Horticulture Substation, Spring Hill. 19. Gulf Coast Substation, Fairhope. |
|---|---|