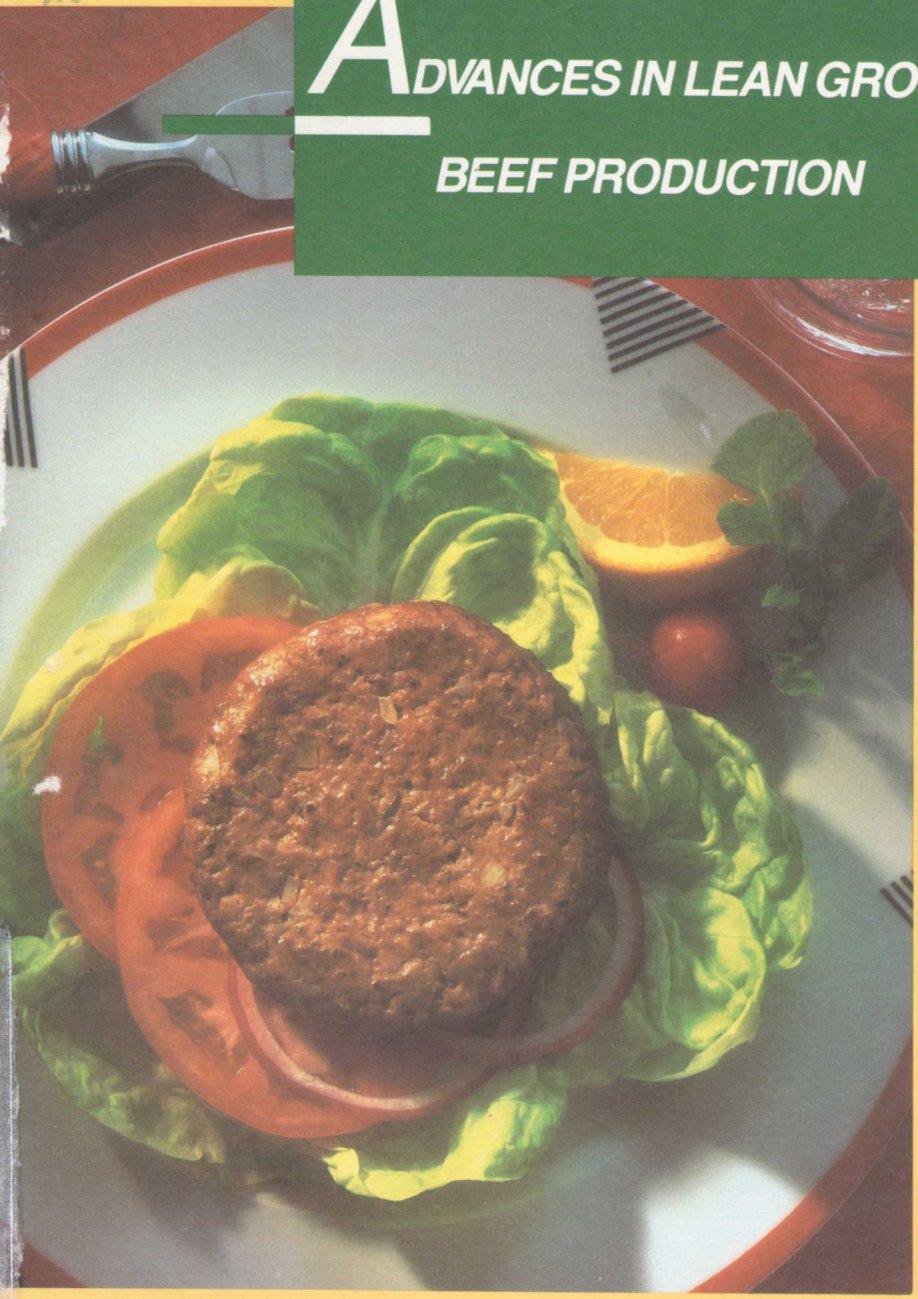
ADVANCES IN LEAN GROUND BEEF PRODUCTION



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Advances In Lean Ground Beef Production

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INTRODUCTION

OVER 3 BILLION pounds of ground beef products are consumed annually in the United States, which accounts for 44 percent of the total fresh beef cuts available for consumption (*4*). These products generally contain between 20 and 30 percent fat. A large segment of today's consumer population is health conscious and is concerned about dietary fat. These consumers avoid meat products with high fat content, such as ground beef. Current trends reflect a shift in consumers' consumption of fats, with a decrease in the intake of visible separable fats and an increase in consumption of low-fat animal products.

A consumer climate survey has indicated that health oriented and active life style consumers make up 50 percent of the population. These two groups of consumers are characterized by their low consumption of red meat. This survey indicated the U.S. population in general is concerned about weight control and caloric intake (*5*). As today's consumers continue to become more health conscious, their demand for lower fat ground beef products will rapidly expand.

It is important that the red meat industry develop low-fat ground beef products tailored to meet the needs of today's diet conscious consumers. The simple reduction of the fat in ground beef to 5-10 percent would be the most efficient method of developing low-fat ground beef products. However, ground beef with a fat content in this range is generally considered less palatable than ground beef with 20-30 percent fat. Therefore, a project was initiated to develop acceptable lean ground beef products. The approach combined present knowledge about the texture, juiciness, and flavor of currently produced ground beef products with changes in the technologies used to produce these products.

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The objective of this project was to develop "lean" (90-95 percent) ground beef products with significantly reduced fat levels, which are as acceptable to the consumer in the same form as current ground beef items.

EXPERIMENTAL DEVELOPMENT

Development of a low fat ground beef product was approached in a series of logical steps (studies), each building on the results of the previous experiments. The first study explored the level of fat desired in ground beef patties based on consumer ratings. Study II was designed to determine consumers' ability to distinguish between ground beef patties with varying levels of fat. The third study was designed to determine the effect of cooking method on sensory properties of ground beef patties and the sensory property differences between ground beef products with differing fat levels. The objectives of Study IV were the same as for Study III, however a different method of cookery was used. The fifth study determined the effect of grind size on sensory traits of ground beef patties. The objective of Study VI was to determine the effect of various nonmeat ingredients on the sensory properties of ground beef patties. Study VII determined the effect of the addition of salt and hydrolyzed vegetable protein on sensory properties of lean ground beef patties. The final study was designed to confirm the findings of the earlier studies and to demonstrate that the overall project objective—the development of a lean ground beef product with sensory properties similar to those of a ground beef product containing 20 percent fat control—had been accomplished.

DESIGN AND METHODOLOGY

Overall Processing Procedure

Each of the "lean" ground beef products developed was compared to a control and was processed using manufacturing practices that yield high quality products. Fresh beef cap meat and 50/50 beef trimmings were each ground twice through a 1/2-inch (1.27-cm) grinder plate. Samples of both the ground cap meat and 50/50 trimmings were taken using the "grab" method. Samples were finely ground using a Kitchenaid mixer with grinder attachments and analyzed for fat content by ether extraction (2). The ground cap meat (lean component) and 50/50 trimmings (fat component) were vacuum

packaged in approximately 10-pound (3.0-kg) packages, frozen, and held at -4°F (-20°C). Prior to manufacturing, the coarse ground lean and fat meat components were thawed at 41-44°F (5-7°C) for approximately 12 hours.

The low fat ground beef products were manufactured using the appropriate quantities of coarse ground lean and fat components as previously formulated. The appropriate amounts of lean and fat were combined and mixed with various combinations of the following: (1) lecithin (or other appropriate phospholipid emulsifying agents); (2) carrageenan (or other non-gel-forming food gums); and/or (3) beef extract and/or other beef flavor enhancers. After the meat and nonmeat ingredients had been mixed (approximately 1 minute), the products were finely ground. These finely ground products were then made into 4-ounce patties using a Hollymatic (Super 54) pattie machine. Ground beef patties were stored (2 days) at 38°F (3°C) until sensory evaluation and cooking loss analyses were completed.

Cooking Methods

Ground beef patties were: (1) Oven broiled at 350°F (177°C) for 8 minutes to a well-done state using a Blodgett forced air convection oven (G. S. Blodgett Company, Burlington, Vermont); (2) griddle broiled to a well-done state on a Model TG-72 Special McDonald's grill (Wolf Range Corporation) at a temperature of 330°F (165°C) for 3 1/2 minutes (2 minutes on the first side, 1 1/2 on the other); or (3) grill broiled to a well-done state on an Emberglo open hearth broiler (Model 310, Mid-Continent Metal Products Co., Chicago, Illinois) for 6 minutes (4 minutes on the first side and 2 minutes on the opposite side).

Cooking Loss

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 (20°C). Patties evaluated for cooking loss were blotted with paper towels after cooking.

Proximate Analysis

Raw and cooked (from cooking loss determination) samples for proximate analysis were ground three times with a Kitchenaid mixer with grinder attachments and the samples were stored frozen at -4°F. Samples held at this temperature were used for determination of moisture, petroleum ether-extractable lipid, and protein content of the raw products. Moisture, lipid, and protein content of each product was determined with AOAC (2) approved methods.

Sensory Evaluation

Cooked patties were cut into six wedges. These were held in a conventional oven at 104°F (40°C) until evaluated by a 9-member trained sensory panel (*1*) for juiciness (initial and sustained), tenderness, flavor, and overall acceptability on an 8-point hedonic scale (1 = extremely dry, extremely tough, extremely bland, extremely unacceptable and 8 = extremely juicy, extremely tender, extremely intense, and extremely acceptable, respectively). Texture was rated on a 7-point hedonic scale (1 = more sandy, 4 = typical of ground beef, and 7 = more mushy). Panel members were selected from students, faculty, and staff of the Department of Animal and Dairy Sciences. Panelists were served one wedge of each of the treatments in a random order. Unsalted crackers, apple juice, and water at room temperature were also served. Each treatment was evaluated once by each panelist on three separate occasions.

Statistical Evaluation

The experimental data were statistically analyzed using the general linear model (*12*) where applicable. When a significant F-value ($P<0.05$) was found, Tukeys' mean separation procedure (*13*) was employed to determine differences between means.

STUDY I: CONSUMER ACCEPTABILITY OF GROUND BEEF PRODUCTS WITH VARYING FAT LEVELS

Design

Ground beef patties were formulated to contain five different levels of fat (5, 10, 15, 20, and 25 percent), using the cap meat and 50/50 trim as previously described. The patties were griddle broiled as previously described and evaluated by a 30-member untrained consumer-type panel. Panelists were instructed to evaluate the samples for overall acceptability on a 10-number descriptive analysis (*1*) scale (0 = dislike extremely and 10 = like extremely). The study was replicated three times and the data were analyzed using analysis of variance procedures as previously described.

Results and Discussion

Proximate Analysis

Proximate analysis data for raw products are presented in table 1. These analyses confirmed that the products contained the desired fat level as formulated (5, 10, 15, 20, and 25 percent fat). As the level of

TABLE 1. PROXIMATE ANALYSIS OF RAW GROUND BEEF WITH DIFFERING LEVELS OF FAT, STUDY I[1]

Fat level	Analysis[2]		
	Moisture	Fat	Protein
	Pct.	*Pct.*	*Pct.*
5	72.34[b]	5.81[f]	21.60[b]
10	69.05[c]	10.04[e]	20.93[b]
15	65.55[d]	14.16[d]	18.93[c]
20	61.89[e]	19.35[c]	18.15[c]
25	58.12[f]	22.22[b]	16.17[d]

[1]From Neale (*10*).
[2]Means within a column with different superscripts are significantly different ($P<0.05$).

fat in the raw ground beef products increased, the level of moisture decreased ($P<0.05$). This supports the findings of other researchers that an inverse relationship exists between fat and moisture content in ground beef (*14, 9*). Percent protein also decreased ($P<0.05$) as the fat level of the ground beef products increased. Generally, other researchers have reported that protein content of ground beef with differing fat levels did not differ (*11, 7*).

Composition of the cooked ground beef products conform to the same trends as the raw products, table 2. Both moisture and protein contents decreased ($P<0.05$) as fat levels increased, with the exception of ground beef with fat levels of 20 and 25 percent which did not differ ($P>0.05$).

TABLE 2. PROXIMATE ANALYSIS OF COOKED GROUND BEEF WITH DIFFERING LEVELS OF FAT, STUDY I[1]

Fat level, pct.	Analysis[2]			
	Moisture	Fat	Protein	Cooking loss
	Pct.	*Pct.*	*Pct.*	*Pct.*
5	61.58[b]	8.96[f]	29.20[b]	29.66[de]
10	59.20[c]	12.63[e]	27.75[c]	28.56[e]
15	56.39[d]	16.13[d]	26.39[d]	31.71[cd]
20	54.15[e]	18.59[c]	25.67[e]	33.74[c]
25	50.68[f]	22.16[b]	25.28[f]	39.13[b]

[1]From Neale (*10*).
[2]Means within a column with different superscripts are significantly different ($P<0.05$).

Cooking Loss

Percent cooking loss increased ($P<0.05$) as the fat level of the ground beef products increased, table 2. These results agree with

TABLE 3. OVERALL ACCEPTABILITY SCORES OF GROUND BEEF PATTIES WITH DIFFERING LEVELS OF FAT, STUDY I

Fat level pct.	Overall acceptability scores[1,2,3]
5	4.82[c]
10	5.13[dc]
15	5.77[cd]
20	6.07[c]
25	5.35[cdc]

[1]From Neale (*10*).
[2]Overall acceptability score on a 10 to 0 scale (10 = like extremely, 0 = dislike extremely).
[3]Means within a column with different subscripts are significantly different ($P<0.05$).

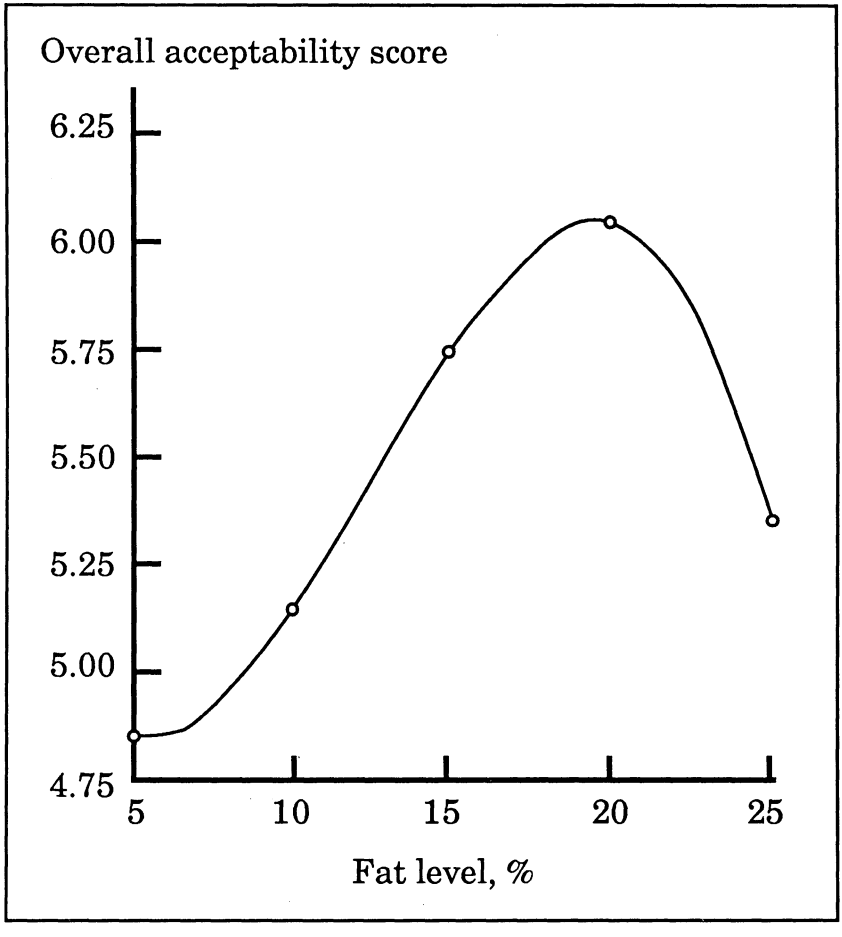

FIG. 1. Optimal overall acceptability of ground beef patties based on fat content, on a 10-0 scale (10 = like extremely, 0 = dislike extremely).

other researchers that cooking yields are inversely related to the fat content of the product (*8,11,9,6*).

Sensory Evaluation

Overall acceptability scores for the ground beef products with differing levels of fat are presented in table 3. Panelists found ground beef with 15 and 20 percent fat to be more desirable ($P<0.05$) than ground beef with 5 percent fat. Overall acceptability tended to decrease with decreasing fat levels. Ground beef with 25 percent fat was not different ($P>0.05$) from any of the other fat levels.

Conclusions

Consumer panelists gave the highest ($P<0.05$) ratings for overall acceptability to ground beef patties formulated to 20 percent fat, followed by patties formulated to 15 percent fat. An increase or decrease in the fat content of ground beef patties from a fat content of 20 percent resulted in a decrease in overall acceptability of the products, figure 1. Based on consumer ratings, ground beef products formulated to 20 percent fat should be used as the control in the development of ground beef products with reduced fat levels.

STUDY II: CONSUMERS' ABILITY TO DISTINGUISH DIFFERENCES IN GROUND BEEF PRODUCTS WITH VARYING LEVELS OF FAT

Design

Ground beef products were formulated to contain 12.5, 15.0, 17.5, 20.0, and 22.5 percent fat using the raw materials and procedures as described previously. These products were evaluated by a consumer panel using a triangle test (*3*). Panelists were served three samples (two samples of one product and one of a second allotted at random) and asked to identify the different sample. All product combinations were evaluated by a 50-member consumer panel. Differences between the ground beef products were determined based on the number of correct responses (*3*).

Results and Discussion

No difference ($P>0.05$) was found between ground beef with a fat level of 12.5 and 15.0 percent, 17.5 and 20.0 percent, and 12.5 and

22.5 percent, table 4. This was expected for the products that differed by only 2.5 percent fat, however not finding a significant difference between ground beef containing 12.5 and 22.5 percent was unexpected. For this reason, the 12.5 and 22.5 percent ground beef products were reformulated and tested a second time with a 50-member consumer panel. The results of the second consumer panel were similar to the first in that the sensory panel could not detect ($P>0.05$) a difference between the samples (could not identify the different sample). However, panelists were able to detect differences of 5 and 7.5 percent in all other cases, table 4. Panelists were also able to detect a difference between ground beef with 15.0 percent fat compared to 17.5 percent and 20.0 percent compared to 22.5 percent (a 2.5 percent difference).

TABLE 4. CONSUMERS' ABILITY TO DISTINGUISH BETWEEN GROUND BEEF WITH DIFFERING LEVELS OF FAT, STUDY II

Fat level pct.	Fat level[1], pct.			
	15.0	17.5	20.0	22.5
12.5	NS	*	**	NS
15.0		**	*	**
17.5			NS	**
20.0				*

[1]NS = no significant difference ($P>0.05$), * = significant difference ($P<0.05$), ** = highly significant difference ($P<0.01$).

A summary of the ability of consumers to detect fat level differences is shown in table 5. Approximately 30 percent of the consumers were able to detect a fat level difference of 2.5 percent, approximately 50 percent of the consumers could detect a fat level difference of 5.0 percent, about 54 percent of the consumers could detect a difference of 7.5 percent, but only approximately 42 percent of the consumers could detect a difference in fat of 10 percent.

TABLE 5. PERCENTAGE OF CONSUMERS ABLE TO DISTINIGUISH BETWEEN GROUND BEEF PRODUCTS WITH A GIVEN DIFFERENCE IN FAT LEVEL, STUDY II

Fat level differences, pct.	Percentage of consumers
2.5	30.4
5.0	49.3
7.5	54.2
10.0	41.8

Conclusions

From this study it was determined that consumers could consistently distinguish between ground beef products that differed by 5 to 7.5 percent fat. Further research in this area could provide useful information for explaining the observation that no difference ($P>0.05$) was detected between ground beef products containing 12.5 and 22.5 percent fat (10 percent difference). Based on these results, it appears that less than half of consumers are able to detect fat level differences of ground beef patties in the range of 2.5 percent to 10.0 percent.

STUDY III: SENSORY DIFFERENCES BETWEEN OVEN AND GRIDDLE BROILED GROUND BEEF PATTIES WITH DIFFERENT FAT LEVELS

Design

Ground beef patties containing 5, 10, 15, and 20 percent fat were prepared using beef cap meat and 50/50 beef trimmings as described previously. Patties were cooked (broiled) for sensory evaluation using either a gas griddle or convection oven as previously described. Prepared samples were served to a trained sensory panel. Panelists were instructed to evaluate each sample for juiciness (initial and sustained), tenderness, beef flavor intensity, and overall acceptability on an 8-point hedonic scale and on a 7-point hedonic scale for texture as described previously. Moisture, fat, and protein content and cooking loss were determined for cooked ground beef patties. The study was replicated three times and the data were analyzed using analysis of variance procedures.

Results and Discussion

Cooking Method

No differences were found ($P>0.05$) between ground beef patties when griddle broiled compared to convection oven broiled for the sensory attributes: juiciness (initial or sustained), tenderness, or texture, table 6. Ground beef patties broiled using the gas griddle, however, were rated higher ($P<0.05$) by sensory panelists for beef flavor intensity and overall acceptability than those broiled using the convection oven, table 6. No differences ($P>0.05$) were found between the two cooking methods for moisture, fat, protein, or cooking loss, table 6. However, there was a trend for patties cooked in the convection oven to have greater losses from cooking than patties broiled on the gas griddle.

TABLE 6. PHYSICAL, COMPOSITIONAL, AND SENSORY DIFFERENCES BETWEEN GAS GRIDDLE AND CONVECTION OVEN BROILED GROUND BEEF PATTIES, STUDY III

Attributes[2]	Rating, by cooking method[1,3]	
	Griddle	Oven
Initial juiciness	5.6[c]	4.9[c]
Sustained juiciness	5.1[c]	4.6[c]
Tenderness	5.7[c]	5.6[c]
Beef flavor intensity	5.5[c]	4.4[d]
Texture	4.0[c]	4.5[c]
Overall acceptability	5.7[c]	4.8[d]
Cooking loss, pct.	26.7[c]	29.3[c]
Moisture, pct.	58.4[c]	58.3[c]
Fat, pct.	14.9[c]	14.0[c]
Protein, pct.	25.5[c]	26.5[c]

[1]Oven broiled at 350°F (177°C) for 8 minutes to a well-done state using a Blodgett forced air convection oven (G.S. Blodgett Company, Burlington, Vermont). Griddle broiled to a well-done state on a Model TG-72 Special McDonald's grill (Wolf Range Corporation) at a temperature of 330°F (165°C) for 3½ minutes (2 minutes on the first side, 1½ on the other).

[2]Juiciness (initial and sustained), tenderness, beef flavor intensity, and overall acceptability were rated on an 8-point hedonic scale (1 = extremely dry, extremely tough, extremely bland, extremely unacceptable, and 8 = extremely juicy, extremely tender, extremely intense, and extremely acceptable, respectively). Texture was rated on a 7-point hedonic scale (1 = more sandy, 4 = typical of ground beef, and 7 = more mushy).

[3]Means in the same row with different superscripts differ ($P<0.05$).

Fat Level

Ground beef patties containing 5 percent fat were found to be less juicy initially than patties containing 15 and 20 percent fat. No differences ($P>0.05$) in initial juiciness were found between ground beef patties with 10 percent fat and the other fat levels, table 7. Patties with 20 percent fat were rated higher ($P<0.05$) by sensory panelists for sustained juiciness than patties with 5 percent fat. No other differences ($P>0.05$) were found between fat levels for sustained juiciness, table 7. No differences ($P>0.05$) were found among the patties

TABLE 7. EFFECT OF FAT LEVEL ON THE SENSORY ATTRIBUTES OF GROUND BEEF PATTIES, STUDY III

Attributes[1]	Rating, by pct. fat level[2]			
	5	10	15	20
Initial juiciness	4.3[c]	5.2[bc]	5.5[b]	6.0[b]
Sustained juiciness	3.8[d]	4.7[cd]	5.2[bc]	5.7[b]
Tenderness	5.0[b]	5.7[b]	5.7[b]	6.1[b]
Beef flavor intensity	4.4[b]	4.8[b]	5.2[b]	5.3[b]
Texture	4.2[b]	4.2[b]	4.3[b]	4.4[b]
Overall acceptability	4.4[c]	5.2[bc]	5.5[b]	6.0[b]

[1]Attributes measured on 8-point and 7-point hedonic scales as described in table 6.

[2]Means in the same row with different superscripts differ ($P<=0.05$).

from the different fat levels for tenderness, beef flavor intensity, or texture. However, there was a trend for ground beef patties with higher percentages of fat to have increased tenderness and beef flavor intensity. Ground beef patties containing 5 percent fat were rated lower ($P<0.05$) for overall acceptability than patties containing 20 percent fat. These results support the finding of Study I where patties with higher percentages of fat were rated higher in overall acceptability by a consumer panel than patties with lower percentages of fat. No other differences in overall acceptability were found among the treatments, table 7. Overall acceptability was found to be correlated ($r=0.69$; $P<0.05$) with beef flavor intensity.

Conclusions

From these results it was concluded that the gas griddle was a better method of cooking ground beef patties than the convection oven, since ground beef patties cooked on the gas griddle were rated higher in beef flavor intensity and overall acceptability. Though not significant, ground beef patties broiled on the gas griddle had lower cooking losses than patties cooked in the convection oven. Juiciness and overall acceptability of ground beef patties were found to increase as the fat content increased. Overall acceptability was also found to be correlated with beef flavor intensity.

STUDY IV: SENSORY DIFFERENCES BETWEEN GRIDDLE BROILED AND GAS GRILL BROILED GROUND BEEF PATTIES WITH DIFFERENT FAT LEVELS

Design

Ground beef patties containing 5, 10, 15, and 20 percent fat were prepared using beef rib cap meat and 50/50 beef trimmings as in Study III. Patties were cooked (broiled) in preparation for sensory evaluation using either a gas griddle or an Emberglo open hearth gas grill as previously described. The products from each of three replications were then evaluated and the statistical analysis completed as described in Study III.

Results and Discussion

Cooking Method

Sensory panelists detected no differences ($P>0.05$) between the two cooking methods (gas griddle versus open hearth gas grill) for

juiciness (initial or sustained), tenderness, beef flavor intensity, texture, or overall acceptability, table 8. This is in contrast with Study III where the gas griddle method of cooking was superior from a sensory aspect to cooking in the convection oven. No differences ($P>0.05$) were found between ground beef patties broiled on the gas griddle compared to patties broiled using the open hearth gas grill for cooking loss, moisture, fat, or protein, table 8. These results indicate that ground beef patties of equal quality can be prepared with either the gas griddle or open hearth gas grill.

TABLE 8. PHYSICAL, COMPOSITIONAL, AND SENSORY DIFFERENCES BETWEEN GAS GRIDDLE AND GAS GRILL BROILED GROUND BEEF PATTIES, STUDY IV[1]

Attributes[3]	Rating, by cooking method[2]	
	Griddle	Grill
Initial juiciness	5.2	5.4
Sustained juiciness	4.9	5.1
Tenderness	5.6	5.9
Beef flavor intensity	5.3	5.3
Texture	4.1	4.2
Overall acceptability	5.5	5.6
Cooking loss, pct.	26.6	28.2
Moisture, pct.	58.9	59.5
Fat, pct.	13.4	12.9
Protein, pct.	26.5	26.4

[1]Griddle broiled to well-done state on a Model TG-72 Special McDonald's grill (Wolfe Range Corporation) at a temperature of 330° (165°C) for 3½ minutes (2 minutes on the first side and 1½ minutes on the other). Grill broiled to a well-done state on an Emberglo open-hearth broiler (Model 310, Mid-Continent Metal Products Company, Chicago, Illinois) for 6 minutes (4 minutes on the first side and 2 minutes on the opposite side).

[2]No differences ($P>0.5$) found between the two cooking methods for any of the traits measured.

[3]Traits rated on 8-point and 7-point hedonic scales as described in text.

Fat Level

Fat level had no effect ($P>0.05$) on the initial juiciness of ground beef patties in this study, table 9. Ground beef patties with 20 percent fat were rated higher ($P<0.05$) by a sensory attribute panel for sustained juiciness than patties with 5 and 10 percent fat, table 9. Patties containing 15 percent were rated higher ($P<0.05$) for sustained juiciness than patties with 5 percent fat. No other differences were found among the ground beef patties for sustained juiciness. No differences were found among the ground beef patties with varying fat levels for tenderness, beef flavor intensity, or texture. However, there was a trend for tenderness and beef flavor intensity sensory panel scores to increase as the fat level of the ground beef patties increased. Ground beef patties containing 20 percent fat were rated higher ($P<0.05$) by sensory panelists for overall acceptability than patties

TABLE 9. EFFECT OF FAT LEVEL ON THE SENSORY ATTRIBUTES OF GROUND BEEF PATTIES, STUDY V

Attributes[1]	Rating, by pct. fat level[2]			
	5	10	15	20
Initial juiciness	4.9[b]	5.2[b]	5.5[b]	5.7[b]
Sustained juiciness	4.5[d]	4.9[cd]	5.2[bc]	5.5[b]
Tenderness	5.4[b]	5.7[b]	5.9[b]	6.0[b]
Beef flavor intensity	5.1[b]	5.1[b]	5.4[b]	5.5[b]
Texture	4.4[b]	4.3[b]	4.1[b]	3.9[b]
Overall acceptability	5.3[c]	5.4[c]	5.7[bc]	5.9[b]

[1]Attributes measured using 8-point and 7-point hedonic scales as shown in table 6.
[2]Means in the same row with different superscripts differ ($P<0.05$).

with 5 and 10 percent fat. These results support the findings of Study I and III where patties with higher percentages of fat were rated higher in overall acceptability by a consumer panel than patties with lower percentages of fat. No other differences in overall acceptability were found among the ground beef patties with varying fat levels, table 9. Overall acceptability was found to be correlated ($r=0.64$; $P<0.05$) with beef flavor intensity.

Conclusions

From these results it can be concluded that acceptable ground beef patties both from a sensory and compositional standpoint can be prepared with either the gas griddle or open hearth gas grill. Results of this study indicate that juiciness (sustained) and overall acceptability of ground beef patties increase as the fat content increases. Sensory panelist scores for overall acceptability were found to be correlated to beef flavor intensity.

STUDY V: EFFECT OF GRIND SIZE ON THE SENSORY CHARACTERISTICS OF LEAN GROUND BEEF PATTIES

Design

Ground beef patties were prepared with different sizes of grinder plates using beef rib cap meat and 50/50 beef trimmings as described previously. The following treatments were prepared for each of three replications: (1) control (20 percent fat) product ground through an ⅛-inch (0.32-cm) grinder plate for the final grind, (2) 10 percent fat product, final grind with ⅛-inch plate, (3) 10 percent fat, final grind (ground twice) with 3/16-inch (0.48- cm) plate, (4) 10 percent fat, final grind (ground once) with 3/16-inch plate, (5) 10 percent fat, final grind

(ground twice) with 3/8-inch (0.96-cm) plate, (6) 10 percent fat, final grind (ground once) with 3/8-inch plate. Patties were cooked (broiled) in preparation for sensory evaluation using the gas griddle as previously described. Prepared samples were served to a trained sensory panel. Panelists were instructed to evaluate each sample for juiciness (initial and sustained), tenderness, beef flavor intensity, and overall acceptability on an 8-point hedonic scale and on a 7-point scale for texture as described previously. Data were analyzed using analysis of variance procedures.

Results and Discussion

Sensory panelists detected no differences ($P>0.05$) among the ground beef patties with varying particle size for juiciness (initial and sustained), beef flavor intensity, texture, or overall acceptability, table 10. However, there was a trend for sensory panelists to rate ground beef patties higher from treatment 4 (10 percent fat, ground once through a 3/16-inch grinder plate) than most treatments for the sensory attributes (juiciness, tenderness, beef flavor intensity, and overall acceptability) evaluated. Ground beef patties from treatment 6 (ground once through a 3/8-inch grinder plate) were rated less tender by sensory panelists than all other treatments except treatment 5 (ground once through 3/8-inch grinder plate). No other differences ($P>0.05$) in tenderness were found among the treatments.

TABLE 10. EFFECT OF GRIND SIZE ON THE SENSORY ATTRIBUTES OF GROUND BEEF PATTIES, STUDY V

Attributes[2]	Rating, by treatment[1,3]					
	1	2	3	4	5	6
Initial juiciness	5.8[c]	5.8[c]	5.6[c]	5.9[c]	5.7[c]	5.4[c]
Sustained juiciness	5.4[c]	5.4[c]	5.3[c]	5.9[c]	5.5[c]	5.1[c]
Tenderness	5.7[c]	5.9[c]	5.8[c]	5.5[c]	4.7[cd]	3.9[cd]
Beef flavor intensity	5.2[c]	5.0[c]	5.1[c]	5.3[c]	5.5[c]	5.0[c]
Texture	4.5[c]	4.5[c]	3.9[c]	4.6[c]	4.6[c]	4.5[c]
Overall acceptability	5.4[c]	5.4[c]	5.4[c]	5.6[c]	5.2[c]	4.8[c]

[1]Treatments include (1) 20 percent fat product (control) ground through 1/8-inch (0.32-cm) grinder plate for the final grind; (2) 10 percent fat product, final grind with 1/8-inch plate; (3) 10 percent fat product, final grind (ground twice) with a 3/16-inch (0.48-cm) plate; (4) 10 percent fat product, final grind (ground once) with 3/16-inch plate; (5) 10 percent fat product, final grind (ground twice) with a 3/8-inch (0.96-cm) plate; (6) 10 percent fat product, final grind (ground once) with a 3/8-inch plate.

[2]Attributes rated on 8-point and 7-point hedonic scales as shown in table 6.

[3]Means in the same row with different superscripts differ ($P>0.05$).

Conclusions

Results from this study indicate that lean products may be improved through the use of a 3/16-inch grinder plate for the final grind.

No advantage appeared to be gained by grinding the lean product twice through the 3/16-inch plate. Since a slight improvement in sensory attributes was found through the use of the 3/16-inch grinder plate, it was used in all further development of lean products.

STUDY VI: EFFECT OF THE ADDITION OF NONMEAT INGREDIENTS ON THE SENSORY PROPERTIES OF LEAN GROUND BEEF

Design

Ground beef patties were prepared using beef rib cap meat and 50/50 beef trimmings as described previously. Three replications of each of the following treatments were prepared: (1) control (20 percent fat) product ground through an 1/8-inch (0.32-cm) grinder plate for the final grind, (2) 10 percent fat product, final grind with a 1/8-inch plate, (3) 10 percent fat product with 0.50 percent salt, ground once through a 3/16-inch (0.48-cm) plate, (4) 10 percent fat product with 0.50 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, 3/16-inch grind, (5) 10 percent fat product with 0.50 percent salt, 0.125 percent HVP, and 0.125 percent white pepper added, 3/16-inch grind, (6) 10 percent fat product with 0.50 percent salt, 0.125 percent HVP, 0.125 percent extractive of red pepper added, 3/16-inch grind, and (7) 10 percent fat product with 0.50 percent salt, 0.125 percent HVP, 0.125 percent white pepper, and 0.125 percent extractive of red pepper added, 3/16-inch grind.

Patties were cooked (broiled) for sensory evaluation using the gas griddle as previously described. Prepared samples were served to a trained sensory panel. Panelists were instructed to evaluate each sample for juiciness (initial and sustained), tenderness, beef flavor intensity, and overall acceptability on an 8-point hedonic scale and texture was rated on a 7-point hedonic scale as described previously. Data were analyzed using analysis of variance procedures.

Results and Discussion

No significant ($P>0.05$) differences were found among the ground beef pattie treatments for any of the sensory traits evaluated, table 11. Because seven treatments were evaluated at one sensory evaluation session, it might have been difficult for the sensory panelists to distinguish small differences between the treatments. However, there was a trend for lean ground beef patties with added salt and HVP to be rated higher for beef flavor intensity and overall acceptability than ground beef patties from other treatments.

TABLE 11. EFFECT OF THE ADDITION OF NONMEAT INGREDIENTS ON THE SENSORY ATTRIBUTES OF GROUND BEEF PATTIES, STUDY VI

Attributes[3]	Rating, by treatment[1,2]						
	1	2	3	4	5	6	7
Initial juiciness	6.0	5.7	5.7	5.7	5.7	5.6	5.5
Sustained juiciness	5.7	5.4	5.4	5.3	5.2	5.3	5.1
Tenderness	5.9	6.0	5.6	5.6	5.6	5.7	5.5
Beef flavor intensity	5.0	4.9	5.0	5.7	5.3	5.0	5.4
Texture	3.9	4.0	4.3	4.4	4.5	4.4	4.3
Overall acceptability	5.4	5.3	5.5	5.9	5.3	5.3	5.3

[1]Treatments are: (1) 20 percent fat product (control) ground through a ⅛-inch (0.32-cm) grinder plate; (2) 10 percent fat product ground through a ⅛-inch plate; (3) 10 percent fat product with 0.50 percent salt, ground once through a 3/16-inch (0.48-cm) plate; (4) 10 percent fat product with 0.50 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, 3/16-inch grind; (5) 10 percent fat product with 0.50 percent salt, 0.125 percent HVP, and 0.125 percent white pepper added, 3/16-inch grind; (6) 10 percent fat product with 0.50 percent salt, 0.125 percent HVP, 0.125 percent extractive of red pepper added, 3/16-inch grind; and (7) 10 percent fat product with 0.50 percent salt, 0.125 percent HVP, 0.125 percent white pepper, and 0.125 percent extractive of red pepper added, 3/16-inch grind.

[2]No differences ($P>0.05$) found between treatment means.

[3]Attributes rated on 8-point and 7-point hedonic scales as shown in table 6.

Conclusions

Based on the trend for ground beef patties with added salt and hydrolyzed vegetable protein (HVP) to have higher sensory scores for beef flavor intensity and overall acceptability, further work should be initiated to refine the level of addition. This became the objective of the following study VII.

STUDY VII: EFFECT OF THE ADDITION OF SALT AND HYDROLYZED VEGETABLE PROTEIN ON THE SENSORY PROPERTIES OF LEAN GROUND BEEF PATTIES

Design

The following treatments were prepared using the raw materials and procedures as previously described: (1) control (20 percent fat) product ground through a ⅛-inch (0.32-cm) grinder plate, (2) 10 percent fat product ground through a ⅛-inch plate, (3) 10 percent fat product with 0.25 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, ground once through a 3/16-inch (0.48-cm) plate, (4) 10 percent fat product with 0.50 percent salt and 0.125% HVP added, 3/16-inch grind, (5) 10 percent fat product with 0.25 percent salt and 0.25 percent HVP added, 3/16-inch grind, and (6) 10 percent fat product with 0.50 percent salt and 0.25 percent hydrolyzed vegetable protein (HVP) added, 3/16-inch grind.

Patties were cooked (broiled) for sensory evaluation using the gas griddle as previously described. Prepared samples were served to a trained sensory panel. Panelists were instructed to evaluate each sample for juiciness (initial and sustained), tenderness, beef flavor intensity, and overall acceptability on an 8-point hedonic scale and on a 7-point scale for texture as described previously. Three replications of the study were completed and the data were analyzed using analysis of variance procedures.

Results and Discussion

Sensory panelists detected no differences ($P>0.05$) between the ground beef patties from the different treatments for juiciness (initial and sustained), tenderness, and texture, table 12. However, panelists detected differences ($P<0.05$) between ground beef patties for beef flavor intensity and overall acceptability. Patties from treatments 3, 4, 5, and 6 had the greatest ($P<0.05$) beef flavor intensity and overall acceptability. Patties from treatment 4 were not different ($P>0.05$) from treatment 1 and patties from treatment 1 were not different ($P>0.05$) from treatment 2 for beef flavor intensity. No difference ($P>0.05$) in overall acceptability of patties from treatments 1, 4, 5, and 6 were detected by sensory panelists. No difference ($P>0.05$) was found between patties from treatments 1 and 2 for overall acceptability. From these results it is evident that the addition of salt and HVP increases beef flavor intensity and overall acceptability of lean ground beef patties. It is also apparent that a level of 0.25 percent salt and 0.125 percent HVP (treatment 3) is sufficient to improve

TABLE 12. EFFECT OF THE ADDITION OF SALT AND HYDROLYZED VEGETABLE PROTEIN ON THE SENSORY ATTRIBUTES OF GROUND BEEF PATTIES, STUDY VII

Attributes[2]	Rating, by treament[1,3]					
	1	2	3	4	5	6
Initial juiciness	5.7[c]	5.5[c]	5.7[c]	5.4[c]	5.6[c]	5.6[c]
Sustained juiciness	5.3[c]	5.0[c]	5.6[c]	5.3[c]	5.3[c]	5.4[c]
Tenderness	6.0[c]	6.0[c]	5.7[c]	5.8[c]	5.6[c]	5.4[c]
Beef flavor intensity	4.6[de]	4.2[e]	5.7[c]	5.4[cd]	5.7[c]	6.0[c]
Texture	4.4[c]	4.4[c]	4.5[c]	4.3[c]	4.4[c]	4.3[c]
Overall acceptability	5.2[de]	4.9[e]	6.2[c]	6.0[cd]	5.7[cd]	5.8[cd]

[1]Treatments are: (1) 20 percent fat product (control) ground through ⅛-inch (0.32-cm) grinder plate; (2) 10 percent fat product ground through ⅛-inch plate; (3) 10 percent fat product with 0.25 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, ground once through 3/16-inch plate (0.48-cm); (4) 10 percent fat product with 0.50 percent salt and 0.125 percent HVP added, 3/16-inch grind; (5) 10 percent fat product with 0.25 percent salt and 0.25 percent HVP added, 3/16-inch grind; and (6) 10 percent fat product with 0.50 percent salt and 0.25 percent HVP added, 3/16-inch grind.

[2]Attributes rated on 8-point and 7-point hedonic scales as shown in table 6.

[3]Means within a row bearing different superscripts differ ($P<0.05$).

the beef flavor intensity and overall acceptability of lean ground beef patties, since no further improvements were found using higher levels (treatments 4, 5, and 6).

Conclusions

Results from this study indicate that salt at a level of 0.25 percent and HVP at a level of 0.125 percent provide an acceptable beef flavor profile in lean ground beef patties. Combinations of salt and HVP similar to these will then be used in all further development.

FINAL STUDY: CHEMICAL ANALYSIS AND SENSORY EVALUATION OF THE DEVELOPED LEAN GROUND BEEF PRODUCTS

Prior to the initiation of the final study, the effects of lecithin and carrageenan on the sensory properties of the developed lean ground beef products were examined. These studies identified one carrageenan and one lecithin as possessing the properties which could improve the overall acceptability of the lean ground beef product. These were studied using various levels of carrageenan and lecithin alone and in combination. It was determined that the most acceptable product could be produced using 0.05 percent carrageenan (Vascarin SD 389, FMC Corporation, Philadelphia, Pennsylvania) alone. The addition of lecithin created flavor problems after only 2 days of storage under refrigerated conditions.

Design

The following treatments were prepared, and sensory evaluation and chemical analyses performed: (1) control (20 percent fat) product ground through a ⅛-inch (0.32-cm) grinder plate, (2) 10 percent fat product ground through a ⅛-inch plate, (3) 10 percent fat product with 0.25 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, ground once through a 3/16-inch (0.48-cm) plate, and (4) 10 percent fat product with 0.375 percent salt, 0.188 percent HVP, 3.0 percent water, and 0.50 percent carrageenan added, ground through a 3/16-inch plate.

Patties were cooked (broiled) for sensory evaluation on an open hearth gas grill as previously described. Cooked samples were served to a trained sensory panel. Panelists were instructed to evaluate each sample for juiciness (initial and sustained), tenderness, beef flavor intensity, and overall acceptability on an 8-point hedonic

scale, and texture evaluation on a 7-point hedonic scale as described previously. Analysis of the ground beef products on both a raw and cooked basis for moisture, fat, protein, and ash was completed as previously described. Cooking loss was also determined as described previously. Data were analyzed using analysis of variance procedures.

Results and Discussion

The two developed products (treatments 3 and 4) were not different ($P>0.05$) from the 20 percent fat control for any of the sensory characteristics tested, table 13. These products had a more ($P<0.05$) intense beef flavor and a greater ($P<0.05$) overall acceptability, figure 2, than the original 10 percent ground beef product (treatment 2). The analysis (raw basis) of these products for fat confirmed that the lean products contained less than 10 percent fat, while the control contained approximately 20 percent fat, table 14. The proximate composition of the cooked final products is presented in table 15. Lean products were lower ($P<0.05$) in fat and higher ($P<0.05$) in protein and moisture than the 20 percent control product. Ground beef patties with 20 percent fat had a greater ($P<0.05$) calorie content than the patties with 10 percent fat content (255 kcal/100 g compared to 196-199 kcal/100 g). Patties with 10 percent fat had a greater ($P<0.05$) portion of the calories from protein than patties with 20 percent fat, figure 3. Ground beef patties with 20 percent fat contained approximately 70 kcal/100 g more ($P<0.05$) from fat than patties with 10 percent fat. No differences ($P>0.05$) were found between the ground beef patties for percent ash.

TABLE 13. SENSORY ATTRIBUTES OF LEAN GROUND BEEF PATTIES AS COMPARED TO THE CONTROL

Treatment[2]	Rating of sensory attributes[1,3]					
	Initial juiciness	Sustained juiciness	Tenderness	Flavor intensity	Texture	Overall acceptability
1	6.2[e]	5.9[e]	5.9[e]	5.9[e]	4.1[cd]	6.0[e]
2	5.8[e]	5.4[e]	5.6[e]	4.3[d]	4.3[d]	4.5[d]
3	6.1[e]	5.9[e]	5.8[e]	5.7[e]	4.6[e]	5.9[e]
4	6.1[e]	6.0[e]	6.2[e]	6.1[e]	4.5[e]	6.3[e]

[1]Sensory attributes were rated on 8-point and 7-point hedonic scales as shown in table 6.

[2]Treatments are: (1) 20 percent fat product (control) ground through a ⅛-inch (0.32-cm) grinder plate; (2) 10 percent fat product ground through a ⅛-inch plate; (3) 10 percent fat product with 0.25 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, ground through a 3/16-inch (0.48-cm) grinder plate; and (4) 10 percent fat product with 3 percent water, 0.375 percent salt, 0.188 percent HVP, and 0.50 percent carrageenan added, ground through a 3/16-inch grinder plate.

[3]Means within a column with different superscripts are significantly different ($P<0.05$).

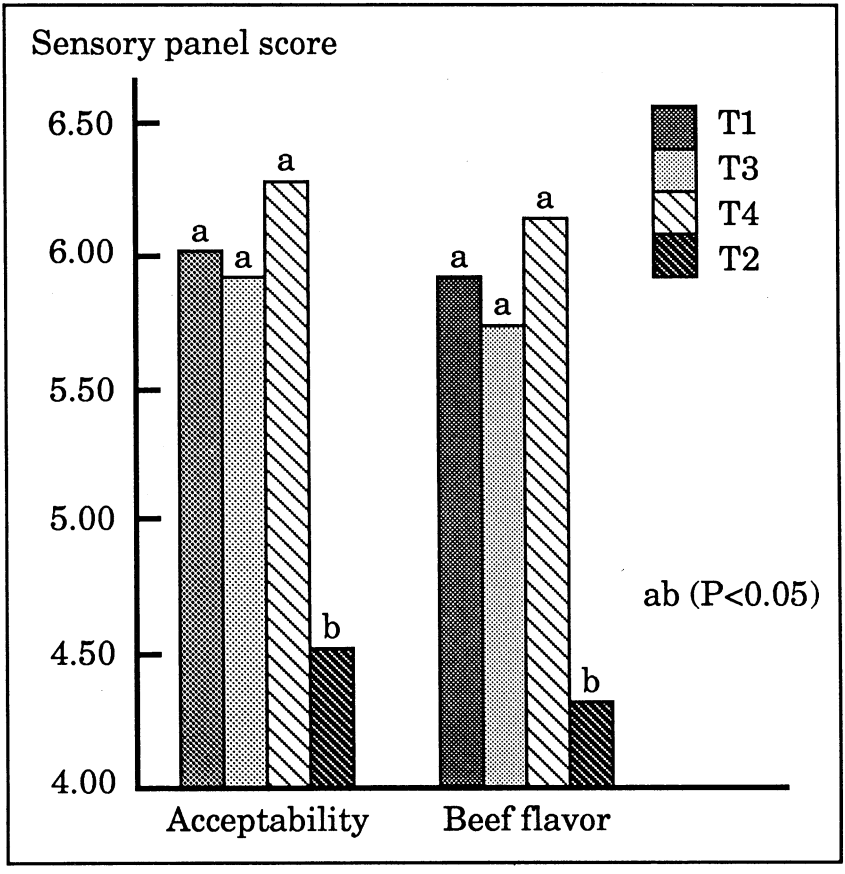

FIG. 2. Overall acceptability and beef flavor intensity of ground beef patties. Treatments are: (T1) 20 percent fat product (control) ground through a 1/8-inch (0.32-cm) grinder plate; (T2) 10 percent fat product ground through a 1/8-inch plate; (T3) 10 percent fat product with 0.25 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, finely ground through a 3/16-inch (0.48-cm) grinder plate and; (T4) 10 percent fat product with 3.0 percent water, 0.375 percent salt, 0.188 percent HVP and 0.50 percent carrageenan added, finely ground through a 3/16-inch grinder plate. Bars with different superscripts are significantly different (P<0.05).

TABLE 14. PROXIMATE ANALYSIS OF RAW GROUND BEEF PATTIES

Treatment[1]	Analysis[2]			
	Moisture	Fat	Protein	Ash
	Pct.	*Pct.*	*Pct.*	*Pct.*
1	61.2^{b}	19.6^{c}	17.7^{d}	0.99^{bc}
2	69.5^{c}	9.9^{b}	20.9^{b}	0.89^{b}
3	69.9^{c}	8.8^{b}	20.1^{bc}	1.25^{c}
4	69.9^{c}	8.8^{b}	19.5^{c}	1.16^{bc}

[1]Treatments same as table 13.
[2]Means within a column with different superscripts are significantly different (P<0.05).

TABLE 15. PROXIMATE ANALYSIS AND CALORIE CONTENT OF COOKED GROUND BEEF PATTIES

Components	Content, by treatment[1,2]			
	1	2	3	4
Moisture, pct.	56.3[b]	63.4[c]	63.2[c]	62.5[c]
Fat, pct.	18.7[c]	10.8[b]	10.9[b]	11.4[b]
Protein, pct.	21.7[d]	25.4[b]	24.5[bc]	24.1[c]
Ash, pct.	1.27[b]	1.14[b]	1.25[b]	1.29[b]
Calories [3]	255[c]	199[b]	196[b]	199[b]

[1]Treatments same as found in table 13.
[2]Means within a row with different superscripts are significantly different (P<0.50).
[3]Calories measured in kcal/100 g cooked product.

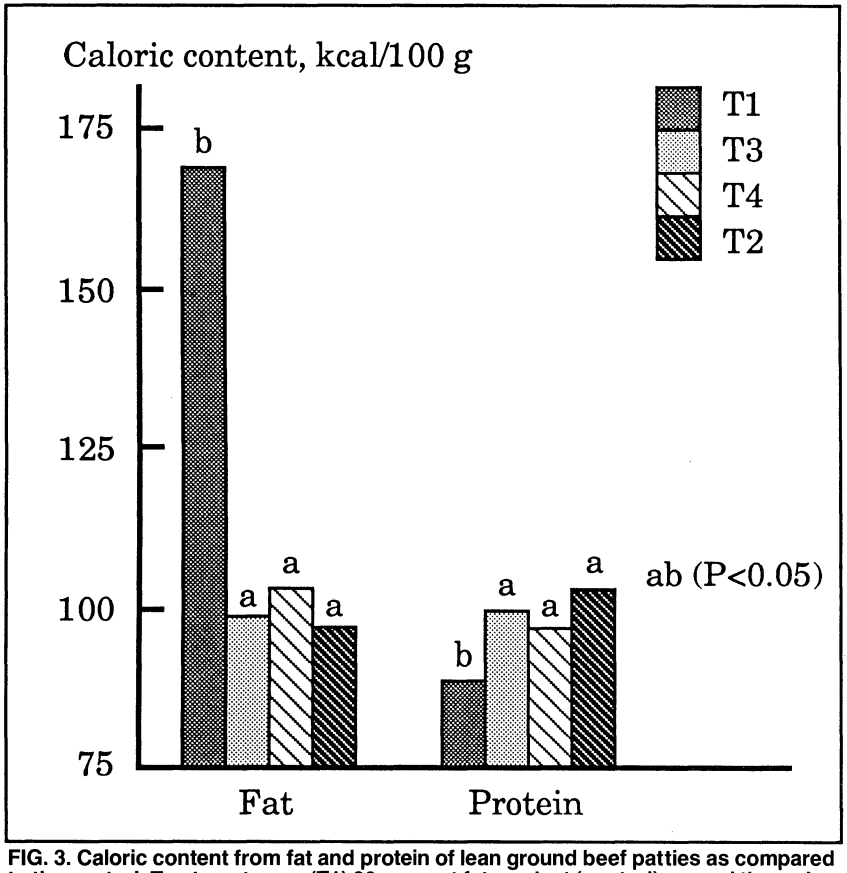

FIG. 3. Caloric content from fat and protein of lean ground beef patties as compared to the control. Treatments are: (T1) 20 percent fat product (control) ground through a 1/8-inch (0.32-cm) grinder plate; (T2) 10 percent fat product ground through a 1/8-plate; (T3) 10 percent fat product with 0.25 percent salt and 0.125 percent hydrolyzed vegetable protein (HVP) added, finely ground through a 3/16-inch (0.48-cm) grinder plate; and (T4) 10 percent fat product with 3.0 percent water, 0.375 percent salt, 0.188 percent HVP and 0.50 percent carrageenan added, finely ground through a 3/16-inch grinder plate. Bars with different superscripts are significantly different (P<0.05).

Conclusions

Ground beef products were developed that were not significantly different from the control (20 percent fat, raw basis) product for any of the sensory traits measured. The developed products were less than 10 percent fat (raw basis) and possessed more intense beef flavor and were more acceptable overall than the ground beef product with 10 percent fat (raw basis) and no additives. The calorie savings obtained from the developed products over the control product would be between 55 and 60 kcal/100 g serving or a caloric decrease of 22-23 percent on an "as eaten" basis with a decrease of 70 kcal/100 g from fat.

SUMMARY

The objective upon initiation of this project was to develop a lean ground beef product with a fat content of 10 percent or less that was as acceptable as the control (as determined by consumer panel to possess the most acceptable sensory characteristics) which contained 20 percent fat. Evidence from this study indicates that this objective has been accomplished. Two products were developed with sensory characteristics that do not differ from the control. These developed products along with the control possess more intense beef flavor and have a greater overall acceptability than the original ground beef product containing 10 percent fat (untreated).

The two products developed contain approximately 40 percent less fat than the control product (with a 20 percent fat content) on an "as eaten" basis. The caloric savings obtained from the consumption of these products compared to the control product are between 55 and 60 kcal/100 g serving or a caloric decrease of 22-23 percent on an as eaten basis. Based on a 100-g serving, calories from the lean ground beef are distributed as follows: 100 kcal from fat and 98 kcal from protein; whereas in the control ground beef the calories are distributed in the following: 168 kcal from fat and 87 kcal from protein.

The development of lean ground beef products (10 percent fat content) which possess sensory properties comparable to ground beef products with 20 percent fat content was accomplished through the following:

(1) An increase in the particle size of the ground product through the use of a large-sized grinder plate.

(2) The addition of small quantities of salt and hydrolyzed vegetable protein as flavor enhancers.

(3) The addition of carrageenan as a product stabilizer.

These newly developed lean ground beef products are tailored to meet the needs of the diet conscious consumer. The products contain less fat and calories than traditional ground beef products. Upon introduction of these products to the retail market, consumers will have the opportunity to substitute the lean ground beef products for the higher-fat ground beef products currently available.

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Alabama's Agricultural Experiment Station System
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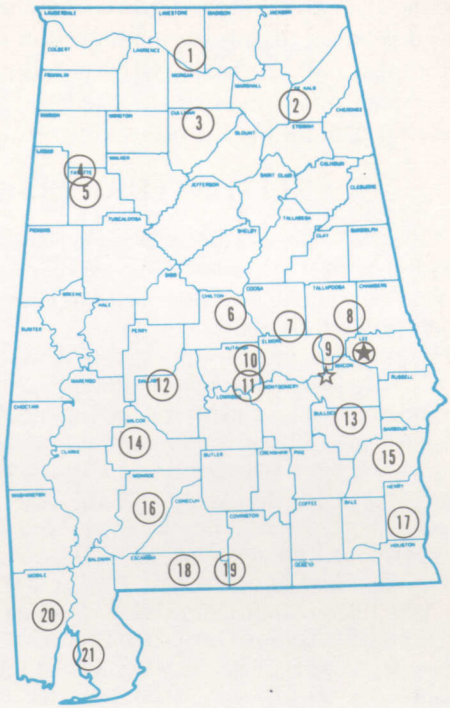

Research Unit Identification

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

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. Plant Breeding Unit, Tallassee.
10. Forestry Unit, Autauga County.
11. Prattville Experiment Field, Prattville.
12. Black Belt Substation, Marion Junction.
13. The Turnipseed-Ikenberry Place, Union Springs.
14. Lower Coastal Plain Substation, Camden.
15. Forestry Unit, Barbour County.
16. Monroeville Experiment Field, Monroeville.
17. Wiregrass Substation, Headland.
18. Brewton Experiment Field, Brewton.
19. Solon Dixon Forestry Education Center, Covington and Escambia counties.
20. Ornamental Horticulture Substation, Spring Hill.
21. Gulf Coast Substation, Fairhope.