S7P03.WP

INSTRUMENTAL MEASURES OF TENDERNESS IN LOW-FAT GROUND BEEF PATTIES

B.W. BERRY[1] and H.C. ABRAHAM[2]

[1] Meat Science Research Laboratory, Agricultural Research Service, United States Department of Agriculture, Beltsville, Maryland, United States

[2] Agricultural Marketing Service, United States Department of Agriculture, Washington, D.C., United States

INTRODUCTION

A vast array of processing procedures and ingredients are frequently used in the manufacture of beef patties. Thus, cooked patty texture and tenderness can differ, substantially, among formulations. Jones *et al.* (1985) found various punch and die measurements useful for segregating the textural properties of grilled patties obtained from numerous commercial outlets. The increased emphasis on fat reductions in beef patty processing is beginning to provide indications of changes in textural properties. Fat reductions in beef patties from approximately 20 to 5% have been shown to increase shear force values (Berry, 1992; 1993; Troutt *et al.*, 1992a; 1992b). Troutt *et al.* (1992b) reported that as fat was reduced in patty formulations from above 20 to below 10%, compression force, springiness and cohesiveness all increased. Use of various fat substitutes and texture-modifying ingredients was found to produce similar shear and compression properties in low-fat patties to that obtained with 20% fat control patties (Troutt *et al.*, 1992a). The objective of this study was to evaluate the effects of the following factors on instrumental measures of tenderness in low-fat (8-12%) beef patties obtained commercially:

(1) raw beef materials;
(2) patty formation and freezing techniques; and
(3) fat replacement.

MATERIALS AND METHODS

Low-fat beef patties (8-12% fat) were obtained from various commercial establishments. These patties were produced within a two-week period. Fifteen different low-fat products were obtained with a sixteenth product being a 20% fat patty which served as a control product. Summarization of the major differences between formulations is provided in Table 1 and 2. Variations in beef materials represented in formulations include:

(1) youthful age vs mature (cow) age beef;
(2) anatomical location (round vs shoulder); and
(3) trimmings vs thick cuts.

Products which used iota carrageenan, oat bran and fibre and a simulated fat matrix had at least 90% of the formulations comprised of beef. The simulated fat matrix was manufactured from hydrogenated canola oil, hydrolysed beef plasma, tapioca flour and sodium alginate. One formulation used rehydrated soy protein concentrate at a 20% substitution level, while frozen pre-hydrated soy (FPS) was employed at usage levels between 17 and 22%. Patties were formed to be between 90 and 100 grams. Patties were either perforated and individually quick frozen (IQF) or subjected to freezing in stacks of boxes so as to reach -18°C in 72 hours.

Patties were cooked from the frozen state on pans to 71°C in a 177°C convection oven. Percent cooking yield and cooking times were recorded for all patties. Degree of " doneness" was determined subjectively using a 12-point photographic scale (12=very rare, 1= very well done).

Two 2.5cm-wide sections were removed from each of six cooked patties/formulation after one hour of cooling at 25°C. Each section was sheared in five separate locations with a straight edge blade attached to an Instron Universal Testing Machine (Model 1122). Both crosshead and chart speeds were set at 25cm/min. Instrumental values from the shear force test included peak load, peak energy (total work expended in shearing until peak load was reached), post-peak energy (total work from peak load to the end of shearing) and stress in relation to strain.

Compression measurements were obtained both on cooked core samples and intact cooked patties using Instron machine. For core samples, six patties/formulation were cooked and following cooling for one hour at 25°C, five 2.5cm diameter cores were removed/patty. Each core was compressed to 75% of its original thickness, six consecutive times using a 7.5cm diameter, circular, flat-surface disk. A full scale load of 100kg with a crosshead speed of 200mm/min were used.

For whole patty compression tests, another six patties for each formulation were cooked and cooled as previously described. Each patty was compressed to 75% of its original thickness in four separate locations, eight consecutive times using a 2.5cm diameter, circular, flat-surface disk. Loads and crosshead chart speeds were the same as for core samples.

Compression measurements included:

hardness= peak force (kilograms) of compression;
springiness= distance in centimetres sample recovered from previous compression to the present compression;
cohesiveness= total energy of present compression divided by total energy of previous compression; and
gumminess= product of hardness times cohesiveness times springiness.

The data was analyzed using a one-way analysis of variance and Tukey's HSD Test for mean separation.

RESULTS AND DISCUSSION

The 20% fat control had lower cooking yields than all low-fat beef patty products (Table 1). Fat reductions in beef patties have previously produced increased cooking yields (Huffman and Egbert, 1990; Berry, 1993). IQF patties (which also had perforation holes) had higher cooking yields than many other formulations. IQF patties had shorter cooking times (data not in tables), which may explain their higher cooking yields. The shorter cooking times for these patties may have been due to the perforations which allowed heat to more easily enter the interior of the patties during cooking. IQF patties appeared more well-done following cooking.

The 20% fat patties had the highest peak load, peak and post-peak energy values (Table 1). This serves to illustrate that higher levels of fat do not always guarantee tender patties. Other studies have shown an increase in shear peak load values when fat decreased from 20 to 5% (Berry, 1992, Troutt *et al.*, 1992a; 1992b). Use of oat bran and fibre, a simulated fat matrix and IQF with perforations (some formulations) lowered peak load and energy values. Addition of FPS and in some cases, carrageenan, elevated shear force values; but, generally not above all-beef, stack frozen patties.

Compression values (Table 2) of hardness are those obtained on the first compression. Gumminess and springiness include relationships between the first and second compression. Patties processed with 20% fat had selected compression values that were lower or comparable to many 10% fat formulations. All-beef patties that were stack frozen, plus product manufactured with FPS exhibited the highest hardness values taken on whole patties, while IQF-perforated, oat bran and fibre and simulated fat matrix patties had the lowest hardness values after one compression. Basically, the same trends in hardness were detected on compression measurements with cores. However, with cores, FPS patties had slightly lower hardness values in relation to all-beef, stack frozen product. With whole patties, the hardness of these two types of products was similar. Thus, the use of FPS may create some patty surface hardening that is not as prevalent in the interior of the product. Previously, increasing levels of fat (15% and above vs 10% and below) and the use of fat replacers have lowered compression hardness values with patties (Troutt *et al.*, 1992a; 1992b).

The highest values for gumminess on whole patties were found when all-beef patties were stack frozen, or when carrageenan or FPS were used in the product.

Similar trends were detected for gumminess with cores, however, extremely low values were observed for the oat bran and fibre and simulated fat matrix products. The low gumminess values are mainly due to low hardness rather than cohesiveness values for these two products. Use of the simulated fat matrix and carrageenan appeared to create more springiness in the cooked patties.

Repeated compression measurements on whole patties produced most of the significant differences ($P<0.05$) during the first three compressions (data not tabular form). With cores, each additional compression, especially for cohesiveness, often produced significant ($P<0.05$) changes over the previous compression.

CONCLUSIONS

In order to reduce instrumental shear force and compression properties in low-fat beef patties, these results suggest the use of oat bran and fibre, a simulated fat matrix and patty perforation coupled with IQF in patty processing.

REFERENCES

BERRY, B.W. 1993. Fat level and freezing temperature affect sensory, shear, cooking and compositional properties of ground beef patties. *J. Food Sci.* 58:34-37, 42.

BERRY, B.W. 1992. Low fat level effects on sensory, shear, cooking and chemical properties of ground beef patties. *J. Food Sci.* 57:537-540, 574.

HUFFMAN, D.L., and EGBERT, W.R. 1990. *Advances in lean ground beef production.* Alabama Agriculture Experiment Station Bulletin 606, Auburn University.

JONES, R. C., DRANFIELD, E., ROBINSON, J. M., and CROSLAND, A. R. 1985. Correlation of mechanical properties, composition and perceived texture of beef burgers. *J. Texture Studies.* 16:241-262.

TROUTT, E. S., HUNT, M. C., JOHNSON, D. E., CLAUS, J. R., KASTNER, C. L., and KROPF, D. H. 1992a. Characteristics of low-fat ground beef containing texture-modifying ingredients. *J. Food Sci.* 57:19-24.

TROUTT, E. S., HUNT, M. C., JOHNSON, D. E., CLAUS, J. R., KASTNER, C. L., KROPF, D. H., and STRODA, S. 1992b. Chemical, physical and sensory characterization of ground beef containing 5 to 30% fat. *J. Food Sci.* 57:25-29.

Table 1. Selected cooking and shear force properties of low-fat ground beef patties.

Principle processing feature or ingredient in formulation	Cooking yield %	Degree of doneness score	Peak load kg	Peak energy kg-cm	Post-peak energy kg-cm
20% fat control	51.3[j]	5.3[cde]	11.5[c]	42.6[c]	46.7[c]
All-beef from young cattle, stack frozen	61.6[fgh]	4.3[e]	6.9[e]	33.5[de]	30.6[defg]
All-beef from thigh muscles, stack frozen	56.6[i]	5.2[cde]	8.3[d]	38.4[cd]	32.1[defg]
All-beef from trimmings, IQF[a]	67.0[cde]	4.3[e]	6.3[ef]	29.7[ef]	24.4[gh]
All-beef from round muscles, IQF[a]	70.2[c]	4.3[e]	4.7h[ij]	23.2[fg]	18.1[h]
Lean beef with PDCB, IQF[a]	65.4[def]	4.3[e]	6.3[efg]	30.0[e]	27.1[g]
Lean beef with oat bran and fibre	69.4[cd]	4.3[e]	4.4[ij]	30.7[e]	17.7[h]
Lean beef with simulated fat matrix, IQF[a]	66.3[cde]	6.0[cd]	4.1[j]	20.5[g]	18.2[h]
Lean beef with carrageenan	63.4[efg]	5.0[de]	6.4[efg]	34.2[de]	37.0[de]
Lean beef with carrageenan	62.9[efg]	5.7[cde]	7.2[de]	38.6[cd]	36.6[def]
Lean beef with carrageenan	60.7[ghi]	5.7[cde]	6.8[ef]	35.6[de]	38.1[cd]

Lean beef with SPC[a]	61.1[gh]	4.7[de]	5.4[ghi]	23.1[fg]	27.8[g]
Lean beef with 17% FPS[a]	65.9[de]	6.7[c]	6.6[efg]	33.1[de]	31.6[defg]
Lean beef with 17% FPS[a]	58.2[hi]	5.0[de]	7.1[e]	34.9[de]	28.2[fg]
Lean beef with 20% FPS[a]	61.4[fg]	5.0[de]	5.7[fgh]	29.2[ef]	29.1[efg]
Lean beef with 22% FPS[a]	60.0[gh]	6.2[cd]	7.2[de]	37.7[cd]	28.3[fg]

[a] IQF = individually quick frozen
PDCB = partially defatted chopped beef
FPS = frozen, pre-hydrated soy
Simulated fat matrix (see text)
SPC = soy protein concentrate

[cdefghij] Means in the same column without a common superscript differ ($P<0.05$).

Table 2. Selected compression properties of low-fat ground beef patties.

Principal processing feature or ingredient in formulation	Hardness on whole patties kg	Hardness on cores kg	Gumminess on whole patties	Gumminess on cores	Springiness whole patties
20% fat control	72.7[ghi]	60.5f[ghi]	44.8[ghi]	31.5[fgh]	.58[ghi]
All-beef from young cattle, stack frozen	88.6[def]	67.5[def]	57.9[de]	37.8[def]	.60f[ghi]
All-beef from thigh muscles, stack frozen	100.2[d]	74.6[d]	56.7[de]	40.3[d]	.56[i]
All-beef from trimmings, IQF[a]	66.5h[ij]	45.2[k]	39.6[hij]	24.4[ij]	.64[efg]
All-beef from round muscles, IQF[a]	50.7[k]	45.7[k]	31.2[k]	25.1[hij]	.57[hi]
Lean beef with PDCB, IQF[a]	56.0[jk]	41.6[kl]	35.2[jk]	22.9[j]	.61[fgh]
Lean beef with oat bran and fibre	64.3[ij]	34.5[l]	44.8[ghi]	14.1[k]	.68[e]
Lean beef with simulated fat matrix, IQF[a]	46.2[k]	23.6[m]	38.0[ij]	10.1[k]	.81[d]
Lean beef with carrageenan	81.7[efg]	58.4[ghi]	52.9[def]	30.9[ghi]	.75[d]
Lean beef with carrageenan	77.7[fgh]	53.8[ij]	53.0[def]	29.6[ghij]	.67[ef]
Lean beef with carrageenan	87.9[ef]	68.2[de]	57.6[de]	39.6[de]	.63[efg]
Lean beef with SPC[a]	84.7[ef]	64.0[efg]	47.0[fg]	33.3[efg]	.58[fg]
Lean beef with 17% FPS[a]	91.2[de]	61.4[efgh]	59.4[d]	38.1[def]	.64[efg]

Lean beef with 17% FPS[a]	87.3^{ef}	55.6^{hi}	51.2^{ef}	30.6^{ghi}	$.62^{efgh}$
Lean beef with 20% FPS[a]	89.2^{def}	46.7^{jk}	53.1^{def}	27.6^{ghij}	$.63^{efgh}$
Lean beef with 22% FPS[a]	80.2^{efg}	53.3^{ij}	46.1^{fgh}	27.8^{ghij}	$.62^{efgh}$

[a] IQF = individually quick frozen
PDCB = partially defatted chopped beef
FPS = frozen, pre-hydrated soy
Simulated fat matrix (see text)
SPC = soy protein concentrate

[defghijklm] Means in the same column without a common superscript differ ($P<0.05$).