COOKING LOSSES AND TENDERNESS OF BEEF-SOY PROTEIN PATTIES

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Cooking characteristics of beef patties containing soy protein depended upon concentration of the hydrated soy product added; the form of the protein, concentrate or textured product, the temperature used for grilling, and the degree of doneness to which the patties were cooked. These factors affected tenderness, cooking shrink, and composition of the resultant cooking juices.

The addition of hydrated soy protein to beef patties lowered the internal patty temperature by 1 to 2°C during cooking. The beef-soy patties were significantly more tender than the all-beef patties. Beef-soy patties formulated with soy concentrate lost more weight during cooking than patties formulated with textured soy protein but less than all-beef patties. Whereas, beef-soy patties formulated with textured soy protein lost more fat and less moisture to cooking juices than all-beef patties, beef-soy patties formulated with soy concentrate lost more moisture and less fat to the cooking juices than the all-beef patties.

Patty composition had a greater effect on tenderness than did final degree of doneness to which the patties were cooked; shrink tended to increase with doneness. The protein content of the cooking juices remained relatively constant between 2.5 and 4.1%. An increase in grill temperature resulted in a concomitant toughening of the patties and increased shrink.

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In the United States, about 25% of each beef carcass is fabricated into ground beef; most of which is consumed as cooked patties. Recently soy protein products have been used widely as extenders in ground meat products and approved for routine use in the School Lunch Program (FNS-19). Consumer acceptance of extenders has been high (Huffman and Powell, 1970; Kotula et al., 1974; Cross et al., 1975). Little research, however, has been reported on the effects of cooking to different degrees of patty doneness on losses in size, weight and tenderness.

Anderson and Lind (1975), who studied beef-soy patties having fat contents of 15, 20, 25 or 35%, reported that the addition of textured soy protein to beef patties increased moisture retention and fat loss from patties during cooking to an internal temperature of 70°C. Judge et al., 1974 evaluated cooking losses of beef-soy patties having fat contents of 16-17 and 24-26% and soy concentrate or textured soy content of 14 or 19%. Their beef-soy patties shrank less in diameter and weight than all-beef patties. The expected limits of shrink for beef-soy patties cooked to different degrees of doneness has not been published.

We have determined cooking losses of beef-soy patties containing levels of textured soy protein, levels of soy concentrate, and level of fat. Patties were cooked to degrees of doneness and compared to all-beef patties. Changes in patty dimensions, composition of cooking juices, and tenderness were also determined.

Procedure

Textured soy protein and soy concentrate were hydrated as recommended by the School Lunch Program; the protein to water ratios were 1:1.5 and 1:2.5, respectively. The beef was 75/25 (lean to fat) blade, chuck and brisket from U.S. Good carcasses, which had been ground through a 2.54 cm plate. Appropriate amounts of hydrated soy proteins were added to the beef to form beef-soy mixtures of 20 and 30% each of textured protein and soy concentrate. The mixtures finally were ground through a .32 cm plate and automatically formed into 85g patties. All-beef patties were prepared similarly but without soy protein. The resulting types of patties, frozen at -25°C and stored at -17°C until evaluated, averaged 84.22g in weight, 10.78 cm in diameter, and 1.1 cm in thickness.

Frozen patties were cooked on an electric grill to doneness end-points, internal temperature of patty, of rare (58°C), medium rare (62°C), medium well (66°C), or well (68°C). Three time-temperature combinations were used to obtain each degree of doneness. To produce a medium rare patty, for example, meat was cooked for 9, 6, or 5 minutes at 121°, 149°, or 177°C, respectively.

Griddle temperature (°C)	Doneness			
	Rare (min)	Medium rare (min)	Medium well (min)	Well done (min)
121	8	9	10	11
149	5	6	7	8
177	4	5	6	7

Three patties of each of the types were cooked at each time temperature and evaluated for weight loss, dimensional change, composition of cooking juices, and tenderness. The Slice Tenderness Evaluator (S.T.E.), puncture and shear, procedure of Kulwich et al. 1963 was used for tenderness evaluation.

Results

The mean squares of the analysis of variance (table 1) indicate that most cooking characteristics of beef-soy patties were significantly influenced by the type and amount of soy protein added and also by the degree of doneness to which the patties were cooked. The internal temperature of cooked patties was significantly higher ($P<.05$) for all-beef patties than for beef-soy patties (table 2); the difference was 1-2 degrees. The all-beef patties appeared to be more well done than patties with soy and required the greatest puncture and shear forces. Huffman and Powell (1970), Kotula et al.(1974), and Cross et al. (1975) also reported the all-beef patties were less tender than soy-patties. The patties with textured soy protein (20%), which had the second highest internal temperature, were more tender than the patties with soy concentrate, which had lower internal temperatures. Patties with soy concentrates were less tender than patties with textured soy protein. The fine particle size of concentrated soy protein may have influenced tenderness adversely.

Shrink in weight, diameter, and thickness were greatest in the all-beef patties. Weight loss was greater from patties with soy concentrate than from patties with textured soy protein, presumably because the hydration ratio was greater for the soy concentrate. This was reflected in a higher moisture content in the cooking juices from the patties with soy concentrate. The data in table 2 support the report of Anderson and Lind (1975) wherein the addition of textured soy protein to ground beef increased retention of moisture and loss of fat over that in all-beef patties. However, the results for patties containing soy concentrate indicate the inverse; more moisture and less fat were lost when soy concentrate was added to ground beef.

Table 3 indicates the range in S.T.E., puncture and shear forces for beef and beef-soy patties which were cooked to various degrees of doneness. The range in tenderness appears less variable among the degrees of doneness than among types of patties. Correlation was high ($r=.77$) between the two S.T.E. methods, puncture and shear. The amounts of weight and diameter shrink tended to increase with patty doneness. Patty thickness did not conform to the same trend but difficulty in measuring patty thickness may have contributed to that nonconformity.

The amount of protein in the cooking juices was significantly greater ($P<.05$) from patties containing 20% added textured soy protein than from the all-beef patties (table 3). However, the magnitude of the difference is of questionable importance. The amount of fat in the cooking juices was significantly greater ($P<.05$) from the patties containing 30% textured soy protein than from patties containing soy concentrates. During cooking, the pattern of fat loss from all-beef patties was similar to the patterns of patties containing either 20 or 30% soy concentrate. Patties containing soy concentrates at both 20 and 30% lost more moisture than patties containing the textured soy protein but not all differences were significant. Both soy proteins had been hydrated with water, but the patties with concentrates reacted like the all-beef patties in moisture loss, whereas the patties with textured soy protein tended to lose less moisture even though some had been added previously. In the all-beef patties and patties containing textured soy protein, the amount of fat loss increased with degree of doneness from rare to well done. Apparent moisture loss from each type of patty tended to decrease with increased doneness probably because of evaporative losses.

The internal temperature of patties increased 2 and 3 degrees respectively as grill temperature was raised from 121 to 149° to 177°C (table 4). Tenderness, by both S.T.E. methods, decreased when a hotter

Table 3. Cooking characteristics of beef-soy patties cooked to various degrees of doneness[a]

Product	Doneness[b]	S.T.E. Puncture (g)	S.T.E. Shear (g)	Shrink Weight (%)	Shrink Diameter (%)	Shrink Thickness (%)	Composition of cooking juices Protein (%)	Composition of cooking juices Fat (%)	Composition of cooking juices Moisture (%)
	1	358de	4120bc	29.6c	12.4bc	6.2a-d	2.5f	9.3cd	87.7ab
All-	2	520ab	4550a	34.6b	14.9ab	8.6ab	2.8c-f	17.6cd	78.0abc
beef	3	622a	4626a	35.8ab	15.5a	8.6ab	2.8c-f	22.3cd	74.0abc
	4	488bc	4354ab	37.7a	17.0a	8.6ab	2.8c-f	28.2bc	68.3bcd
	1	303de	2998g	18.3hi	7.6fg	0 e	4.1a	19.9cd	74.9abc
Textured	2	302de	3075g	22.1fg	9.5c-f	0 e	3.7ab	28.6bc	66.2cde
soy	3	309de	3094g	24.8def	10.4c-f	0 e	3.7ab	44.8ab	49.7def
20%	4	380cde	3136g	25.9de	11.9cd	0 e	3.7ab	56.3a	39.2f
	1	367cde	2553h	10.8k	4.1h	3.3b-e	3.1b-f	46.5ab	48.9def
Textured	2	260e	2497h	13.8j	6.0gh	2.2cde	3.5a-d	45.6ab	49.6def
soy	3	296de	2640h	17.0i	8.1fg	6.7abc	3.2b-f	47.7ab	47.8ef
30%	4	333de	2588h	20.1gh	9.0d-g	0.8de	3.1b-f	61.6a	34.3f
	1	318de	3984cde	22.4fg	7.8fg	9.9a	2.7ef	3.3d	92.9a
Soy	2	383cde	3773def	26.8de	11.6cde	6.2a-d	3.1b-f	13.7cd	82.4abc
concentrate	3	371cde	3693ef	24.7def	8.7efg	3.7b-e	3.1b-f	15.5cd	80.2abc
20%	4	482bc	4094bcd	27.4cd	10.3c-f	0 e	3.5abc	14.1cd	80.6abc
	1	336de	3541f	21.1g	6.2gh	3.6b-e	3.1b-f	5.4d	90.1a
Soy	2	350de	3511g	27.1cd	9.0d-g	1.2cde	3.2b-f	12.3cd	84.4ab
concentrate	3	327de	3579f	23.9ef	8.1fg	2.5cde	3.3b-e	15.4cd	75.3abc
30%	4	395cd	3812c-f	26.2de	7.6fg	4.7a-e	3.2b-f	20.2cd	80.5abc

[a] Basic values based on 9 observations. Values for composition of cooking juices based on 12 observations because data from 3 patties were pooled in each instance. Means with a column followed by the same letter are not significantly different (P <.05) according to the multiple range test (Duncan 1955).

[b] 1 = rare, 2 = medium rare, 3 = medium well, 4 = well done; cooked to internal temperatures of 58°, 62°, 66°, and 68°C respectively.

Table 4. Cooking characteristics of patties as affected by grill temperature[a]

Cooking temperature (°C)	Internal temperature (°C)	S.T.E. Puncture (g)	S.T.E. Shear (g)	Weight shrink (%)	Diameter shrink[b] (%)	Composition of cooking juices Protein (%)	Composition of cooking juices Fat (%)	Composition of cooking juices Moisture (%)
121	61c	356b	3440b	22.6c	8.2c	3.25a	22.5b	73.2a
149	63b	361b	3477b	24.9b	10.1b	3.23a	23.0b	72.6a
177	66a	408a	3618a	26.1a	11.0a	3.17a	33.7a	62.1b

a Basic values based on 60 observations. Values for composition of cooking juices based on 20 observations because data from 3 patties were pooled in each instance. Means within a column having the same letter are not significantly different (P<.05) according to the multiple range test (Duncan 1955).

b Thickness change due to cooking was calculated at less than .5%. Average diameter of raw patties = 1.1 cm.

grill was used. Shrink in weight and diameter of the patties increased significantly (P<.05) with each increase in temperature. Amount of moisture in the cooking juices did not change with temperature increase, whereas amount of fat increased and of moisture decreased; thus suggesting that the moisture was released first and then, as more heat was applied, greater quantities of fat were rendered from the patties.

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Table 1. Mean squares and their statistical significance obtained from analysis of variance

Source	d.f.	Mean squares: Internal temperature	S.T.E. Puncture	S.T.E. Shear	Shrink Weight	Shrink Diameter	Shrink Thickness
Corrected total	179						
Doneness	3	938.39**	50413.*	200533	338.4**	104.4**	27.3
Patty types	4	32.07*	197880.**	18369277**	1665.3**	357.0**	310.6**
Doneness x patty types	12	12.27	34453.**	201774*	19.2**	10.3	54.3*
Error	160	11.35	13268	111333	7.8	7.9	24.8

*P<.05
**P<.01

Table 2. Cooking characteristics of beef-soy patties[a]

Product	Internal temperature (°C)	S.T.E. Puncture (g)	S.T.E. Shear (g)	Shrink Weight (%)	Shrink Diameter (%)	Shrink Thickness (%)	Composition of cooking juices Protein (%)	Composition of cooking juices Fat (%)	Composition of cooking juices Moisture (%)
All-beef	64.9a	497a	4412a	34.4a	14.9a	8.0a	2.7c	19.3c	77.3b
Textured soy 20%	63.8b	324cd	3076d	22.7c	9.9b	0 c	3.8a	37.4b	57.5c
Textured soy 30%	62.6c	314d	2969e	15.4d	6.8c	3.3b	3.2b	50.3a	45.2d
Soy concentrate 20%	62.7c	388b	3889b	25.3b	9.6b	4.9b	3.1b	11.7d	84.1a
Soy concentrate 30%	63.9b	352c	3611c	24.6b	7.7c	2.9b	3.2b	13.3cd	82.7ab

a Basic values based on 36 observations; Values for composition of cooking juices based on 12 observations because data from 3 patties were pooled in each instance. Means within a column having the same letter or letters are not significantly different (P<.05) according to the multiple range test (Duncan 1955). Three of each type of patty were cooked at 121°C for 8, 9, 10, 11 min.; 149°C for 5, 6, 7, 8 min.; 177°C for 4, 5, 6, 7 min.