Quality Characteristics of Ground Beef Patties Extended with Moist-Heated and Unheated Seed Meals

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ABSTRACT

Extending ground beef with 5% peanut, soybean, pecan, or field pea meals increased cooked yields and water-retention properties of beef patties. Extended patties were more tender, requiring less force to compress than all-beef patties. Protein content was significantly increased by the addition of peanut and soybean meal to ground beef. Unheated meals produced patties with larger volumes but were poorer in aroma and flavor qualities than all-beef patties or those prepared with heated meals. Moist heat effectively improved aroma and flavor qualities of the meals without altering their binding properties.

INTRODUCTION

The use of vegetable and oilseed proteins in foods has been limited to some extent by off-flavors (e.g., bitterness, beaniness) imparted to products in which they are incorporated. Moist heat has been applied effectively to soy proteins to modify naturally occurring components responsible for off-flavors (1) and thus extend the usefulness of this protein product as an ingredient. During the heating process, certain functional characteristics including solubility of proteins and other components may be altered (2,3). On the other hand, nutritional qualities of products such as soy flour are substantially improved by live steam treatment (100 C for 30 min) which inactivates trypsin inhibitors and other compounds that cause adverse biological and physiological responses (4).

Important benefits of using vegetable proteins as meat extenders include cost reductions and increased product yields. Bird (5) estimated that replacement of up to 30% of meat with soy protein in products prepared for school lunch feeding programs reduced the cost of these programs by ca. $38 million during 1973-74. Other workers (6-8) found that the addition of soy protein to ground meat systems (e.g., patties, loaves) significantly reduced cooking losses. Anderson and Lind (9) showed that ground beef patties extended with hydrated textured vegetable protein retained a greater percentage of moisture and a lesser percentage of fat in cooking than all-beef patties of comparable fat level. The higher water-retention capacity of vegetable protein was reflected in increased juiciness of cooked patties.

The need to determine the functional characteristics of vegetable proteins in actual food systems has been emphasized by Terrell and Staniec (10), Johnson (11), and Mattil (12). Functional properties imparted to meat products by proteins other than soy are now receiving increased research emphasis. These proteins include coagulated lactalbumin from cheese whey (13), faba bean and field pea protein concentrates (14), sunflower protein products (15), delactosed whey (16), and nonfat dry milk, peanut flour, and grits (17).

In our laboratory we have been involved in determining the influence of moist heat on certain functional characteristics of peanuts (*Arachis hypogaea*). We found that water-soluble proteins of moist-heated peanut kernels were altered sequentially to various structural components, aggregates, and insoluble forms (18). Functional properties such as emulsion and foam capacity (19), water uptake, textural attributes, and cookie baking qualities were also significantly influenced by the time and temperature conditions to which the nuts were exposed during moist heating (20). From a nutrition standpoint, the quality of peanuts has been reported to be improved by wet heat, apparently because of elevated available lysine levels (21).

Recently we expanded our investigations to include soybeans (*Glycine max*), pecans (*Carya illinoensis*), and field peas (*Vigna unguiculata*). A preliminary study which utilized a model system to test the ability of unheated defatted meals prepared from these four seeds to form oil-in-water emulsions indicated that each meal possessed unique oil and water binding properties. Techniques of using the model system were previously described (19).

The purpose of the present study was to investigate the potential application of defatted meals prepared from soybeans, peanuts, pecans, and field peas as extenders for ground beef patties. All-beef patties and patties containing unheated and steam-heated meals were compared to determine the influence of moist heat treatment and type of meal on functional and quality characteristics.

MATERIALS AND METHODS

Meal and Pattie Preparation

Four defatted meals derived from Florunner peanuts, Bragg soybeans, Stuart pecans, and Dixie Cream field peas were utilized in this study. The process for hexane extraction and meal preparation was previously described by McWatters et al. (22). Protein levels (dry wt basis) in the four meals were 54.9% (peanut), 50.6% (soybean), 42.1% (pecan), and 24.2% (field pea); oil content ranged from 1.0-1.5%. Both unheated and moist-heated meals were compared as extenders for ground beef patties containing 95% beef and 5% meal.

Portions of meals for moist-heat treatment were spread in stainless steel pans, partially covered, placed in a temperature-controlled retort and steamed for 30 min at 100 C. Following treatment, the pans containing the meals were transferred to a forced draft oven at 25 C and left overnight for drying. The following day the meals were pulverized with a mortar and pestle, and the ground products stored in glass jars at 1 C until used. Moisture content of the meals was reduced from 9-11% to 7-8% as a result of steam heating and drying.

Ground beef (26% fat) from a local supermarket was divided into 600-g portions, packaged in moisture-proof polyethylene bags, and frozen at -18 C until used. Each type of meal was tested separately and compared with a separate all-beef control. For pattie preparation, packages of ground beef were thawed overnight at 0 C; appropriate amounts of beef, salt (2% of solids), and defatted meals were used in the pattie formulation. The dry ingredients (salt, meal) were cut into the beef with a rubber spatula and then mixed for 30 sec in a Hobart mixer at low speed.

To attain a uniform pattie thickness of 9 mm, the beef mixture was rolled between two sheets of wax-coated freezer paper, with wooden guides placed on either side of the mixture. Sixteen patties of 6.5-cm diameter were cut

TABLE I

Moisture and Fat Content of Uncooked and Cooked All-beef and Extended Beef Patties and Retention of Moisture and Fat in Cooked Patties

Pattie formula	% Yield	% Moisture		% Fat (wet basis)		% Retention	
		Uncooked	Cooked	Uncooked	Cooked	Water[a]	Fat[b]
Control 1 (all beef)	65.5	56.1	56.0	26.2	17.3	65.4	43.2
Peanut - 5% heated	72.1	51.8	55.6	25.8	16.8	77.5	46.9
Peanut - 5% unheated	72.3	52.3	53.3	25.6	17.9	73.7	50.6
Control 2 (all beef)	71.9	54.3	54.3	26.4	16.9	71.8	45.9
Soybean - 5% heated	73.6	51.7	52.8	26.7	18.1	75.3	49.9
Soybean - 5% unheated	72.5	52.0	55.4	25.3	14.9	77.1	42.9
Control 3 (all beef)	67.8	54.0	55.3	26.0	18.7	69.4	48.8
Pecan - 5% heated	72.1	51.6	53.4	26.6	17.4	74.7	47.0
Pecan - 5% unheated	72.5	51.6	54.0	26.0	16.9	76.0	47.3
Control 4 (all beef)	68.7	54.4	55.0	26.3	19.9	69.4	52.0
Field pea - 5% heated	73.7	51.6	52.0	25.7	19.9	74.3	57.1
Field pea - 5% unheated	72.7	52.3	53.7	25.7	16.9	74.7	48.0

$^{a}\%\text{ Water Retention} = \frac{\%\text{ yield x }\%\text{ moisture (cooked)}}{\%\text{ moisture (uncooked)}}$.

$^{b}\%\text{ Fat Retention} = \frac{\%\text{ yield x }\%\text{ fat (cooked)}}{\%\text{ fat (uncooked)}}$.

from the mixture. Three patties were collected at random for color measurements and then frozen for subsequent proximate composition analyses. The remaining thirteen patties were placed on preweighed baking pans with racks and baked in a rotary oven at 177 C for 15 min. Upon removal from the oven, pans were allowed to cool before reweighing to determine total cooking losses and yields of cooked products (23). Percentages of moisture and fat retention of all-beef and extended patties were calculated by the formula of Anderson and Lind (9).

Cooked patties were transferred to pans lined with absorbent paper and drained. Three patties were collected at random for color, specific volume, and tenderness measurements and then frozen for subsequent proximate composition analyses. The remaining ten patties were covered with aluminum foil and kept warm for sensory evaluation. Baking pans were returned to the oven to remelt drippings for aqueous, fat and total volume measurements.

Specific Volume, Color and Texture Measurements

Diameter and thickness of cooked patties were measured with a caliper. The same patties were weighed in order to calculate specific volume (cc/g) and were then used for subsequent color and texture measurements. Color differences (including visual lightness, redness, and yellowness) were measured with a Gardner Color Difference Meter Model C-4 (L; orifice size – 2.5 mm) set against a white standard placed over an optical glass cover plate. Reference values for the standard were L = 93.9, a = -1.3, b = 2.5. Readings were taken of the exterior surfaces of uncooked patties and the browner side (top) of cooked patties.

Texture of individual cooked patties was determined with a Food Technology Corp. Shear Press, Model TP-1, equipped with a standard meat shear compression cell unit. A 300-lb transducer ring, down-stroke speed of 30 sec, and recorder range setting of 20 were used. Peak heights for both compression and shear force were measured and reported as kg force/g; area under texturegram curves was measured with a planimeter and reported as sq cm/g.

Sensory Quality Evaluation

A paired comparison test was used for sensory quality evaluation of cooked patties. Whole patties were arranged on coded white plates so that an all-beef control pattie was scored first as a reference sample, a pattie containing heated oilseed meal was scored second, and a pattie containing unheated oilseed meal was scored last because of the obvious differences in aroma. The plates containing the patties were covered with aluminum foil and kept warm in a conventional oven at 121 C. A ten-member panel evaluated sensory quality attributes (appearance, color, aroma, texture and flavor) of cooked patties using a 9-point scale (9 = excellent, 1 = very poor).

Analytical Procedures

Moisture content of raw and cooked patties was determined by breaking the patties apart, using the tines of two forks to separate the tissue into small pieces, and vacuum drying 5-g samples for 24 hr at 70 C. Fat content was determined by ether extraction of moisture-free samples for 24 hr in a Goldfisch apparatus and is reported on a wet wt basis. Nitrogen content of moisture-containing samples was determined by the Kjeldahl method (24) and converted to protein using conversion factors of 5.46 for peanut, 5.71 for soy, and 6.25 for field pea, pecan, and beef (25). The protein content of the patties was calculated by the following formula, using weighted conversion factors: [(% beef)(6.25) + (% meal)(meal conversion factor)] x % Nitrogen.

Appropriate data were subjected to statistical analysis of variance; significance of mean differences was determined by the Duncan's multiple range test.

RESULTS AND DISCUSSION

Cooked Yields

Data in Table I indicate that the yields of cooked, extended beef patties were slightly higher than the all-beef controls. There were no significant yield differences between heated and unheated meals nor among kinds of meal. The lower moisture content of uncooked extended patties compared to the all-beef controls was expected since no water adjustments were made with the addition of the defatted meals. Under commercial processing conditions, the addition of water would be necessary to facilitate machine handling and pattie formation.

Extending ground beef with the plant protein meals consistently increased the percentage of water retained by patties during cooking. Heated peanut meal had slightly higher water-retention properties than unheated, while heated and unheated soybean, pecan, and field pea meals did not differ substantially in water-retention properties. Field pea meal contained considerably less protein than the other meals but had equally as good binding properties. This suggests that some functional properties usually attributed to proteins may be related to quality rather than quantity or to other seed components such as carbohydrates.

Fat retention percentages were more variable. While

TABLE II

Protein Content of Uncooked and Cooked All-beef and Extended Ground Beef Patties[a]

Pattie formula	% Protein[b]	
	Uncooked	Cooked
Control 1 (all beef)	15.00 de	22.31cd
Peanut - 5% heated	16.79a	23.35a
Peanut - 5% unheated	16.62a	22.65bc
(Test mean)	(16.14a)	(22.77a)
Control 2 (all beef)	15.00 de	21.71ef
Soybean - 5% heated	16.39ab	23.11ab
Soybean - 5% unheated	16.45ab	23.36a
(Test mean)	(15.95a)	(22.72a)
Control 3 (all beef)	14.90de	21.98de
Pecan - 5% heated	15.90bc	22.00de
Pecan - 5% unheated	15.92bc	22.31cd
(Test mean)	(15.57b)	(22.10b)
Control 4 (all beef)	14.86e	22.33cd
Field pea - 5% heated	15.44cd	20.63g
Field pea - 5% unheated	15.04de	21.25f
(Test mean)	(15.11c)	(21.40c)

[a]Values in a column followed by a common letter are not significantly different at P ⩽ 0.01.
[b]Wet basis.

heated and unheated peanut meals, heated soybean meal, and heated field pea meal increased fat retention over the all-beef controls, the reverse was true for unheated soybean, heated and unheated pecan, and unheated field pea meals. Results indicate that these meals had more consistent water-binding than fat-binding capacity and agree with the findings of Anderson and Lind (9). It was noted that the drippings collected for measurement of aqueous and fat portions consisted totally of fat. Moisture was evidently lost by evaporation during cooking. The increase in cooked yields of beef patties by the addition of even this small amount (5%) of meal suggests the further studies are needed to examine the effects of substituting higher levels of these products.

Protein

Data in Table II show that protein levels were highest in peanut and soybean-extended patties, intermediate in pecan meal patties, and lowest in field pea-extended patties. Uncooked patties containing moist-heated and unheated meals did not differ significantly in protein content, though both types of extended patties were higher in protein content than the uncooked all-beef controls. Protein percentages were higher in the cooked than uncooked patties because proportions of water and fat were reduced during cooking. Cooked peanut and soy patties contained higher percentages of protein than their respective all-beef controls, pecan patties were about the same, and field pea patties were lower.

Specific Volume and Texture

Data in Table III indicate that peanut meal patties were smaller in specific volume than patties containing the other meals. There were no significant differences, however, in average specific volume values for soybean, pecan, and field pea patties. Specific volume values were lowest in patties containing no meal (all-beef), intermediate in those with heated meals, and highest in patties containing unheated meals. Both types of extended patties had less cooking loss and shrinkage than the all-beef samples and, hence, had higher specific volume values.

Texture values for compression and shear of cooked patties and the area under texturegram curves are also shown in Table III. Compression values were influenced by meal heat treatment but not by type of meal. Patties extended with either heated or unheated meals required significantly less force to compress than all-beef patties. Values for shear and area under texturegram curves did not differ significantly due to the type of meal or meal heat treatment. The higher water-retention properties of extended beef patties evidently contributed to their increased tenderness as indicated by lower compression values.

Color

Gardner color data (Table IV) revealed that the most significant differences in beef pattie color were reflected in lightness (L - reflectance), redness (a), and total color differences (TCD) values. Variations in yellowness (b) values were not significant.

In the uncooked patties, lightness values were influenced by meal heat treatment but not by type of meal. Patties

TABLE III

Specific Volume and Texture Measurements of Cooked All-beef Extended Ground Beef Patties[a]

Pattie formula	Specific volume	Texture		
		Compression	Shear	Area under curve
	cc/g	kg force/g	kg force/g	sq cm/g
Control 1 (all beef)	1.058	.165	.212	.160
Peanut - 5% heated	1.080	.132	.180	.132
Peanut - 5% unheated	1.073	.107	.189	.126
(Test mean)	(1.070y)	(.135)	(.193)	(.139)
Control 2 (all beef)	1.132	.136	.188	.129
Soybean - 5% heated	1.170	.100	.174	.114
Soybean - 5% unheated	1.212	.108	.180	.148
(Test mean)	(1.171x)	(.114)	(.180)	(.130)
Control 3 (all beef)	1.045	.135	.175	.140
Pecan - 5% heated	1.169	.097	.157	.129
Pecan - 5% unheated	1.218	.120	.175	.143
(Test mean)	(1.144x)	(.117)	(.169)	(.137)
Control 4 (all beef)	1.147	.149	.195	.129
Field pea - 5% heated	1.159	.105	.169	.113
Field pea - 5% unheated	1.200	.105	.168	.138
(Test mean)	(1.169x)	(.119)	(.177)	(.127)
Treatment means				
Controls (all beef)	1.096y	.146a	.192	.139
Beef + heated meals	1.144xy	.108b	.170	.122
Beef + unheated meals	1.176x	.110b	.178	.139

[a]Values in a column followed by a common letter are not significantly different at P ⩽ 0.01 (a,b) or at P ⩽ 0.05 (x,y).

TABLE IV

Variations in Gardner Color Values of Exterior Surfaces of All-beef and Extended Beef Patties[a]

Pattie formula	"L" Values		"a" Values		TCD Values[b]	
	Uncooked	Cooked	Uncooked	Cooked	Uncooked	Cooked
Control 1 (all beef)	37.1d	30.1	17.6ab	8.3xyz	60.2	64.6
Peanut - 5% heated	39.5a	29.7	16.2bc	5.2z	57.5	64.6
Peanut - 5% unheated	38.5abc	28.7	16.3bc	6.3yz	58.4	65.7
(Test mean)	(38.4)	(29.5b)	(16.7a)	(6.6y)	(58.7xy)	(65.0b)
Control 2 (all beef)	37.7cd	31.6	15.2cd	7.8xyz	58.8	63.2
Soybean - 5% heated	39.9a	30.6	16.4bc	7.5xyz	57.3	64.1
Soybean - 5% unheated	39.1ab	30.5	14.4cd	9.8x	57.3	64.5
(Test mean)	(38.9)	(30.9a)	(15.3b)	(8.4x)	(57.8z)	(63.9b)
Control 3 (all beef)	39.2ab	30.4	18.8a	5.9z	58.7	64.1
Pecan - 5% heated	36.8d	26.8	9.5e	5.2z	58.4	67.5
Pecan - 5% unheated	39.1ab	27.4	13.4d	6.1z	57.0	67.0
(Test mean)	(38.4)	(28.2c)	(13.9c)	(5.7y)	(58.0yz)	(66.2a)
Control 4 (all beef)	37.0d	31.0	17.5ab	7.3xyz	60.2	63.6
Field pea - 5% heated	39.7a	31.3	17.4ab	9.2xy	57.7	63.6
Field pea - 5% unheated	38.0bcd	28.5	14.4cd	5.4z	58.4	65.9
(Test mean)	(38.2)	(30.3ab)	(16.4a)	(7.3xy)	(58.8x)	(64.4b)
Treatment means						
Controls (all beef)	37.8b	30.8a	17.3a	7.3	59.5a	63.9b
Beef + heated meals	39.0a	29.6b	14.9b	6.9	57.7b	64.9a
Beef + unheated meals	38.7a	28.8b	14.6b	6.8	57.8b	65.8a

[a]Values in a column followed by a common letter are not significantly different at $P \leq 0.01$ (a through e) or at $P \leq 0.05$ (x through z).
[b]TCD (Total Color Difference) is equal to $\sqrt{\Delta L^2 + \Delta a^2 + \Delta b^2}$ where ΔL, Δa, Δb are the respective differences between standard and sample.

TABLE V

Sensory Quality Scores of Cooked All-beef and Extended Ground Beef Patties[a]

Pattie formula	Sensory quality scores[b]				
	Appearance	Color	Aroma[b]	Texture	Flavor
Control 1 (all beef)	7.2	7.6	7.0x	7.0	7.3a
Peanut - 5% heated	8.2	7.8	6.9x	7.9	7.4a
Peanut - 5% unheated	7.9	7.9	6.2xyz	7.5	4.6cd
Control 2 (all beef)	7.5	7.6	7.0x	7.4	7.5a
Soybean - 5% heated	7.8	7.8	7.4x	7.5	7.4a
Soybean - 5% unheated	7.9	7.8	5.3yz	6.9	4.4cd
Control 3 (all beef)	7.8	7.6	7.6x	7.5	7.7a
Pecan - 5% heated	7.9	7.7	6.7xy	7.4	6.8ab
Pecan - 5% unheated	7.9	7.5	6.5xy	7.3	5.6bc
Control 4 (all beef)	7.7	7.9	7.5x	7.6	7.9a
Field pea - 5% heated	7.6	7.8	7.4x	7.7	8.0a
Field pea - 5% unheated	7.6	7.6	4.9z	7.5	3.6d

[a]Values in a column followed by a common letter are not significantly different at $P \leq 0.01$ (a through d) or at $P \leq 0.05$ (x through z).
[b]Based upon score of 9 = excellent to 1 = very poor.

extended with heated and unheated meals had similar lightness values; both types were generally lighter (higher reflectance values) than the all-beef controls. In the cooked patties, "L" values were influenced by both type of meal and meal heat treatment. Soybean and field pea meal patties were lightest, peanut meal patties were intermediate, and pecan meal patties were darkest. Cooked patties containing moist-heated and unheated meals did not differ significantly in degree of lightness; both types were slightly darker than the all-beef controls.

Redness (a) values of uncooked patties were influenced by both type of meal and meal heat treatment. Uncooked peanut and field pea meal patties had the highest "a" values while pecan meal patties had the lowest. Uncooked patties containing moist-heated and unheated meals did not differ significantly in degree of redness; both types had lower "a" values than the all-beef controls. In the cooked patties, redness values were influenced by type of meal but not by meal heat treatment. Cooked soybean meal patties had the highest redness (a) values; patties containing peanut and pecan meal had similar "a" values and were significantly lower than those containing soybean or field pea meal.

Total color differences (TCD) values of patties in uncooked and cooked forms were influenced by both type of meal and meal heat treatment. In the uncooked form, the greatest color difference (highest TCD value) between the color standard and the sample was noted with the use of field pea and peanut meal while the least change occurred with soybean meal. Uncooked all-beef patties differed more from the color standard than patties containing either heated or unheated meals. In the cooked patties, however, the greatest total color difference occurred with the addition of pecan meal to ground beef. TCD values for patties containing the other three meals were not significantly different. Cooked patties containing either moist heated or unheated meals differed more from the color standard than the all-beef samples; this was a reverse trend from that observed in the uncooked samples.

Visual observations made of the uncooked meat-meal mixtures indicated that the most pronounced color change occurred with the use of pecan meal. These patties were consistently darker and less red than any of the other meat-meal mixtures. The addition of the other seed meals to ground beef produced mixtures which were lighter and less intense in redness than all-beef. These distinct color variations would be important factors to consider in relation to consumer acceptance, particularly if the beef mixtures were marketed in the uncooked state, as in supermarket sales.

Sensory Quality Evaluation

Data in Table V indicate that cooked all-beef and extended beef patties did not differ substantially in appearance, color, or texture qualities. Aroma and flavor scores, on the other hand, were significantly influenced by meal heat treatment. Panelists consistently rated patties containing the moist-heated meals as similar in aroma and flavor characteristics to the all-beef controls; those extended with unheated meals, however, had distinct "beany" or "spice-like" characteristics and received significantly lower aroma and flavor ratings.

Several of the taste panelists described the flavor of patties extended with unheated peanut meal as resembling spiced, seasoned sausage. Others noted that the flavor of patties containing pecan meal was distinctly "nut-like." The most pronounced improvement in meal flavor due to moist heat treatment occurred with field pea meal: patties containing the unheated product were described as "hay-like," "beany," and "strong," while those containing the heated meal were described as "mild" and "tasty."

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