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EFFECTS OF SOY PARTICLE SIZE AND COLOR ON THE SENSORY PROPERTIES OF GROUND BEEF PATTIES

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ABSTRACT

A study was conducted to assess the effect of both size and color of textured soy protein particles on the visual and textural properties of extended (20% replacement) ground beef patties. A trained texture profile panel judged the hardness, cohesiveness, chewiness, moistness, and oiliness of nine different samples. In addition, judgments of the visual attributes of darkness, size of particles, and density of particles were made. Significant effects of soy ingredient were found for all judged attributes. It was concluded that soy ingredients having particle sizes smaller than the diameter of the openings of the grind plate used to process the meat/soy mixture produced the greatest change in the texture of the ground beef patties, because these particles passed through the grind plate unscathed, producing an easily discernable matrix of large meat particles and small soy particles. It was also concluded that carmel-colored soy ingredients produced less lightening of the cooked samples than uncolored soy ingredients.

INTRODUCTION

Several studies have examined the effect of the addition of textured soy protein or other soy ingredients on the flavor and texture properties of ground beef (Huffman and Powell, 1970; Judge, *et al.*, 1974; Kluter, *et al.*, 1974; Williams and Zabik, 1975; Drake, *et al.*, 1975, 1977; Smith *et al.*, 1976; Loh and Breene, 1977; Twigg, *et al.*, 1977; Seideman, *et al.*, 1977;

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Gradze, *et al.*, 1979). However, most of these studies have investigated either the effects of level of extension on sensory properties or the flavor differences between soy flours, concentrates, and isolates. Two important variables that have been less often investigated are the color of the soy ingredient and its particle size.

Soy protein ingredients are available either with added caramel coloring or without coloring. Both Judge, *et al.*, (1974) and Dagerskog and Bengtsson (1974) have shown significant effects of soy protein extenders on the color of ground beef patties, and Harris and Jaynes (1977) have demonstrated significant lightening of the color of cooked, ground beef patties following the addition of soy flour with added caramel color. In addition, soy flours, soy concentrates and more recently, soy isolates, have become available in a variety of textured particle sizes and shapes. No study to date has examined the effect of these particle sizes on the perceived texture of extended ground beef products. In order to assess the effects of these two variables on the visual and textural properties of ground beef patties, the present study was conducted.

MATERIALS AND METHOD

Soy Ingredients and Sample Preparation

Nine different soy ingredients varying in particle size and color were used to extend ground beef patties. Eight were textured flours and one was a granulated concentrate. Ingredients were selected so as to produce an ordered series of particle sizes within a range of sizes recommended by soy manufacturers for use in ground beef products. Included were both colored and uncolored products. The nine soy protein ingredients chosen for testing are listed in Table 1, along with the results of a sieve test used to determine their particle size distributions. The sieve test used 250 g of each sample. Six sieves (12.7 mm, 9.52 mm, 4.76 mm, 238 mm, 1.41 mm, 0.25 mm) were stacked on a bottom pan and shaken for 2.5 minutes on a ROTO-TAP Testing Sieve Shaker (W. S. Tyler, Co., Cleveland, OH).

Figure 1 is a photograph of the raw ingredients showing the differences in size, shape, and color (darkness) of the soy particles. Ingredients are shown in order of increasing particle sizes from left to right.

Each of the nine soy ingredients was rehydrated to 18% protein and mixed by hand with course ground beef (3/4« grind) prepared from trimmed choice chuck to produce a 20% extended product. The beef used in the extended samples was adjusted to 22% fat, so that the fat level of the extended products was 17.6%. The control sample consisted of 100%

Table 1. Soy ingredients and particle size distribution of each, as determined by a sieve test.

					% Soy Product Remaining on Each Sieve						
Manufacturer	Product Number	Style	Coloring	Density g/ml	12.7mm	9.52mm	4.76mm	2.38mm	1.41mm	0.25mm	Bottom Pan
Staley	SFL 2591B	Procon 2060	Uncolored	0.58	0.00	0.02	0.01	0.03	0.38	98.13	0.25
ADM	165–112	Minced 120	Uncolored	0.39	0.00	0.04	0.20	42.40	37.36	19.04	0.76
ADM	165–118	Minced 180	Uncolored	0.39	0.00	0.00	0.41	41.44	36.21	20,86	0.83
ADM	165–224	Minced 240	Colored	0.36	0.00	0.00	1.37	35.47	36.10	25.10	1.74
ADM	165–250	Minced 500	Colored	0.34	0.00	1.43	55.38	30.33	6.52	4.57	1.52
ADM	165–208	Gran. #8	Colored	0.46	0.00	0.00	79.00	20.44	0.24	0.04	0.16
ADM	165–203	Chunk #3	Colored	0.41	0.20	10.48	87.52	0.80	0.16	0.36	0.32
ADM	165–205	Strip #5	Colored	0.38	0.68	41.04	53.68	3.92	0.08	0.20	0.32
ADM	165–210	Chunk #10	Colored	0.39	12.44	61.48	24.32	0.48	0.12	0.56	0.52

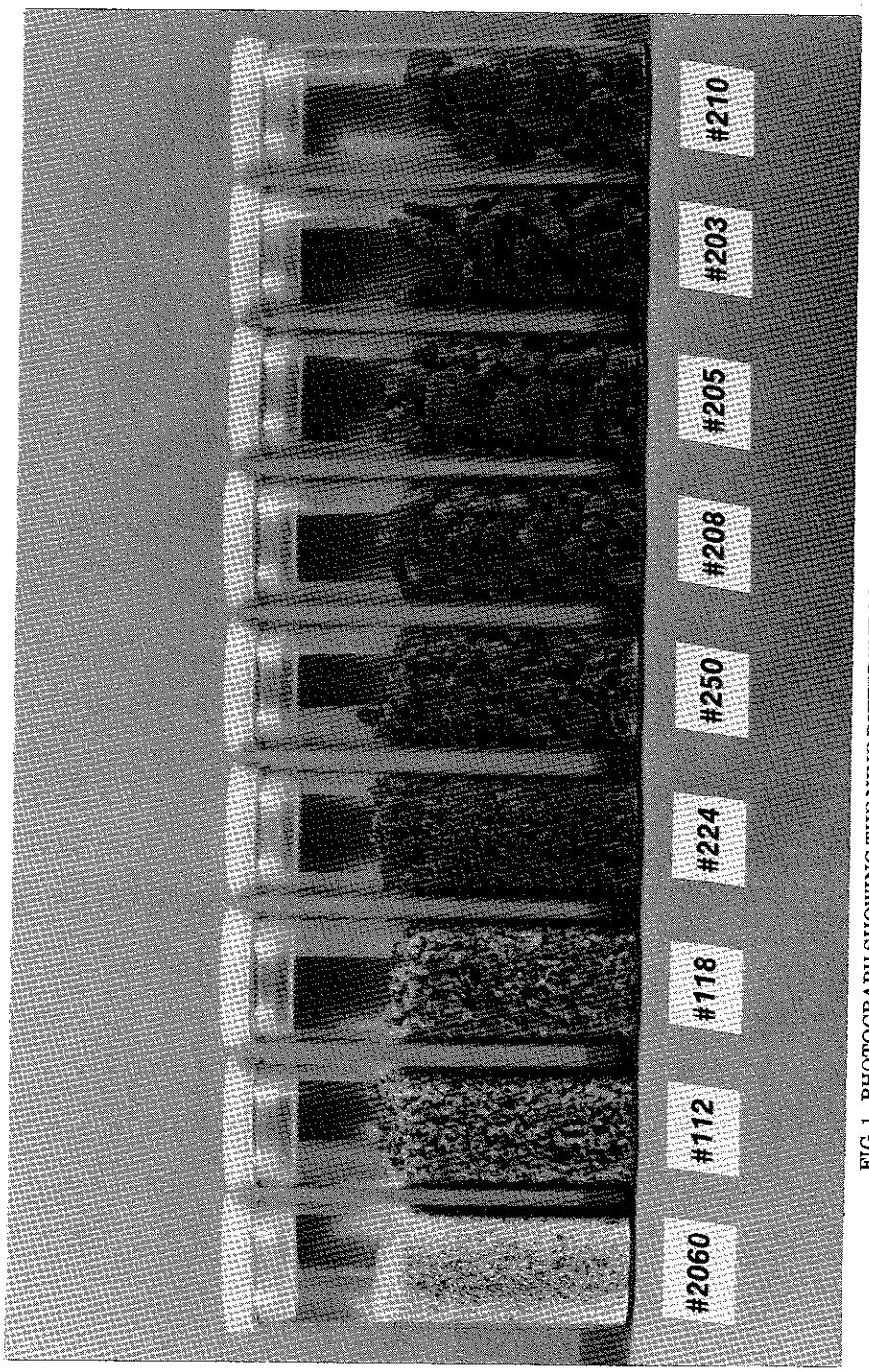

FIG. 1. PHOTOGRAPH SHOWING THE NINE DIFFERENT SOY INGREDIENTS USED IN THIS STUDY

ground beef, adjusted to an 18% fat level. The ground beef or ground beef/soy mixture was then passed through a ⅛" grind plate, and 3 oz patties were prepared using a Hollymatic Press (Model 50).

At the time of testing, all samples were cooked on a Faberware Grill (Model 55N) to an internal temperature of 160° F, turning once at an internal temperature of 150° F.

Sensory Panel and Methods

The sensory panel used to evaluate the products was a trained texture profile panel. The panel had been trained previously in the General Foods Texture Profile Method, and all members had previous experience in judging the textural attributes of ground beef, whole-muscle beef, and flaked and formed beef products. The panel for these tests consisted of six members.

Since the panel had previous experience in evaluating ground beef patties, the textural attributes used for evaluation were derived from previous work. In addition, three visual attributes were included for assessment. The complete set of attributes and their definitions appear in Table 2.

Table 2. Sensory texture profile attributes applied to soy-extended beef patties.

Visual	
Darkness:	The perceived darkness of the cooked surface.
Size of Particles:	The perceived size of individual particles on the cut surface.
Denseness:	The perceived degree of compactness of the particles on the cut surface.
First Bite	
Hardness:	The perceived force required to compress the sample between the molar teeth.
Cohesiveness:	The perceived degree to which the sample holds together upon biting.
Mastication	
Chewiness:	The total perceived effort required to reduce the sample to a consistency ready for swallowing when chewed at a constant rate.
Moistness:	The perceived amount of water and/or oil in the sample.
Cohesiveness of the Mass: (after 10 chews)	The perceived degree to which the sample holds together as a single mass during mastication.
Residuals	
Oily Mouthcoating:	The perceived degree of oil left on the teeth, tongue, and/or palate after swallowing.

After four training sessions, during which panelists became familiarized with the range of samples to be encountered, testing began. All panel judgments were made using a 7-pt labeled category scale of intensity, where 1 = slight and 7 = extreme. A "zero" category was also included. Samples were presented in random series of three samples per session, with a total of four replicates of each sample being made during 12 consecutive sessions.

RESULTS

Mean ratings for each sample and attribute were calculated and are shown in Table 3. The results of analyses of variance on these data showed significant effects of ingredients on all judged attributes ($p < .05$). The results of Neuman-Kuels contrasts tests performed on the differences among means are also shown. Mean values without the same superscript are significantly different at the .05 probability level.

Table 3. Mean panel ratings on each attribute for each of the test samples. Superscripts represent the results of Neuman-Kuels contrast tests. Samples with common superscripts are not significantly different ($p < .05$).

Darkness		Size of Particles		Density of Particles	
Control	4.68^{a}	118	4.59^{a}	2060	4.75^{a}
203	4.10^{b}	210	4.40^{ab}	208	4.43^{ab}
205	3.75^{bc}	112	4.38^{ab}	205	4.05^{ab}
208	3.71^{bc}	250	4.10^{ab}	224	4.00^{ab}
250	3.70^{bc}	205	4.00^{abc}	Control	4.00^{ab}
210	3.65^{bc}	203	3.90^{abc}	203	3.95^{ab}
224	3.55^{bc}	224	3.55^{bc}	250	3.80^{ab}
118	2.96^{cd}	Control	3.54^{bc}	112	3.71^{b}
112	2.96^{cd}	208	3.33^{c}	210	3.70^{b}
2060	2.55^{d}	2060	2.35^{d}	118	2.58^{c}

Hardness		Cohesiveness		Chewiness	
Control	4.36^{a}	Control	4.61^{a}	Control	4.86^{a}
210	3.70^{b}	210	3.80^{b}	210	4.70^{ab}
224	3.40^{b}	2060	3.60^{b}	203	4.35^{abc}
205	3.40^{bc}	203	3.45^{b}	205	3.95^{bcd}
112	3.38^{bc}	205	3.40^{b}	250	3.90^{bcd}
2060	3.30^{bc}	224	3.30^{bc}	112	3.83^{cd}
203	3.10^{bc}	112	3.17^{bc}	208	3.71^{cd}
208	3.00^{bc}	208	3.14^{bc}	118	3.67^{cd}
250	2.95^{bc}	250	3.05^{bc}	224	3.55^{cd}
118	2.58^{c}	118	2.42^{c}	2060	3.25^{d}

Table 3. (Continued)

Moistness		Cohesiveness of the Mass		Oiliness	
Control	5.07[a]	Control	4.75[a]	Control	3.71[a]
205	4.05[b]	250	3.50[b]	118	2.00[b]
203	3.95[b]	205	3.45[b]	2060	1.95[b]
2060	3.85[b]	112	3.38[b]	112	1.75[b]
210	3.85[b]	210	3.15[bc]	224	1.50[b]
118	3.83[b]	118	3.13[bc]	203	1.45[b]
224	3.65[b]	208	2.95[bc]	210	1.45[b]
208	3.62[b]	203	2.90[bc]	208	1.38[b]
250	2.60[b]	224	2.85[bc]	205	1.35[b]
112	3.42[b]	2060	2.25[c]	250	1.30[b]

In order to easily compare the differences among the various samples, the data were plotted as in Figures 2-4. The various extended samples are shown at the bottom of the figures. They are listed in order of increasing particle size from left to right. (Note that samples #112, #118, and #224 had almost identical particle sizes. Samples #112 and #118 were plotted left-most, so that the uncolored samples would be adjacent to one another.) The ordinates are measures of the relative

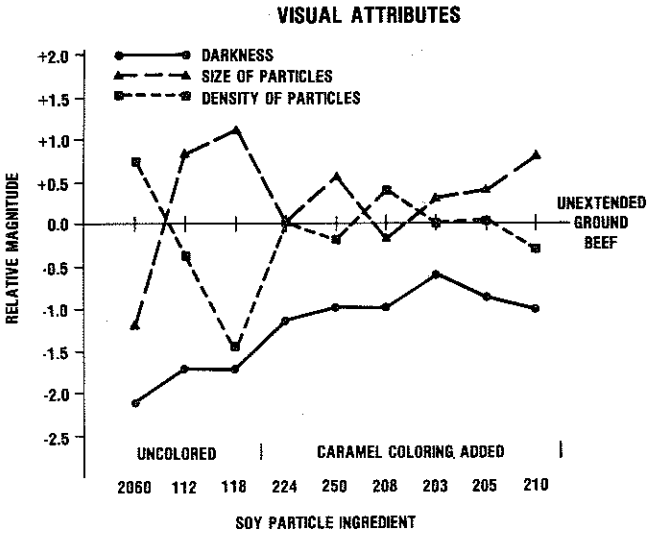

FIG. 2. A PLOT OF THE RELATIVE MAGNITUDES OF EACH OF THE JUDGED VISUAL ATTRIBUTES FOR THE NINE TEST SAMPLES
The mean ratings for each test sample have been plotted relative to the mean ratings for the control sample

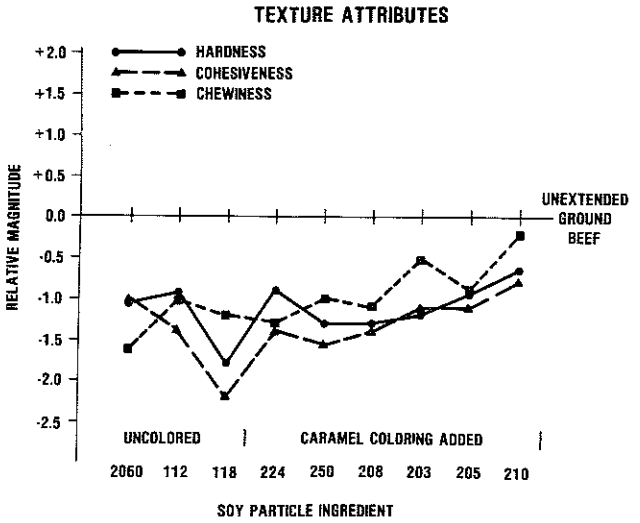

FIG. 3. A PLOT OF THE RELATIVE MAGNITUDES OF THE JUDGED ATTRIBUTES OF "HARDNESS," "COHESIVENESS," AND "CHEWINESS" FOR THE NINE TEST SAMPLES
The mean ratings for each test sample have been plotted relative to the mean rating for the control sample

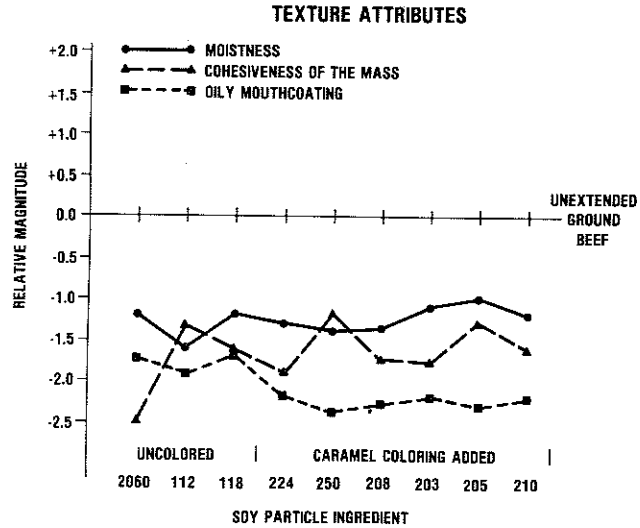

FIG. 4. A PLOT OF THE RELATIVE MAGNITUDES OF THE JUDGED ATTRIBUTES OF "MOISTNESS," "COHESIVENESS OF THE MASS," AND "OILY MOUTHCOATING" FOR THE NINE TEST SAMPLES
The mean ratings for each test sample have been plotted relative to the mean rating for the control sample

magnitude of the extended samples to the unextended, 100% ground beef control. Ratings for the latter appear as the horizontal line passing through zero on the ordinate. The relative magnitude measure for each sample and for each attribute was calculated by subtracting the mean attribute rating obtained for the unextended ground beef sample from the mean attribute rating obtained for the test sample. Therefore, scores greater than 0 (zero) indicate that the sample possessed more of that attribute than the control, scores less than 0 (zero) indicate that it had less of the attribute, and scores of 0 (zero) indicate that the sample was identical to the control on that attribute.

Figure 2 is a plot of the data for the three visual attributes. All nine extended samples were significantly ($p < .05$, Table 3) lighter (less dark) than the unextended sample, and the three uncolored soy ingredients (#2060, #112 and #118) produced lighter samples than did the colored soy ingredients. In addition, the granulated concentrate (#2060) and the two soy flours with the smallest particle sizes (#112 and #118) produced larger mean differences from the control on perceived size and density of particles than did the other test samples (with the possible exception of sample #210).

Figure 3 is a plot of the data for the attributes of hardness (firmness), cohesiveness, and chewiness. With increasing particle size, increases in all three attributes occurred. Maximum similarity to the unextended sample occurred at the larger particle sizes.

Figure 4 is a plot of the data for the attributes of moistness, cohesiveness of the mass (during chewing), and oily mouthcoating. There are no observable differences among the extended samples on moistness, although all of the extended samples are significantly less moist than the control (Table 3). The cohesiveness of the mass for the sample extended with soy concentrate (#2060) is less similar to that of the control than are any of the flours, while the perceived oiliness of the extended samples appears to decrease with increasing particle size.

Since nine different attributes of the products were evaluated, it is not surprising that some samples are more similar to the control on some attributes, but less like the control on others. In order to index the overall degree of difference of each extended sample from the control, the average absolute deviation of the mean ratings of each test sample from the mean rating for the control were calculated across all attributes. The resulting average absolute deviations appear in Table 4. As can be seen, samples #203 (textured flour, chunk #3, colored) and #205 (textured flour, strip #5, colored) produced the smallest deviation from the unextended samples. The granular soy concentrate (#2060) and the uncolored textured flours (#118 and #112) produced the largest deviations from the unextended sample.

Table 4. Average absolute deviations across all attributes of the mean panel ratings for the extended samples from the mean panel ratings for the control.

Extended Sample No.	Average Absolute Deviation from Control
118	1.55
2060	1.47
112	1.25
208	1.24
250	1.22
224	1.14
210	1.13
205	.98
203	.98

DISCUSSION

It is clear from these data that both the color and particle size of soy protein ingredients affect the visual and textural appearance of extended ground beef patties. The significantly lighter color of all of the cooked, extended patties, as compared to the cooked control, supports the previous findings of Seideman, et al. (1977). Moreover, the fact that all three uncolored samples produced significantly lower mean ratings on darkness than the caramel-colored samples, suggests that the addition of caramel color to soy ingredients is beneficial in reducing the color disparity between cooked, extended patties and cooked, whole beef patties. Moreover, these data suggest that a higher level of colorant may be more beneficial, since the patties extended with colored soy ingredients still differed significantly from the control.

The data on visual "size of particles" and "density of particles" (Figure 2) are of interest. Looking first at perceived size of particles, there is a great disparity between samples #2060, #112, and #118 and the control sample. Sample #2060 has smaller perceived particles than the control, while samples #112 and #118 have larger perceived particles. Yet, sample #224 and all samples with larger particles sizes do not differ greatly from the control. Similarly, sample #2060 has a greater mean perceived density of particles than the control, samples #112 and #118 have lesser mean perceived density than the control, and sample #224 and all other samples differ only slightly from the control. This diminished disparity from the control for sample #224 is curious, since sample #224 is not observably different in particle size distribution from samples #112 and #118 (Table 1). The best interpretation of these data is that the color difference between sample #224 and both samples #112 and #118 is responsible for the difference in ratings on these attributes. That is, the samples made with soy ingredient #224, which had caramel

coloring added, were darker and less distinguishable from the unextended control than were samples made with soy ingredients #112 and #118, which were not colored, light in appearance, and the soy particles of which could be easily distinguished and judged in terms of their size and/or density within the meat/soy matrix. Such an explanation also accounts for the absences of disparity from the control that were observed for all of the colored samples on these two visual dimensions.

The data on the hardness, cohesiveness, and chewiness of the samples (Figure 3) reveals that all of the extended samples are more "tender" than whole beef patties, supporting previous work by Huffman and Powell (1970); Cross, et al., (1975); Twigg, et al., (1977); Loh and Breene (1977); and Drake, et al., (1977). Also it seems clear that, as particle size increases, gradual increases occur in all three attributes. While, upon first analysis, this latter effect might be attributed to the increases in the size of the soy particles present in the samples, as reflected in Table 1, this explanation is not entirely valid. The reason for this is that a 1/8« (3.175 mm) grind plate was used to process all the samples in this test. Since the sieve size representing the largest soy particles in samples #2060, #112, #118, and #224 was 2.38 mm, and the next larger sieve size was 4.76 mm, the size of the grind plate fell between the particle size represented by sample #224 and the next larger soy ingredient. Therefore, it would be expected that the larger particle sizes in the samples prepared with soy ingredients #250 through #210 would not differ greatly, if at all. Faced with this fact, it would appear that the increase in hardness, cohesiveness, and chewiness seen in Figure 3, must either be due to the distribution of particle sizes that are equal to or smaller than the 1/8« grind plate openings or to differences in the shape of the soy particles after passing through the grind plate. The latter possibility derives from the fact that "granulated," "minced," "chunked," and "strip" particle geometries were all used in these tests. However, the fact that hardness, cohesiveness, and chewiness all increase systematically with measured ingredient particle size (whether particle size is indexed using the whole range of particle sizes in Table 1 or only those equal to and smaller than the grind plate opening) argues strongly that the effects are related to particle size differences within the meat/soy matrix.

Although significantly lower ratings were found for all the extended products than for the control on the attributes of moistness, cohesiveness of the mass, and oily mouthcoating (Figure 4), no systematic differences among ingredient particle sizes are observable for these attributes.

CONCLUSIONS

It can be concluded from the above data that samples with larger particle sizes, such as #203 (textured flour, chunk #3, colored) and #205 (textured flour, strip #5, colored) produce the least change in the visual and textural properties of ground beef when added at a 20 percent extension level (rehydrated). The greatest change in ground beef characteristics is produced by extension with the smallest particle sizes, as represented by the granular soy concentrate and the two uncolored textured soy flours.

Concerning these effects, it should be pointed out that the concentrate vs flour distinction is not relevant, as both may be obtained in a variety of textured particle sizes. Moreover, one important factor determining appropriate particle size may be the size of the grind plate, and that particle sizes that are small enough to pass unscathed through the grind plate may produce a matrix composed of both small soy particles and large beef particles that produces a texture that is distinct from unextended ground beef, as contrasted with particle sizes that are large enough to be ground by the plate into a size that is uniform with the size of the beef particles. In addition, caramel coloring of the soy ingredient will mask visual differences apparent between extended products made with uncolored soy ingredients and unextended control products.

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