THE EFFECTS OF COLORED TEXTURED SOYBEAN PROTEIN (TSP) ON SENSORY AND PHYSICAL ATTRIBUTES OF GROUND BEEF PATTIES

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ABSTRACT

*Defatted soybean flour mixed with a combination of 0.03% Red No. 40 and 0.01% annatto (*Bixa orellana*) colorants was extruded into textured soy protein (TSP) in a counter-rotating twin extruder to produce a red-meat like product suitable for hamburger patties. Ground beef patties were processed replacing the meat (15 and 30%) with resulting hydrated textured soybean protein (TSP) prepared with and without the colorants. The resulting cooked patties were evaluated by eight trained judges for tenderness, juiciness, number of chews, beef flavor and overall flavor quality using a nine point nonstructured horizontal scale. Other patty characteristics examined included cooking losses (weight loss and diameter reduction) and color, by tristimulus colorimetric measurement. The results from sensory analysis revealed that ground beef patties with high TSP level were more tender than control, and they had less beef flavor and overall flavor quality. Weight loss was not significantly ($P > 0.05$) affected by TSP level but the patties with 30% TSP showed less shrinkage than the others. Results of the study suggested that while patties with 15% TSP had sensory attributes similar to the control, adding 30% TSP with coloring significantly ($P < 0.05$) increased the redness of the patties.*

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INTRODUCTION

In underdeveloped countries, processed meat products are usually prohibitory too expensive and unaffordable for the general population. Processed meat products are high in fat, cholesterol and saturated fatty acids; dietary nutrients linked to higher incidence of cardiovascular disease and arteriosclerosis (Riaz 1999; Liu *et al.* 1991). Textured soybean proteins (TSP) have traditionally been used as meat analogs or extenders. The incorporation of high concentrations of TSP into meat systems usually negatively affects flavor, color and texture but presents advantages from the cost-benefit and nutritional viewpoint. Ground beef patties are extensively used in modern cookery due to their low price, when compared to whole muscle meat, and also for their convenience. That is the reason why they are considered as one of the most popular meat products and a multi-billion dollar commodity in the United States (Troutt *et al.* 1992).

TSP and other soy ingredients have been used in ground beef products to improve their functional properties and aid in reducing fat and cholesterol content, providing consumers with healthier products (Riaz 1999; Brewer *et al.* 1992; Liu *et al.* 1991). Besides, there are potential cost saving in the production of ground beef, which could help in bridging the high price barrier of animal products (Saleh and Ahmed 1998). The use of TSP as a meat extender increased markedly in 1971 when the Food and Nutrition Services of USDA approved inclusion of such products at levels as high as 30% in School Lunch Programs (Smith *et al.* 1976).

The palatability of ground beef patties is directly related to the amount of meat and consequently to their fat content. If any change or replacement in the formulation has to be done to improve either the nutritional or functional characteristics and even to reduce cost, it is essential to carry out a sensory study.

There are several criteria of quality in ground beef patties, and the appearance (especially the color of the raw and final products) is one of the major concerns in the addition of soy products (Smith *et al.* 1976). Color is a very important attribute which has to be considered during the product evaluation. It is probably the most important aspect of appearance because of its established association with other quality attributes. The color of food itself may influence acceptance (MacDougall 1987), and may be an incentive to buy a product. The effects of soy protein extenders on the color of ground beef patties has been demonstrated, and Cardello *et al.* (1983) has shown greatest lightening of the color of cooked ground beef patties following the addition of granular soy concentrate and two uncolored textured soy flours.

It has been highly demanded from the Brazilian meat industry a colored TSP, suitable to be added to ground beef patties. The Brazilian food producer

believes it is possible to deliver to the consumer a better product by improving the color of the patties. The restrictions on synthetic colors have encouraged the use of naturally derived colors as alternatives or as addition to increase color intensity. The use of erythrosine (Red No. 3) has been banned in some countries around the world due to its toxicological effects (potential mutagenic and carcinogenic). In contrast, Red No. 40 or Allura is considered as GRAS and is currently substituted for Red No. 3 in many food systems. Annatto (*Bixa orellana*), is the seed of a tropical shrub native to Central and South America. It is produced in large quantities in Brazil where it is generally sold in retail outlets. Around 7000 tons of annatto seed are used annually as a food color worldwide (Hendry and Houghton 1996). Annato do not require certification and is permanently listed as safe. Most of its color is imparted by chloroform soluble carotenoid pigments bixin and norbixin.

The increased public awareness of food colors has also contributed to produce a stronger demand to substitute natural colors, such as annatto for synthetics (Lancaster and Lawrence 1995). Annatto is a popular natural color and its use in ground beef patty formulations has become a very attractive proposition. Besides enjoyment and convenience, consumers think the naturalness of a product is the top priority when judging food (Anon. 1995).

There has been some research on ground beef patties to examine the addition of other soy products such as soy flours, concentrates and isolates (Bernal *et al.* 1988; McMindes 1991) and even other ingredients such as carrageen and oat meal (Desmond *et al.* 1998; Egbert *et al.* 1991; Giese 1992; Pszczola 1991; Taki 1991) on the quality of the products. Some studies showed the effects of soy protein extenders on the color of ground beef patties (Judge *et al.* 1974; Smith *et al.* 1976). Cardello *et al.* (1983) pointed out the importance of investigating the visual properties of ground beef patties.

This work is aimed at assessing the effects of the introduction of textured soy protein with and without coloring (annatto and Red No. 40) on the sensory and physical attributes of ground beef patties.

MATERIAL AND METHODS

Textured Soybean Protein Preparation

Commercial defatted soybean (Prosam, Samrig S.A. Moinhos Rio Grandenses, Esteio, Rio Grande do Sul, Brasil) was conditioned to 26% moisture in a mixer (Werner & Pleiderer do Brasil DK 65 N) for 12 min and textured in a twin extruder (Brabender DSE 45, Duisburg, Germany) equipped with 65 cm long counter rotating screws (13:1 length to diameter ratio) operating at 200 rpm, a barrel with smooth internal walls divided into four zones electrically heated to 90, 100, 150 and 170C. The conditioned material was

gravimetrically fed with a vertical feeder at the rate of 430 g/min. The extruder's feeding conical chamber equipped with a paddle mixer was regulated to operate at 68 rpm. The material exited the barrel through a pair of 5 mm diameter round dies each located right in the center of the two barrel's sections. The expanded TSP was cut into 3.5 cm long chunks with a pair of rotating knives operating at 40 rpm. The TSP exiting the extruder with about 13-14% moisture was immediately placed on perforated trays and dried at 55C for 3 h in a commercial drier. The dried TSP was allowed to equilibrate to room temperature before packaging in polyethylene bags. A reddish colored TSP suitable for hamburger patties was produced similarly by adding a combination of 0.03% Red No. 40 and 0.01% of annatto to the defatted soybean flour prior to conditioning and extrusion.

Ground Beef Patties Formulations and Sample Preparation

Five formulations of ground beef patties varying in their TSP levels (with and without coloring) were used. All the formulations were identical, just varying the amount of meat replaced by hydrated TSP. The TSP chunks were soaked in excess cold water for at least 3 hr in a refrigerator adjusted to have an internal temperature of 10C. After draining excess water, the moisture content of the hydrated TSP was approximately 61%. The formulations tested were: 0% TSP (control), 15% TSP with and without coloring and 30% TSP with and without coloring. The control contained 70% bovine chuck, 15% pork belly, 13% water, and 2% starch. Formulations 1 and 3 contained 55% bovine chuck and 15% hydrated TSP, with and without colorants, respectively. Formulations 2 and 4 had 40% of bovine chuck and 30% of hydrated TSP, with and without colorants, respectively. The other ingredients used in the patties formulations were kept identical to the control. Salt and condiments were kept the same for all five formulations. The ingredients were those typically used in commercial practice. The formulations were prepared at the SENAI (National Service of Industry Support, Vassouras - Brazil) and stored at -15C until one day before the analysis, when they were withdrawn from the freezer and placed in the refrigerator.

At the time of testing, patties were cooked individually on a preheated 25 cm diameter pan. All patties were cooked for 2.5 min on each side to an internal temperature of 80 $\pm$ 1C. This cooking duration was selected as it provided cooked patties generally without a visual pink color that were not overcooked (Berry and Abraham 1996). After cooking, they were immediately covered with aluminum foil and stored at 60 $\pm$ 2C until the arrival of the assessors. The samples were cut into squares of 2 $\times$ 2 cm and presented to the trained panel. Each portion was one bite and allowed testing for texture and flavor attributes. Panelists swallowed the samples.

Sensory Evaluation

Eight assessors were selected for their abilities to discriminate both salty taste and different soy texture protein levels in ground beef patties, following Cross *et al.* (1978). The panel was trained at the EMBRAPA Food Technology, and all members had previous experience in judging texture and flavor attributes. Similarly as described by Luchsinger *et al.* (1997) each panelist has more than 100 h of training in flavor and texture analysis, over 2000 h of sensory testing experience, and extensive experience in testing food products. After six training sessions, during which panelists became familiar with the range of samples, testing began.

The attributes used for evaluation were based on previous work (Cross *et al.* 1980). In addition, number of chews, and overall flavor quality were included for evaluation. The training sessions followed the procedures outlined by the American Society of Testing and Materials (Chambers and Wolf 1996) in relation to tenderness, juiciness, and beef flavor. Ground beef patties prepared by varying the amount of TSP (with higher and lower levels of TSP than those described in this study) were used in the training of the attribute *Overall flavor quality*. One or two attributes were performed per training session. The references were presented to panelists together with the scale, and each assessor was asked to rate the perceived intensity of the attribute on the scale. After six training sessions, during which panelists became familiar with the range of samples, attributes and their intensities, testing began. Such attributes and their definitions appear in Table 1.

TABLE 1.
THE SENSORY ATTRIBUTES STUDIED IN SOY EXTENDED BEEF PATTIES

Attribute	Description
Tenderness	Degree of force required to break through the sample between the molar teeth, evaluated after five chews.
Juiciness	The amount of liquid released from sample during first and second chew.
Number of chews	Number of chews required to reduce the sample to a consistency ready to swallowing when chewed at a constant rate.
Beef flavor	A measure of how much a sample is recognized as distinctly meat rather than another type of protein product.
Overall flavor quality	The complete flavor sensation perceived during chewing.

Adapted from Cross *et al.* (1980).

All sensory tests to evaluate texture and flavor attributes were conducted in individual sensory booths at EMBRAPA Food Technology, using red light to mask appearance, and avoid the possible interference of the color of the products on the judges evaluation, which could affect judges performance. The effect of the colorant on the patties was evaluated using a colorimeter as described below. Tenderness, juiciness and beef flavor were evaluated using a nine-point unstructured horizontal scale with word anchors located ½ cm from each end, corresponding to 1 and 9 (where 1 = extremely tough, dry and weak; 9 = extremely tender, juicy and intense). Overall flavor quality scaled ranged from 1 = very poor to 9 = very good. The subject's task was to make a vertical line across the horizontal line at the point that best reflected the intensity of that attribute (for that product). The cooked samples were coded with three digit numbers, presented to assessors one at a time (monadically) and the order of sample presentation followed a balanced design. Water at room temperature was provided to rinse the mouth between samples.

Samples were presented in a complete block design (3 samples in the morning and the other two, which belong to the same block, in the afternoon), with 3 replications.

Cooking Shrinkage and Instrumental Color Evaluation

Shrinkage tests were conducted by determining the difference in diameter between the raw and the cooked ground beef when the latter reached the equilibrium to room temperature. It was measured with a ruler. Percentage cooking loss was determined by the difference in weight before and after cooking as follows:

$$\% \text{ Cooking loss} = \frac{\text{raw frozen weight} - \text{cooked weight}}{\text{raw frozen weight}} \times 100$$

The instrumental color evaluation was made by reflex, utilizing the SUGA Colorimeter (SH-4-CH Model) giving the following parameters: L_{Hunter} (lightness), a_{Hunter} (redness) and b_{Hunter} (yellowness when positive and blueness when negative). The red reference plate showed the following values: L_{hunter} = 34.58; a_{Hunter} = 56.49 and b_{Hunter} = 21.38. For each sample six readings were performed.

Statistical Analysis

Sensory, diameter reduction, cooking loss, and color evaluation data were analyzed using Analysis of Variance and Tukey Test ($P < 0.05$) to compare

means. The panelist effect was included in the model for sensory evaluation characteristics.

RESULTS AND DISCUSSION

Sensory Evaluation

The results of the analysis of variance on the data showed significant effects of the TSP on several sensory attributes ($P < 0.05$). Table 2 presents the mean ratings for each sample and attribute.

TABLE 2.
SENSORY ATTRIBUTES AND COOKING PROPERTIES OF THE GROUND BEEF PATTY SAMPLES

Attributes	Samples				
	Control (no TSP)	15% TSP no coloring	15% TSP + coloring	30% TSP no coloring	30% TSP + coloring
• **Sensory attributes**					
Tenderness	5.8[b]	7.8[a]	6.6[ab]	7.3[a]	7.6[a]
Juiciness	6.3[a]	6.1[a]	6.3[a]	6.2[a]	6.3[a]
Number of chews	29.0[a]	27.0[a]	27.0[a]	26.0[a]	28.0[a]
Beef flavor	6.9[a]	5.9[abc]	6.7[ab]	5.5[bc]	5.2[c]
Overall flavor quality	6.5[a]	6.4[a]	6.7[a]	6.0[ab]	5.3[b]
• **Cooking properties**					
Diameter reduction (%)	29.6[a]	29.6[a]	27.7[a]	22.0[b]	22.6[b]
Cooking loss (%)	30.4[a]	34.2[b]	31.1[ab]	31.1[ab]	27.5[a]

Different letters in the same row denote a statistically significant difference ($P < 0.05$). Sensory scales varied from 1 to 9, and each value represented the mean of three replications per panelist. Cooking properties are the mean of six replications.

The data on tenderness of samples revealed that the patties were positively affected by TSP addition, i.e., the samples which TSP were considered more tender than the sample without TSP (control), by the panel. These findings support previous work by Cardello *et al.* (1983) and Cross *et al.* (1975). Liu *et*

al. (1991) reported that the addition of soy protein gave a more tender ground beef patty, however the juiciness of the products decreased with the addition of TSP.

Sensory panelists ratings revealed that the addition of TSP had no effect on juiciness of the samples. This is a very positive result as TSP did not damage the juiciness of the patties. Similar results were obtained by Cross *et al.* (1975) with levels of TSP varying from 0 to 20%. However, in a study with consumers, Drake *et al.* (1977) reported that patties containing 30% TSP were rated significantly higher in acceptability of juiciness than those with 10% or no added TSP (control). Other researchers have found addition of textured soy protein either increased or had no effect on juiciness of ground beef patties (Liu *et al.* 1991; Smith *et al.* 1976).

Beef flavor intensity decreased as the amount of TSP increased in the patty formulations, although TSP addition up to 15% showed no difference ($P > 0.05$) compared to control. The 30% level of TSP (with and without coloring) gave the lowest beef flavor sensory mean scores.

The number of chews was not affected by the addition of TSP. It may imply that the addition of TSP would not affect the rubberiness of the patties. This result is also positive since it has been reported in the literature (Beilken *et al.* 1991) that consumers preferred samples with either coarse, chewy structures which were juicy or which broke up easily over those which were rubbery, i.e., held together or were well bound. This was a valuable result achieved by the products described in this study.

The overall flavor quality decreased significantly ($P < 0.05$) for the patty with 30% TSP, compared to the control and the samples with 15% TSP added.

Cooking Shrinkage

The diameter reductions between the raw and cooked patties indicated that the TSP significantly ($P < 0.05$) reduced shrinkage in both 30% TSP with and without coloring. At the 15% level of TSP, no difference ($P > 0.05$) was found compared to the control (Table 2).

Cooking losses were similar among samples (Table 2). The similarities may indicate that the various formulations underwent the same general cooking process. Besides, no difference ($P > 0.05$) was found in terms of the juiciness of the patties. Berry (1992) working on low fat ground beef patties showed similar cooking yield by using 15 patties/determination. Berry and Abraham (1996) working on commercially processed ground beef patties, showed cooking losses higher than those identified in this study.

Judge *et al.* (1974) working with soy protein concentrate (SPC) reported that by using a high level of SPC in the ground beef patty formulation, the shrinkage (cooking loss) was reduced to 15.2%, compared to 22.1% of the control.

Instrumental Color Evaluation

Differences were found among ground beef patties samples for Hunter color "L" (lightness) values. Raw patties with 15% TSP (with and without coloring) were slightly ($P<0.05$) lighter than the control, and the product with 30% TSP with no coloring was slightly lighter ($P<0.05$) than its 15% counterpart.

Hunter color "a" values varied among the samples. The data obtained from the instrumental color evaluation showed that the addition of 30% TSP with coloring increased the redness of the samples (a_{Hunter}), when compared to control. No difference ($P > 0.05$) was found between the control and the sample with 15% of TSP with coloring (Table 3).

TABLE 3.
MEAN VALUES FOR THE COLOR ATTRIBUTES OF SAMPLES

	Raw			Cooked		
Sample	L	a	b	L	a	b
Control	47.3^{c}	4.2^{b}	-28.5^{a}	23.8^{c}	5.8^{b}	-4.8^{b}
15% TSP no coloring	48.2^{b}	3.0^{c}	-27.9^{a}	26.9^{b}	4.7^{c}	-5.2^{b}
15% TSP + coloring	48.0^{b}	3.7^{b}	-29.4^{a}	25.9^{b}	6.2^{b}	-5.6^{b}
30% TSP no coloring	50.0^{a}	2.6^{c}	-28.3^{a}	30.2^{a}	5.1^{c}	-6.6^{a}
30% TSP + coloring	48.2^{b}	5.9^{a}	-27.3^{a}	29.1^{a}	7.5^{a}	-5.3^{b}

L = lightness, a = redness, -b = blueness.
Different letters in the same column denote a statistically significant difference ($P < 0.05$).

The instrumental color evaluation of the patties revealed that the products with uncolored TSP (either 15 or 30% of TSP) were less red than the control, i.e., the TSP in the formulation paled the products. Similar results were found in cooked ground beef patties.

The redness of the raw and cooked products increased with the addition of coloring TSP, when compared to control, only at the 30% level. The addition of 15% TSP with coloring did not change significantly ($P > 0.05$) the redness of the patty, comparatively to control, for both raw and cooked products. By using beef plus 20% rehydrated soy flour, Brewer *et al.* (1992) found no difference in terms of redness between that sample and control (100% beef).

The cooking had no impact on the coloring performance, since similar effects were noticed in the raw and cooked samples.

It can be concluded from the above data that the addition of TSP in the ground beef patties changed some sensory properties, mainly for those prepared with colored TSP. The annatto in ground beef formulations is a natural suitable color additive which can rectify the light color of soy protein, one of the major problems in its use as an extender. The use of annatto and Red No. 40 together with TSP may be beneficial ingredients in improving the appearance of the patties. The use of those ingredients is an attractive idea for the ground beef patty industries, because it can save cost without compromising the sensory product quality. By having an adequate appearance, it could favor product consumption by consumers, making available nutritious products which would contribute to the quality of the diet. The consumer would benefit with this product since she/he would have available a product with the nutritional advantages of soybean (i.e. less fat, saturated fat and cholesterol, and more protein).

The ground beef patties had an adequate performance when analyzed by the trained panel. As a consequence, the product with 15% colored TSP merits a step ahead, which would be to carry out further studies focusing on consumer perception of the product. The relationship between the sensory and the consumer panel is important when attempting to develop new products or to assess the effect of changes in product formulation.

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