SENSORY CHARACTERISTICS OF BEEF AND PORK PROCESSED MEATS CONTAINING NONSOLVENT EXTRACTED TEXTURIZED SOY PROTEIN

G. RENTFROW[1,2], M.S. BREWER[3], K.E. WEINGARTNER[3] and F.K. MCKEITH[1,4]

[1]*Department of Animal Sciences*
University of Illinois Urbana, IL, 61801
[2]*Department of Animal Science*
University of Missouri
Columbia, MO, 65211
[3]*Department of Food Science and Human Nutrition*
University of Illinois
Urbana, IL, 61801

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ABSTRACT

The objective of this study was to characterize the sensory properties of four common meat products (ground beef, fresh pork sausage, smoked sausage, and frankfurters) all manufactured with nonsolvent extracted textured soy protein (NSTSP) used as a lean meat replacement. High levels (45%) NSTSP added to ground beef and fresh pork sausage resulted in products which were more mushy with much more off-flavor than control samples, whereas juiciness was unaffected. Addition of 30% or 45% NSTSP increased ($P < 0.05$*) the juiciness of smoked sausage, while NSTSP at any level decreased the juiciness of frankfurters. Fifteen percent NSTSP affected (*$P > 0.05$*) neither texture and mouth feel nor off-flavor of smoked sausage. Up to 30% NSTSP had no effect on either texture or mouth feel nor on off-flavor of frankfurters. Addition of NSTSP increased off-flavor of all products except frankfurters. Practical levels of lean replacement appear to be less than 30% for these meat products.*

INTRODUCTION

In the 1970's, the use of soy proteins became popular when the United States Department of Agriculture (USDA) approved its use in Class A

[4] Send all correspondence to: F.K. McKeith, University of Illinois, Department of Animal Science, 205 Meat Science Laboratory, 1503 Maryland Drive. Urbana, IL, 61801. TEL: (217)-333-1684; FAX: (217)-333-3585; EMAIL: mckeith@uiuc.edu

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school lunch programs (Foster *et al.* 1978). More recently on October 26, 1999, the Food and Drug Administration (FDA) authorized the use health claim labels on products containing soy protein. These labels indicate that foods containing soy protein included in a diet low in saturated fat and cholesterol may reduce the risk of coronary heart disease by lowering blood cholesterol levels (Food and Drug Administration 1999). The approval of this statement has renewed interest in soy products and products that contain soy protein.

The bulk of soy proteins utilized today are derived from dehulled, solvent-extracted intermediates known as defatted or "white" flakes (Lusas and Riaz 1995). The soy flakes are made by a process of: cleaning, heating, cracking the seed, dehulling by aspiration, and removing the oil with hexane. This is the starting material for most commercial soy products (Lusas and Riaz 1995; Garcia *et al.* 1998). However, technology has been developed for the manufacture of textured soy protein products beginning with the whole soybean and eliminating the use of solvents, thus eliminating the dependence on more expensive defatted soy flour or soy protein concentrates.

The use of soy protein as an extender/lean meat replacement has been practiced for decades in the United States with varying degrees of success. Williams and Zabik (1975) reported that juiciness of ground beef and ground pork decreased, compared to controls, when textured soy protein (TSP) was added. Soy protein in meat products may result in "cereal like" off-flavors (Williams and Zabik 1975). Brewer *et al.* (1992) reported that addition of soy extenders decreased beefy flavor and increased off-flavor scores of ground beef patties. However, Vasquez *et al.* (1979) found no juiciness difference when 30% TSP was added to ground beef.

Soy proteins have been added to processed meats as binders and emulsifiers. Goltry *et al.* (1976) found that TSP decreased juiciness of sausage when added at higher (30%) levels. Substitution of soy protein for lean meat in emulsified meat products depends on the level of substitution, and on the fat and water contents of the batter (Sofos *et al.* 1977; Sofos and Allen 1977). Sofos *et al.* (1977) replaced up to 50% of the lean in emulsified sausage batters with TSP and reported that above 15% TSP, texture of the finished product was crumbly. Matulis *et al.* (1995) reported that in lower fat frankfurters, soy protein increased off-flavor and decreased juiciness, saltiness and flavor intensity when added above 3%.

The objective of this study was to characterize the sensory properties of nonsolvent extracted textured soy protein used as a lean meat replacement in four common meat products: ground beef, fresh pork sausage, smoked sausage, and frankfurters.

MATERIALS AND METHODS

The effects of nonsolvent extracted textured soy protein (NSTSP) were evaluated in four meat products; ground beef, fresh pork sausage, smoked sausage, and frankfurters. Nonsolvent extracted textured soy protein was donated by Insta-Pro International (Des Moines, Iowa). The ground beef and fresh pork sausage were made from same batch of beef and pork trimmings, while the smoked sausage and frankfurters were made from two separate batches of beef and pork trimmings. The NSTSP was hydrated in the same manner for each product, as directed by the manufacture. The NSTSP was 4.5% moisture, 48% protein, and 7% fat. NSTSP was hydrated with tap water (908 g NSTSP: 454 g water; water was at room temperature) for approximately 30 min prior to use, according to manufacturers instructions.

Moisture and Fat Determination of Beef and Pork Trimmings

Lean and fat trimmings derived from meat processed in the University of Illinois Meat Science Laboratory and were ground in a Hobart mixer/grinder (Hobart; Troy, OH) separately, through a 2.5 cm plate (Kasco; St. Louis, MO). Six random samples were collected from each batch of trimmings and homogenized (Robot Coupe Food Processor; Ridgeland, MS). Proximate analysis (fat and moisture) was determined on each sample using a modified procedure described by Novakofski *et al.* (1989). Moisture content was determined by placing a 5 g sample in a drying oven (Fisher-Scientific; Pittsburgh, PA) at 110C for 24 h. Dried samples were extracted with an azeotropic mixture of warm chloroform and methanol (4 : 1) to determine the fat content in each sample. The average fat content of each batch of trimmings (lean and fat) were used to formulate the final product. This procedure was followed for fat and moisture determination in all trimmings and all meat products.

Product Formulation

Since the NSTSP contained fat, the percentage of fat was adjusted for each replacement level to keep the fat content constant (20% ± 1% fat). Formulations for the meat products were calculated utilizing the Pearson Square procedure.

Manufacture of Ground Beef and Fresh Pork Sausage

Ground beef and fresh pork sausage were formulated to contain 20% ± 1% fat. Lean was replaced at 0%, 15%, 30%, and 45% with NSTSP. Following fat and moisture determination, coarsely ground (2.5 cm) lean and fat beef or

pork trimmings were re-ground through a 5-mm plate (Kasco, St. Louis, MO). NSTSP and/or fresh pork sausage seasonings (RTU Super G-4, Griffiths Laboratory, Alsip, Ill.) were added and hand mixed thoroughly. After hand mixing, a sample (~25 g) was removed from each product batch and proximate analysis was performed to confirm that each batch contained approximately 20% ± 1% fat. Both ground beef and pork sausage were stuffed into chubs (454 g, E-Z Pak™ Poly bags; Koch Supplies INC; Kansas City, MO). The chubs were frozen (−20C) until further evaluation could be performed (~1 to 2 weeks). Each product was formulated in duplicate 4.5 kg batches for each NSTSP level.

Cooking of Ground Beef and Fresh Pork Sausage

Prior to sensory evaluation, ground beef and fresh pork sausage were thawed at 4C for 24 h then cut into 1.25 cm thick slices. Slices were cooked in a convection oven (South Bend Ovens) at 177C to a final internal temperature of approximately 70C. The internal temperature was monitored using copper-constantin thermocouple wires (Type T, Omega Engineering, Stamford, CT) with a Barnant scanning thermocouple thermometer (Model 692-2800; Barnant Co., Barrington, IL).

Manufacture of Smoked Sausage

The smoked sausage was formulated to contain approximately 20% ± 1% fat and made from lean beef trimmings and fat pork trimmings. The NSTSP was used to replace lean at 0%, 15%, 30%, and 45%. Coarsely (2.5 cm) ground beef and pork was reground through a 5-mm plate (Kasco, St. Louis, MO) and mixed in a bowl chopper (Talsa, Jersey City, NJ) for approximately 1.5 min. During that time the smoked sausage seasonings were added. The mixture was removed from the bowl chopper and NSTSP was hand mixed and the mixture was hand stuffed into natural casings. Sausages were hung on a smoke rack, and smoked. Following smoking/cooking the smoked sausage was vacuum packaged and stored at 4C until sensory panel evaluation could be performed (~1 week). Each NSTSP replacement was performed in duplicate in 4.5 kg batches.

Manufacture of Frankfurters

The frankfurters were formulated to contain 0%, 15%, and 30% NSTSP as a lean replacement and formulated to contain 20% ± 1% fat. The 45% lean replacement treatment was omitted from the study due to previous poor results with ground beef, fresh pork sausage, and smoked sausage where that level resulted in significant off-flavor scores. The lean beef and fat pork

coarsely ground trimmings (2.5 cm) were chopped in a bowl chopper (Talsa, Jersey City, NJ) for approximately 3.5 min. During chopping, NSTSP, salt (to produce 1.75% NaCl in the batter), Griffith's Prague Powder (to produce 156 ppm sodium nitrite in the batter; Griffith's Laboratories, Alsip, Ill), sodium erythorbate (to produce 550 ppm in the batter) and spice mix (Griffith's Wiener Seasoning #011-8424, Griffith's Laboratories, Alsip, Ill) were added to the batter. The same hydration protocol was used for this type of NSTSP as for the NSTSP used for ground beef, fresh pork, and smoked sausage. The mixture was then reground through a Bench Mince Master emulsifier (model GL 86, Griffith Design and Equipment Co., Chicago, Ill). The frankfurter batter was stuffed into cellulose casings (Viscase, Chicago, Ill) using a vacuum stuffer (Handtmann VF80, Albert Handtmann Maschinefabrik, Biberah/Riss 1, Germany) and smoked using the following schedule: 20 min, dry bulb (DB) = 54.4C, smoke off; 20 min, DB = 65.8C, wet bulb (WB) = 57.2C smoke on; to an internal temperature of 68C, DB = 76.8C, WB = 71.1C, smoke on. After smoking, the frankfurters were soaked in lukewarm water and the cellulose casings were removed. The frankfurters were vacuum packaged and stored at 4C until sensory panel evaluation could be performed (~1 week). Each level of NSTSP replacement was performed in duplicate in 4.5 kg batches.

Cooking of Smoked Sausage and Frankfurters

Smoked sausage and frankfurters were prepared by steeping. The water (~1 L) was brought to boil, at that time the smoked sausage and frankfurters (two, 15.24 cm pieces from each treatment and each sausage product) were added, the pan was covered, and removed from the heat source. Due to the larger diameter of the smoked sausage, the smoked sausage was allowed to steep for approximately 15 min and the frankfurters were allowed to steep for 10 min.

Sensory Evaluation

A six-member trained sensory panel (AMSA 1995) consisting of University of Illinois students and staff evaluated juiciness, texture and mouth feel, and off-flavor intensity on a 15 cm unstructured line scale where 0 = extremely dry, soft and mushy, or intense off-flavor, 15 = extremely juicy, hard and chewy, or no off-flavor. Ground beef and fresh pork sausage patties were quartered; the smoked sausage and frankfurters were cut perpendicular to the long axis into 2.54 cm pieces. Each product was served warm on paper plates coded with 3-digit random numbers. Panelists received distilled water to cleanse the palate between samples. Panelists were seated in individual booths and evaluated samples individually under red lights.

Statistical Analysis

Data were subjected to Analysis of Variance using the General Linear Model procedure (SAS 2001). Means with a difference of $P < 0.05$ were considered to be significantly different.

RESULTS AND DISCUSSION

Sensory Characteristics of Ground Beef and Fresh Pork Sausage

Sensory results for ground beef and fresh pork sausage are presented in Table 1. No significant differences ($P > 0.05$) in juiciness were detected among formulations of ground beef or fresh pork sausage. These findings are similar to those of Vasquez *et al.* (1979) who found no differences in juiciness between controls and ground beef containing 30% TSP. Goltry *et al.* (1976) found that 10% textured soy protein replacement and control sausage were more juicy that those with 20% and 30% TSP replacement. However, Williams and Zabik (1975) reported that juiciness scores decreased with the addition of 30% textured soy protein to ground beef and ground pork when compared to controls. Differing results among studies may be due to the levels of fat included in the various formulations and to the type of protein used.

Control ground beef samples (0% NSTSP) received the highest ($P < 0.05$) scores for texture and mouth feel. Addition of 45% NSTSP significantly reduced texture and mouth feel scores indicating they were more

TABLE 1.
SENSORY CHARACTERISTICS OF GROUND BEEF AND FRESH PORK SAUSAGE WITH ADDED NONSOLVENT EXTRACTED SOY PROTEIN

	Nonsolvent Extracted Soy Protein Content				
	0%	15%	30%	45%	SEM
Ground beef Juiciness[1]	7.85	7.59	7.47	7.61	0.39
Texture and Mouth Feel	8.75[a]	7.50[b]	6.78[b]	4.97[c]	0.38
Off-flavor Intensity	13.07[a]	8.20[b]	7.44[b]	3.97[c]	0.59
Fresh sausage					
Juiciness	8.48	7.80	7.78	7.74	0.49
Texture and Mouth Feel	7.96[a]	7.53[a]	6.23[b]	5.99[b]	0.53
Off-flavor Intensity	14.80[a]	13.16[b]	9.32[c]	5.69[d]	0.00[e]

[1] Line scale: 0 = Extremely dry, soft and mushy, or intense off-flavor; 15 = Extremely juicy, hard and chewy, or no off-flavor.

[a,b,c,d] Means with different superscripts in a row are significantly different ($P < 0.05$).

[e] SEM < 0.005.

soft and mushy. Vasquez *et al.* (1979) found that beef patties with 30% TSP had higher sensory panel scores for texture (tender, grainy, and elastic) than patties without TSP. In the present study, control (0% NSTSP) and fresh pork sausage containing 15% NSTSP received the highest texture and mouth feel scores, while the 30% and 45% NSTSP replacement levels resulted in lower scores. Cross *et al.* (1975), and Kotula (1976) found that increasing the amount of TSP caused sensory panel tenderness scores to increase. However, Drake *et al.* (1975) reported no differences in texture scores between various soy protein levels and controls. Smith *et al.* (1976) found that texture scores were acceptable at levels less than 40% TSP replacement.

Off-flavor scores increased ($P < 0.05$) as the level of NSTSP increased in both ground beef and fresh pork sausage. Little off-flavor could be detected in control (0% NSTSP) ground beef or fresh pork sausage, however the ground beef and fresh pork sausage containing 45% NSTSP resulted in significant ($P < 0.05$) amounts of off-flavor. These findings are similar to those of Seideman *et al.* (1977) and Williams and Zabik (1975) who found that the addition of 20% and 30% TSP caused ground beef patties to be significantly higher ($P < 0.05$) off-flavor scores than all-beef patties. Seideman *et al.* (1979) also reported that flavor desirability scores decreased as TSP levels increased. This is consistent with reports by Drake *et al.* (1975) and Bowers and Engler (1975). Miller *et al.* (1987) also found that beef and pork blends containing TSP had lower flavor and overall desirability scores than the controls. Brewer *et al.* (1992) reported that addition of soy extenders decreased beefy flavor and increased off-flavor scores of ground beef patties. Goltry *et al.* (1976) found that pork sausage containing 0% or 10% TSP had a more desirable flavor compared to those containing 20% and 30%. However, the authors showed no difference among treatment in general acceptability (Goltry *et al.* 1976).

Sensory Characteristics of Smoked Sausage and Frankfurters

The sensory characteristics of smoked sausage and frankfurters are shown in Table 2. The addition of 30% or 45% NSTSP in smoked sausage significantly increased ($P < 0.05$) juiciness scores with 45% NSTSP replacement receiving the highest numerical scores. The opposite effect was observed in frankfurters with the addition of 15% and 30% NSTSP reduced ($P < 0.05$) juiciness scores equally with the controls being the juiciest. These results are similar to those of Matulis *et al.* (1995) who reported that as soy protein content in frankfurters increased, and juiciness scores decreased. These authors suggested that the soy protein binds more free water, resulting in reduced moisture release in the initial bite. In the present study, the particle

TABLE 2.
SENSORY CHARACTERISTICS OF SMOKED SAUSAGE AND FRANKFURTERS WITH ADDED NONSOLVENT EXTRACTED SOY PROTEIN

	Nonsolvent Extracted Soy Protein Content				
	0%	15%	30%	45%	SEM
Smoked sausage Juiciness[1]	8.91[a]	8.83[a]	9.70[b]	10.63[b]	0.39
Texture and Mouth Feel	8.90[a]	7.58[a]	6.06[b]	4.25[c]	0.38
Off-flavor Intensity	14.88[a]	14.38[a]	12.47[b]	7.35[c]	0.59
Frankfurters					
Juiciness	10.03[a]	8.33[b]	8.26[b]	–[d]	0.49
Texture and Mouth Feel	6.93	6.42	6.22	–	0.53
Off-flavor Intensity	15.00	15.00	15.00	–	0.00[e]

[1] Line scale: 0 = Extremely dry, soft and mushy, or intense off-flavor; 15 = Extremely juicy, hard and chewy, or no off-flavor.
[a,b,c] Means with different superscripts in a row are significantly different ($P < 0.05$).
[d] 45% replacement not done.
[e] SEM < 0.005.

size of the NSTSP used in smoked sausage was larger than that used in frankfurters. This difference could have contributed to the increase in juiciness scores for smoked sausage.

In smoked sausage, the control (0% NSTSP) and 15% NSTSP produced the highest ($P < 0.05$) sensory panel scores for texture and mouth feel, whereas the 45% NSTSP level produced the lowest scores (soft and mushy; $P < 0.05$). No significant differences ($P > 0.05$) existed in texture and mouth feel among the various NSTSP levels in frankfurters. Sensory scores for frankfurters were toward the middle of the scale, indicating the texture and mouth feel were in the desirable range for this product. Again, this could be due to the smaller particle size of the NSTSP and better emulsification of fat with/by NSTSP in this frankfurter product. Sofas *et al.* (1977) found that an increase in TSP level used to replace lean meat caused Instron hardness to decrease (softer) in wiener-type products. These authors noted that the addition of 40% and 50% TSP lowered texture scores (softer). Matulis *et al.* (1995) reported the opposite effect, hardness increased as soy protein concentration increased in frankfurters. Differing results among various studies could be due to differing fat levels and TSP particle size.

Smoked sausage containing 45% NSTSP had the highest ($P < 0.05$) off-flavor intensity. The least off-flavor occurred in controls (0% NSTSP) and those containing 15% NSTSP. In frankfurters, no off-flavor could be detected in any NSTSP level. In contrast, Matulis *et al.* (1995) reported that soy protein increased off-flavor and decreased juiciness, saltiness, and flavor intensity in reduced fat frankfurters.

IMPLICATIONS

The results of this study suggest that nonsolvent extracted textured soy protein (NSTSP) can be used to replace lean at levels up to 30%, with limited effects on texture and mouth feel, and juiciness in ground beef and fresh pork sausage. However, in smoked sausage, juiciness increased as NSTSP level increased, while practical levels for texture and mouth feel appear to be less than 15% NSTSP. The opposite effect was observed in frankfurters. Juiciness decreased, and texture and mouth feel were not affected by the addition of NSTSP. Off-flavor intensity was affected by the addition of NSTSP to all products except for frankfurters. Practical levels of lean replacement appear to be less than 30% for these meat products.

REFERENCES

AMSA. 1995. Guidelines for cookery and sensory evaluation of meat. American Meat Science Association, Chicago, IL.

BOWERS, J.A. and ENGLER, P.P. 1975. Freshly cooked and cooked, frozen reheated beef and beef-soy patties. J. Food Sci. *40*, 624–625.

BREWER, M.S., MCKEITH, F.K. and BRITT, K. 1992. Fat, soy and carrageenan effects on sensory and physical characteristics of ground beef patties. J. Food Sci. *57*, 1051–1055.

CROSS, H.R. and STANFIELD, M.S. 1975. Effect of fat and textured soy protein content on consumer acceptance of ground beef. J. Food Sci. *40*, 1331–1334.

DRAKE, S.R., HINNERGARDT, L.C., KLUTER, R.A. and PRELL, P.A. 1975. Beef patties: The effect of textured soy protein and fat levels on quality and acceptability. J. Food Sci. *40*, 1065–1068.

Food and Drug Administration 1999. FDA approves new health claim for soy protein and coronary heart disease. Accessed: June 30, 2003. http://www.cfsan.fda.gov/~lrd/tpsoypr2.html

FOSTER, J.F., GUTHERTZ, L.S., HUNDERFUND, R.C. and FOWLER, J.L. 1978. Comparison of bacterial species isolated from ground beef, textured soy protein, and ground beef extended with textured soy protein. J. Food Prot. *41*, 961–964.

GARCIA, M.C., MARINA, M.L., LABORDA, F. and TORRE, M. 1998. Chemical characterization of commercial soybean products. Food Chem. *62*, 325–331.

GOLTRY, S.J., STRINGER, W.C. and BALDWIN, R.E. 1976. Sensory evaluation of pork sausage containing textured vegetable protein. J. Food Sci. *41*, 973–974.

KOTULA, A.W., TWIGG, G.G. and YOUNG, E.P. 1976. Beef patties containing soy protein during 12-month frozen storage. J. Food Sci. *41*, 1142–1145.

LUSAS, E.W. and RIAZ, M.N. 1995. Soy protein products: Processing and use. J. Nutr. *125*, 573S–580S.

MATULIS, R.J., MCKEITH, F.K., SUTHERLAND, J.W. and BREWER, M.S. 1995. Sensory characteristics of frankfurters as affected by salt, fat, soy protein, and carrageenan. J. Food Sci. *60*, 48–54.

MILLER, M.F., DAVIS, G.W., WILLIAMS JR., A.C., RAMSEY, C.B. and GALYEAN, R.D. 1987. Acceptability of beef patties extended with pork and/or textured soy protein. J. Food Quality *10*, 117–129.

NOVAKOFSKI, J., PARK, S., BECHTEL, P.J. and MCKEITH, F.K. 1989. Composition of cooked pork chops: Effects of removing subcutaneous fat before cooking. J. Food Sci. *54*, 15–17.

SAS. 2001. SAS User's Guide: Statistics Version 6 Ed., SAS Inst., Cary, NC.

SEIDEMAN, S.C., SMITH, G.C. and CARPENTER, Z.L. 1977. Addition of textured soy protein and mechanically deboned beef to ground beef formulations. J. Food Sci. *42*, 197–201.

SEIDEMAN, S.C., SMITH, G.C., CARPENDER, Z.L. and DILL, C.W. 1979. Plasma protein isolate and textured soy protein in ground beef formulations. J. Food Sci. *44*, 1032–1036.

SMITH, G.C., MARSHAL, W.H., CARPENTER, Z.L., BRANSON, R.E. and MEINKE, W.W. 1976. Textured soy proteins for use in blended ground beef patties. J. Food Sci. *41*, 1148–1151.

SOFOS, J.N. and ALLEN, C.E. 1977. Effects of lean meat source and levels of fat and protein on the properties of wiener-type products. J. Food Sci. *42*, 875–878.

SOFOS, J.N., NODA, I. and ALLEN, C.E. 1977. Effects of soy proteins and their incorporation on the properties of wiener-type products. J. Food Sci. *42*, 879–884.

VASQUEZ, M., SANCHEZ, F., HICHE, E. and YANEZ, E. 1979. Sensory evaluation of textured sunflower/soy protein. J. Food Sci. *44*, 1717–1720.

WILLIAMS, C.W. and ZABIK, M.E. 1975. Quality characteristics of soy-substituted ground beef, pork, and turkey meat loaves. J. Food Sci. *40*, 502–505.