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FORMULATION AND COMPARATIVE EVALUATION OF SOY PROTEINS IN MEAT FOOD PRODUCTS

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SUMMARY

Formulation and evaluation of eight commercial textured soy proteins in three institutional meat food products are reported. The meat products are: Fresh frozen, deep fat fried, and char-broiled patties. The textured soy proteins evaluated and trade names thereof are: Griffith Laboratories (GSVP), Archer Daniels Midland (ADM-120 and 240), Far-Mar-Co (Ultrasoy), Swift & Co. (Texgran), Ralston Purina Co. (Eddi-Pro), Miles Laboratories (Maxten), Cargil, Inc. (18-BF), and H. B. Taylor (Textrasoy).

The objectives are: (1) To evaluate the performance of different soy proteins with respect to textural properties as measured by Instron analysis. (2) To compare ingredient formulations by type of product and region of the U.S. and (3) To provide basic data for marketing direction and development of Griffith Laboratories soy protein programs.

Differences in textural measurements are more closely related to the amount of skeletal meat in the formulation and the use of soy protein concentrates in combination with textured soy protein, than to textured soy protein alone. Fresh frozenpatties ranged 66.0 - 72.0 per cent skeletal meat with Instron readings from 5.84 to 7.86 (lbs./gram force).

Deep fat fried patties ranged from 37.9 per cent skeletal meat to 61.7 per cent with Instron textural readings from 2.65 to 10.74. Char-broiled patties had 55 per cent skeletal meat and ranged in textural measurements from 7.63 to 12.16. There was no textural difference within char-broiled patties between GSVP and Eddi-Pro (isolate). However, both had more texture

than the Textrasoy (compacted flour). General textural differences in relationship to soy protein are more discernable at higher meat levels in formulations (60 - 70 per cent) than in lower meat levels (37 - 50 per cent). Textural differences are closely related to the proportion of skeletal meat and the combination (types) of soy proteins used in formulations.

INTRODUCTION

The growth and development of institutional meat food products (as measured by dollar sales) is accelerating at a faster rate (16 to 23 per cent per year) than traditional sausage type products (6 to 10 per cent per year). Strong demand for these institutional meat food products is created by a highly mobile society where an estimated one out of three meals is eaten away from home (school, industrial cafeterias, airlines, hotels, etc.). At the same time, world economic conditions have forced the manufacturer of meat food products to look for alternative ingredients that will compliment his products. The alternative ingredient must (1) reduce manufacturing raw material cost, (2) maintain nutritional product qualities and (3) provide functionality in the meat food product. Various types of soy protein products fulfill this alternative.

Soy products are made in many shapes and sizes (bits, chunks, diced, crumbles). They have different colors and many different trade names. They are classified according to U.S. Department of Agriculture regulations and defined on the basis of minimum protein content as follows:

1. Soy Flour -- 50% protein, minimum, dry basis. The defatted soy bean flake which has not been further processed (ie. -- grits, flour)

2. Soy Protein Concentrate -- 70% protein, minimum, dry basis. (Granular or powder.)

3. Soy Isolates -- 90% protein, minimum, dry basis. (Powder or fiber.)

4. Textured Vegetable Proteins -- 50% protein, minimum, dry basis. These products are fabricated by heat extrusion or fiber spinning.

The Griffith Laboratories Inc. is involved in the manufacture and sale of the soy protein concentrates and textured vegetable proteins. The objectives of the research reported herein are: (1) To evaluate the performance of different textured vegetable proteins in institutional meat food products, (2) To evaluate other ingredients in product formulations, and (3) To provide basic data for the marketing direction and development of Griffith Laboratories' proteins.

EXPERIMENTAL

The basic design consisted of eight commercial soy proteins and three types of meat food formulations (fresh frozen, deep fat fried and char-broiled patties). Experiments were conducted in six commercial meat processing plants, under U.S. Department of Agriculture Inspection, located in four different regions of the U.S. From an average in-plant batch size of 340 lbs., a 15 lb. composite sample at the beginning, middle and end of the batch was frozen and delivered to the laboratory for analysis.

Moisture, fat and salt were analyzed on five patties from each experiment according to A.O.A.C. methods. Objective textural evaluations, using the Instron were also run on five patties from each experiment. The patties were heated in a convection oven at 325°F to an internal temperature of 155°F. Samples 1 x 1½" were taken from each patty and placed on the Instron (Model 1132, Instron Corporation, Canton, Maine, U.S.A.) before temperature dropped below 100°F. Machine settings for the Instron were: (a) D-Cell, (b) Range = 100 lbs./sq.in., and (c) Ram Speed = 5"/min.

RESULTS AND CONCLUSIONS

Institutional portion controlled meat food products are non-specified

products. They currently have no standard of identity as other U.S. meat products (frankfurters, etc.). As a result, the institutional products vary widely in ingredient formulation and lend themselves to complete experimentation as meat food systems rather than as meat, per se.

Results of these experiments are presented according to type of meat product and U.S. Region (plant and location). Accompanying tables on formulation contain chemical and textural measurements. The final tables (7 & 8) summarize all experiments: meat, soy proteins and residual ingredients, and present statistical evidence for differences related to type of soy protein used.

TABLE I

-FRESH FROZEN BEEF PATTIES-
FORMULATION BY U.S. REGION, AND TYPE SOY PROTEIN

NORTHEAST		SOUTHWEST	
GSVP	ADM-120	GSVP	ULTRASOY
72.0%	Beef (60/40) Frozen	33.0%	Beef (50/50) Frozen
9.1%	Textured Soy Protein[a]	26.4%	Beef Cheeks, Frozen
18.4%	Ice Water	6.6%	Cow Beef 85/25, Frozen
0.5%	Salt, Seasoning, etc.	3.3%	Textured Soy Protein[a]
100.0%		6.6%	Soy Flour
		23.1%	Ice Water
		1.0%	Salt, Seasoning, etc.
		100.0%	

[a]Each region represents a separate plant in which the textured soy proteins were tested at level shown.

Tables 1 and 2 present data on fresh frozen patties from the Northeast and Southwest regions. Maintaining a good fresh red color in this type of product has always been a problem. Therefore, the Southwest formula used beef cheeks to give additional color. The soy proteins compared were Griffith Structured Vegetable Protein (GSVP), Archer Daniels Midland

(ADM-120) and Far-Mar-Co (Ultrasoy).

TABLE 2

-FRESH FROZEN BEEF PATTIES-
CHEMICAL[a] AND TEXTURAL MEASUREMENTS
BY U.S. REGION AND TYPE SOY PROTEIN

NORTHEAST		SOUTHWEST				
	Instron[b]		M	F	S	Instron
GSVP	7.86	GSVP	59.3	17.2	1.2	7.61
ADM-120	5.84	ULTRASOY	56.2	25.1	0.6	6.27

[a]M = Moisture, F = Fat, S = Salt. Five patties each were analyzed by A.O.A.C. methods.

[b]Five patties each were grilled and subjected to the Instron for objective textural evaluation (pounds/gram force). The larger the number, the firmer the texture.

Mean textural measurements are presented in Table 2. Patties containing GSVP are firmer than those patties containing the alternative proteins in both regions. Although these differences in means are supported by analysis of variance (Table 7), it is possible that most of the observed differences in this specific case are associated more with differences in fat content and amount of skeletal meat than type of soy protein.

TABLE 3

-BATTER AND BREADED DEEP FAT FRIED BEEF PATTIES-
FORMULATION BY U.S. REGION AND TYPE SOY PROTEIN

SOUTHWEST GSVP, ULTRASOY, ADM-240	WEST GSVP, ULTRASOY, BONTRE	NORTHWEST GSVP, TEXGRAN
38.8% Beef Trim (50/50) Frozen	7.6% Cow Meat *80/20) Fresh	24.7% Beef (60/40) Frozen
16.2% Beef Hearts,Decap Frozen	30.3% Beef, 50/50 Frozen	37.0% Beef (70/30) Frozen
9.7% Partially Defatted Beef Fatty Tissue	12.6% Textured Soy Protein	6.2% Textured Soy Protein
6.4% Textured Soy Protein[a]	1.5% Soy Protein Concentrate Emulsifyer	3.1% Soy Protein Concentrate Granular (GL-219)
1.8% Soy Protein Concentrate Emulsifyer(GL-301)	3.5% Cereal Binder	3.1% Soy Protein Concentrate Emulsifyer(GL-301)
3.2% Soy Flour	43.0% Ice/Water	
22.6% Ice/Water	1.5% Salt,Seasoning,etc.	24.7% Ice/Water
1.3% Salt,Seasoning,etc.	100.0%	1.2% Salt,Seasoning,etc.
100.0%		100.0%

[a]Each region represents a separate plant in which the textured soy proteins were tested at level shown.

Table 3 shows the formulations for battered and breaded, deep fat fried product. These products are more highly extended than the fresh frozen product because fresh meat color is no problem. In the Southwest formulation, beef hearts and partially defatted beef fatty tissue are used for economical reasons. There is little binding property in these meats because the major protein source is collagen. In the West formula, there is only 37.9 per cent skeletal meat. Here advantage is taken of the soy protein concentrate emulsifyer (GL-301) in combination with the textured soy protein. The textured soy provides bite and mouth feel, whereas the soy concentrate emulsifyer provides bind. In the Northwest formulation, more skeletal meat was used in combination with textured soy protein and soy protein concentrate.

TABLE 4

-BATTER AND BREADED DEEP FAT FRIED BEEF PATTIES-
CHEMICAL[a] AND TEXTURAL MEASUREMENTS BY U.S. REGION AND TYPE SOY PROTEIN

	SOUTHWEST					WEST					NORTHWEST			
	M	F	S	Instron[b]		M	F	S	Instron		M	F	S	Instron
GSVP	50.1	17.1	1.0	4.13	GSVP	45.1	23.7	1.6	2.71	TEXGRAN	51.9	22.9	1.9	9.55
ULTRASOY	49.8	17.5	1.1	3.70	ULTRASOY	52.0	22.2	1.7	2.87	GSVP	48.9	22.2	2.1	10.74
ADM-240	48.9	18.3	1.1	4.64	BONTRE	44.3	25.3	1.6	2.65					

[a] M = Moisture, F = Fat, S = Salt. Five patties each were analyzed by A.O.A.C. methods.

[b] Five patties each were deep fat fried, at 375°F for 60 to 80 seconds, cooled to 100°F, evaluated on Instron for textural properties (pounds/gram force).

Formulation differences with respect to chemical and textural measurements are readily apparent in Table 4. The Northwest product had higher Instron values than either the West or Southwest. Differences in chemical composition within each experiment are minimal. Therefore, differences in textural measurements among these deep fat products are more closely associated with differences in soy proteins and skeletal meat. However, only the Southwest formulation provided significant differences (Table 7).

TABLE 5

-CHAR-BROILED BEEF PATTIES-
FORMULATION BY U.S. REGION AND TYPE SOY PROTEIN[a]

NORTHEAST	WEST
GSVP, CARGIL - 18BF, MAXTEN	GSVP, EDDI-PRO, MAXTEN, TEXTRASOY
55.0% Beef Trim (80/20) Frozen	55.0% Beef, 70/30, Fresh
24.4% Partially Defatted Beef Fatty Tissue	6.0% Textured Soy Protein[b]
5.9% Textured Soy Protein[b]	5.0% Soy Protein Concentrate Emulsifyer (GL-301)
13.6¢ Ice/Water	1.0% Soy Protein Concentrate Granular (GL-219)
1.1% Salt, Seasoning, etc.	30.0% Ice/Water
100.0%	1.0% Fresh Frozen Onions
	2.0% Salt, Seasoning, etc.
	100.0%

[a] GSVP, Cargil, Maxten = 50% textured soy protein; Eddi-Pro = 90% soy isolate fibers; Textrasoy = 50% soy flour -- compressed.

[b] Each region represents a separate plant in which the textured soy proteins were tested at level shown.

Char-broiled data is presented in Tables 5 and 6. These products are pre-cooked on a chain belt that moves through an open gas flame. Therefore, fresh meat color is not as important as bind and flavor. The West formulation used less meat than the Northeast, and employed a combination of soy concentrates and textured proteins. Instron data for the West formulations suggest significant textural differences (Table 7). Maxten appears to give the most bite or texture in the West char-broiled formulations, followed by GSVP, Eddi-Pro and Textrasoy.

TABLE 6

-CHAR-BROILED BEEF PATTIES-
CHEMICAL[a] AND TEXTURAL MEASUREMENTS
BY U.S. REGION AND TYPE SOY PROTEIN[b]

NORTHEAST				WEST				
	M	F	S		M	F	S	Instron
GSVP	55.4	20.9	.64	EDDI-PRO	55.1	17.9	1.7	10.02
CARGIL	55.3	20.9	.40	GSVP	57.5	17.4	1.7	10.28
MAXTEN	55.7	21.9	.30	MAXTEN	58.4	17.3	1.6	12.16
				TEXTRASOY	54.3	19.4	1.5	7.63

[a] M = Moisture, F = Fat, S = Salt. Five patties each were analyzed by A.O.A.C. methods.

[b] GSVP, Cargil, Maxten = 50% textured soy protein; Eddi-Pro = 90% soy isolate fiber; Textrasoy = 50% soy flour, compressed.

A summary of means and variance estimators ($\hat{\sigma}^2$) for the Instron textural data among regions, products and soy proteins is presented in Table 7 (Terrell, W.T., 1973). The null hypothesis that means are equal is rejected in the fresh frozen experiments. In formulations compared, GSVP had more texture than ADM-120 or Ultrasoy. No significant differences are observed in the case of deep fat fried products within the West and Northwest formulations (GSVP, Ultrasoy, Bontre); (GSVP, Texgran). However, differences within the Southwest formulation are noted (ADM-240 had more texture than GSVP and Ultrasoy). Regarding char-broiled products from the West, the null hypothesis of equal firmness is rejected.

NOTE: Student's "T" distribution was used in testing the hypothesis of equal means where the columns in Table 7 have only two entries. Otherwise, one-way analysis of variance and Fisher's "F" distribution was used. Among the four cases of rejection, only the last column suggested unequal variances. For a complete statistical explanation, see Freund, J.E., Mathematical Statistics, Prentice Hall, 1971.

TABLE 7

-SUMMARY OF MEANS AND VARIANCE ESTIMATORS-
INSTRON TEXTURAL EVALUATION OF DIFFERENT TYPES OF BEEF PATTIES
BY U.S. REGION AND TYPE OF SOY PROTEIN

		FRESH FROZEN		DEEP FAT FRIED			CHAR-BROILED
		Northeast	Southwest	Southwest	West	Northwest	West
GSVP	$\bar{X}$	7.86	7.61	4.13	2.87	10.74	10.28
	σ^2	1.23	1.50	.08	.04	2.84	2.45
ULTRASOY	$\bar{X}$		6.27	3.70	2.68		
	σ^2		1.05	.10	.08		
ADM-240	$\bar{X}$			4.64			
	σ^2			.33			
BONTRE	$\bar{X}$				2.65		
	σ^2				.29		
EDDI-PRO	$\bar{X}$						10.02
	σ^2						.45
ADM-120	$\bar{X}$	5.84					
	σ^2	.32					
TEXTRASOY	$\bar{X}$						7.63
	σ^2						2.12
TEXGRAN	$\bar{X}$					9.55	
	σ^2					1.24	
MAXTEN	$\bar{X}$						12.16
	σ^2						4.93
Hypothesis That Means are Equal		Rejected	Rejected	Rejected	Accepted	Accepted	Rejected
Confidence Level (Rejection)		(.005)	(.05)	(.01			(.01)

The variance estimators are a measure of dispersion (non-homogeneity). Factors affecting the value are: (1) Uniformity of mesh size in the textured soy protein and (2) Uniformity of mix into the meat food formulation. Where variance estimators are large, the soy protein may be non-homogeneous in mesh size, which would contribute to quality control problems in the finished product. On the other hand, if soy proteins are not hydrated sufficiently and mixed uniformly into the formulation, a non-homogenous texture would result.

Bulk density is a physical property that affects the rate of rehydration and amount of rehydration in textured soy protein. The composition (per cent moisture) of the soy mass as it passes through the extrusion cooker relates to the rate of expansion (puffing) and, therefore, the bulk density of the product. If the bulk density is high (50 - 60 lbs/cu.ft.) the textured product is more dense and will rehydrate slower than if the bulk density is low (20 - 30 lbs./cu.ft.).

In general, when Instron measurements were between 2.6 and 4.6, product formulations had less skeletal meats than when the Instron values were 7.8 to 12.1, regardless of type and combination of soy proteins used.

TABLE 8

-MEAT, SOY PROTEINS AND OTHER RESIDUAL INGREDIENTS-
GENERAL FORMULATIONS OF THREE DIFFERENT BEEF PATTIES BY U.S. REGION

Component	FRESH FROZEN		DEEP FAT FRIED			CHAR-BROILED	
	Northeast	Southwest	Southwest	West	Northwest	Northeast	West
Skeletal Meat	72.0	66.0	38.8	37.9	61.7	55.0	55.0
Total Soy Proteins	9.1	9.9	9.6	14.1	12.4	5.9	12.0
Residual Ingredients	18.9	24.1	35.4	48.0	25.9	39.1	33.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

A summary of gross formula composition is presented in Table 8. Fresh frozen products had 66 to 72 per cent skeletal meat and 9.1 to 9.9 per cent total soy proteins. Deep fat fried products had 37.3 to 61.7 per cent meat and 9.6 to 14.1 per cent total soy protein. Char-broiled products had 55 per cent meat and 5.9 to 12.0 per cent total soy protein. The pre-cooked (deep fat or char-broiled) products incorporated combinations of soy concentrates and textured soy proteins to reduce shrinkage (Terrell, 1973).

REFERENCES

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