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SENSORY AND NUTRITIONAL EVALUATION OF MEAT LOAVES WITH AND WITHOUT GRANULAR SOY CONCENTRATE

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Meat loaves were prepared in accordance with Armed Forces Recipe L–35 using ground meat extended with hydrated granular soy concentrate (18% protein-wet basis). The hydrated soy protein was added to the ground meat at 10 and 20% levels.

The primary objective of the study was to determine the effect of soy extension of ground beef on the nutritional content of meat loaf. The second objective was to evaluate the consumer

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acceptability of meat loaf made with and without soy. A final objective was to determine the effect of soy extension on the cooked yield of meat loaf.

The soy-extended meat loaves had higher mineral content than the 100% ground beef meat loaf. The thiamin and riboflavin levels were higher in the 100% ground beef meat loaf than in the 20% soy-extended meat loaf. Consumers independently rated the 20% soy-extended meat loaf comparable to that made with 100% beef. The 20% soy-extended meat loaf gave the greatest cooked yield.

PREFACE

This study was conducted to supplement the Armed Forces evaluation of ground beef with added granular soy concentrate. The evaluation was conducted during 1978 and 1979 and provided data on the nutritional content, consumer acceptance and yield of meat loaf prepared using ground beef containing 0, 10, and 20% hydrated granular soy concentrate.

This effort was undertaken under the OMA .19 Production Engineering in support of the DoD Food Program, work units 13146558000, Storage Stability of Rations and Subsistence Items, and 13146644000, Support to Armed Forces Recipe Service.

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SENSORY AND NUTRITIONAL EVALUATION OF MEAT LOAVES WITH AND WITHOUT GRANULAR SOY CONCENTRATE

INTRODUCTION

The use of soy protein as an extender in meat products has increased significantly in recent years.[1] Based on an analysis of the planned menus for a three-month period in 1980, 64% of beef utilized by the Armed Forces is ground beef (39% bulk and 25% patties).[2,3] Substantial cost savings were anticipated if this meat were extended with 20% granular soy concentrate.*

Prior testing of soy-extended meat products has included consumer acceptability, technical panel sensory ratings, percent yield, and nutritional quality.

Kotula et al. (1975) evaluated the cooking losses and tenderness characteristics of soy-extended beef patties and found those extended with soy to be more tender than all-beef patties when tested by puncture shear force. The all-beef patties lost more weight during cooking than soy extended patties.[4]

Anderson (1975) reported that the level of soy in a meat product determines the amount of moisture retention. A functional property of soy is to retain moisture; consequently the cooking yield of soy-extended products is greater than that of all beef products.[5] Judge (1974) reported less shrinking with soy-extended beef.[6]

[1] C.W. Williams and M.E. Zabik. Quality characteristics of soy substituted ground beef, pork and turkey meat loaves. J. Food Sci., 40:502 (1975).

[2] SB–10–260 Master Menus for July, August, and September 1980.

[3] SB–10–260–1 Recapitulations of Master Menus for July, August, and September 1980.

[4] A.W. Kotula and D.K. Rough. Cooking losses and tenderness of beef soy protein patties. Proceedings of European Meat Workers Conference 1975.

[5] R.H. Anderson and K.D. Lind. Retention of water and fat. Food Technol., 29(2):44 (1975).

[6] M.D. Judge, C.G. Haugh, G.L. Zachariah, G.E. Parmelee, and R.L. Pyle. Soya additives in beef patties. J. Food Sci., 39(1):137 (1974).

*Actual savings for fiscal years 1980 and 1981 were $11,516,288 and $10,736,085, respectively.

Within controlled limits of soy extension, equal or superior quality characteristics are found in the soy-extended products. Drake et al. (1975) evaluated texturized soy protein (TSP) levels at 0, 15, 20, and 25%, in beef patties using consumer acceptance and technical sensory panels.[7] The trained panel found that TSP had no effect on the attributes of appearance and color, and a limited effect on odor; neither the trained nor the consumer judges perceived any differences in texture within the levels of TSP studied; and both trained and consumer panels judged the flavor of the 0% TSP patties to be, respectively, significantly better in quality and significantly more acceptable than those containing TSP.[7] Williams et al. (1975) evaluated the effect of a 30% soy substitution in ground beef loaves using a trained sensory panel. No differences were found in flavor, juiciness or overall acceptability between the all-beef loaf and the 30% soy-extended loaf.[1] Cross (1975) reported that a consumer panel found the textured soy-extended patties to be equal or superior to the all-beef patties.[8]

Meat loaf and hamburger patties were extended with 10% and 20% hydrated soy concentrate and stored for 12 months at the US Army Natick Research and Development Laboratories (NLABS). Consumer acceptance did not change as a result of storage time. There was also no significant difference in acceptability between the 10% and 20% levels of soy extension.[9]

In most studies, the nutritional quality of soy-extended beef has been judged on the basis of protein quality. Methionine is a limiting amino acid in soy.[10] As a dinner or supper entree, meat loaf is only one protein source of the Armed Forces menu. The A ration menu used in garrison feeding[11] provides not only protein in excess of the Daily Dietary Nutrient Allowances (DDNA),[12] as prescribed for the military services by their respective Surgeons General, but other nutrients as well (Table 1).

[7]S.R. Drake, L.C. Hinnergardt, R.A. Kluter, and P.A. Prell. Beef patties: The effect of texturized soy protein and fat levels on quality and acceptance. J. Food Sci., 40:1065 (1975).

[8]H.R. Cross, M.S. Stanfield, E.C. Green, J.M. Heinmeyer, and A.B. Hollick. Effect of fat and textured soy protein content on consumer acceptance of ground beef. J. Food Sci., 40:1331 (1975).

[9]E.R. Baush, J.L. Secrist, W.J. Fitzmaurice, V. Mason, and V. White. Granular soy protein concentrate as an extender for ground beef. NATICK/TR–80/010, January 1980. (AD A083 324)

[10]P.V.J. Hegarty and P.C. Ahn. Nutritional comparisons between a soy based meat analog and ground beef in unheated and heated states. J. Food Sci., 41:1133 (1976).

[11]SB–10–260, Master Menu, published monthly.

[12]Medical Services Nutritional Standards, Joint Regulation No. 40–25/BUMED Instruction No. 10110.3E/Air Force Regulation No. 160–95, 1976.

Table 1. Average nutrient values of A Ration menu (July, August, September 1980)

Nutrient	Amount provided, Menu/day	Percent of DDNA Men	Women
Protein	149 g	149%	186%
Calcium	1927 mg	241	241
Iron	24 mg	133	133
Thiamin	2.2mg	138	200
Riboflavin	3.7mg	185	264
Niacin	26 mg	124	173

NOTE: Pyridoxine value not available.

The most recent concern with soy-extended beef is the question of decreased mineral availability, specifically iron. The iron in soy is in the form of non-heme iron. Non-heme iron is not absorbed as efficiently as that of heme iron predominantly found in meat.[13] When evaluating the iron content of food, other considerations will have an effect on how much of the iron is utilized. The iron status of the subject in part determines the amount of iron that will be absorbed. Iron deficient subjects absorb more iron than non-deficient subjects. Iron absorption is also dependent on what other foods are eaten with the soy. The iron content of the meal as a whole and not only of individual components must be evaluated.[14] When soy is mixed with animal protein, the absorption of the non-heme iron is increased.[15]

A preliminary in-house study of soy extension on meat loaf tested consumer acceptance of 0, 9, and 18% levels of soy extension. An NLABS consumer panel rated the 100% ground beef, 9% soy-extended and 18% soy-extended meat loaves in a single session. Mean ratings are listed in Table 2.

Table 2. Consumer ratings of meat loaf made using hydrated granular soy concentrate (N=40)

Proportions	Mean + S.D.
100% ground beef	6.82 ± 1.05 A*
91% ground beef/9% soy	6.50 ± 1.43 AB
82% ground beef/18% soy	6.17 ± 1.84 B

*Unlike letters indicate statistically significant differences at $p < 0.05$.

[13]J.D. Cook. Absorption of food iron. Federation Proceedings 36(7):2028 (1977).

[14]E. Bjorn-Rasmussen and L. Hallberg. Effect of animal proteins on the absorption of food iron in man. Nutr. Met., 23:192 (1979).

[15]J.D. Cook and E.R. Monsen. Food iron absorption in human subjects. Am. J. Clin. Nutr., 29:859 (1976).

There did prove to be a significant difference in consumer acceptance at the 18% level of soy when all three samples were tested by each consumer during one sitting. Due to the fact that the 9% level of soy was not any less acceptable than the 100% ground beef control, it was decided that for the follow-on study (described in this report) the 10% soy-extended meat loaf would not be consumer tested.

The first objective of this research was to evaluate the nutritional content of meat loaves made with hydrated granular soy concentrate added to the ground beef at levels of 0, 10, and 20%. The second objective was to determine consumer acceptability. The third objective was to determine the effect of soy on the cooked yield meat loaves.

MATERIALS AND METHODS

Meat loaf was prepared according to the Armed Forces Recipe, L–35, (Appendix A) except that the meat loaves weighed 5 pounds 12 ounces before cooking instead of 5 pounds. USDA choice square-cut chucks were procured from a local source and boned to an analyzed fat level of 18 ± 2%. The beef was rough-ground using a 3/4" plate.[16] Granular soy concentrate (hydrated to 18% protein content) was blended with the beef at 0, 10, and 20% extension levels. The fat level was adjusted in the beef/soy blends to provide equal fat levels in all treatments (18 ± 2%). A 1/8" plate was used for the final grind. The remaining ingredients used in the three meat loaf recipes were all from the same lots of products.

Complete 100-portion meat loaf recipes – eight loaves; average weight before cooking, 5 pounds 12 ounces – were prepared using, respectively, 100% ground beef and 20% soy-extended beef. An additional 50-portion recipe, four loaves, was made using 10% soy-extended beef. All meat loaves were baked in conventional ovens (gas and electric) for 1–1/2 hours at 163°C (325°F). The average internal temperature of the baked meat loaves was 71°C (160°F). The meat loaves were weighed prior to cooking and after cooking. The drip loss was measured.

Five of the no-soy and five of the 20% soy-extended baked meat loaves were randomly designated as nutrition samples. Twenty minutes after baking these samples were quartered and packaged in double polyethylene bags, coded, frozen, and held frozen at –23°C (–10°F) until comminuted as samples for nutritional analyses. Each sample consisted of two diagonally opposite quarters of a meat loaf.

After baking all four of the 10% soy-extended meat loaves were prepared for nutritional analyses in the same manner as the no soy and 20% soy products except that each sample size was two-fifths of a meat loaf.

Three each of the no soy and of the 20% soy-extended meat loaves were designated sensory test samples. Twenty minutes after they were removed from the oven these samples were sliced to yield 13 six-ounce portions per loaf and delivered to the NLABS Food Acceptance Laboratory for consumer testing.

[16]USDA Schedule AA July 1978, Amendment 4, August 1979.

Nutritional Analysis

A contract laboratory* performed proximate, fatty acid, cholesterol, mineral, and vitamin analysis. Proximate analysis included moisture, protein, fat, and ash. Mineral analysis included calcium, phosphorus, iron, sodium, potassium, magnesium, and chloride as NaCl. Vitamin analyses included thiamin, riboflavin, niacin, pyridoxine, and B_{12}. Appendix B lists the methods of analyses used.

Statistical Analysis

Statistical analysis on the nutrient data (proximate, minerals, and vitamins) was on a moisture-free/fat-free basis. The data were treated statistically by analysis of variance. When the F values were significant ($p \leq 0.05$), Newman-Keuls range tests were used to determine where these differences existed.

Sensory Evaluation

Two groups of 40 randomly selected consumer panelists were chosen for acceptance testing. Panelists were asked to rate their preference for meat loaf as a meal item. A 9-point hedonic scale was used where 9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely. Samples of the 100% ground beef meat loaf were rated by the panel and the samples of the 20% soy-extended meat loaf were rated independently by the second panel. Sample size was one-half of an inner slice portion, approximately three ounces. End portions of the meat loaves were not used. All samples were served hot.

RESULTS AND DISCUSSION

Nutritional Data

Analyses of variance were done on all of the nutrient data received to determine if there were any significant differences among the sample means. The Newman-Keuls range test was used to determine where significant differences existed. The nutrient data obtained are summarized on a moisture/fat-free basis in Table 3. Fatty acid data (percent of total fatty acids as fatty acids) are provided in Table 4.

Protein, ash, phosphorus, iron, sodium, potassium, chloride as NaCl, niacin, and vitamin B_{12} were not significantly altered in the meat loaves by the addition of hydrated granular soy.

*Shankman Laboratories, Inc., Los Angeles, CA, performed the required analyses under Contract No. DAAK60–79–D–0003 and forwarded the data (unpublished) to NLABS.

Table 3. Nutrient content of cooked meat loaves using hydrated granular soy concentrate (Moisture and fat-free values per 100 g)

Test Variable (Meat Ingredient)	Protein g	Ash g	Calcium mg	Phosphorus mg
No Soy – 100% Beef	66.7 ± 1.46* A	8.7 ± 0.47 A	168 ± 6.3 B	576 ± 8.6 A
10% Soy – 90% Beef	65.1 ± 1.47 A	8.2 ± 2.02 A	190 ± 8.6 A	599 ± 8.3 A
20% Soy – 80% Beef	63.9 ± 1.44 A	8.7 ± 0.41 A	206 ± 11.0 A	609 ± 18.5 A

	Iron mg	Sodium mg	Potassium mg	Magnesium mg
No Soy – 100% Beef	9.0 ± 0.48 A	2119 ± 121. A	1034 ± 68.4 A	88.0 ± 4.79 C
10% Soy – 90% Beef	8.5 ± 0.47 A	2040 ± 747. A	1051 ± 86.9 A	100.2 ± 2.58 B
20% Soy – 80% Beef	9.0 ± 0.26 A	2061 ± 126. A	1115 ± 67.7 A	119.5 ± 4.41 A

	Chloride as NaCl g	Cholesterol mg
No Soy – 100% Beef	6.01 ± 0.34 A	451 ± 10.6 A
10% Soy – 90% Beef	5.56 ± 1.74 A	407 ± 8.4 B
20% Soy – 80% Beef	5.49 ± 0.47 A	393 ± 11.0 C

	Thiamin mg	Riboflavin mg	Niacin mg	Pyridoxine mg	Vitamin B_{12} μg
No Soy – 100% Beef	0.38 ± 0.017 A	0.69 ± 0.032 A	9.9 ± 0.49 A	0.80 ± 0.039 A	4.60 ± 0.214 A
10% Soy – 90% Beef	0.38 ± 0.050 A	0.66 ± 0.030 A	9.8 ± 0.74 A	0.74 ± 0.078 AB	3.24 ± 0.24 A
20% Soy – 80% Beef	0.36 ± 0.00 B	0.58 ± 0.044 B	9.1 ± 0.26 A	0.66 ± 0.094 B	3.34 ± 1.721 A

*Mean ± standard deviation (N=5)

Note: Unlike letters indicate statistically significant differences at $p < 0.05$.

Table 4. Fatty acids in cooked meat loaves using hydrated granular soy concentrate (Percent of total fatty acids)

Lab I

	14:0 (myristic)	14:1 (myristoleic)	16:0 (palmitic)	16:1 (palmitoleic)
No Soy	2.48 ± 0.057 A*	0.66 ± 0.065 A	25.91 ± 0.134 A	4.43 ± 0.182 A
10% Soy	2.18 ± 0.027 C	0.51 ± 0.022 B	25.59 ± 0.216 B	4.47 ± 0.208 A
20% Soy	2.25 ± 0.035 B	0.49 ± 0.022 B	25.82 ± 0.199 AB	4.55 ± 0.352 A

	16:2 (hexadecadienoic)	18:0 (stearic)	18:1 (oleic)	18:2 (linoleic)
No Soy	0.75 ± 0.079 A	15.80 ± 0.166 C	47.46 ± 0.244 A	2.09 ± 0.294 A
10% Soy	0.59 ± 0.124 B	16.95 ± 0.154 B	47.14 ± 0.156 A	2.38 ± 0.264 A
20% Soy	0.60 ± 0.061B	17.56 ± 0.096A	46.39 ± 0.327 B	2.24 ± 0.195 A

*Mean ± standard deviation (N = 5)

NOTE: Unlike letters indicate statisically significant differences at $p < 0.05$.

Figure 1 shows the observed significant differences in nutrient content for meat loaf with zero, 10 and 20% soy. Nutrient variations that were not significant are not illustrated.

As the amount of added soy increases from zero to 10% to 20%, the calcium level increases by 13% and 23%, respectively; also the magnesium increases by 14% and 36%, respectively. These mineral increases in the soy-extended meat loaves were expected. Soy has a greater amount of calcium, phosphorus, potassium, and magnesium than does the same amount of ground beef. Hegarty (1976)[10] evaluated beef patties extended with soy for protein and mineral content. He concluded that calcium, phosphorus, and potassium increased with the addition of soy. In this study, however, while slight differences were noted in phosphorus and potassium content, they were not statistically significant.

Neither thiamin, riboflavin nor pyridoxine levels were altered by the 10% soy extension of meat loaf (Figure 1). The decreases of 5% for thiamin, 16% for riboflavin, and 18% for pyridoxine which occurred with the 20% soy extension were significant ($p < 0.05$). However, they are not considered detrimental to the soldiers' nutrition. This conclusion can be drawn because of the vitamin excesses provided in the A Ration (Table 1) and also because meat loaf is only one menu source of these vitamins.

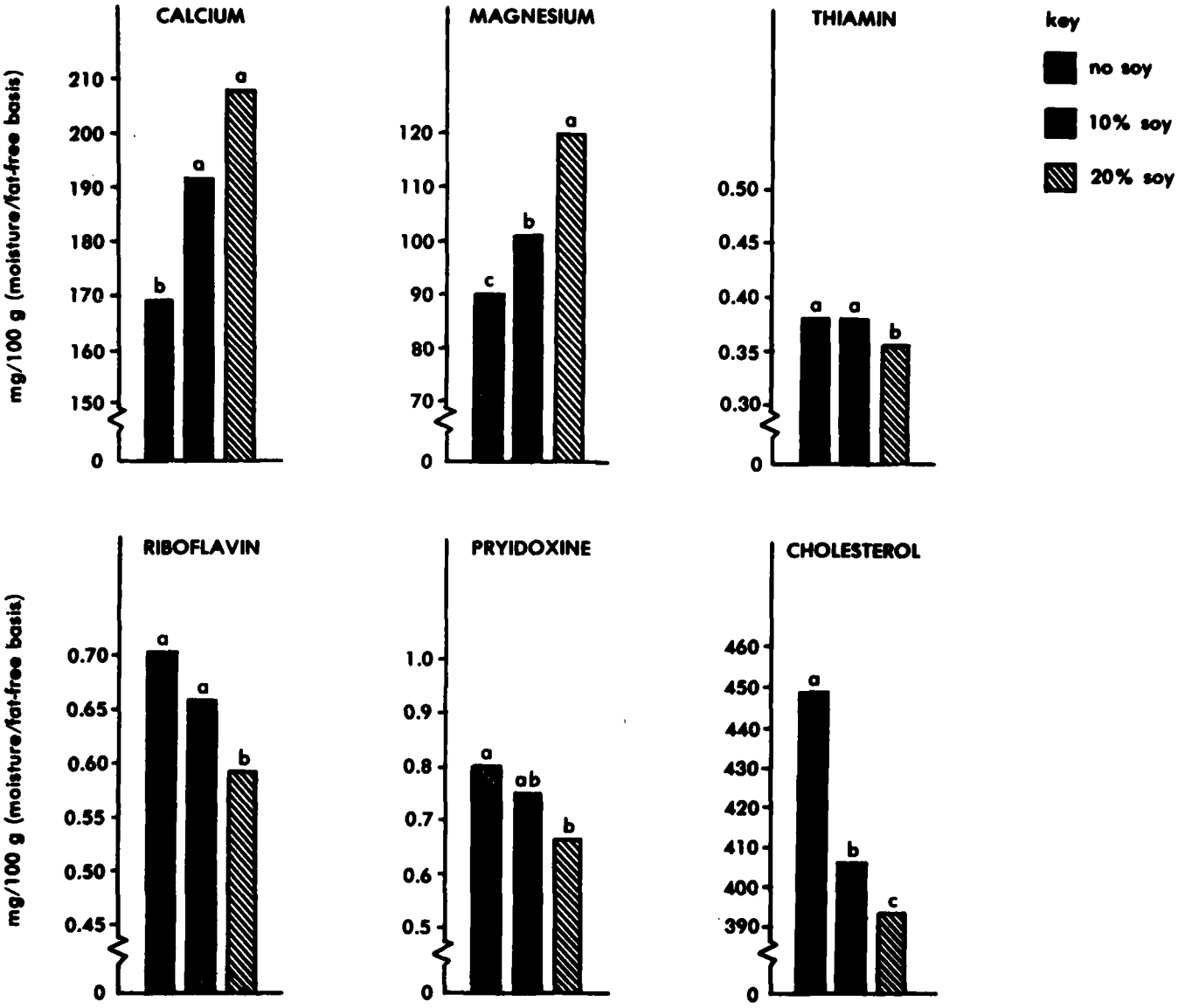
Cholesterol content was found to decrease significantly when soy was used in the meat loaves. With the 10% soy extension, cholesterol content decreased 10%, and with 20% soy extension cholesterol decreased by 13%.

There were some significant differences in the percent of fatty acid data (Table 4) among the no soy, 10% soy, and 20% soy samples. These differences however have little impact on the total amount of saturated fatty acids in the meat loaves. Also, since the fat content of granular soy concentrate is extremely low, the differences are believed to be due to product and/or analytical variations rather than to the addition of soy. Both commercial producers of granular soy concentrate (AE Staley Co. and Central Soya) have reported fat levels of less than 0.5% for granular soy concentrate. Therefore an addition of 20% soy (hydrated basis) could not affect the fatty acid content of a product such as meat loaf.

The nutrient data (means and standard deviations) reported on an as-is (wet) basis are included as Laboratory I data (i.e. the contract laboratory) in Appendix C. Fatty acids were estimated to be 90% of the total fat in the sample.[17] The average fat content of the sample was adjusted by the factor 0.9 to estimate the amount of fatty acid per 100 grams of product. The saturated fatty acid content of the no soy meat loaf is 4.58%, that of the 10% soy-extended meat loaf is 4.07%, and that of the 20% soy-extended meat loaf is 4.47%.

Using the data provided in Appendix C (for Laboratory I), the 100% ground beef meat loaf and the 20% soy extended meat loaves were compared as to their contribution to the military nutritional allowances. The differences are small, ± 3%, as can be seen in Table 5.

[17] E.W. Murphy, L. Page and P.C. Koons. Lipid components of type A school lunch. J. Am. Diet Assoc., 56:504, 1970.



NOTE: Unlike letters indicate significant ($p < 0.05$) differences between 0, 10, and 20% GSC extended meat loaves.

Figure 1. Mineral, vitamin and cholesterol content of cooked meat loaves made with and without hydrated granular soy concentrate.

Table 5. Percentage of military nutritional allowances for selected nutrients provided by one portion (184 grams) of meat loaf using hydrated granular soy concentrate

	100% ground beef	80% ground beef + 20% hydrated soy
Protein	31	29
Calcium	10	12
Phosphorus	33	35
Iron	23	23
Magnesium	10	13
Thiamin	11	10
Riboflavin	16	13
Niacin	22	20

Supporting Data from In-house Analyses

The remaining two quarters of all meat loaf samples analyzed by the contract laboratory were analyzed by NLABS in-house laboratories. The data obtained are also reported in Appendix C, as Laboratory II data. In-house vitamin analysis were limited to thiamin and riboflavin. As will be noted, the differences among the results of the two laboratories are small. They are also within the normal ranges usually found among data from different laboratories due to slight differences in analytical techniques, catalysts, etc. even when, as in this case, the same analytical methods were used. All in-house data were statistically analyzed on a moisture/fat-free basis. Any statistical trends noted with the data from the contract laboratory were confirmed.

With the in-house data (Table 6), it is interesting to note that the increases in phosphorus and potassium that occurred with the 10% and 20% additions of soy were statistically significant. Increases in calcium were also more defined. Magnesium maintained the same significance levels; however, the percent increase at both the 10% and 20% addition of soy were greater.

Table 6. Percent change in calcium, phosphorus, potassium and magnesium of cooked meat loaves made with 10% and 20% soy from meat loaf made without soy. (Based on moisture and fat-free values per 100 g)

Test Variable (Meat Ingredient)		Calcium	Phosphorus
No Soy	100% Beef	–	–
10% Soy	90% Beef	+ 15% A	+ 10% A
20% Soy	80% Beef	+ 27% B	+ 13% A
		Potassium	**Magnesium**
No Soy	100% Beef	–	–
10% Soy	90% Beef	+ 4% A	+ 23% A
20% Soy	80% Beef	+ 12% B	+ 45% B

A – Significantly different from no soy meat loaf ($p \leq 0.05$) but not from 10% soy meat loaf.

B – Significantly different from no soy and 10% soy meat loaf ($p \leq 0.05$).

The results are in agreement with those found by Hegarty (1976)[10] and confirm the trends suggested by the contract laboratory data for phosphorus and potassium.

Sensory Data

Two consumer panels independently rated the meat loaves on the same day they were cooked. The mean ratings for the 100% ground beef meat loaf and the 20% soy-extended meat loaf were not significantly different and are provided in Table 7; both rated "like moderately."

Table 7. Consumer ratings of meat loaf made using hydrated granular soy concentrate

Meat loaf	Mean Rating	$p < 0.05$
100% ground beef	7.07	NS
80% beef/20% soy	6.82	

Percent Yield

As previously reported by Drake (1975),[7] meat loaf extended with 20% soy produced the greatest cooked yield. Soy has the ability to bind water and fat, making cooking losses less than when 100% ground beef is used. The percent yield after cooking of the three samples of meat loaf extended with 0, 10, and 20% hydrated granular soy are 84.4, 86.1, and 89.5, respectively (Table 8).

Table 8. Yield of meat loaves made using hydrated granular soy concentrate

	Percent Yield
100% ground beef meat loaf	84.4
10% soy-extended meat loaf	86.1
20% soy-extended meat loaf	89.5

CONCLUSIONS

From a nutritional standpoint, the use of hydrated soy concentrate as an extender in meat loaf at the 20% level is acceptable. Changes in nutrient content were observed. With the addition of 20% hydrated soy, calcium increased 23%, magnesium 36%, phosphorus 6%, and potassium 8%. Decreases in thiamin, riboflavin, and pyridoxin of 5, 16, and 17%, respectively, also occurred. Cholesterol was 13% higher in the meat loaf made without soy than in the product made with 20% hydrated soy concentrate. Very slight differences in fatty acid content were noted; however, these differences are thought to be due to product variability rather than soy extension because of the extremely low level of fat in the added soy concentrate.

When tested independently, the 100% ground beef meat loaf and the 20% soy-extended meat loaf were equal in consumer acceptance. Both samples rated "like moderately."

The effect when soy is added to meat loaf is that cooking losses are decreased, resulting in a greater percent yield of meat loaf.

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APPENDICES

A. Meat Loaf Recipe No. L–35

B. Methods of Analyses

C. Composition of Meat Loaf Made With and Without Hydrated Granular Soy Concentrate

L. MEAT, FISH, AND POULTRY No. 35(2)[18]

MEAT LOAF

YIELD: 100 Portions (2 Pans)				EACH PORTION: 1 Slice (6½ Ounces)
PAN SIZE: 18 by 24-inch Roasting Pan				TEMPERATURE: 325°F. Oven
INGREDIENTS	WEIGHTS	MEASURES		METHOD
Beef, ground, thawed	30 lb	.....	.....	1. Combine beef with bread crumbs, salt, and pepper; mix until blended.
Bread crumbs, dry, ground (coarse)	4 lb	1½ gal ..	.....	
Salt	8 oz	¾ cup ...	.....	
Pepper, black	.....	1 tbsp ...	.....	
Celery, fresh, finely chopped	1 lb	3 cups ...	.....	2. Add celery, onions, garlic, sweet peppers, eggs, milk, water, and tomato juice. Mix lightly but thoroughly. Avoid overmixing if using mixer.
Onions, dry, finely chopped	1 lb	3 cups ...	.....	
Garlic, dry, minced (optional)	.....	2 tsp (2 cloves)	.....	
Peppers, sweet, fresh, chopped (optional)	8 oz	1½ cups.	.....	
Eggs, whole, slightly beaten	2 lb 8 oz .	1¼ qt (24 eggs)	.....	
Milk, nonfat, dry ..	5 oz	1⅛ cups .	.....	
Water	.....	5½ cups .	.....	
Juice, tomato, canned	.....	5¾ cups (1-No. 3 cyl cn)	.....	
				3. Shape into 8 loaves weighing about 5 lb each; place 4 loaves, crosswise, in each pan. 4. Bake 1½ hours. Skim off excess fat and liquid during cooking period. 5. Cool slightly. Cut 13 slices per loaf.

NOTE: 1. In Step 2, 1 lb 6 oz fresh celery A.P. will yield 1 lb finely chopped celery and 1 lb 2 oz dry onions A.P. will yield 1 lb finely chopped onions.

[18] Meat Loaf Recipe No. L-35, Armed Forces Recipe Service, TM 10-412, NAVSUP Publication 7, AFM 146-12-Volume 1, MCO P10110.16C, May 1980.

APPENDIX B

Methods of Analyses[19]

AOAC Methods, 13th Edition (1980)[20]

Assay	Reference
Moisture	24.003
Total Fat	24.005
Protein	2.057
Crude Fiber	7.065
Ash	14.006
Phosphorus	2.021
Chloride as NaCl	18.034
Cholesterol	14.149
Atomic absorption spectrophotometer[21]	
Calcium	AASP
Iron	AASP
Sodium	AASP
Potassium	AASP
Magnesium	AASP
Other	
Iodine	Anal. Chemica Acta 10, 78 (1954)[22]
Fatty Acid Profile	28.057

Methods of Vitamin Assay — Third Edition (1966)[23]

Assay	Pages
Vitamin A	70–79
Carotene	104–115
Thiamin	127–140
Riboflavin	158–164
Niacin	172–176
Pyridoxine	212–219
Vitamin E[24,25]	366–396
Ascorbic Acid	299–306
Folacin	227–234
Vitamin B_{12}	262–270

[19] Horwitz, W. (ed.) Official methods of analysis of the assoc. of official analytical chemists, Assoc. Off. Anal. Chem., 11th Ed. 1970.

[20] Ibid., 13th Ed. 1980.

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APPENDIX C

Composition of Meat Loaf Made With and Without Hydrated Granular Soy Concentrate (nutrients per 100 grams, as is basis)

Nutrient and Unit		LAB I			LAB II		
		No Soy	10% Soy	20% Soy	No Soy	10% Soy	20% Soy
Proximates							
Moisture	g	63.5 ± 0.52*	64.8 ± 0.31	64.3 ± 0.56	63.4 ± 0.39	63.9 ± 0.36	64.6 ± 0.55
Food Energy	kcal+	199	185	190	200	190	189
Protein	g	16.7 ± 0.48	16.4 ± 0.25	15.8 ± 0.32	15.1 ± 0.42	15.0 ± 0.30	14.6 ± 0.40
Fat	g	11.5 ± 0.27	10.1 ± 0.27	10.9 ± 0.13	11.7 ± 0.29	10.5 ± 0.49	10.8 ± 0.42
Carbohydrate	g	6.1**	6.6	6.8	7.6	8.2	8.8
Ash	g	2.2 ± 0.15	2.1 ± 0.52	2.2 ± 0.05	2.2 ± 0.08	2.4 ± 0.46	2.2 ± 0.06
Minerals							
Calcium	mg	42 ± 1.6	48 ± 1.7	51 ± 2.3	37 ± 0.60	44 ± 1.7	47 ± 0.8
Phosphorus	mg	144 ± 3.7	150 ± 2.5	151 ± 2.7	128 ± 3.63	145 ± 6.14	143 ± 3.08
Iron	mg	2.2 ± 0.11	2.1 ± 0.11	2.2 ± 0.05	2.2 ± 0.04	2.3 ± 0.002	2.2 ± 0.05
Sodium	mg	530 ± 38.8	514 ± 192.9	510 ± 0.00	576 ± 27.6	619 ± 169.3	552 ± 17.9
Potassium	mg	259 ± 19.2	265 ± 23.5	276 ± 12.0	263 ± 0.63	2.83 ± 3.2	2.92 ± 4.7
Magnesium	mg	22 ± 1.2	25 ± 0.4	29 ± 1.1	18.0 ± 0.71	22.8 ± 1.1	25.8 ± 0.84
NaCl	g	1.50 ± 0.11	1.40 ± 0.45	1.36 ± 0.11	1.48 ± 0.05	1.60 ± 0.45	1.43 ± 0.07
Vitamins							
Thiamin	mg	0.10 ± 0.004	0.10 ± 0.011	0.09 ± 0.007	0.12 ± 0.005	0.11 ± 0.003	0.10 ± 0.003
Riboflavin	mg	0.17 ± 0.008	0.16 ± 0.006	0.14 ± 0.008	0.13 ± 0.008	0.12 ± 0.005	0.11 ± 0.003
Niacin	mg	2.59 ± 0.14	2.50 ± 0.08	2.30 ± 0.02			
Pyridoxine	mg	0.20 ± 0.007	0.19 ± 0.021	0.16 ± 0.02			
Vitamin B12	mg	1.15 ± 0.035	0.82 ± 0.067	0.83 ± 0.408			
Lipids							
Total Fatty Acids		10.35‡	9.09	9.81	0.53	9.45	9.72
Saturated							
14:0	g	0.26	0.20	0.22	0.30	0.27	0.29
16:0	g	2.68	2.33	2.53	2.77	2.49	2.36
18:0	g	1.64	1.54	1.72	1.51	1.36	1.17
Monosaturated							
14:1	g	0.07	0.05	0.05	0.16	0.14	0.14
16:1	g	0.46	0.41	0.45	0.63	0.60	0.65
18:1	g	4.91	4.29	4.55	4.71	4.28	4.68
Polyunsaturated							
16:2	g	0.08	0.05	0.06	0.06	0.05	0.05
18:2	g	0.22	0.22	0.22	0.36	0.28	0.36

*Mean ± standard deviation

**Determined by difference.

+Specific energy values for no soy product: P = 4.23 kcal, F = 9.00 kcal, CHO = 4.03 kcal; for 10% soy product: P = 4.14 kcal, F = 9.00 kcal, CHO = 4.03 kcal; for 20% soy product: P = 4.10 kcal, F = 9.00 kcal, CHO = 4.03 kcal.

‡Fatty acids are estimated to be 90% of total fat. See Reference 17.