INTRODUCTION

PARTIALLY DEFATTED (PD) chopped beef and PD beef fatty tissue are products which according to USDA specifications, are produced in low temperature rendering of beef tissues particularly at a maximum temperature of 48.9°C.

Low temperature rendering originated because it is capable of producing high quality lard and tallow with improved color, odor and taste (Pavia, 1950; Swift and Hankins, 1952; Kramer, 1954a, b; Orsi, 1957; Downing, 1958, 1959; Sullivan, 1959; Christianson, 1961; Little and Villeville, 1963). This rendering is economically most feasible when profitable uses can be made of the resulting partially defatted tissues. One use was made possible as a result of USDA regulations which permit the use of limited amounts in meat products, i.e., 15% of the meat in frankfurters labeled "with by-products."

The products and by-products are designated according to species source and composition of the material rendered, PD chopped beef and pork being prepared from tissue containing at least 12% lean, classified as meat products, and PD fatty tissue from material containing none to an amount less than 12% lean, classified as by-products. (Currently, there is a proposal by USDA to amend its meat inspection regulations which includes reclassifying PD chopped beef and PD chopped pork as meat by-products.) The present study was concerned with products of bovine origin, PD beef fatty tissue, PD chopped beef and a third type, PD cured cooked chopped beef.

This study represents cooperative effort between the Animal & Plant Health Inspection Service and the Agricultural Research Service, USDA, to obtain analytical and nutritional data on samples of the above edible rendered tissues.

EXPERIMENTAL

TWO PD chopped beef, one PD cured cooked chopped beef, and three PD beef fatty tissue samples from six commercial establishments were analyzed for proximate and amino acid composition. Protein efficiency ratios (PER) of the partially defatted products were obtained. PER's were also obtained on lean beef, on a sample of collagen, and on combinations of lean beef protein with one each of a PD chopped beef or of two PD beef fatty tissue, and with combinations of whey or soy protein concentrates with one each of two PD beef fatty tissue samples.

Preparation of samples

Partially defatted products. The samples consisted of six boxes, 22.7 kg each, of partially defatted frozen products: three of beef fatty tissue, two of chopped beef, and one of cured, cooked chopped beef. They were stored in the range −23.3 to −20°C for a maximum of 2 wk. In preparation for freeze drying samples for feeding tests and analyses, each 22.7 kg frozen sample was cut into slabs with a band saw, ground in a Hobart meat grinder using a 1/2-in. plate opening and well mixed in a Buffalo ribbon blender for 5 min, using dry ice to keep the samples frozen. Aliquots of 1.5 kg and 4.5 kg of each ground frozen product were stored frozen until used for proximate analysis of the original materials and for preparation of freeze-dried samples, respectively.

Samples of each partially defatted product were freeze dried to less than 1% moisture in a Stokes shelf dryer at 41.6–43.3°C with a vacuum of 0.5 mm mercury. The dryer trays were each loaded with 2.3 kg of a ground frozen partially defatted product. 18 hr total drying time was necessary. During drying of the cured cooked chopped beef sample fat separated from the tissue and defatting was required before grinding. A 2.5-kg sample was washed successively with about 2 liters of Skellysolve F on Whatman #2 filter paper. The washed sample after drying weighed about 1.2 kg.

Each of the above products, after mixing with powdered dry ice, was ground as quickly as possible in a dry-ice cooled Wiley mill to pass a 2-mm screen. The ground samples were placed in loosely tied plastic food storage bags and refrigerated at 3–5°C until the carbon dioxide was vaporized. They were then well mixed and aliquots of each were removed for proximate and amino acid analyses and for feeding tests.

Lean beef. Six eye-of-round muscles (*semitendinosus*) were trimmed to remove outside fat, ground through a Hobart meat grinder using a 1/2-in. plate to prepare a 12 kg sample of lean beef, and well mixed in the Buffalo mixer. Because fairly large pieces of meat remained in the mixture, it was again ground in the Hobart, using a 3/16-in. plate, and again well mixed. The lot was sampled for proximate analyses by taking several aliquots of the ground beef, totaling 660g, combining and mixing them. The remainder of the sample was frozen in Stokes shelf drying trays, 1.8 kg of lean beef per tray, and dried in the Stokes dryer as described above in 12–14 hr. The dried samples were ground, stored, mixed and sampled as described above.

Collagen. The dried collagen used in this study was a sample removed from a large-scale lot prepared as follows: 200 lb of food-grade, limed cattlehide splits from a tannery were cut 1/4 in. wide by a Taylor-Stiles stripper and recut through a Taylor-Stiles granulator with 1-in. screen openings; the hide pH was adjusted to about 6 with lactic acid solution in a tanning drum, followed by water washing of the hide pieces. The pieces were then cut to 0.060 in. with the Urshel "Comitrol" and freeze dried as described for the partially defatted products. The dried samples were ground, stored, mixed and sampled as described above.

Chemical analyses

Official methods of the AOAC (1970) for meat and meat products were used to determine moisture, ash, fat (petroleum ether extractables) and Kjeldahl nitrogen. Percentage protein was calculated from the total nitrogen using the factor for the protein(s) analyzed, i.e., N X 6.25 for meat protein.

Amino acid analyses were determined in duplicate using the Piez and Morris system (1960) on samples that were extracted with petroleum ether to remove the fat, dried in a vacuum oven at 50°C, and then hydrolyzed with 6N HCl for 24 hr. Tyrptophan was determined on a separate sample hydrolyzed with methanesulfonic acid (Liu and Chang, 1971). Each amino acid in Table 3 was calculated as grams of amino acid residue per 100 grams of total amino acid residues.

Protein efficiency ratios

Protein efficiency ratios (PER) were determined at the USDA Western Regional Research Center, ARS, on the partially defatted products, lean beef, collagen, a whey protein concentrate (ENRPRO 50), a soy protein concentrate (PROMOSOY-100), and on several combinations of these proteins using the meth-

Table 1—Analyses of PD chopped beef, PD beef fatty tissue and lean beef

Product[a] No.	Description	As received: Moisture (%)	N (%)	Protein N X 6.25 (%)	Fat[b] (%)	Ash (%)	Total H_2O, prot, fat & ash (%)	Moisture free: N (%)	Protein N X 6.25 (%)	Fat[b] (%)	Ash (%)
5	PDCCCB	48.8	3.07	19.2	29.1	1.8	98.9	5.99	37.4	56.7	3.6
6	PDCB	71.4	2.91	18.2	9.5	0.9	100.0	10.15	63.4	33.2	3.3
2	PDCB	63.5	3.85	24.1	13.0	0.8	101.4	10.54	65.9	35.6	2.3
3	PDBFT	60.7	3.17	19.8	17.4	1.4	99.3	8.12	50.8	44.2	3.4
4	PDBFT	63.7	2.96	18.5	16.7	1.0	99.9	8.15	50.9	46.0	2.8
1	PDBFT	61.8	3.30	20.6	17.1	0.9	100.4	8.63	53.9	44.9	2.5
	LB	72.6	3.48	21.8	4.6	1.1	100.1	12.72	79.5	16.6	4.0

[a] Product code: PDCCCB, partially defatted cured cooked chopped beef; PDCB, partially defatted chopped beef; PDBFT partially defatted beef fatty tissue; LB, lean beef
[b] Extracted with petroleum ether (30–60°C boiling temperature range)

Table 1—Analyses of PD chopped beef, PD beef fatty tissue, lean beef, and other protein sources

Product[a] No.	Description	Freeze-dried products, As dried: Moisture (%)	N (%)	Protein (%)	Fat[b] (%)	Ash (%)	Total H_2O, prot, fat, & ash (%)	Moisture free: N (%)	Protein (%)	Fat[b] (%)	Ash (%)
				N X 6.25					N X 6.25		
5	PDCCCB	9.0	12.34	77.1	6.5	7.7	100.3	13.56	84.8	7.1	8.5
6	PDCB	3.4	9.79	61.2	33.0	3.4	101.0	10.13	63.3	34.2	3.6
2	PDCB	4.0	9.93	62.1	33.7	2.2	102.0	10.34	64.6	35.1	2.3
3	PDBFT	3.2	8.05	50.3	43.8	3.0	100.3	8.32	52.0	45.2	3.1
4	PDBFT	6.8	7.72	48.3	43.0	2.6	100.7	8.28	51.8	46.1	2.8
1	PDBFT	3.6	8.24	51.5	43.7	2.4	101.2	8.55	53.4	45.3	2.5
	LB	5.0	11.94	74.6	16.1	4.0	99.7	12.56	78.5	17.0	4.2
				N X 5.62					N X 5.62		
	Collagen	6.6	15.20	85.4	5.0	2.0	99.0	16.28	91.5	5.4	2.2
Other proteins products											
				N X 6.38					N X 6.38		
	WPC[c]	6.7	8.15	52.0	0.8	10.1	69.6	8.72	55.6	0.9	10.8
				N X 6.25					N X 6.25		
	SPC	6.8	10.47	65.4	1.9	6.1	80.2	11.23	70.2	2.0	6.6

[a] Product code: PDCCCB, partially defatted cured cooked chopped beef; PDCB, partially defatted chopped beef; PDBFT, partially defatted beef fatty tissue; LB, lean beef; WPC, whey protein concentrate; SPC, soy protein concentrate.
[b] Extracted with petroleum ether (30 to 60°C boiling temperature range).
[c] Percent lactose was 21.5.

od of Derse (1965). The method involved feeding rats a diet containing 10% protein (N X 6.25, except N X 6.38 for whey and N X 5.32 for collagen), supplied by the test protein only, for 4 wk. Rats of the Sprague-Dawley strain (5 per group) were used. Casein was fed as the protein in the control diet for each PER Trial. The PER values were corrected to that of casein at 2.5. Standard deviation was determined and Duncan Multiple Range tests were calculated on the actual PER values before correction to 2.5.

RESULTS & DISCUSSION

BEEF fatty tissue ranges around 85–93% fat, 6–13% water and 2–3% protein. Fatty tissue with meat would contain considerably less fat and more protein and water, depending on the percent of meat present. During low-temperature rendering, the fat cellular tissue retains some fat and only relatively small quantities of water are evaporated. The resulting tissue residues contain appreciable quantities of fat and water, and proteins in the range 18.0–24.0%. The proteins are those of connective tissue, principally collagen, and those of muscle tissue, which include about 1% collagen, proteins of the actomyosin complex, and water-soluble proteins, such as myoglobin, enzymes and nucleoproteins.

Products as received

All partially defatted products appeared to be rope-like extrusions, about 1-1/2 in. in diameter, coiled into a corrugated box and hard frozen. The chopped beef products were light beige and pinkish in color. The beef fatty tissue products were pinkish to reddish brown in color.

Table 1 shows the proximate analyses

ance of the protein in a food product is 45g if the PER of the total protein in the product is equal to, or greater than that of casein; and 65g if the PER of the total protein in the product is less than that of casein. Total protein in a food product with a PER less than 20% of the PER of casein is to be labeled "not a significant source of protein" (Federal Register, 1973). These considerations indicate that a partially defatted chopped beef with a PER of 2.38 would be nutritionally acceptable when used alone although is is not the equal of meat (PER 2.85). The other partially defatted chopped beef and the partially defatted beef fatty tissue products would be acceptable as food ingredients, provided they are blended with meat, whey protein concentrate, or vegetable protein foods, the amino acid composition of which supplements the amino acids of the partially defatted products.

REFERENCES

AOAC. 1970. "Official Methods of Analysis," 11th ed. Association of Official Agricultural Chemists, Washington, D.C.

Christianson, G. 1961. Process for recovering protein from fatty tissue. U.S. Patent 3,008,831.

Derse, P.H. 1965. Evaluation of protein quality (Biological Method). JAOAC 48: 847.

Downing, F.P. 1958. Process for rendering animals fat. U.S. Patent 2,823,215.

Downing, F.P. 1959. The production of meat and fat products through centrifugal rendering. J. Amer. Oil Chem. Soc. 36: 319.

Eastoe, J.E. 1967. Composition of collagen and allied proteins. In "Treatise on Collagen," Vol 1, p. 31. Academic Press, New York, N.Y.

Federal Register. Jan. 19, 1973. Dept. of Health, Education and Welfare, Food & Drug Adm. Food Labeling. 38(13): 2131.

Kramer, A.J. 1954a. Rendering fat. U.S. Patent 2,697,113.

Kramer, A.J. 1954b. Method of removing protein from fatty tissue. U.S. Patent 2,-697,112.

Little, T.H. and Milleville, H.P. 1963. New lean raw meat product. Food Processing 24(2): 60.

Liu, T.-Y. and Chang, Y.H. 1971. Hydrolysis of proteins with p-toluenesulfonic acid. J. Biol. Chem. 246: 2842.

Orsi, L. October 5, 1957. Beef fat fast. Nat. Prov. 137: 116.

Pavia, C. 1950. (to Pavia Process Inc.) Rendering fats. U.S. Patent 2,516,071.

Piez, K.A. and Morris, L. 1960. A modified procedure for the automatic analysis of amino acids. Anal. Biochem. 1: 187.

Rama Rao, P.B., Norton, H.W. and Johnson, B.C. 1961. The amino acid composition and nutritive value of proteins. J. Nutrition. 73: 38.

Rose, W.C. and Wixom, R.L. 1955a. The amino acid requirements of man. 13. The sparing effect of cystine on the methionine requirement. J. Biol. Chem. 216: 763.

Rose, W.C. and Wixom, R.L. 1955b. The amino acid requirements of man. 14. The sparing effect of tyrosine on the phenylalanine requirement. J. Biol. Chem. 217: 95.

Rose, W.C. and Wixom, R.L. 1955c. The amino acid requirements of man. 16. The role of nitrogen intake. J. Biol. Chem. 217: 997.

Schweigert, B.S. and Payne, B.J. 1956. A summary of the nutrient content of meat. Amer. Meat Inst. Fnd. Bull. No. 30.

Sullivan, F.E. 1959. Continuous low-temperature rendering process. J. Amer. Oil Chem. Soc. 36: 70.

Swift, C.E. and Hankins, O.G. 1952. Rendering lard at low temperatures. Food Technol. 6: 161.

Ms received 5/22/74; revised 8/22/74; accepted 8/26/74.

The authors thank the ERRC Engineering Div. for freeze drying samples of lean beef, PD chopped beef and PD beef fatty tissue and collagen for use in these studies, and for the lactose analysis of the whey protein concentrate.

The authors thank Stauffer Chemical Co. for a sample of whey protein concentrate and Central Soya for a sample of soy protein concentrate.

Reference to brand or firm name does not constitute endorsement by the U.S. Dept. of Agriculture over others of a similar nature not mentioned.

Table 4—Rat PER data on PD beef products, lean beef, a whey protein concentrate, a soy protein concentrate, collagen, casein and combinations of these protein sources[a]

Dietary protein source[b,c]			Final mean body wt[e]	PER[f]	
No.	Description	% Nitrogen digestibility[d]	g ± std dev	Actual std dev[g] ±	Corrected
5	PDCCCB	92	182 ± 21	3.66 ± 0.25^{B}(1)[h]	2.58
6	PDCB	90	179 ± 15	3.38 ± 0.11^{B}(1)	2.38
2	PDCB	90	103 ± 4	2.28 ± 0.11^{C}(1)	1.61
3	PDBFT	85	117 ± 11	2.42 ± 0.17^{C}(1)	1.70
4	PDBFT	91	117 ± 13	2.39 ± 0.19^{C}(1)	1.68
1	PDBFT	88	84 ± 6	1.61 ± 0.19^{D}(1)	1.13
	LB	93	231 ± 15	4.05 ± 0.12^{A}(1)	2.85
	Collagen	88	43[i] ± 1	Wt loss (1)	—
	Casein	94	146 ± 15	3.55 ± 0.16^{B}(1)	2.50
	WPC	90	192 ± 23	3.84 ± 0.20^{A}(3)	2.74
	Casein	—	172 ± 13	3.51 ± 0.17^{B}(3)	2.50
	SPC	90	142 ± 21	3.05 ± 0.19^{CD}(5)	2.18
			Protein combinations		
	2/3 LB + 1/3 of #1	88	182 ± 20	3.24 ± 0.22^{CDE}(4)	2.40
	2/3 LB + 1/3 of #2	90	194 ± 34	3.39 ± 0.26^{A}(2)	2.46
	2/3 LB + 1/3 of #3	89	199 ± 20	3.50 ± 0.14^{A}(2)	2.54
	Casein	94	168 ± 15	3.45 ± 0.16^{A}(2)	2.50
	2/3 WPC + 1/3 of #1	86	162 ± 14	3.47 ± 0.24^{BC}(4	2.57
	2/3 WPC + 1/3 of #3	88	187 ± 10	3.68 ± 0.08^{AB}(4	2.72
	Casein	93	164 ± 24	3.38 ± 0.31^{BCD}(4)	2.50
	2/3 SPC + 1/3 of #1	86	141 ± 7	2.78 ± 0.09^{D}(5)	1.99
	2/3 SPC + 1/3 of #3	87	139 ± 11	2.79 ± 0.13^{D}(5)	1.99
	1/4 LB + 1/4 WPC + 1/4 SPC + 1/4 of #1	88	194 ± 24[j]	3.47 ± 0.14^{B}(5)	2.48
	1/4 LB + 1/4 WPC + 1/4 SPC + 1/4 of #3	89	219 ± 5	3.67 ± 0.06^{AB}(5)	2.62
	Casein	93	173 ± 19	3.50 ± 0.14^{B}(5)	2.50

[a] Rat feeding tests ran 27 or 28 days
[b] All diets contained 10% protein
[c] Product code: PDCCCB, partially defatted cured cooked chopped beef; PDCB, partially defatted chopped beef; PDBFT, partially defatted beef fatty tissue; LB, lean beef; WPC, whey protein concentrate; SPC, soy protein concentrate
[d] Nitrogen digestibility = N intake − fecal N/N intake X 100.
[e] Five weanling male rats per group. Initial age, 21 days; initial mean body weight, 54, 55, or 56g
[f] PER = protein efficiency ratio = weight gain (grams)/ protein intake (grams)
[g] Within each PER trial, means without a superscript letter in common are significantly different. Probability = <0.01.
[h] (1) = PER trial No.
[i] Data on three rats, one death
[j] Data on four rats

(1956). They found that the 18 amino acids assayed accounted for approximately 85% of the total nitrogen present in the meat.

There was no significant difference between the PER values of one chopped beef (2.38) and of the cured cooked chopped beef product (2.58) or between either one and the PER for casein (2.5). Chopped beef samples by definition or requirement are prepared from materials containing 12% or more separable lean; it can be presumed that the lean beef protein in the chopped beef samples reflects the percentage of protein from this source. One chopped beef, product 2, and two beef fatty tissue products had significantly lower PER values, 1.61, 1.70 and 1.68, respectively. There was no significant difference between these three. One beef fatty tissue had a low PER value, 1.13, significantly different from the values for all other products and lean beef. The results indicate that a statistically significant variation existed between beef fatty tissue products, undoubtedly relating back to variations in the stock material rendered.

PER values for combinations of proteins were: 2.40 for 2/3 of the protein supplied by lean beef and 1/3 by product 1, beef fatty tissue; 2.46 for 2/3 supplied by lean beef and 1/3 by product 2, chopped beef; and 2.54 for 2/3 supplied by lean beef and 1/3 by product 3, beef fatty tissue. These values were significantly greater than those of the three products separately, and were close to or the same as that of casein at 2.5.

The PER value was 2.57 when 2/3 of the protein was supplied by a whey protein concentrate and 1/3 by product 1, beef fatty tissue, and was 2.72 when 1/3 of the protein was supplied by product 3, another beef fatty tissue. These values were significantly greater than the value for either beef fatty tissue product separately.

PER values for combinations of two proteins, 2/3 from a soy protein concentrate and 1/3 from either product 1 or product 3, were 1.99. The data indicate that the proteins of lean beef or the whey concentrate supplement the PD beef fatty tissue proteins better than the proteins of the soy concentrate.

PER value for a combination of proteins, 1/4 from lean beef, 1/4 from whey protein concentrate, 1/4 from soy protein concentrate, and 1/4 from either product 1 or product 3 was the same or better than that of casein.

The U.S. Recommended Daily Allow-

of the six partially defatted products and the lean beef sample. The fat content, approximately 17%, and the moisture content, 60.7–63.7% of the three PD beef fatty tissue products were fairly uniform. There was greater variation of fat and moisture in the PD chopped beef products. Generally, the moisture present was inversely proportional to the fat. When the analyses were calculated on a moisture-free basis (m.f.b.), each type product tended to have a distinctive compositional pattern.

Products after freeze drying

The dried and ground PD products had a ground-fiber appearance. The beef fatty tissues were mainly brown with a reddish tint with some light colored material intermixed. The chopped beef and cured cooked chopped beef were mainly beige intermixed with brown. Lean beef was uniformly light brown with a reddish tint.

Bacteriological tests, conducted to determine the wholesomeness of the materials, indicated that after freeze drying all products, lean beef and collagen were negative for coliforms and Salmonellae except one chopped beef product which had a count of 23 coliforms per gram.

The proximate analytical data are in Table 2. When the proximate data are calculated m.f.b., there is agreement between the nitrogen, fat and ash analyses of the products as received (Table 1) and after freezing drying (Table 2), excepting the cured cooked chopped beef. This product was extracted with Skellysolve F to lower the fat, which facilitated grinding and produced a more uniform sample.

Table 3 shows the amino acid composition grouped as essential and nonessential amino acids, and PER values for the proteins of each product, and of lean beef and collagen. Histidine is included in the list of essential amino acids because it is essential in the rat diet. Cystine and tyrosine also have been included with the essential amino acids because cystine can replace part of the methionine requirement and tyrosine part of the phenylalanine requirement (Rama Rao et al., 1961; Rose and Wixom, 1955a, b).

The data show that in these partially defatted products and collagen, the quantity of nonessential amino acids varies, and that this variation is largely accounted for by the differences in glycine, hydroxylysine and hydroxyproline. Collagen has the greatest amounts of these three nonessential amino acids (Table 3). Lean beef and the products with the highest totals of essential amino acids, one chopped beef and the cured cooked chopped beef, had the lowest quantities of glycine and little or no hydroxylysine and hydroxyproline, indicating that the collagen content was low in these products. The amounts of glycine, hydroxylysine and hydroxyproline in the other chopped beef and the three beef fatty tissue products indicate that the proteins of these products contained larger amounts of collagen.

Table 3—Amino acid analyses and PER values of PD beef products, lean beef and collagen (Grams of amino acid residue per 100 grams of total amino acid residues)[a]

		Partially defatted products						
		Chopped beef			Beef fatty tissue			
Amino acid	Lean beef	Cooked, cured 5	6	2	3	4	1	Collagen
		Essential amino acids						
His	3.6	2.9	3.0	2.1	1.8	1.9	1.9	0.8
Ile	5.0	5.2	4.1	3.2	2.9	2.7	2.6	1.6
Leu	8.3	7.8	7.2	6.1	5.8	5.7	5.3	3.0
Lys	8.8	8.6	7.9	5.3	5.3	5.2	4.9	3.7
Met	2.6	2.7	1.9	1.2	1.3	1.2	1.0	0.7
1/2 Cys	1.3	1.0	1.0	1.3	1.1	1.1	0.9	–
Phe	4.9	4.4	4.2	3.9	3.8	3.6	3.4	2.1
Tyr	3.9	3.7	3.1	2.3	2.3	2.2	2.0	0.9
Thr	4.4	4.2	3.8	2.7	3.0	3.2	2.7	1.9
Tryp	1.3	0.7	0.6	trace	trace	trace	trace	–
Val	5.5	4.6	4.6	5.8	4.8	4.9	4.6	2.3
Total	49.6	45.8	41.4	33.9	32.1	31.7	29.3	17.0
		Nonessential amino acids						
Ala	6.0	5.9	6.4	8.9	7.9	8.4	8.5	8.6
Arg	6.5	7.3	7.5	6.8	7.1	6.7	7.2	8.6
Asp	9.6	9.2	8.6	6.5	7.3	7.1	6.7	5.7
Glu	15.7	15.0	14.5	10.7	11.3	11.6	10.6	10.2
Gly	4.9	6.0	8.6	14.9	14.6	15.3	16.5	21.5
Hyl	–	0.7	1.0	0.9	0.8	0.9	1.1	1.3
Hyp	–	1.8	2.9	5.6	6.5	6.4	7.0	10.8
Pro	4.2	4.6	5.7	8.8	9.3	8.5	9.9	13.3
Ser	3.6	3.7	3.7	3.0	3.4	3.5	3.3	3.0
Total	50.5	54.2	58.9	66.1	68.2	68.4	70.8	83.0
Approx % of total N accounted for	81.9	88.5	82.7	85.8	83.6	84.0	85.6	92.8
PER value	2.85	2.58	2.38	1.61	1.70	1.68	1.13	<0

[a] Grams of amino acid residue per 100 grams of total amino acid residues may be converted to grams amino acid residue/100 grams of protein by multiplying by the % total nitrogen accounted for, and dividing by 100. For example, the value for histidine in lean beef becomes 2.95.

Although the sum of glycine, hydroxylysine and hydroxyproline varies among lean beef and the six products, the totals of the remaining nonessential amino acids remain rather constant, ranging from 44.7–46.4%. The total nonessential amino acids supply nitrogen for the synthesis in the body of any nonessential amino acids which may be lacking (Rose and Wixom, 1955c).

Results of the PER tests are shown in Table 4. Based on nitrogen digestibility, the range was 85–93% indicating that the observed nutritional value of the product proteins should be related directly to their amino acid composition. Such a relationship between the amino acid composition of each product analyzed and its PER value is apparent from the data. Examination of the PER values of these products and lean beef shows they are directly proportional and highly correlated (r = 0.97) to the total quantity of essential amino acids present. The proportion of each essential amino acid present to the total essential amino acids also can be expected to be reflected in the PER values. In fact, the correlation coefficient (r) of the linear regression ranges from 0.92–0.98 for the individual essential amino acids excepting valine. A correlation coefficient could not be calculated for tryptophan.

The data further indicate that the presence of small amounts, even traces, of tryptophan, the most limiting amino acid in partially defatted products, had a strikingly beneficial effect on the PER value.

Lean beef had the highest essential amino acid composition and the highest PER value, 2.85, significantly better than those of the six products. It is included as a reference meat protein and, as intended, supplied a parameter for interpreting the data. This amino acid analysis of lean beef is similar to that of Schweigert and Payne