would be similar in digestibility, regardless of the season of the year in which it was produced.

There has been considerable research to prove that the digestibility of western range grasses decreases with advance in season. Patton and Giesker (*4*) reported an increase of lignin in Montana grasses from 5% in May to 18% in September. They sampled the entire season's growth, however, making the grass cut in September 4 months older than that cut in May. Striking changes in physiological development of the plants also occurred during their test period. Grass cut in May, for example, was described as "snow disappearance to flower stalks first in evidence," whereas that cut in September had "seedheads shattered." Thus, it is believed that seasonal differences in digestibility and lignin content previously observed have been largely the result of differences in age and stage of development on the grass rather than a result of seasonal changes in temperature and rainfall.

The data in Table II show an interesting and highly significant interaction between clipping frequency and nitrogen level as they affect the lignin content of Coastal Bermuda grass. When the grass was clipped at 2-week intervals, increasing rates of nitrogen decreased the lignin content of the forage harvested, but at 6- and 8-week intervals, lignin tended to increase with increasing increments of nitrogen. When fertilized with 100 pounds or less of nitrogen per acre, 8-week-old grass contained no more lignin than 2- and 3-week-old grass. When fertilized at the heavier rates, the lignin content of the grass increased noticeably with its age.

A partial explanation for these results may be found in the effect of these treatments upon the leafiness of the forage harvested (*5*). As Coastal Bermuda stems contain more lignin than the leaves (12.88 *vs.* 10.88% in 8-week-old grass), any treatment that would increase the stem percentage might also be expected to increase the lignin content. When the grass was clipped at 2-week intervals, leaf percentages did not change—ranging from 84.1 to 85.4% with nitrogen increases from 0 to 900 pounds per acre. Leaf percentages decreased from 64.8 to 49.1 with increased rates of nitrogen when the grass was cut at 8-week intervals. With no nitrogen, leaf percentages dropped from 84.1 to 64.8% with increasing age; whereas they dropped from 85.4 to 49.1% with age when fertilized with 900 pounds of nitrogen per acre. As changes in leaf percentage did not always result in lignin changes, other factors, as yet unknown, influenced the lignin development in this study.

The data presented in Table III show that the digestibility of the Coastal Bermuda cut in 1954 generally decreases as the length of the clipping period or age of the grass increased. The big drop in digestibility occurred, however, between the 6- and 8-week-old hay, suggesting that no more than 6 weeks should elapse between cuttings where high quality hay is sought. The close negative correlation between the crude-fiber content of the hay (Table IV) and its total digestible nutrients (TDN) content is interesting. Although lignin analyses of the forage collected in 1954 were not made, they would probably have been similar to those obtained in 1953. As the forage fed the lambs in this digestion trial received 600 pounds of nitrogen per acre in 1954, the lignin analyses in Table II for forage receiving 600 pounds of nitrogen per acre should be applicable. These data show a linear increase in lignin content from 9.45% for 2-week-old grass to 12.05% for 8-week-old grass. With the exception of the 8-week-old grass, the Coastal Bermuda forage exceeded the annual lespedeza check in digestibility. A full ration (rather than the maintenance ration fed) might have decreased the digestion coefficients slightly, but it should not have altered the relative performance of the hays studied.

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AMINO ACIDS IN FOODS

Cystine, Tyrosine, and Essential Amino Acid Content of Selected Foods of Plant and Animal Origin

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In recent years, emphasis has been placed on the evaluation of protein quality, rather than the total quantity of protein in foods. This is indeed a timely approach, as utilization of the amino acids, which are constituents of protein, is dependent on all of the essential amino acids being present simultaneously and in proper proportions. More information on the amino acid composition of foods commonly consumed is necessary to evaluate these foods as sources of protein in the diet. This approach is also of value in practical nutrition education programs, where it may be possible to recommend foods, individually, which may be low in specific amino acids, but which supplement each other when eaten at the same time. Thus, knowing the amino acid composition of ordinary foods in the diet, the nutritionist may be able to raise the level of health and well being through assisting the population in specific areas to achieve a good state of protein nutrition without altering the basic dietary pattern.

This work represents the second in a series of determinations of the moisture, ash, total nitrogen, and amino acid contents of selected foods, including grain, meat, milk, and vegetable products. Foods reported in the first investigation (*3*) were commonly consumed in the southeastern section of the United States. Those reported herein are generally consumed throughout the country. Determinations of 10 essential and two other important amino acids, cystine and tyrosine, are reported for 20 foods.

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Twenty foods commonly consumed in the United States have been analyzed for 12 amino acids, total nitrogen, moisture, and ash. Using whole egg as a standard to evaluate the foods, on the basis of 100 grams, corn-soya, cottage cheese, and liverwurst were rated as excellent suppliers of the essential amino acids, with few exceptions. However, when menus cannot be based on protein of excellent quality, diets should be planned to include, simultaneously, two or more foods rated as good or fair sources of the amino acids.

Experimental Procedures

All of the foods (brand names are available upon request) analyzed in this project were purchased on the local market, with exception of light and dark rye flour. The quantities of grain, meat and milk products, and vegetables purchased were approximately 100 times those used for preparation of hydrolyzates. The total quantity of each food was carefully mixed before subsamples were taken for assay.

The buckwheat flour was made of pure buckwheat, grown in Minnesota, harvested in 1953, and milled by the regular roller milling process. The cornflakes were made of flaked, milled corn. Degermed white corn meal was used as a source of corn meal. The corn-soya was ribbon-milled. Plain macaroni was made from No. 1 Semi-nola. The noodles were made from Durum fancy patent flour, containing 5.5% egg solids. Long-grain converted rice served as a source of converted rice. Both light and dark rye flour were pure, and were provided by the B. A. Eckhart Milling Co., Chicago, Ill. The wheat flakes and shredded wheat were made of whole wheat.

Bologna, frankfurters, and liverwurst were prepared from all meat products. The buttermilk was pasteurized and cultured. Cottage cheese was also pasteurized and creamed. The cream cheese was pasteurized with vegetable gum added.

The lima beans were fresh, and were analyzed 1 day after picking. The pork and beans and baked beans were canned and baked in tomato sauce.

Determination of Moisture. Moisture assays on fresh foods were conducted within 2 to 3 hours after the foods were purchased. Three to five weighed fresh samples of each food were heated to constant weight in glass weighing bottles in a vacuum oven at 50° to 60° C. Moisture was calculated as per cent of the fresh weight of the sample.

Because they could be obtained only at specific times in the year, small weighed quantities of fresh lima beans were frozen and stored at −10° C. for future assays of amino acids.

Determination of Ash. Three to five fresh or dried samples of the foods were ashed to constant weight in a muffle furnace in platinum or porcelain crucibles. Ash was calculated as per cent of the original fresh weight of the sample.

Determination of Total Nitrogen. Nitrogen analyses on all foods were conducted by a modified Kjeldahl-Gunning procedure. Three to eight fresh samples of all foods were digested for 2 hours with 25 ml. of concentrated sulfuric acid and 15 grams of a potassium sulfate–mercuric oxide catalyst. After cooling and addition of 200 ml. of tap water, an excess of concentrated sodium hydroxide–sodium sulfide solution and a few grains of zinc were added. The samples were distilled into a 4.5% boric acid solution and titrated with standard 0.1*N* hydrochloric acid, using a methylene blue–methyl red indicator.

Nitrogen was calculated as per cent of the fresh sample. Values for total nitrogen, moisture, and ash represent the average of five to eight assays which were in excellent agreement.

Preparation of Acid Hydrolyzates. Samples of all foods, containing 1 gram of protein, were refluxed for 24 hours after the addition to each of 35 ml. of 20% hydrochloric acid. After cooling, the pH of the samples was adjusted to 4.0. They were made to a volume of 100 ml. and filtered through a fritted-glass funnel of medium porosity.

For the assay of cystine, the foods were hydrolyzed with acid for only 2 hours, as recommended by Horn (*6*). In other respects, the procedure for acid hydrolysis was the same as listed previously.

Fat was extracted from bologna, buttermilk, cottage and cream cheese, frankfurters, liverwurst, and pork and beans with ethyl ether.

At the time of assay, aliquots of the hydrolyzed food solutions were adjusted to pH 6.8 and diluted to convenient concentrations. Assays of arginine, cystine, histidine, lysine, methionine, phenylalanine, threonine, tryptophan, and tyrosine were conducted immediately after preparation of hydrolyzates. Those for other amino acids were conducted within 7 to 10 days.

In foods where the ratio of carbohydrate to protein exceeds 1 to 1, higher values are often obtained when alkaline hydrolyzates are used for tryosine assay. For this reason, preliminary tyrosine assays were conducted on both acid and alkaline hydrolyzates of all foods. However, the values obtained were consistently higher after acid hydrolysis. Therefore, acid hydrolyzates were used for all subsequent tyrosine assays, and for determinations of all amino acids except tryptophan.

Preparation of Alkaline Hydrolyzates. Alkaline hydrolyzates were used in tryptophan assays. For each sample, 100 mg. of L-cysteine hydrochloride was added to 16 ml. of 4*N* sodium hydroxide, and the solution was autoclaved at 15-pound pressure for 1 hour, according to the method of Lyman and Kuiken (*8*). While the solution was hot, another 100-mg. portion of cysteine was added along with the sample to be hydrolyzed. Autoclaving was then continued for 16 hours.

After the samples had cooled, the pH was adjusted to 4.0. They were made to a volume of 100 ml. and filtered through a fritted-glass funnel of medium porosity.

Microbiological Assay. Barton-Wright's modification of the basal medium of Schweigert (*10*) was used for the assay of leucine, isoleucine, and valine, employing *Lactobacillus arabinosus* 17-5. The basal medium of Greenhut (*4*) was used for the assay of arginine, with *Streptococcus faecalis* serving as the assay organism. Histidine, lysine, phenylalanine, methionine, and tyrosine assays were conducted by the methods of Barton-Wright (*1*, *2*) with *Leuconostoc mesenteroides* P-60. Barton-Wright's basal medium (*2*) was used for the assay of tryptophan, employing *L. arabinosus* 17-5. The basal medium of Stokes (*11*) was used for the determination of threonine with *Streptococcus faecalis* serving as the assay organism. Cystine was determined by the method of Horn (*6*), employing *L. mesenteroides* P-60.

U. S. Pharmacopeia standards were used as reference amino acids in assays of isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. The samples of arginine, cystine, histidine, and tyrosine for standard curves were secured from Nutritional Biochemicals, Inc. L forms were used in all assays.

Three tubes were assayed on each of 13 levels of the standard, whereas two tubes were assayed on each of five levels of the food hydrolyzates.

The tubes were capped with aluminum thimbles, placed in labeled wire racks, and sterilized at 10-pound pressure for 10 minutes. After they had cooled,

one drop of inoculum was aseptically added to each.

Inoculated tubes were incubated at 30° C. for 72 hours, after which growth was inhibited by refrigeration. The tubes were allowed to come to room temperature and titrated to pH 7.0 using a Beckman pH meter.

Three freshly hydrolyzed samples of bologna, frankfurters, and liverwurst, purchased at different times, were assayed for the 12 amino acids. This was also true of baked beans, buttermilk, cottage and cream cheese, and pork and beans.

Four to five hydrolyzed fresh samples of buckwheat, cornflakes, cornmeal, corn-soya, lima beans, macaroni, noodles, rice, shredded wheat, and wheat flakes from the same original lots were assayed, whereas three hydrolyzed fresh samples of light and dark rye flour were used.

Discussion

Assays of total nitrogen, moisture, and ash in 20 selected foods are given in Table I.

The amino acids studied included the eight which are at present considered to be essential for the human adult—isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Foods were also analyzed for cystine and tyrosine which have partial replacement value for methionine and phenylalanine, respectively, and arginine and histidine, which may be essential in infancy and childhood. These data are given in Table II as grams of amino acid per 100 grams of crude protein (calculated to 16% nitrogen), and as grams of amino acid per 100 grams of food in Table III.

Comparison of Amino Acid Content of Foods on the Basis of 100 Grams of Protein. Determinations of the amino acid content of macaroni, noodles, shredded wheat, and wheat flakes are in close agreement with comparable values for whole wheat published by Horn and coworkers (7). The values for degermed cornmeal are also similar to those reported by these workers for whole corn, except in phenylalanine and tyrosine contents. In contrast, the amino acids in converted rice are all lower than figures reported by Horn and associates, suggesting that the amino acid content of converted rice is lower than that of regular white rice.

Concentrations of histidine, cystine, isoleucine, leucine, lysine, methionine, threonine, tryptophan, and valine in cream and cottage cheese are similar to each other and comparable to literature values for casein (7). The amino acid content of cottage cheese was similar to that of skim milk powder, except in the case of arginine.

A somewhat higher value for the valine content of lima beans, 6.74%, was obtained in this investigation than by Horn and associates, 5.78% (5), for the analysis of this legume.

Schweigert (9) has reported data for amino acids in bologna and frankfurters. The total nitrogen content obtained for bologna in this investigation, 2.05%, is in excellent agreement with the value of 2.07% calculated from Schweigert's report. The amino acid contents of meat products such as bologna, liverwurst, and frankfurters, may be expected to vary in samples purchased at different times on the market if the amounts of collagen and elastin in these samples differ. In comparison to muscle meat, collagen is high in arginine and elastin is high in valine; both are low in all other essential amino acids.

The values obtained for bologna are comparable to those of muscle meat. Frankfurters were lower than muscle meat in all amino acids except arginine, suggesting that meat of a higher collagen content may have been used in the preparation of the lots of frankfurters assayed. In contrast, liverwurst was found to be low only in methionine when compared to muscle meat.

The lysine and phenylalanine contents of canned baked beans were lower than those of canned pork and beans, though values for other amino acids compared favorably.

Comparison of Amino Acid Content of Foods on the Basis of 100 Grams of Food. Whole egg was used as a basis for the evaluation of the amino acid content of the foods on the basis of 100 grams of the food. In an earlier investigation (3), egg white and egg yolk were assayed for amino acids. The values for whole egg were calculated from the data on egg white and egg yolk, using 31 grams of white and 17 grams of yolk as the proportions of these components in whole egg.

When 100 grams of a food contained 100% or more of the quantity of the amino acid in 100 grams of whole egg, the food was rated as an excellent source of that amino acid. Similarly, if the food contained 75 to 99% of the quantity of the amino acid in whole egg, it was rated as a good source. Those foods listed as fair sources contain 50 to 74% of the amino acids in whole egg, whereas poor sources contain less than 50%.

When the foods are appraised, corn-soya appears to be an excellent supplier of the essential amino acids, with the exception of methionine and tryptophan, in which this food is rated good. As corn-soya is also an excellent source of cystine, the supplementary relationships which exist between this amino acid and methionine may operate to provide better than average sources of the latter amino acid. Similarly, cottage cheese also proved to be an outstanding source of the essential amino acids, being rated excellent in all except arginine.

In sharp contrast, however, the amino acids contained in cream cheese were usually rated poor or fair. Buttermilk, because of a high percentage of water, is a poor source of the amino acids on the basis of 100 grams of the food.

Liverwurst proved to be an excellent source of essential amino acids, with the

Table I. Total Nitrogen, Moisture, and Ash Contents of Selected Foods

Food	Total Nitrogen, %	Moisture, %	Ash, %
	Grain Products		
Buckwheat flour	1.82	9.65	1.82
Corn flakes	1.11	9.47	0.33
Corn meal (degermed)	1.14	7.40	0.44
Corn-soya	2.87	5.41	1.21
Macaroni	1.85	10.34	0.54
Noodles	1.99	9.55	0.88
Rice (converted)	1.15	6.50	0.61
Rye flour (dark)	2.67	6.95	2.50
Rye flour (light)	1.49	8.62	0.60
Wheat flakes	1.59	4.88	2.91
Wheat (shredded)	1.62	7.04	1.59
	Meat Products		
Bologna	2.05	50.23	1.71
Frankfurters	2.14	60.67	0.79
Liverwurst	2.34	41.58	1.87
	Milk and Milk Products		
Buttermilk	0.51	90.20	0.63
Cottage cheese	2.18	78.63	0.86
Cream cheese	1.05	52.78	0.80
	Vegetables		
Beans (canned baked)	1.20	62.23	1.45
Lima beans (fresh)	1.02	71.20	0.92
Pork and beans	1.05	69.59	1.56

Table II. Per Cent Amino Acids in Selected Foods[a]

Food	Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenylalanine	Tyrosine	Threonine	Tryptophan	Valine
Grain Products												
Buckwheat flour	7.74	2.29	4.04	6.07	6.15	1.58	1.23	3.34	2.02	3.52	1.05	5.27
Corn flakes	1.73	2.45	3.60	12.54	0.43	2.02	1.87	3.75	2.02	3.17	0.29	4.47
Corn meal (degermed)	3.79	3.09	3.79	12.21	2.53	1.96	2.11	4.35	2.11	3.65	0.28	5.19
Corn-soya	5.46	2.62	4.68	9.20	4.29	1.51	1.73	4.63	3.12	4.40	0.89	5.85
Macaroni	4.15	2.16	4.58	6.05	2.94	1.38	1.73	4.76	2.51	3.55	0.86	4.76
Noodles	4.50	2.17	4.50	6.03	2.97	1.53	1.77	4.42	2.25	3.86	0.96	4.82
Rice (converted)	5.70	1.95	4.03	7.23	3.62	2.09	1.81	4.31	2.64	3.90	1.11	5.70
Rye flour (dark)	4.85	2.28	4.02	6.77	3.66	1.32	1.92	3.84	2.04	3.66	0.72	4.85
Rye flour (light)	3.44	2.15	4.08	7.09	3.54	1.40	1.72	4.72	1.29	4.19	0.54	4.83
Wheat flakes	4.13	1.91	4.23	6.24	2.01	1.21	1.61	4.33	1.81	3.42	0.81	4.63
Wheat (shredded)	4.84	2.17	4.15	6.32	3.06	1.28	1.88	4.44	2.17	3.75	0.79	5.04
Meat Products												
Bologna	7.89	2.97	5.31	7.57	9.44	2.26	1.01	4.14	3.04	5.07	0.86	6.17
Frankfurters	6.95	2.54	4.26	7.03	7.55	1.57	1.05	2.92	2.47	3.44	0.52	4.19
Liverwurst	5.74	3.15	4.92	8.34	8.41	2.05	1.03	4.44	2.53	4.58	1.09	6.22
Milk and Milk Products												
Buttermilk	4.08	3.14	6.27	10.98	10.04	2.51	0.94	6.27	5.33	5.33	1.25	7.84
Cottage cheese	4.84	3.30	5.94	10.94	8.59	2.79	0.88	5.50	5.50	4.77	1.10	5.87
Cream cheese	3.50	3.20	5.94	10.51	8.23	2.59	0.91	6.25	4.57	4.57	0.91	6.10
Vegetables												
Beans (canned baked)	5.87	2.27	4.40	7.47	4.93	0.80	0.40	4.53	2.53	4.13	0.93	4.27
Lima beans (fresh)	6.43	3.29	5.18	8.16	6.90	1.25	1.10	5.49	3.45	5.18	1.10	6.74
Pork and beans (canned baked)	4.27	3.20	5.03	8.38	6.10	1.07	0.30	5.79	2.90	4.72	0.91	5.33
Whole egg[b]	6.5	2.1	4.4	9.4	6.0	3.1	1.7	5.6	5.0	5.0	1.9	6.7

[a] All results are expressed in grams per 100 grams of crude protein, calculated to 16% nitrogen.
[b] Calculated from previously published data on egg white and egg yolk (*3*), using 31 grams of white and 17 grams of yolk as components of whole egg.

Table III. Per Cent Amino Acids in Selected Fresh Foods

Food	Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenylalanine	Tyrosine	Threonine	Tryptophan	Valine
Grain Products												
Buckwheat flour	0.88	0.26	0.46	0.69	0.70	0.18	0.14	0.38	0.23	0.40	0.12	0.60
Corn flakes	0.12	0.17	0.25	0.87	0.03	0.14	0.13	0.26	0.14	0.22	0.02	0.31
Corn meal (degermed)	0.27	0.22	0.27	0.87	0.18	0.14	0.15	0.31	0.15	0.26	0.02	0.37
Corn-soya	0.98	0.47	0.84	1.65	0.77	0.27	0.31	0.83	0.56	0.79	0.16	1.05
Macaroni	0.48	0.25	0.53	0.70	0.34	0.16	0.20	0.55	0.29	0.41	0.10	0.55
Noodles	0.56	0.27	0.56	0.75	0.37	0.19	0.22	0.55	0.28	0.48	0.12	0.60
Rice (converted)	0.41	0.14	0.29	0.52	0.26	0.15	0.13	0.31	0.19	0.28	0.08	0.41
Rye flour (dark)	0.81	0.38	0.67	1.13	0.61	0.22	0.32	0.64	0.34	0.61	0.12	0.81
Rye flour (light)	0.32	0.20	0.38	0.66	0.33	0.13	0.16	0.44	0.12	0.39	0.05	0.45
Wheat flakes	0.41	0.19	0.42	0.62	0.20	0.12	0.16	0.43	0.18	0.34	0.08	0.46
Wheat (shredded)	0.49	0.22	0.42	0.64	0.31	0.13	0.19	0.45	0.22	0.38	0.08	0.51
Meat Products												
Bologna	1.00	0.38	0.68	0.97	1.21	0.29	0.13	0.53	0.39	0.65	0.11	0.79
Frankfurters	0.93	0.34	0.57	0.94	1.01	0.21	0.14	0.39	0.33	0.46	0.07	0.56
Liverwurst	0.84	0.46	0.72	1.22	1.23	0.30	0.15	0.65	0.37	0.67	0.16	0.91
Milk and Milk Products												
Buttermilk	0.13	0.10	0.20	0.35	0.32	0.08	0.03	0.20	0.17	0.17	0.04	0.25
Cottage cheese	0.66	0.45	0.81	1.49	1.17	0.38	0.12	0.75	0.75	0.65	0.15	0.80
Cream cheese	0.23	0.21	0.39	0.69	0.54	0.17	0.06	0.41	0.30	0.30	0.06	0.40
Vegetables												
Beans (canned baked)	0.44	0.17	0.33	0.56	0.37	0.06	0.03	0.34	0.19	0.31	0.07	0.32
Lima beans (fresh)	0.41	0.21	0.33	0.52	0.44	0.08	0.07	0.35	0.22	0.33	0.07	0.43
Pork and beans (canned baked)	0.28	0.21	0.33	0.55	0.40	0.07	0.02	0.38	0.19	0.31	0.06	0.35
Whole egg[a]	0.83	0.25	0.52	1.15	0.75	0.38	0.21	0.67	0.60	0.63	0.21	0.79

[a] Calculated from previously published data on egg white and egg yolk (*3*), using 31 grams of white and 17 grams of yolk as components of whole egg.

exception of tryptophan. The quantities of amino acids supplied by frankfurters and bologna were usually rated fair; however, bologna proved to be a somewhat better source than frankfurters.

Dark rye flour contains three of the essential amino acids (histidine, isoleucine, and valine) in excellent quantities, and was usually rated as a good source of others. This is in marked contrast to light rye flour, which appeared to be a poor to fair source of the amino acids.

On the basis of 100 grams of the food and food protein, macaroni, noodles, wheat flakes, and shredded wheat were similar in contents of all amino acids, except lysine, which was considerably lower in wheat flakes. Lima beans provided a better source of cystine and valine than either canned baked beans or pork and beans, both on the basis of fresh weight and protein.

Fresh lima beans, baked beans, and pork and beans are similar in their contents of amino acids, being usually classified as poor or fair. This was also true of cornmeal, rice, and cornflakes, though cornmeal rated somewhat higher than the other two in this group.

The need for such evaluations of foods becomes apparent when one attempts to assess the protein quality of foods. When menus cannot be based on protein of excellent quality, planning of dietaries to include, simultaneously, two or more foods—which are classified as good or fair sources of the amino acids—may enable supplementary relationships to play an important role in the maintenance of good nutrition in the individual.

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NUTRITIVE VALUE OF MILK PRODUCTS

Growth and Reproduction of Rats on Diets of Evaporated Milks and a Vegetable Fat Milk Product

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Growth and reproduction studies were carried out with rats to compare the nutritive value of an experimental vegetable fat milk product with a conventionally processed and a high-temperature, short-time processed evaporated milk. Weanling rats maintained on the milk diets with minerals added grew well for 12 weeks. Second and third generations were successfully reared on the milk diets. Judged by the criteria of weight gain and reproduction performance, the milk product made from nonfat milk solids, vegetable fats, and water, and fortified with vitamins, was somewhat better nutritionally than the other two milks. The poorest performance was shown by the rats fed the conventional evaporated milk, which appeared to be inadequate to meet the needs of female rats during repeated gestation and lactation.

Milk is recognized as an important component of the diet, and its nutritional adequacy in both raw and processed forms has been investigated in several animal species. Raw milk supplemented with iron, manganese, and copper has been demonstrated to be adequate for normal growth and reproduction in rats (*3, 6*) and in dogs (*2*). Results reported by Bixby and coworkers (*3*) indicate that homogenized milk heated for 30 minutes at 165° F., dried whole milk, and a canned whole milk sterilized by a high-temperature, short-time process suffered little if any change in nutritive value.

Conflicting findings have been reported regarding the effects of the usual commercial processes of evaporation, sterilization, and spray-drying of milk. Cook and coworkers (*4*) found by rat growth methods that the nutritive value of milk proteins was slightly reduced by commercial methods of producing evaporated milk. Schroeder, Iacobellis, and Smith (*12*) used a nitrogen balance study in dogs to show that there was no decrease in digestibility or biological value due to the evaporation process. Nitrogen balance studies in rats, carried out by Whitnah (*13*), indicated very small differences in nutritive value between fresh, experimental evaporated, and commercial evaporated milks.

Similarly, Hodson (*8*) found no significant lowering of protein nutritive value in the sterilization of evaporated milk as measured by the rat repletion method, but later (*9*) reported slight differences when rat growth methods were used. In contrast, loss of some protein efficiency was incurred during preheating prior to the spray-drying proc-