NUTRITIVE VALUE OF CANNED FOODS

Vitamin B_6, Folic Acid, Beta-Carotene, Ascorbic Acid, Thiamine, Riboflavin, and Niacin Content and Proximate Composition

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Vitamin assays and proximate analyses were performed on canned food products in order to obtain values not available from the literature or to bring the number of samples studied in the National Canners Association–Can Manufacturers Institute program in line with geographical distribution and volume of production. Of 48 products for which 1 to 10 samples were assayed for vitamin B_6 on a basis of total edible contents, pineapple juice, corn, tomatoes, cherries, and meat products were found to contain the highest levels of this vitamin. Of 48 products tested, spinach, asparagus, beans, peas, blackberries, boned chicken, and oysters were highest in folic acid. In general, the β-carotene, ascorbic acid, thiamine, riboflavin, and niacin results checked values previously reported as did proximate analyses on 62 samples representing 15 products. These results substantiate old data and provide new information on canned food composition. They will be especially useful to nutritionists and dietitians in planning menus and feeding programs.

Quantitative data on the nutritive value of canned foods have become available more slowly than similar information on fresh foods. In 1942 the National Canners Association and Can Manufacturers Institute embarked on a nutrition program designed to provide data on amounts of nutrients in canned foods and the effect of preparatory procedures on certain vitamins (Phase I) and to study factors in producing and canning foods which influence their nutritive value (Phase II). These studies have been reported in a series of publications and discussed in two reviews (*15*, *16*). A comprehensive compilation of these data has been presented by Cameron and Esty (*8*).

A review in 1950 of data developed in the Phase I studies of this program revealed that the tables of nutrient composition of canned foods were somewhat out of balance with regard to the number of analyses for some products and for some vitamins. The analyses made up to that time were not in an orderly ratio with regard to annual production and usage and it was apparent that certain nonformulated products packed in substantial quantities were omitted from the previous program. The need for further work was also made obvious by the fact that advances had been made in analytical methods and in determining the significance of some of the newer vitamin factors in human nutrition.

On the basis of production ratios, the 1951 Phase I studies were therefore an effort to bring the total number of determinations of each vitamin for each product into a more correct relationship with the extent of production. New products introduced into the Phase I program at that time were as follows:

Apple juice	Cranberry sauce
Beans, wax	Fruit cocktail
Cherries, sweet	Fruit for salad
Chicken, boned	Lemon juice
Chili con carne	Olives
Clams	Peas, black-eyed
Corned beef hash	Potatoes, white
Crab	Pumpkin

Additional vitamin assays were run on a number of products to bring the number of assays up to that required by the production ratio or a minimum of five assays for each vitamin for each product.

The vitamin assays and proximate analyses reported herein are a continuation of the tables of composition of canned foods in accordance with the objectives previously defined.

Collection and Preparation of Samples

The general method of collecting the samples has been described by Clifcorn (*9*). The samples were shipped under code to the laboratories of the Wisconsin Alumni Research Foundation, Madison, Wis., where all the assay work was carried out.

The contents of six cans of each sample were used to prepare a composite sample. Four general procedures were used.

1. Discrete Particles in a Liquid. The contents were drained on a $^1/_8$-inch mesh screen. The liquid and solid portions were mixed individually and aliquots of each phase were recombined in their original weight proportion in a Waring Blendor. If the blending did not proceed smoothly, an equal volume of water was added. (The Waring Blendor was also used for samples in the other categories which were not homogeneous or did not mix readily.)
2. Discrete Particles in a Liquid; Drained Solids Only. The products in this group were olives, shrimp, and tuna.
3. Semi-solid Products. Cranberry sauce, pumpkin, squash, sweet potatoes (solid pack), tomatoes, crab, chili con carne, corned beef hash, and chicken (boned) fell into this category. The sample was mixed and a representative aliquot was taken.
4. Juices were mixed and a representative sample was taken.

Records of liquid and solid weights were kept, but they are not reported here, as they were found to be fairly constant and in line with previous reports. The pits of cherries, plums, and olives were not included in the solids weights.

If blending was necessary in the case of samples on which ascorbic acid was to be run, a separate sample was prepared by blending with an equal weight of 6% metaphosphoric acid. Ascorbic acid assays were performed on the same day the samples were prepared and β-carotene assays were carried out within a few days. Sample preparations were stored under refrigeration with small amounts of chloroform and toluene added.

Assay Methods

For vitamin B_6 the microbiological method of Atkins *et al.* (*7*) was employed with nicotinic acid added to the medium as suggested by Hopkins and Pennington (*11*). Samples were autoclaved at 15 pounds for 2 hours in 0.06*N* sulfuric acid. Folic acid was determined by a microbiological method using *S. faecalis* (*5*). Samples were digested with chick pancreas enzyme. Ascorbic acid was determined in the higher potency fruit juices by a titration method (*19*). For other samples the Robinson-Stotz method (*18*) was used. β-Carotene was assayed by a chromatographic method (*6*). It was found that the extraction of carotene from the blended samples could be carried out most conveniently in 250-ml. centrifuge tubes. Niacin, thiamine, and riboflavin assays were run by well standardized methods (*20–22*), as were moisture (*2*), ash (*3*), ether extract (*4*), protein (*1*), and crude fiber (*4*). Calories were calculated by assuming 9 calories per gram of fat and 4 calories per gram of protein or carbohydrates.

Results and Discussion

Vitamin B_6 and folic acid results are listed in Table I. There are limited data on these vitamins in canned foods available for comparison, particularly if one considers only those folic acid studies in which either chick pancreas enzyme or hog kidney conjugase has been used. Because some of the early Phase I studies on folic acid (*13*) were carried out before these improved methods of enzyme treatment became available, it is not surprising that for some products the present folic acid values are considerably higher. However, the folic acid values on asparagus, green beans, wax beans, peas, and spinach are in excellent agreement with the more recent findings of Fager *et al.* (*10*) and the folic acid result on sweet peas check closely with an extensive study by Ives (*12*). Figures for both vitamins in citrus products are in good agreement with the report of Krehl and Cowgill (*14*). Vitamin B_6 results on grapefruit juice and sweet peas agree well with those reported by Ives *et al.* (*13*), but present results are somewhat higher in the case of asparagus, green beans, carrots, yellow corn, peaches, spinach, and tomatoes. This may be due to the fact that in the previous study the samples were autoclaved in 0.06*N* sulfuric acid for 1 hour (*12*), while in the present work, on the basis of the report of Rabinowitz and Snell (*17*), the samples were autoclaved in the same concentration of acid for 2 hours.

The human requirements for vitamin B_6 and folic acid have not been established but they may be of the order of 1.5 mg. of vitamin B_6 and 0.1 to 0.2 mg. of folic acid per day. Examination of Table I will show that 100-gram servings of many of the products studied will make substantial contributions toward supplying one day's requirement of these vitamins. On a total edible contents basis, the highest levels of vitamin B_6 were found in corn, cherries, pineapple juice, potatoes, sauerkraut, tomatoes, and meat products. The products highest in folic acid were asparagus, beans, berries, boned chicken, peas, pears, spinach, and oysters.

Table II summarizes other vitamin assay results obtained in this study; in cases in which values can be compared with those previously reported by Cameron and Esty (*8*) there is good agreement except in the following instances: The present figure for β-carotene in sweet potatoes is about 50% higher, thiamine in boned chicken is somewhat higher and in tuna considerably lower, the riboflavin results are about 30% lower, and most of the present niacin results that can be compared run somewhat higher. There is no ready explanation for these differences, but in both the previous and present studies a considerable variation in values among different samples of the same product has been observed and the number of samples of each product tested has varied.

In Table II values are reported for

Table I. Vitamin B_6 and Folic Acid in Canned Foods

Product	No. of Samples	Vitamin B_6, Mg./100 G. Range	Vitamin B_6, Mg./100 G. Av.	Folic Acid, Mg./100 G. Range	Folic Acid, Mg./100 G. Av.
Apple juice	4	0.018 –0.066	0.035	0.0001–0.0003	0.0002
Apricots	5	0.044 –0.064	0.054	0.0001–0.0010	0.0005
Asparagus, green	7	0.026 –0.129	0.075	0.016 –0.033	0.027
Asparagus, white	3	0.014 –0.061	0.037	0.021 –0.023	0.022
Beans, green	10	0.015 –0.113	0.043	0.005 –0.019	0.012
Beans, lima	8	0.029 –0.166	0.081	0.0044–0.0290	0.013
Beans, wax	9	0.017 –0.122	0.042	0.0059–0.0132	0.0099
Beets	10	0.016 –0.110	0.054	0.0010–0.0078	0.0028
Blackberries	5	0.022 –0.027	0.024	0.0085–0.0162	0.014
Blueberries	5	0.014 –0.082	0.039	0.0030–0.0052	0.0042
Carrots	9	0.016 –0.088	0.041	0.0016–0.0127	0.0033
Cherries, R.S.P.	7	0.033 –0.054	0.044	0.0012–0.0120	0.0039
Cherries, sweet	5	0.022 –0.382	0.157	0.0009–0.0076	0.003
Chicken, boned	3	0.062 –0.140	0.104	0.0044–0.0280	0.013
Chili con carne	4	0.044 –0.161	0.103	0.0022–0.0150	0.0052
Clams	5	0.030 –0.133	0.083	0.0009–0.0036	0.0020
Corn, white W.K.	1	...	0.316	...	0.0080
Corn, yellow W.K.	8	0.061 –0.206	0.116	0.0021–0.0130	0.0075
Corned beef hash	5	0.061 –0.084	0.075	0.0020–0.0160	0.0067
Crab	1	...	0.364	...	0.0004
Cranberry sauce	5	0.012 –0.040	0.022	0.0007–0.0014	0.0009
Fruit cocktail	5	0.024 –0.042	0.033	0.0004–0.0006	0.0005
Fruit salad	5	0.022 –0.047	0.032	0.0004–0.0007	0.0004
Grapefruit juice	5	0.006 –0.018	0.011	<0.0001–0.0019	0.0008
Grapefruit segments	4	0.008 –0.036	0.021	0.0001–0.0007	0.0004
Lemon juice	4	0.034 –0.064	0.051	0.0001–0.0003	0.0002
Mushrooms	4	0.042 –0.097	0.063	0.0035–0.0048	0.0039
Olives, ripe	6	0.009 –0.021	0.016	0.0001–0.0015	0.0007
Orange juice	5	0.024 –0.094	0.046	<0.0001–0.0009	0.0006
Oysters	3	0.010 –0.090	0.037	0.0016–0.0300	0.0113
Peaches, clingstone	3	0.018 –0.028	0.024	0.0002–0.0005	0.0004
Peaches, freestone	2	0.020 –0.025	0.023	0.0004–0.0005	0.0005
Pears	5	0.0005–0.0043	0.0015	0.014 –0.085	0.043
Peas, Alaska	4	0.018 –0.054	0.044	0.0060–0.0144	0.0094
Peas, black-eyed	5	0.040 –0.060	0.053	0.015 –0.038	0.026
Peas, sweet	9	0.022 –0.086	0.044	0.0021–0.0159	0.0103
Pineapple, sliced	5	0.058 –0.088	0.077	0.0005–0.0012	0.0008
Pineapple juice	5	0.23 –0.54	0.33	0.0008–0.0011	0.0009
Plums, purple	5	0.020 –0.036	0.027	0.0008–0.0014	0.0010
Potatoes, white	5	0.040 –0.162	0.102	0.0019–0.0036	0.0026
Pumpkin	5	0.032 –0.094	0.056	0.0044–0.0103	0.0059
Sauerkraut	4	0.067 –0.210	0.130	0.0014–0.0036	0.0021
Shrimp	5	0.0148–0.372	0.111	0.0009–0.0044	0.0018
Spinach	12	0.057 –0.117	0.095	0.030 –0.110	0.049
Sweet potatoes	7	0.025 –0.100	0.066	0.0011–0.0080	0.0034
Tomatoes	10	0.133 –0.304	0.151	0.0023–0.0074	0.0037
Tomato juice	10	0.101 –0.332	0.192	0.0046–0.0093	0.0067
Tuna	4	0.45 –0.92	0.67	0.0006–0.0032	0.0018

various vitamins on from 7 to 14 products not previously covered with respect to these vitamins (*8*). In most cases the values could be checked against those of Watt and Merrill (*23*), and in general there is excellent agreement.

Proximate analyses are reported in Table III. Average values are used because there was little variation among samples except for chili con carne and corned beef hash. Some proximate analysis figures have been given for all the products except black-eyed peas in (*8*) and in general the values are in good agreement, although the present figure for ash in cranberry sauce is higher and fat in the one sample of crab tested is lower.

Table II. β-Carotene, Ascorbic Acid, Thiamine, Riboflavin, and Niacin in Canned Foods[a]

Product	β-Carotene, Mg./100 G.		Ascorbic Acid, Mg./100 G.		Thiamine, Mg./100 G.		Riboflavin, Mg./100 G.		Niacin, Mg./100 G.	
	Range	Av.	Range	Av.	Range	Av.	Range	Av.	Range	Av.
Apple juice	...	...	<1.0–9.8 (4)	2.9	0.003–0.014 (4)	0.007	0.023 (1)	0.023	...	...
Beans, wax	0.023–0.055 (8)	0.035	1.58–7.1 (8)	5.1	0.005–0.038 (8)	0.028	0.030–0.047 (8)	0.037	0.19–0.70 (8)	0.37
Cherries, R.S.P.	0.42–0.74 (7)	0.53	...	...	...	...	...	...	...	...
Cherries, sweet	0.015–0.036 (6)	0.026	1.10–4.46 (6)	3.30	0.017–0.023 (6)	0.019	...	...	...	...
Chicken, boned	...	...	...	...	0.002–0.004 (6)	0.003	0.070–0.140 (3)	0.103	4.0–7.0 (3)	5.5
Chili con carne	...	...	...	...	0.019–0.048 (5)	0.032	0.060–0.093 (5)	0.083	1.08–2.10 (5)	1.56
Clams	...	...	...	...	0.002–0.021 (5)	0.009	0.052–0.168 (5)	0.093	0.30–2.00 (5)	0.95
Corned beef hash	...	...	...	...	<0.001–0.40 (6)	0.010	0.030–0.100 (6)	0.067	1.50–2.50 (6)	2.09
Crab	...	...	...	...	0.001 (1)	0.001	0.144 (1)	0.144	2.48 (1)	2.48
Cranberry sauce	0.001–0.047 (7)	0.009	...	...	...	...	...	...	...	...
Fruit cocktail	0.030–0.137 (23)	0.083	<1.0–2.96 (23)	1.92	0.011–0.020 (10)	0.016	...	...	0.45–0.55 (10)	0.49
Fruit salad	0.16–0.38 (5)	0.27	1.55 3.54 (5)	2.44	0.006–0.016 (5)	0.013	...	...	0.39–0.95 (5)	0.57
Lemon juice	...	...	31.4–51.3 (4)	39.3	0.027–0.035 (4)	0.031	...	...	...	...
Olives, ripe	0.040–0.083 (6)	0.064	...	...	0.001–0.004 (6)	0.003	1.1–2.9 (6)	2.3	...	...
Orange juice	...	...	29.8–55.0 (22)	36.3	0.038–0.092 (38)	0.068	0.011–0.027 (11)	0.016	0.24–0.46 (21)	0.33
Oysters	...	...	...	...	0.012–0.033 (3)	0.020	0.125–0.330 (3)	0.20	0.56–1.64 (3)	1.02
Peaches, clingstone	...	...	2.24–7.00 (19)	4.07	...	...	...	...	0.65–1.65 (9)	0.88
Peaches, freestone	...	...	1.08–3.51 (6)	2.72	...	...	...	...	0.62–0.82 (2)	0.72
Peas, black-eyed	0.023–0.082 (5)	0.036	2.45–3.77 (5)	3.10	0.050–0.177 (5)	0.076	0.040–0.052 (5)	0.047	0.24–0.59 (5)	0.44
Pineapple, sliced	...	...	0.94–5.85 (26)	3.59	0.066–0.097 (26)	0.081	...	...	0.20–0.37 (8)	0.28
Pineapple juice	...	...	5.90–10.60 (17)	7.87	0.041–0.061 (17)	0.046	0.010–0.016 (11)	0.012	0.23–0.30 (7)	0.27
Potatoes, white	...	...	6.30–22.2 (5)	12.7	0.026–0.052 (5)	0.038	0.014–0.035 (5)	0.021	0.18–0.85 (5)	0.64
Pumpkin	1.40–17.1 (5)	6.8	...	...	0.010–0.077 (5)	0.025	0.040–0.061 (6)	0.053	0.25–0.98 (5)	0.48
Sauerkraut	...	...	6.75–30.1 (15)	16.0	0.018–0.036 (6)	0.028	0.016–0.040 (6)	0.028	0.060–0.41 (6)	0.21
Sweet potatoes	1.96–5.65 (6)	3.78	9.5–22.4 (6)	15.1	0.034–0.059 (6)	0.042	0.024–0.084 (6)	0.047	0.45–1.10 (6)	0.77
Tuna	...	...	...	...	0.010–0.036 (4)	0.019	0.070–0.120 (4)	0.089	10.4–15.4 (4)	13.6

[a] Figures in parentheses indicate number of samples assayed.

Table III. Proximate Analysis of Canned Foods

(Average values, %)

Product	No. of Samples	Solids	Ash	Ether Extract	Protein	Crude Fiber	Carbohydrate	Calories/ 100 Grams
Beans, wax	4	6.1	0.73	0.19	0.90	0.55	3.7	20
Cherries, R.S.P.	1	10.4	0.61	0.08	0.73	0.18	8.8	39
Cherries, sweet	5	26.7	0.36	0.18	0.56	0.22	25.4	105
Chicken, boned	3	32.4	1.65	10.0	20.3	0.23	0.2	172
Chili con carne	4	27.2	2.06	9.5	6.5	0.68	8.5	145
Clams	5	15.4	2.27	0.40	9.9	0.04	2.8	54
Corned beef hash	5	30.1	1.73	10.9	7.7	0.54	9.2	166
Crab	1	23.9	2.80	0.32	18.7	0.05	2.0	86
Cranberry sauce	5	38.6	1.62	0.19	0.02	0.25	36.5	148
Fruit cocktail	5	22.6	0.16	0.08	0.38	0.47	21.5	88
Fruit salad	5	21.8	0.19	0.06	0.34	0.42	20.8	85
Olives, ripe	6	20.9	1.72	7.7	0.93	0.05	10.5	115
Oysters	3	16.5	0.72	1.58	8.8	0.12	5.2	70
Peas, black-eyed	5	16.7	1.12	0.28	4.4	0.59	10.3	61
Pumpkin	5	9.9	0.44	0.52	1.22	1.53	6.2	34

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PROTEIN SUPPLEMENTATION

Relationships Between Milled Rice and Milled Flour And Between Milled Rice and Milled White Corn Meal

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Because the proteins in milled rice were found to be much superior to the proteins in milled wheat and corn, the possible supplementary relationships among these proteins were investigated. When one half of the proteins in milled wheat was replaced by an equivalent amount of proteins in milled rice, there were 114% increase in growth and 86% increase in protein efficiency; when one third of the proteins in wheat was replaced by proteins in milled rice, there was 55% increased growth and 55% increase in protein efficiency. When one half of the proteins in milled corn meal was replaced by proteins in milled rice, there were 236% increase in body weight and 165% increase in protein efficiency; when one third of the proteins in corn meal was replaced by proteins in milled rice, there were 190% increase in growth and 148% increase in protein efficiency. It would seem most desirable for people of low income level, now using corn for their basic cereal food, to consume a greater proportion of rice to balance the deficient proteins in corn.

Of all the proteins ingested, only those of animal origin are considered to be of superior biological value, but it takes approximately 2 acres of land to graze a cow, if soil and moisture conditions are favorable. The conversion of vegetable calories into animal calories has long been known to be inefficient. Only 15% of vegetable calories is recovered in producing milk, 7% in eggs, and 4% in beef (*2*). It is consequently impossible to raise sufficient cattle for human consumption in overpopulated and underdeveloped countries; plant proteins of inferior biological value must necessarily provide sustenance for the greater portion of the world, and these are supplied chiefly by cereal grains. It has been suggested that a high incidence of infectious diseases is related to low intake of high quality protein foods (*1, 3, 4*). The world's food supply is dominated by cereals. Cereal grains are the most economical sources not only of proteins but also of fuel requirements of the human race. About 80% of the earth's population belong either to the rice- or wheat-eating worlds. Rice has always been the food of the yellow and brown races, while for several centuries wheat, through preference, has been the universal grain of the white race.

Experimental Procedure and Results

The author has demonstrated the low biological value of the proteins in milled wheat flour and milled white corn meal and the supplementary values of dried food yeasts, soybean flour, peanut meal, dried nonfat milk solids, and dried buttermilk (*10–12*).

As the proteins in milled rice were found to be much superior biologically to the proteins in milled wheat (*13*) and milled corn (*8*), it was of interest to investigate the possible supplementary value of the proteins in milled or polished rice to the proteins of milled patent-enriched wheat flour and to milled white corn meal, the latter being used extensively in the South in quick breads—i.e., corn muffins and corn bread. A summary of the results of this study is presented in Table I.

This investigation was carried out on Wistar strain albino rats, 30 days old; each weighed 50 to 55 grams when started on experiments. They were housed in metal cages on false screen bottoms and, therefore, had no access to fecal excretions. There were 12 males and 12 females in each group.