NUTRIENT VARIATIONS IN CANNED FRUITS AND VEGETABLES

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The National Food Processors, NFPA, (formerly the National Canners Association, NCA), has long been very active in the subject of nutrient content of canned foods. Nutrient composition research has been carried out in the NFPA laboratories located in Washington, DC; Berkeley, California; and Seattle, Washington, and through cooperative programs with member food processing companies and government agencies.

Scope

Our discussion on the nutrient content of canned fruits and vegetables will emphasize national nutrient variability as it may occur between lots, geographical locations and seasons. Our perspective will be that of a food scientist associated with the food processing industry and who is faced with assembling the data base to support nutrition labeling statements. This paper will also look at the historical development of nutrient information on canned fruits and vegetables and relate this to current programs to update the National Nutrient Data Bank.

Historical perspectives

Historically, the canning industry has placed a major emphasis on cataloging and conserving the micronutrients in its products. A major nutrition program was launched in the 1920's and early 1930's, well before several of the vitamins had been recognized and isolated. A second major effort to catalog the nutrient content of canned fruits and vegetables and to study the effects of canning operations and storage on their retention was carried out in the 1940's and early 1950's. Cameron (2) records a complete bibliography of publications resulting from these two major programs.

These early research efforts on the part of the canning industry reflected widespread interest in the vitamins and the conditions necessary for optimum vitamin retention in food products during preservation and preparation for serving. These data on the effects of various operating and food preparative conditions on nutrient retention are summarized in a 1955 NCA monograph entitled *"Retention of Nutrients During Canning"* (20). This document remains in print and is still widely used in the food processing industry today.

The eagerness to conserve and catalog micronutrients was prompted in the early days by the existence of clinical malnutrition problems, where malnutrition meant vitamin deficiencies.

In America today, classical malnutrition problems are almost entirely of historic interest only. The food supply available to the American public today will generally provide adequate micronutrient intake if it is utilized sensibly and in reasonable variety.

The attention of some nutritionists and of those among today's consumers who are nutrition conscious, appears to be shifting from micronutrients toward the macronutrients. The calorie content of foods is of primary interest to most consumers; but, what are the optimum dietary proportions of protein, carbohydrate and fat, and in what form? Dietary fiber which is present in abundance in processed fruits and vegetables is also the focus of much nutritional research, but its role in human nutrition is not yet fully understood (16).

Literature highlights

Interest in the nutrient content of fruits and vegetables remains very high, but substantial gaps in nutrient content data exist for fruits and vegetables. The 1969 White House Conference on Food, Nutrition and Health (18), and the 1977 McGovern Senate Select Committee Report on *"Dietary Goals for the United States"* (22) have no doubt contributed to increased scientific activity. And, as mentioned earlier, an additional impetus to nutrient research has come from the Food and Drug Administration's (FDA) voluntary nutrition labeling program. The FDA program, as it applies to canned foods, has been reviewed by Farrow (9).

In recent years, NFPA scientists have published a number of reports presenting original data on the nutrient content of canned fruits and vegetables, especially tomato juice (7,8), corn (8,3), green beans, peaches and sweet potatoes (5,6). The subject of interlaboratory variability in nutrient analyses as well as analytical methodology has received attention also at NFPA, USDA and in the industry (4, 12). The natural variability of California canned fruits and vegetables was reviewed by Farrow, Kemper and Chin at the recent Institute of Food Technologists Annual Meeting (10).

Nutritional qualities of raw fruits and vegetables were reviewed in detail at a 1972 symposium sponsored by the American Medical Association Council on Foods and Nutrition with the cooperation of USDA (24). This symposium documented that nutrient content of individual fruit or vegetable cultivars can vary significantly at the time of harvest as a result of climatological, geographical, agronomic and other factors. Additional variation of raw fruits and vegetables can result from postharvest treatment and storage factors such as time, temperatures, humidity, availability of oxygen, etc. There are also unidentified factors which influence nutrient retention of raw fruits and vegetables. And, of course, it is well known that final preparation and cooking exert considerable influence on the nutrient content at the point of consumption.

The potential for improving the nutrient composition of horticultural crops was reviewed in 1975 by Kelly and Rhodes (15) who focused on attempts to increase the protein quality of green beans, cowpeas, and of starchy vegetables, plus improving mineral and vitamin content of a variety of fruits and vegetables. Their conclusion was that average values of nutrient levels in a particular crop do not properly represent the genetic variation which exists between cultivars and the variation produced by environmental conditions. They further concluded that breeding is a practical means of influencing the nutrient levels of certain fruits and vegetables within practical limitations.

The influence of processing on vitamin and mineral content in processed foods was placed in perspective in a brief review by Hein and Hutchings (14). The authors concluded that the geneticist and grower must be encouraged to emphasize nutritional properties rather than yield and appearance only. They further emphasized that great effort is needed to preserve nutrient qualities by correct raw material handling, minimizing blanching losses, rapid heat processing, good packaging and proper storage conditions. Three books which review in depth the factors influencing the nutritional qualities of fruits and vegetables, both raw and processed, were recently published. (1, 13, 21).

Today's scientific setting

In spite of the voluminous literature on factors affecting the nutrient content of fruits and vegetables, there is surprisingly little published information on the actual nutrient variations in raw or processed fruits and vegetables which are available to American consumers. Although the 1963 edition of USDA Agriculture *Handbook 8* (23) still serves as a standard reference for average nutrient values, as we will see later, there is a substantial degree of uncertainty as to whether these data are representative of today's products. This is especially true, because the last 15 years have seen many changes in cultivars, growing locations, harvest and postharvest handling techniques. Another problem with *Handbook 8,* which was unavoidable at the time it was compiled, is that the variabilities surrounding the reported average nutrient values are not published and, in many cases, are not known.

Recently, two authors have attempted to use *Handbook 8* data to calculate vitamin losses which occur during processing of raw fruits and vegetables (11, 17). Extrapolations of about 40% Vitamin A loss attributable to processing were shown for both canned and frozen fruits, and losses were calculated for Vitamins B_1, B_2, niacin and C (11). Both authors concluded that nutrient losses appear to be

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quite significant in the canning process, in spite of many well-designed experiments which have shown that virtually no Vitamin A is lost in thermally-processed foods (20,5).

Overlooked in these papers was the fact that *Handbook 8* nutrient values for raw products were derived from entirely different data bases than were the values for corresponding types of processed fruits and vegetables. Furthermore, in relating the nutrient content of a processed food to that of a raw product, it is necessary not only to determine the nutrients in the raw product and in the processed food prepared from that same lot of raw product, but also to account for changes in weight of the product brought about by moisture changes due either to the pick-up of moisture from washing and blanching operations or to loss of moisture from drying or dehydration. Assuming no gain or loss of solids during the operations, changes in moisture content may be accurately accounted for by determining the total solids content of both the raw and processed food and expressing the nutrient content on the basis of dry solids. The percent retention of the processed food is then the ratio of the amount of nutrient found in the processed food to that found in the raw food multiplied by 100.

Questions on the degree of nutrient loss encountered by heat processing and other methods of fruit and vegetable preservation remain valid, in our opinion, but unfortunately, comprehensive data to make accurate comparisons between alternate processing methods simply do not exist. *Handbook 8* data cannot be used for this purpose. In our judgment, from a nutrition standpoint, the central issue is the level and variability of nutrients in both raw and processed fruits and vegetables *as actually consumed.* Sources of variability mentioned previously, including handling and storage conditions, method of preservation, if any, and final preparation for serving, must be taken into consideration. Studies to address these issues directly, using single source fruits and vegetables, are currently under consideration.

National Nutrient Data Bank

In recognition of the increasing demands for more comprehensive nutrient content data for foods, the U.S. Department of Agriculture has established a National Nutrient Data Bank (19). This computerized Data Bank has a general goal to include variability data, as well as averages, for all known nutrients in foods. NFPA, as well as other trade associations representing processors of fruits and vegetables, have contributed some data to the Bank, but the information contained in the Bank is by no means complete at this time. For example, the Data Bank contains information for some of the key nutrients found in frozen blanched vegetables, but data are lacking on the nutrient content of these same vegetables after cooking and ready to eat. In the case of canned fruits and vegetables, the nutrient contents in the Data Bank are on a ready-to-eat basis, but data on minor nutrients are lacking for both canned and frozen fruits and vegetables. The food processing industry is continuing its efforts to provide the Data Bank with up-to-date nutrition information as it becomes available, both from the company laboratories and from research conducted in NFPA laboratories.

Voluntary FDA nutritional labeling program

Although the FDA has actively supported USDA's efforts with the National Nutrient Data Bank, for compliance purposes, FDA has not recommended that data in the Bank be used as the basis for nutritional labeling statements in their Voluntary Nutritional Labeling Program. Rather, FDA has published compliance procedures which recommend that individual food processors establish their own data base for individual nutrients in each food product. In recognition of the inherent variability of the nutrient content of food commodities packed essentially as they are harvested, FDA regulations state that nutrients must be present in amounts equal to or exceeding 80 percent of the values declared on the label. Declaration of calories, carbohydrates and fat are, in affect, maximum declarations and, to avoid misbranding, must not be exceeded by more than 20%. Reasonable excesses of a vitamin, mineral or protein over label amounts are acceptable within good manufacturing practices. Testing for compliance is on the basis of a 12-can composite sample, each can being drawn from a separate shipping case. It should be noted, however, that for nutrient fortified foods, FDA has more stringent requirements.

NFPA guidelines for nutrition labeling

The NFPA staff continuously reviews nutrient data in published sources as well as new values from NFPA surveys or values supplied by member canners. From these data, NFPA guidelines for nutrition label statements are derived that are considered by the staff to be consistent with the most recent information. However, it should be remembered that data from previous years will be applied to next year's harvest. Unusual growing or processing conditions could lead to values which are significantly different from those values shown in the nutrient guidelines.

It must be noted that the FDA has indicated that canners will be accountable for the accuracy of nutritional statements used on their labels. Any canner using the suggested nutritional statements on his label must be certain that his product does not depart from the normal to the extent that their use would constitute misbranding. Each canner should obtain sufficient analytical values on his own production to provide an indication of the variation he can expect to encounter during his production season.

We have, thus far, developed 25 nutrient labeling guidelines. These guidelines exist for apricots, peaches, pears, tomato products, corn, peas, beans, and so on. These were last revised in 1976 and 1977 and will continue to be revised as new data become available.

Development of a nutrition labeling guideline

We have selected canned sweet peas to illustrate the development of an NFPA nutrition labeling guideline. Table 1 shows data collected from protein in sweet peas. The NFPA 1970 survey data were obtained on 25 six-can composite samples drawn from all major growing areas in rough proportion to their contribution to the total pack. The shelf life of the samples at time of testing was 18 to 24 months.

In 1972 and 1973, a group of Midwest canners obtained data on 18 and 14 composite samples, respectively. A composite in this sampling was 12 cans of a code lot. The value listed from the Northwest is the average of 9 samples. We have also listed a composite average which includes recent values from individual companies.

Data for sweet peas were not sufficient to perform an analysis of variance; however, we have listed the standard deviation which is an indication of the variation about the mean. In the case of protein, the variability does not seem to be great compared with micronutrients, as we will see shortly. The data show sweet peas to be a respectable source of protein: a one-cup serving contributes 12.6% of the U.S. RDA. For labeling purposes, this is rounded to 10% of the U.S. RDA.

In Table 2, we show the same type of data for Vitamin A in sweet peas. Our composite average is 407 IU/100g. One cup supplies 20% of the U.S. RDA of Vitamin A. Again, the standard deviations would indicate that the natural variability of Vitamin A in peas is not excessive.

Table 3 shows Vitamin C data in peas. The data sources are the same as outlined earlier. Cultivar and climatic factors, as well as the performance of individual canning operations, no doubt contribute to the considerable variability found in the Vitamin C content, especially in the 1970 survey. Our composite average for Vitamin C is 10.4 mg/100g, which results in a one-cup serving supplying over 40% of the U.S. RDA.

Table 4 shows the same type of data for niacin in canned peas. Data sources are the same as outlined. A one-cup serving supplies over 10% of the U.S. RDA and, based on the data analyzed, variability does not seem great.

Table 5 shows thiamin levels found in canned peas. A one-cup serving supplies 18.3% of the U.S. RDA. In making this calculation, we used 0.11 mg/100g as the value.

Table 6 shows data for the iron content of canned sweet peas. Using the composite average, canned peas supply 13.8 percent of the U.S. RDA for this nutrient.

These and other data from the NFPA nutrient data bank are displayed in Table 7, which shows a suggested label statement for canned sweet peas. From this statement, one can conclude that canned peas represent a very valuable source of protein and micronutrients while,

Table 1. Protein in canned sweet peas.

Source	Protein (%)
NFPA survey 1970	3.1 ± 0.33
Midwest survey 1972-1973	3.4 ± 0.18
Northwest survey 1972	3.0 ± 0.48
Composite Average	3.2[z]
% U.S. RDA/1 cup serving	12.6

[z]Includes all survey lots plus lot averages supplied by individual companies.

Table 2. Vitamin A in canned sweet peas.

Source	I.U./100 g
NFPA survey 1970	328 ± 63
Midwest survey 1972-1973	423 ± 49
Northwest survey 1972	405 ± 37
Composite average	407[z]
% U.S. RDA/1 cup serving	20.0

[z]Includes all survey lots plus lot averages supplies by individual companies.

Table 3. Vitamin C in canned sweet peas.

Source	mg/100 g
NFPA survey 1970	9.9 ± 2.4
Midwest survey 1972-1973	12.3 ± 0.53
Northwest survey 1972	11.0 ± 1.3
Composite average	10.4[z]
% U.S. RDA/1 cup serving	41.5

[z]Includes all survey lots plus lot averages supplied by individual companies.

Table 4. Niacin in canned sweet peas.

Source	mg/100 g
NFPA survey 1970	0.96 ± 0.24
Midwest survey 1972-1973	0.965 ± 0.04
Northwest survey 1972	0.85 ± 0.15
Composite average	0.894[z]
% U. S. RDA/1 cup serving	10.6

[z]Includes all survey lots plus lot averages supplied by individual companies.

Table 5. Thiamin in canned sweet peas.

Source	mg/100 g
NFPA survey 1970	0.11 ± 0.03
Midwest survey 1972-1973	0.125 ± 0.007
Northwest survey 1973	0.11 ± 0.01
Composite average	0.118[z]
% U.S. FDA/1 cup serving	18.3

[z]Includes all survey lots plus lot averages supplied by individual companies.

Table 6. Iron in canned sweet peas.

Source	mg/100 g
NFPA survey 1970	1.3 ± 0.404
Midwest survey 1972-1973	0.85 ± 0.042
Northwest survey 1972	0.96 ± 0.14
Composite average	1.02[z]
% U.S. RDA/1 cup serving	13.8

[z]Includes all survey lots plus lot averages supplied by individual companies.

Table 7. Nutrition information – canned sweet peas.

Serving size 1 cup			
Calories	130	Carbohydrate	25 g
Protein	8 g	Fat	1 g
Percent of U.S. Recommended Daily Allowance			
Protein	10	Riboflavin	8
Vitamin A	15	Niacin	10
Vitamin C	40	Calcium	2
Thiamin	15	Iron	10

at the same time, contributing only a moderate level of calories and virtually no fat.

Analysis of NFPA nutrient composition data

Source and general discussion of data The remainder of our discussion will focus on an analysis of selected nutrient content information from NFPA's canned food nutrient data base. The foregoing discussion on key nutrients in canned peas and derivation of the nutrition label could be repeated for each of the 25 canned products for which NFPA guidelines for nutrient label statements have been prepared. Literally thousands of individual chemical analyses are represented in the data base, including work from many individual company and independent laboratories, as well as by NFPA laboratories. But we will discuss only micronutrients found that represent 10% or more of the U.S. RDA levels per serving and will further restrict ourselves to high consumption fruits and vegetables for which the data are sufficiently complete to allow an analysis of variance. We will also compare our data with *Handbook 8* values.

It should be noted that the data were collected in a variety of surveys for reasons other than sorting out sources of variance. We analyzed the data to see if any leads for future more systematic research might be warranted. With this in mind, we are very cautious not to reach any final conclusions, but rather to view the analysis of variance as "suggestive" only.

For our purposes, the source of variance entitled "lot" refers generally to a given company pack code or day's production. "Regions" will be discussed with individual tables. The interaction term has the usual meaning within the context of a classical analysis of variance and generally refers to sources of unidentified variation or analytical error. In this sense, interaction terms which are significant at 1% or 5% levels generally can be taken to suggest that further research, possibly with a more tightly controlled experimental plan with refined methodology, is warranted.

Vitamin A Our next series of tables will summarize variability for Vitamin A. Table 8 shows Vitamin A content in canned California tomato juice for the 1972 through 1975 seasons. Qualitatively, we see yearly means ranging from 400 to almost 600 International Units. It can also be noted that the grand mean of 500 I.U. is some 37% lower than the *Handbook 8* value. Since Vitamin A retention in the canning process has been shown to be virtually quantitative, these data suggest the decline in the level of Vitamin A in tomato juice is due to factors other than processing.

Table 9 shows a typical analysis of variance for the same data given in Table 8. The analysis shows that lot-to-lot, year-to-year, and interaction sources of variation are all significant.

Regional data for Vitamin A in the 1973 crop for canned tomato juice are shown in Table 10. Note differences in the means and also the the ranges. Analysis of variance shows significance between regions at 5% level of confidence for the 1973 season (Table 11). Lack of data to compare other years' production do not allow us to conclude that this is truly representative for other years.

Regional data for Vitamin A in green beans are summarized in Table 12. Analysis of variance for this 1972 season shows no significant difference between Northeastern, Mid-Atlantic, Midwestern, Southern and Western regions. But again note the discrepancy between the grand mean and the *Handbook 8* value. We can offer no explanation for this.

Table 13 gives 1971 data on Vitamin A in yellow whole kernel corn paced in brine. Here the higher *Handbook 8* value probably can be attributed to methodology problems with Vitamin A in yellow fruits and vegetables. *Handbook 8* methodology did not distinguish between beta-carotene and cryptoxanthin, which has only 50% of beta-carotene's activity. Regional differences were not significant in 1971.

Table 14 shows 3 years' data for California green asparagus spears. Here, the Vitamin A grand mean is virtually identical with the *Handbook 8* value. Analysis of variance showed lot-to-lot, year-to-year and interaction sources of variance to be highly significant.

Table 15 summarizes analysis of variance data discussed previously for Vitamin A in the selected vegetables.

Table 16 summarizes Vitamin A content for apricots in 1973-75. Lot-to-lot variation was significant at the 5% confidence level; years and interactions were highly signficant.

With peaches (Table 17) we see a grand mean for 3 years' production of clingstone peach halves which is slightly higher than the *Handbook 8* value. But note the extreme difference between the 1975 mean of only 300 I.U.'s versus 550 I.U.'s for the previous two seasons. A major nutritional labeling problem might have occurred if 1973-74 data had been the sole source of information used to draw

Table 8. Vitamin A in canned California tomato juice.

Year	No. lots	I.U./100 g^z Mean	SD	Range
1972	18	399.5	78.68	231 - 519
1973	23	587.7	52.07	478 - 679
1974	23	515.7	61.67	374 - 657
1975	18	496.6	63.35	369 - 597

^zGrand mean of samples tested: 506.2 I.U./100g. *Handbook 8* value 800 I.U./100g.

Table 9. Analysis of variance of Vitamin A in canned California tomato juice.

Source	D.F.	Mean square	F
Lots	5	17,053.272	6.729 **
Years	3	120,525.22	47.541 **
Interaction	15	5,632.296	2.221 *
Within subclass	58	2,235.169	
Total D.F.	81		
Range: 250 - 657 I.U./100 g			

* Significant at 5% level of confidence
** Significant at 1% level of confidence

Table 10. Vitamin A in canned tomato juice (1973).

Region	No. lots	I.U./100 g^z Mean	SD	Range
West	23	587.7	78.68	478 - 679
Midwest	12	743.5	172.5	477 - 1,060

^zGrand mean of samples tested 682 I.U./100g *Handbook 8* value 800 I.U./100g.

Table 11. Analysis of variance of Vitamin A in canned tomato juice (1973).

Source	D.F.	Mean square	F
Regions	1	105,207	5.3 *
Within regions	14	19,816	
Total D.F.	15		
Range: 477 - 1,060 I.U./100 g			

* Significant at 5% level of confidence

Table 12. Vitamin A in canned green beans (1972).

Region	No. lots	I.U./100 g^z Mean	SD	Range
Northeast	14	154.7	35	104 - 226
Mid-Atlantic	5	158.0	47	101 - 230
Midwest	14	172.5	48	86 - 242
South	5	224.4	65	160 - 331
West	6	195.2	37	160 - 255

^zGrand mean of samples tested 174.2 I.U./100g. *Handbook 8* value 290 I.U./100g.

Table 13. Vitamin A in canned yellow whole kernel corn (brine pack) (1971).

Region	No. lots	I.U./100 g^z Mean	SD	Range
East	5	195.6	19.7	171 - 222
Midwest	12	205.1	61.7	130 - 277
Northwest	10	167.1	47.9	100 - 261

^zGrand mean of samples tested 189.3 I.U./100g. *Handbook 8* value 270 I.U./100g.

Table 14. Vitamin A in canned California green asparagus spears.

Year	No. lots	I.U./100 g^z Mean	SD	Range
1972	20	529	89	408 - 712
1973	18	461	99	326 - 657
1974	13	522	82	408 - 634

^zGrand mean of samples tested 503 I.U./100g. *Handbook 8* value 510 I.U./100g.

Table 15. Analysis of variance summary of Vitamin A in canned vegetables.

Product and year	Lots	Years	Regions	Interaction
Green beans (1972)			n.s. (NE, MA, MW, S, W)	
Tomato juice (1973)			*	
California tomato juice (1972-1974)	**	**		*
Yellow whole kernel corn (1971)			n.s. (E, MW, NW)	
California green asparagus spears (1972-1974)	**	**		**

*,**,ns Significant at 5% (*), 1% (**), or nonsignificant (ns).

Table 16. Vitamin A in canned apricot halves.

Year	No. lots	I.U./100 g^z Mean	SD	Range
1973	21	1,489.5	348.9	929 - 2,143
1974	12	1,754.9	347.2	1,277 - 2,581
1975	20	1,496.0	142.7	1,269 - 1,690

^zGrand mean of samples tested 1,552 I.U./100g. *Handbook 8* value 1,740 I.U./100g.

Table 17. Vitamin A in canned California clingstone peach halves.

Year	No. lots	I.U./100 g^z Mean	SD	Range
1973	18	546.9	116.4	317 - 761
1974	13	558.2	80.0	470 - 683
1975	10	302.9	65.0	240 - 411

^zGrand mean of samples tested 491 I.U./100g. *Handbook 8* value 430 I.U./100g.

up a label for the 1975 season. For example, using the 1973 and 1974 data, 550 IU/100g yields 1400 IU per serving, or 28% of the U.S. RDA. The label statement would be 25% U.S. RDA. If this value were used for 1975 grown peaches which contained on the average only 300 IU/100g, then the peaches would contain only 15% of the U.S. RDA, or 10% less than the label statement, and would clearly be out of compliance. As a matter of fact, the entire 10 lots sampled in 1975 would be out of compliance (high lot 411 IU/100g yields less than 80% of label statement based on 1973-74 data). Methodology problems in yellow fruits and vegetables may be partly responsible for the low value obtained in 1975.

Although strictly speaking, the lower value is probably closer to being correct, this is because of a change in methodology that would exclude pigments having no beta-carotene activity from being determined as beta-carotene. Analysis of variance showed no lot-to-lot variation, but years and interactions were highly significant.

Table 18 summarizes analysis of variance for Vitamin A in apricots and peaches. No doubt, the cryptoxanthin analytical problem contributes in part to highly significant interaction terms for both peaches

Table 18. Analysis of variance of Vitamin A in canned fruits.

Product and year	Lots	Years	Interaction
Apricots (1973-1975)	*	**	**
California clingstone peach halves (1973-1975)	n.s.	**	**

*,**,ns Significant at 5% (*), 1% (**), or nonsignificant (ns).

Table 19. Vitamin C in canned green beans (1972).

Region	No. lots	mg/100 g[z] Mean	SD	Range
Northeast	14	5.7	2.8	2.0 - 13.7
Mid-Atlantic	5	5.5	2.1	1.9 - 7.2
Midwest	14	5.0	2.0	2.2 - 10.3
South	5	4.3	2.2	2.9 - 7.9
West	6	5.3	1.4	3.7 - 6.9

[z]Grand mean of samples tested 5.2 mg/100g. *Handbook 8* value 4 mg/100g.

Table 20. Vitamin C in canned tomato juice (1973).

Region	No. lots	mg/100 g[z] Mean	SD	Range
West	23	11.6	3.5	4.3 - 15.5
Midwest	12	11.2	4.0	2.3 - 18.0

[z]Grand mean of samples tested 11.3 mg/100g. *Handbook 8* value 16 mg/100g.

Table 21. Vitamin C in canned California tomato juice.

Year	No. lots	mg/100 g[z] Mean	SD	Range
1972	18	12.1	3.6	7.9 - 21.6
1973	23	11.6	3.5	4.3 - 15.5
1974	23	9.5	4.6	2.0 - 18.7
1975	26	9.1	3.9	2.0 - 16.4

[z]Grand mean of samples tested 10.4 mg/100g. *Handbook 8* value 16 mg/100g.

Table 22. Vitamin C in canned California green asparagus spears.

Year	No. lots	mg/100 g[z] Mean	SD	Range
1972	20	17.0	2.6	13.0 - 20.8
1973	18	13.9	1.7	10.8 - 17.0
1974	13	16.7	3.9	10.3 - 22.0

[z]Grand mean of samples tested 15.6 mg/100g. *Handbook 8* value 15 mg/100g.

Table 23. Analysis of variance summary of Vitamin C in canned vegetables.

Product and year	Lots	Years	Regions	Interaction
Green beans (1972)			n.s. (NE, MA, MW, S, W)	
Tomato juice (1973)			n.s. (W, MW)	
California tomato juice (1972-1975)	**	**		*
California green asparagus spears (1972-1974)	n.s.	**		n.s.

*,**,ns Significant at 5% (*), 1% (**), or nonsignificant (ns).

and apricots.

Moving on to Vitamin C in canned vegetables, Table 19 shows regional data on green beans for 1972. Analysis of variance showed no significant difference between the 5 regions. It would be tempting to speculate that the relatively high grand mean value compared to *Handbook 8* is due to improved processing practices, but no doubt this would be an over extension of 1 year's data.

Table 20 shows 1973 content of Vitamin C in tomato juice from the West and Midwest. While a discrepancy is apparent between the *Handbook 8* value and the grand mean, analysis of variance showed no difference between regions.

Analysis of variance between 4 years of production of California tomato juice (Table 21) showed highly significant lot-to-lot, year-to-year, and significant interaction sources of variation. Unlike Vitamin A, Vitamin C is susceptible to processing operations, including exposure to oxygen, and holding times and temperatures. The wide ranges seen for tomato juice probably reflect, to some extent, processing variations as well as other factors discussed previously.

Three years' data for Vitamin C in green asparagus spears show highly significant year-to-year variations (Table 22). Table 23 summarizes analysis of variance data for Vitamin C in vegetables.

Vitamin C data for apricots and peaches are shown in Tables 24 and 25. A one-cup serving of both clingstone peaches and apricots supplies about 10-11% of the U.S. RDA of Vitamin C. But while lot, year and interaction sources of variance are highly significant for apricots, such variability is not observed with clingstone peaches, as is shown in Table 26.

The next section deals with certain other micronutrients present at levels of 10% or more of the U.S. RDA selected canned vegetables. We are highlighting these sources of micronutrients, because fruits and vegetables are good sources of nutrients other than Vitamins A and C. Unfortunately, we can mention only those nutrients for which there are sufficient data in the NFPA files to allow analysis of variance. Much more work on other nutrients, such as folacin, pantothenic acid, biotin, B_6, zinc, copper and so on, in canned fruits and vegetables remains to be done.

Table 24. Vitamin C in canned apricot halves.

Year	No. lots	mg/100 g[z] Mean	SD	Range
1973	21	4.2	1.11	2.3 - 6.2
1974	12	3.3	0.52	2.6 - 4.3
1975	20	2.9	0.39	2.5 - 3.8

[z]Grand mean of samples tested 3.5 mg/100g. *Handbook 8* value 4 mg/100g.

Table 25. Vitamin C in canned California clingstone peach halves.

Year	No. lots	mg/100 g[z] Mean	SD	Range
1973	18	2.9	.67	1.6 - 4.1
1974	13	2.9	.68	1.8 - 4.1
1975	10	2.7	.54	1.9 - 3.5

[z]Grand mean of samples tested 2.9 mg/100g. *Handbook 8* value 3 mg/100g.

Table 26. Analysis of variance summary of Vitamin C in canned fruits.

Product and year	Lots	Years	Interaction
Apricots (1973)	**	**	**
California clingstone peach halves (1973-1974)	n.s.	n.s.	n.s.

**,ns Significant at 1% (**), or nonsignificant (ns).

Table 27. Analysis of variance summary of selected vitamins in canned vegetables.

Vitamins, product and year	Lots	Years	Regions	Interaction
Niacin				
Yellow whole kernel corn (1971)			n.s. (E, MW, NW)	
California green asparagus spears (1972-1974)	n.s.	**		n.s.
Riboflavin				
California spinach (1972-1974)	n.s.	**		n.s.

**,ns Significant at 1% (**), or nonsignificant (ns).

Table 28. Analysis of variance summary of selected minerals in canned vegetables.

Minerals, product and year	Lots	Years	Regions	Interaction
Calcium				
California spinach (1972-1974)	*	**		n.s.
Magnesium				
California spinach (1972-1974)	**	**		**
Phosphorus				
Yellow whole kernel corn (1971)			** (E, NE, MW)	

*,**,ns Significant at 5% (*), 1% (**), or nonsignificant (ns).

Table 27 shows analysis of variance summary data for niacin and riboflavin. Regional differences were not significant for niacin in 1971, a year in which, incidentally, the grand mean was very close to the *Handbook 8* value. With asparagus spears, only the year-to-year variability was (highly) significant for niacin. Riboflavin grand mean values for 3 years' production of spinach exactly match that given in *Handbook 8;* only year-to-year variation was significant.

Wide variability is seen in the calcium content of 3 years' production of spinach, with significant lot-to-lot variation and highly significant year-to-year variance (Table 28). The same can be said for magnesium; but here the interaction term is also highly significant.

Finally, we find a highly significant difference in phosphorus in yellow whole kernel corn between Eastern, Northeastern, and the Midwestern regions for 1971.

Food energy and micronutrient content

To complete the record, we will turn our attention very briefly back to a major nutrition issue of today, that of food energy or calories. Food energy variability, of course, largely reflects the variability of the carbohydrate content, since fruits and vegetables have negligible fat and, with the exception of legumes, have little or no protein. The variability of food energy in canned fruits and vegetables was examined in a paper presented by NFPA scientists this spring at the meeting of the Institute of Food Technologists (14). Data presented show an average of coefficients of variation for calories of approximately 7%, even though these fruit and vegetable products exhibit a wide range of mean food energy values. Micronutrients, on the other hand, often show coefficients of variability in the range of 10 to 20%. Table 29 illustrates this point quite adequately. Since the calorie statement probably gets more attention from consumers than any other of the nutrient factors on the label, the fact that it is likely to be the least variable is worth noting.

A final point regarding canned fruits and vegetables is that, by and large, these products contribute substantial quantitites of the vitamins and minerals discussed today without an intake of an excess of food energy. In other words, they have high nutrient-calorie ratios.

Concluding remarks

In summary then, the literature of nutrient variability in canned fruits and vegetables has been reviewed and new analyses of NFPA nutrient composition data have been highlighted. Without exception, a wide range of variability exists for individual nutrients. The fact that we have seen significant interaction terms in our analyses of variance further reenforces that we are still missing a great deal of information. The impact of this variability has been related to the problems encountered in nutrition labeling. It is our hope that those of you who practice the arts and sciences of horticulture will continue your programs to improve the nutrient quality of fruits and vegetables and that this paper will highlight the practical importance of nutrients to both the food processors and consumers.

Literature Cited

1. Cain, R.F. 1976. Factors influencing the nutritional quality and fortification of fruits and vegetables. p. 76-92 *In* Technology of fortification of foods. National Academy of Sciences, NRC, Washington, DC.
2. Cameron, E.J. 1954. The canning industry nutrition program. *Food Tech.* 8: 586.
3. Elkins, E.R., F.C. Lamb, and R.P. Farrow. 1972. Determination of nutritional changes in canned whole kernel corn as a result of varietal and processing changes. Contract No. FDA 71-270. National Canners Association, Washington, DC.
4. ________ . Interlaboratory variability in nutrient analyses: Two cooperative studies. *J. Assoc. Offic. Agr. Chem.* 47:1193.
5. ________, K. Kemper, and F.C. Lamb. 1976. Investigation to determine the nutrient content of canned fruits and vegetables, Contract No. USDA 12-14-100-11, 054(62). National Canners Association, Washington, DC.
6. ________. 1978. Nutrient content of raw and processed green beans, peaches and sweet potatoes. Presentation at the 38th Annu. Meeting Inst. Food Tech. Dallas, Texas. June 4-7.
7. Farrow, R.P., E.R. Elkins, J. Wang, F.C. Lamb, N. Low, and K. Kemper. 1971. Nutritive value of canned tomato juice. National Canners Association, Washington, D.C. and Berkeley, CA.
8. ________ and ________. 1973. Nutritive content of canned tomato juice and whole kernel corn. *J. Food Sci.* 38:595-601.
9. Farrow, R.P. 1974. Nutrition labeling. *J. Milk & Food Tech.* 37: 17-21.
10. ________, K. Kemper, and H.B. Chin. 1978. Natural variability in nutrient content of California fruits and vegetables. Presentation at the 38th Annu. Meeting Inst. Food Tech. Dallas, Texas. June 4-7.
11. Fennema, O. 1977. Loss of vitamins in fresh and frozen foods. *Food Tech.* 31: 32-35, 38.
12. Gebhardt, S.E., E.R. Elkins, and J. Humphrey. 1977. Comparison of two methods for determining the Vitamin A value of clingstone peaches. *J. Agr. Food Chem.* 25: 629.
13. Harris, R.S. and E. Karmas. 1975. Nutritional evaluation of food processing 2nd ed. Avi, Wesport, Conn.
14. Hein, R.E. and I.J. Hutchings. 1974. Influence of processing on vitamin-mineral content and biological availability in processed foods. p. 59-68 *In* P.L. White and D.C. Fletcher (eds.) Nutrients in processed foods, vitamins, minerals. Publishing Sciences Group, Acton, Mass.
15. Kelly, J.F. and B.B. Rhodes. 1975. The potential for improving the nutrient composition of horticultural crops. *Food Tech.* 29: 134-136; 138, 140.
16. Kimura, K.K. (ed.). 1977. The nutritional significance of dietary fiber. Contract No. FDA 223-75-2090. Federation of American Societies for Experimental Biology Bethesda, Md.
17. Lund, D.B. 1975. Effect of blanching, pasteurization, and sterilization on nutrients. p. 205 *In* R.S. Harris and E. Karmas (eds.) Nutritional evaluation of food processing, 2nd. ed. Avi. Westport, Conn.
18. Mayer, J. 1969. White House conference on food nutrition and health, final report. U.S. Govt. Printing Office, Washington, D.C.
19. Murphy, E.W., B.K. Watt, and R.L. Rizek. 1974. U.S. Department of Agriculture nutrient data bank. *J. Assoc. Offic. Agr. Chem.* 47: 1198-1204.
20. National Canners Association. 1955. Rentention of nutrients during canning. National Canners Association, Washington, D.C.
21. Salunkhe, D.K. (ed.). 1974. Storage, processing and nutritional quality of fruits and vegetables. CRC Press, Cleveland, Ohio.
22. U.S. Congress Senate. 1977. Dietary goals for the United States, Stock No. 052-070-04376-8. U.S. Govt. Printing Office, Washington, D.C.
23. Watt, B.K. and A.L. Merrill. 1963. Composition of foods, raw, processed, prepared U.S. Dept. Agr. Handb. 8 (rev.).
24. White, P.L. and N. Selvey (eds.). 1974. Nutritional qualities of fresh fruits and vegetables. Futura Publi., Mount Kisco, N.Y.