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NUTRITIONAL VALUE OF FOODS

Vitamin C in Canned Pineapple Products at the Retail Level

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Vitamin C analyses were run on 266 samples of canned pineapple juice and 279 of solid pack pineapple at the retail level during the winter of 1962–63, collected in 40 states in the continental United States. The effect of market location appeared to relate to the average temperatures of the various regions, the higher temperatures lowering the vitamin C mean values to as low as 6.6 mg. per 100 ml., and the cooler locations favoring as high as 9.3 mg. as a mean content in the juice. On solid pack items the range for locations was 3.0 to 8.9 mg. per 100 ml. Companies varied in the level of vitamin C in their products, especially for pineapple juice, where the range was from 6.1 to 9.8 mg. per 100 ml. The products in supermarkets had somewhat more vitamin C than those of the same age in neighborhood groceries; the product in the latter stores was generally 3 to 4 months older. Age exerted a modest influence on vitamin C content. The products were all at least 6 months old, and some were in marketing channels for 55 months. A typical mean value of 7.8 mg. per 100 ml. for juice and 6.4 mg. per 100 ml. for canned pineapple at the point of consumption is indicated by this study.

ONLY meager information on the vitamin C (ascorbic acid) level in canned pineapple products at the point of purchase has appeared in the literature. Perhaps the most thorough was the report of Teply *et al.* (*3*) in the series of studies of the nutritive value of canned foods. This paper reported on the vitamin C content of 26 cans of sliced pineapple and 17 cans of pineapple juice. The former ranged from 0.94 to 5.85 mg. per 100 grams, averaging 3.59. The juice ranged from 5.90 to 10.60, averaging 7.87 mg. per 100 grams.

Both length of time in storage and storage temperatures may affect the vitamin C level of the products after they have left the cannery. In turn, these may vary in different parts of the country and even with different kinds of stores. Some authoritative publications (*4, 5*) summarizing information on the nutrient content of food products give the vitamin C value of canned pineapple juice as approximately 9 mg. per 100 grams or 9.3 mg. per 100 ml. of juice. It is not clear whether the vitamin C value refers to the product after canning or at the time of consumption after a normal shelf life. This study was undertaken to provide information on the range in content of vitamin C in pineapple as it is offered on the retail shelf.

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Experimental

Budget, distance, and time argued against an extensive and completely representative sampling. The plan decided upon was to obtain shelf samples from each of two stores in a major marketing center located in each of 48 continental states. Sales personnel representing the Hawaiian pineapple companies agreed to do the actual can purchasing, identifying, packing, and shipping of the selected material to Honolulu for subsequent chemical analysis.

The instructions were kept to a minimum for obvious reasons. In a city, the instructions were to obtain samples from a major supermarket and from a small (neighborhood) store. In a store, buyers were instructed to select from the retail shelf a can of each of four brands of No. 1 or No. $1^1/_4$ pineapple slices (or other comparable solid pack) and a can of each of four brands of No. 2 or No. 211 cylinder pineapple juice. The cities selected were left to the discretion of the personnel handling the area.

Forty-one locations distributed in 40 states geographically well dispersed comprised the final sample. No claim is made or implied that this constitutes a truly representative sample, but it does offer information not otherwise available.

Four rather obvious sources of variation existed in the data as collected: company that prepared the pack, location where sample was procured, type of store in which displayed, and time elapsed since the product was sealed in the can. Least squares procedures, as described by Kempthorne (*2*), were applied to estimate the magnitudes of these factors. Prior to analysis the vitamin C values were transformed using $\log_{10}(X + 1)$, where X represents vitamin C in milligrams per 100 ml., which ensured the assumption of additivity in the model.

In the original sample, some cans packed in Taiwan, Malaya, Texas, and Mexico were obtained along with those from Hawaii and the Philippines. They were not used in the analysis, however, because there were only a few cans, and these could not be decoded with respect to age.

The vitamin C analyses were carried out using the standard indophenol titration method. Earlier studies (*7*) had indicated that only reduced ascorbic acid was present. All analyses were calculated on a volume rather than a weight basis. For the solid pack items, the sirup was pipetted off for vitamin C titration. It was found unnecessary to blend the slices and sirup for sampling, since the vitamin had diffused and reached an equilibrium between the solid and liquid phases. There was less than 1% difference in the titers of the sirup and the blended can contents.

The samples were all collected in late 1962 or early 1963 and were analyzed for vitamin C during January-March 1963.

Results and Discussion

The analyses of the two products, juice and solid pack, closely parallel each other and therefore have been combined for tabular presentation, as well as for discussion of the findings.

Significance of Estimates. The analyses of variance are summarized in Table I. All classification variables, except type of store for solid pack, exerted a significant influence upon vitamin content. The wide range and number of locations combine to indicate an important influence ($P < 0.01$) on the vitamin C content. Company processing of juice indicates more marked differences ($P < 0.01$) than for solid pack ($P < 0.05$). The store effect was appreciable on the juice pack only ($P < 0.05$) and negligible on the solid pack. The regression on age was significant in both juice and solid pack ($P < 0.05$).

Considering the manner in which the can samples were obtained, the coefficients of variation of the transformed vitamin C values indicate a reasonable level of sampling variation. Parallel computations using the observed vitamin C values produced coefficients of variation twice as large; this reduction is largely due to the success of the logarithmic transformation in achieving additivity and linearity.

The actual locations, the mean transformed and rectified vitamin C values, and the January and July proximate average temperatures (*6*) are presented in Table II. The rectified vitamin C values ranged from 9.3 to 6.6 mg. per 100 ml. for juice, and from 8.9 to 3.0 mg. for the solid pack.

A scrutiny of the means suggests regional differences. Outside air temperature, as it may influence store and warehouse temperatures, could be of some importance. The association

Table I. Analyses of Variance Using Transformed Vitamin C Values for Juice and Solid Pack Data Sets

Variation Due to	D.F.	Transformed Vitamin C Mean Square: Juice	Transformed Vitamin C Mean Square: Solid
Location	40	0.012957[a]	0.039281[a]
Companies	6	0.177948[a]	0.029547[b]
Stores	1	0.041000[b]	0.021410
Age	1	0.038300[b]	0.043900[b]
Residual (juice)	217	0.006827	
Residual (solid)	230		0.011983
Coeff. var., %		8.8	12.8

[a] $P < 0.01$. [b] $P < 0.05$.

Table II. Juice and Solid Pack Location Means for Vitamin C Values Adjusted for Age, Stores, and Companies

Location	Transformed Vit. C Mean: Juice	Transformed Vit. C Mean: Solid	Rectified Mean, Vit. C, Mg./100 Ml.: Juice	Rectified Mean, Vit. C, Mg./100 Ml.: Solid	Mean Temp.: January	Mean Temp.: July
Northeast						
Portland, Me.	0.926	0.858	7.4	6.2	22	68
Manchester, N. H.	0.951	0.857	7.9	6.2	21	70
Burlington, Vt.	0.954	0.926	8.0	7.4	18	71
Boston, Mass.	0.964	0.880	8.2	6.6	30	74
Providence, R. I.	0.955	0.866	8.0	6.3	29	72
Roslyn Heights, L. I., N. Y.	0.895	0.904	6.9	7.0	33	77
Philadelphia, Pa.	0.957	0.855	8.1	6.2	32	76
South Central						
Louisville, Ky.	0.960	0.876	8.1	6.5	35	77
Tennessee	0.914	0.890	7.2	6.8	41	81
Mobile, Ala.	1.011	0.861	9.3	6.3	53	81
Mississippi	0.888	0.801	6.7	5.3	49	82
Arkansas	0.947	0.838	7.9	5.9	41	82
Louisiana	0.881	0.790	6.6	5.2	56	83
Oklahoma City, Okla.	0.910	0.777	7.1	5.0	37	81
Texas	0.886	0.604	6.7	3.0	53	84
South Atlantic						
Wilmington, Del.	0.925	0.892	7.4	6.8	33	76
Baltimore, Md.	0.982	0.846	8.6	6.0	37	79
Huntington, W. Va.	0.941	0.919	7.7	7.3	35	76
Charlotte, N. C.	0.930	0.855	7.5	6.2	42	78
Greenville, S. C.	0.954	0.802	8.0	5.3	50	80
Atlanta, Ga.	0.901	0.776	7.0	5.0	45	79
Miami, Fla.	0.973	0.806	8.4	5.4	67	82
North Central						
Cleveland, Ohio	0.879	0.902	6.6	7.0	28	71
Evansville, Ind.	0.921	0.898	7.3	6.9	29	75
Chicago, Ill.	0.942	0.877	7.8	6.5	26	76
Detroit, Mich.	0.976	0.997	8.5	8.9	27	74
Oshkosh, Wis.	0.971	0.850	8.4	6.1	21	69
Minneapolis, Minn.	0.926	0.969	7.4	8.3	12	73
Cedar Rapids, Iowa	0.962	0.919	8.2	7.3	21	77
Aberdeen, S. D.	0.950	0.878	7.9	6.6	22	74
Omaha, Neb.	0.906	0.987	7.1	8.7	22	79
Gering, Neb.	0.999	0.910	9.0	7.1	22	79
Wichita, Kan.	0.894	0.817	6.8	5.6	31	80
West						
Great Falls, Mont.	1.014	0.928	9.3	7.5	19	68
Boise, Idaho	0.930	0.905	7.5	7.0	29	75
Denver, Colo.	0.993	0.878	8.8	6.5	30	73
Albuquerque, N. M.	0.975	0.900	8.4	6.9	35	79
Phoenix, Ariz.	0.913	0.930	7.2	7.5	51	91
Reno, Nev.	0.978	0.799	8.5	5.3	32	68
Portland, Ore.	0.962	0.883	8.2	6.6	40	69
San Francisco, Calif.	0.999	0.966	9.0	8.3	49	63

Table III. Juice and Solid Pack Company Means for Vitamin C Values, Adjusted for Age, Stores, and Location

Company No.	Transformed Vit. C Mean		Rectified Mean, Vit. C, Mg./100 Ml.	
	Juice	Solid	Juice	Solid
1	1.032	0.857	9.8	6.2
2	0.956	0.859	8.0	6.2
3	0.854	0.840	6.1	5.9
4	1.005	0.817	9.1	5.6
5	0.882	0.920	6.6	7.3
6	0.969	0.905	8.3	7.0
7	0.907	0.892	7.1	6.8

Table IV. Juice and Solid Pack Store Means for Vitamin C Values, Adjusted for Age, Company, and Location

Store	Transformed Vit. C Mean		Rectified Mean, Vit. C, Mg./100 Ml.	
	Juice	Solid	Juice	Solid
Supermarket	0.958	0.878	8.1	6.6
Neighborhood	0.930	0.862	7.5	6.3

Table V. Juice and Solid Pack Regression Coefficients for Transformed Vitamin C Values on Age

(Adjusted for stores, companies, and locations)

Pack	Regression Coefficient
Juice	−0.0004774
Solid	−0.0004969

Table VI. Juice and Solid Pack General Means for Transformed and Rectified Vitamin C Values

(Adjusted for age, store, company, and location effects)

Pack	General Mean for Vitamin C	
	Transformed	Rectified, mg./100 ml.
Juice	0.944	7.8
Solid	0.870	6.4

between the vitamin C measure and a function of winter and summer temperatures, using the 41 location pairs, just approached significance for juice (R = 0.392) and displayed a measurable influence ($P < 0.01$) on solid pack (R = 0.503), the higher ambient temperature leading to a lower vitamin C content in the canned product.

Previous work (*1*) had demonstrated that vitamin C in canned pineapple is stable at low temperatures, but rapidly drops within a few months at 100° F.

Company Effects. All of the Hawaii packers were represented in the samples collected. In addition, the Philippine pineapple pack had a significant representation. Thus, it was possible to classify the juice and solid pack samples into seven companies.

The vitamin C value of pineapple juice or solid pack can be expected to be dependent upon where and under what conditions the fruit was produced (plantation management, soil, and climate effects); also in part upon variations in the canning process (cannery effects). In the present study, all of these contributions are lumped together and termed the "company" effect, since it was impossible to obtain estimates of any of the "company" components from the samples collected.

The company means are presented in Table III, adjusted for the other variables. The range in rectified vitamin C values was from 9.8 to 6.1 mg. per 100 ml. for juice, and from 7.3 to 5.6 for the solid pack.

Store Effect. The matter of store type, supermarket or neighborhood store, played only a minor role in the vitamin C level of pineapple products reaching the consumer. The mean transformed vitamin C values presented in Table IV indicate slightly higher values in the supermarket type, but the difference is only 0.6 rectified unit (mg. per 100 ml.) in juice and 0.3 rectified unit in solid pack. Additionally, however, there is about a 3- to 4-month difference in the age of product, the supermarket reflecting its larger customer volume in somewhat fresher shelf stock.

Age of Can. The rate of decline of transformed vitamin C with age (Table V) is almost identical for juice and for solid pack. The magnitude of the regression coefficients indicates that age has only a modest effect. However, this aspect of vitamin C loss takes on increased importance when it is pointed out that cans were found ranging in age from 6 to 55 months. The mean age for the juice samples was 20.4 months; for solid pack it was 19.8 months.

There is a pronounced time and temperature interdependency in vitamin C loss from canned pineapple (*1*). The modest effect of age of the can in the present study, when adjusted for location, does not negate the possible adverse effect of a slow market turnover of products in locations having warm climates or improper warehousing.

The implied relationship is that the logarithm of vitamin C is linearly dependent on age in months. Rather than including a quadratic covariant term in the model, parallel calculations using the logarithm of age were carried out. This evidence did not point to any particular benefit to be expected through the use of a more complex model.

General Level of Vitamin C. This study stemmed from questions raised by producers, nutritionists, and potential purchasers as to the level of vitamin C in canned pineapple juice or solid pack as consumed. The estimates of the mean level are presented in Table VI, being 7.8 mg. of vitamin C per 100 ml. of product for pineapple juice and 6.4 for pineapple solid pack.

The standard errors of the mean transformed vitamin C values are 0.005 and 0.006 for juice and solid pack, respectively. Letting $t = 2$ gives approximate 95% confidence limits of 0.944 ± 0.010 and 0.870 ± 0.012 for the transformed vitamin C values in juice and solid pack, respectively. These appear to be reliable estimates from a statistical point of view.

The mean values for vitamin C found in this study are far above the mean for sliced pineapple as reported by Teply *et al.* (*3*), though comparable to their value for pineapple juice. The vitamin C means are somewhat lower than the "typical" values reported in accepted food composition tables (*5*). The data suggest that the product from some companies or some locations may approach the 9.3 mg. per 100 ml. value of Watt and Merrill, while others clearly will not.

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