

Analysis of Citrus Fruit 1962-1964

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The constituents potassium, phosphorus and nitrogen have been determined on oranges from various sources and the results examined statistically. Whilst each of these constituents may be used to ascertain the potable fruit or fruit juice content of fruit products, it appears that phosphorus is the most reliable single constituent and a combination of all three is to be preferred. Some additional data, insufficient for statistical treatment, is given for lemons and grapefruit.

Introduction

For some time analysts have been in difficulty when asked to ascertain the potable fruit content or fruit juice content of fruit products, particularly soft drinks. It appears that potassium, phosphorus and nitrogen contents are most widely used for this purpose.

Although the available data on citrus fruit juices are fairly adequate, that for the whole fruit appears to be much more sparse, and it is this latter data which is required for the assessment of comminuted products such as orange drink. Recently Hart¹ has reported a large number of analyses of Texan orange juice and Sherratt and Sinar² have published results for the analysis of a range of grapefruit juices from various producing countries. McCance and Widdowson³ give analytical data for whole citrus fruits but there is no indication of the probable range of variation. Kefford⁴ quotes a range for phosphorus (P_2O_5) in orange juice from 0.019 per cent. to 0.072 per cent. and Birdsall, Derse and Tepley⁵ state an average phosphorus (P_2O_5) figure for the juice of Californian Valencia oranges of 0.045 per cent. apparently based on only two oranges.

The authors have carried out a number of analyses of the three fruits, oranges, lemons and grapefruit for the constituents potassium, phosphorus and nitrogen and hope that the results may be of interest and assistance to other analysts.

The oranges analysed came from the four regions, South Africa, Eastern Mediterranean (Israel and Cyprus), Spain and Brazil, and the results have been examined statistically to see if there is any correlation between constituents and if there are any significant differences between the results for oranges from these regions.

Potassium, phosphorus and nitrogen were estimated in whole orange products manufactured from oranges of known variety and origin in order to derive a formula for the estimation of the potable fruit in the product.

Methods of Analysis

The fruits were peeled and the peel and edible portion examined separately, and for each juice analysis the juice was hand reamed from three fruits and combined.

Potassium and phosphorus were determined using a flame photometer and the molybdenum blue method of Fogg and Wilkinson⁶ respectively, after destruction of the organic matter by wet oxidation. Nitrogen was determined by the Kjeldahl method.

Results

TABLE I
CONSTITUENTS OF SOUTH AFRICAN ORANGES

Variety	Part of fruit	Potassium as K, w/w		Phosphorus as P, w/w		Total nitrogen as N, w/w	
		Average per cent.	Standard deviation	Average per cent.	Standard deviation	Average per cent.	Standard deviation
Valencia (10 samples)	Edible	0.164	0.022	0.022	0.005	0.163	0.039
	Peel	0.192	0.022	0.018	0.005	0.248	0.050
	Whole	0.173	0.012	0.021	0.005	0.187	0.036
Navel (5 samples)	Edible	0.158	0.012	0.020	0.003	0.175	0.016
	Peel	0.188	0.050	0.022	0.004	0.255	0.042
	Whole	0.166	0.023	0.021	0.002	0.198	0.020

The results shown in Table I above were examined statistically and from the data available it can be said that there is no significant difference between the potassium, phosphorus or nitrogen contents of South African Valencia and South African Navel oranges.

TABLE II
CONSTITUENTS OF ORANGES FROM VARIOUS SOURCES

Origin	Part of fruit	No. of analyses	Potassium as K w/w		Phosphorus as P w/w		Total nitrogen as N w/w	
			Average per cent.	Standard deviation	Average per cent.	Standard deviation	Average per cent.	Standard deviation
South Africa	Edible	15	0.162	0.029	0.021	0.005	0.167	0.042
	Peel	15	0.191	0.048	0.019	0.005	0.250	0.046
	Whole	15	0.171	0.026	0.021	0.004	0.190	0.040
	Juice	6	0.178	0.061	0.019	0.005	0.143	0.026
Eastern Mediterranean	Edible	19	0.163	0.039	0.025	0.008	0.205	0.066
	Peel	19	0.197	0.053	0.019	0.006	0.266	0.066
	Whole	19	0.170	0.032	0.022	0.004	0.225	0.059
	Juice	7	0.158	0.047	0.020	0.005	0.140	0.056
Spain	Edible	8	0.155	0.048	0.021	0.004	0.165	0.049
	Peel	8	0.297	0.097	0.018	0.007	0.248	0.051
	Whole	8	0.171	0.064	0.020	0.004	0.184	0.049
	Juice	4	0.137	0.016	0.016	0.003	0.121	0.042
Brazil	Edible	9	0.198	0.042	0.022	0.005	0.162	0.036
	Peel	9	0.364	0.071	0.021	0.002	0.244	0.068
	Whole	9	0.231	0.036	0.023	0.004	0.178	0.040
	Juice	4	0.174	0.018	0.019	0.002	0.103	0.018
All Regions Averages	Edible	51	0.169	0.046	0.023	0.006	0.181	0.055
	Peel	51	0.230	0.090	0.020	0.006	0.259	0.060
	Whole	51	0.183	0.043	0.021	0.005	0.202	0.051
	Juice	21	0.154	0.047	0.019	0.004	0.130	0.040

Table II shows the average figures and standard deviations obtained for the analysis of oranges in the regions South Africa, Eastern Mediterranean, Spain and Brazil.

For each region average figures for whole oranges are shown in Table III. A statistical analysis of the data did not show any significant correlation between any two of the three constituents.

TABLE III
AVERAGE POTASSIUM, PHOSPHORUS AND NITROGEN CONTENT OF ORANGES

Region	Potassium (K) per cent. w/w	Phosphorus (P) per cent. w/w	Nitrogen (N) per cent. w/w
South Africa	0.171	0.021	0.190
Eastern Mediterranean	0.170	0.022	0.225
Spain	0.171	0.020	0.184
Brazil	0.231	0.022	0.178

A comparison of results for each constituent for the different regions shows:—

(a) *Potassium*

The average figures for oranges from S. Africa, Eastern Mediterranean and Spain are very close, but Brazilian oranges show a significantly higher figure. Statistical tests show that there is a 95 per cent. chance that the potassium content of oranges from Brazil will be higher than of oranges from the other regions.

(b) *Phosphorus*

The phosphorus content is consistent throughout the four regions.

TABLE IV
CONSTITUENTS OF LEMONS FROM VARIOUS SOURCES

Origin	Part of fruit	No. of analyses	Potassium as K w/w		Phosphorus as P w/w		Total nitrogen as N w/w	
			Average per cent.	Standard deviation	Average per cent.	Standard deviation	Average per cent.	Standards deviation
California U.S.A.	Edible	5	0.128	0.049	0.022	0.003	0.122	0.013
	Peel	5	0.166	0.060	0.023	0.004	0.222	0.038
	Whole	5	0.142	0.051	0.022	0.004	0.160	0.020
	Juice	2	0.139	0.008	0.011	nil	0.061	0.003
Italy	Edible	3	0.162	0.016	0.023	0.004	0.172	0.019
	Peel	3	0.180	0.040	0.017	0.004	0.237	0.060
	Whole	3	0.168	0.017	0.021	0.003	0.196	0.024
	Juice	1	0.153	—	0.013	—	0.074	—
South Africa	Edible	2	0.175	0.007	0.020	0.004	0.155	0.013
	Peel	2	0.245	0.050	0.023	0.001	0.332	0.093
	Whole	2	0.195	0.007	0.021	0.003	0.191	0.024
	Juice	1	0.160	—	0.009	—	0.090	—
All Regions	Edible	10	0.148	0.039	0.022	0.003	0.144	0.027
	Peel	10	0.186	0.057	0.022	0.005	0.248	0.066
	Whole	10	0.160	0.041	0.021	0.003	0.177	0.026
	Juice	4	0.148	0.010	0.011	0.002	0.071	0.014

(c) Nitrogen

There is a 90 per cent. chance that the differences shown in the table for the regions are real. Also there is a 90 per cent. chance that the nitrogen content of oranges from the Eastern Mediterranean will be higher than oranges from the other regions.

Tables IV and V show the results obtained for Lemons and Grapefruit, but there were insufficient figures to carry out any statistical analysis.

TABLE V
CONSTITUENTS OF SOUTH AFRICAN GRAPEFRUIT

Origin	Part of fruit	No. of analyses	Potassium as K w/w		Phosphorus as P w/w		Total nitrogen as N w/w	
			Average per cent.	Standard deviation	Average per cent.	Standard deviation	Average per cent.	Standard deviation
South Africa	Edible	2	0.124	0.002	0.020	0.004	0.144	0.007
	Peel	2	0.196	0.001	0.025	0.003	0.204	0.028
	Whole	2	0.146	0.002	0.019	0.004	0.162	0.028
	Juice	1	0.126	—	0.017	—	0.106	—

Conclusions

The phosphorus content of an orange product is probably the most satisfactory measure of potable fruit or fruit juice content, but potassium and nitrogen should also be determined for confirmation.

Estimation of Potable Fruit Content of Whole Orange products

Twenty-eight samples of a whole orange compound, nominally 22 per cent. w/v potable fruit content, were examined for potassium, phosphorus and nitrogen. Using the appropriate data for whole oranges the potable fruit contents were calculated from each constituent. These results were examined statistically in order to find the best formula combining the three constituents to give a more reliable estimate of potable fruit content.

The proposed formula is:—

$$W = 0.05 (7X + 10Y + 3Z)$$

where W = estimated potable fruit

X = potable fruit content based on potassium content

Y = potable fruit content based on phosphorus content

Z = potable fruit content based on nitrogen content

It should be noted that strictly speaking this formula applies only to one particular type of comminution process.

Below are shown the average figures and standard deviations for the potable fruit content based on the separate constituents and on the formula.

TABLE VI
FRUIT CONTENT OF "WHOLE ORANGE COMPOUND"

X (Potassium)		Y (Phosphorus)		Z (Nitrogen)		W (Formula)	
Average per cent.	Standard deviation	Average per cent.	Standard deviation	Average per cent.	Standard deviation	Average per cent.	Standard deviation
23.3	3.95	22.3	3.60	22.0	4.00	22.6	2.85

The authors wish to thank C.W.S. Soft Drinks Division for supplying the samples of fruit and comminuted fruit, Mr. C. Meredith and Mr. N. Batty for assistance with the statistical work and also the Directors of the C.W.S. for permission to publish this data.

References

1. Hart, Samuel M., *J. Assoc. Off. Agric. Chem.*, 1961, **44** (4), 633.
2. Sherratt, J. G., and Sinar, R., *J. Assoc. Publ. Analysts*, 1963, **1**, 18.
3. McCance, R. A., and Widdowson, E. M., "The Composition of Foods", Medical Research Council Special Report No. 297, H.M.S.O., London, 1960.
4. Kefford, J. F., "The Chemical Constituents of Citrus Fruits", *Adv. Food Res.*, 1959, **9**, 285.
5. Birdsall, J. J., Derse, P. H., and Teply, L. J., "Nutrients in Californian Lemons and Oranges", *J. Amer. Diet. Assoc.*, 1961, **38**, 555.
6. Fogg, D. N., and Wilkinson, N. T., *Analyst*, 1958, **83**, 406.