

# THE COMPOSITION OF LOCAL AND IMPORTED CITRUS FRUIT

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A. W. R. JOACHIM, Ph.D., Dip. Agric. (Cantab.),  
*CHEMIST*

*AND*

D. G. PANDITTESEKERE, Dip. Agric. (Poona),  
*ASSISTANT IN AGRICULTURAL CHEMISTRY*

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**T**HE average number of cases of citrus fruit imported annually into Ceylon between 1932 and 1938 was 9,030, the record being 13,581 in 1935 since when there has been a decline. There is likely to be a further decline in the future owing to the restriction which has been placed upon the import into Ceylon of fruit from countries affected by the Mediterranean fruit fly. On the other hand, during the period under review there has been a steady and appreciable increase in the acreage under the crop in the Island, an increase which appears to show promise of being maintained. As a result, production will, in due course, reach the point when the Island's entire requirements of citrus fruit for several months in the year can be met. The question has therefore been raised as to how the quality of locally-grown citrus compares with that of imported fruit. Quality in citrus is determined by such factors as abundance and flavour of juice, texture of pulp, thickness of rind, facility of peeling, seedlessness, amount and character of rag. Inasmuch as the flavour of the fruit is governed to a large degree by its chemical composition, it was considered that analyses of representative samples of local and imported citrus fruit would furnish useful comparative data on the point at issue. Accordingly, analyses have been made during the past twelve months of 62 samples of imported and local oranges and grapefruit, and though the samples examined were not, in the case of every sample group, as numerous as was desirable they were considered to be adequate for the purposes of this inquiry.

The samples comprised the following :—

Local oranges	..	..	..	15
Imported oranges	..	..	..	23
Local grapefruit	..	..	..	17
Imported grapefruit	..	..	..	7

The countries of origin of the imported samples were South Australia, California, South Africa, and Rhodesia. No samples of fruit were available from countries from which the importation of citrus fruit is prohibited. Samples of imported grapefruit were difficult to obtain, presumably because of the non-importation of fruit from the latter countries. The imported orange samples were of the Navel and Valencia varieties and the imported grapefruit mainly of the Marsh's Seedless variety. The local orange samples were good quality fruit of the Kotte, Valencia, Washington Navel and Indian types. Some samples were from seedling trees, others from grafts. The local grapefruit samples included the following varieties :—Marsh's Seedless, Cecily Seedless, Walters, McCarty, Triumph, Fosters and Ellen. All the local samples of oranges and grapefruit were obtained from the Government Experiment Stations or from private growers.

#### METHODS OF ANALYSIS.

On receipt, each sample, which consisted of 6 to 8 fruits in the case of oranges and 3 to 4 fruits in the case of grapefruit, was examined for the following characteristics :— Size and weight of fruit, colour and thickness of rind, degree of seediness, colour and flavour of pulp, character of rag and percentage by weight of juice in the fruit. The following analytical determinations of the strained juice, which was extracted with a Sunkist extractor, were carried out by the methods specified, except in regard to sugars which were omitted in certain samples :—

*Total solids (Brix).*—These were determined by the Brix hydrometer, corrections for temperature being made from de Villiers' table (17), and also by the Zeiss refractometer fitted with a sugar scale.

*Acidity* was calculated as citric acid with one molecule of water and in ml. of deci-normal caustic soda required to neutralize 10 ml. of juice.

*Sugars.*—Total and reducing sugars were determined by Lane and Eynon's method with methylene blue as internal indicator.

*Vitamin C.*—The recent improved iodine method of the California Fruit Growers Exchange was adopted for the estimation of vitamin C (21).

*pH.*—The quinhydrone method was used.

## CITRUS MATURITY STANDARDS

In most citrus-growing countries, regulations are in force to prevent the export of citrus fruit, particularly oranges, unless they attain a minimum "maturity" standard. The standard commonly in use is based on the total soluble solids/acid ratio of the juice, and is frequently, though incorrectly, designated the sugar/acid ratio, since sugars are the most important of the soluble solids. In these calculations the acidity is reckoned as citric acid. The ratio varies in the different countries with the species of fruit and occasionally with the variety or other factor. Thus in California and Florida, all oranges for export should have a minimum maturity ratio of 8 to 1 (19, 20)\*. In South Africa (18) the ratio varies according to the variety, being 5.5 for seedling oranges, 6.0 for Valencias and 6.5 for Navels. But fruit for export should, in addition, contain at least 45 per cent. juice by weight. The Palestine regulations demand a minimum sugar/acid ratio of 7 to 1 (15). In New South Wales (16), maturity is expressed in terms of titratable acidity. Navel oranges are considered "mature" when less than 23 ml. of deci-normal caustic soda are required to neutralize the acidity in 10 ml. of juice. In Jamaica (6), the corresponding maturity maximum suggested is 20 ml. The export regulations in regard to grapefruit are less explicit. Thus the Palestine regulations state that "no grapefruit shall be exported from Palestine unless the fruits have reached an adequate state of maturity". The reason why no rigid standards have been prescribed for grapefruit are: (1) the solid/acid ratios for fruit of satisfactory flavour and quality have been found to vary appreciably with the district of origin. In California and Arizona they range from 5.5 to 6.8, and in Jamaica from 7.3 to 11.3 (6); (2) the ratios are dependent on the total solid contents of the juices, being generally the lower, the higher the latter. Suitable ratios suggested for grapefruit (6) are 5.5 to 6.5.

While the total solid/acid ratios afford a fairly reliable indication of maturity in oranges, they have certain limitations as indexes of flavour. Thus two oranges may have identical maturity ratios but distinct flavours owing to the actual quantities of sugar and acid in the juices being markedly different. A juice with a low concentration of these constituents would tend to be insipid. A better guide to flavour is the true sugar/acid ratio, considered in conjunction with the actual amounts of sugar or acid or both present in the juice. Tentative formulae (6, 22) have been suggested for calculating from the chemical data indexes of flavour, but these are not generally applicable to all varieties of citrus fruit,

\* Numbers relate to references on pages 19 and 20.

nor to all countries, and soil and climatic conditions. In the analytical tables which follow, both the total solids/acid and the sugar/acid ratios for the samples examined are furnished.

### RESULTS AND DISCUSSION OF DATA

The results of the examination and analysis of the samples are presented in four tables. I. and II. show certain characteristics of, and analytical figures for, local orange and grapefruit samples, and III. and IV. the corresponding data for the imported samples. In these tables the samples are classified, where possible, into sub-groups according to variety, country of origin and nature of parent tree, *i.e.*, whether graft or seedling. When discussing the data, comment will only be made on any sub-group comprising at least six samples. In table V. the analytical data of the samples examined are summarized, while in table VI. the corresponding data, obtained from the literature, for citrus fruit of various countries, are furnished.

(For Tables I. and II. see pages 21 and 22.)

### ORANGES

An examination of the tables I. and II. indicates that :

(1) There are considerable variations in the analytical composition of different samples of both imported and local oranges. A wide range of variation will be apparent (*cf.* table V.) in the case of every constituent determined. To take a few examples. In regard to juice percentage, the range for local fruit is 35·4 to 63·0 and for imported fruit 36·9 to 62·2 ; for total solids the corresponding ranges are 8·2 to 12·7 and 9·2 to 11·9. The range is widest with the solids/acid and sugar/acid ratios, and narrowest in the case of the pH values. The flavour also varies from sweet to sour through mildly sweet, mildly tart and tart.

(2) Considered as a whole, the average composition of the local samples is not significantly different from that of the imported samples.

(3) The lowest solids/acid ratio in the case of the local samples is 8·3, a figure which is higher than the standard set for Californian fruit. All the local samples examined are, therefore, from the standpoint of maturity, up to export standard. Of the imported samples, only one has a ratio less than 8, but even this, from Rhodesia, would pass the standard adopted in its country of origin, *viz.*, 6·5. All the samples are well above the New South Wales standard.

(4) The average vitamin contents of both imported and local oranges are quite high, being respectively 52·3 and 49·6 mgm. per 100 ml. of juice.

(5) There is no appreciable difference in the average analytical composition of local fruit from grafted and seedling trees. Of imported fruit, Navels are significantly superior to the Valencias in vitamin C content.

(6) There is a fairly close correspondence between the total solids/acid and sugar/acid ratios and flavour; but this is more noticeable when the data for any particular sub-group are compared.

(For Tables III. and IV. see page 23.)

### GRAPEFRUIT

A study of the data of tables III. and IV. shows that :

(1) As with oranges, though to a lesser degree, there is an appreciable variation in the composition of individual samples of both local and imported grapefruit. Thus the juice percentages and total solids/acid ratios vary from 30·5 to 55·2 and 4·6 to 8·9 respectively in the case of the local fruit, and from 32·5 to 45·3 and 4·4 to 9·5 with the imported fruit.

(2) The average vitamin C values, sugar contents and maturity ratios of both the imported and local grapefruit samples are lower, and the acidities higher than the corresponding figures for the orange samples.

(3) The local samples, on the average, are not significantly different to the imported samples in analytical composition.

(4) There is no significant difference between the average analytical composition of the Marsh's Seedless samples and that of the other varieties, grouped together.

(For Tables V. and VI. see page 24.)

### GENERAL DISCUSSION

On examining the data of table VI. which shows the analyses of representative samples of oranges and grapefruit of various countries, it will be found that the local samples of oranges and grapefruit compare very favourably in analytical composition with the fruit grown elsewhere. The general conclusions arrived at from a comparison of the analyses of local and imported citrus fruit are thus confirmed. In other respects, however, there are striking differences between local and imported oranges. Many of the local orange samples are inferior to the imported fruit in such characteristics as colour and looseness of rind, facility of peeling, character of rag, seedlessness, &c. Artificial colouration by means of ethylene does not often produce the typical colour in local oranges. These defects are probably the effects of the warm, continuously-humid climate, and are less marked in local fruit grown in the

cooler dry districts, *e.g.*, Welimada. Most samples of local grapefruit, on the other hand, are in every respect of the standard of, and some even superior to, the fruit imported into the Island. When the colour is lacking, artificial colouration can easily be resorted to with excellent results.

#### SUMMARY

The analyses of 62 samples of local and imported grapefruit and oranges have indicated that locally grown oranges of good quality compare favourably with imported fruit in analytical composition. Many of the local samples are, probably because of climatic conditions, inferior to imported fruit in such characteristics as colour, thickness of rind, facility of peeling, character of rag, seedlessness, &c. Most samples of local grapefruit, on the other hand, are in every respect equal, and in some cases superior, to imported fruit. Local citrus fruits have a very similar composition to fruit grown in other countries.

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TABLE I.

## Local Oranges

Locality	Variety	Flavour	Seediness	Juice Per cent.	Total solids gm. per 100 ml.	Acidity			Total solids/ acid ratio	Reducing sugars gm. per 100 ml.	Sucrose gm. per 100 ml.	Total sugars gm. per 100 ml.	Vitamin C per 100 ml.	pH	Sugar/ acid ratio
						Gm. citric acid per 100 ml.	ML. N/10 soda per 100 ml.	Total solids per 100 ml.							
<i>Grafted</i>															
Hewaheta ..	Navel	Sweet	Seedless	47.0	11.8	0.47	6.7	25.1	3.76	4.37	8.13	47.6	4.3	17.3	
Welimada ..	do.	Mildly tart	Few seeds	40.1	9.9	0.62	8.9	15.9	2.86	3.78	7.67	50.0	4.3	12.4	
Haputale ..	do.	do.	Seedless	40.3	9.3	0.67	9.5	18.9	2.88	4.04	6.92	54.2	4.4	10.3	
Biblle ..	do.	do.	do.	44.2	11.8	0.93	13.3	12.6	2.85	4.86	7.71	50.8	4.4	8.3	
<i>Average</i> ..				42.9	10.7	0.67	9.6	16.9	3.34	4.26	7.61	52.2	4.4	12.1	
Maha Ilupalama ..	Valencia	Mildly tart	Few seeds	52.1	9.6	0.69	9.9	13.9	—	—	—	40.4	4.0	—	
Mundel ..	Indian	Sweet	do.	39.5	13.4	0.57	8.1	23.6	2.28	5.10	7.35	54.0	4.1	12.9	
<i>Average (grafted)</i> ..				43.9	11.0	0.66	9.4	17.5	3.13	4.44	7.54	50.5	4.3	12.9	
<i>Seedling</i>															
S. K. East ..	Kotie type	Mildly tart	Few seeds	54.4	8.2	0.90	12.8	9.1	—	—	—	42.0	3.8	—	
Kotugoda ..	do.	do.	do.	63.0	8.9	0.98	14.1	9.0	—	—	—	42.2	—	—	
Kotie ..	do.	Tart	Many seeds	48.1	12.7	1.32	18.9	9.6	4.13	3.58	7.71	51.3	3.7	5.8	
Nathandiya ..	do.	Sweet	do.	40.0	12.2	0.92	13.2	13.3	3.61	5.23	8.84	59.6	4.0	9.6	
<i>Average</i> ..				51.4	10.5	1.03	14.8	10.2	3.87	4.40	8.28	48.8	3.8	7.7	
Matugama ..	Valencia type.	Tart	Few seeds	53.2	9.3	1.13	16.1	8.3	2.27	3.68	5.95	36.6	3.8	5.3	
Puttalam ..	do.	Mildly tart	Many seeds	35.4	12.8	0.53	7.5	24.4	—	—	—	59.7	—	—	
Teldeniya ..	do.	Sweet	Few seeds	37.5	9.4	0.55	7.8	17.2	1.98	3.61	5.54	40.8	4.1	10.1	
Tinnevelly ..	do.	do.	do.	49.7	10.9	0.60	18.5	18.1	2.41	4.80	7.21	47.0	4.1	12.0	
Yavuniya ..	do.	Mildly tart	do.	42.5	10.3	0.77	10.9	13.5	2.40	4.55	7.04	62.2	4.2	9.1	
<i>Average</i> ..				45.7	10.5	0.72	10.2	16.3	2.25	4.16	6.44	49.3	4.1	9.1	
<i>Average (seedling)</i> ..				47.1	10.5	0.86	12.9	13.6	2.81	4.27	7.05	49.0	4.0	8.7	
<b>General average</b> ..				<b>45.4</b>	<b>10.7</b>	<b>0.79</b>	<b>11.1</b>	<b>15.1</b>	<b>2.95</b>	<b>4.32</b>	<b>7.28</b>	<b>49.6</b>	<b>4.1</b>	<b>10.3</b>	

TABLE II.

## Imported Oranges

Country of Origin	Variety	Flavour	Seediness	Juice Per cent.	Total solids gm. per 100 ml.	Acidity				Total solids/acid Ratio	Reducing sugars gm. per 100 ml.	Sucrose gm. per 100 ml.	Total Sugars gm. per 100 ml.	Vitamin C per mgm. 100 ml.	pH	Sugar/acid Ratio
						Gm. citric acid per 100 ml.	Ml. N/10 soda per 10 ml.	Total solids/acid Ratio	Reducing sugars gm. per 100 ml.							
South Australia	Navel	Mildly tart	Seedless	36.9	10.9	0.98	11.0	11.1	3.61	3.01	6.62	53.8	3.0	6.8		
Do.	do.	Sweet	do.	50.2	10.7	0.78	14.1	13.8	—	—	—	57.0	3.6	—		
Do.	do.	Mildly sweet	do.	43.1	10.9	0.61	8.8	17.8	4.05	4.26	8.31	52.5	3.5	13.6		
Average				43.4	10.8	0.79	11.3	14.2	3.83	3.64	7.47	54.4	3.7	—		
South Africa	Navel	Mildly tart	Seedless	50.9	11.2	0.97	13.9	11.5	4.31	3.78	8.09	57.1	4.4	8.3		
Do.	do.	Tart	do.	49.3	11.6	0.88	12.5	13.3	—	—	—	53.3	3.9	—		
Average				50.1	11.4	0.93	13.2	12.4	4.31	3.78	8.09	55.2	4.0	9.6		
California	Navel	Mildly tart	Seedless	47.8	11.7	0.96	14.1	11.9	4.31	3.89	8.20	58.8	4.0	8.5		
Rhodesia	do.	Sour	do.	50.9	9.2	1.25	17.8	7.4	4.14	2.60	6.78	64.6	3.6	5.4		
Average (Navel)				47.0	10.9	0.92	13.2	12.4	4.08	3.51	7.60	56.7	3.8	8.5		
South Australia	Valencia	Tart	Few seeds	50.4	9.8	0.93	13.3	10.5	2.65	3.05	5.70	53.6	3.7	6.1		
Do.	do.	Mildly tart	do.	55.4	11.7	0.83	11.8	14.0	4.07	2.56	6.63	53.3	3.9	8.0		
Do.	do.	Mildly sweet	Seedless	59.2	11.9	0.71	10.9	16.7	2.70	6.71	9.41	42.0	3.9	13.3		
Do.	do.	Sweet	do.	52.6	10.9	0.59	8.4	17.5	1.83	3.81	5.64	34.8	4.0	9.6		
Do.	do.	Mildly tart	Many seeds	47.2	10.7	0.77	10.9	14.0	3.68	3.14	6.82	47.2	4.0	8.9		
Average				53.0	11.0	0.77	11.1	14.5	2.99	3.85	6.84	46.2	3.9	9.2		
California	Valencia	Mildly tart	Seedless	48.6	11.0	0.91	13.0	12.1	2.68	5.05	7.73	60.2	3.9	8.5		
Do.	do.	Mildly sweet	do.	49.5	10.7	0.97	13.9	11.0	2.16	6.18	8.34	43.6	3.8	8.6		
Do.	do.	Mildly tart	do.	47.1	11.7	1.02	14.6	11.5	4.81	3.53	8.34	66.2	4.0	8.2		
Do.	do.	do.	do.	46.9	10.7	0.90	11.9	11.9	4.31	3.09	7.40	56.1	4.0	8.2		
Do.	do.	Mildly sweet	Few seeds	62.2	10.9	0.55	7.8	19.9	4.29	4.94	9.23	35.0	4.0	16.8		
Average				50.9	11.0	0.87	12.2	13.3	3.65	4.56	8.21	52.2	3.9	10.1		
Average (Valencia)				51.9	11.0	0.82	11.7	13.9	3.32	4.21	7.52	49.2	3.9	9.6		
<b>General average</b>				<b>49.9</b>	<b>10.9</b>	<b>0.86</b>	<b>12.3</b>	<b>13.3</b>	<b>3.57</b>	<b>3.97</b>	<b>7.42</b>	<b>52.3</b>	<b>3.9</b>	<b>9.3</b>		

TABLE III.  
Local Grapefruit.

Acidity

Locality	Variety	Acidity				Total solids/100 ml.	Total solids/acid Ratio	Reducing sugars/100 ml.	Sucrose/100 ml.	Total Sugars/100 ml.	Vitamin C/100 ml.	pH	Sugar/acid Ratio
		Juice Per cent.	Gm. citric acid per 100 ml.	Ml. N/10 soda per 10 ml.	Gm. per 100 ml.								
Maha Illupalama	Marsh's Seedless	47.7	1.07	14.41	8.1	8.1	3.20	4.28	7.48	44.2	3.4	7.0	
Mundel	do.	46.5	1.11	15.8	8.1	8.1	3.45	2.11	5.56	44.1	3.7	5.0	
Talangama	do.	51.7	1.32	18.9	6.4	6.4	3.72	2.47	6.19	39.8	—	4.7	
Do.	do.	52.7	1.37	19.5	5.1	5.1	3.36	1.92	5.28	34.1	—	3.9	
Do.	do.	30.9	1.29	18.4	5.7	5.7	3.49	2.10	5.59	39.0	—	4.8	
Do.	do.	38.1	1.50	21.4	5.9	5.9	2.23	2.03	4.26	39.2	3.8	2.8	
Nalanda	do.	38.1	1.77	25.3	4.6	4.6	4.00	2.11	4.19	42.0	3.3	3.1	
Do.	do.	55.2	1.87	26.7	5.0	5.0	4.00	1.71	5.71	45.8	3.3	3.1	
Dambulla	do.	40.9	1.83	26.1	4.6	4.6	3.18	2.19	5.37	37.2	3.4	2.9	
Minneriya	do.	41.3	1.17	16.7	7.6	7.6	3.74	2.69	6.43	43.6	3.5	5.5	
Haputale	do.	36.7	1.11	15.7	7.6	7.6	2.89	2.36	5.25	33.6	3.6	4.7	
Wellmada	do.	35.4	1.94	27.7	4.7	4.7	2.92	1.97	4.89	42.9	3.5	2.5	
Mundel	do.	42.8	1.87	26.7	5.1	5.1	3.32	1.70	5.02	49.0	3.5	2.7	
Average (Marsh's Seedless)		45.9	1.48	21.0	6.0	6.0	3.20	2.28	5.48	41.1	3.5	4.0	
Mundel	Cecily	46.5	1.09	15.5	7.7	7.7	—	—	—	38.2	3.8	—	
Do.	do.	41.7	1.15	16.5	6.1	6.1	—	—	—	40.8	3.8	—	
Do.	Ellen	41.6	0.92	13.1	8.9	8.9	—	—	—	38.5	3.9	—	
Bibile	McCarty	45.1	1.40	20.0	6.1	6.1	2.77	2.24	5.01	35.7	3.7	3.6	
Mundel	Roster's	50.3	1.20	17.1	7.0	7.0	2.29	2.60	4.89	36.7	3.6	4.1	
Minneriya	Triumph	43.5	1.09	15.1	7.6	7.6	3.47	1.43	4.90	33.3	3.9	4.5	
Matugama	Walters	51.5	1.39	19.9	6.8	6.8	2.50	2.67	5.17	38.5	3.8	3.7	
Mundel	do.	30.5	1.13	16.0	7.8	7.8	—	—	—	37.0	3.5	—	
Peradeniya	do.	46.6	1.94	27.9	5.5	5.5	—	—	—	38.4	3.3	—	
Do.	do.	44.3	1.44	17.5	6.3	6.3	—	—	—	42.2	4.0	—	
Average (other varieties)		43.5	1.28	17.9	7.0	7.0	2.76	2.24	4.99	37.9	3.7	4.0	
<b>General average</b>		<b>43.5</b>	<b>1.39</b>	<b>19.6</b>	<b>6.5</b>	<b>6.5</b>	<b>2.92</b>	<b>2.14</b>	<b>5.07</b>	<b>39.6</b>	<b>3.6</b>	<b>4.0</b>	

TABLE IV.  
Imported Grapefruit.

Acidity

Country of Origin	Seediness	Acidity				Total solids/100 ml.	Total solids/acid Ratio	Reducing sugars/100 ml.	Sucrose/100 ml.	Total Sugars/100 ml.	Vitamin C/100 ml.	pH	Sugar/acid Ratio
		Juice Per cent.	Gm. citric acid per 100 ml.	Ml. N/10 soda per 10 ml.	Gm. per 100 ml.								
South Australia	Few Seeds	48.0	1.32	18.9	9.4	9.4	4.58	1.23	5.81	39.8	3.4	4.4	
Do.	Seedless	34.2	1.74	24.9	8.2	8.2	2.51	1.37	3.88	37.1	3.3	2.2	
Do.	do.	40.1	1.56	22.3	9.2	9.2	2.73	1.15	4.65	34.6	3.5	3.0	
Do.	do.	37.4	2.56	37.4	11.3	11.3	3.33	3.53	6.26	42.2	3.5	2.4	
Average (S. Australia)		41.3	1.79	26.0	9.5	9.5	2.39	1.82	5.15	38.4	3.4	3.0	
South Africa	Many seeds	45.3	1.79	25.7	8.6	8.6	4.11	2.03	4.42	40.8	3.4	2.5	
California	Seedless	44.0	1.18	16.0	9.6	9.6	3.50	3.16	7.27	31.3	3.4	6.2	
Do.	do.	44.7	1.30	18.5	7.4	7.4	3.81	1.82	5.32	30.9	3.5	4.1	
Average (California)		40.1	1.24	17.7	10.4	10.4	3.33	2.49	6.30	31.1	3.5	3.5	
<b>General average</b>		<b>40.1</b>	<b>1.63</b>	<b>23.5</b>	<b>9.6</b>	<b>9.6</b>	<b>3.33</b>	<b>2.04</b>	<b>5.37</b>	<b>36.7</b>	<b>3.4</b>	<b>3.5</b>	

