BRIX AND ACID DETERMINATIONS

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Certain plant organs accumulate large amounts of edible materials to be used at times of high energy demand. The reserve "foods" are of various kinds and include fats, starches, sugars, acids, etc. In citrus fruits sugars acids constitute approximately 85% of the organic reserves (Wardowski et al 1979). The sugars and acids, together with small amounts of dissolved vitamins, proteins, pigments and minerals, are commonly referred as "soluble solids"

The term Brix is frequently used interchangeably with "total soluble solids". Brix, however, refers only to sugar content of citrus juices (Krezdorn 1978). Both terms have become almost synonymous since, as mentioned above, sugars constitute approximately 85% of the soluble solids of sweet oranges, grapefruit, and tangerines. In limes, however, sugars constitute only 25% of the soluble solids the remaining being mostly citric and malic acid

There are numerous kinds of sugars present in plant tissues, three of which predomonate in citrus juices (namely sucrose, glucose and fructose). Differences in their concentration and proportions are due not only to variety, are also greatly influenced by rootstock, geographical location, weather and cultural practices (Reuther et al 1968). Figure 7 is a graphical representation of the total soluble solids in mature fruit of three citrus cultivars their interrelationship. As a result of their abundance, the soluble sugars and acids in citrus juices constitute a principal flavour parameter. The concentration of the total soluble solids (TSS or Brix), total acidity (TA), and their ratios (BRIX/TA) are not static, but vary considerabily during fruit development. In sweet oranges for example, the juice acid concentration is much higher in younger fruit and declines during development (Sinclair 1984). The opposite

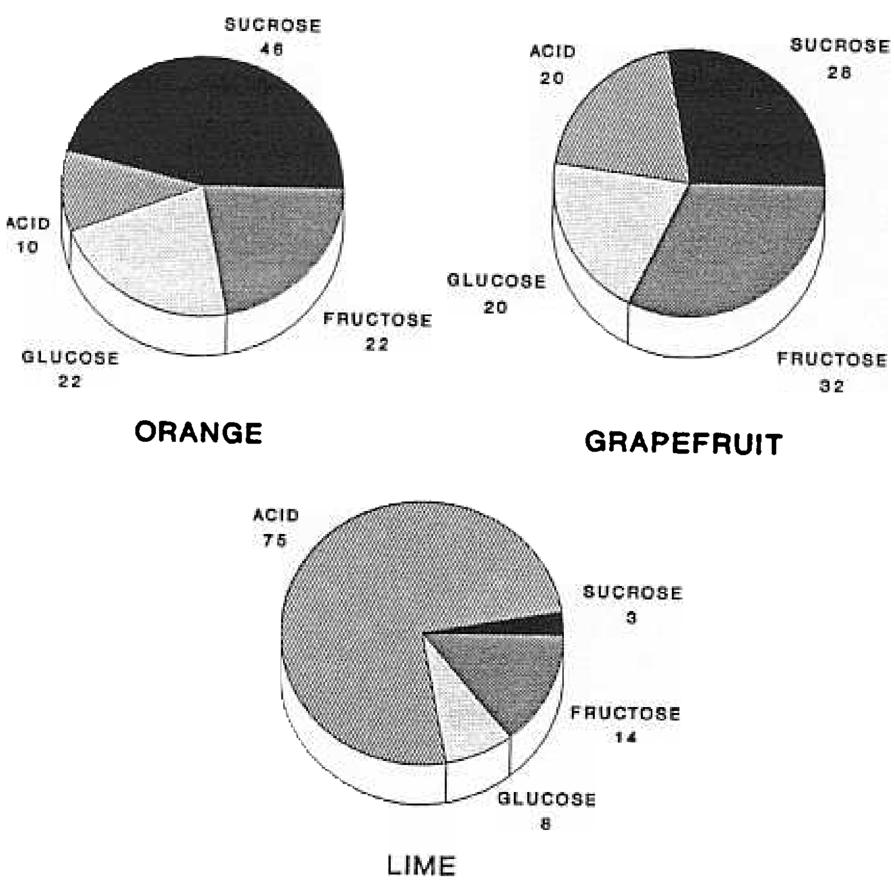

Figure 7. Total soluble solids in mature citrus fruit.

trend is true for sugars which accumulate rapidly as the fruit matures.

Minimum maturity requirements for TSS, TA and TSS/TA have been established to keep immature fruit off the market. Such requirements are revised in a regular manner by the Division of Fruit and Vegetable Inspection, P. O. Box 1072, Winter Haven, Florida 33880 and vary according to time of harvest and fruit variety. They will supply a copy of the current standards on request.

Brix Determinations

1. Hydrometer - Official Brix measurements are performed a hydrometer (Figure 8) (Soule and Grierson 1986). Hydrometers are instruments used for determining the specific gravity of liquids. In the case of soluble compounds, such as sugars and acids in citrus juices, the more soluble solids higher the specific gravity of the solution. Since the specific gravity of solutions vary with temperature, minor corrections are necessary when the juice temperature deviates from the standard 20C. These are given in Table 10.

Juice samples should be deaerated with an aspirator if a high speed reamer is used for juicing the fruit or if believed to contain considerable trapped air (Wardowski *et al*. 1979). Hand squeezed samples contain little air and can be sampled as is. A Brix hydrometer and a thermometer are placed in the juice sample. The hydrometer will sink to a level determined by the amount of dissolved solids (TSS or Brix) and the reading taken directly from the calibrated neck

2. Refractometer An indication of the total soluble solids of citrus juices can also be obtained from measurements of the refractive index of juice samples. Refractive index refers to the change in the angle of light as it passes through a solution. The higher the density of the solution (higher soluble solids), the higher the angle of diffraction. The change in the angle of the passing light varies with

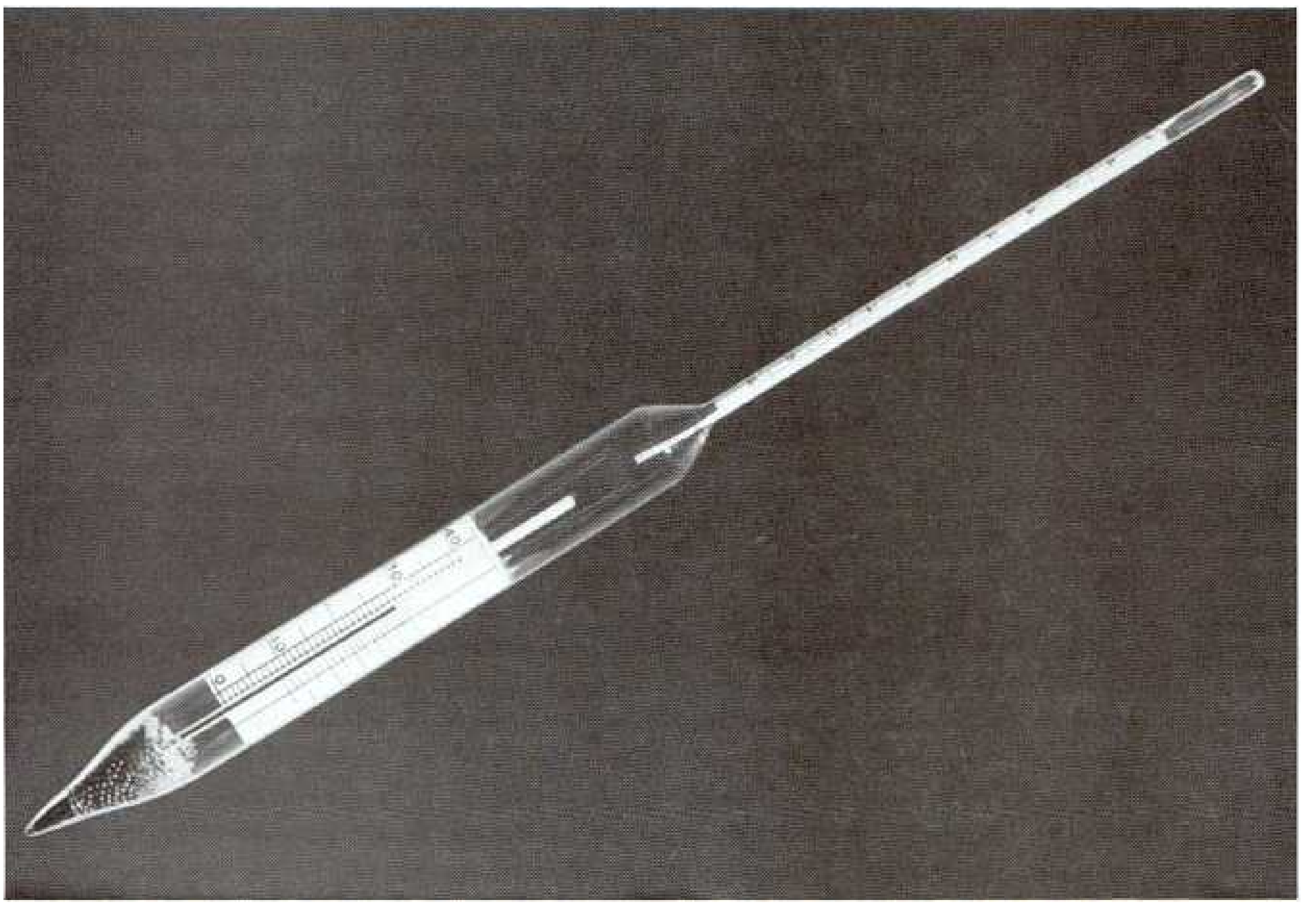

Figure 8. A Brix hydrometer.

Table 10. Temperature correction for degrees brix to standard temperature 20°C.

Temperature °C	Correction Factor °Brix	Temperature °C	Correction Factor °Brix
10.0	-0.45	25.0	+0.25
11.0	-0.40	25.5	+0.30
12.0	-0.40	26.0	+0.35
13.0	-0.35	26.5	+0.35
14.0	-0.30	27.0	+0.40
15.0	-0.30	27.5	+0.40
15.5	-0.25	28.0	+0.45
16.0	-0.25	28.5	+0.50
16.5	-0.20	29.0	+0.55
17.0	-0.15	29.5	+0.55
17.5	-0.10	30.0	+0.60
18.0	-0.10	30.5	+0.65
18.5	-0.05	31.0	+0.65
19.0	-0.05	31.5	+0.70
19.5	0.00	32.0	+0.75
20.0	0.00	32.5	+0.75
20.5	+0.05	33.0	+0.80
21.0	+0.05	33.5	+0.85
21.5	+0.10	34.0	+0.90
22.0	+0.10	34.5	+0.90
22.5	+0.15	35.0	+0.95
23.0	+0.15	35.5	+1.00
23.5	+0.20	36.0	+1.05
24.0	+0.20	36.5	+1.10
24.5	+0.25	37.0	+1.10
		37.5	+1.15

temperature, for which corrections have to be made. Most modern refractometers (Figure 9) automatically correct for the temperature effect. Smaller portable refractometers (Figure 10) are also available for field determinations.

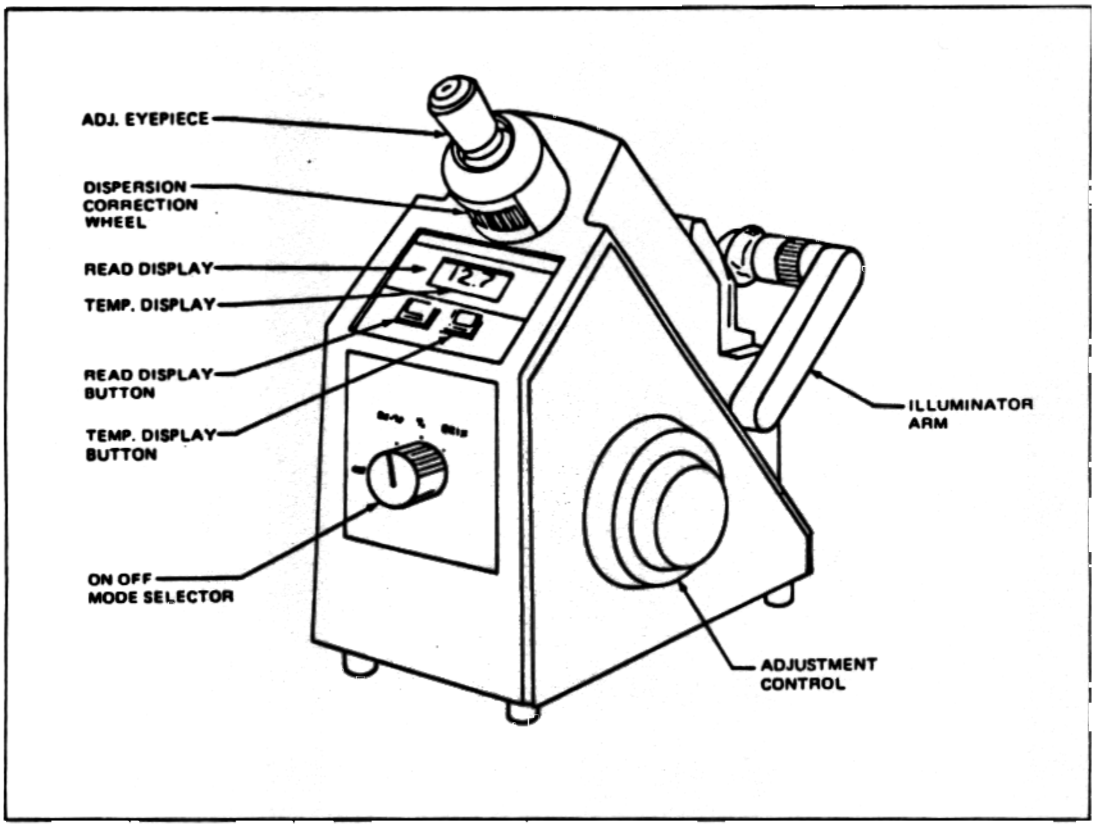

Figure 9. Laboratory refractrometer.

Acid Determinations

Per cent acid in citrus juices vary widely according to variety, age of fruit, weather and location. Organic acids mainly citric and malic, constitute between 10-20% of the total soluble solids of citrus juices and are the major soluble constituent in lime juices (Figure 7) (Reuther <u>et al</u>. 1968; Sinclair 1984).

Acidity is measured by titrating a given amount of citrus juice with a 0.3125 N solution of NaOH. A 25 ml sample of

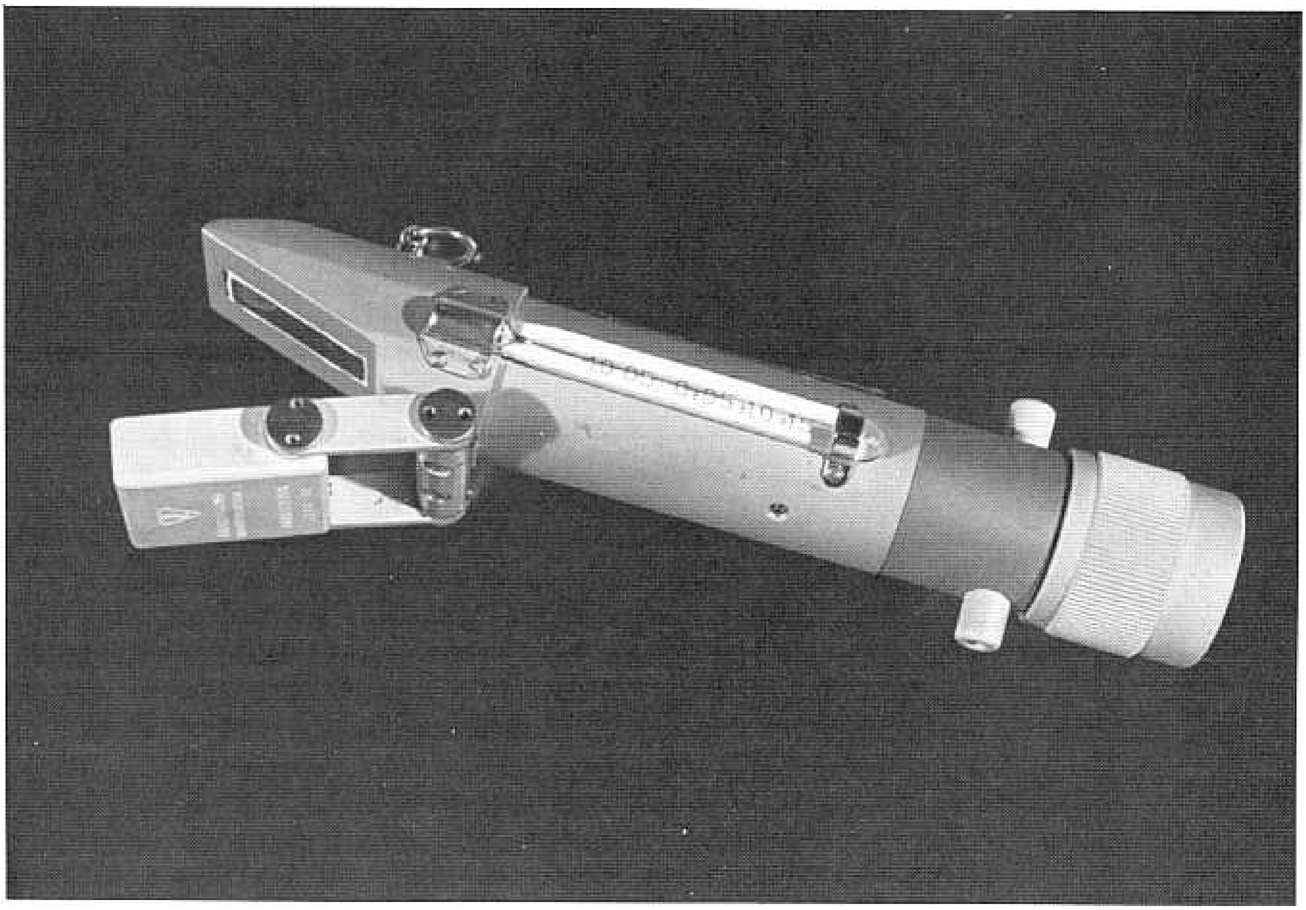

Figure 10. Hand held refractrometer for use in the field.

juice is placed in a beaker. Three or four drops of phenophthalein indicator are added to the juice solution. The indicator turns pink when the acid in the juice solution is neutralized as the NaOH is added drop by drop. The process of adding the NaOH to the juice-with-indicator is called titration. If an ordinary burette (not special direct reading burette) is used, the percent total titratable acidity can be calculated with the use of a conversion table (Table 11)

Table 11. Conversion standard (0.3125N) alkali solution to percent anhydrous citric acid.

Standard (0.3125 N) Alkali C. C.	Citric Acid Anh. Pct.	Standard (0.3125 N) Alkali C. C.	Citric Acid Anh. Pct.	Standard (0.3125 N) Alkali C. C.	Citric Acid Anh. Pct.
1.0	.08	7.8	.60	12.5	.96
2.0	.15	7.9	.61	12.6	.97
2.5	.19	8.0	.615	12.7	.98
3.0	.23	8.1	.62	12.8	.985
3.5	.27	8.2	.63	12.9	.99
3.6	.28	8.3	.64	13.0	1.00
3.7	.285	8.4	.645	13.1	1.01
3.8	.29	8.5	.65	13.2	1.015
3.9	.30	8.6	.66	13.3	1.02
4.0	.31	8.7	.67	13.4	1.03
4.1	.315	8.8	.68	13.5	1.04
4.2	.32	8.9	.685	13.6	1.045
4.3	.33	9.0	.69	13.7	1.05
4.4	.34	9.1	.70	13.8	1.06
4.5	.345	9.2	.71	13.9	1.07
4.6	.35	9.3	.715	14.0	1.08
4.7	.36	9.4	.72	14.1	1.085
4.8	.37	9.5	.73	14.2	1.09
4.9	.38	9.6	.74	14.3	1.10
5.0	.385	9.7	.745	14.4	1.11
5.1	.39	9.8	.75	14.5	1.115
5.2	.40	9.9	.76	14.6	1.12
5.3	.41	10.0	.77	14.7	1.13
5.4	.415	10.1	.78	14.8	1.14
5.5	.42	10.2	.785	14.9	1.145
5.6	.43	10.3	.79	15.0	1.15
5.7	.44	10.4	.80	15.1	1.16
5.8	.445	10.5	.81	15.2	1.17
5.9	.45	10.6	.815	15.3	1.18
6.0	.46	10.7	.82	15.4	1.185
6.1	.47	10.8	.83	15.5	1.19
6.2	.48	10.9	.84	15.6	1.20
6.3	.485	11.0	.845	15.7	1.21
6.4	.49	11.1	.85	15.8	1.215
6.5	.50	11.2	.86	15.9	1.22
6.6	.51	11.3	.87	16.0	1.23
6.7	.515	11.4	.88	16.1	1.24
6.8	.52	11.5	.885	16.2	1.245
6.9	.53	11.6	.89	16.3	1.25
7.0	.54	11.7	.90	16.4	1.26
7.1	.545	11.8	.91	16.5	1.27
7.2	.55	11.9	.915	16.6	1.275
7.3	.56	12.0	.92	16.7	1.28
7.4	.57	12.1	.93	16.8	1.29
7.5	.58	12.2	.94	16.9	1.30
7.6	.585	12.3	.945	17.0	1.31
7.7	.59	12.4	.95	17.1	1.315

Standard (1.3125 N) Alkali C. C.	Citric Acid Anh. Pct.	Standard (0.3125 N) Alkali C. C.	Citric Acid Anh. Pct.	Standard (0.3125 N) Alkali C. C.	Citric Acid Anh. Pct.
17.2	1.32	22.3	1.715	27.4	2.11
17.3	1.33	22.4	1.72	27.5	2.115
17.4	1.34	22.5	1.73	27.6	2.12
17.5	1.345	22.6	1.74	27.7	2.13
17.6	1.35	22.7	1.745	27.8	2.14
17.7	1.36	22.8	1.75	27.9	2.145
17.8	1.37	22.9	1.76	28.0	2.15
17.9	1.38	23.0	1.77	28.1	2.16
18.0	1.385	23.1	1.775	28.2	2.17
18.1	1.39	23.2	1.78	28.3	2.175
18.2	1.40	23.3	1.79	28.4	2.18
18.3	1.41	23.4	1.80	28.5	2.19
18.4	1.415	23.5	1.81	28.6	2.20
18.5	1.42	23.6	1.815	28.7	2.21
18.6	1.43	23.7	1.82	28.8	2.215
18.7	1.44	23.8	1.83	28.9	2.22
18.8	1.445	23.9	1.84	29.0	2.23
18.9	1.45	24.0	1.845	29.1	2.24
19.0	1.46	24.1	1.85	29.2	2.245
19.1	1.47	24.2	1.86	29.3	2.25
19.2	1.475	24.3	1.87	29.4	2.26
19.3	1.48	24.4	1.88	29.5	2.27
19.4	1.49	24.5	1.885	29.6	2.28
19.5	1.50	24.6	1.89	29.7	2.285
19.6	1.51	24.7	1.90	29.8	2.29
19.7	1.515	24.8	1.91	29.9	2.30
19.8	1.52	24.9	1.915	30.0	2.31
19.9	1.53	25.0	1.92	30.1	2.315
20.0	1.54	25.1	1.93	30.2	2.32
20.1	1.545	25.2	1.94	30.3	2.33
20.2	1.55	25.3	1.945	30.4	2.34
20.3	1.56	25.4	1.95	30.5	2.345
20.4	1.57	25.5	1.96	30.6	2.35
20.5	1.58	25.6	1.97	30.7	2.36
20.6	1.585	25.7	1.98	30.8	2.37
20.7	1.59	25.8	1.985	30.9	2.375
20.8	1.60	25.9	1.99	31.0	2.38
20.9	1.61	26.0	2.00	31.1	2.39
21.0	1.615	26.1	2.01	31.2	2.40
21.1	1.62	26.2	2.015	31.3	2.41
21.2	1.63	26.3	2.02	31.4	2.415
21.3	1.64	26.4	2.03	31.5	2.42
21.4	1.645	26.5	2.04	31.6	2.43
21.5	1.65	26.6	2.045	31.7	2.44
21.6	1.66	26.7	2.05	31.8	2.445
21.7	1.67	26.8	2.06	31.9	2.45
21.8	1.68	26.9	2.07	32.0	2.46
21.9	1.685	27.0	2.075	32.1	2.47
22.0	1.69	27.1	2.08	32.2	2.48
22.1	1.70	27.2	2.09	32.3	2.485
22.2	1.71	27.3	2.10	32.4	2.49
				32.5	2.50

Brix/Acid Ratio

The Brix to acid ratio is crucial in that it constitutes a measure of the balance between sugars and acids. As a consequence the Brix/acid ratio serves as an indication of the palatability of the juice. The figure is obtained by dividing the % Brix by the % titratable acid. Large values indicate a sweeter taste, but very high values may be indicative of an insipid tasting juice.

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