PRODUCTION AND ENVIRONMENTAL FACTORS AFFECTING THE BRIX/ACID RATIO

K. E. KOCH

Probably the best-known and generally most reliable indicator of juice quality is the combined measurement of total soluble solids (mostly sugars) as °Brix and the ratio of these soluble solids to organic acids. Dramatic differences in Brix/acid ratios can occur in citrus fruit due to environmental factors and cultural practices.

Climatic Effects

Overall climatic effects on citrus fruit quality have been well-documented and are discussed by W. Reuther in his section on "Climate and Fruit Quality". These can be briefly summarized as higher sugar levels and lower acidity in humid areas with warm nights. Conversely, sugar levels tend to be lower and acidity higher in arid areas with cool nights. Such generalizations often vary when shorter-term effects are considered, however.

Seasonal Effects

Shorter-term climate variations and their effect on fruit quality do not necessarily parallel the responses to long-term environments. For example, seasonal changes overlap developmental changes in the fruit, so that the effect of prevailing conditions can be quite different on young vs. nearly mature fruit. An interesting relationship was evident when total available heat units in April and May were compared to the Brix/acid ratio at harvest of Washington navel oranges. Greater numbers of hours above 55°F during early fruit growth corresponded to greater Brix/acid ratios later (Jones et al. 1962). This correlation was only evident for early season temperatures.

It is generally well recognized that the solids (°Brix) drop after several days of precipitation. In some instances this can occur after a single heavy rain. Dilution of fruit sugars and acids is considered the cause. The solids per acre therefore are not likely to change, but the Brix per fruit may drop temporarily below the level desired for picking.

Data on short-term effects of cold night temperatures are less clear. As noted earlier, fruit grown in arid climates with long-term exposure to cool nights generally have higher acidity. In contrast, the view has become widely held that a short period of cool weather will "sweeten" fruit in areas such as Florida. Actual evidence is variable. Dr. A. Purvis and coworkers at the A.R.E.C. in Lake Alfred showed that levels of hexoses (sugars often formed by sucrose breakdown) increased dramatically in leaves and peel of grapefruit after trees were exposed to chilling temperatures. The response was much less pronounced in juice tissues, but appeared to

follow the same trend. These results were derived from a 3-week period of gradual chilling.

Effects of very cold night temperatures (near 32°F [0°C]) were also examined by C. Campbell and K. Koch at the U.F. in Gainesville, using calamondin trees. Photosynthetic products (primarily sugars) were tagged with carbon-14 before some of the trees were exposed to cold nights. In cold-treated trees, these sugars remained primarily in the leaves rather than moving into fruits. Eight days later the tagged sugars were still in leaves of the cold-treated trees, but had moved into fruits of trees with warm nights (approximately 70°F). The supply of sugars moving from leaves to fruits thus appears to decrease when nights are cold rather than cool.

Diurnal Changes

Little or no data exists in regard to changes in Brix/acid ratio possibly occurring during a given day. Many succulent desert plants have high acid levels in their tissues at dawn, especially after cool nights, but there is as yet no evidence for such an occurrence in citrus. Attempted studies in this area have often been confounded by the daily shrinking and swelling of fruit, which can lead to erroneous sampling. Fruit of comparable age and physiological condition will be smaller at noon than at sunrise due to peel shrinkage during water loss. When fruit of the same size are sampled throughout the day, maturity differences are likely to result. The possibility that fruit picked at some times of day may have a different Brix/acid ratio than at other times remains unresolved, but the minimal information available seems to run counter to this idea.

The reduction in fruit volume which occurs during a given daylight period is well documented (Sinclair, 1984) and is believed to result from temporary water loss. A similar response is more pronounced under dry conditions. It has long been known that water can move from citrus fruit to leaves under drought stress, as well as being lost directly from the fruits. T. Huang and coworkers at the U.F. in Gainesville have recently examined the movement of water tagged with tritium (^3H_2O) to determine what portion of the moisture lost from grapefruit under these conditions exits from the juice sacs. Surprisingly, <u>none</u> of the tagged water which entered juice tissues in the first two days of this experiment <u>ever</u> moved back out of them, even during 4 to 6 weeks of drying. Leaves dehydrated severely during this time, and water movement out of peel was extensive. Water thus appears to enter juice sacs far more easily than it leaves them.

Influence of Canopy Position

Variation in quality of fruit from different parts of a single tree can be so great that those on the outside may reach maturity <u>long</u> before those on the inside. Classic studies of 'Valencia' oranges by Sites and Rites from Lake Alfred and Gainesville showed that in one year fruit on the outer canopy averaged 11.1% soluble solids with a Brix/acid ratio of 12.56 compared to 8.7% with a 10.4 ratio for fruit inside the tree. Their work

also demonstrated a higher level of solids in fruit on the south and west portions of the tree. Acidity was also higher in these fruit from the south and west sides. Juice content showed no apparent relation to fruit position in the tree canopy (Sites and Rites, 1951).

Cultural Practices

The effect of irrigation on internal citrus fruit quality is generally regarded as that of dilution. Fruit from well-irrigated trees tend to have lower levels of soluble solids (°Brix) and less acidity, yet this appears almost entirely due to the larger fruit size (more water) (Sinclair, 1984). Higher internal quality can therefore arise from limited water availability, but total solids per acre are likely to remain similar (unless trees become severely stressed).

The Brix/acid ratio has shown little change in many studies of varied irrigation regimes (Sinclair, 1984). In tangerines, however, Koo and McCornack (1965) found that irrigation resulted in more rapid attainment of a high Brix/acid ratio and hence legal maturity. Similar responses were observed throughout their 5-year study despite lowered levels of both solids and acids in fruit from irrigated trees. A delay in maturity can also result from frequent irrigation if it is combined with high N applications (Sinclair, 1984).

Spot picking is often ignored as a potential means of obtaining high returns for early fruit. Lack of skilled labor and/or costs of such an endeavor may be prohibitive, but data of early experiments in this area are worth bearing in mind. When fruit from an entire 'Valencia' orange tree 25 years old were harvested, the average total soluble solids (°Brix) for the entire crop was 10.24. When only the very outermost fruit were harvested, total solids averaged 11.12. In this instance, the °Brix measurement of juice was increased an entire degree solely by careful spot picking. It is conceivable that such an undertaking might be worthwhile if high enough prices could be obtained for very early or high quality fruit.

Hedging and/or topping trees has long been known to increase color and internal quality of fruit. The extent to which this occurs often depends on the amount of internal shading prior to pruning, however.

Arsenical sprays to reduce fruit acidity are commonly used and safely applied to grapefruit shortly after bloom. Dramatic and consistent decreases in acid levels result later in the season. Recent difficulties in obtaining these materials have led to extensive studies of arsenillic acid by Dr. W. Wilson of A.R.E.C. Lake Alfred. Arsenillic acid was found as effective as its predecessors in numerous experiments. As with earlier compounds, its effects can be negated by copper sprays if both are applied from the same spray tank. Many other formulations are also being marketed for the purpose of reducing fruit acidity. Most appear to be producing erratic results, with striking responses in some instances and none in others.

REFERENCES

Davies, F.S. 1986. The navel orange. Horticultural Reviews, 8:129-180

Koo, R.C.J. and A.A. McCornack. 1965. Effects of irrigation and fertilization on production and quality of 'Dancy' tangerine. Proc. Fl. State Hort. Soc. 78:10-15.

Koch, K.E. 1984. The path of photosynthate translocation into citrus fruit Plant Cell and Env. 7:647-653.

Jones, W.W., T.W. Embleton, and C.B. Cree. 1962. Temperature effects on acid, Brix in Washington navel oranges. California Citrograph, 47:132-134.

Purvis, A.C. and G. Yelenowsky. 1983. Translocation of carbohydrates and proline in young grapefruit trees at low temperatures. Plant Physiol. 73:877-880.

Sinclair, W.B. 1984. Biochemistry and physiology of the lemon and other citrus fruits. Univ. of Calif. and Division of Agriculture and Natural Resources, Oakland, CA. 946 p.

Sites, J.W. and H.J. Reitz. 1950. The variation in individual 'Valencia' oranges from different locations of the tree as a guide to sampling and spot-picking for quality. Part I. Titratable acid and soluble solids/titratable acid ratio of the juice. Proc. Amer. Soc. Hort. Sci. 55:73-80.

Wilson, C.W. 1987. Results of experiments using arsenillic acid to reduce acidity of grapefruit in Florida. Proc. Plant Growth Reg. Soc. of Amer Vol 14 (in press).