Navel Orange Juice Bitterness

rootstock determines amount of bitterness in juice of Washington Navel oranges investigations reveal

George L. Marsh and S. H. Cameron

The striking effect that rootstock exerts on bitterness in extracted navel orange juice was apparent at the first sampling period in experiments conducted during the 1947–48 and 1948–49 Washington Navel seasons.

The tests conducted during the 1948–1949 season substantiated those of the previous season in nearly every respect.

The earliest samples of this series indicated that none of the tested rootstocks produces a truly nonbitter juice if harvested at very early maturity. The same marked gradation noted between samples the first season was again noted during the second season, however.

The sample that was not bitter at the first sampling in the 1947–1948 season was just slightly bitter after 24 hours' standing at the first sampling period during the 1948–1949 season. Bitterness had completely disappeared from the juice of fruit grown on this stock by the second sampling which was approximately two weeks later.

It appears probable that a precursor—which in itself is nonbitter but in reaction becomes bitter—is present to a greater or lesser degree in the Washington Navel orange during its early formative period when grown on any rootstock. Growth on some rootstocks apparently causes it to disappear at a more rapid rate than does growth on other rootstocks. By the time the fruit has reached commercial maturity the nonbitter precursor has nearly or completely disappeared from fruit grown on grapefruit rootstock. Within a short space of weeks it has likewise disappeared from fruit grown on the trifoliate orange and the sweet orange rootstocks. Only in late season does it disappear from fruit grown on the sour orange and navel cutting trees and it never disappears completely from fruit grown on rough lemon rootstock.

The Washington Navel orange as grown in California is not suited for conversion to juice products on a commercial scale despite its many superior characteristics.

The juice after extraction turns bitter and becomes unpalatable.

A great deal of work has been done by many investigators on navel orange juice bitterness. This has resulted in the separation and the identification of the bitter compound. Moreover it has been determined that the bitter substance is not present in the tissues of the navel orange as such, but is probably present as a nonbitter precursor and that the nonbitter precursor is present in greatest concentration in the central pith and albedo respectively; that its concentration in these tissues decreases and finally disappears as the fruit matures; and, that the rate of bitter development is a function of concentration, temperature and perhaps pH value—the measurable alkalinity and acidity value.

Physiological and chemical changes induced by rootstock have long been recognized in the citrus fruits.

The effect of rootstock on chemical composition was reported from the Los Angeles campus in 1935 and later confirmed at the Citrus Experiment Station at Riverside.

At Los Angeles, Valencia as well as navel oranges grown on trifoliate orange rootstock were considered to be superior in quality to fruits of the same variety grown on other rootstocks. The scion variety is identical in each instance. The trees are growing side by side and receive identical care. Since the two are alike—except for rootstock—the observed differences in fruit quality suggested the possible solution to the bitterness mystery and made it appear essential to determine the effect of rootstock on the development of bitterness in the extracted juice from the Washington Navel orange.

Juice samples from Washington Navel trees grown on five different rootstocks and on their own roots—*1*, sour orange; *2*, sweet orange; *3*, rough lemon; *4*, grapefruit; *5*, trifoliate orange and Washington Navel cutting were included in the tests.

Although much was known concerning the chemistry of the bitter substance no chemical or physical procedures for estimating the concentration of this substance existed when these tests were first undertaken. Subjective testing was of necessity the method used for assaying the samples received from the test plot.

A standardized procedure was adopted for testing purposes. This consisted of extracting, straining, and deaerating each lot separately using the same equipment and as nearly the same time intervals of handling each lot as possible. Four-ounce crown sealed bottles were withdrawn and placed in freezing storage for subsequent analysis. The remainder of the juice was placed in a beaker and was then taste tested at intervals for bitterness and otherwise subjectively evaluated.

The effect of rootstock on bitterness in the juice was noticeable in the very first sampling period.

After 24 hours of standing at room temperature—a time-temperature treatment long enough to permit detection of all but the merest traces—the samples graded from no bitterness to extremely bitter. The sample grading extremely bitter developed bitterness within a very few minutes after extraction, those of intermediate bitterness requiring considerably longer periods.

Subsequent testing changed the pattern only insofar that bitterness decreased progressively with the maturity of the samples. More samples showed less tendency for the juice to become bitter at each successive testing interval but the relative ranking within the group remained the same.

Although this series of observations was primarily concerned with the development of bitterness in the juice, the samples were also judged for general quality at each sampling period.

Flavor and aroma were particularly noted, as was the rate at which stale flavor developed and the clearing of the juice occurred. General quality as assayed by the above factors also proved to be affected by the rootstock on which the fruit was grown. The pattern was not identical to that shown by the bitterness pattern but was similar in many respects.

Fruit grown on the trifoliate orange rootstock produced juice of excellent quality, possessing good orange aroma which it retained without change until the sample molded or fermented. It also appears to have a weak pectic enzyme system as the juice clears very slowly.

Fruit grown on the grapefruit and the Washington Navel rooted cuttings produced juice of good quality, possessing a fairly good orange aroma which became somewhat stale upon standing for 24 hours.

The juice from fruit grown on the Washington Navel cutting trees developed a stale flavor more quickly than that grown on the grapefruit rootstock.

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Freeze Injuries to Citrus

tests during 1949 reveal facts important to growers of Valencia oranges and Marsh grapefruit

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Valencia oranges and Marsh grapefruit showed a remarkable recovery from the effects of the freezes of the winter of 1948–49.

Tests extending from February 28th through October 10th, 1949, were made on oranges picked and analyzed from predetermined plots every two weeks, in addition to general observations, storage tests and separator tests. The following statements refer to Valencia oranges, except where the grapefruit is specifically mentioned.

There were variations in the results of tests on the fruits from the different plots but, as a rule, the percentage of freeze injury in the fruits decreased as the season advanced.

Many more segments were frozen in the stem end than in the center of both Valencia oranges and grapefruit. To determine accurately the extent and severity of freeze injury, both stem end and center cuts were made.

Some of the early characteristics of freeze injury to the pulp, such as a water-soaked appearance, a gray or milky color and hesperidin crystals usually disappeared within one to three months. The same held true for gelatinized juice sacs, except in fruits that were badly frozen.

Wavy segment walls and the light yellow grainy or granular condition of some of the vesicles showed no tendency to disappear.

Where a portion of a segment or even one or two entire segments were killed and the shrunken tissues left hollow spaces, the remaining noninjured segments enlarged and partially or completely filled the spaces.

The presence of surface injury on the peel was the exception rather than the rule. Excessive peel thickness was not a common characteristic of the frozen fruits examined. Evidence of albedo—white portion of peel—injury was exceptional.

The average volume in milliliters of juice per fruit and the percentage of juice per fruit on a weight basis, for both nonfrozen and frozen fruits, increased as the season advanced, with the possible exception of the last test, made on October 10th.

Total soluble solids and total sugars increased in both nonfrozen and frozen fruits from the time of making the first test in February until about the middle of August and then began to decrease. Juice volume, total soluble solids and total sugars were always greater in nonfrozen than in frozen fruits.

Total free acids decreased rapidly in both nonfrozen and frozen fruits from February 28th to April 25th. They decreased very little after the latter date. In several instances they temporarily increased.

Granulation in the 1949 crop of Valencias was much less severe than in most years. This situation is of special interest because many growers and others have been of the opinion that granulation is caused by low temperatures.

Under the conditions which prevailed during the spring, summer and early fall of 1949, mature Valencia fruits in the plots remained on the trees from early May until the middle of August without showing a decrease in quality. There was a small decrease in quality from the middle of August to October 10th, the date of the final picking.

Freeze injury in the Marsh grapefruit tests, based on number of frozen segments, was much more severe on those borne on the outside of the tree than on those borne on the inside.

Concentrations of total soluble solids and total sugars were higher in nonfrozen than in frozen Marsh grapefruits, whether borne on the outside or the inside of the tree.

There were no consistent differences in the concentrations of free acids among the grapefruits, whether frozen or nonfrozen or borne on the outside or inside of the tree.

Response of nonfrozen and frozen oranges and grapefruits to the effects of the different temperatures and humidities in the cold storage room and in the large, aerated room were not great enough to outweigh the natural differences that are always found in a series of samples from different sources.

Measurements of specific gravity of the oranges and grapefruit and measurements of juice on both a volume and a weight basis showed the X ray and water separation of nonfrozen and frozen fruits to be more efficient than separation by hand at the grading belt.

Weather conditions following the nights of low temperatures were such that there was appreciable recovery in a rela-

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Juice produced from fruit grown on the sour orange and sweet orange rootstocks were only of fair quality initially and developed the stale flavor of preserved juice very rapidly.

The fruit grown on the rough lemon rootstock resembled the others in appearance and size, and were their equal in this respect, but the juice was very different organoleptically—in composition as it effects flavor. In addition to the rapid development of bitterness it possesses little to no orange aroma and flavor and becomes stale quickly on standing.

From an over-all general quality standpoint the trifoliate orange rootstock produced fruit which yielded juice that was consistently ranked superior in these tests.

These tests appear to open up a new field for study. They further indicate the necessity for cooperative investigation in horticulture and its related branches particularly in studies involving the development and introduction of new varieties or the reevaluation of old varieties. No longer can studies involving size and shape of tree or vine, yield of fruit per acre, disease resistance, climatic adaptation, its behavior during shipment, etc., serve solely to evaluate a variety. Studies involving organoleptic evaluation of the fresh product and its ability to retain its desirable organoleptic properties and structure during the many different methods of preservation now possible, must be included in the general plan. Specialists trained in genetics, plant physiology, horticulture and food technology or enology should team together in their work.

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