Table 2. Force needed to remove fruit from 'Valencia' orange trees on Lakeland fine sand into which ethylene had been injected 3 weeks previously.

Treatment	Lbs. force after treatment
Control	17.77
300 liters	14.48
400 liters	14.70

and effort is involved in erecting, lowering, and moving a tent, and this procedure would not appear to be economical unless the application time could be greatly reduced.

The soil injection method of applying ethylene showed some promise of having practical horticultural use. It has been tried on a limited basis with 'Valencia' orange, but did not produce fruit abscission as had been hoped. Tests with early and midseason oranges, grapefruit, tangerines, and tangelos will be conducted during the and winter of 1966-1967.

The dormancy induced by soil injections of ethylene lasted over 2 months in some cases. This is not beneficial to 'Valencia' oranges during the normal summer growth period, but might be beneficial as a means of inducing dormancy of citrus trees in winter.

The use of charcoal as a carrier of ethylene in sprays has not been successful, but additional studies are planned. Future research will include injecting ethylene into overhead sprinkler system lines, and applying ethylene in foam materials of the type used for fire fighting.

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PROCESSING QUALITIES OF NEW CITRUS FRUIT HYBRIDS

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Abstract

Lee, Osceola, and Robinson tangerines, Page orange, and a new tangerine hybrid (Selection 6-8-16) were processed and evaluated by comparison with Dancy tangerines. Color of Selection 6-8-16 was comparable to that of Murcott orange, and much deeper than any of the other hybrids. Next in order of depth of color were Robinson and Osceola tangerines, while colors of Page orange and Lee tangerine were approximately the same as that of Dancy tangerines. Off-flavors were developed in the processing and storage of all hybrids, but were reduced by the removal of volatiles by concentrating the juice. Concentrated juice of the darker varieties could be used in quantities up to 10% (single strength basis) to improve the color of better flavored orange juice products without deleterious effect on flavor. When added in this amount to lightly colored orange juice, Robinson juice raised the score from its original 36 points to 37 points, and Selection 6-8-16 to 38 points.

Introduction

The development of new citrus hybrids has been an important project of the Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, for many years. Five new hybrids resulting from crosses made in 1942 have been released to the industry. In 1959 "Robinson," "Osceola," and "Lee' tangerine were released (4). "Page" orange was released in 1963 (5) and "Nova" tangelo in 1964 (6). These hybrids are now in various stages of production. Production and fruit characteristics are given in the above references with additional information given in an article by Rasmussen et al. (7). All of these hybrids, plus a new one not yet released but included in this study, are ¾ tangerine and ¼ grapefruit.

A cooperative plan has been initiated, under which new hybrids will be tested, as soon as they

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References to specific products of commercial manufacture are for illustration only and do not constitute endorsement by the U.S. Department of Agriculture.

come into sufficient production for processing suitability by the U.S. Fruit and Vegetable Products Laboratory, Winter Haven. The need for this type of investigation has been emphasized by the recent popularization of the Murcott orange in Florida, and the Marrs orange in Texas. These selections were discovered and propagated by private interests. Bearing characteristics and fruit quality pleased both grower and shipper, so that plantings and production increased at a rapid rate. These varieties, however, are not suitable for processing into juice products in themselves (2, 3).

For a new variety of fruit to merit a market in processed form, in its own right, it would have to be superior in every respect. It would have to be unique and instantly liked by consumers, as it would have to compete with all other types of fruit that are harvested and processed at their prime maturities. Fortunately, new hybrids do not have to meet all these requirements to be useful in the processing industry.

If the new hybrid has any outstanding characteristic that can be used to improve the quality of existing products it will be welcomed by the processors. It is important to find out whether a new variety will be welcomed or resisted by processors, and the grower has the right to such information before he invests in extensive plantings. Althoug this program of evaluating hybrids is of limited value for those already released, it is designed to fill this need in the future.

Processing Problems

Most of the new hybrids covered by this study were of the mandarin type. The handling of these varieties requires special care in picking, hauling, conveying, juice extraction, and finishing. If the fruit is pulled, rather than clipped, some plugging or tearing of skin is likely to occur. Varieties that are flat do not rotate properly on roller conveyors or washer-brushes. It is obvious that there is danger of excessive amounts of dirt or detergent being carried into the juice extractors by plugged and/or flat fruit. These can lead to the development of off-flavors.

Juice extractors appropriately are designed for round oranges. Loose-skinned or flat hybrids present difficulties in extraction that are reflected in low juice yields, and sometimes by excessive peel oil content.

Experimental

Processing studies on the new hybrids were initiated in the Fall of 1964. At this time fruit was available only from Lee, Osceola, and Robinson tangerines and Page oranges. Juice from these was canned as single strength juice, as was also, for comparison, juice from commercial Dancy tangerines. In 1965 juice was processed both by canning and concentrating from the Robinson tongerine, Page orange, and a new tangerine hybrid designated as Selection 6-8-16 as it has not yet been released or formally named.

Juices were extracted with an FMC In-Line juice extractor, finished through an 0.020" screen, pasteurized at 190° F and filled hot into No. 2 cans. Following rapid cooling, the cans were stored at 40° and 70° F. For concentrating, the outlet from the heat exchanger was connected to the inlet of the evaporator and the hot juice instantly cooled by flashing into the evacuated system. Juice was concentrated to approximately 62° Brix at temperatures not exceeding 80° F. Part of the concentrate was cut back to 43° Brix with unheated juice, and the balance held for later blending with orange juice.

Juice was evaluated for flavor immediately after processing and after storage. In order to evaluate the effectiveness of these juices in improving the color of orange juice, a sample of early orange juice that exhibited minimum color for Grade A requirements (1) was obtained, and mixed with various quantities of the more deeply colored hybrid juices.

Results and Discussion

None of the fruit tested, including commercial tangerines, produced a canned or concentrated juice that was as pleasing as similar products made from Valencia oranges. Fortunately, most of the objectionable flavor of the hybrids seems to come from the volatile components. If processors have the opportunity to remove the volatile components from a juice, then they are free to capitalize on any advantageous features, such as color, that the juice may have. This is being demonstrated by the manner in which processors are currently using

tangerines. Some ten or fifteen years ago considerable effort was being spent on merchandising canned or frozen concentrated tangerine juice. Now, only very small packs of these products are being manufactured, and these under customers labels. Tangerines are still not a liablity, however, as both canners and concentrators of early orange juice compete for tangerines for blending to improve color. Such use is limited to 10% of the finished product, on a single strength basis.

For canning, orange juice containing even small quantities of tangerine juice must be extensively de-oiled to prevent the development of off-flavors during storage. At concentrate plants, it is essential that tangerines be received separately from oranges, so that all the juice can be fed to the evaporators and the volatile fractions removed from the juice during evaporation to high density. The concentrated product may then be used as needed to improve color of better flavored established products without introducing off-flavor development, as would occur if the tangerines were mixed with fruit used to prepare "cutback" juice.

It would seem doubtful that an exotic variety could readily be used for a new juice of novel flavor. It would need to be kept separate in marketing channels and would require considerable expense for market development.

Varietal characteristics of the hybrids studied are shown in Table 1. Since color promises to be the most valuable asset, from the processor's viewpoint, the varieties are presented in order of decreasing color.

Selection 6-8-16 was in a class by itself among the new hybrids, and is very similiar in color to that reported for the Murcott orange. This variety, grown on Rough lemon rootstock in the Ridge area, was some weeks later in reaching maturity than other hybrids, but was still a month earlier than the Dancy tangerine. It had a fairly low Brix/acid ratio, but few of our taste panel considered it to be objectionably sour. Its flavor was not especially pleasing, either as fresh or canned juice. Immediately after processing, the 4-fold concentrate was considered to be of superior quality; but after a month of storage at —5° F it had developed a distinctly stale flavor. Juice which had been concentrated to 62° Brix, and not cut back with single strength juice, did not develop as strong an off-flavor. This indicate that the juice, stripped of peel oil and other volatile flavors, might

Table 1. Varietal characteristics of samples of tangerines and hybrid citrus fruits.

Variety	Rootstock	Date of harvest	Solids °Brix	Acid g/100 ml	Ratio B/A	Juice color 3/
6-8-16	Rough lemon	11/30/65	11.7	1.07	11.4	1
Osceola	Seedling	10/30/64	11.7	1.12	10.5	2
Robinson	Rough lemon	10/30/64	11.3	0.86	13.1	2
"	Cleopatra	10/25/65	11.0	0.81	13.6	2+
Lee	Seedling	10/30/64	11.4	0.56	20.4	3
Page O.	Rough lemon	11/13/64	12.0	0.74	16.0	3
"	Cleopatra	11/12/65	11.5	0.68	17.0	3
Dancy	--	1/7/65	12.7	1.00	12.7	3

3/ Visual color grouping, No. 1 having deepest color.

Table 2. Scores of orange juice with added tangerine juice.

Added Juice	Color scores[4] 6-8-16	Robinson
0	36	36
2.5%	36	36
5%	37	37
10%	38	37
20%	39	38
40%	40	39

4/ Courtesy of USDA Inspectors

be used to strengthen the color of good-flavored but poorly colored orange juice.

The Osceola and Robinson tangerines were next in depth of color, and matured at about the same time, a month earlier than Selection 6-8-16. The Osceola was examined only in one season, and was quite acid. The Robinson was very acceptable when grown in the Ridge area on Rough lemon rootstock or in the Indian River area on Cleopatra, but the latter was slightly better in ratio and color. Although the canned Robinson juice was not very good, the frozen concentrate after a month of storage was acceptable to those who like tangerine juice.

Juices from the Page orange and Lee tangerine were similar in color to that of the Dancy tangerine. The Lee tangerine was so low in acid that it was insipid. While its flavor was not considered attractive by any of our panel, it deteriorated less than any of the others during processing and storage. The Page orange grown on Cleopatra in the Indian River area was slightly favored over that grown on Rough lemon in the Ridge area.

Addition of 6-8-16 and Robinson tangerine juices to 36-score orange juice improved the color scores as shown in Table 2. Two and a half percent of either juice was insufficient to raise the score, while 5% of either raised it one point. With 10% additions, and above, of tangerine juice, the deeper color of the 6-8-16 juice was significantly more effective in raising scores.

It is probable that a processor would prefer to sell 1000 gallons of 37-point concentrate than 500 gallons of 38-point or 250 gallons of 39-point concentrate, so would not use more than 5% of 6-8-16 tangerine juice in his weakest colored pack. At this level, any flavor effect of the tangerine juice, with volatiles removed by concentration, would be negligible.

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EFFORTS TOWARD IMPROVEMENT OF CONCENTRATED ORANGE JUICE FLAVOR USING ENZYMES[1]

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ABSTRACT

The mitochondrial fraction was separated from the juice sacs of 'Hamlin,' 'Pineapple,' and 'Valencia' oranges at various stages of maturity and added to high Brix orange concentrate. Flavor changes, resulting from the action of enzymes associated with the mitochondria, were evaluated organoleptically. The formation of a

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