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## **CONTRASTING EFFECTS OF ACID AND NONACID PUMMELOS ON THE ACIDITY OF HYBRID CITRUS PROGENIES**

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## **CHANDLER—AN EARLY-RIPENING HYBRID PUMMELO DERIVED FROM A LOW-ACID PARENT**

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# CHANDLER—AN EARLY-RIPENING HYBRID PUMMELO DERIVED FROM A LOW-ACID PARENT<sup>1</sup>

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## INTRODUCTION

THE PUMMELO (*Citrus grandis* Osbeck) is a citrus species which is widely grown and used as a fresh fruit in southeast Asia, but is little known in the United States. Many varieties exist, partly because pummelos produce only sexual progeny and each new seedling is likely to be somewhat different from the next.

Pummelos and pummelo culture have been described by Wester (1917)<sup>4</sup> in the Philippine Islands, Reinking and Groff (1921) and Groff (1927, 1930) in Thailand, and Ochse (1931) in the Dutch East Indies. Reasoner (1888) discussed some varieties of pummelo growing in Florida. Swingle (1943) and Webber (1943) have discussed the botany and some of the cultivated varieties of the pummelo.

Among citrus fruits, the grapefruit is the closest relative of the pummelo. The two are similar in many respects, but the pummelo fruit is larger and has firmer flesh. In most varieties, it also has a considerably thicker rind. It often lacks the bitterness characteristic of grapefruit, although some pummelo varieties have highly unpleasant flavors. At Riverside, pummelos ripen earlier than grapefruit. In the Orient, the pummelo flesh apparently develops greater firmness than in California, and the juice vesicles can be eaten out of hand, even after removal of the segment membranes.

At the University of California Citrus Experiment Station, Riverside, a collection of some fifty pummelo varieties, mostly obtained through the United States Department of Agriculture, Bureau of Plant Introduction, has been maintained since about 1932. Under Riverside climatic conditions, most of these varieties have not been particularly promising. A few become good-flavored by March or April, some eleven months after flowering, but nearly all show severe fruit drop by that time, particularly during periods of high winds, which usually occur one or more times during the winter season. All the varieties have contained many seeds in the mixed plantings at the station, although in southeast Asia, fruits with few seeds are produced under some conditions.

In the United States, the seediness and firmness of the pummelo reduce its suitability for eating by halves with a spoon, as grapefruit are eaten. Likewise, it is not suitable for juicing. It serves best as a specialty fruit, to be eaten by slices out of hand, in salads, or fruit cups. By cutting pie-shaped or tangential sections, one can largely avoid the seeds and core. Unlike most

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<sup>4</sup> See "Literature Cited" for citations, referred to in the text by author and date.

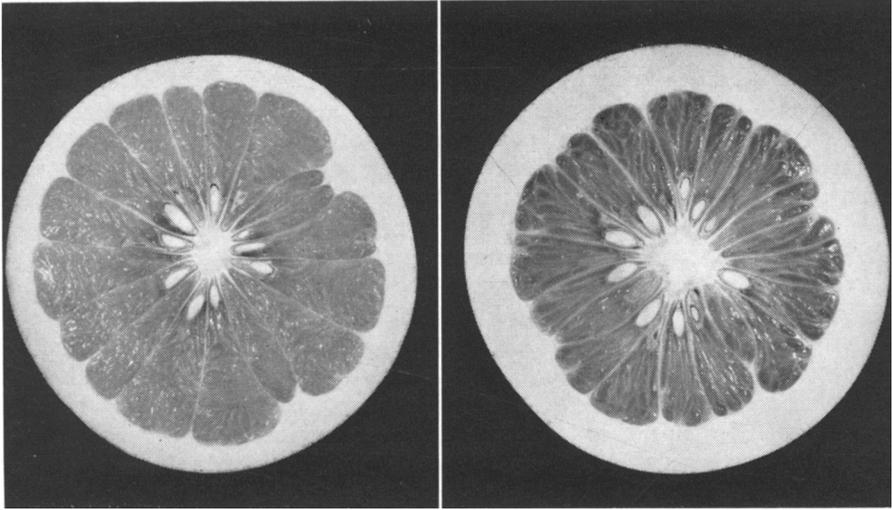
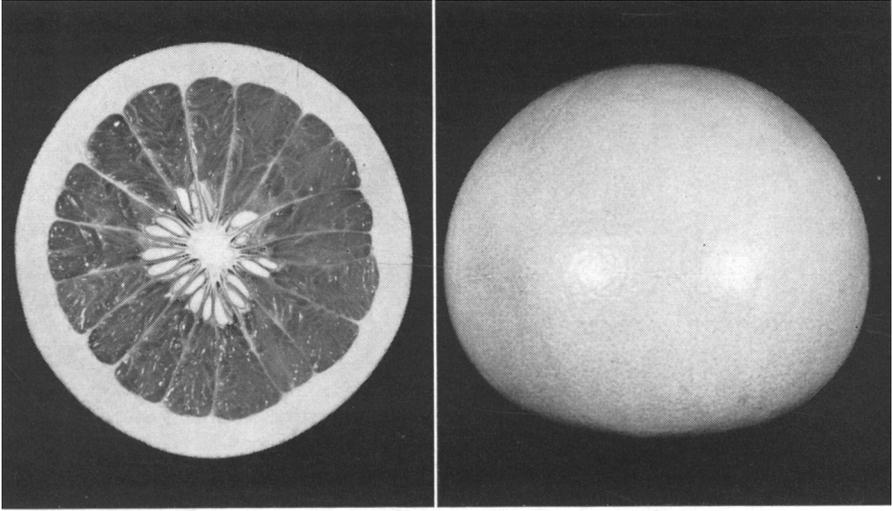


Fig. 1. (*Top*). The hybrid pummelo, Chandler. The fruit is slightly flattened globose, with a pale yellow rind, and has a mild, sweet flavor. About two-fifths natural size.

Fig. 2. (*Bottom*). Fruits of the parents of the hybrid. Left, low-acid pummelo 2240; right, pummelo 2241. The hybrid combines several of the better characters of the parents.

citrus fruits, pummelos can often lie on the ground for many days without decaying. They also store well, showing little shriveling or loss of freshness.

## PARENTAGE OF THE HYBRID

In 1945, extensive hybridization involving pummelos was carried out at the University of California Citrus Experiment Station under the direction of Dr. H. B. Frost and Dr. J. W. Lesley, Soost and Cameron (1961) (in this issue of *Hilgardia*) discuss some of these pummelos and their progenies, with respect to inheritance of levels of acidity and soluble solids. Among the progenies were a few from pummelo × pummelo, including the hybrid which is the subject of this paper. The seed parent of this hybrid bears fruit which has a medium level of soluble solids, but is essentially acidless. This pummelo is Citrus Experiment Station (C.E.S.) Accession Number 2240, and was received in 1930 under United States Department of Agriculture Plant Introduction Number CPB 10126. It has behaved as a dwarf at Riverside, on bitter-sweet orange rootstock. The fruit has no red coloration. The pollen parent (C.E.S. 2241, U.S.D.A. No. 10127) was one of several introductions (not all alike) which have carried the name "Kao Pan." It shows slight interior pink coloration, varying in amount from year to year.

## CHARACTERISTICS OF THE HYBRID AND ITS PARENTS

Fruit of the new hybrid pummelo is shown in figure 1, at about two-fifths natural size. Cross sections of the fruits of the parents are shown in figure 2. The hybrid ripens at Riverside in December, nearly two months earlier than most of the presently established older varieties. It is of medium size (four and one-half to six inches in diameter), of flattened-globose shape, and has a smooth to grained rind. The rind is pale yellow and of medium thickness for a pummelo, varying from ten to twelve mm. The flesh is pale yellow, with varying amounts of pink in portions of the segment membranes and juice vesicle membranes. As with other pigmented pummelos and pigmented grapefruits, this pink color is not present in the juice. At Riverside, it varies in intensity from year to year. However, in the six years during which the hybrid has been studied, its fruit has never failed to show some pink in cross section.

Table 1 shows juice analyses of fruit of the hybrid and of its parents over a three-year period. The hybrid has a moderate level of soluble solids and a moderate to slightly low percentage of acid, resulting in a mild, sweet-tasting fruit. There is no bitterness in the juice vesicles and only a trace in the albedo. Levels of soluble solids are generally similar to those of both parents, while the acidity is intermediate between that of the very low-acid 2240 and the rather high-acid 2241. This behavior follows the general pattern found in progenies of which pummelo 2240 was a parent (Soost and Cameron, 1961, in this issue). The solids : acid ratios of the hybrid have been higher than 11 : 1 throughout each season; in the very warm winter of 1958-1959, the ratio reached 16.4 : 1 by December 11. Neither of the parents has had satisfactory ratios, except parent 2241 in the 1958-1959 winter.

Several of the desirable characteristics of the parents have been combined in the Chandler. It has a thinner rind, smaller core, thinner segment membranes, and a finer flesh texture than pummelo 2241 (see figs. 1 and 2). It averages a higher degree of pink in the flesh than does 2241 (2240 has none). It ripens earlier than 2241 and has a better over-all flavor than either parent. Since pummelo 2240 contains essentially no acid at maturity, this parent can hardly be compared to the hybrid for palatability, and would not be acceptable to most consumers in the United States.

Like its parents, and like the other pummelo varieties, the hybrid has many seeds. This may be partly due to climatic effects or to pollination by other citrus varieties. Experiments are under way to determine whether seediness in pummelos can be influenced by the source of pollen.

TABLE 1  
JUICE COMPOSITION OF THE HYBRID PUMMELO, CHANDLER, AND  
ITS PUMMELO PARENTS, OVER A THREE-YEAR PERIOD

Seasons and sampling dates*	Hybrid Chandler			Seed parent 2240			Pollen parent 2241		
	Percentages:		S : A† ratio	Percentages:		S : A ratio	Percentages:		S : A ratio
	Solids	Acid		Solids	Acid		Solids	Acid	
1956-57									
Jan. 10.....	14.0	1.14	12.3	12.6	0.10	126	12.0	1.53	7.8
Feb. 6.....	14.5	1.18	12.3	12.5	0.17	74	12.8	1.59	8.1
Mar. 7.....	14.0	1.21	11.6	12.6	0.14	90	12.4	1.50	8.3
1957-58									
Dec. 13.....	12.0	0.98	12.2	11.7	0.08	146	11.3	1.60	7.1
Jan. 13.....	12.1	0.92	13.2	12.6	0.08	158	10.8	1.59	6.8
1958-59									
Dec. 11.....	12.1	0.74	16.4	12.3	0.06	205	11.7	1.04	11.3
Jan. 5.....	12.0	0.78	15.4	12.3	0.10	123	11.6	1.24	9.4
Feb. 13.....	12.6	0.83	15.2	13.0	0.12	108	12.1	1.26	9.6

\* Five fruits were regularly used for each sample.

† S : A means ratio of solids to acid.

Pubescence on leaves and twigs is a characteristic of many pummelo varieties. The parent pummelo 2240 has much fine pubescence on its leaves, twigs, and also on its fruit. Pummelo 2241 has moderate pubescence on leaves and twigs, but practically none on its fruit. The hybrid shows less pubescence on leaves and twigs than either parent, and only a little on the fruit.

The hybrid tree has been vigorous, fast-growing, and fairly open. It has not shown serious thorniness, although the early growth of many citrus varieties is highly thorny after reproduction by seed. With sweet orange rootstock, the bud union after twelve years is smooth and without indication of disease. The variety is now being tried on Cleopatra mandarin and Troyer citrange rootstocks. Long-time bearing behavior and longevity of the tree are not known, nor has its performance been tested in areas other than Riverside.

There is not likely to be a large market demand for pummelos in the

United States, and therefore Chandler is recommended only for home garden trial or for limited commercial planting as a specialty fruit. It may have a place as a dessert, salad, or breakfast fruit, and may be especially attractive to people of Asiatic extraction, among whom the pummelo is a favorite variety of citrus.

### BOTANICAL DESCRIPTION

**Tree** vigorous, spreading, moderately open, only slightly thorny. Fruits borne singly or in pairs, well distributed throughout the tree. Leaves large, broad; apex acute; base acute to slightly rounded. Petioles broad, typical of pummelo. Leaves and twigs nearly glabrous, but not completely so.

**Fruit** ripens at Riverside in December, and is good until February or March—longer if picked and stored. As is characteristic of pummelos, rind does not puff; fruit remains firm until past season. **Fruit size** similar to large grapefruit, four and one-half to six inches in transverse diameter. **Shape** good, globose to very deep oblate, with no neck. Radius of fruit cross section often slightly greater on one side than on the other. **Rind** smooth, except for many small, slightly raised oil glands. Rind surface often slightly pubescent. Stem end slightly rounded, without furrows; blossom end nearly flat, not mammillate; styler scar about one-eighth inch in diameter. **Rind color** light yellow, darkening slightly as season progresses. **Rind thickness** ten to twelve mm., medium for a pummelo (thicker than grapefruit). Albedo adherent to flesh. Rind oil little, odor not prominent.

**Core** solid, six to ten mm. in diameter, small for a pummelo. **Segments** usually fourteen to sixteen; segment membranes of medium thickness, moderately tender. **Pulp color** pale yellow to pale pink, variable within a fruit; yellow similar to Ridgway's plate XVI, Naphthalene Yellow; pink similar to Ridgway's plate XIII, Old Rose, occurring in membranes and albedo. More pink in some years than in others. **Pulp texture** medium (not coarse); firm but tender. Pulp vesicles medium to large, highly variable in shape. Pulp moderately juicy. Juice pale yellow, similar to Ridgway's plate XVI, Naples Yellow. (Ridgway, 1912.) Juice aroma pleasant but weak.

Level of **total soluble solids** medium; acid medium to low-medium. Solids : acid ratio moderately high in December and January. **Seeds** many, typical of pummelo; large, twelve to fifteen mm. in length; angular, often near flat, though with well-developed cotyledons. Cotyledons white; outer seed coats cream; inner coats brown.

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