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The Non-Melting Semi-Freestone Peach

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Abstract

Since the unconfirmed report by Blake nearly 60 years ago, the combination of non-melting flesh with the freestone trait in peach has been a long sought goal of breeders. Non-melting flesh, semi-freestone peach selections were found in 1992 and confirmed on budded trees fruiting in 1995. These unique phenotypes are segregants from two sources: Fla. 9-20C and Fla. 9-26C. Crosses of open-pollinated selections from both sources with 'Oro A' have also produced non-melting semi-freestone selections. Test crosses are in progress to determine the specific genotypes of these selections and that of their progenitors. At this time we assume their genotype to be non-melting freestone (*F_mm*) which would be consistent with the original hypothesis of 2 genes. each with 2 alleles.

Additional index words. *Prunus persica*, breeding.

The first linkage in peach [*Prunus persica* (L.) Batsch], that of genes for flesh texture and pit adhesion to the fruit flesh was reported by Bailey and French in 1933. When viewed individually, both flesh texture and stone adhesion behave as simply inherited traits which segregate freely and display complete dominance. In the case of flesh texture, melting flesh (*M*) is dominant over non-melting flesh (*m*). Hence, a heterozygous selection (*Mm*) will segregate in a 3:1 ratio (melting: non-melting) when selfed. Pit adhesion to fruit flesh behaves in a similar manner. Freestone (*F*) is dominant over clingstone (*f*) and a heterozygous selection (*Ff*) will segregate in a 3:1 ratio (freestone:clingstone) when selfed.

However, when a selection heterozygous for both traits (*FfMm*) is selfed, the resulting population does not segregate in the ratio one would expect for two independent genes. i.e. 9:3:3:1 (melting freestone, melting cling, non-melting freestone, and non-melting clingstone, respectively). Instead, one observes a lower than expected number of melting clingstones and a complete absence of non-melting freestones. This indicates a linkage between the non-melting and clingstone genes.

Bailey and French estimated a cross-over rate of 8-15% based on the small number of melting clingstones observed in their test cross progeny (1933 and 1949). However the melting clingstone phenotype was the only cross-over type observed. In order to account for the absence of the complementary cross-over (non-melting freestone), they proposed an epistatic interference to the expression of the freestone trait in non-melting flesh phenotypes. Hence. these individuals behaved as non-melting clingstones.

In 1937, Blake reported having found a non-melting freestone peach selection, but no mention of it was ever made in subsequent reports leaving its authenticity in question. For nearly 60 years since, a long-sought goal of peach breeders has been the non-melting freestone phenotype in peach. Indeed, the absence of such reports lead Monet (1989) to propose that, instead of 2 linked genes, there was only one gene with 3 alleles: (1) melting freestone, (2) melting clingstone, and (3) non-melting clingstone, with dominance from left to right. However, Monet's proposed system fails to account for the observed segregation of all 3 types in progenies from selfed heterozygous individuals (*FfMm*) as reported by

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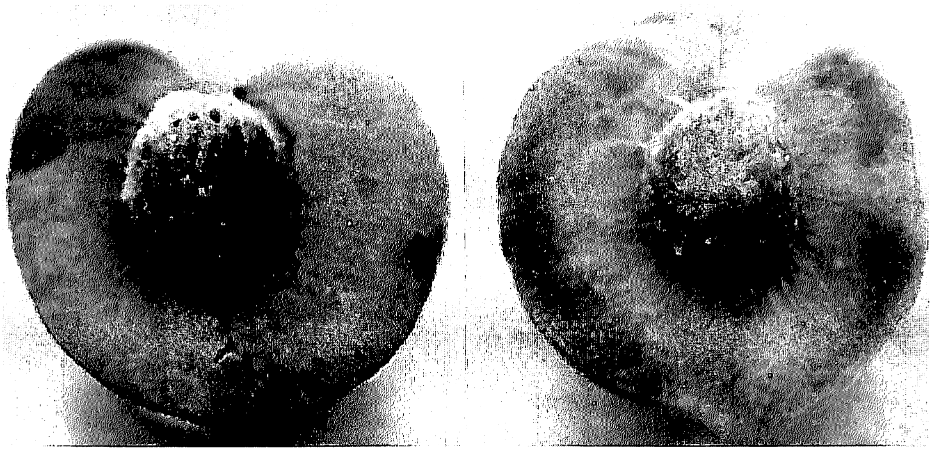

Figure 1. On the left, Fla. 92-9C, a non-melting semi-freestone peach selection (ca. 85 day FDP) vs., on the right, Fla. 90-39C, a non-melting clingstone peach selection (ca. 90 day FDP). Both are from crosses of Fla. 86-28C with 'Oro A.'

Bailey and French (1933 and 1949). The purpose of this paper is to report the identification of several non-melting, semi-freestone peach phenotypes segregating out of at least 2 sources.

One of the major problems in identifying non-melting freestone phenotypes has been the difficulty in discerning the genotype. Freestone peaches vary in the ease with which they separate from the pit, depending on fruit development period (FDP). maturity, variety and growing conditions. Many early ripening freestones which have short a short FDP are free only at the soft-ripe stage of maturity. Early ripening freestone genotypes that appear clingstone are termed physiological clingstones.

The 3 classes of flesh adhesion proposed by Weinberger (1944) are clingstone. semi-freestone and freestone. Traditionally, the phenotypical classes include the following genotypes:

1. Clingstone
   a. homozygous recessive genotypes (*ff*) in both melting (*M*_) and non melting (*mm*) flesh. All canning non-melting genotypes are clingstone (*ffmm*) and examples of melting clingstones (*ffM*_) can be found in all ripening seasons.
   b. early ripening, i.e. short fruit development period (typically < 75 day FDP), genetic freestone genotypes (*F*_*M*_) behave as clingstone.

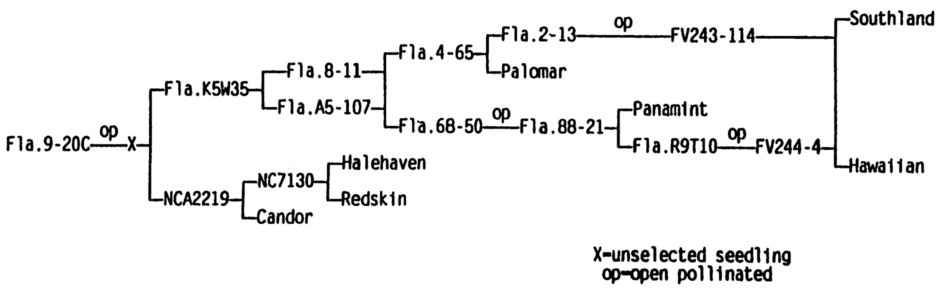

Figure 2. Pedigree of Fla.9-20C.

2. Semi-freestone
   a. genetic melting freestone (*F_M_*) genotypes with varying degrees of flesh adhesion or separation mainly due to length of FDP in moderately early ripening varieties (mostly genotypes ripening between 75 to 100 day FDP).
3. Freestone
   a. homozygous dominant (*FF*) or heterozygous (*Ff*) genotypes found in melting flesh (*MM* and *Mm*). Most of these freestones are found in genotypes ripening more than 100 day FDP. Air-free phenotypes generally occur in late-ripening (> 120 day FDP) varieties.

Stone adhesion is best judged when fruit are soft ripe (eating ripe) to minimize misclassifications of freestones as clingstones due to insufficient FDP for clear expression.

Non-melting types (canning or processing varieties) cannot always be differentiated from melting types (typical fresh market, dessert varieties) at the shipping ripe stage. i.e. as ground color begins to change from green to yellow, but perceptible flesh softening has not yet begun. However, as the ripening process proceeds and fruit develop significant yellow ground color and aroma, accompanied by flesh softening, non-melting types soften at a much slower rate than melting types. Moreover. non-melting types have a 'rubbery' feel when squeezed. i.e. they 'rebound' readily rather than deform permanently like typical melting types. We have also observed that non-melting types typically retain their shape and decompose at a much slower rate after dropping to the ground. In order to confidently distinguish the 2 flesh types we have found it necessary to revisit selections every 3-4 days as the ripening process proceeds.

We first found non-melting semi-freestone phenotypes in a 1992 fruiting progeny. These were reconfirmed in 1995 on budded trees evaluated at Gainesville, FL and at Attapulgus, GA. Figure 1 shows an example of a non-melting, semi-freestone selection (Fla. 92-9C) compared with a typical non-melting clingstone selection (Fla. 90-39C). Since 1992, similar non-melting semi-freestone phenotypes have been selected from a second source of non-melting flesh. The two sources are as follows:

1. An open-pollination of a seedling from Fla. K5-35 (melting freestone) x NCA 2229 (melting semi-freestone) gave Fla. 9-20C (non-melting clingstone). Pedigree is shown in Figure 2. Open-pollinations of Fla. 9-20C at Gainesville and at 2 locations in Australia (G. Richards and G. Porter, pers. comm.) have segregated for non-melting semi-freestones.
2. An open-pollination of a seedling from 'Sunred' nectarine (melting freestone) x 'Mexican cling' (non-melting clingstone) gave Fla. 9-26C (non-melting clingstone). Open-pollinated Fla. 9-26C and sib crosses segregate for non-melting semi-freestones.

Additionally, crosses of 'Oro A' (non-melting clingstone of Brazilian origin) with Fla. 86-28C (Fla.9-20C op) and 'AztecGold' (Fla. 86-31C=Fla. 9-26C op), both of which are non-melting clingstones, have segregated for non-melting semi-freestones.

It is apparent that both of our non-melting clingstone sources contributed to producing non-melting semi-freestones, even when crossed with 'Oro A.' The relative ease with which we have developed these 2 lines which readily segregate for non-melting semi-freestones in small populations (< 75) suggests that we may have broken the proposed linkage between the non-melting and clingstone traits. However, in the absence of complete segregation data for the populations from which these selections were made and/or test cross data to verify the genotypes of our various progenitors and selections we can only speculate on this matter at this time. Nevertheless, we have evidently overcome the proposed epistatic interference of non-melting flesh in the expression of the freestone trait. This may be due to the unique low-chill material used in the development of our germplasm. Again, we can only speculate as to whether these materials possess unusual alleles or allelic combinations modifying the expression of flesh type or pit adhesion.

If we assume that our materials do not have any unusual alleles or mutations then the inability to find non-melting freestones in all the seedlings handled in breeding programs over the years is puzzling. Apparently the freestone allele is not present among the canning non-melting genotypes as none have been reported despite millions of seedlings from feral populations of Spanish origin in the Americas or from intercrossing to produce new canning varieties in programs throughout the world. Admittedly, it is unlikely that breeders would have intentionally introduced the freestone allele from melting flesh germplasm into canning variety development programs because this would have included genes for skin and flesh anthocyanins from the highly colored melting dessert genotypes. This would have required several generations of rigorous selection to eliminate these undesirable (in canning types) red pigments in the flesh near the skin and pit.

The use of early ripening (short FDP) varieties carrying the non-melting allele (typically used for breeding early ripening genotypes) may explain why late maturity (longer FDP) non-melting freestone genotypes were never found. The intercrossing of early ripening varieties would produce mostly early ripening progeny and freestone genotypes would likely behave as physiological clingstones. Until recently, clingstone phenotypes would probably have been immediately discarded in programs developing later-ripening fresh market varieties due to a perceived consumer aversion to clingstones if freestone peaches are available.

The development and release of only a few non-melting flesh varieties, such as 'Delta,' 'Crimson Lady,' 'Davidsun,' 'Maysun' and the recent 'Spring Baby,' for fresh market use is also puzzling, especially in light of the fact that a non-melting allele occurs in some early ripening varieties released nearly 30 years ago (such as 'Springcrest'). Presumably breeders commonly encountered non-melting segregants in many of their hybrid populations. We are inclined to conclude that the presence of so few early ripening non-melting varieties is likely the result of willful discarding of this genotype by the breeder.

One possible explanation is that breeders were convinced that consumers would not accept non-melting flesh varieties for fresh market consumption. Another reason may be that many non-melting flesh genotypes develop a strong 'off-flavor' in the over-ripe stage of maturity. We have observed that same 'off-flavor' in seedlings of melting flesh genotypes and discard them. We also find 'off-flavor' in our non-melting genotypes which appears to be independent of degree of stone adherence. A third explanation may be the excessive rubberiness of some non-melting flesh genotypes (such as exhibited in 'Delta'). However, we have been able to obtain non-melting genotypes with less rubberiness and more tenderness of flesh.

Inappropriate handling and marketing of earlier available materials may also have led to grower aversion to this type of material. 'Merrill Gem,' an early ripening, non-melting flesh clingstone introduced in 1947, was tried briefly for fresh market use. However, the variety's ability to develop significant red color well before physiological maturity led to its downfall. Growers picked it at an immature stage to take advantage of the early market. However, the immature fruit shriveled rather than ripened resulting in consumer rejection of the product (Ramming, personal communication).

It is our belief that the development of attractive non-melting flesh varieties that can be allowed to fully ripen on the tree while still retaining sufficient firmness for shipping, would offer a clear advantage over traditional melting types, particularly in the early part of the season, when fruit size, appearance, firmness and eating quality are typically wanting (Sherman et al., 1990; Beckman et al., in press). The development of freestone types should enhance the acceptance of non-melting flesh varieties in the fresh market. To this end Brecht et al. (1995) demonstrated that consumers could readily discern the difference between non-melting and melting type peaches; however, they held no bias for one or the other.

Non-melting semi-freestones have been obtained from 2 distinctly different non-melting sources, namely Mexican Cling and North Carolina germplasm (and possibly Brazilian). However, we cannot rule out the introduction of critical alleles in the open-pollinated generation that immediately preceded Fla. 9-20C and Fla. 9-26C. Our cooperative breeding program for low to moderate winter chill requirement has largely been in the short (< 75 day) and medium (75-100 day) FDP range with our non-melting semi-freestone phenotypes appearing in the medium FDP range.

We propose to have non-melting freestone genotypes to fit at least 2 of the flesh adherence classes of Weinberger (1944) namely the early ripening physiological clingstones, and the medium ripening semi-freestones (and possibly the later ripening freestones). The identification of the non-melting semi-freestone phenotype is compatible with Bailey and French's (1933) original proposal of 2 genes each with 2 alleles.

In the absence of test cross data and complete data on the segregating populations from which selections were made, we can only speculate as to the specific genotypes of our non-melting semi-freestone selections and their progenitors (Fla. 9-20C and Fla. 9-26C). At this time we presume all to be non-melting freestones (F_mm) and that Fla. 9-20C, Fla. 9-26C and 'Oro A' are all carry genes that allow the expression of the freestone phenotype in combination with non-melting flesh. We expect the determination of the inheritance of this trait will be fertile ground for future research.

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