FURTHER INFORMATION REGARDING THE BENEFITS OF THE SUPER FIRM AND ALCOBACA GENES IN TSH53 AND TSH54

TOMATO SOLUTIONS

2026

BACKGROUND

SUPER FIRM (sf) GENE

The super firm gene is the designation we have given to material containing the all flesh (aff) gene that has been selected with enhanced firmness. The aff gene is a natural mutation that was discovered in a research field in Italy in1982. It is a simple recessive gene. This was patented in 2002 by Peotec and they released several hybrids, but these did not perform well agronomically. The patent has since expired. We obtained germplasm 15 years ago and by backcrossing and selection have developed hybrids that have outstanding yield and quality. The basic expression of the aff gene varies depending on the associated genetic material, and it is not as simple as just having the aff gene present. We use the super firm (sf) genetic designation for material that results in the high level of firmness shown in our hybrids.

Historically, it often takes many years to incorporate a new gene with positive effects into material that performs well agronomically. A case in point is the jointless (j2) gene which is also a simple recessive. The first machine harvest tomatoes all had stems which caused problems both in harvesting and processing. Stems adhering to fruit often punctured other fruit during harvesting which was detrimental to fruit integrity especially when lye peeling. Also, stems on the whole pack sorting line had to be removed manually. It would seem to be a simple thing to incorporate the j2 gene into machine harvest hybrids, but due to closely linked genes it took many years before acceptable hybrids were available. Many rounds of backcrossing and selection were required but eventually we got to where we are today, so that all machine harvest hybrids are jointless (stemless). Actually, the j1 gene was also considered (it also results in stemless fruit) but was eventually rejected in favor of j2. It was not a straight line path.

The ogc (old gold crimson) gene increases lycopene and red color in tomatoes and was also found as a natural mutant and was described in the early 1950's although probably discovered well before that. Many hybrids now have this gene but it is not yet universal. We have incorporated this gene into all of our machine harvest hybrids because of the benefits it offers, particularly when combined with the alcobaca (alc) gene in specific hybrids.

ALCOBACA (alc) GENE

The alc gene was first described in 1961 and came from landraces that were grown in Portugal and used for winter storage of the fruit. It is also a simple recessive gene and is similar to other genes that affect ripening. Relative to other “non-ripening”genes it has a much milder effect because genetically, it only affects one amino acid. The basic effect is to decrease the amount of pectic enzyme so that the fruit remain very firm. Like the sf gene it has many associated effects such a providing a high level of resistance to fruit rotting pathogens. When only used in one parent in a hybrid, the fruit ripen to a normal red color but remain firmer and resistant to rot for an extended period of time. We have been using and improving this material for over 25 years to develop parents that combine high yield and color in hybrid combination. By using ogc, sf, and alc/+ in hybrid combination in TSH53, the level of field storage is truly remarkable. We have identified pure alc/alc selections with the ogc and sf genes that could be machine harvested with juice color similar to current non-ogc hybrids. However, since the field storage capability of alc/+ hybrids such as TSH53 is already outstanding, a further level of holdability is not really needed.

ADVANTAGES AND RESULTS FROM USING SUPER FIRM AND ALCOBACA GENES

The super firm gene results in the following advantages compared to conventional hybrids:

- ★ The locular area does not liquefy upon ripening but remains solid thus adding to firmness and color.
- ★ The levels of pectic enzyme are reduced significantly during ripening allowing the flesh of the tomato to remain firmer for an extended period.
- ★ When combined with the crimson (ogc) gene, juice color is increased significantly in the locular area, resulting in higher color than any conventional hybrid even with the crimson gene.
- ★ Flavor is enhanced due to higher levels of 2-phenylethanol which is a natural flavor compound in tomatoes.
- ★ Fruit is naturally more resistant to fruit rots.
- ★ The harvest window is extended by several weeks over conventional tomato hybrids.
- ★ Due to the high firmness, recovery of peeled fruit using either lye or steam is enhanced.
- ★ Peeled color is excellent since fruit ripen uniformly, avoiding the problems with yellow shoulder disorder (YSD) more commonly known as blotchy ripening.
- ★ When combined with the alc gene (TSH53) which reduces softening due to a further reduction in pectic enzymes, field storage of fruit is taken to a new level, with a significant improvement in resistance to fruit rotting organisms.

Practical results:

- ★ Planting schedule and harvest timing are not as critical resulting in logistical efficiencies.
- ★ Tomatoes can be heaped up higher without excessive damage reducing transportation costs.
- ★ Contamination of roads and staging areas at the factory from juice leaking from trucks is eliminated.
- ★ Peel recovery is improved since fewer smashed fruit are destroyed by the lye solution.
- ★ Steam peeling is more efficient since fruit remain intact after heat is applied.
- ★ Waste load from contaminated flume water in the processing plant is reduced leading to fewer environmental problems.
- ★ Higher quality tomato paste is produced due to better color and viscosity as well as lower mold counts.

TSH54 combines the crimson gene (ogc) with the super firm gene (sf) and can be harvested throughout September.

TSH53 combines crimson, super firm, and the alc genes for the ultimate in fruit vine storage for late harvests if planted in early June.

PHYSICAL APPEARANCE

FLAVOR ENHANCEMENT WITH SF

The flavor compound 2-phenylethanol which is already present in tomatoes is increased in concentration in super firm fruit thus enhancing flavor. This is only one of many naturally occurring chemicals in tomatoes as shown in the diagram below, but judging from my own experience the flavor of super firm tomatoes is excellent. The additional flavor boost should be welcomed by consumers of peeled product in particular, but should be positive for juice and paste as well.

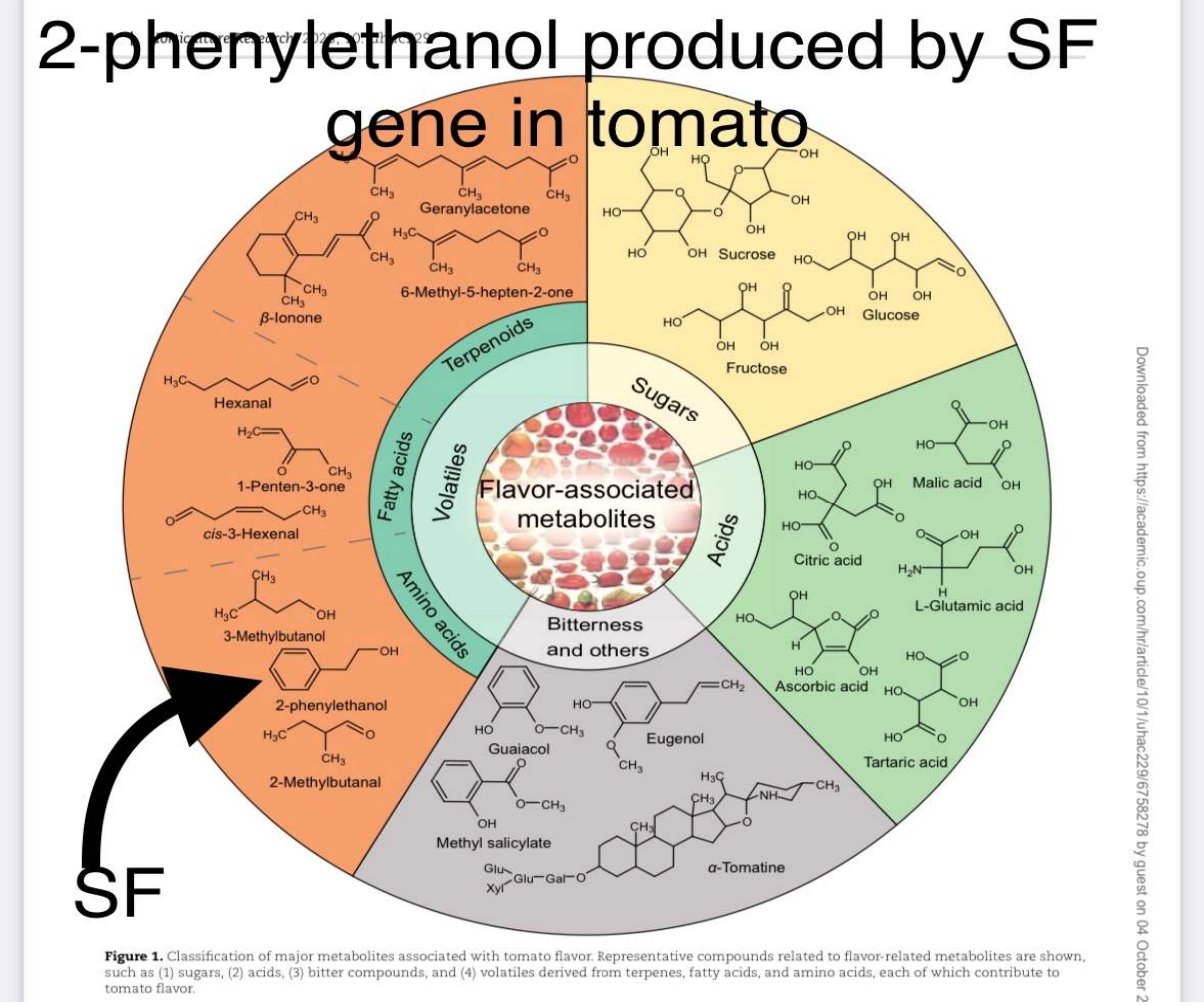


Figure 1. Classification of major metabolites associated with tomato flavor. Representative compounds related to flavor-related metabolites are shown, such as (1) sugars, (2) acids, (3) bitter compounds, and (4) volatiles derived from terpenes, fatty acids, and amino acids, each of which contribute to tomato flavor.

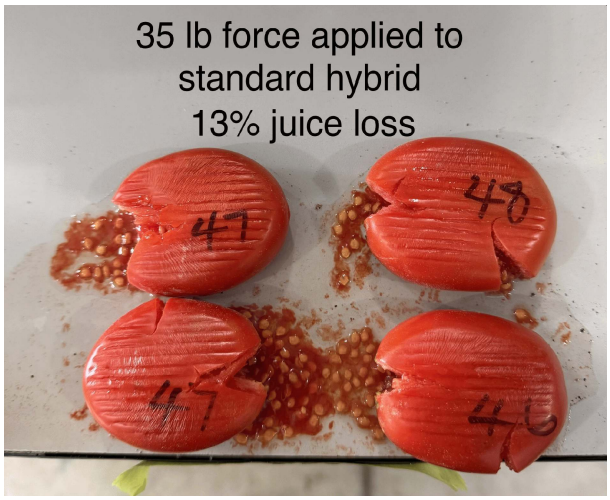
DETERMINATION OF RELATIVE RESISTANCE TO FIELD ROTS FROM SOIL CONTACT

To simulate rot occurring from tomatoes in contact with soil, moistened field soil was placed in plastic tubs to a depth of approximately 25 mm (1 inch) and 42-44 tomatoes were placed in each tub and gently pressed into the soil to make good contact. In the first experiment about 1" square of skin was shaved off each tomato on the side contacting the soil. The tubs were covered in plastic and incubated in the dark at 27°C for 3 days. All of the tomatoes from each hybrid tested developed severe rot and no differences were evident among hybrids.

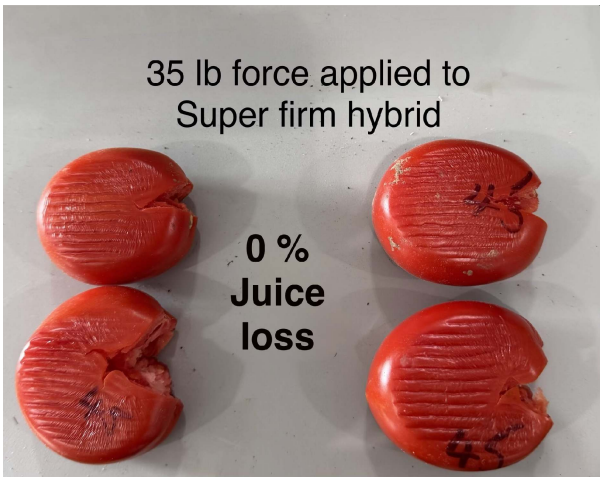
In the second experiment shown below, the tomatoes were intact and not injured but incubation time was 11 days at 27°C. This differentiated the hybrids quite clearly showing that the super firm gene by itself in TSH54 only had 14% rot compared to 32% rot in H1648, a reduction of 56%. When the super firm gene was combined with alcobaca in a heterozygous form as in TSH53, the amount of rot was only 4%, a reduction of 88%. It is suspected that the 2 fruit that rotted in the TSH53 group may have been injured when the tomatoes were pressed into the soil, thus breaking the skin and allowing rot to develop as it did in the first experiment. At any rate, these experiments clearly show that the tomato skin plays a very large role in the development of rot in tomatoes contacting the soil, and that **the super firm and alcobaca genes can reduce the amount of soil rot to a high degree as long as the skin remains intact**.

POSITIVE EFFECT OF SF ON REDUCING JUICE LOSSES AND MAINTAINING FRUIT INTEGRITY

An experiment was devised to demonstrate the effect of crushing tomato fruit on the release of locular juice. The picture shows the apparatus that was used. Crude but effective.



PROBLEM



SOLUTION: TSH53 & TSH54

ILLUSTRATION OF THE PRACTICAL PROBLEMS HARVESTING CONVENTIONAL TOMATO HYBRIDS

The use of hybrids containing the sf gene will eliminate the loss of juice from crushed and broken fruit. This will also alleviate the contamination of roads and staging areas where loads of tomatoes are waiting to be processed. By keeping the fruit intact, contamination of flume water in the factory is also reduced resulting in a much cleaner environment.

DEMONSTRATION OF SUPERIOR FIELD HOLDABILITY AND RESISTANCE TO FRUIT BREAKDOWN IN TSH53 DUE TO INCORPORATION OF THE ALCOBACA GENE WITH SUPER FIRM

As can be seen in the photos below, almost no fruit have developed rot in the TSH53 hybrid with both sf and alc genes, and the fruit are still very firm as of November 6. The TSH54 had a significant amount of rot even though the fruit were still firm. No fungicide sprays were applied after August 31st in this planting. Fruit were ready for machine harvest approximately September 7th at the latest. Note that these are single rows not twin rows as in commercial fields. TSH54 will hold for about 3 weeks after full maturity, but TSH53 will hold for at least a month and longer. TSH53 really solves the problem of having tomatoes available for harvest late in the season, without the continuous application of fungicides.

Juice data collected from these plots on November 6, 2025 shows that TSH53 retained an acceptable pH level of 4.43 after approximately 2 months of field storage. It's not likely that this would be needed as frost usually ends production much sooner.

HYBRID	% NTSS	BOSTWICK VISCOSITY (CM)	pH	Hunter color a/b	Lypopene (ppm)
TSH53	4.55	7.0	4.43	2.10	121
TSH54	4.85	6.2	4.56	2.26	129

TSH54 CANNED SAMPLE SHOWING UNIFORM EXTERIOR COLOR AND SMALL CORE

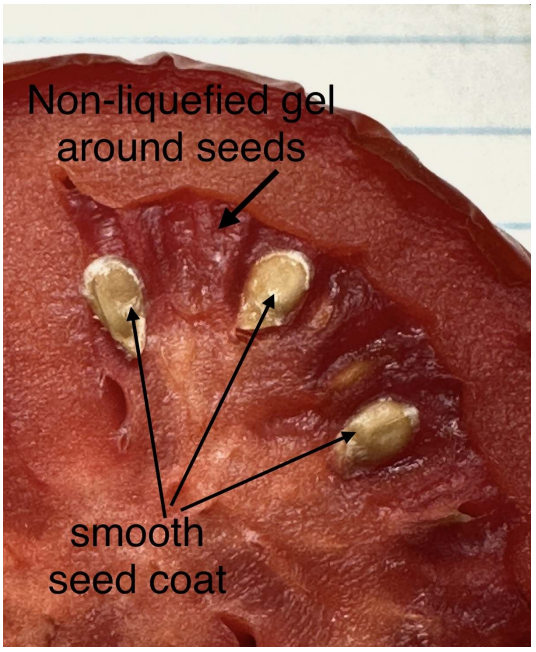
INTERNAL STRUCTURE
OF THE SUPER FIRM TSH54

TSH54 showing the thick outer walls (pericarp) and thick internal cross-walls after removal of the locular areas containing the seeds. Excellent for whole pack with high retained solids after draining off packing juice, as well as for high quality diced.

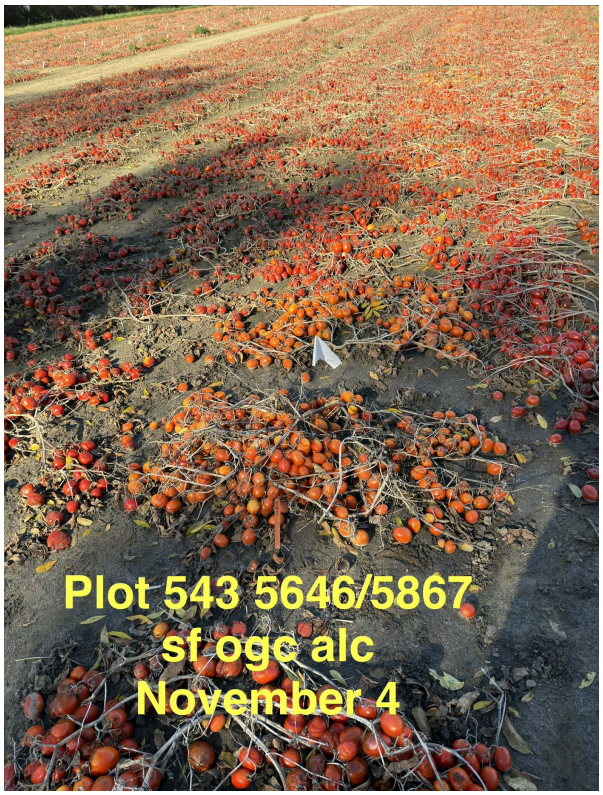
INTERNAL APPEARANCE OF TYPICAL SUPER FIRM TOMATO IN CROSS-SECTION

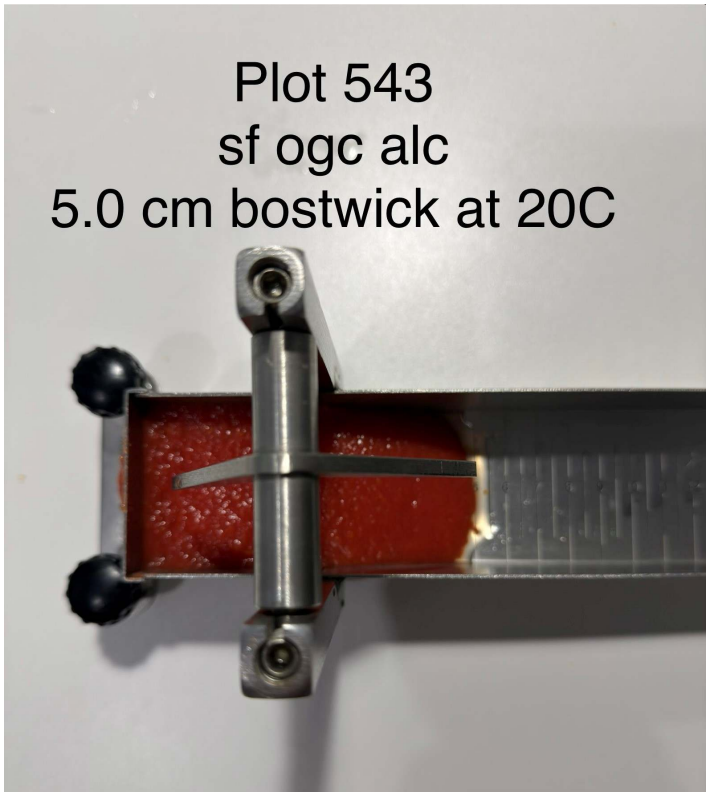
The super firm (or aff) gene has another associated trait in that the seeds do not have the typical “hairs” on the surface of the seeds, leaving a relatively smooth surface. These hairs in a conventional tomato are actually elongated cells that have broken down so that just the cell walls remain. These provide a good place for pathogenic bacteria such as bacterial spot and canker to survive in conventional tomatoes. In the super firm types, it is much easier to have an effective seed treatment using either hydrochloric acid or chlorine (which Tomato Solutions uses) . The amount and severity of the treatment may need to be adjusted to account for the reduced organic matter on the surface of the seed, so as to avoid reducing germination.

Another interesting comment is that seed extraction from super firm females in the hybrid seed production system in India is adjusted by adding a significant amount of water to the crushed tomato pulp. This allows the seed to be separated efficiently from the chopped and crushed seed pulp. The pectic enzyme that we use completes the process, but the lack of gel surrounding the seeds actually makes extraction easier.



HIGH INTERNAL COLOR OF ALC/ALC SELECTION WITH SF AND OGC





The alcobaca gene with sf and ogc still has an orange-red exterior color in this selection which could be used to make a hybrid. The internal colour of the juice has a very acceptable red color when extracted. The fruit from this selection were all harvestable with no rot as of November 4th when some fruit were harvested to make experimental pulp samples. Viscosity was very good as can be seen from the Bostwick test shown above. Other data is shown below:

SELECTION	% NTSS	BOSTWICK VISCOSITY (CM)	pH	Hunter color a/b	Lypopene (ppm)
PLOT 543	4.75	5.0	4.31	1.97	108

The alcobaca gene when used in hybrid combination (one copy) transmits a high degree of field holdability while retaining excellent color because the basic color level of the juice in the pure line is still excellent. This is evident in the characteristics of TSH53 which provides outstanding performance for late harvested tomatoes when disease pressure is high, and harvest may be delayed past the optimum for conventional hybrids. While it might be possible to make pure alc/alc hybrids, it doesn't appear to offer any advantage for machine harvest over the heterozygous types such as TSH53. However, your comments regarding this are welcome.

FUTURE DEVELOPMENTS

We are continuing development of a broader range of super firm hybrids of earlier maturity.

TSH56 will be the earliest with maturity similar to TSH44 and pelletized seed will be available in 2027.

TSH55 will be intermediate in maturity between TSH56 and TSH54 and pelletized seed will be available in 2027 as well.