Handling and Processing Section

EVALUATION OF FLORIDA-GROWN TOMATO CULTIVARS AND BREEDING STOCKS FOR THERMAL PROCESSING

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ABSTRACT

Fruit of a number of tomato lines under varietal evaluation were grown during the 1968 season at Homestead and in 1969 at Homestead, Bradenton, and Immokolee and studied for their thermal processing characteristics. Florida breeding lines 1346, 407, 2086, and 442 produced the highest quality whole-tomato packs, although location and fruit handling were important modifying influences. Other lines were marginally suitable for processing even after careful handling and sorting. Fresh tomatoes receiving a U. S. No. 1 grade usually produced the highest canned tomato scores. Serious defects were size extremes among lots (>130 or <80 tomatoes/25 lbs), yellow top, or uneven ripening.

INTRODUCTION

Although Florida is a major producer of fresh market tomatoes, only a modest canning industry is supported in the state (1). Raw material for processing generally comes from secondary harvest of tomato plantings grown primarily for fresh market. In view of the inevitable dominance of mechanized harvest systems and the attendant need to develop tomato varieties specifically for mechanization, it is important that some effort be directed toward fulfilling the future needs of Florida tomato processors.

Fortunately, many of the requirements for machine harvest are similar to those of the processor. The Tomato Subcommittee of the National Canners Association, Agricultural Research Committee has released the following recommended mechanical harvest specifications as a guide to breeders:

1. Concentrated ripening of fruit with uniform maturity in order to produce a minimum of 80% acceptable fruit and less than 5% rots at one harvest time.
2. An array of varieties or strains suitable for various product uses as well as for peeling with small cores providing a wide range in time of fruit maturity. (Early ripening varieties will be important in the East and Midwest, while late maturing varieties are needed in California).
3. Dependable fruit setting, ripening, and color development over a wide range of environmental and cultural conditions.
4. Relatively easy removal of mature fruit from the plant with stems remaining attached to the plant. Fruit should not shatter, however, in cutting and pick-up. (Mechanical harvest of at least 80% stemless fruit desired).
5. Fruits which are (1) firm and (2) resilient, i.g., resistant to bruising, cracking or rupturing during mechanical harvesting and bulk handling.
6. A high degree of resistance to preharvest fruit cracking related to climatic or cultural factors.
7. Resistance or tolerance to *major plant diseases and disorders* as per area, i.e., Fusarium, Verticillium, Stemphylium, Anthracnose, tobacco mosaic virus, early blight, late blight, bacterial canker, ground rots, bacterial spot, gray wall, blotchy ripening, blossom end rot, and nematodes.

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8. A vine compatible with machine harvest which provides adequate foliage cover to prevent sunburn of fruit.

9. Varieties which will permit vine storage of mature fruit for two weeks or longer without substantial loss in quality. (Freedom from seed sprouting and satisfactory retention of acidity are of particular concern.)

10. Maintenance or improvement of present standards of flavor, color, acidity, solids, and viscosity.

11. Ability to germinate and emerge under adverse conditions, particularly cold temperatures.

12. Minimum potential commercial yield — 20 tons/acre.

A recent comprehensive study in Ohio (2) described those tomato characteristics of significance in processing as: good internal color, minimal locular volume, firm even exterior, small smooth core, lack of stylar end deformities, low pH, high soluble and total solids, and absence of fiber. Predominant defects in 1961 Florida canned tomatoes were color, low drained weight, and peel (3). Newly introduced varieties — Tropi-Red and Walter — offer the opportunity of upgrading the quality of whole tomatoes canned in Florida; however, the most promising tomatoes for processing are Florida breeding stocks being developed for machine harvest. This study compares their processing potential with that of standard fresh market varieties.

Experimental Methods

Tomatoes for canning were harvested from experimental plantings at Homestead during the 1968 season and at Homestead, Bradenton, and Immokolee in 1969 and transported by truck to the Food Science Department in Gainesville for evaluation. Lots were either hand picked or selected from shaker tests during harvest. Fruit were received in the mature green to ripe maturity stages and ripened at 50 to 70°F, depending on distribution of maturities. After elimination of damaged and immature fruit, tomatoes selected for processing were evaluated for the following

1. Size — count/25 lbs.

2. Grade — based on USDA standards for canning tomatoes, which include color, firmness, shape, and absence from decay, mold or damage (4).

3. pH — determined by glass electrode using 10 ml juice in 90 ml distilled water.

4. Titratable acidity — reported as g citric acid/100 ml juice and determined by titrating the above 1:9 solution with 0.1N sodium hydroxide to a pH 8.1 end point.

5. Soluble solids—direct Abbe refractometer reading on strained juice.

Fruit were passed through steam for 75 seconds to crack skins, sprayed with cool water, and hand peeled and cored. No. 303 cans were filled with 10.5 to 11.0 oz of whole peeled tomatoes, a 25-grain sodium chloride:calcium chloride (80:20) tablet was added, and brought to 16 oz with juice derived from the same lot. Cans were hot water exhausted at 190°F for 10 minutes, sealed, processed for 30 minutes in boiling water, and water cooled. Packs were stored at 75 to 80°F until pack evaluation which occurred 4 to 6 months after canning.

Samples of 3 cans from each experimental lot and 2 commercial brands of California canned whole tomatoes were selected randomly and analyzed for:

1. Drained weight — a score derived from USDA standards for canned tomatoes was assigned (5).

2. Wholeness — degree of intactness displayed by drained tomatoes.

3. Flavor — samples were tasted by the analyst, to detect atypical flavors.

4. Color and defects based on USDA Standards (5).

Whole tomatoes and drainage were then combined and passed through a 0.040″ mesh seive for subsequent determinations of pH, titratable acidity, and soluble solids.

Color was also determined on the sieved sample by a Hunter Color and Color Difference Meter using a color standard with Rd = 7.0, a = +33.9 and b = +16.2. Values were reported as a/b ratios. This value was not used to derive color scores which were based on whole fruit prior to seiving.

Results and Discussion

Table 1 summarizes data collected over 2 seasons at 3 locations. Complete data was not obtained from the 1968 pack which was a preliminary survey. Thus statistical analyses were not applicable.

TABLE 1. SUMMATION OF FRESH AND PROCESSED QUALITY OF FLORIDA-GROWN TOMATOES

	Location	Harvest Date	Fresh Grade[1]	Fruit/ 25 lb	pH		Titratable Acidity g citric/100 ml		Soluble Solids Brix	
					Fresh	Proc.	Fresh	Proc.	Fresh	Proc.
1346-D10-S3-D10-NYF1-DBK	H'stead	5-1-69	1	122	4.5	4.4	.423	.456	5.27	5.23
1346-D10-S3-DBK	H'stead	1968				4.3		.32		5.6
1346-D10-S3-DBK-NYF2-DBK-CAVSTW	Immok.	5-26-69	2CYF	69	4.3	4.4	.428	.400	5.30	5.66
1346-D10-S3-D1-S2-FPBK	Brad.	6-1-69	2CF	99	4.5	4.6	.316	.344	4.9	4.51
1346-D11-D10-R1-DBK	H'stead	5-1-69	2CD	102	4.3	4.1	.540	.506	5.40	5.41
1346-D11-D10-R1-DBK-CAVSTW	Immok.	5-26-69	2CF	86	4.3	4.5	.376	.352	5.5	5.50
1346-D11-S3-D10-BG2-DBK	H'stead	5-1-69	2CF	140	4.1	4.2	.528	.520	4.67	4.87
407-D3-D4-D1-D13-DBK	H'stead	5-1-69	1	95	4.6	4.4	.469	.550	5.52	5.81
407-D3-D4-D2-BGBR	H'stead	1968				4.2		.50		5.4
407-D3-D4-D1-D13-CBK	Immok.	5-26-69	1	55	4.4	4.5	.405	.397	5.2	5.28
407-D3-D4-D1	Brad.	6-1-69	2FD	76	4.5	4.5	.384	.346	4.2	4.49
2001-D3-D1	H'stead	5-1-69	1	146	4.4	4.1	.547	.570	4.25	4.66
2001-D3-D1-BGBK-407-D3-D4-D1-DB-CBK-CAVSTW	Immok.	5-26-69	1	65	4.5	4.4	.379	.305	5.2	5.01
2001-D3-D1-BGBK	Brad.	6-1-69	2CYF	137	4.4	4.4	.351	.369	3.9	4.13
412-1-D1-SBK-DBK-NG2-DBK	H'stead	5-1-69	2FD	132	4.3	4.2	.540	.542	5.02	5.62
412-1-D1-S1-D1-M1-DBK-CAVSTW	Immok.	5-26-69	2CYF	77	4.4	4.4	.479	.401	5.2	5.14
2086-S1-D1-BGBK	H'stead	5-1-69	1	102	4.3	4.3	.478	.506	5.95	6.34
2086-S1-D1-BGBK-CAVSTW	Immok.	5-26-69	1	84	4.6	4.5	.377	.298	5.0	5.14
1339-D3-S1-D1-BG2-D11-CBK-CAVSTW	Immok.	5-26-69	2CF	69	4.3	4.4	.369	.379	5.4	5.78
1339-D3-S1-BG2-D11-CBK	Brad.	6-1-69	1	101	4.3	4.4	.341	.340	4.8	5.31
442-BG1-D2-DBK-SBK	H'stead	5-1-69	1	139	4.3	4.4	.408	.327	4.80	5.09
442-BG1-D1-NYE1-DBK	H'stead	5-1-69	2CF	112	4.2	4.2	.584	.523	4.60	4.91
Tropi-Red-D4-S3#10	Immok.	5-26-69	2CF	66	4.5	4.4	.365	.376	5.2	5.70
"	H'stead	1968				4.1		.42		4.8

	Location	Harvest Date	Fresh Grade[1]	Fruit/ 25 lb	pH		Titratable Acidity g citric/100 ml		Soluble Solids Brix	
					Fresh	Proc.	Fresh	Proc.	Fresh	Proc.
Parker	Brad.	6-1-69	2CYFD	245	4.5	4.5	.333	.307	4.2	4.50
Walter	Brad.	6-1-69	2FC	52	4.5	4.4	.400	.368	4.0	5.12
1346-D1-WG-BG-BK	Brad.	6-1-69	2FD	93	4.4	4.5	.321	.335	4.9	5.40
Roma-D3-CBK-AGROW#27062	Brad.	6-1-69	2FD	165	4.5	4.5	.318	.318	4.2	4.34
Harvester #4	Brad.	6-1-69	2CYFD	210	4.6	4.5	.288	.327	4.3	4.23
La Bonita #2	Brad.	6-1-69	2CD	219	4.6	4.5	.331	.373	4.4	4.16
Chico Grande	Brad.	6-1-69	2CYFD	110	4.6	4.5	.360	.351	3.8	4.02
Commercial Brand 1	Calif.					4.8		.364		6.08
Commercial Brand 2	Calif.					4.3		.419		6.21

1 C = color defect
Y = yellow top
F = firmness defect
D = general defect - cracking or blemish

Fresh Tomato Quality

In Table 1 a composite USDA numbered score of 1 or 2 was assigned to all lots of the 1969 harvest. As noted, when a No. 2 grade was given it was due to either color (C), yellow top (Y), firmness (F), or defects (D). Where *(C)* is noted without (Y) it is the result of mature green fruit not ripening adequately to achieve redness. Due to the limited quantity of available fruit, some pink fruit were included in the pack. Where yellow top occurred fruit reddened up quite well either on the vine or in storage, but the shoulder retained marked yellowness. It was impossible to cull out or trim such fruit since the majority of fruit in such lots possessed yellow top. This is a serious defect and cannot be tolerated in commercial packs. An (F) denotes marked softening of fruit due to over maturity. Usually, softness developed in ripe fruit held at 60°F while mature greens were ripening at 70°F to obtain sufficient sample size for processing. A (C) (F) notation is the result of uneven samples; some fruit were overripe (F) while others had not completely turned (C). Defects (D) were invariably split fruit or blemishes and generally the result of either packing injury during transport or post harvest field conditions.

It should be noted that the use of U.S. No. 1 fresh grade fruit greatly improves the quality of the subsequent canned product (Table 2). This

TABLE 2. USDA GRADE SCORE OF FLORIDA-GROWN TOMATOES

	Drain Weight		Wholeness Score	Color		Defect Score	Processed Grade	
	Oz.	Score		Score[2]	Hunter a/b		Total Score[3]	Assigned Grade
1346-D10-S3-D10-NYF1-DBK	10.71	17	17	26B	2.00	30	90B	B
1346-D10-S3-DBK					1.95			
1346-D10-S3-DBK-NYF2-DBK-CAVSTW	9.68	16	17	21C	1.82	28	82C	C
1346-D10-S3-D1-S2-FPBK	10.75	17	17	21C	2.03	26B	81C	C
1346-D11-D10-R1-DBK	9.50	16	17	25B	1.85	30	88	B
1346-D11-D10-R1-DBK-CAVSTW	12.02	20	17	23C	1.96	30	90C	C
1346-D11-S3-D10-BG2-DBK	10.23	16	16	20S	1.96	30	82S	S
407-D3-D4-D1-D13-DBK	10.10	16	16	28	1.96	30	90	A
407-D3-D4-D2-BGBK					1.77			
407-D3-D4-D1-D13-CBK	12.52	20	19	21C	1.98	30	87C	C
407-D3-D4-D1	10.57	17	16	25B	1.74	27	85	B
2001-D3-D1	9.85	16	16	27	1.69	30	89	B
2001-D3-D1-BGBK-407-D3-D4-D1-DB-CBK-CAVSTW	10.47	16	18	18S	1.66	30	82S	S
2001-D3-D1-BGBK	10.70	17	16	18S	1.41	30	81S	S
412-1-D1-SBK-DBK-NG2-DBK	9.91	16	17	26B	1.60	30	89	B
412-1-D1-S1-D1-N1-DBK-CAVSTW	10.90	17	19	20S	1.46	28	84S	S
2086-S1-D1-BGBK	9.75	16	16	29	1.64	30	91	A
2086-S1-D1-BGBK-CAVSTW	10.63	17	18	20S	1.88	30	85S	S
1339-D3-S1-D1-BG2-D11-CBK-CAVSTW	10.92	17	17	25B	2.23	30	89	B
1339-D3-S1-BG2-D11-CBK	11.08	17	16	21C	1.78	29	83C	C
442-BG1-D2-DBK-SBK	10.33	16	19	26B	1.75	30	91B	B
442-BG1-D1-NYE1-DBK	11.39	17	17	20S	1.35	30	84S	S
Tropi-Red-D4-S3#10	10.73	17	17	25B	1.79	30	89	B
					1.49			

TABLE 2 (CONTINUED)

	Drain Weight		Wholeness Score	Color		Defect Score	Processed Grade	
	Oz.	Score		Score[2]	Hunter a/b		Total Score[3]	Assigned Grade
Parker	10.92	17	18	20S	1.67	30	85S	S
Walter	10.63	17	17	22C	1.65	25B	78	C
1346-D1-UG-BG-BK	10.73	17	16	24B	2.19	28	85	B
Roma-D3-CBK-AGROW#27062	10.42	16	18	23C	1.70	28	87C	C
Harvester #4	11.28	18	16	23C	1.63	30	87C	C
La Bonita #2	10.83	17	16	18S	1.50	30	81S	S
Chico Grande	10.68	17	16	18S	1.83	30	81S	S
Commercial Brand 1	9.63	15C	17	27	2.00	30	90	C
Commercial Brand 2	12.42	20	18	30	2.11	29	97	A

2 Limiting rule, grade based on color defects observed visually

3 Score accompanied by grade letter or S = Substandard indicates limit rule.

may be realized more easily in experimental packs than in commercial practice, by careful fruit selection both in the field and from ripening mature greens during storage. Mature greens ripened quite unevenly at 70°F. Such a trait would present a handling problem for the processor faced with a range of maturities supplied by a once-over machine harvest.

The fruit size as manifested by count/25 lbs was quite uniform within any lot (± 4 fruit) but varied markedly with variety and location. Values of 90 to 110 are desirable for processing (2). When counts exceed 130, the labor involved in handling operations is excessive and counts below 80 are awkward to pack in 303 cans. Thus fruit over about 130/25 lbs or under 80 would be economically difficult to can whole, irrespective of tomato quality.

Processed Quality

Aside from the laborious handling of lots of small size and the difficulty of packing large fruit, the canning operation went smoothly. The high incidence of yellow top necessitated excessive trimming; and slow ripening of mature greens required inclusion of pink fruit in order to reach at least a 5-can sample pack.

The pH of the fresh sample, titratable acidity and soluble solids were reasonably close to the

processed values. The flavor of the canned tomatoes was uniform and no influence of these parameters on pack quality was detected. However, for eventual utilization as juice, puree, and ketchup, soluble solids above 5.0% are desirable and a pH of 4.5 or below assists in the destruction of microorganisms during heating and allows processing at atmospheric pressure. Those samples at pH 4.6 may be acidified, although commercial sterility was not a problem in this study. Both acidity and soluble solids were lower in fruit from Bradenton.

All lots processed contained some fruit of good color (Hunter a/b values over 2.0), but color values and assigned color score were quite variable and reflected the yellow top condition as well as the presence of pink fruit. Recent selections of 407, 1346 and several other processing candidate stocks possess the uniform green fruit pigmentation system. Such fruit lack the characteristic dark green shoulder color and do not sunburn or yellow top. Any future variety introduction for processing will have this pigmentation system.

Drained weight and wholeness are good indices of canned tomato quality. U.S. standards for canned tomatoes rely heavily upon these factors (Table 3). Almost all samples achieved drained weight and wholeness scores of 16 or above classifying them as grade B on these attributes. All samples were practically free from defects, which reflect careful handling during processing.

The overall scores reflect to a great extent the quality of the fresh tomatoes and *resulting* processed pack. In general, the breeding lines 1346, 407, 2086, and 442 seemed to yield the highest quality packs, particularly when grown at Homestead in contrast to tomatoes from Bradenton and Immokolee. In the 1968 preliminary trials 1346 and 407 also rated highest. However, if sufficient care is taken in fruit selection and handling, any of the lines examined could, with proper fruit size, produce an acceptable pack. Conversely, lines 1346 or 407, if not handled properly, can yield mediocre packs. The California tomatoes included for comparison were coreless and probably harvested, peeled, and packed by machine. The resulting high quality (Table 2) reflects an excellent operation from field to market. Can Florida processed tomatoes attain similar quality commercially? The plant breeders and food technologists involved in this report believe so.

In summary, newer tomato breeding lines possess processing potential which exceeds that of existing cultivars; however, the influence of season, location, and field handling are critical and merit extended investigation. Quality attributes which caused serious downgrading of both fresh and processed tomatoes were primarily size variation, yellow top, and uneven ripening. Other defects associated with cultivation, machine harvest, and yield will need to be minimized if promising lines are to be processed satisfactorily. The continuing horticultural and breeding research is focused on minimizing the influence of these problem areas.

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Table 3. Allowable USDA Score Points for Canned Tomatoes (5).

U.S. Grade Classification	Drain Wt.		Wholeness	
	Points	Drain Wt. in 303 cans, oz.	Points	Definition
A	20	11.8	20	95% of drain wt. or greater whole
A	19	11.5	19	80 to 95% whole
A	18	11.1	18	
B	17	10.5	17	
B	16	9.8	16	70% or greater whole
C	15	9.1	15	
C	14	8.5	14	less than 70% whole

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