PEELABILITY AND YIELD OF PROCESSING TOMATOES BY STEAM OR LYE

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ABSTRACT

Approximately 25% of the processed tomatoes grown in California are made into value-added foods such as whole peeled and diced tomatoes. Peel removal is the first step in this process, and it must be optimized for both quality and yield. The effect of peeling conditions on tomato cultivars Halley 3155 and Heinz 8892 (H 8892) was evaluated. Considerable texture loss results from peeling; however, firmness was greater for cv. Halley 3155 than for cv. H 8892 regardless of peeling conditions utilized. Peeling under low steam pressures (12 psig) was insufficient to adequately peel either cultivar. While high pressure steam (18 psig) was more efficient at peel removal, increasing vacuum level from 20 in. to 24 in. did not improve peelability of either cultivar. Because cultivar affected peelability and yield, specific tomato cultivars should be evaluated and directed to either paste or whole peeled and diced tomatoes as appropriate.

INTRODUCTION

In California, about three-quarters of the processing tomatoes are manufactured into bulk paste, while approximately 25% of the production is made into value-added tomatoes. During the manufacture of whole peeled, diced and other tomato products, it is important to retain high quality color, uniformity and appearance and at the same time minimize loss of yield. The peeling operation itself often results in considerable yield losses unless temperature, pressure and residence time in the peeler are closely controlled. About a

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quarter of the tomato's weight is discarded as peeling waste (Barringer *et al.* 1999).

Typically, processing tomatoes are peeled by chemical lye peeling (using NaOH or KOH), steam or scalding-hot water. These three methods remove the cuticle and some of the most external cell layers of tomatoes. Overpeeling is a problem frequently associated with improper lye peeling, in which many layers of tomato flesh are removed resulting in an undesirable light red color and exposure of some superficial yellowish vascular bundles. In addition to this undesirable appearance, overpeeling leads to poor yield; therefore, operations must be closely monitored to ensure removal of peel without excessive flesh loss. Moreover, the use of lye peeling may create a waste disposal problem that may be both deleterious to the environment and costly (Schlimme *et al.* 1984; Corey *et al.* 1986).

Mechanical systems of peeling, which employ primarily steam or hot water, on the other hand, offer the advantage of being safe for the environment. In California, about 70% of processing tomatoes are peeled with either steam or hot water, and the remaining 30% are lye peeled. However, the use of lye peeling is increasing. Yields are commonly higher with lye peeling, and the cost of waste disposal is not prohibitive. In the Midwest region of the U.S., chemical peeling is the most commonly used method (Das and Barringer 1997).

Following the steam, hot water or lye exposure, tomatoes pass over disc or pinch rollers that mechanically eliminate peel. The efficiency of this process is important because this decreases the need for hand sorting to remove residual peel flags attached to the tomatoes. According to the Standards of Identity issued under the Federal Food, Drug and Cosmetic Act, the amount of residual peel in canned peeled tomato products must be less than 15 cm^2/kg (6.8 cm^2 /lbs) based on the average of containers evaluated. Peel removal must be complete for tomato products to receive a USDA grade A (Anon 1995).

Peeling efficiency may vary with the particular peeling conditions as well as with the tomato cultivars used. In this study, we selected two processing tomato cultivars (cvs.), Halley 3155 and Heinz 8892 (H 8892), which represented about 50% of the processing tomatoes grown in California during the year this study was conducted (Hartz *et al.* 1999). Tomatoes are mechanically harvested in a once-over fashion when 90% of the field is red; therefore, a certain percentage of the tomatoes are at two or three weeks past the ripe maturity. In this study, the efficiency of steam peeling followed by the use of mechanical peel eliminators was investigated, with emphasis on peel removal and yield of tomatoes from two selected cultivars and growing locations.

MATERIALS AND METHODS

Tomatoes

Processing tomato (*Lycopersicon esculentum*) cvs. Halley 3155 (also known as BOS 3155; Orsetti Seed Co., Hollister, CA) and H 8892 (Heinz Tomato Products, Stockton, CA), from two selected growing locations designated #1 and #2, were supplied by commercial growers. Tomatoes were harvested at ripe maturity, then sorted to eliminate defects, washed, towel dried and separated into subsets for subsequent studies.

Steam Peeling Treatment

The combination of steam exposure followed by vacuum is utilized widely in the tomato peeling industry and was adopted for this study. Selected peeling conditions, pressure, exposure time and vacuum were compared for evaluation of peeling efficiency. A total of nine combinations of peeling conditions were carried out. For each tomato cv. or growing location, four replicate batches of 20 tomatoes were preweighed, arranged in a single layer in a small pressure chamber and exposed to one of the nine peeling conditions compared. We defined a *standard peeling condition* as the use of 15 psig (250F) steam pressure for 60 s, followed by 22 in. vacuum. Other peeling conditions employed steam pressures of 12 or 18 psig, exposure times of 45 or 75 s and vacuums of 20 or 24 in. Following the steam plus vacuum treatments, tomatoes were passed over mechanical peel eliminators, consisting of disc and pinch rollers (Imdec Inc., Woodland, CA). Percent peeled tomatoes were determined after steam plus vacuum treatment and after the tomatoes passed over the mechanical peel eliminators. Peeling losses were calculated from the weight difference between unpeeled and peeled tomatoes.

Lye Peeling

As a comparison, tomatoes of the cv. Halley 3155 grown in only one location were submitted to lye peeling followed by vacuum. For this experiment, the tomatoes were treated with a hot lye solution (18% NaOH w/v) at approximately 95C in steam-jacketed kettles for periods ranging from 30 to 75 s. Vacuums of 20, 22 and 24 in. were tested. A total of 12 lye peeling treatments were performed. After immersion in the lye solution and vacuum treatment, tomatoes were run over mechanical peel eliminators as described for the steam peeled tomatoes. Results are the means of three peeling replicates.

Raw and Peeled Tomato Evaluation

A percentage of peeled tomatoes was evaluated using a subjective grading system, rating the observable degree of peel removal on a one (unpeeled) to five (completely peeled) basis. The number of tomatoes in each batch (20 tomatoes/batch) with either no peel attached, or a small flag at the stem scar were designated as peeled. The means of three batches are reported. The peeled tomatoes were weighed, and percent whole peel yield was calculated in relation to the initial weight of the 20 tomatoes. The peeled tomatoes were then diced into $^1/_2$ in. pieces using an Urschel dicer (Urschel Laboratories Inc., Valparaiso, ID), drained on a screen for 1 min, weighed and the percentage dice yield calculated by dividing by initial weight of the 20 tomatoes.

Two hundred grams of diced tomatoes in triplicate were used for texture measurement. Textural evaluation was performed by using a Kramer shear press and a TA.XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, NY) as described previously (Ma and Barrett 2002). Tomatoes hand-peeled with sharp pairing knives spaced at $^1/_2$ in. were used as a raw control in the texture evaluation.

RESULTS AND DISCUSSION

Peelability

Nine selected combinations of steam exposure times and vacuums were utilized (Table 1). Overall, low steam pressures (12 psig) were insufficient to peel either Halley 3155 or H 8892 tomatoes and to produce desirable yields greater than 65%. Large variability among samples in both peelability and yield was observed when using mild peeling conditions (treatments 1–3) unless exposure to steam was long (75 s) and/or high vacuum (24 in.) was applied as in treatment 4. Steam pressures of 18 psig (C) resulted in more efficient peeling of tomatoes than lower steam pressures and temperatures (Fig. 1). Increasing vacuum from 20 to 24 in. did not improve the peeling of either tomato cv. A long exposure time of 75 s was required for complete peeling of tomatoes using low steam pressure. Conversely, when high steam pressure was used, peeling of tomatoes using short or long exposure time was comparable. The peeling conditions considered standard in our pilot plant (treatment 5) resulted in about 90% peeling of Halley 3155 tomatoes from location 1 and 99% for Halley 3155 tomatoes from location 2. Standard peeling treatment of H 8892 resulted in about 99% peeling of tomatoes from location 1 and 86% for tomatoes from location 2.

For comparison, tomatoes of the Halley 3155 cv. (location 1) were also chemically peeled with lye, followed by vacuum. Previous reports (Juven *et al.*

TABLE 1.
PEELING LOSSES AFTER SELECTED STEAM PEELING CONDITIONS

Peeling treatment number	Peeling conditions			Peeling losses (%)			
	Steam pressure (psig)	Exposure time (s)	Vacuum (in.)	cv. Halley 3155 #1	cv. Halley 3155 #2	cv. H 8892 #1	cv. H 8892 #2
1	12	45	20	50.2 ± 16.0	58.3 ± 20.3	45.1 ± 16.3	43.2 ± 14.2
2	12	45	24	54.9 ± 16.3	60.9 ± 21.0	42.4 ± 13.0	54.6 ± 4.3
3	12	75	20	27.9 ± 3.7	42.5 ± 10.7	38.2 ± 2.6	63.4 ± 7.7
4	12	75	24	29.0 ± 9.1	30.8 ± 11.7	37.1 ± 9.3	42.6 ± 9.2
5	15	60	22	32.9 ± 10.5	25.8 ± 2.9	30.4 ± 1.3	39.1 ± 13.9
6	18	45	20	28.4 ± 7.7	32.6 ± 15.7	29.4 ± 2.6	40.6 ± 22.0
7	18	45	24	23.8 ± 4.9	23.6 ± 1.9	26.9 ± 1.8	37.0 ± 18.1
8	18	75	20	28.5 ± 0.8	27.6 ± 2.5	46.1 ± 8.5	50.4 ± 13.6
9	18	75	24	27.9 ± 2.1	30.8 ± 3.3	44.9 ± 6.6	40.7 ± 7.0

cv., cultivar.

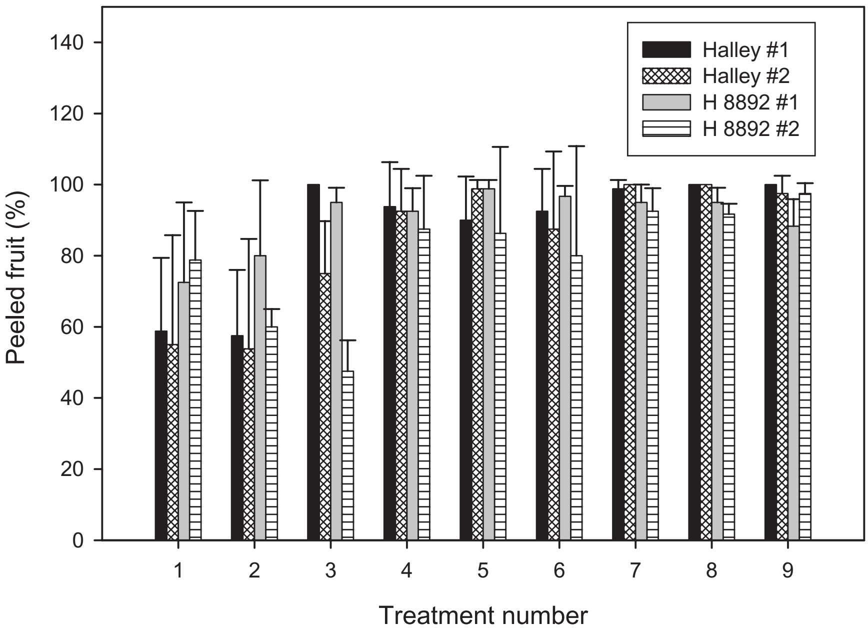

FIG. 1. STEAM AND VACUUM PEELING OF TOMATO cv. HALLEY 3155 AND H 8892

1969) concluded that the use of 18% lye at close to 95C for 20–25 s followed by hand peeling under a water stream led to satisfactory peel removal for VF145-21–4 cv. tomatoes. In our study, costly and labor-intensive hand peeling was replaced by the passage of steam or lye treated tomatoes across mechanical peel eliminators. The efficiency of lye peeling was observed even at the mildest treatment, which resulted in about 80% of the tomatoes being peeled (Fig. 2). Moreover, a smaller degree of variability in the peelability in comparison to steam peeling was also recorded. Some processors select lye peeling in the preparation of premium tomato products, such as whole peeled tomatoes, because when appropriate peeling conditions are used, tomatoes have a smoother deeper red surface and thus have a better appearance compared to steam- or hot-water-peeled tomatoes.

Peeling Losses, Tomato Firmness and Yield

Although standard deviations for some peeling pressures and times were large, peeling losses tend to decrease with higher steam pressures (Table 1). Peeling losses were generally higher for cv. H 8892 than Halley 3155 tomatoes exhibiting losses close to or less than 30% in treatments 4–9. Barringer *et al.*

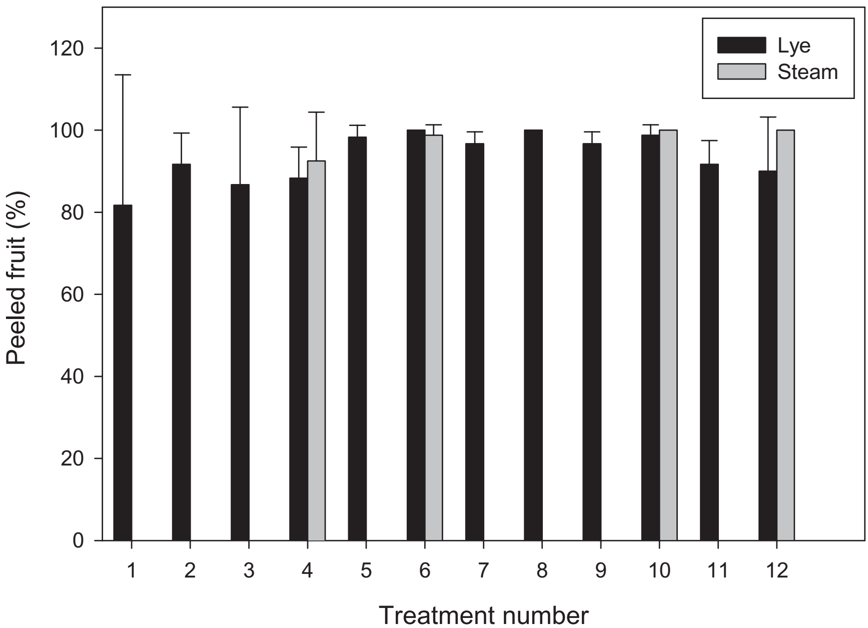

FIG. 2. PEELING OF HALLEY 3155 TOMATOES USING LYE PEELING PLUS VACUUM

(1999) reported that optimum conditions peeling result in losses of 7–10%, while commercial peeling may lead to losses of 25–28%. Losses are relatively higher for tomatoes of small size, probably because of the larger proportion of the tomato surface area to its weight (Juven *et al.* 1969), and possibly because of loss of small tomatoes through mechanical peel eliminator rollers. The desirable range of 7–10% for peeling losses was obtained only in the hand peeled control tomatoes.

As for the lye peeled tomatoes, losses ranged between ~22% for treatments 1–3 and ~40% for treatment 11 (Table 2). Barringer *et al.* (1999) reported about peeling losses varying between 21.8 and 29.5% in tomato cvs. P696, OH8245 and SO12 treated with 18% lye (~82C), no vacuum and followed by rubber disk peel eliminators. However, length of tomato exposure to lye is not presented by Barringer *et al.* (1999), prohibiting comparison with the treatment conditions adopted in our study.

The temperatures selected for steam peeling or lye solutions are directly related to the firmness of peeled tomatoes. Considerable loss in firmness after steam peeling was observed across treatments and cvs. The raw cv. Halley 3155 control grown either at location 1 or 2 and hand peeled (Fig. 3, treatment C) exhibited a slightly firmer texture than the firmness of raw cv. H 8892

TABLE 2.
YIELD AND PEELING LOSSES OF LYE PEELED TOMATOES

Peeling treatment number	Peeling conditions		Yield (%)		Peeling losses (%)
	Exposure time (s)	Vacuum (in.)	Whole peeled	Diced	
1	30	20	64.0 ± 24.8	45.1 ± 17.7	36.0 ± 24.8
2	30	22	76.8 ± 5.9	53.9 ± 8.7	23.2 ± 5.9
3	30	24	70.1 ± 14.2	49.1 ± 7.5	29.9 ± 14.2
4	45	20	67.4 ± 5.7	48.9 ± 5.5	32.6 ± 5.7
5	45	22	76.0 ± 2.9	55.1 ± 6.9	24.0 ± 2.9
6	45	24	77.0 ± 1.7	56.8 ± 7.3	23.0 ± 1.7
7	60	20	71.4 ± 2.9	53.5 ± 7.2	28.6 ± 2.9
8	60	22	73.6 ± 3.7	49.1 ± 1.9	26.4 ± 3.7
9	60	24	73.0 ± 2.4	52.7 ± 3.2	27.0 ± 2.4
10	75	20	68.7 ± 3.4	46.8 ± 3.3	31.3 ± 3.4
11	75	22	60.5 ± 3.7	42.2 ± 2.8	39.5 ± 3.7
12	75	24	59.2 ± 13.6	41.6 ± 16.3	40.8 ± 13.6

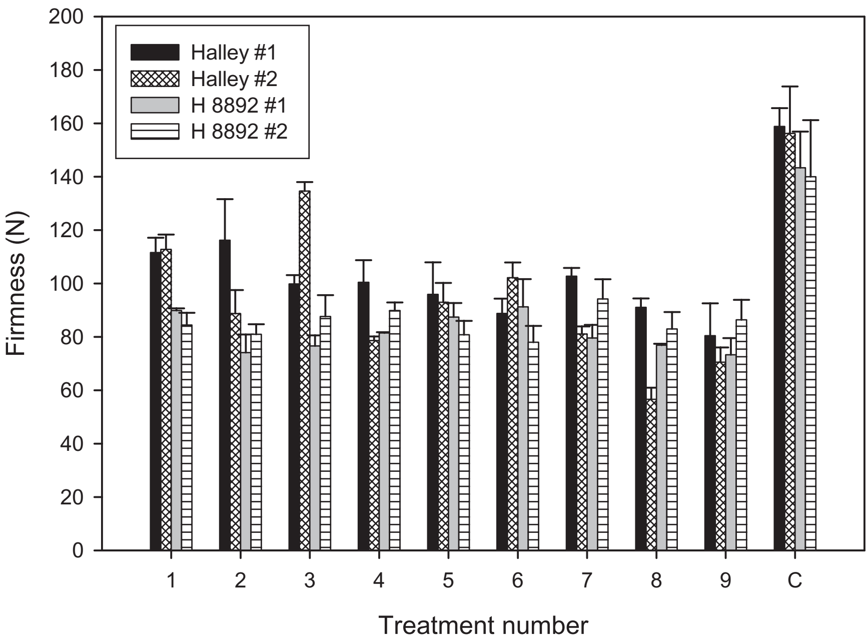

FIG. 3. STEAM PEELING CONDITIONS AND FIRMNESS OF cv. HALLEY 3155 AND H 8892 TOMATOES

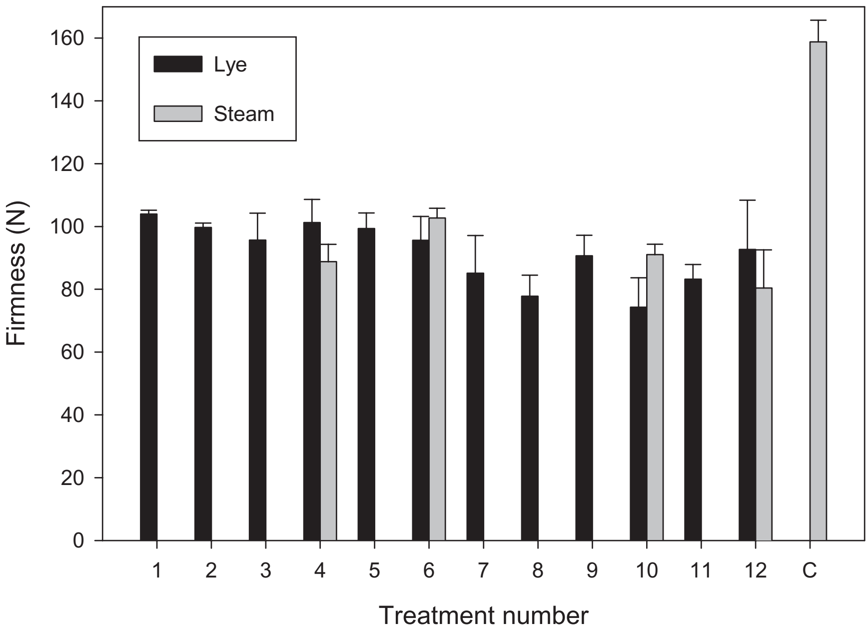

FIG. 4. FIRMNESS OF HALLEY 3155 TOMATOES AFTER LYE PEELING

control tomatoes. Such differences in firmness may be related to the tomato cv. or maturity of the tomatoes at peeling. Nevertheless, differences faded upon the use of more severe steam peeling conditions.

In relation to the raw control tomatoes, the decrease in firmness between tomatoes, given treatments 1 and 9, was: 37% to 49% for H 8892 and 30% to 49% for Halley 3155 for tomatoes grown at location 1, and 40% to 38% for H 8892 and 28% to 55% for Halley for tomatoes grown at location 2. The largest texture losses were observed for cv. Halley 3155 grown at location 2 (treatments 8 and 9, Fig. 3), regardless of the greater firmness of these tomatoes cvs. when raw. The slightly more pronounced softening of tomato cv. Halley 3155 may be a cultivar-inherent susceptibility to the higher steam exposure time and/or vacuum during peeling.

As for the lye peeled tomatoes (Fig. 4), the firmness ranged between ~39% (for treatment 1) and ~56% (for treatment 10) relative to the control tomatoes. The best lye peeling treatment was number 6 (45 s lye exposure, followed by vacuum of 24 in.), which resulted in greater yields and the smallest peeling loss. Such a treatment resulted in tomatoes with a mean firmness of 56.3% of the firmness of the hand peeled raw control tomatoes.

TABLE 3.
YIELD OF STEAM PEELED TOMATOES UNDER DIFFERENT CONDITIONS

Peeling treatment number	Yield (%)							
	Whole peeled tomatoes				Diced tomatoes			
	cv. Halley 3155 farm 1	cv. Halley 3155 farm 2	cv. H 8892 farm 1	cv. H 8892 farm 2	cv. Halley 3155 farm 1	cv. Halley 3155 farm 2	cv. H 8892 farm 1	cv. H 8892 farm 2
1	49.8 ± 16.0	41.7 ± 20.3	54.9 ± 16.3	56.8 ± 14.2	49.2 ± 27.4	37.5 ± 17.7	42.6 ± 15.6	40.4 ± 7.9
2	45.1 ± 16.3	39.1 ± 21.0	57.6 ± 13.0	45.4 ± 4.3	29.7 ± 10.6	24.5 ± 3.4	40.4 ± 9.0	33.3 ± 5.0
3	72.1 ± 3.8	57.5 ± 10.8	61.8 ± 2.6	36.6 ± 7.7	55.9 ± 2.5	43.8 ± 6.6	47.3 ± 1.4	29.8 ± 6.6
4	71.0 ± 9.1	69.2 ± 11.7	62.9 ± 9.3	57.4 ± 9.2	53.6 ± 8.7	53.3 ± 9.7	51.4 ± 10.1	44.7 ± 9.7
5	67.1 ± 10.5	74.2 ± 2.9	69.6 ± 1.3	60.9 ± 13.9	49.5 ± 7.8	58.1 ± 6.4	52.3 ± 2.4	41.3 ± 8.5
6	71.6 ± 7.7	67.4 ± 15.7	70.6 ± 2.6	59.4 ± 22.0	55.4 ± 5.1	51.4 ± 14.3	53.9 ± 4.7	40.4 ± 15.2
7	76.2 ± 4.9	76.4 ± 1.9	73.1 ± 1.8	63.0 ± 18.1	51.1 ± 19.8	61.3 ± 2.3	53.5 ± 4.8	44.9 ± 15.5
8	71.5 ± 0.8	72.4 ± 2.5	53.9 ± 8.5	49.6 ± 13.6	54.9 ± 2.4	55.8 ± 5.7	41.5 ± 6.0	37.7 ± 9.0
9	72.1 ± 2.1	69.2 ± 3.3	55.1 ± 6.6	59.3 ± 7.0	50.9 ± 4.8	54.2 ± 4.3	37.7 ± 2.8	40.2 ± 7.8

cv., cultivar.

Tomato yields were larger with shorter steam exposure times, presumably because of limited tomato softening. With the exception of milder steam peeling treatments, cv. Halley 3155 exhibited greater yields of whole peeled and diced tomatoes than cv. H 8892 (Table 3). Overall, yield after lye peeling was less variable (treatments 1–9), but yield decreased with the application of long exposure times and greater vacuum (treatments 10–12).

Better understanding of the raw tomato and peeling factors that govern peel removal from tomatoes may potentially improve existing tomato peeling technologies. Lye peeling was more efficient and resulted in greater peeling and yield than steam peeling tomatoes. If waste lye disposal is a concern, steam peeling tomatoes at higher steam pressures (18 psig) resulted in the largest percent peeling and yields.

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REFERENCES

ANONYMOUS. 1995. *The Almanac of the Canning, Freezing, Preserving Industries*, 78th Ed., Edward E. Judge & Sons, Westminster, MD.

BARRINGER, S.A., BENNETT, M.A. and BASH, W.D. 1999. Effect of fruit maturity and nitrogen fertilizer levels on tomato peeling efficiency. J. Veget. Crop Prod. *5*, 3–11.

COREY, K.A., SCHLIMME, D.V. and FREY, B.C. 1986. Peel removal by high pressure steam from processing tomatoes with yellow shoulder disorder. J. Food Sci. *51*, 388–390, 394.

DAS, D.J. and BARRINGER, S.A. 1997. Factors affecting the peelability of tomatoes. In *Advances in Food Engineering* (G. Narsimhan, M.R. Okos and S. Lombardo, eds.) pp. 35–39, Proceedings of the 4th Conference on Food Engineering (CoFE 1995), West Lafayette, IN.

HARTZ, T.K., MIYAO, G., MULLEN, R.J., CAHN, M.D., VALENCIA, J. and BRITTAN, K.L. 1999. Potassium requirements for maximum yield and fruit quality of processing tomato. J. Am. Soc. Hortic. Sci. *124*, 199–204.

JUVEN, B., SAMISH, Z. and LUDIN, A. 1969. Investigation into peeling of tomatoes for canning. Israel J. Technol. *7*, 247–250.

MA, W.H. and BARRETT, D.M. 2002. Effects of maturity and processing variables on heat penetration times, firmness, and drained weight of diced tomatoes (Halley Bos 3155 cv.). J. Food Process. Pres. *26*, 75–89.

SCHLIMME, D.V., COREY, K.A. and FREY, B.C. 1984. Evaluation of lye and steam peeling using four processing tomato cultivars. J. Food Sci. *49*, 1415–1418.