DEFECTS AND PEELABILITY OF PROCESSING TOMATOES

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ABSTRACT

Peeling is one of the first operations in the manufacture of whole peeled and diced tomatoes, and the peelability of processing tomatoes is significantly affected by the presence of various tomato defects, in particular yellow eye and blossom-end rot. Tomato maturity also impacts both the percentage of peeled fruit and yield. Immature fruits are typically undercolored and small in size. Sunburned regions on the tomato surface are difficult to peel as well. In this study, we determined the impact of 24 selected tomato defects on tomato peelability and yield of whole peeled tomatoes. There are potential advantages to sorting to remove selected tomato defects early in the process.

INTRODUCTION

Ease of peel removal, or peelability, of processing tomatoes is influenced by several factors, with cultivar (cv.) and maturity stage being the most important. Moreover, production-related factors such as major crop cultural management practices, climate and growing location are believed to influence tomato peelability. For about a decade, we have been working on processing tomatoes, with a particular focus on peelability and peeled tomato quality and yield.

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The majority of our research on peeling of processing tomatoes was conducted using tomatoes without any type of defect. Selection of defect-free tomatoes was intentional so that physical characteristics of the cv. might be better evaluated without the overriding influence of defects confusing interpretation of results. However, commercially grown and harvested tomatoes often arrive at the processing plant with a number of defects; many defects may be cosmetic, affecting only tomato appearance, while others may affect quality aspects such as the presence of a heavy load of mold. Defects may result from bacterial disease, attack of insects, mold growth, advanced maturity, inadequate plant nutrition/fertilization or mishandling during harvesting and/or transportation. Examples of defects commonly observed in processing tomatoes are immature or less colored tomatoes, tomatoes with stems still attached, broken tomatoes, skin and flesh cracks, open holes, scars, zippers, soft spots, sunburn, yellow eye, blossom-end rot or stink bug bite. Some of these defects are illustrated in Fig. 1.

In California, processing tomatoes are mechanically harvested and loaded into trucks pulling two gondolas. Each gondola holds up to 25,000 pounds of tomatoes. The Processing Tomato Advisory Board (PTAB) randomly obtains a 50-pound sample from each gondola and determines the percentage of selected defects. The categories of defects included in the grading program and their allowable percentages in the total 50,000-pound load are worm/insect damage ($<2\%$), presence of mold ($<8\%$), green tomatoes ($<4\%$), extraneous material ($<3\%$), tomatoes of limited use (broken with visible locules, or $>50\%$ of the tomato is soft/mushy, or tomatoes has a soft water condition with $>25\%$ of peel is separated from flesh). In addition to the cited defects established primarily for paste tomatoes, the PTAB will conduct additional inspections related to peel grade for processors who agree to pay a fee. The defects included in the peel grade inspection differ by processor and debates remain about which defects are most important to document. Defects currently observed by PTAB include cracks, stems, spots, stink bug bites, blossom-end rot, scars, zippers, size, shape and holes among others. There are many defects, which may be considered cosmetic, that may affect the quality of peeled tomatoes, but are not deleterious when tomatoes are comminuted and made into juice or paste.

Defects such as cracks, blossom-end rot, watery tissue and small immature tomatoes are major abnormalities related to high temperatures occurring during growth of heat sensitive tomato cvs. (Abdul-Baki 1991). The interaction of several factors is related to the presence of blossom-end rot in tomatoes (de Kreij 1996). In fresh market tomatoes, the presence of blossom-end rot, cracks and zippers are associated with soil moisture and cv. (Sperry *et al.* 1996).

In California, stink bugs are a major problem for tomato producers. Several species of stink bug (*Hemiptera: Pentatomidae*) damage tomatoes in

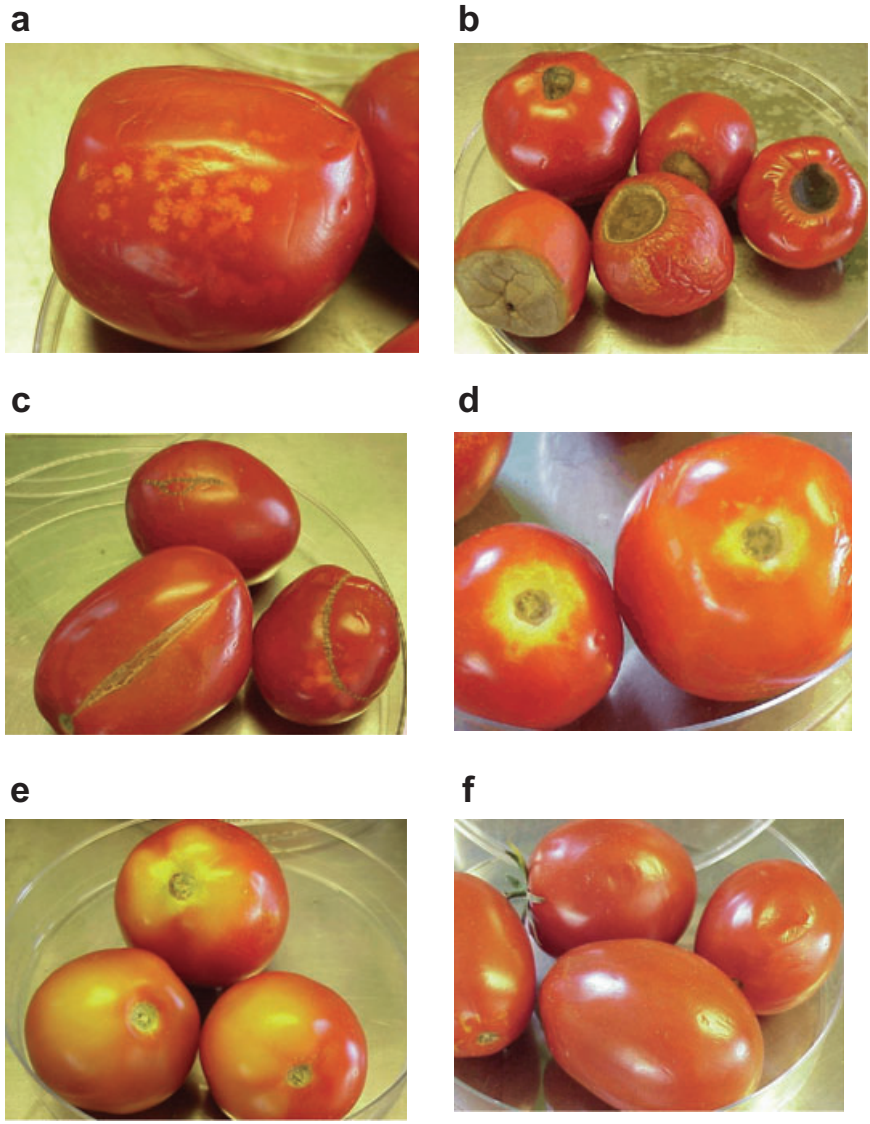

FIG. 1. COMMON PROCESSING TOMATO DEFECTS
(a) Stink bug bites. (b) Blossom-end rot. (c) Zippers. (d) Yellow eye. (e) Sunburn. (f) Soft spots.

California, with the consperse stink bug (*Euschistus conspersus* Uhler) the most common and of particular importance in the Sacramento and northern San Joaquin valleys (Zalom *et al.* 1997; Zalom *et al.* 2003). Stink bug bites on tomatoes produce light-colored blemishes on the skin and white corky areas just below the skin (Hoffmann *et al.* 1987). Although of significance to fresh market tomatoes, such damage is generally not of major concern for processing tomatoes destined for tomato paste production. However, the significance of stink bug bites on peeling performance of tomatoes as well as the significance of other tomato defects on peeling is unclear.

Under ideal conditions, for example, if only tomatoes devoid of defects are peeled, the ease of peeling depends mainly on cv. and maturity, and the yield of premium products such as whole peeled and diced tomatoes can be large (Garcia and Barrett 2006). California processing tomato industry is responsible for approximately 94% of the processing tomatoes grown in the U.S.A. Considering the large tonnage, more than 10.5 million tons in 2003 (ERS/USDA 2003), of tomatoes processed yearly, the negative impact of the presence of defects on acceptable peeling of processing tomatoes may be commercially significant. The California state standards grading program, operated by the PTAB, offers inspection of tomatoes prior to processing and suggests optional percentages of maximum tolerance for defects on processing tomatoes (PTAB 1997).

In this study, we monitored the occurrence of tomato defects in the highest volume cv. of processing tomatoes grown, identified a large number of defects present and determined the effect of defect type on peelability and tomato yield.

MATERIALS AND METHODS

Processing tomato cv. Halley 3155 (also known as BOS 3155) (Orsetti Seed Co., Hollister, CA) was obtained from commercial fields in the 2002 season. Tomatoes were hand harvested, washed and sorted in 24 categories including perfect, undersized, undercolor, sunburn, small (<1/4 in.) blossom-end rot, large (>1/4 in.) blossom-end rot, open holes, small (<1/2 in.) soft spots, large (>1/2 in.) soft spots, yellow eye, spots, wrinkles, stink bug bite, nipples, inverted nipples, small (<1/2 in.) scars, large (>1/2 in.) scars, shallow flesh cracks (affecting only pericarp), deep flesh cracks (into the locule), stems, skin cracks, halo, gold flecks and zippers. Only tomatoes with one predominant defect were utilized in this study; tomatoes with more than one defect were not used because of potential confounding effects of various defects. Tomatoes with similar defect types were grouped into batches of 10, weighed and peeled as a batch.

Tomatoes were peeled using an Odenberg (West Sacramento, CA) steam peeler and mechanical peel eliminators (Imdec, Woodland, CA) that simulated commercial peeling conditions. Tomatoes were exposed to steam at 30 psig for 74 s while tumbled in a steam-jacketed vessel. At the end of the cycle, steam was exhausted from the vessel and the tomatoes were released to atmospheric pressure (0 psig). Following the steam exposure, tomatoes were placed on two types of mechanical peel eliminators placed in sequence. The first was a disc roller bed, which loosened the peel, and the second was a pinch roller bed, which pinched or pulled peel away from the tomatoes. Peel tags commonly adhere to the stem scar, and commercial processors allow a certain percentage of tomatoes, depending on the individual processor, to continue on into the finished product. In this study, tomatoes were considered peeled when peel was completely removed or there was a small amount (<1 cm^3) of peel tag attached.

Peelability was calculated from the percentage of peeled tomatoes, and whole peeled yield was estimated from the weight difference between unpeeled and peeled tomatoes. Statistical analysis of the results was carried out using the SAS system (SAS 2000). Significance was predetermined as $P \leq 0.05$.

RESULTS AND DISCUSSION

From 1987 to 1997, the percentage of processing tomatoes rejected by the California State grading program (PTAB 1997) was between 0.1 and 0.7%, based on tonnage. Because the California state grading program establishes optional degrees of tolerance, the processor may accept the recommendations of the inspection program, accept higher percentages of defects or impose lower percentages of defects.

Data collected in our laboratory in previous years demonstrate that the percentage of defects present in processing tomatoes is quite variable and may be related to growing region, insect and disease pressure, season or other factors. In the 1999 season, approximately 44.5% of about 6500 tomatoes exhibited some type of defect. In 2001, 82.4% of 10,020 tomatoes contained observed defects, with the following defects being the most predominant: stink bug bite (20%), yellow eye (8.7%), spots (8.2%), scars (7.5%), blossom-end rot (6.7%), sunburn (4,7%), pin holes (4.1%) and other defects that occurred at levels less than 4%.

In the 2002 season, only 4% of the observed tomato harvest (390 out of a total of 9741 tomatoes studied) were considered defect-free tomatoes (Table 1). The percentage of defects present most often included large soft spots (7.5%), gold flecks (6.7%), small scars (6.3%), spots (6.1%) and small

TABLE 1.
DEFECTS OBSERVED IN COMMERCIALLY GROWN PROCESSING TOMATO cv. HALLEY 3155†

Tomato defect	Number of tomatoes analyzed	Defect frequency (%)	Peeled tomatoes (%)	Yield (%)
Undercolor	400	4.1	21.2 ± 17.2	17.3 ± 14.4
Yellow eye	468	4.8	35.7 ± 22.6	28.5 ± 17.6
Sunburn	246	2.5	37.6 ± 19.0	29.5 ± 14.4
Size	480	4.9	43.5 ± 18.3	29.2 ± 11.7
Large blossom-end rot	173	1.8	48.3 ± 22.6	34.4 ± 16.1
Stink bug bite	413	4.2	58.6 ± 20.8	44.2 ± 15.1
Wrinkles	401	4.1	60.3 ± 19.5	44.5 ± 14.2
Large scars	428	4.4	61.4 ± 16.8	45.6 ± 13.1
Open holes	411	4.2	63.1 ± 19.3	48.3 ± 15.0
Large soft spots	734	7.5	65.9 ± 15.4	44.4 ± 11.0
Nipples	513	5.3	66.3 ± 16.6	48.9 ± 12.4
Small blossom-end rot	326	3.3	66.6 ± 16.9	49.4 ± 13.2
Small soft spots	556	5.7	67.6 ± 20.4	50.0 ± 15.1
Spots	596	6.1	71.0 ± 14.5	52.8 ± 11.2
Small scars	618	6.3	71.2 ± 18.2	54.1 ± 15.1
Halo	323	3.3	71.6 ± 17.4	53.3 ± 13.7
Inverted nipples	363	3.7	73.8 ± 14.8	55.6 ± 11.3
Deep flesh cracks	93	1.0	76.3 ± 18.6	48.4 ± 12.7
Zippers	241	2.5	77.0 ± 17.8	56.2 ± 13.0
Gold flecks	651	6.7	77.5 ± 15.6	62.2 ± 24.0
Stems	145	1.5	79.7 ± 13.2	58.8 ± 10.8
Shallow flesh cracks	436	4.6	82.4 ± 13.4	57.2 ± 12.1
Skin cracks	336	3.4	83.7 ± 13.3	61.0 ± 10.9
Perfect fruit	390	4.0	79.7 ± 15.0	60.9 ± 10.3

† Statistical significance of the difference between the median of percentage peeled tomatoes and percentage yield for each type of defect and that for perfect tomatoes: $***P < 0.001$; $*P < 0.05$.
ns, not significant.

soft spots (5.7%). The frequency of various defects observed in the 2002 trial is plotted, showing smallest to largest percent peeled from left to right in Fig. 2. Viewed in Fig. 2, gold flecks, for example, occurred on 6.7% of the tomatoes and the presence of this defect corresponded with 77.5% of the tomatoes being acceptably peeled. On the other hand, while only 1.8% of the harvested tomatoes exhibited large blossom-end rot defects, this defect resulted in less than half (48.3%) of the tomatoes being acceptably peeled.

The effect of each specific defect on percentage of peeled tomatoes and yield varied widely (Table 1). Steam peeling batches of processing tomatoes with equivalent types of defects resulted in mean percentages of peeled tomatoes ranging from 21.2 to 83.7%. The defects that resulted in the most negative impact on percentage peeled and subsequent tomato yield were undercolor (21.2% peeled), yellow eye (35.7%) and sunburn (37.6%).

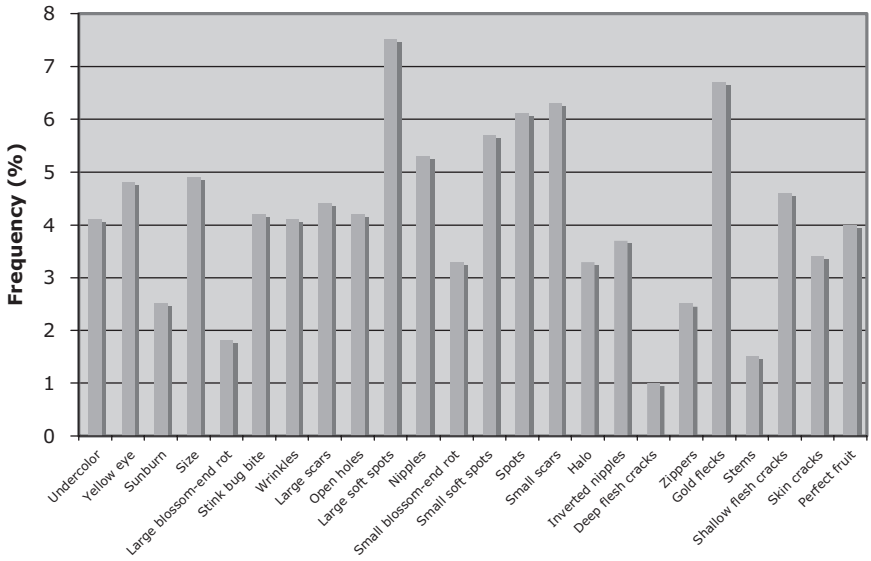

FIG. 2. FREQUENCY OF TOMATO DEFECTS OBSERVED IN 2002

The mean peelability obtained with perfect tomatoes was 79.7%, resulting in a 60.9% yield of whole peeled tomatoes. Although most defects adversely affected peeling, some defects did not impair tomato peelability. The presence of zippers, gold flecks, stems attached to tomatoes or shallow flesh cracks and skin cracks led to comparable peelability and whole peeled tomato yields equivalent to those for perfect tomatoes (Table 1). Other defects resulted in less peelability than perfect tomatoes, but the most detrimental effect on peelability was observed with undercolored tomatoes. In fact, the California State grading program (PTAB 1997) establishes a minimum standard for red color because of the importance of appearance to the final quality of tomato products.

Statistical analysis of results relating defects to peelability and yield suggested that the undercolor defect exhibited a highly significant effect ($P < 0.001$) on peelability and yield. Statistically less significant effects ($P < 0.05$) were observed for yellow eye, sunburn, small size and large blossom-end rot. The significant losses in percentage of peeled tomatoes and yield resulting from the presence of these five defects are illustrated in Fig. 3.

From previous research conducted in our laboratory prior to 2002, the medians of peelability and yield for batches of perfect tomatoes were 80% and 57%, respectively. These peelability and yield values are similar to those obtained in 2002 for perfect tomatoes, that is 79.7% and 60.9%. In contrast, in

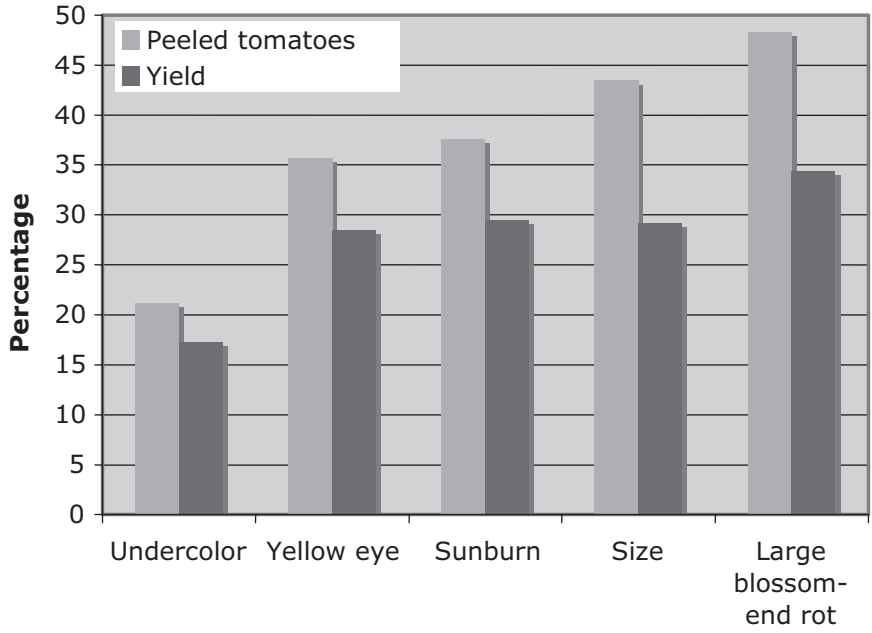

FIG. 3. TOMATO DEFECTS SIGNIFICANTLY AFFECTING PEELABILITY AND YIELD

previous years when normal batches including various defects on tomatoes were peeled, the medians for peelability and yield were 55% and 36%, respectively. The data set used in this study produced medians of 70% for peelability and 49% for yield. Sorting machines currently available detect several types of defects including undercolor, size, and sunburn. Companies involved in this technology should improve their ability to sort out blossom-end rot, stink bug bites and other defects. Although this study did not touch on the cost of implementation of tomato defect sorters, based on the peelability outcome the potential advantages of sorting tomatoes for the most detrimental defects prior to peeling are significant.

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