Future Innovations in Tomato Processing

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Abstract

While tremendous improvements in efficiency and cost of production have been made in the processing tomato industry world-wide over the past 100 years, there is still opportunity for innovation. For decades, processing tomatoes have been direct seeded in many parts of the world, however, over the past ten years the use of transplants has increased the success rate and yield of the crop. Likewise, the use drip rather than furrow irrigation has improved the grower's control over production. Breeding of multi-use and extended field storage (EFS) cultivars has dominated in California and other locations.

On the processing side, higher value whole peel and diced tomato products have benefited from innovations in the peeling process. Advanced technologies which utilize less energy, and result in a higher quality product, are being studied and to some extent commercialized. These include electric field process such as ohmic, pulsed electric fields, microwave and radiofrequency as well as high pressure processing. Both production and processing of tomatoes is currently being carried out under more sustainable practices, and this will continue to be a goal for the future. This paper offers a birds-eye view of potential future advances, with a quick look at production improvements, and a more focused insight into potential process innovations.

INTRODUCTION

Over the past 20 years, breeding multi-use and extended field storage (EFS) cultivars has dominated in California, while the use of transplants rather than direct seed, and drip rather than furrow irrigation have improved the grower's control over production. Precision agriculture and satellite imaging may allow the grower to identify disease incidence during production and to determine fruit soluble solids content and therefore harvest maturity. Recent surveys of mold species in California tomato fields have determined that *Alternaria*, *Geotrichum* and *Fusarium* molds are common in both symptomatic and randomly sampled fruit. New methods of DNA profiling allow for identification of bacterial and fungal communities present on incoming fruit, as well as on processing equipment and building surfaces. Antibody test strips offer a fast, easy means of mold determination on both raw fruit and finished products. Recent advances have been made at the inspection station in automated sampling of pH, °Brix and color. All of these technological innovations should result in optimization of harvest timing, and production of more sanitary raw materials and final products.

In the process itself, increased sustainability and efficiency must result from water reduction as well as water recycling and improvements in energy efficiency. California may grow fewer acres of processing tomatoes in the future, and there is potential for restricted use of wells, which would result in higher price/ton processing tomatoes.

New technologies such as ohmic processing may conceivably generate final products with better color, flavor, nutrient content and piece integrity. Ohmic and other electric field processes such as microwave and pulsed electric fields utilize electric current, and the natural conductivity in high solids materials such as tomato juice and diced tomatoes, to achieve pasteurization. Come-up time is much faster in such systems, and temperature of the process is lower. High pressure processing also has the potential for rapid inactivation of polygalacturonase and simultaneous activation of pectin

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methylesterase, which would result in superior viscosity in tomato juice, sauce and paste.

Novel equipment for tomato juice evaporation include alternatives to mechanical vapor recompression, such as 'thermally accelerated short time evaporation' or TASTE, which has been used for years in the citrus industry. These single-pass systems may operate as pre-evaporators, with reduced electrical demand and excellent steam efficiency. Another alternative means of concentration is to centrifugally separate tomato liquid and solids, sterilize each separately, and recombine them in a concentrated product with improved retention of lycopene and color, texture, flavor and nutrient content.

Bulk tomato paste undergoes dramatic changes in viscosity early in storage, and determination of these changes, and how viscosity can be recovered following storage, is vital. Research has shown that high-temperature heat treatments of diluted paste can result in recovery of initial Bostwick and serum viscosity on the day of pack. Implementation of these practices during reformulation with ingredients has the potential to greatly improve viscosity.

Innovations are also in the future for the high value whole peeled and dice tomato markets. The selectivity of foreign material and dice sorters will continue to improve to the point where only red ripe, optimally mature tomatoes are peeled for high value diced and whole peel products. It should be possible to separate an incoming load of tomatoes more effectively into peelable red fruit and non-peelable light red, orange or green fruit, such that the peel operation is only applied to a small percentage of the load and therefore is more efficient and less costly. Innovations are also taking place in peelers, with new mechanical designs in steam peelers achieving yields similar to lye peelers. In Europe, where lye is not desirable, these modifications in the capabilities of water and steam peelers will continue.

Finally, evaluation of cultivars in collaboration with both chefs and formulated product manufacturers will allow for improvements in 'breeding for purpose'. Sensory trials that involve chefs cooking and tasting various dishes, and correlation of sensory data with instrumental compositional data will offer a new avenue for the tomato seed industry. Likewise, screening of the same raw material for use in canned, frozen, dried and other end products for retail and foodservice customers will open up markets for specific cultivars that may be low-yielding, but uniquely flavored.

RESULTS AND DISCUSSION

Processing Tomato Production

Life cycle analysis (LCA) has been utilized recently to quantify the energy use, gas house emissions (GHG) and water use in two organic and conventionally grown processing tomato products, e.g., canned paste and canned diced tomatoes (Brodt et al., 2013). Tomatoes grown and processed in California then shipped by rail to Michigan were compared to those grown and processed in Michigan. Surprisingly, the energy use and GHG were almost equivalent in California grown conventional and organic tomato paste and diced tomatoes (Figs. 1A and B), but water use was six times higher in California-grown products (Fig. 1C). California tomato yields were higher and soil amendments had lower GHG emissions, which offset added transportation energy (if using rail) and GHG costs.

Although production of tomatoes in California requires a significant amount of water, Hanson and May (2006) found that the actual consumption remained the same over a 35 year period from 1970-2005. In addition, these authors found that the requirements for furrow vs. drip were the same during this period. During the same 35 year period, yields increased 90% from 24 to 47 t/acre. This resulted from both improvements in cultivars and better water control with drip and elimination of stress, therefore the overall water use efficiency increased. California and other parts of the world continue to fine-tune their production systems, and in the future, use of crop monitoring systems has the potential to save money and allow conformance with regulations. Field images may be captured using small drones or GPS and used for applications such as optimizing site locations, bed shaping, visualizing drainage, identifying vegetation density, modeling weather impact in real time, and identifying drivers of variability.

As stated earlier, the use of transplants rather than direct seed and drip rather than furrow irrigation is increasing world-wide. To envision the extent to which these two innovations exist at the present time, Figure 2 was created. While many countries already use close to 100% transplants, others such as Hungary and China have opportunities to increase. Drip irrigation is not required in many locations were rainfall provides adequate moisture, however in other countries where water is lacking installation of drip may increase yields and profits.

Processing Innovations

The California Tomato Inspection Program (California Dept. of Food and Agriculture, 2014) establishes quality standards for processing tomatoes and carries out a grading program during the season. Currently samples are hand-sorted and graded for worm/insect, mold, green, limited use and material other than tomato. In addition, samples are vacuum blended to test for color, soluble solids and pH. Research being conducted at the University of California, Davis (Slaughter et al., 2013) is exploring the use of an automated inspection system that would vacuum blend the sample and automatically present the juice to three inline sensors for pH, Brix and color. Results would be transmitted electronically and grower prices per load could be determined real-time.

One of the first steps in the whole peel and diced process is sorting, and recent developments in sorters utilize the latest technology with light emitting devices, CCD cameras and near-infrared spectroscopy. One company named Torma (http://tomra.com/en/solutions-and-products/sorting-solutions/food) for example, implements a top-mounted pre-grade sorter for whole and partial fruit which can differentiate size, shape and color, while their advanced sorters have both top and bottom sensors and are able to distinguish foreign material in addition. Currently the average yield of peeled tomatoes is only about 30%, but with more sensitive technologies in the future, it may be possible to increase this to 50-75%. Previous work in our lab (Barrett et al., 2006) evaluated the effects of specific defects on percentage peelability. It was found that under-color fruit or those with yellow eye, sunburn, small size or blossom end rot were the most difficult to peel peelability and some defects such as skin cracks or stems may actually assist peeling (Fig. 3). Future advances in the optical and sorting arena will provide additional opportunities.

Processing equipment manufacturers are also developing new equipment that utilize advanced electric field technologies such as radiofrequency and ohmic heating, with the advantage of reduced heat and therefore improved color, flavor and nutrient content. JBT Food Tech (http://www.jbtfoodtech.com/en) has developed a radiofrequency heating system for viscous products with dice, which uniformly heats with no product burn-on. CFT Rossi Catelli (http://www.cft-group.com/group/history/default.aspx) produces an ohmic heater that capitalizes on the natural conductivity in high solids materials such as tomato juice and diced tomatoes to achieve pasteurization. JBT Food Tech is also installing “Thermally Accelerated Short Time Evaporation” or TASTE in tomato processing facilities. These evaporators, traditionally used for orange juice, allow a single pass with 5-6 effects which has tremendous potential for producing superior quality hot and cold break tomato juice.

ANALYTICS

Rapid methods for the determination of the safety and quality of tomato products have made advances in the last 10-15 years and will continue to do so in the future. Surveys of the various mold species present in California tomato fields have determined that *Alternaria*, *Geotrichum* and *Fusarium* molds are common (Fig. 4) in both symptomatic and randomly sampled fruit (Davis, 2012). Antibody strips have been developed to the predominant species and could, in the future, be used prior to harvest to dictate spray regimes or on stored tomato products to determine end of shelf life. New methods of DNA profiling allow for identification of bacterial and fungal communities present on incoming fruit, as well as on processing equipment and building surfaces (Bokulich et al., 2013). In the future, this technology allow for mapping of microflora prior to, during and after the harvest season, to improve sanitation programs.

On the quality side, the use of field portable infrared (FTIR) sensors in conjunction with soft independent modeling of class analogy (SIMCA) statistical programs allows for differentiation of fresh, hot break, canned and stored canned tomato products (Fig. 5). Characterization of the red layer and pericarp of processing tomatoes using magnetic resonance imaging (Zhang et al., 2013) is also possible. In the future, MRI, FTIR and other sensor technologies may become routine tools in the tomato industry and ensure the highest quality raw materials and finished products.

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Figures

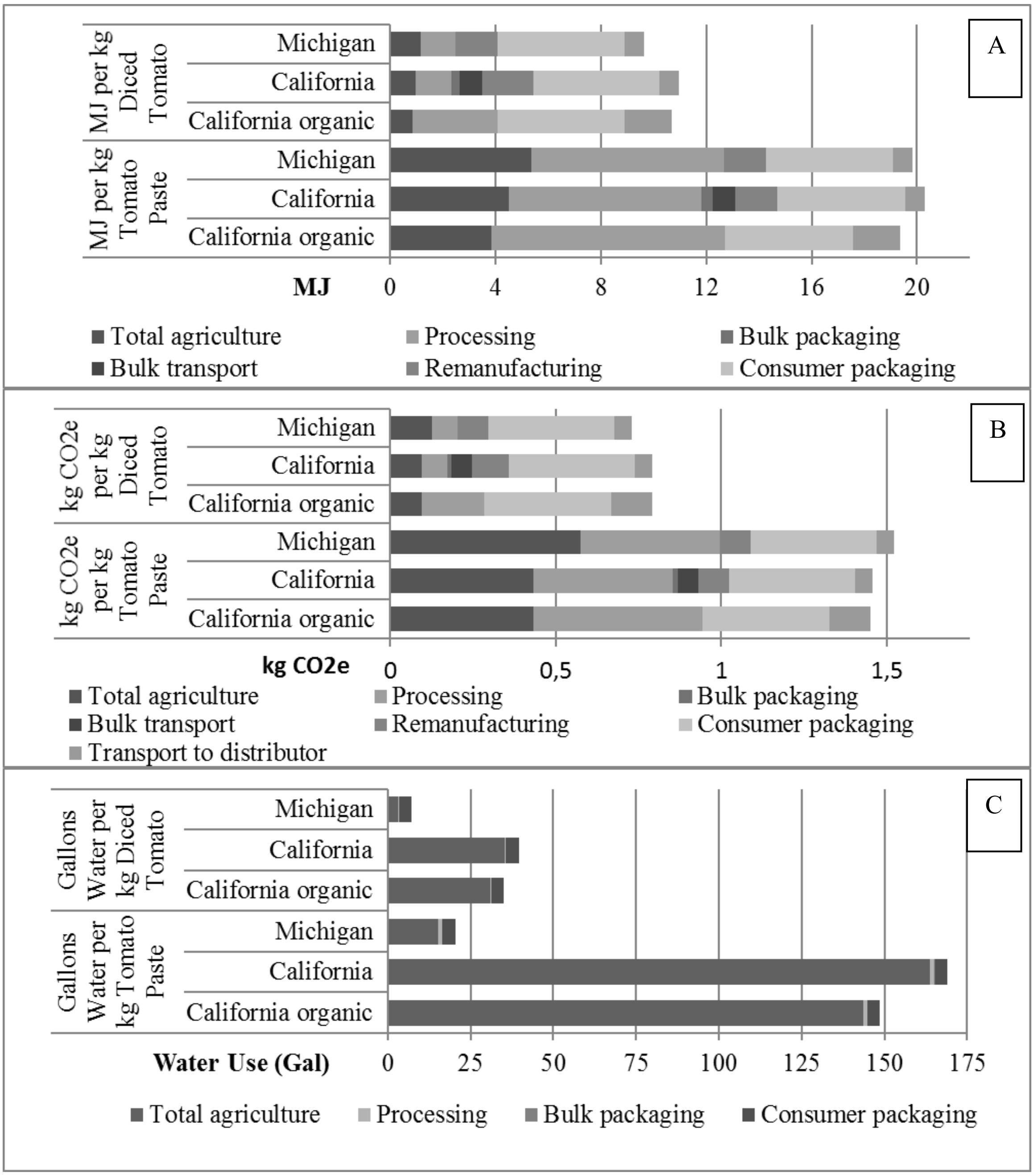

Fig. 1. Life cycle analysis of energy use (A), gas house emissions (B) and water use (C) in two organic and conventionally grown processing tomato products, e.g., canned paste and canned diced tomatoes. Source: Brodt et al. (2013).

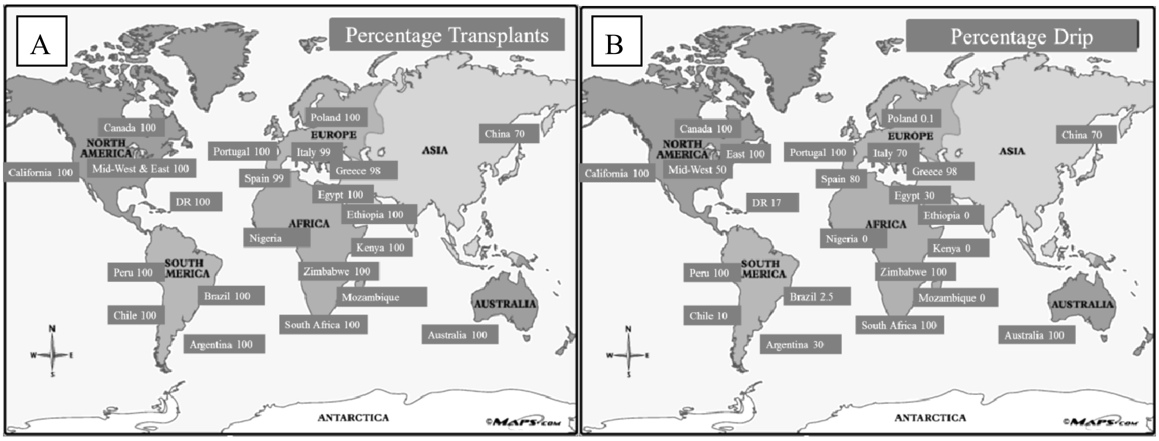

Fig. 2. Estimated percentage use of transplants (A) and drip irrigation (B) by processing tomato-growing countries.

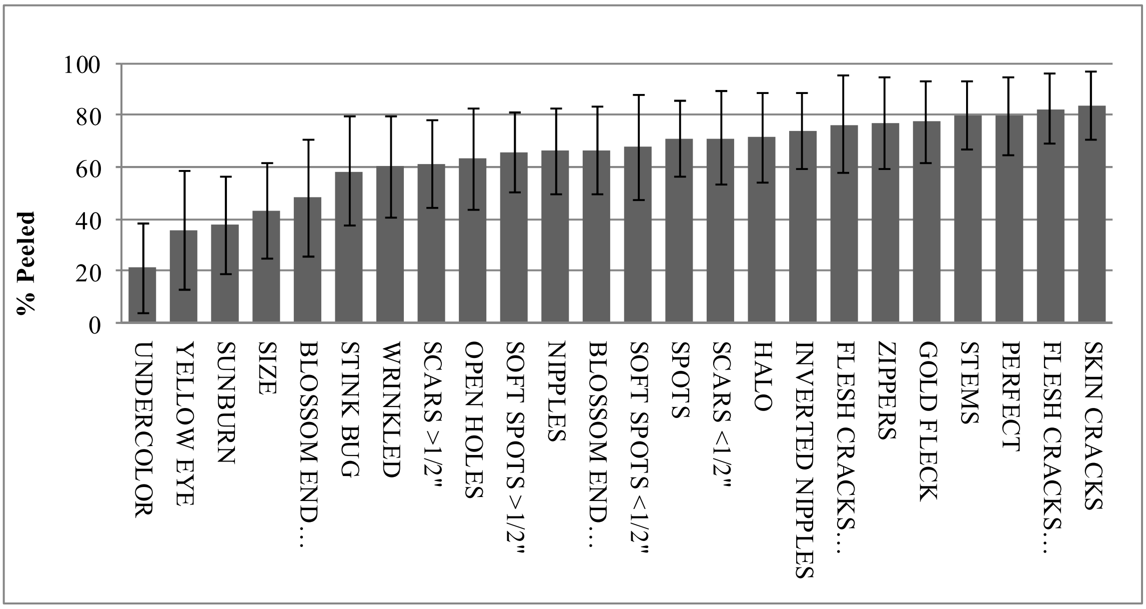

Fig. 3. Percentage of tomatoes with given defects that peeled following standard steam peeling process. Source: Barrett et al. (2005).

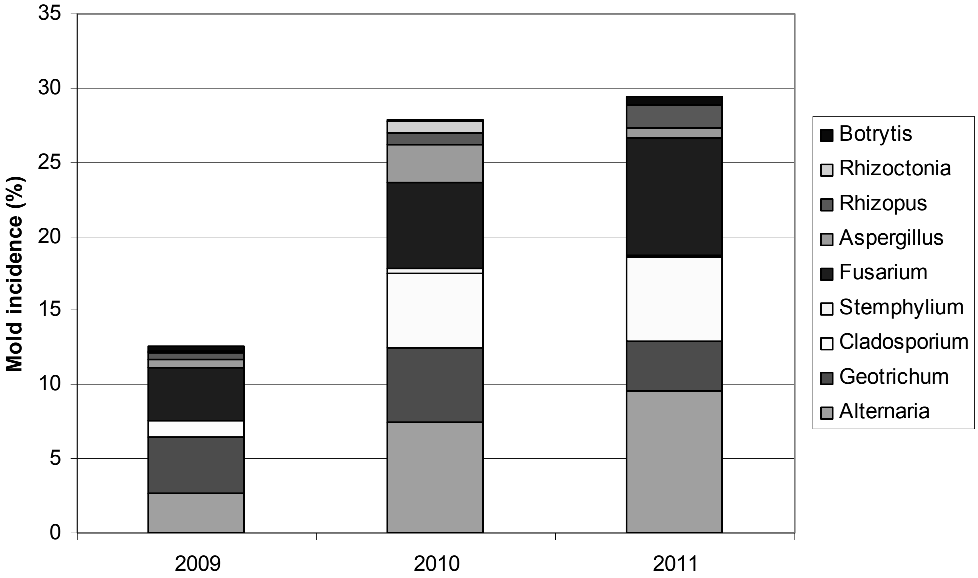

Fig. 4. Incidence of mold in randomly sampled California tomato fields. Source: Davis (2012).

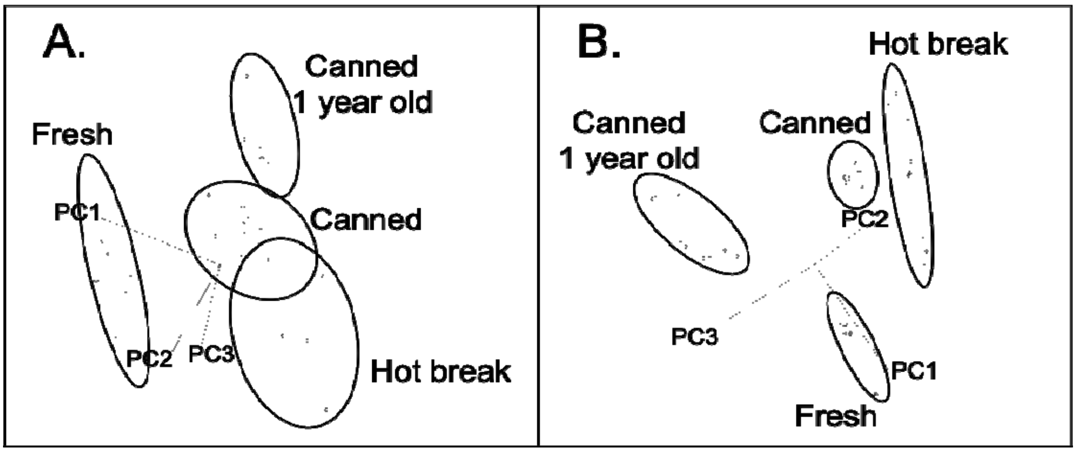

Fig. 5. Class projections of (A) paste and (B) lipid fraction spectra from Tangerine tomato samples. Source: Rubio (2010).