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PROCESSING FRESH CITRUS JUICE

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Abstract. **Fresh citrus juice is an important component to the offering of roadside fruit retailers and is a significant part of fresh fruit juice retail sales. Fresh juice has been subjected to a relatively large amount of regulatory activity since 1995, when a salmonellosis outbreak associated with fresh orange juice was reported. In response to this outbreak, and another in 1996 associated with fresh apple juice, the U. S. Food and Drug Administration (FDA) has issued rules and proposals pertaining to fresh juice safety and quality. Researchers are working concurrently to better understand fresh juice technology, including washing, grading and sanitizing techniques, and develop alternative processes that would produce high-quality, citrus juice products with the characteristics of freshly-squeezed juice.**

Introduction

Orange juice is the most popular fruit juice in the United States and accounts for about 60% of total US fruit juice sales. Consumers like orange juice because of its nutrient density (healthfulness) and a unique and universally desirable flavor. For many consumers, marketers, and processors of citrus juices, the flavor benchmark for processed citrus juices continues to be freshly-squeezed juice. However, fresh juice has only been available seasonally and locally, at roadside stands and in retail outlets that squeeze juice. This is due to the very limited shelf life of fresh juice (approximately two weeks at 4°C), and the financial implications of limited distribution, cost of handling and high product loss. In the past several years, larger, regional fresh juice producers have developed wider distribution systems for fresh juice products and have driven consumer awareness and demand. Nonetheless, fresh citrus juice maintains only about 1-2% of the total volume share of citrus juice sales in the US (NFPA, 1998).

Despite the small size of the fresh citrus juice industry in Florida, state and federal regulators, scientists, trade organizations and the citrus industry have all increased their focus on fresh citrus juice in the past few years. There are a variety of reasons for this: an outbreak of salmonellosis associated with fresh orange juice in 1995; a serious outbreak of illness due to the pathogenic organism *E. coli* O157:H7 that was traced to fresh juice (apple) in 1996; a federal administration that is making food safety, especially that of produce and minimally-processed fruit and vegetable products, a priority; and acknowledgment by the processed segment of the citrus industry that understanding the chemical, sensory and microbiological aspects of fresh citrus juice is part of their own required body of knowledge. This paper discusses some important aspects of fresh citrus juice processing, some emerging technologies that bridge the gap between fresh and thermally processed citrus juices, and summarizes the current state of regulatory activity surrounding the fresh product.

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Discussion

Processing

While raw material harvesting, handling, grading and cleaning are important steps in the manufacture of any processed food product, performing these steps correctly is absolutely critical to the production of high-quality, fresh citrus juices. Even before the fruit reaches the processing operation, there are practices which may help ensure the safety and quality of the final product. Valuable information relating to pre- and post-harvest handling of fresh agricultural products has been summarized by several trade organizations for their constituents and by the federal government (FDA, 1998). Fresh juice is a minimally-processed product and these guidelines for the production of safe fresh and fresh-cut food products should be adopted. While specific practices might differ depending on commodity and geographical area, all handlers of fresh and minimally-processed products must consider the efficacy of their operating procedures in the following areas: pre-harvest practices and harvesting; pre-cooling and temperature control; packing; and shipping and merchandising. Additional considerations include agricultural water quality and handling, and organic production practices.

The unit operations of a typical fresh juice manufacturing scheme include fruit sourcing and harvesting, transportation to the plant, fruit grading and washing, juice extraction, juice chilling, filling, warehousing and distribution. Large citrus juice processing plants share many of the same steps and differ from fresh juice processing plants primarily in the scale of operations, and in the thermal processing and storage of the juice after extraction. Schrader and Kane (1996) have outlined some generally accepted best practices for fresh juice processing at each point in the product flow. Thorough grading and cleaning of the fruit, strict sanitation of equipment, and integrity of the cold chain to the point of consumption are three major control points in processing wholesome, high-quality fresh citrus juice. Schmidt et al. (1997) have provided a discussion of individual unit operations and critical control points for small, fresh-squeezed citrus juice operations as part of their overall presentation of a model HACCP plan for these manufacturers. Traditional orange juice pasteurization processes are designed to inactivate pectinmethylesterase (PME) and destroy spoilage microorganisms to extend shelf-life beyond that of fresh juice. Researchers have identified sensory and chemical differences between fresh and pasteurized citrus juices (Moshonas and Shaw, 1988; Sadler et al., 1992). Some feel that these processes have a detrimental effect on flavor and nutritional aspects of the juice; this is the basis for much of the marketing effort surrounding the sale of fresh citrus juice. The quality differences between fresh and pasteurized citrus juices have provided impetus for the development of alternative processes that yield requisite product safety and stability, yet still maintain the character of

the fresh product. High pressure processing (HPP) has been shown to inactivate the PME while preserving the fresh taste and appearance of orange and grapefruit juice (Goodner et al., 1998).

Future advances in the area of minimal processing may lead to additional steps in the process flow of "fresh" citrus juice. The FDA has been quite clear that juice subjected to any preservation method (except for chilling) will not be allowed to carry the word fresh in the product identification, no matter how fresh-like the product may be (CFR, 1998a). Despite this marketplace impediment, the field of minimal processing of citrus and other juices continues to grow as the fresh-cut segment of the produce industry continues to grow, because consumers are looking for convenient, fresh-tasting products that are safe and high-quality. Relevant research in this field includes the work of Sharma et al. (1998), who have proposed a combination system consisting of mild heating and pulsed-electric-field treatments to preserve the fresh taste, vitamin C content, and product consistency, and extend the shelf life of fresh-like orange juice for up to six weeks.

Microbiology, Shelf-life, and Food Safety

Much of the microbial information surrounding fresh citrus juices has been developed with the objective of extending the rather limited shelf life of these products. Spoilage of citrus juices is due to the presence of microorganisms that can tolerate and grow in the high acid environments. Spoilage organisms include yeasts such as *Saccharomyces cerevisiae* and lactic acid bacteria such as various *Lactobacillus* and *Leuconostoc* species. According to Carter (1989), the factors which are most critical to the microbial stability of unpasteurized citrus juice are pH, chilling, and sanitation.

Late season fruit, with a pH as high as 4.0 to 4.3, is especially susceptible to microbial spoilage. Juice pH cannot be adjusted by the processor, but it can be monitored and controlled by the use of sound, high-quality fruit that is not overly mature, and by careful blending of fruit streams of various acid levels.

Juice temperatures can be controlled by the processor, and it is desirable to chill the freshly extracted juice to -2-0°C as quickly as possible, and to maintain that juice temperature over subsequent steps such as filling and distribution. Larger-scale producers of fresh juices utilize shell-and-tube chillers to rapidly achieve the juice temperatures recommended. This type of chiller is also capable of running juices containing floating pulp (juice sacs), which is desirable to many fresh citrus juice producers.

Winniczuk and Parish (1997) emphasized the importance of cleaning and sanitizing both fruit and equipment to achieve an adequate fresh juice shelf life. They studied various antimicrobial compounds and concluded chlorine dioxide, iodophor and a quaternary ammonium compound provided the best efficacy against common citrus microflora at the lowest usage level.

Orange and other citrus juices have not typically been considered vectors of food-borne illness, primarily due to their inherently high acid, low pH characteristics. However, nonpasteurized orange juice was implicated in a salmonellosis outbreak during the summer of 1995 and was associated with a specific citrus processing facility (Parish, 1998a). The specific source of the pathogens in this outbreak was not determined; apparent inadequate equipment cleaning protocols suggested environmental contamination, combined with inadequate sanitation of processing equipment, led to the production of contaminated product.

Laboratory studies confirmed that salmonellae which might contaminate orange juice could survive sufficient time to cause illness (Parish et al., 1997). Producers of fresh orange juice in Florida were cautioned to take care in utilizing only sound fruit and in maintaining excellent sanitation of the fruit and equipment.

One of the most serious juice-related food-borne illness outbreaks occurred in the fall of 1996 and was associated with unpasteurized apple juice. In this outbreak, *E. coli* O157:H7 caused diarrhea and hemolytic uremic syndrome (HUS) in over 60 individuals and one death was reported. The company implicated in the outbreak was the largest producer of fresh fruit and vegetable juices in the US with modern production facilities and relatively widespread distribution (most of Western US states). In this case, incoming product quality was most likely the root cause of the outbreak, as the incident was associated with primarily one production lot and raw material quality was of minimum company standard (Parish, 1997). Although citrus juices were not implicated, it is necessary to emphasize this incident heightened awareness of the acid tolerance of this particular virulent organism. The severity of this outbreak, along with clear identification of the processing source, was probably a major force for the somewhat disproportionate regulatory activity surrounding fresh juice production.

Finally, it must be noted that additional research in the area of food safety and fresh citrus juice will continue. As scientists learn more about the etiology of pathogenic microorganisms in fresh juice systems, there will be an increase in the amount of scientific information available. This increases the responsibility for producers and marketers of such products to properly evaluate and control the risks inherent to their product and protect the safety of their consumers. For instance, it has recently been reported that *E. coli* O157:H7 is more acid tolerant that previously thought; it is capable of growth, under some conditions, at pH levels that occur occasionally in fresh citrus juice (Brudsinski and Harrison, 1998).

As noted in the previous discussions, alternatives to traditional juice pasteurization, leading to a fresh-like processed product, is an area of further citrus microbiological research. For example, Parish (1998b) has shown that HPP is capable of yielding a high-quality, minimally-processed orange juice in with inactivation of endogenous microflora to a degree comparable to traditional thermal pasteurization. The effect of these processes on microbes of public health significance is being studied by various government agencies and corporate and academic researchers.

Regulatory Activity

Overall, any fresh juice processing operation should follow current good manufacturing practices (cGMPs) as outlined in the Code of Federal Regulations (CFR, 1998b). These cGMPs are general rules under which food for human consumption must be produced: Practices specified include those for personnel, equipment, buildings and facilities, process controls and sanitation. The rules in their entirety comprise the basis for regulation of fresh juice products by the Federal government. Rules and regulations of the Florida Department of Citrus and the Florida Department of Agriculture and Consumer Services apply at small roadside stands and for products that are in intrastate commerce.

Undoubtedly, outbreaks of food-borne disease caused by fresh juices have lead to scrutiny of this market segment by the Federal government. Two days of hearings to understand current science and technology of nonpasteurized juice production were held in December 1996, in response to the outbreaks, discussed above, that were linked with fresh juice. Testimony was received from industry and academic experts, processors and trade organizations and was used by representatives of the FDA and the subcommittee of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF). The major objective of the meeting was to identify policies and procedures that could be adopted to enhance the safety of fresh fruit and vegetable juices (FDA, 1997).

Based on information from the public hearings and recommendations received from NACMCF, the FDA developed a strategy that they felt would address the immediate and long-term goals of ensuring the safety of fruit juice products. In August, 1997, the FDA announced that they would 1) initiate rule-making for the mandatory adoption of HACCP for some or all juice products, and 2) they would propose some type of label warning to inform at-risk consumers of the risks in consuming fresh juice products (62 FR 45593). On April 21, 1998, the FDA proposed two regulations to improve the safety of juice products. The first proposed regulation would require domestic and foreign processors of packaged fruit and vegetable juices to implement hazard control programs at their plants to prevent microbiological, chemical and physical contamination of their products. Part of that proposal set a performance criteria of a 10^5 reduction (5 log reduction) of harmful organisms in finished product as compared to product that had been untreated. The second proposal regulation would require warning labels on all packaged juice products that had not been pasteurized, or otherwise treated to eliminate harmful microbes.

The final rule on labeling was announced on July 8, 1998 (63 FR 37030). This rule required the implementation of warning labels on all fresh juices by the 1998 harvest season, unless a producer could demonstrate a proven 5 log reduction in harmful microorganisms in their process. The final ruling on mandatory HACCP was delayed for additional comment. Some fresh juice processors were able to demonstrate to the FDA the requisite safety data to avoid the warning labels; due to these demonstrations and additional information provided by the citrus industry, the FDA responded in a two-part manner. The first was to sponsor two scientific workshops, held in November, 1998, to discuss and share industry information on achieving the 5 log reduction in microbes that would allow avoidance of the warning label. Secondly, the FDA has extended the deadline for adopting the warning label to fresh citrus juice processors that register with the FDA and commit in writing to develop, adapt and validate a HACCP program that would deliver the requisite performance standard. This deadline extends to July 8, 1999 and at that time, all processors that cannot demonstrate a 5 log microbe reduction process will have to display the warning label.

Because of the relationship between the warning label rule and the HACCP rule, the FDA announced its intention to reopen the comment period on the juice HACCP proposal (63 FR 20450). At this time, most fresh citrus juice producers are working on developing and refining their plant procedures in order to comply with the FDA deadline extension. There will no doubt be an enormous amount of technical and regulatory activity concerning fresh juice technology and safety continuing through 1999 and into the next fruit harvesting season.

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