FACTORS INVOLVED IN DEVELOPING APPLE SLICES

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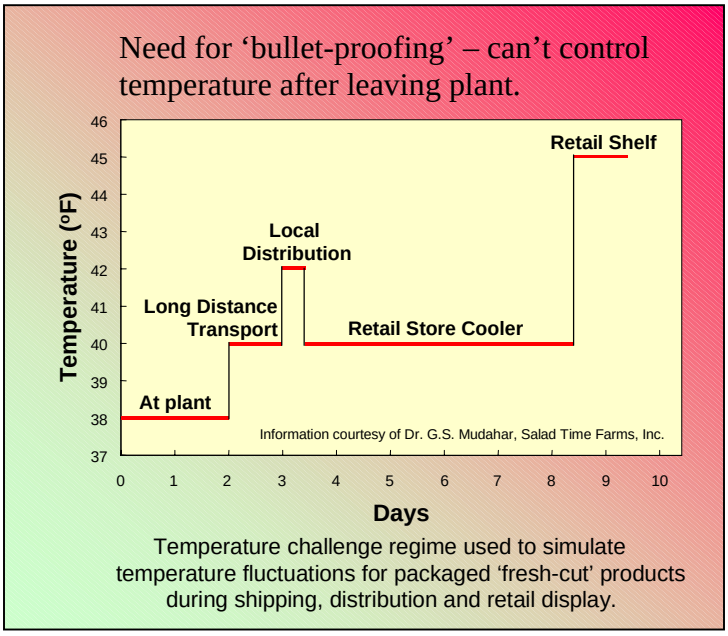
INTRODUCTION

There are several challenges involved with developing a successful fresh-cut apple program. While there has been much work done to develop anti-browning technologies, initial apple quality and microbial quality remain the largest challenges to success. Currently only few cultivars are working well in commercial practice and 'Fuji' and 'Granny Smith' are likely the most prominent of these. 'Red Delicious' is widely grown in Washington State and there is great interest in making this a successful fresh-cut cultivar. However 'Red Delicious' slices have problems in the commercial practice that may hinder its success. This summary will touch on some major points that have been identified during the course of research at the Pacific Agri-Food Research Centre over the past several months.

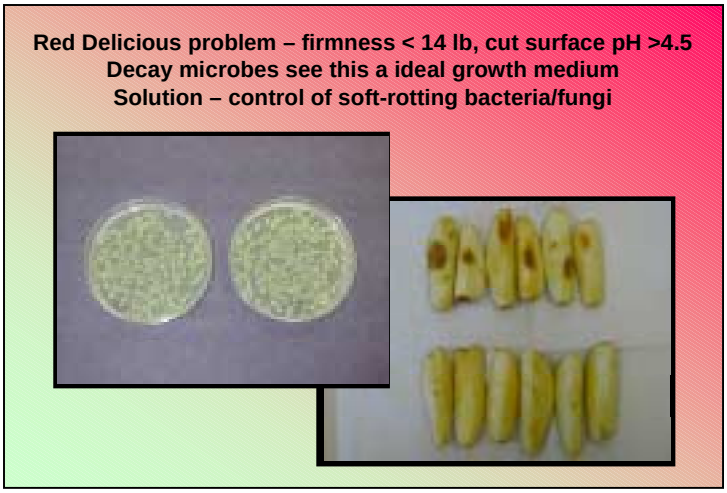
EARLY RESULTS AND DISCUSSION OF IMPORTANT ISSUES

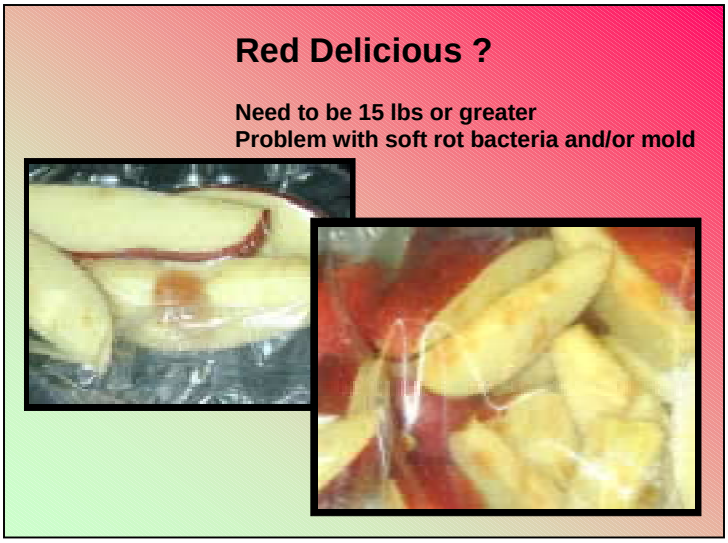
The most important factor in regards to successful modified atmosphere technology involves control of deteriorative processes for the fresh cut product. The use of anti-browning dips such as Nature Seal AS-1 can control the surface browning of apple slices as well as improve the texture to a small degree. However the matching of an appropriate film to bag the slices is important ensure complete control of browning and to control other deteriorative processes. Oxygen levels can get too low in the wrong bag and



Temperature challenge regime used to simulate temperature fluctuations for packaged 'fresh-cut' products during shipping, distribution and retail display.

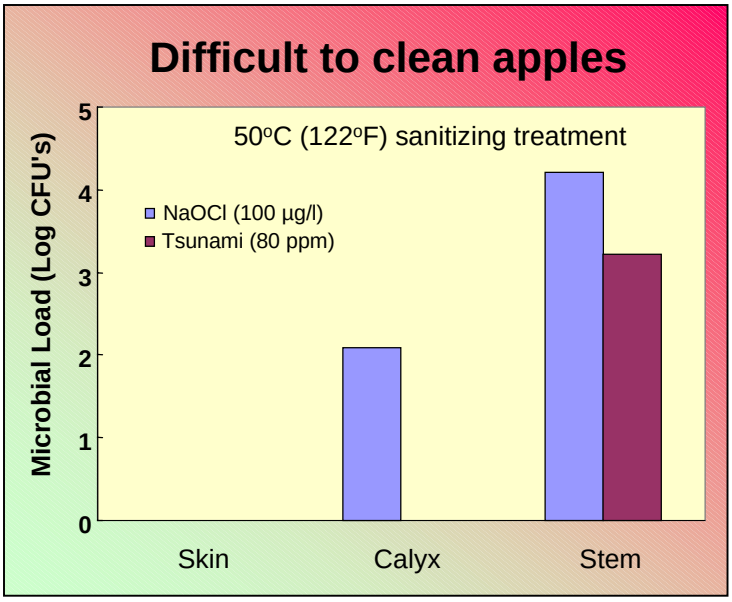
this can lead to off-flavor development as a result of anaerobic respiration. The challenge is to select a package system which will have low enough oxygen to assist in quality retention without leading to off-flavor development. Generally a range of 2 to 5% oxygen is recommended for apples. Another complication is that as much as the fresh-cut company fights to maintain good temperature control (the cool chain), fresh-cut product invariably will be subject to temperature abuse during transportation, distribution and retail. Therefore the package system has to be reasonably robust such that anaerobic atmospheres do not develop when packages are exposed to expected temperature abuse cycles. This approach is called "bullet-proofing". While it is accepted that there will be temperature abuse during distribution, this is not meant to imply that the fresh-cut producer should disregard good temperature management. If the processor temperature abuses the product, it will be less able to withstand subsequent abuse later on in the distribution chain.





The data collection to aid selection of a package for apple slices for systems where good temperature control exists has been completed. However, during the course of conducting the respiration and package selection research at PARC, problems in the apple slices were discovered. 'Red Delicious' apple slices were found to have unusual browning and softening problems. After investigation, it was determined that the problems were not due to deficiencies in the anti-browning dip (Nature Seal AS-1). The problem was that there were pectolytic bacteria and fungi found to be associated with the brown, softened area. The development of this problem increased as the firmness of the 'Red Delicious' apples dropped below 14 lb. This is two pounds firmer than the Washington Fancy Standard. In addition, the surface pH of the cut edges of was found to be 4.5 or higher, which is known encourage growth of many bacteria and fungi. It is likely the combination of weak fruit tissue (i.e., soft flesh) and high pH that encourages the development of these soft-rotting organisms. Since it is difficult to obtain very firm 'Red Delicious' apples over the winter season, it appears that with current technology that it cannot be used as a fresh-cut apple. If the growth of soft rot bacteria and/or fungi can be controlled using other technologies or modifications of handling protocols, it may be possible to overcome this problem. One final point, if soft-rotting microorganisms can

be a problem on older 'Red Delicious' fruit, it may also be a problem with all other cultivars if they are stored beyond a stage where the fruit integrity begins to decline.



The importance of initial apple quality has been outlined in the previous discussion. Another aspect of a fresh-cut apple program is that it poses a technical challenge that no other fresh-cut product currently has. The difficulty with apples arises from the fact that local product is available at fresh quality for only a short period of the year. Therefore this industry must utilize fresh and stored product to supply customers year round. As with any product which is stored, the quality of apples slowly declines over time in storage. CA storage can help to reduce the rate of decline, however it cannot halt the deterioration of the product. Fresh-cut product must be made from fruit of the best available quality – a fresh-cut program is not a way to get rid of cull fruit that have bruises or spots of decay. Such apples will add to the problem of sanitation and safety management. Fresh-cut products are fresh-processed and so contamination from wounded or decayed fruit will allow accumulation of disease and pathogen inoculum in the wash water, the dip tank, on the corer/slicer, and all along the handling and packaging line. We have documented the accumulation of soft rotting microbes in anti-oxidant dip solution, despite the fact that slices had been washed in chlorine before placement in the dip. Therefore it is imperative to emphasize that only top quality product is used to manufacture fresh-cut slices.

Sanitation is a key element for a successful fresh-cut program. The above discussion touched upon the occurrence of soft-rot organisms on slices. There is also risk for contamination with human pathogens such as *E. coli*. Work at PARC has shown that while the skin of the apple can be easily sanitized, it is difficult to remove or kill microorganisms that reside in the stem and calyx cavities of the fruit. It generally recommended that whole apples be washed before they enter the fresh-cut processing plant. This is usually done in an adjacent room and once apples are washed/sanitized and then sent to the processing area that is kept sealed from the receiving area. But if the stem and calyx cavities carry contamination, this isolation from dirty

product at receiving is no protection. Contamination from a calyx or stem cavity which is cut during the coring or slicing process is sure to cross-contaminate slices and the contamination levels will increase in the wash water during the day as more and more apples move through the line. Therefore it is recommended that there be frequent, routine procedures to sanitize the process line during the course of a day to minimize this cross-contamination accumulation. Another point to keep in mind is that most sanitizers used at safe concentration such as chlorine only keep the inoculum levels down in the water. Much higher levels are required to actually decontaminate most fruits and vegetables. However, equipment surfaces can be sanitized routinely and wash water can be changed frequently as well. Most fresh-cut plants change the wash water several times in a production day.

An important part of sanitation is proper plant set up to meet food-processing standards. Raw product moves in one end and processed product leaves at the other end. The equipment and floor and wall surfaces must all be easily cleaned and sanitized. This means that proper food compatible materials are used. Minimization of risks requires (and law may require) the development of a HACCP program to identify risk areas that allows the plant to improve practices to reduce or eliminate risks. In addition, buyers will likely want some assurance or ask to audit your plant. Therefore good manufacturing practice and food regulations must be incorporated into every fresh-cut plant.

Another aspect of quality and safety assurance is to understand the quality and consistency in the packaging materials that are purchased to bag the cut slices. Work a PARC has shown that packaging films could be out as much as 100 to 200% from stated supplier specifications. This is of course an extreme case, a good supplier with normally be within 20 to 30% of stated specifications. Therefore it is buyer beware in regards to where packaging material is sourced. A little homework and package testing can save a lot of headaches and prevent customer complaints.

Leaks around seal when using 'zip-lock' type bags.

Bag Constructon: Leaks if seal is narrow or poorly made

There are also new technologies being developed for use in the fresh-cut industry. At PARC there has been extensive work done on the use of warm water to sanitize fruit and vegetable products. Use of warm water (47 to 50 °C or 115 to 122 °F) with sanitizing agent can actually lead to significant reductions of microbial load on fruits and vegetables. In addition browning can be reduced and firmness can also be enhanced with warm water treatment. It must be kept in

mind that the product must be cooled after such treatment. Another technology that is being explored is the use of pre-slicing treatment of whole apples with high oxygen. The high oxygen treatment leads to better firmness retention, lowered browning and reduction of anaerobic volatile accumulation in slices made from treated apples. These and other up and coming technologies may offer improvements in the future. The challenge at hand is to integrate current technology and research to make the sliced fresh apple a commercial success. Future research developments will lead to improved scope of the fresh-cut program and hopefully reduce processing costs.