To assess the presence and physiological significance of nutrients and other functional components of fresh-cut vegetables and fruits as affected by storage and handling. To develop and evaluate novel approaches for assuring the quality and safety of fresh-cut vegetables and fruits. To develop a better understanding of the physiology of fresh-cut vegetables and fruits in response to processing and during storage and handling. To assess the role of specific enzymes responsible for the deterioration of fresh-cut fruits and vegetables. Project Methods This project will focus on the effects of fresh-cut preparation and handling, including techniques and technology, on the physiology, biochemistry, and quality of fresh-cut vegetables and fruits. Technology to be evaluated will include modified atmosphere packaging, application of novel food grade GRAS chemicals, and use of temperature-control regimes as alternatives to application of chemical compounds. We will also investigate the physiological and biochemical causes of quality changes, especially aroma, color including browning, and textual changes, in fresh-cut vegetables and fruits. These studies will include the role of ethylene and the respiratory response and recovery or re-equilibration of fresh-cut vegetables and fruits following wounding and fluctuating temperatures. As one means of assessing the role of ethylene, commodities will be treated with the ethylene-action inhibitor 1-methylcyclopropene prior to processing into fresh cut. We will investigate textural changes associated with wounding during preparation and storage of fresh-cut vegetables and fruits. We will investigate the physiology of fresh-cut tropical and subtropical species when exposed to low temperatures in terms of the tissue response to chilling stress such as textural alterations, and aroma volatile production. Fresh-cut vegetables and fruits that will be studied include sweet corn kernels, lettuce, mango, papaya, peaches, and watermelon. Selection of intact items for cutting will include studies on initial product quality, identification of appropriate cultivars, and optimum maturity at harvest. Whole apples and mangoes were pretreated with 1-MCP, heat or ethanol. Heat and ethanol pretreatments resulted in extended shelf life for cut apple, and ethanol treatment enhanced appearance and reduced decay in mango, although some off flavor was associated with the higher level ethanol treatments. Correlation of total sensory appearance, texture, flavor, odor, compositional, and microbiological quality changes in fresh-cut zucchini in MAP with machine vision and electronic nose measurements were done. Coatings on apple, peaches and mango showed some promising results for inhibition of browning and maintenance of flavor volatiles mango that warrant further research. Slices from whole light red or red tomatoes pretreated with 1-MCP maintained greater pericarp firmness and developed less watersoaking senescence symptoms. Nonmelting-flesh NMF peach cultivars are better suited for fresh-cut processing than melting-flesh MF cultivars because their firmer texture allows the use of riper fruit with better flavor than the less ripe fruit that must be used for fresh-cut MF peaches. Fresh-cut sweetcorn kernels shelf life is limited by flavor loss and after-cooking browning. The latter increases with advanced maturity and higher storage temperature. The effects of cutting on the firmness, activities of cell wall and membrane hydrolases, and ethylene biosynthetic enzymes in fresh-cut versus intact papaya fruit during storage at 5°C were studied. The data suggest that the increase in the activities of enzymes targeting cell walls and membranes, and changes in the apoplastic environment of fresh-cut tissue as a result of membrane damage, contribute to the rapid deterioration of fresh-cut tissue. The comparison of mRNA transcripts between intact and fresh-cut papaya fruit revealed that 12 genes were differentially expressed in response to cutting. Impacts Fresh-cut produce can help increase the consumption of fresh produce due to its convenience and attractive appearance and flavor. Development of novel approaches for assuring the quality and safety of fresh-cut produce depends on a better understanding of fresh-cut vegetable and fruit physiology, including nutrients and other functional components as affected by storage and handling. Effects of low dose...
electron beam irradiation on respiration, microbiology, texture, color, and sensory characteristics of fresh-cut cantaloupe stored in modified atmosphere packages. Effects of low dose electron beam irradiation on respiration, microbiology, color and texture of fresh-cut cantaloupe. Influence of low oxygen and high carbon dioxide on shredded Galega kale quality for development of modified atmosphere packages. Ethanol vapor prior to processing extends fresh-cut mango shelf-life by decreasing spoilage, but does not always delay ripening. For fresh-cut tomatoes, 1-MCP reduced, but did not eliminate, the negative textural consequences of slicing accelerated softening; watersoaking, and was most effective when applied to less ripe tomatoes and those with relatively high initial pericarp firmness. Watersoaking development in fresh-cut tomato slices during storage at 5C appears to be an ethylene-mediated symptom of senescence and not a symptom of chilling injury as had previously been suggested. Effect of pretreatment of intact Gala apple with ethanol vapor, heat, or 1-methylcyclopropene on quality and shelf life of fresh-cut slices. Influence of 1-methylcyclopropene 1-MCP on the shelf life and deterioration of fresh-cut cantaloupe. Responses of fresh-cut watermelon to 1-methylcyclopropene and CaCl2. Effect of pretreatment of intact Kent and Tommy Atkins mangoes with ethanol vapor, heat, or 1-methylcyclopropene on quality and shelf life of fresh-cut slices. Sweetcorn tolerance to reduced O2 with or without elevated CO2 and effects of controlled atmosphere storage on quality. The main benefit of this controlled atmosphere CA was to prevent after cooking browning. Preliminary results indicate that after cooking browning is not associated with a Maillard reaction since 5-hydroxymethylfurfural HMF, the characteristic intermediate compound produced during the Maillard reaction, is not present in cooked sweet corn kernels exhibiting browning. There were no significant changes in the total soluble phenolics content during storage in air or CA, but the soluble phenolic levels decreased with cooking, which suggests that the after cooking brown color may be due to as yet unidentified insoluble phenolic-protein complexes in the cooked sweet corn tissue. The total aerobic microbe count increased with storage and the increase was significantly greater in air. This suggests that the browning could be a response of the sweet corn tissue to the microorganisms, or it may be associated with some product of microbial enzyme activity. Sweetcorn was more sensitive to reduced O2 plus elevated CO2 than to either alone. Treatments that reduced respiration maintained higher levels of sugars, which is the main quality parameter for sweetcorn. The impact of CA on dimethyl sulfide DMS, the main characteristic aroma component in sweetcorn, was also measured. Fresh-cut vegetables and fruits. CA transport of fresh produce in MAP: Designing systems for optimal atmosphere conditions throughout the postharvest handling chain. Maintaining optimal atmosphere conditions for fruits and vegetables throughout the postharvest handling chain. Evaluation of the physiological response of shredded Galega kale under low oxygen and high carbon dioxide concentrations. Perforation-mediated modified atmosphere packaging: Influence of package geometry and perforation location on O2 and CO2 transfer. Browning of fresh-cut sweet corn kernels after cooking is prevented by controlled atmosphere storage. An example of the design procedure was given from our work with fresh-cut kale Brassica oleracea var. The main benefit of using controlled atmosphere CA storage is preventing after-cooking browning. Preliminary results indicate that after after-cooking browning is not associated with a Maillard reaction since 5-hydroxymethylfurfural HMF, the characteristic intermediate compound produced during the Maillard reaction, is not present in cooked sweetcorn kernels exhibiting browning. There were no significant changes in the total soluble phenolics content during storage in air or CA, but the soluble phenolic levels decreased with cooking, which suggests that the after-after-cooking brown color may be due to as yet unidentified insoluble phenolic-protein complexes in the cooked sweetcorn tissue. The total aerobic microbe count increased with storage and the increase was significantly greater in air. This suggests that the browning could be a response of the sweetcorn tissue to the microorganisms, or it may be associated with some product of microbial enzyme activity. Modelling respiration rate of fresh fruits and vegetables for MAP: Modelling respiration rate of shredded Galega kale for development of modified atmosphere packaging. Application of mathematical modelling and computer simulation to the design of modified atmosphere packages accounting for product variability. Controlled atmosphere storage of fresh-cut sweetcorn kernels. An atmosphere of
percent O2 plus percent CO2 extends the shelf life of shredded Galega kale at 20C to 4 days, compared to 2 days in air storage. Perforation-mediated MAP relies on the use of perforations tubes of different dimensions to control package O2 and CO2 exchange in order to create the desired atmosphere for preservation of intact and fresh-cut fruits and vegetables. Two perforations tripled O2 and CO2 exchange compared to one, showing the importance of draft effects, but the relative position of the tubes did not show a significant effect on the process. The ratio of the O2 and CO2 mass transfer coefficients beta ratio was not significantly different for the conditions tested. The design of MAP for fresh-cut produce requires an adequate model for prediction of respiration rate as a function of both temperature and gas composition. In this work, the O2 consumption and CO2 production rates of shredded Galega kale were studied. Temperature 1, 5, 10, 15 and 20C had the greatest influence on respiration rate and the effect of gas composition air or 1, 5 or 10 percent O2 plus 0, 10 or 20 percent CO2 increased with temperature. The dependence of respiration rate on gas composition was described by a Michaelis-Menten type equation with uncompetitive CO2 inhibition. The respiratory quotient RQ was found to be constant for the range of temperatures and gas compositions tested and was equal to 0. The constants of the Michaelis-Menten equation increased exponentially with temperature. Respiration rate decreased with time and the ratio between the respiration rate of shredded and intact leaves was equal to 2.

Introduction and popularity of supersweet sweetcorn has enabled the sweetcorn distribution chain to be extended up to 3 weeks using optimum handling practices compared with days for normal sweetcorn. Given the inherently longer shelf life of modern sweetcorn cultivars, we examined the potential for handling fresh-cut sweetcorn kernels. Fresh-cut sweetcorn kernels are extremely perishable, with a very high respiration rate; thus, temperature control during preparation and handling is critical. With proper sanitation, cut kernels did not show any signs of microbial growth even when stored for 10 days at 5C. Rather, shelf life was limited by loss of flavor. The most important problem with fresh-cut sweetcorn is brown discoloration of the kernels after cooking. The discoloration after cooking was greater in more mature kernels and after 5C storage, but did not occur in cut kernels stored for up to 10 days at 1C. Intact kernels are superior to cut kernels, maintaining their flavor at least twice as long and not discoloring after cooking, but are very difficult to prepare. Controlled atmospheres reduced fresh-cut sweetcorn respiration and maintained higher sugar levels after 10 days at 1C. Exogenous ethylene treatment stimulated ACC oxidase activity in both climacteric tomato and nonclimacteric strawberry fruits at all ripeness stages. Ethylene production was inhibited by ethylene treatment at all stages of strawberry ripeness, but was inhibited in immature tomato pericarp and stimulated in mature-green and pink tomato tissue. The transition from negative to positive ethylene feedback with the onset of ripening distinguishes climacteric from nonclimacteric fruit. Negative ethylene feedback in tomato locule gel applied only to ethylene production as red color development, tissue liquefaction, seed maturation, and onset of autocatalytic ethylene production were hastened. Perforation-mediated modified atmosphere packaging MAP uses macro perforations or tubes to control oxygen and carbon dioxide CO2 exchange and create the desired atmosphere inside an otherwise gas-tight package. Shredded leaves of Galega kale were used as a case study of the application of perforation-mediated MAP, which allows higher CO2 levels to be attained than conventional semipermeable film MAP. A methodology and models were developed for design of perforation-mediated MAP for fresh respiring produce. Ethylene feedback mechanisms in tomato and strawberry fruit tissues in relation to fruit ripening and climacteric patterns. Ripening of tomato fruit locule gel tissue in response to ethylene. Development of perforation-mediated modified atmosphere packaging for fresh-cut vegetables, p. Quality optimization and process assessment. Modelling O2 and CO2 exchange for development of perforation-mediated modified atmosphere packaging.
Standardize methods for recovering pathogenic and spoilage microorganisms from intact and fresh-cut produce including tree nuts. Evaluate and control unintentional and intentional microbial contamination of intact and fresh-cut produce including tree nuts. H7, Salmonella, and Listeria monocytogenes and for the effectiveness of physical methods and chemical sanitizers in removing or killing these microorganisms. Adoption of the inoculation and recovery methods would facilitate comparison of the relative effectiveness of sanitizers and physical treatments for raw vegetables, fruits, and tree nuts regardless of the laboratory conducting the test. The basic protocol could also be used in challenge studies to determine survival and growth characteristics of pathogens on raw produce and tree nuts subjected to various processing and storage conditions. The goals of the research to be performed under this objective are: To develop a standard method for inoculating the surface of fresh and fresh-cut vegetables and fruits, and tree nuts with bacteria capable of causing foodborne illness. To determine the effects of time between inoculation and retrieval on viability and recoverability of foodborne pathogens. To develop a standard method for evaluating the effectiveness of chemical sanitizers and physical treatments such as heat to remove or kill foodborne pathogenic bacteria on the surface of fresh and fresh-cut vegetables and fruits, and tree nuts. Poster presentations disseminating results were given at the following National Meetings: Fate of Escherichia coli O H7 and Salmonella spp. Fate of Salmonella and Listeria monocytogenes on fresh-cut celery. Development of a mathematical model to describe the growth of Salmonella spp. Vanessa Morales Graduate student: Schaffner, Rutgers University, M. Danyluk, University of Florida, C. Nothing significant to report during this reporting period. Impacts Fresh-cut produce is considered to be ready to eat without any further preparation. However, there are a number of standard consumer practices that may increase or reduce the likelihood of pathogen growth or survival in the cut product. Our results show that Salmonella spp. H7 do not grow but slowly decline on fresh-cut carrots during storage of up to 5 days at 4 and 23 C. For shredded carrots small decreases were observed at 4 C but a 1-log increase for both pathogens was observed over a h period at 23 C. For lettuce samples stored at 23 C, both E. H7 and Salmonella can grow on lettuce and shredded carrots with significant increases at about 8 h at room temperature. Collaborator data have developed models for fresh cut celery and fresh cut melons. These data will be useful for quantitative microbial risk assessment and for further development of scientifically sound consumer food safety messages. Preharvest and harvest food safety. Impact of pre-inoculation culture conditions on the behavior of Escherichia coli O H7 inoculated onto Romaine lettuce Lactuca sativa plants and cut leaf surfaces. Impact of pre-inoculation growth and inoculum handling conditions on the behavior of Escherichia coli O H7 inoculated onto romaine lettuce Lactuca sativa plants and cut leaf surfaces. Experiments on the behavior of E. H7 inoculated onto lettuce plants and fresh-cut product were conducted by graduate and undergraduate students and research scientists. These experiments involved collaboration and consultation with the lettuce and leafy greens industry. Approximately industry personnel attending. Approximately 50 members of the carrot industry in attendance. H7 in field-inoculated lettuce”. California Lettuce Research Board. Approximately industry attendees. Aftermath of the Spinach Crisis: Approximately 20 lawyers attending. H7 and leafy greens California Industry Response”. Approximately 50 government, industry attendees. Approximately industry attendees Presentation: Approximately industry and academic attendees. Brochure for consumers distributed via county nutrition and consumer science advisors: Safe-handling of fruits and vegetables. AND Manejo seguro de frutas y verduras. English and Spanish Brochures and magnets. Harris Additional Persons training and professional development: Student, completed September Both assisted in development of research plans and execution of research experiments. Growers, Processors, Consumers Dissemination: Safe-handling of fruits and vegetables.
brochure and magnet for consumers were updated and printed in both English and Spanish and distributed to California County Nutrition Advisors for use in nutrition education programs. Consumer information continues to be distributed through: Not relevant to this project. Impacts Findings from multiple years of this research have cumulatively been used to inform the produce industry and consumers of means to improve the safety of fresh fruits and vegetables. The research findings have been distributed to industry via web sites, participation in industry and university organized educational events, lay publications and scientific publications as well as published recommendations. Consumers have been provided information through interactions with the media radio, print, lay publications that have been extended through educators at the county level, and via web sites. Standard methods were developed to inoculate and recover E. H7 from lettuce plants and from cut and packaged lettuce. Numerous inoculation methods were evaluated with a focus on inoculum growing conditions. Unlike other produce previously evaluated, pre-inoculation growth conditions were found to have minimal impact on survival of E. Significant differences in survival of E. H7 were noted on growing plants rapid death post inoculation followed by slow, steady decline and cut lettuce surfaces no decline. Greenhouse grown plants were shown to respond similarly to field lettuce despite large differences in background populations. This information will be important in extrapolation of laboratory-based data to real-world settings. Techniques were developed that permit enumeration of very low levels of E. Survival and growth of Salmonella Enteritidis PT 30 in almond orchard soils. Migration of Salmonella Enteritidis PT 30 through almond hulls and shells. Survival of attenuated Escherichia coli O H7 ATCC in field-inoculated lettuce. Impact of pre-inoculation growth conditions on the behavior of Escherichia coli O H7 inoculated onto Romaine lettuce plants and cut leaf surfaces. Effects of static and variable storage temperatures on the survival and growth of Escherichia coli O H7 on prewashed bagged lettuce. Centennial Meeting of the American Phytopathological Society. Minneapolis, MN, July H7 inoculated onto lettuce plants and fresh-cut product were conducted by graduate and undergraduate students and postdoctoral scholars. Tree Crop Food Safety Symposium October 17 - 18, involved 30 members of the tree crop industry and academic researchers. Provided funding for the research. Michelle Danyluk, University of Florida Impacts Findings from multiple years of this research have cumulatively been used to inform the produce industry and consumers of means to improve the safety of fresh fruits and vegetables. The research findings have been distributed to industry via web sites, participation in industry and university organized educational events, lay publications and scientific publications as well as published recommendations. Recommendations for handling fresh-cut leafy green salads by consumers and retail foodservice operators. Safe methods to store, preserve, and enjoy. A simple guide to handling fruits and vegetables safely. No significant reductions of Salmonella were observed during storage at and 4C over days. At 35C, a biphasic survival curve was observed with calculated reductions of 1. An overall average calculated reduction at 23C was 0. Salmonella Enteritidis PT 30 survives for long periods on almond kernels under a variety of common storage conditions. Impacts Methods developed in this lab and in collaboration with others are being used to study to evaluate survival and growth of foodborne pathogens on the surface of fresh and fresh-cut produce and tree nuts. In addition, developed methods are being used to evaluate washing procedures designed to remove foodborne pathogens from the surface of fresh produce and tree nuts as well as to evaluate other thermal and non-thermal processes for reducing or eliminating foodborne pathogens from these products. Results are being used in publications directed to consumers and the food industry for the safe handling of fresh and fresh-cut fruits and vegetables and tree nuts. These produce items present may challenges in this repsect because of the remarkable difference in the surface structure of the vast number of products readily available. In addition, production, harvesting, processing, and storage conditions vary greatly and all of these factors will have an impact on the behavior of foodborne pathogens in these products. The standard methods developed were used to evaluate antimicrobial agents such as chlorine and propylene oxide for reduction of pathogens on the surface of a variety of produce items and almonds. Greatest reductions occurred when friction such as rubbing or brushing was applied. Reduction on smooth surfaces such as honeydew melon was significantly greater than on complex surfaces such as cantaloupe.
Based on the extensive research in this area during the past 10 years, this reference is the first to cover the complete spectrum of science, technology, and marketing issues related to this field, including production, processing, physiology, biochemistry, microbiology, safety, engineering, sensory, biotechnology, and economics.

More recently, Belgian and Dutch processors have manufactured fresh fruit salads with syrup stabilized with sorbate (to prevent yeast growth), ascorbic acid (as an antibrowning agent), and calcium chloride (to reduce texture breakdown).

Fresh-cut fruits and vegetables are a relatively new and rapidly developing segment of the fresh produce industry. Fresh-cut products have been freshly cut, washed.