

THESIS

FARM-TO-TABLE FOOD SAFETY FOR COLORADO PRODUCE CROPS: A WEB-
BASED APPROACH FOR PROMOTING GOOD AGRICULTURAL AND
HANDLING PRACTICES

Submitted by

Gretchen Lynn Wall

Department of Food Science and Human Nutrition

In partial fulfillment of the requirements

For the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Summer 2011

Master's Committee:

Advisor: Marisa Bunning

Patricia Kendall

Dennis Lamm

ABSTRACT

FARM-TO-TABLE FOOD SAFETY FOR COLORADO PRODUCE CROPS: A WEB-BASED APPROACH FOR PROMOTING GOOD AGRICULTURAL AND HANDLING PRACTICES

Fresh fruits and vegetables have been increasingly associated with cases of foodborne illness (CDC, 2010; FDA, 1998). Direct links of these outbreaks to farms highlights the need to employ strategies to reduce pathogenic microbial contamination of fresh produce at this stage of the food system (Bihn & Gravani, 2006). One approach to fresh produce safety on the farm involves participation in voluntary audits based on Good Agricultural Practices (GAPs) and Good Handling Practices (GHPs). Currently, only a small percentage of Colorado producers employ this strategy. In response to new regulations and guidelines, changing food consumption patterns, and improved market access, Colorado producers need to have the flexibility to adopt programs that can help them meet the demands of providing a safer food supply (Rejesus, 2009). In response to these issues, *Farm to Table Food Safety for Colorado Producers*, a series of three web-based GAPs/GHPs trainings, was developed following the guidelines of FDA, USDA, and the National GAPs program. These trainings were implemented and evaluated targeting small farm producers of fresh fruits and vegetables based on an initial needs assessment to identify potential barriers and drivers for adopting these types of programs. In addition, a series of consumer-friendly, down-loadable fact sheets with nutrition, safe

food handling, and recommended storage guidelines was developed to help promote ten selected Colorado specialty crops: apples, berries, broccoli, leafy greens, melons, peaches, peppers, potatoes, squash, and tomatoes. The approach of developing technology-based training modules and educational materials allowed for improved accessibility to growers and produce consumers across the state while accommodating their variable time schedules and need for convenient, reliable information. Pre and post questionnaires were used to measure self-assessed knowledge outcomes along with overall course evaluation items. As a result of participating in the webinar series, producers, buyers, and Extension professionals indicated they planned to utilize the information and resources. Specific topics related to GAPs such as irrigation water quality, management of manure and compost, and food safety legislation were of most interest to the participants and had the most significant increases ($p < 0.001$) in self-reported knowledge, pre to post webinar. The course evaluation showed that produce buyers, Extension professionals, and other webinar attendees intend to utilize the material presented in the webinar series directly or indirectly in their professions, with average mean scores on a 5-point Likert scale (1= Very Unlikely and 5= Very Likely), of 4.2, 4.2, and 3.6, respectively. Overall, reviewers rated the produce fact sheets with a mean score of 4.34 for usefulness (1=Not Useful and 5= Extremely Useful). Feedback gained from the webinar and produce fact sheet evaluations will be a helpful tool in making improvements for future web-based on-farm food safety educational materials.

ACKNOWLEDGEMENTS

One page of acknowledgements does not give enough credit or appropriate space to thank all those who made this thesis possible. First and foremost, I would like to thank Dr. Marisa Bunning, my advisor, who invited me to join this project even before she had met me while I was finishing up my undergraduate degree at Penn State. Her expertise in food safety and local food markets helped to make this research not just a rewarding and challenging graduate project, but also a future career for me. I would also like to thank the members of my committee, Dr. Dennis Lamm and Dr. Patricia Kendall, for providing such thorough and immediate feedback to challenges that arose during my project.

I was incredibly fortunate to have worked with some of the finest colleagues at Colorado State, who provided me their assistance, expertise, and time to make this project a success. I would like to thank all those who helped to review, edit, promote, and launch the fact sheets and webinars, including Mary Schroeder, Dr. Jessica Davis, John Wilson, James zumBrunnen, Adrian Card, Troy Bauder, Martha Sullins, and Ruth Willson. I would also like to acknowledge Tracy Vanderpool, who provided me with valuable insights into the current status of GAPs in Colorado's produce industry as well as timely and accurate feedback through the design and implementation of the webinar series.

I would like to thank my friends, more specifically the best roommates I have ever had the opportunity to live with, Jess, Andy, and Ryan (an honorary roommate) for their humor, company, and willingness to share their delicious (and much healthier) food

during our long nights glued to our laptops at the kitchen table. Most importantly, I would like to thank my parents and sister for all of their support, encouragement, and even ‘plan-your-life spreadsheets’ that enabled me to have the confidence to surmount challenges that I didn’t think I ever could. Finally, my apologies to all the friends, family, and presentation attendees that I have ever grossed out with my overly-enthusiastic approach to food science, gastro-intestinal distress, and food safety horror stories. Even with a degree in food safety, I still wholeheartedly believe in the five second rule.

TABLE OF CONTENTS

| | |
|---|----|
| ABSTRACT..... | ii |
| ACKNOWLEDGEMENTS..... | iv |
| TABLE OF CONTENTS..... | vi |
| LIST OF TABLES..... | ix |
| CHAPTER I: INTRODUCTION..... | 1 |
| CHAPTER II: REVIEW OF LITERATURE..... | 2 |
| Fresh Produce and Foodborne Illness Outbreaks..... | 2 |
| Outbreak Statistics and Economic Impact..... | 2 |
| Contributing Factors to Produce Related Outbreaks..... | 5 |
| Preventative Guidelines and Recommendations..... | 6 |
| Reporting Illness..... | 7 |
| Good Agricultural Practices (GAPs)..... | 8 |
| Historical Perspective of Food Safety and the Role of GAPs..... | 8 |
| Good Agricultural Practices: Barriers and Drivers for Adoption..... | 10 |
| Regulatory Landscape..... | 13 |
| Good Agricultural Practices Principles..... | 14 |
| Irrigation..... | 15 |
| Manure Use..... | 18 |
| Animal Contamination..... | 20 |
| Worker Health and Hygiene..... | 20 |
| Field and Harvest Sanitation..... | 22 |
| Packing Facilities and Washing Operations..... | 23 |
| Recall and Traceability..... | 25 |
| Risk Based Food Systems..... | 26 |
| Risk Analysis..... | 26 |
| Risk Reduction and Adoption of Good Agricultural Practices..... | 28 |
| Web-Based Approaches to Education..... | 31 |
| Distance Learning Advantages and Disadvantages..... | 31 |
| Web-based Educational Technologies..... | 32 |
| Adult and Non-Traditional Learning Styles..... | 34 |
| Objectives..... | 35 |

| | |
|--|----|
| CHAPTER III: METHODS | 36 |
| Needs Assessment | 36 |
| Interview Development | 36 |
| Producer Interview | 37 |
| Buyer Interview..... | 38 |
| Participant Recruitment and Interview Process | 38 |
| Produce Fact Sheets | 40 |
| Design and Development | 40 |
| Evaluation Instruments..... | 41 |
| Potential Uses and Availability | 42 |
| Good Agricultural Practices Webinars | 42 |
| Course Development..... | 43 |
| Technology..... | 45 |
| Recruitment | 45 |
| Launch..... | 46 |
| Incentive..... | 46 |
| Evaluation Instrument | 47 |
| Data Analysis | 48 |
| CHAPTER IV: RESULTS AND DISCUSSION | 49 |
| Needs Assessment | 49 |
| Producer Demographics | 49 |
| Producer Interview Summary | 52 |
| Producer Barriers and Drivers for Adoption of GAPs..... | 56 |
| Produce Buyer/Distributor Demographics..... | 59 |
| Produce Buyer Interview Summary | 60 |
| Produce Buyer Barriers and Drivers for Adoption of GAPs..... | 62 |
| Produce Fact Sheets..... | 65 |
| Good Agricultural Practices Webinars | 71 |
| Demographics | 71 |
| Webinar Development | 72 |
| Webinar Evaluation..... | 73 |
| Behavioral Intent..... | 75 |
| Producers..... | 76 |
| Produce Buyers | 80 |
| Educators/Extension..... | 82 |
| Industry Professionals/Students/Regulatory/Other | 83 |

| | |
|---|-----|
| CHAPTER V: CONCLUSION AND RECOMMENDATIONS | 85 |
| REFERENCES | 88 |
| APPENDIX A | 98 |
| APPENDIX B | 99 |
| APPENDIX C | 101 |
| APPENDIX D | 102 |
| APPENDIX E | 104 |
| APPENDIX F | 127 |
| APPENDIX G | 130 |
| APPENDIX H | 131 |
| APPENDIX I | 176 |
| APPENDIX J | 177 |
| APPENDIX K | 180 |
| APPENDIX L | 181 |
| APPENDIX M | 185 |
| APPENDIX N | 192 |
| APPENDIX O | 194 |
| APPENDIX P | 196 |
| APPENDIX Q | 197 |
| APPENDIX R | 198 |

LIST OF TABLES

| Table | Page |
|--|-------------|
| 2.1: Examples of outbreaks of human infections and intoxications epidemiologically associated with fresh fruits and vegetables and unpasteurized products | 4 |
| 2.2: Sales of spinach lag, one year after the 2006 outbreak of <i>E.coli</i> O157:H7 | 28 |
| 2.3: Impact of the 2003 Hepatitis A outbreak on Mexican growers, by GAP status | 30 |
| 4.1: Demographic distribution for producer needs assessment participants | 51 |
| 4.2: Producer telephone interview responses | 55 |
| 4.3: Producer perceived barriers and drivers for the adoption of GAPs | 59 |
| 4.4: Demographic distribution for produce buyer/distributor needs assessment participants | 60 |
| 4.5: Produce buyer telephone interview responses | 61 |
| 4.6: Produce buyers perceived barriers and drivers for the adoption of GAPs | 63 |
| 4.7: Mean scores for knowledge of the fact sheet topic before and after reading | 67 |
| 4.8: Mean scores for knowledge of food safety, preservation, and produce storage and handling before and after reading | 68 |
| 4.9: Mean scores for usefulness of major fact sheet content topics | 69 |
| 4.10: Demographic distribution for post-survey webinar participants by profession/age | 72 |
| 4.11: Participant interests for webinar topics | 73 |
| 4.12: Pre and post self-reported knowledge scores for webinar topics | 73 |
| 4.13: Mean scores for basic webinar evaluation questions | 75 |
| 4.14: Producers' intent to participate in GAPs/food safety audits | 76 |
| 4.15: Summary of producer behavioral intent for specific GAPs activities | 78 |
| 4.16: Produce buyers' intent to impose mandatory food safety/GAPs audits on their suppliers | 80 |
| 4.17: Produce buyers' mean scores for behavioral intent | 81 |
| 4.18: Extension Professionals and Educators' mean scores for behavioral intent | 83 |
| 4.19: Students', industry professionals', and others' mean scores for behavioral intent | 84 |

CHAPTER I: INTRODUCTION

Between the farm and the dinner table, there are many opportunities for disease causing organisms and other food safety hazards to enter the food supply. Food safety issues can arise at any stage from food production to consumption: on the farm, during processing, at the retailer, or in the hands of the consumer. Advances in agronomic, processing, packaging, and distribution technologies have enabled the produce industry to supply consumers with a wide range of high quality products year round. Some of these same technologies, coupled with traditional practices, have also increased the risk for foodborne illness (CDC, 1997). Potential direct and indirect contamination can occur through contact with the soil, manure, irrigation water, livestock, packinghouse equipment, transportation vehicles, and workers who handle fruits and vegetables anywhere along the supply chain (Bihn & Gravani, 2006). In order to ensure the road food follows from farm to fork is safe, every link must share the responsibility of maintaining an unbroken chain of safe practices. Nearly all food, including meat, dairy, and produce comes from farms; therefore, farm practices serve a critical role in their microbial safety. Keeping foods safe until they leave the farm poses a number of challenges to growers and producers ranging from broad fundamental problems such as failure to implement a systematic approach to food safety to more specific issues such as irrigation water contamination (Buckley & Reid, 2010). Through applied research, continued and increased diligence on behalf of growers and shippers, and improved oversight, farm to table food safety can be strengthened.

CHAPTER II: REVIEW OF LITERATURE

Foodborne illness outbreaks, traced to a variety of different foods, have been documented worldwide. Contamination by microbial pathogens ultimately occurs from external environmental sources anywhere between the farm and the consumers' plate. Microbial food safety should be a part of any comprehensive management plan for growers, specialty crop producers, harvest workers, distribution handlers, direct marketers, and fresh cut processors. This diversity of environments, agricultural management, and handling practices makes a single approach to food safety unrealistic; instead, focus should be placed on promoting a more integrated food safety culture among producers of fresh fruits and vegetables.

Fresh Produce and Foodborne Illness Outbreaks

Outbreak Statistics and Economic Impact

The Centers for Disease Control and Prevention (CDC) estimates that foodborne pathogens cause 48 million illnesses, 128,000 hospitalizations, and 3,000 deaths in the United States each year (Scallan et al., 2011). Fresh fruits and vegetables have been increasingly linked to cases of foodborne illness in the past decade (CDC, 2010). A foodborne disease outbreak is defined as the occurrence of two or more similar illnesses resulting from ingestion of a common food. State, local, and territorial health departments use a standard, Internet-based form to voluntarily submit reports of foodborne outbreaks to the Foodborne Disease Outbreak Surveillance System (Batz et al., 2005). The best

available measure of the health-related cost of foodborne illness in the United States is approximately \$152 billion, of which \$39 billion can be attributed to produce-related outbreaks (Scharff, 2010). This estimate includes the long-term health outcomes associated with acute foodborne illness as well as the impact to others in society. These costs include medical expenses paid by insurance companies, but excludes costs to industry such as recalls or lawsuits. Approximately 12.3 percent of all foodborne outbreaks from 1990 to 2007 were associated with produce (Alliance for Food and Farming, 2010). The majority of foodborne illness outbreaks, nearly 65%, are associated with produce contaminated after leaving the farm is primarily due to mishandling at the food service level. While not traditionally associated with transmission of foodborne disease twenty years ago, fresh fruits and vegetables have been considered a vehicle for human disease, harboring bacteria, pathogens, protozoa, and fungi (Beuchat, 1996; Crutchfield & Roberts, 2000). The sporadic occurrence of contaminated fresh produce typically results from external environmental sources, from the time of production to food processing and preparation.

The United States Food and Drug Administration (FDA) and the CDC have reported high-profile outbreaks involving the microbial contamination of tomatoes (FDA, 2006), peppers (FDA, 2008b), leafy greens (FDA, 2005), melons (FDA, 2008a), and raspberries (CDC, 1997), to name a few, which have greatly impacted the produce industry. Between 1996 and 2007, there were 72 reported outbreaks of foodborne illness associated with roughly 20 fresh produce commodities, both domestic and imported (CDC, 2010). Of this total, repeated outbreaks were associated with specific fruits and vegetables, including but not limited to: tomatoes (13), melons (11), and leafy greens

such as lettuce and spinach (24). As illustrated by the aforementioned examples, a wide range of fresh fruits and vegetables, as well as unpasteurized fruit juices, have been implicated in outbreaks and infections (Beuchat, 2002). Selected examples of outbreaks of human infections and intoxications that have been associated with fresh produce are found in Table 2.1.

Table 2.1: Examples of outbreaks of human infections and intoxications epidemiologically associated with fresh fruits and vegetables and unpasteurized products (Beuchat, 2004).

| Human Pathogen | Produce |
|---|---|
| <i>Bacillus cereus</i> | Soybean sprouts, mustard sprouts, cress sprouts |
| <i>Campylobacter jejuni</i> | Lettuce, salad |
| <i>Clostridium botulinum</i> | Cabbage, salad, chopped garlic in oil |
| <i>Clostridium perfringens</i> | Salad |
| <i>Escherichia coli</i> O157:H7 | Alfalfa sprouts, apple cider, cantaloupes, coleslaw, fruit salad, lettuce, radish sprouts |
| <i>Escherichia coli</i> (enterotoxigenic) | Shredded carrots, orange juice |
| <i>Listeria monocytogenes</i> | Cabbage, celery, lettuce, tomatoes |
| <i>Salmonella</i> | Alfalfa sprouts, apple juice, cantaloupes, fruit salad, lettuce, mamey, mung bean sprouts, orange juice, tomatoes, watermelon |
| <i>Shigella flexneri</i> | Fruit salad, green onions |
| <i>Shigella sonnei</i> | Lettuce, parsley, scallions, watermelon |
| <i>Vibrio cholerae</i> | Cabbage, coconut milk, raw vegetables |
| <i>Yersinia enterocolitica</i> | Bean sprouts |
| <i>Cyclospora cayetanensis</i> | Basil, blackberries, lettuce, raspberries, raw vegetables |
| <i>Cryptosporidium parvum</i> | Apple cider, green onions, raw vegetables |
| <i>Giardia lamblia</i> | Lettuce, onions, tomatoes |
| Calicivirus | Raspberries (frozen), salad |
| Hepatitis A | Lettuce, raspberries (frozen), strawberries (frozen), tomatoes, water cress |
| Norwalk | Celery, coleslaw, fruit salad, green salad, melon |

Contributing Factors to Produce Related Outbreaks

A myriad of factors may contribute to the increasing number of produce related outbreaks documented within the past decade. Coinciding with the increasing number of foodborne outbreaks, current nutrition recommendations for consumers promote consumption of fruits and vegetables as part of a balanced diet (Powell et. al, 2004). Recent data indicate the availability of fresh fruits has increased 26% and fresh vegetables 29% between 1970 and 2005 (USDA, 2007). The increased consumption of fresh produce also poses a unique food safety risk. Fruit and vegetables are often consumed raw and do not include a cooking step that would otherwise kill harmful pathogens (Bazzano, 2006; Scott et al., 2009). Instead, the pathogen load on fresh produce must be controlled or reduced by proper storage, adequate washing, and avoidance of cross-contamination (Burnett & Beuchat, 2001). Perpetuating the issue of proper handling and washing of fresh produce to remove pathogens, certain types of fruits and vegetables are more susceptible to harboring disease-causing organisms.

Differences in surface morphology and metabolic processes of the leaves, stems, and roots of fruits and vegetables provide a wide range of environments for harmful microorganisms to thrive. Normally, the exterior of a fruit or vegetable will serve as a physical barrier against bacteria penetrating into the interior. The surface of most produce items are complex, for example the convoluted nature of a lettuce leaf, therefore making it very difficult to clean. However, once the integrity of the surface is broken, such as bruises or cuts that may result from improper handling, bacterial growth can be rapid (NACMCF, 1995). Treatment of postharvest produce with sanitizers is effective in reducing populations of pathogenic organisms; however, total destruction of the

population cannot be achieved without affecting the sensory quality (Beuchat, 2006). In organic farming systems, the use of sanitizers and other chemical microbial control methods are limited (Plotto & Narciso, 2006). Prevention of contamination is preferred over methods of treatment, such as chlorinated water baths, to remove harmful microorganisms (Zhang et. al, 2009a).

Technological advances in the production, processing, and distribution methods have vastly improved the quality, shelf-life, and availability of fresh produce to consumers worldwide (Bazzano, 2006). Unfortunately, advances in technology and handling methods can lead to unanticipated changes in the microbial ecology of food items, allowing for the emergence of new pathogens or higher incidence of known pathogens (Burnett & Beuchat, 2001). Bacteria such as *Yersinia enterocolitica*, *Listeria monocytogenes*, and *E. coli* O157:H7 are capable of growing slowly at refrigeration temperatures (Beuchat, 2002). In addition, *E. coli* O157:H7 and *Salmonella enteritidis* can cause serious human illness when only a few cells are ingested. These adaptive responses and genetic changes by microorganisms pose serious challenges to scientists who are devoted to devising better methods for their detection and control in the food system (Rangarajan et al., 2000).

Preventative Guidelines and Recommendations

In the mid-1990s, microbial contamination of both domestic and imported produce shifted the focus of the food industry from microbial testing of foods to the prevention of contamination at the grower and shipper level (Tauxe, 1997). In response to the growing concern about the safety of the food supply, the FDA, CDC, United States Department of Agriculture (USDA), local and state governments, retailers, and growers

began working together to keep unsafe food off the market while focusing on preventative measures for reducing the risk of contamination. A single approach to food safety is unrealistic; therefore, key guiding principles have been outlined for prevention of contamination, cross contamination, and reduction of pathogen survival (University of California, 2010).

Voluntary guidelines such as the FDA's *Guide to Minimize Food Safety Hazards in Fruits and Vegetables* (FDA, 1998), Good Agricultural Practices (GAPs) (GAPsNET, 2009), and Hazard Analysis Critical Control Points (HACCP) (FDA, 2009) provide recommendations to growers and food processors on how to reduce foodborne outbreaks. While these recommendations may help reduce the risk of microbial contamination, they cannot completely eliminate a risk. An in-depth understanding of microbial ecosystems on surface areas of pre- and post-harvest fruits and vegetables is necessary to develop successful interventions for the removal of pathogens (Beuchat, 1998).

Reporting Illness

Although technologies for detecting, identifying, and confirming foodborne illnesses have advanced, most illnesses are still not recognized or reported as often as they actually occur. For every foodborne illness case that is reported, as many as 40 more illnesses are not reported or lab confirmed (Mead, 1999; Voetsch, 2004). Unless an illness is severe enough to require a visit to the doctor or hospital, it is unlikely that the source and identity of the pathogen will be determined (Sobel et al., 2002). Other limitations to outbreak data include the underrepresentation of pathogens which are difficult to identify or rarely cause outbreaks. Outbreaks of large magnitude or those that cause serious illness are more likely to be investigated or reported (Scallan et al., 2011). It is virtually impossible to know how many people become ill from eating a food, which

pathogens caused the illness, and where those pathogens entered the food system (Batz et al., 2005). Food safety is a complex subject; a perfectly safe food supply is an unrealistic goal. However, through the development and evaluation of food safety education programs such as the ones described in this report, opportunities exist for improving food safety at each step in the food supply chain, beginning at the farm.

Good Agricultural Practices (GAPs)

Increased concerns about foodborne illness from fresh produce and the subsequent economic loss have motivated many growers to adopt Good Agricultural Practices (GAPs). Good Agricultural Practices are broadly defined as "practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products" (FDA, 2003a). The concept of GAPs has evolved in recent years due to the rapidly changing and increased globalization of our food supply, as well as concerns from stakeholders about food production and security, food safety and quality, and environmental sustainability of the agricultural system. Stakeholders responsible for the protection of public health in association with the food supply include farmers, slaughterhouse operators, food processors, transporters, distributors, consumers, and governments. In order to ensure a safe, nutritious food supply, responsibility towards this goal must be shared along the entire food chain (FDA, 2003b).

Historical Perspective of Food Safety and the Role of GAPs

In describing the role of GAPs in food safety, a historical perspective must be examined within the context of the entire food system. Food safety traditionally has been focused on enforcement mechanisms to remove unsafe food from the market, instead of the prevention of food safety problems prior to their inception (Bihn & Gravani, 2006).

To complete an accurate assessment of the safety of a food, it is necessary to understand the intricacies of biological, chemical, and physical hazards from raw material production to consumption of the finished product (FDA, 2009). In order to accomplish these goals, a methodology of food safety called Hazard Analysis Critical Control Points (HACCP) was developed by Pillsbury Co. in 1959 for food products to be used in the space program (Bauman, 1990). HACCP is a seven point method of monitoring food processing from receiving to service. The system consists of evaluating each step of production for possible critical problems that may cause individuals to become ill if contaminated food is consumed (Higgins & Hatfield, 2004). The use of HACCP has been mandated by the FDA and USDA for a variety of industries such as seafood, juice, meat, and poultry processing facilities and has become a valuable tool in preventing foodborne outbreaks (FDA, 2009).

Unfortunately, HACCP cannot be implemented in on-farm food safety programs for fresh produce, as there is no definite kill step for pathogens, such as pasteurization. Additionally, the variability of environmental factors, types of food produced, and complexity of pathogen transmission in fresh produce makes HACCP principles nearly impossible to achieve for producers of fruits and vegetables. However, basing on-farm food safety programs on HACCP principles can provide scientific credibility for guidelines; however, the National Advisory Committee on Microbiological Criteria for Foods suggests that while a formal HACCP system is too rigid for the farm, the basic principles can still be loosely adapted to reduce risk (FDA, 2009). Translating HACCP-based strategies to the farm level has resulted in a set of generic guidelines which

eventually evolved into the present day Good Agricultural Practices (GAPs) Program (Bihn & Gravani, 2006).

As part of President Clinton's 1998 Food Safety Initiative, the FDA (1998) issued a guidance document to the industry entitled *Guide to Minimize Food Safety Hazards for Fresh Fruits and Vegetables*. The FDA guide set the foundation for a variety of practices and programs commonly referred to as Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs). Growers, packers, shippers, and others can use GAPs/GMPs to address common risk factors in their operations as a method to minimize the potential for foodborne illness. This guidance document recognizes that there are different agricultural practices among produce types as well as among growing regions (FDA, 2003b). Producers must be aware of the importance of food safety, opportunities available, and potential barriers before making informed decisions about whether or not to adopt Good Agricultural Practices on their farm.

Good Agricultural Practices: Barriers and Drivers for Adoption

Many individual growers have reacted to the increased concern about foodborne illnesses and subsequent financial losses by improving their food safety systems and participating in third-party audits (Calvin, 2004). The philosophy behind auditing is to provide verification; however, an audit alone does not necessarily promote the culture of food safety. On-farm food safety systems must be integrated into both managerial and employee culture in order to reinforce and ensure the use of good agricultural practices (Chapman, 2005). Moreover, many produce buyers are now requiring their growers to have proof of proper handling and agricultural practices from farm to fork in order to maintain consumer confidence in the industry by reducing the risk for foodborne outbreaks (Bihn & Gravani, 2006).

Perceived barriers to successful implementation of GAPs programs may include knowledge barriers, attitudinal barriers, and financial barriers. First and foremost, the concept of GAPs must reach producers, both large and small, before widespread use of GAPs on-farm food safety plans become commonplace. Secondly, agreeing with the principles of the program and believing actions will have an impact on food safety is an important attitudinal obstacle to overcome. Lastly, financial barriers and the allocation of resources such as time, money, and staff may present a significant hurdle to producers (FDA, 2003a).

According to an FDA report on growers' understanding and implementation of GAPs guidance, growers who were interested in adopting on-farm food safety programs anticipated significant barriers to employing and sustaining their GAPs programs. Changing requirements, unclear standards, and lack of scientifically supported information deterred some producers from adopting the program (Butte, 2010). Ideally, all GAPs would be scientifically proven, but evaluating and validating the efficacy of GAPs in reducing food safety risks is difficult, especially when the events that the practices are meant to prevent are rare (Buckley & Reid, 2010). Sound scientific evaluation of the impact of on-farm practices is extremely challenging; on-farm research is expensive, complex, and may vary from one farm to another. To develop interventions that will have the greatest impact on reducing foodborne illness, processes must be developed through research, then validated, implemented, and subjected to rigorous documentation to ensure they achieve the desired objective. Interventions must be suitable for a broad spectrum of production environments and types of foods while still being economically feasible (FDA, 2003a). In a 2007 multi-state survey, it was found

growers and packers who had a knowledge of GAPs were more likely to adapt and integrate the educational concepts of GAPs into their farm food safety programs (Jackson et al., 2007). Regardless of GAPs knowledge, any on farm food safety program has its' limitations. Appropriate documentation, increased oversight of employee actions, and the inclusion of third party auditing services have all been cited as potential barriers by growers and processors of fresh fruits and vegetables (Wilson et al., 2009).

In response to new regulations and guidelines, changing food consumption patterns, and improved market access, producers need to have the flexibility to adopt programs that can help them meet the demands of providing a safer food supply (Rejesus, 2009). Improved market opportunities exist for growers who are able to assure their buyers they have followed the appropriate food safety practices on their farms (Bihn & Gravani, 2006). GAPs are currently being promoted by the industry in response to consumer demand for safely and responsibly produced food. One of the primary incentives for on-farm food safety programs is to maintain market share and strengthen relationships with customers and consumers by enhancing trust through proactive food safety programs (Chapman, 2005). Research also suggests producers' current food safety goals and activities are driven primarily by customer expectations, buyer requirements, and pending governmental regulations. Concern for legal and financial liability resulting from a contamination event, as well as the moral obligation to protect the public's health were also cited as factors driving the adoption of GAPs (Butte, 2010).

Regulatory Landscape

Currently, GAPs are not mandatory regulations, but instead, were developed by the FDA to provide recommendations and guidance to the fruit and vegetable industry to reduce microbial risks (GAPsNET, 2009; FDA 1998). Mandatory safety standards for produce appear to be on the horizon. Along with the Food and Drug Administration's voluntary guidance documents, Congress has also introduced a number of bills with provisions that would direct the FDA to establish standards for the safe production of fruits and vegetables (O'Hara, 2009).

On January 5, 2011, the S.510 Food Safety Modernization Act was signed into law (GovTrack.US, 2011). The bill will increase the FDA's regulatory authority over the food production system in order to prevent contamination and foodborne illness outbreaks. It also gives the FDA mandatory recall authority, requires food producers to have qualifying plans in place for identifying and addressing safety risks, and specifies that importers must verify the safety of all imported foods. Small farms and food facilities that generate less than \$500,000 in sales annually and sell most of their food locally will be exempt from most of the new regulations in the bill. Applying directly to on-farm food safety, Section 105 of S.510 states that the bill:

Sets forth provisions related to produce safety, including to require the Secretary to: establish science-based minimum standards for the safe production and harvesting of those types of fruits and vegetables that are raw agricultural commodities to minimize the risk of serious adverse health consequences or death; and publish updated good agricultural practices and guidance for the safe production and harvesting of specific types of fresh produce (GovTrack.US, 2011).

As a result of the growing movement toward mandatory produce safety standards, GAPs audits are becoming increasingly important to all stakeholders in the industry. In the future, potential implications of these mandatory produce safety standards as well as

insights for how standards could be modified to fit current industry needs will require in-depth evaluation (O'Hara, 2009).

Good Agricultural Practices Principles

Fruits and vegetables can become contaminated with harmful bacteria as well as unintended chemicals and other food safety hazards in a variety of ways. Factors that may result in pre-harvest contamination of fresh produce include the use of contaminated animal manure as fertilizer, fecal contamination from feral animals, the use of contaminated irrigation water, and human handling. At the post-harvest level, critical factors include the use of contaminated wash water or ice for packing, human handling, the presence of rodents in the processing facility, the use of contaminated equipment or transportation vehicles, and improper storage (NACMCF, 1995). Irrigation practices, manure use, wild and domestic animals, worker training and hygiene, packing facilities, and transportation are all important considerations in the production of fruits and vegetables since contamination has been linked to all of these factors (Brackett, 1999; Kudva et al., 1998; Tauxe, 1997; Wachtel et al., 2002). Figure 2.1 illustrates the cycle of pathogens between humans, animals, and the environment and the impact it has on fresh produce.

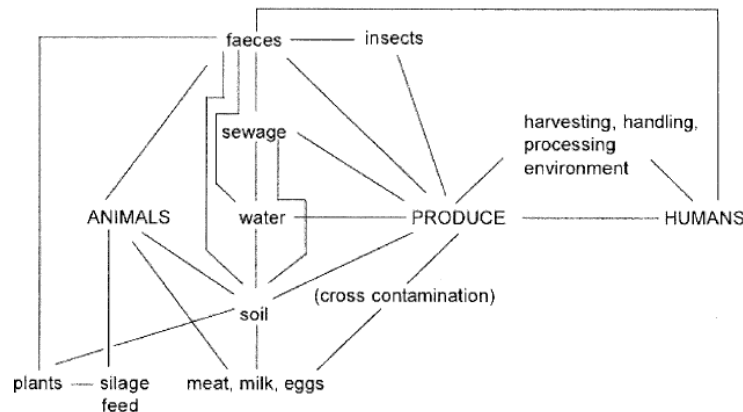


Figure 2.1: Cycle of pathogens in fresh fruit and vegetable production (Beuchat, 1996).

As with any food safety intervention program, successful implementation relies on growers and farm managers prioritizing GAPs throughout all parts of the operation, from the field to the packing facility and beyond (Butte, 2010). Although detailed more thoroughly by the FDA (1998), Cornell University (2009), and the University of California (2010), the following guiding principles serve as fundamental components of microbial food safety management plans. Growers, specialty crop producers, harvest operators, distribution handlers, direct marketers, and fresh cut processors may benefit from adhering to these guidelines, especially if tailored to their own working environment and adapted to their current handling practices (Rangarajan et al., 2002).

Irrigation

Currently in the United States, there are no irrigation water quality standards, only guidelines based on drinking water quality. Historically, water quality testing was done to monitor water hardness, pH, mineral content, and other factors that affect plant growth and development. However, recent outbreaks have been attributed to production water as a source of pathogenic bacteria and viruses that contaminate fruit and vegetables in the field (Bihn & Gravani, 2006).

Contamination of both surface and ground water sources may occur from infected livestock or improperly treated effluents, such as sewage from treatment plants. Animal and human fecal material may contain Norovirus, Hepatitis A, or bacterial pathogens such as *E.coli* O157:H7, *Salmonella* spp., and *Shigella* spp. (Beuchat, 1998). Methods of delivering water to crops on the farm can greatly influence the risk of microbial contamination of produce. Water may be delivered to crops in a variety of ways including overhead, surface, and drip irrigation. Solomon and colleagues (Solomon et al., 2002) discovered the transmission of *E.coli* O157:H7 to lettuce was possible through the use of

both spray and drip irrigation. In a follow-up study, Solomon and colleagues (2003) also found *E.coli* O157:H7 from contaminated manures used in soil amendments could be transmitted internally into lettuce plants following irrigation. Viable pathogenic cells were found to have migrated into the inner tissues of the lettuce plants from the soil, thus protecting the pathogen from topical sanitizing agents. Although research has shown pathogenic organisms can be taken up by the roots of certain plants, these studies were done with much higher concentrations of pathogens than would naturally be present in the field (Wachtel et al., 2002; Zhang et al., 2009b). Application of irrigation water beneath the soil, where potential contaminated water does not come into direct contact with the edible parts of the plant, results in a lower risk of causing foodborne illness outbreaks than produce irrigated using overhead spray systems (Bihn & Gravani, 2006). While it has been suggested that halting irrigation with contaminated water prior to harvest can be an effective strategy to reduce human exposure to pathogens (Qadir et al., 2010), pathogen survival times cited in the literature are highly variable.

Standards for the levels of coliforms in drinking water are well established and fairly consistent throughout the United States. However, irrigation water standards are not well established and are highly variable from state to state, as well as internationally. The World Health Organization has developed guidelines stating that foods eaten raw should be irrigated with water that has less than 100 coliform/100ml in 80% of samples (Okafo et al., 2003). These guidelines were updated in 2006 utilizing a “health-based target approach” to provide more flexibility to international governments in addressing the issue of coliforms in irrigation water (Qadir et al., 2010). Most states call for some level of treatment of reused water that will be applied to food crops, but these rules are

highly variable. The EPA summarizes the states regulations and guidelines related to food crops as follows:

“Average fecal and total coliform limits range from non-detectable to 200/100 ml. Arizona requires no detectable limit for fecal coliform when reclaimed water will be used for spray irrigation of food crops. Florida requires that 75 percent of the fecal coliform samples taken over a 30-day period be below detectable levels, with no single sample in excess of 25/100 ml. Conversely, Nevada requires a maximum fecal coliform count of less than 400/100 ml with only surface irrigation of fruit and nut bearing trees. Again, some states allow higher single sample coliform counts (USEPA, 2004).”

This variability in regulation, coupled with the need for more research in detection methods, contamination risks, modes of human internalization and other relevant issues, indicates the need for caution in creating any guidelines related to human pathogens in irrigation water. The following Good Agricultural Practice guiding principles for crop production water are listed below (GAPsNET, 2009):

- Know routes and handling of surface water sources, seasonal influences, and any microbial monitoring programs of the supplier (if using delivered water).
- Know the history of the land and any prior uses and inputs such as chemicals or fertilizers.
- Identify potential sources of contamination, especially those within ability to control.
- Ensure wells are properly designed and maintained to prevent surface run-off from contaminating the supply.
- Water used for spray irrigation (foliar application) should be from a pathogen-free source.
- Any foliar application of water two weeks prior to harvest should be from a potable or pathogen-free water source.

Manure Use

Manure and other soil amendments provide many benefits to soil fertility and crop growth. Overall productivity of fruit and vegetable crops are often reliant on the organic matter acquired from manures to provide proper nutrients, water-holding capacity, and soil texture. The use of manures for soil fertility also assists the animal production industry in waste management (Bihn & Gravani, 2006). Despite these benefits, the application of soil amendments contaminated with pathogens from animal feces or untreated sewage can cause foodborne outbreaks to occur (Tauxe, 1997).

Cattle, chickens, sheep, and swine naturally shed pathogenic organisms such as *E.coli* O157:H7, *Salmonella* spp., or *Campylobacter jejuni* in their feces, which can then be transferred to fruits and vegetables grown in the field through manure (Beuchat, 2002, Beuchat & Ryu., 1997). Risk for contamination may be linked to the type of animal manure used; cattle manure was found to have *E.coli* O157:H7 present 2.4 times more in comparison to other animal types. In a small-scale comparative study conducted in Minnesota, organically grown produce was compared to conventionally grown produce for the presence of harmful pathogens (Mukherjee et al., 2004). While most samples were virtually free from pathogens, *E.coli* O157:H7 appeared 19 times more on produce grown on the organic produce than the conventional produce. Researchers attributed this difference to organic producers applying manure that was aged less than one year to produce crops. *E.coli* O157:H7 can survive in soil for over 3 months, making manure application within three months of harvest a high risk practice for many fruit and vegetable crops (Kudva et al., 1998). The National Organic Standards for processed animal manure recommends a 120 day interval between application of raw manure and harvest of the crop (USDA, 2010). Furthermore, Islam and colleagues (2005) have

suggested a 210 day period between raw manure application and harvest; citing that pathogen survival is dependent on soil type and temperature, competition from natural flora, and crop type. Although efforts have been conducted to reduce pathogenic organisms in manure through herd management, microorganisms will never be completely removed; therefore proper manure management and composting should be followed (Schamberger et al., 2004).

Prior to application, proper composting is an effective way to reduce pathogen load in animal manures. One misconception about proper composting is that manure can be ‘aged’ by letting it sit in a pile for a specified period of time. Although this method will affect the overall pathogen load, it is not a consistent way to manage manure for food safety concerns (Bihn & Gravani, 2006). The National Organic Standards final rule outlines specific temperature and time requirements for manure composting, and has been shown to be effective in consistently reducing pathogen populations (USDA, 2010). The Good Agricultural Practice guiding principles for manure application are listed below (GAPsNET, 2009):

- Be informed about compost management and documentation for pathogen reduction.
- Obtain documentation about specific compost management for each lot.
- Maximize time between application of raw manure during production and harvest.
- Spreading of manure without incorporation into the soil requires careful attention to ensure pathogen reduction practices have been met.
- Document the dates, locations, and type of manure applied to crops.

Animal Contamination

Some of the most overlooked and difficult sources of contamination to control during fresh fruit and vegetable production are spread by wild and domestic animals. Pathogenic bacteria can be picked up by wild animals as a result of feeding on garbage, contacting raw sewage, or walking through soil that has had fresh manure applications (Beuchat & Ryu, 1997; Powell & Luedtke, 2004). Wild birds potentially harbor bacterial food pathogens in their feces such as *Campylobacter jejuni* and *Salmonella* - and can result in the contamination of fruit and vegetable crops (Hanning et al., 2009). It is not possible to eliminate every animal influence from production fields; however, steps to minimize their presence can be followed. The Good Agricultural Practice guiding principles for minimizing contamination from animals are listed below (GAPsNET, 2009):

- Domestic animals should not be allowed into the field during the growing and harvesting season.
- Minimize the presence of attractants of wild animals (such as cull piles) within the production field area.
- Install fencing, where feasible, to reduce wild animal and livestock contact with produce crops.
- Document animal presence in the field and record corrective actions, if possible.

Worker Health and Hygiene

Lack of worker personal hygiene is one of the most important factors resulting in contaminated produce reaching the end consumer. The degree of an employee's personal hygiene can have a direct impact on the transmission of pathogenic bacteria to produce being harvested (Todd et al., 2009). Agricultural employees are on the frontlines of food safety; providing effective training and making food safety information available

demonstrates to employees that food safety should be a priority. Farm workers often come from culturally diverse backgrounds which may not stress proper personal hygiene as an important behavioral characteristic (Bihn & Gravani, 2006). Insufficient training of food handlers on proper food safety and handling practices is a primary underlying cause contributing to the spread of foodborne illness (Medeiros et al., 2001). Ideally, training will motivate workers to willingly conform to proper sanitary practices. However, a strict requirement should be conveyed that hygienic practices are mandatory regardless of willingness (NACMCF, 1995). Several critical steps can be taken to reduce the incidence of foodborne illness caused by agricultural workers. Sanitary portable toilets and hand washing facilities must be provided and readily accessible to work areas at minimum (Rangarajan et al., 2000). A multi-state survey that was conducted in 2007 indicated that growers and packers who had a knowledge of GAPs were more likely to provide hand washing and toilet facilities for workers on the farm to encourage proper hygiene practices in agricultural operations (Jackson, 2007).

In 1998, forty-three cases of Hepatitis A were confirmed among individuals who ate at a restaurant in Ohio (Dentinger et al., 2001). The outbreak investigation identified that 38 of the 40 affected individuals ate green onions as part of their menu item. The contamination of green onions most likely occurred at the farm level from an ill worker. Green onions require extensive handling at harvest, including peeling the outer layer off the onion, securing the onions in bundles, cutting off the roots, and trimming the stems. Failing to employ simple hygienic practices, such as hand washing, also led to an outbreak of cholera associated with sliced melon (Ackers et al., 1997). Given the large number of cases and high cost of medical expenses related to human fecal pathogens,

hand washing can help reduce the incidence of fecal pathogens such as the Norwalk virus, *Shigella* spp., and Hepatitis A (Medeiros et al., 2001). The Good Agricultural Practice guiding principles for minimizing worker contamination through proper hygienic practices are listed below (GAPsNET, 2009):

- Provide convenient, clean, well maintained, and serviced toilet facilities in the field.
- Supply liquid soap, potable water, and single use paper towels for hand washing.
- Emphasize the importance of restroom use and proper hand washing.
- Reassign sick employees to duties that do not require direct contact with produce.
- Provide training to help workers understand the relationship between food safety and personal hygiene.

Field and Harvest Sanitation

The overall food safety of produce crops, prior to consumer handling, is primarily dependent on the growing environment and pre-harvest conditions. However, farm tools such as harvesting equipment, including harvest totes and bins, may serve as a vehicle for contamination (Bihn & Gravani, 2006). One misconception held by producers is that raw produce is already soiled because it is grown in an agricultural environment and cleanliness with equipment and harvesting materials is not necessary. All equipment and harvesting materials should be constructed of easily cleanable materials and sanitized on a daily basis. For example, if tractors used in the spread of manure are then used in the direct harvest of produce, contamination of produce with harmful pathogens could possibly occur (Brackett, 1999). The following Good Agricultural Practice guiding principles for field harvest and sanitation are listed below (Rangarajan et al., 2000):

- Pressure wash, rinse, and sanitize all produce containers, prior to harvest.
- Cover clean bins before harvest to minimize any contamination by birds and animals.

- Remove field soil from the outside of harvest bins prior to entering the packinghouse.
- Do not allow animals, including poultry or pets, to roam into crop areas, especially close to harvest time.
- Use harvest containers that are made from easily cleanable materials and keep record of sanitation practices.

Packing Facilities and Washing Operations

In addition to harvest equipment, sites with poor sanitation in the washing and packing area can significantly increase the risk of contaminating fresh produce.

Pathogenic organisms can live on floors, ceilings, and drains in the packing facility. They may also remain viable and grow on the surfaces of sorting, grading, and packing equipment. If proper sanitary practices are not followed, any surfaces that come in contact with fresh fruits and vegetables could be a potential source of microbial contamination. The packinghouse should be properly designed and constructed, ensuring that it is protected from the outside environment and maintained in a sanitary manner. Several large produce related outbreaks have been traced back to poor sanitary conditions of packinghouses and washing equipment. A multi-state outbreak of *E.coli* O157:H7 associated with the consumption of mesclun lettuce contaminated at the packinghouse resulted in infection of at least 61 persons, including 21 hospitalizations, and three cases of hemolytic uremic syndrome (HUS) (Hilborn et al., 1999).

Potable water should be used for all postharvest applications, including cooling and cleaning. Operations often recirculate water through these systems to conserve energy; however, dirt and organic matter may accumulate and reduce the effectiveness of chlorinated solutions and increase pathogen populations (Bihn & Gravani, 2006). Sanitizers are primarily used to maintain the bacteriological quality of the water, rather

than reduce populations on fruits and vegetables (Brackett, 1999). Two outbreaks of *Salmonella* infections occurred in 1990 (176 cases of *S. javiana*) and 1993 (100 cases of *S. montevideo*) (Hedberg et al., 1999). Contamination most likely occurred at the packing shed, where tomatoes were dumped into an inadequately monitored chlorinated cooling water bath. Water used in the processing of all fruits and vegetables should be potable and chlorinated to maintain sufficient levels of free chlorine to compensate for the continual addition of organic material. For organic fruits and vegetables, sanitation products must comply with specific regulations. Through the National Organic Program standards, chlorine materials are allowed as long as “residual chlorine levels do not exceed the maximum residual disinfectant limit under the Safe Drinking Water Act.” The limit of free chlorine is currently established by the Environmental Protection Agency at $4 \mu\text{L}\cdot\text{L}^{-1}$ for organic producers (Plotto & Narciso, 2006). The Good Agricultural Practice guiding principles for packing facilities and washing operations are listed below (GAPsNET, 2009):

- Clean and sanitize the packing area and lines daily.
- Be sure to keep animals (such as birds or other rodents) out of the packinghouse and storage facilities.
- Do not allow packinghouse workers to eat or smoke in the packing area.
- Do not wear field clothes, especially shoes and boots into the packinghouse.
- Use chlorinated water and other approved disinfectants to wash produce.
- Accurately maintain chlorine and sanitizer levels in the wash water.
- Change wash water at regular intervals, or when the organic load of the water has increased.

Transportation

Once food has been harvested or processed, it is usually packaged and moved to the location of sale or to the purchaser. Farmers involved in the transportation of produce are encouraged to scrutinize product transport at each level of the system, from the field

to the packing facility and on to distribution and wholesale. The proper transportation of fresh produce helps reduce the potential for microbial contamination. Maintaining frequent communication with personnel responsible for transportation is essential for delivering safe foods to the end consumer (Beuchat, 1997). The Good Agricultural Practice guiding principles for packing facilities and washing operations are listed below (GAPsNET, 2009):

- Ensure that vehicles used to transport fresh produce have not also been used to transport live animals, field products, or any other materials that could cause contamination.
- Transportation workers must practice good hygiene and have taken part in food safety training programs.
- Temperature is maintained and documented.
- A pre-transportation review is completed and documented for cleanliness.
- Produce is loaded and unloaded in trucks in a manner that will minimize damage and cross contamination.

Recall and Traceability

A recall is an action taken by growers, packers, and distributors to remove from commerce consumer products potentially injurious to human health (CDC, 2011).

Traceability refers to the record keeping system designed to trace the flow of product through the production process or supply chain. A recall plan is a written collection of documents that can identify what product has been sold and to whom, who or what will be involved in the actual recall, and how the recall will be carried out to remove all harmful product from the consumers' reach. Through the use of GAPs, documentation and maintenance of a farm food safety plan will address these issues should a recall and traceback become necessary (Chang et al., 2009). In the event of an outbreak, identification investigations can lead to a specific source, rather than an entire commodity, thereby lessening the economic burden on multiple industry operators who

are not involved in the outbreak (Buckley & Reid, 2010). The following Good Agricultural Practice guiding principles for recall and traceability are listed below (GAPsNET, 2009):

- Proper data storage and recording of transactions will ensure product can be traced from farm to fork.
- A program should be developed to track individual units through the supply chain, including field of origin as well as date and packaging location.
- Traceability systems should be used in conjunction with retail stores to ensure that common units of tracking are utilized in the system.

Risk Based Food Systems

Risk Analysis

Risk analysis is widely recognized as the fundamental methodology underlying the development of food safety standards. Risk management is defined within the Codex Alimentarius as the “process of weighing policy alternatives in the light of the results of risk assessment and implementing appropriate control options (FAO, 2007).” The increase in foodborne illness in recent years suggests the need to develop more effective tools for risk management in the current food system. As a result of the risk management process, committees within the Codex Alimentarius system have developed standards, guidelines, and other recommendations for food safety such as GAPs and HACCP (FDA, 1997, 2007b).

The World Health Organization (WHO) has stated that a risk-based approach should be applied to food production and distribution systems worldwide (WHO, 2009). This risk-based system strives to reduce human exposure to foodborne pathogens by preventing, eliminating, or reducing food safety hazards. Many factors have contributed to the global emergence of food safety as a significant issue; better risk assessment and

communication, increased technology applied for safety uses, stricter public health standards, and international cooperation are just a few of the drivers toward the use of risk based systems. In addition, experts and crucial stakeholders in the food system have been major proponents in the development of science and risk-based systems to prioritize and manage foodborne hazards (Ruzante et al., 2010).

The primary goal of risk management with food is to protect public health by controlling such risks as effectively as possible through the selection of appropriate implementation measures (FDA, 1997). Secondly, microbial food safety incidents have often resulted in market disruptions and negative public media attention. By incorporating broader economic and public factors into risk prioritization, those who manage risk will be able to make more scientifically sound and defensible management decisions in an effective and timely manner (Ruzante et al., 2010). These decisions can then be made not only in the interest of public health, but also in the interest of all those involved in the country's food system.

Scientific rationale is increasingly being incorporated into many different approaches to food safety. Through the framework of risk analysis, human health risks caused by foodborne illness can be assessed and better controlled. The World Health Organization identifies a three stage process for risk analysis (Henson & Caswell, 1999).

- 1.) *Risk assessment*: an assessment is made of the human health risk associated with a particular foodborne hazard.
- 2.) *Risk management*: decisions are made according to the acceptable level of risk and methods for control of the risk.
- 3.) *Risk communication*: information about the risk and chosen methods of control are communicated with all involved parties.

Risk Reduction and Adoption of Good Agricultural Practices

Although GAPs and third-party certification do not guarantee food safety, they can reduce the risk that foodborne disease will originate on the farm. In relationship to economic risk reduction, the “positive externality” effect, as economists describe it, can potentially affect the entire produce industry. Essentially, each grower who participates in third party audits or becomes GAPs certified reduces his or her own farm’s risk of spreading foodborne illness, therefore, lowering the risk of an outbreak that affects an entire community of producers. In contrast, the “negative externality” effect occurs when a producer does not adopt GAPs and an outbreak is traced back to his or her farm. Both the producer responsible for the outbreak, as well as the industry suffers as a whole (including those producers who do adopt and follow GAPs) (Rejesus, 2009). For example, in August and September of 2006, a 26 state outbreak of *E.coli* O157:H7 sickened more than 200 people and killed three. The eight-day recall had a major impact on the spinach industry. The spinach industry estimated that the economic losses from this recall ranged from \$37 to \$74 million (FDA, 2007a; Rejesus, 2009). Table 2.2 outlines bagged spinach and salad retail sales value after the 2006 *E. coli* O157 H:7 outbreak.

Table 2.2: Sales of spinach lag, one year after the 2006 outbreak of *E.coli* O157:H7 (Calvin, 2007).

| In 2007, bagged spinach and salad retail sales values still lagged | | |
|---|---|--------------------------------------|
| | Percent change in sales value from a year ago for: | |
| | January 24, 2007- February 24, 2007 | August 24, 2006- January 24, 2007 |
| | <i>Percent</i> | |
| Bagged spinach | -27 | -43 |
| Bagged salad with spinach | -24 | -42 |
| Bagged salad without spinach | -5 | -8 |

The risk of large economic losses, such as a plummet in sales (especially if the produce is traced to a specific farm operation), damage to a producer’s reputation, and potential law suits, may be reduced with adoption of GAPs practices and third-party auditing (Buckley& Reid, 2010; Butte, 2010; GAPsNET, 2009). Lawsuits in the food industry are on the rise due to better scientific methods for proving foodborne illness causation. In 2008, a law firm in Seattle, Washington has reported handling over 1,000 foodborne illness cases originating in locations within all 50 states (Connally & Floyd, 2009). The overwhelming cost of legal action due to a foodborne outbreak can be illustrated by the 2003 outbreak of Hepatitis A, the largest single-source epidemic of the virus in United States history. Green onions contaminated with Hepatitis A were served at a ChiChi’s Mexican Restaurant near Pittsburgh, Pennsylvania. The outbreak was attributed to poor sanitation practices of the four Mexican farms producing green onions

for the restaurant chain (CDC, 2003). The total compensation paid by ChiChi's was over \$50 million (Connally & Floyd, 2009).

For a two week period following the outbreak, estimated losses to the Mexican green onion industry totaled \$10.5 million. A series of interviews were completed in 2004 to determine whether the growers' implementation of GAPs affected their economic loss and subsequent crop demand. The summary of responses is shown in Table 2.3.

Through the implementation of GAPs programs and food safety risk management strategies, some Mexican farmers were able to mitigate the effects the Hepatitis outbreak had on their farm (Calvin, 2004).

Table 2.3: Impact of the 2003 Hepatitis A outbreak on Mexican growers, by GAP status (Calvin, 2004).

| GAP status | Impact on: | |
|--------------------------|---------------------------------------|--|
| | Volume of green onion sales | Demand for other products |
| GAPs | Fairly constant | No impact |
| Partial GAPs | Down a bit | Some impact |
| No GAPs | Down by 50 percent | Down by about 30 percent |
| No GAPs and named by FDA | No sales and most fields plowed under | Shippers stopped selling all or almost all products from these growers |

Web-Based Approaches to Education

In today's high technology society, adults must continually learn new concepts and skills to succeed in their careers (Divine, 1998). Distance education has emerged as a viable and popular alternative to provide educational opportunities to working adults. Educational technology, specifically associated with the internet, is constantly evolving and widely used as a learning tool in both the home and workplace (Garrison et al., 2000). Internet usage in the United States has increased significantly since the turn of the century. In 2009, 69% of households (119 million) compared to 42% in 2000 reported having internet access. In addition, 79% of adults report using the internet at their workplace, home, or school (U.S. Census Bureau, 2009). Along with the increase of internet usage, broadband connections have allowed for the development of live internet broadcasting, or webcasting, educational techniques (Allred & Smallidge, 2010). On-line teaching strategies can help to engage a wide variety of adult learners and outreach methods can be customized to target audiences (Bairstow et al., 2002; Divine, 1998). Despite their convenience and availability for use, several considerations need to be taken into account when developing web-based educational courses and materials.

Distance Learning Advantages and Disadvantages

Outside of the classroom, continuing education has traditionally occurred through workshops and professional conferences. With the emergence of the internet, web-based methods of learning have become an increasingly convenient way to earn continuing education credits as well as acquire new skills and information (Wallner et al., 2007). The online classroom setting provides flexibility while accommodating time constraints of both the educator as well as student (Allred & Smallidge, 2010; Jones et al., 2007). Improved access for geographically dispersed audiences is continually attracting students

who might not otherwise be engaged in lifelong learning opportunities (Garrison et al., 2002). Web-based education can be cost effective for both the educator as well as the student. Online programs are typically more cost effective than publishing printed materials or renting classroom space. Students are able to access materials online from the location of their choice, saving them valuable time and money that travel to a classroom session may require (Jones et al., 2007).

Many of the practices taken for granted in the educational process are removed when learning is taken outside of the classroom setting. Creative ways to address these issues must be incorporated by educators and developers of web-based courses in order to ensure the success of their students (Garrison et. al, 2000). Disadvantages of distance education include inability to interact face-to-face with the instructors and other students, decreased likelihood for participation and asking of questions, distractions from variable learning environments, and technology related issues, such as internet access or usability of the program (Allred & Smallidge, 2010). In addition, the type of student, technological ability, and motivation to self-educate are crucial factors affecting the success of distance education (O'Bryan et al., 2009).

Web-based Educational Technologies

While direct interaction with educators is a valued and effective mode of education, distance education via online materials can also be an valuable tool with the added benefit of being convenient and cost effective (O'Bryan et al., 2009). Two categories of web-based courses are often used for distance education, independent self-paced or interactive. The independent self-paced modules are automated and scripted, typically with no interaction with the instructor or other students taking the course. These

types of web-based course are best suited to teach simple skills or train a user to perform tasks. Interactive courses use a different approach and may include more complex subject matter. This type of course may contain some self-paced information combined with interaction with instructors and other students (Garrison et al., 2000).

The specific web-based education process chosen for this project is a type of interactive method, a series of webinars. The term ‘webinar’ is a union of the words ‘web’ and ‘seminar,’ simply meaning a seminar conducted over the internet. Internet software programs such as Adobe Connect, Go-To-Meeting, and Elluminate, allow for the interaction and collaboration of people over vast geographical boundaries through the World Wide Web. This type of computer platform enables two-way communication between the educator and learner, increasing the effectiveness and involvement of the audience. Typically, a webinar consists of a presentation hosted by a specific service provider on a web server. Webinar features may also include the following characteristics that allow for increased interaction and dissemination of information (Verma & Singh, 2010):

- Sharing application- allows the presenter to share his or her desktop, applications, or other audio and visual materials.
- Chat Window- attendees can ask questions without disrupting the flow of the presentation through entering text comments into the box.
- Private Chat Window- enables attendees to privately ask questions and talk to moderators, educators, and other attendees.
- Session recording- makes the presentation available for unlimited use after the live session has ended, convenient for those who want to review materials or recommend the presentation to others.

- Survey- the presenter may develop a survey or poll to assess course content or for other evaluation purposes.

Adult and Non-Traditional Learning Styles

Delivering educational programs to those of different cultures, educational backgrounds, and under-served audiences can be a rewarding, but challenging task to undertake. A successfully designed learning experience can increase a student's ability to process information and subsequently apply it in their own life. Cultural considerations are one key to determining the scheduling of programs, detail of subject matter, and extent of technology use (Bairstow et al., 2002). Learning style can be defined as "one's preferred way of engaging and processing information." Each person has the ability to utilize a variety of learning styles, however, they may only feel comfortable when using his or her dominant learning style (Divine, 1998). Failing to accommodate these socio-cultural differences may affect the level of participation and usefulness of the program (Bairstow, 2002).

Distance education has come under much scrutiny over the last decade, as these types of educational delivery methods may introduce 'cultural discontinuities,' or lack of a contextual match between the learning conditions and the learner's socio-cultural experiences (Wilson, 2001). Problems arise within web-based education technologies when information from the presentation is misinterpreted or misunderstood by the student. In the classroom, these issues are typically resolved through interactions between the student and teacher, however in distance education, these interactions are often not present or are very weak (Divine, 1998; Wilson, 2001).

As with any educational course, the quality is based on the organization of materials, relevance of activities, and understanding of the audience's learning style. Encouraging students to become active learners is another integral part to the delivery of successful web-based instruction. Both the instructor and student must be self-motivated for distance education to serve as a beneficial learning experience. Although it is unlikely that distance education and web-based educational models will replace traditional classroom education, the potential for these types of programs to serve as an innovative and convenient method of learning persists (Garrison et al., 2000).

Objectives

The overall objective of this study, to increase Colorado producer and consumers' knowledge and participation in safe production and handling of fresh fruits and vegetables, was accomplished in three phases. The first part was a needs assessment to identify perceived benefits and barriers encountered by small farm producers and commercial buyers of Colorado produce to participating in a fresh produce audit verification programs, such as GAPs. Part two consisted of the development and evaluation of a series of consumer-friendly fact sheets containing nutrition, safe food handling, and recommended storage guidelines to promote selected Colorado specialty crops. In part three, a series of three web-based GAPs/GHPs presentations targeting small producers of fresh fruits and vegetables was developed, implemented, and evaluated.

CHAPTER III: METHODS

Approval for this research project was obtained from the Human Research Committee at Colorado State University (Appendix A). This study was divided into three parts. The first part was a needs assessment to identify perceived benefits and barriers encountered by small farm producers and commercial buyers of Colorado produce to participating in a fresh produce audit verification programs, such as GAPs. Part two consisted of the development and evaluation of a series of consumer-friendly fact sheets containing nutrition, safe food handling, and recommended storage guidelines to promote selected Colorado specialty crops. In part three, a series of three web-based GAPs/GHPs presentations targeting small producers of fresh fruits and vegetables was developed, implemented, and evaluated.

Needs Assessment

A needs assessment was conducted to determine the perceived barriers and benefits to participating in fresh produce audit verification programs. A search of current literature revealed information on behavior, attitudes, motivators, and barriers to on-farm food safety and audit verification programs is not available or very limited and therefore data in this subject needed to be collected and analyzed.

Interview Development

Initial interview questions were developed by the author and a panel of three food safety Extension specialists, two agricultural Extension professionals, and one industry

leader for Colorado's GAPs program. The pilot questionnaire was then distributed via electronic mail to select food safety professionals, extension agents, and academic faculty for review. Based on the feedback collected, the questions were further modified to reflect producers and produce buyers as separate target populations. In addition, several specific behavioral intent questions were amended. The interview questionnaire for producers (Appendix B) and produce buyers (Appendix C) consisted of four main sections: 'demographics,' 'requirements and current practices,' 'future participation and interests,' and 'barriers and drivers for adoption.' Each section was tailored specifically to each target population.

Producer Interview

Demographic questions for producers included the gender of interview subject, size of the farm, producer profile, water source used for irrigation, types of products grown and methods of sale, and previous or current participation in fresh produce audit verification programs. Requirements and current practice questions included specific requirements set by produce buyers and distributors, employee training, and transportation logistics. The third set of questions within the future participation and interests section probed for interest in participation for fresh produce audit verification programs and other educational methods for food safety on the farm. Lastly, producers were allowed to elaborate on their perception or experience with fresh produce audit verification programs; more specifically their perceived drivers and barriers for adoption. At the end of the interview, additional comments were requested for the development of educational materials and web-based presentations for the *Good Agricultural Practices: Farm to Table Food Safety for Colorado Producers* series.

Buyer Interview

Demographic questions for produce buyers and distributors included gender of interview subject, type of buyer (wholesale, market, large store, small store), and primary supply source of fresh produce. Requirements and current practice questions included documentation practices for food safety, specific requirements for suppliers (including GAPs or other types of audits), opinions on higher priority crops to be audited, cost assistance, and actions taken in the event of a foodborne illness outbreak originating from a supplier. The third set of questions within the future participation and interests section probed for interest in participation of fresh produce audit verification programs and other educational methods for food safety on the farm. Lastly, produce buyers were allowed to elaborate on their perception or experience with fresh produce audit verification programs; more specifically their drivers and barriers for adoption. At the end of the interview, additional comments were accepted for the development of educational materials and web-based presentations for the *Good Agricultural Practices: Farm to Table Food Safety for Colorado Producers* series to assist growers in successfully passing these types of audits.

Participant Recruitment and Interview Process

Producers listed in the 2010 Colorado Proud Farm Fresh directory were targeted for the needs assessment interviews in this part of the study. Subjects were recruited by using publicly available contact information published in the directory. Participants were chosen by convenience sample from the directory by meeting two fundamental criteria: the producer was located in Colorado and was responsible for the production, packing, or distribution of fresh fruits and vegetables. These identified participants (76) were then

sent an introductory letter (Appendix D) through e-mail describing the project and intent for the telephone interview. Interested participants were then asked to contact the researchers to set up a convenient date and time to conduct the telephone interview. Each producer who agreed to participate was sent an e-mail to confirm the date and time of the scheduled interview. Participants were then telephoned at that specific date and time. Four participants were not available during the originally scheduled call and were contacted the following day to reschedule.

Produce buyers and distributors from a convenience sample of Colorado grocery chains and food distribution companies were targeted for the needs assessment interviews in this part of the study. Subjects were recruited by using referred contact information or publicly available contact information from store managers and company websites. The identified participants were sent an introductory letter (Appendix D) through e-mail describing the project and intent for the telephone interview. Interested participants were then asked to contact the researchers to set up a convenient date and time to conduct the interview.

Interviews were conducted by reading each question from the questionnaire sheet and providing ample time for the participant to respond. The interviews were not recorded but were documented by the researcher through typed responses and structured note-taking. Data were collected and summarized both quantitatively and qualitatively to identify the key themes and responses from the producers and buyers.

Produce Fact Sheets

A series of consumer-friendly, down-loadable fact sheets with nutrition, safe food handling, and recommended storage guidelines was developed to help promote selected Colorado specialty crops including apples, berries, broccoli, leafy greens, melons, peaches, peppers, potatoes, squash, and tomatoes (Appendix E).

Design and Development

The objective of this part of the project was to utilize research-based information to create a series of produce fact sheets to educate consumers on basic nutritional aspects, safe food handling, and storage guidelines for select Colorado specialty crops. A content outline was developed for the fact sheets through collaboration with a graduate level food safety class. The major topics chosen for the fact sheet template included the following: (a) introduction, (b) seasonality, (c) selection, (d) handling, (e) storage, (f) nutrition facts panel, (g) potential uses, (h) recipes, (i) general nutrition, (j) food safety concerns, and (k) references and resources. In order to ensure accessibility, the fact sheets were written in a short format with simple language. Numerous prototypes were developed using Microsoft Word. Each prototype was reviewed by the graduate food safety class and voted upon for final layout, content, and aesthetics.

Expert review was conducted during the initial stages of development of the fact sheets. Reviewers were selected based on their expertise on each particular produce item or produce group. Prior to sending the fact sheets out for review, each expert reviewer was provided with a brief description of the project and asked to participate by reviewing the fact sheet and completing a feedback survey. The focus of the expert review was on the accuracy and usefulness of the content. Several rounds of revisions to the fact sheets

ensued through e-mail distribution to Master Food Safety Advisors (7), academic faculty (7), Extension agents (6), graduate students (6), industry professionals (2), producers (2), and peers (2). Each fact sheet was e-mailed to the specific expert reviewer with instructions for review and preferred dates of review completion. Changes were made according to comments and suggestions from the reviewers.

In addition to the finalized produce fact sheets, a produce fact sheet quiz (Appendix F) was developed to test the knowledge of readers or for use in a classroom or outreach curriculum. Two reading comprehension questions were chosen from each fact sheet for the quiz. The quiz was then posted on the Colorado State University Department of Food Science and Human Nutrition website (www.farmtotable.colostate.edu) on a page entitled “Know Your Farmer/Know Your Food.”

Evaluation Instruments

A formalized survey (Appendix G) to assess the usefulness and pre and post knowledge of the completed fact sheets was distributed using a Google Document online survey to ten reviewers per fact sheet (a total of 100 reviews). Survey participants were recruited from three sections of a graduate level course (EDRM 600- Introduction to Research Methods), a convenience sample of graduate students in the department, and an e-mail listserve for Master Food Safety Advisors. An e-mail was sent to each participant with the URL for the online survey which was active to collect responses for one week after the e-mails had been sent.

A paired sample t-test was conducted to determine pre- and post-knowledge of the basic fact sheet topic as well as food safety and preservation. The results of the survey

questions regarding usefulness of specific fact sheet aspects were also summarized to identify areas where revisions were focused.

Potential Uses and Availability

The produce fact sheets were intended to be used by both producers and consumers for the promotion of Colorado specialty crops. The fact sheets will aid in mitigating food safety concerns while promoting locally grown fruits and vegetables as healthful diet choices. Extension professionals and educators may also benefit from using or recommending these fact sheets to buyers and consumers of fresh produce. The finalized produce fact sheets were published on the Colorado State University Department of Food Science and Human Nutrition website on a page entitled “Know Your Farmer/Know Your Food.” Each fact sheet as well as the produce quiz can be downloaded in PDF form and printed.

Good Agricultural Practices Webinars

Although Colorado is a major producer of fruits and vegetables, as of May 1, 2009, only 14 Colorado producers had successfully passed an initial audit under the voluntary United States Department of Agriculture (USDA) GAP/GHP Fresh Produce Audit Verification Program. The purpose of the audit-based system is to verify the risk of contamination has been minimized through the use of good agricultural and handling practices. In order to address these issues, a series of three web-based GAPs and GHPs trainings were developed, implemented, and evaluated targeting small farm producers of fresh fruits and vegetables. The approach of developing technology-based training modules (webinars) allowed for improved accessibility to growers across the state while accommodating their variable time schedules. By participating in the webinar trainings,

growers, their employees, and other stakeholder groups in the food industry were provided the appropriate resources and information to aid in implementing Good Agricultural Practices and Good Handling Practices on the farm.

Course Development

Farm to Table Food Safety for Colorado Producers was designed as an online, distance-based educational series primarily targeting Colorado producers; however, produce buyers, Extension agents, educators, students, and other industry professionals were also identified as potential participants. The first step in the project's development involved identifying course objectives for each webinar, with the intent to give participants a summary of important course concepts during three, one-hour webinar sessions. These objectives were adapted from the National Good Agricultural Practices Program developed by Cornell University (2009) and the current Food and Drug Administration's Guide to Minimize Food Safety Hazards for Fresh Fruits and Vegetables (1998). To tailor the webinar sessions and course content specifically to Colorado producers, the initial telephone interview (needs assessment) as well as collaboration with the Colorado GAPs coordinator identified other topics of importance. Three modules were developed with content based on the following topics:

- **Module One-Introduction to Food Safety On the Farm:** Foodborne illness, sources of contamination, regulatory landscape, third party audit basics, and worker health and hygiene
- **Module Two-Minimizing Risks During Production:** manure handling and application, water quality, sources, and testing
- **Module Three-Minimizing Risks During Harvest and Post-Harvest:** washing and packing operations, cooling and storage, and transportation and traceback

To assure content accuracy and validity, an expert review was conducted throughout the formative stages of each webinar. Academic and industry professionals in each field related to the webinar topics were contacted and sent the webinar presentations via e-mail for review. Several rounds of revisions ensued to produce credible and science-based presentations that reflected current industry practices, as well as current and possible future food safety regulations. Comments from reviewers were received by e-mail and were compiled and summarized using Microsoft Word. The presentations were then edited and revised per the suggestions of the expert reviewers. Finalized PowerPoint slides were then loaded into the Adobe Connect program one day prior to the scheduled webinar session to ensure their compatibility and proper display.

Slides featured the main points for each lecture topic based on the adapted content from the National GAPs Program and the FDA guidelines. To boost participation and attention, an interactive quiz was conducted half way through each of the webinar sessions. Participants were able to choose the correct answer, see the results, and engage in discussion through the chat box. A loose script for the audio was also written to prompt the speaker for each slide. Webinar participants were able to see the PowerPoint slides advance on their computer screens while simultaneously hearing audio and seeing a live or static photo of the presenter. The intended length for each module was 60 minutes, including ample time for questions and answers. Two remotely based guest speakers were invited to join the sessions to assist in answering questions at the end of the presentation.

Technology

Course content was presented on Microsoft PowerPoint slides utilizing Adobe Connect, an internet-based software conferencing program. Participants were provided a web link to log onto the Adobe Connect session at the time of the scheduled presentation. Participants did not need a name or password to enter the session, but were prompted to 'Enter as a Guest' into the online conference room. Both audio and video were utilized to broadcast the presentations from a location on the Colorado State University campus. Each session was recorded and active links were created for post-presentation viewing. The active links for the recorded presentations were then posted on the Colorado State University Department of Food Science and Human Nutrition Farm to Table Food Safety website. In addition to the recorded and posted webinar sessions, a PDF of the PowerPoint slides (Appendix H) was created and posted onto the Farm to Table website for download. Participants were able to communicate with the presenter, session moderator, and other webinar participants through a chat box feature. The chat box was also utilized to collect participants' names and e-mail addresses for attendance purposes. In addition to on-site broadcasting equipment, audio was connected via telephone for two remotely based topic experts in the field of GAPs and organic agriculture.

Recruitment

Participants were recruited by utilizing ten different electronic mail listserves through Colorado State University and the Colorado Department of Agriculture reaching from local producers in Colorado to more remote locations, even as far as Guam. The recruitment e-mail included either a.) A plain text description of the webinar series or b.) A description of the webinar series with attached PDF of the webinar invitation

(Appendix I). Included within the invitation was a web link directing interested participants to a Google Documents survey (Appendix J). The survey was designed as a method to track attendance as well as collect demographic and self-reported pre-knowledge and topic interest information. Through this survey, informed consent to participate in the webinars and subsequent evaluative surveys was implied.

Launch

After discussion with several producers and Extension professionals, it was determined that late winter/early spring would be the best time for producers to attend the sessions due to their seasonal availability. Sessions were conducted on three Wednesdays in March 2011 during the lunch hour, from noon to 1:00 PM, so that producers had a better opportunity to attend the sessions without interrupting their busy work day. Each session had more than 50 participants in attendance. For those participants who were unable to attend a particular session, a recording of the presentation was made available on the Farm to Table website (www.farmtotable.colostate.edu) within five days of the original launch and before the next scheduled session.

Incentive

As an incentive, participants who attended two or more webinar sessions were eligible to receive water testing kits for fecal coliform and *E. coli* count (a \$30 value) from the Colorado State University Environmental Water Quality Laboratory and a certificate of participation (Appendix K) in the series. E-mail addresses were collected at the time of the presentation through the chat box feature for attendance tracking purposes. Those who qualified for the incentive (attended two or more webinar sessions) were

contacted by e-mail within one week after the last webinar session to notify them of their eligibility and to provide instructions (Appendix L) for the next steps should they be interested in receiving a water testing kit. Qualified participants then provided a mailing address, phone number, and indication of whether they would like to receive both a water testing kit and certificate, or just the certificate. Water testing kits were mailed via campus United Postal Service (UPS) to each participant (32 total). Each water testing kit included a 125 mL plastic sampling bottle, latex gloves, an ice pack, a pre-paid, overnight return mailing label, instructions for sampling methods, and a laboratory sample submission form. Upon receipt of the water testing kit, participants were given specific instructions for the return of the kits to the Environmental Water Quality Laboratory. Cumulative water quality data will be analyzed by another member of the research team in the summer months of 2011. Results will be provided to each participant, including an interpretation of the data.

Evaluation Instrument

Feedback and evaluative information was gathered using pre- and post-questionnaires. The first instrument was designed to collect demographic information, potential topics of interest for content development, and initial knowledge of the proposed webinar topics (Appendix J) using a Google documents survey in December of 2010. Self-reported knowledge of the proposed webinar topics was evaluated using a 5-point Likert scale format: no knowledge, slightly knowledgeable, neutral, moderately knowledgeable, and extremely knowledgeable. Proposed webinar topics included in the knowledge assessment were: food safety basics, food safety legislation, liability, third party auditing, worker hygiene and health, manure management, water quality and

irrigation practices, washing and packing operations, cooling and storage, transportation, and traceability and recall.

The second evaluative piece developed for the three-part webinar series was a course evaluation instrument (Appendix M). Upon completion of the third webinar, a list of participant e-mails was compiled and used to distribute a Google Document evaluation survey and further information about the project incentive. The follow-up survey included initial evaluation questions related to the presentation content, speakers, and features. Participants were also asked to rank their knowledge of the webinar topics using the same 5-point Likert scale used in the pre-evaluation instrument. The last basic evaluation question asked each survey participants to indicate their profession. Based on their profession, participants in the survey were forwarded to a specific page tailored to their answer. Producers were asked the most rigorous set of questions to collect behavioral intent data. Extension professionals, educators, and industry professionals were also asked to rank their intent to utilize the recorded sessions, materials presented, and knowledge they obtained from the webinars directly or indirectly in their profession.

Data Analysis

Data that were collected from the pre- and post-surveys were analyzed qualitatively or quantitatively, depending on the type of question. All quantitative statistical tests were conducted using SAS Windows software (release 9.2). Differences between the mean scores of the pre and post knowledge questions were evaluated using a t-test to compare self-reported knowledge on a 5-point Likert scale. Qualitative responses were reviewed and then categorized according to general themes of statements.

CHAPTER IV: RESULTS AND DISCUSSION

There were three parts to this study designed to focus on the safe production and handling of a variety of Colorado grown produce crops. The first part was a needs assessment to identify perceived benefits and barriers encountered by small farm producers and commercial buyers of Colorado produce to participating in fresh produce audit verification programs, such as GAPs. Part two consisted of the development and evaluation of ten consumer-friendly fact sheets containing nutrition, safe food handling, and recommended storage guidelines to promote selected Colorado specialty crops. In part three, a three-part web-based GAPs/GHPs series targeting small producers of fresh fruits and vegetables was developed, implemented, and evaluated.

Needs Assessment

A needs assessment was conducted to identify the perceived benefits and barriers encountered by small farm producers related to participating in fresh produce audit verification programs as well as gather information from commercial buyers and distributors of Colorado produce on potential opportunities.

Producer Demographics

Demographic information was collected from nine producers who completed the telephone interview. Table 4.1 shows the demographic distribution of participants by gender, size of farm, producer profile, water source, farm items produced/sold, primary methods of sale, and GAPs audit participation. As shown, most interviews were conducted with males, most often who were the farm owner. The majority of interview

participants farmed between two and eight acres of land with a variety of organic and conventional fruits and vegetables. The most common irrigation water sources were municipal (45%) and surface water (36%). Irrigation water quality plays a significant role in the safety of fresh produce. Contamination of both surface and ground water sources may occur from infected livestock or improperly treated effluents, such as sewage from treatment plants (Bihn & Gravani, 2006).

The original target number of participants to be recruited for the producer telephone interviews was 15-20 fruit and/or vegetable producers from various regions across Colorado. Thirteen producers responded (17% response rate) with interest to participate in the study. A total of eleven telephone interviews were conducted. Two participants requested not to have their information shared or decided to end the telephone interview prematurely. The researchers experienced challenges in both initial response rate and willingness to share potentially sensitive information. Given the narrow sampling frame (focusing on small growers in Colorado), as well as the volume of non-response, it appears the sample of producers interviewed may not be representative of a broader set of produce growers across the nation. The sample may also be biased toward producers who may be more supportive of GAPs and other food safety regulation and were more willing to share their current on-farm food safety practices.

Table 4.1: Demographic distribution for producer needs assessment participants (n=9).

| Category | Frequency (%) |
|---|---------------|
| Gender of interview subject | |
| Male | 8 (89%) |
| Female | 1 (11%) |
| Size of farm | |
| >8.0 acres | 1 (11%) |
| 4.0-8.0 acres | 4 (45%) |
| 2.0-4.0 acres | 3 (33%) |
| <2.0 acres | 1 (11%) |
| Producer Profile | |
| Grower/Packer/Shipper | 4 (45%) |
| Grower/Packer | 2 (22%) |
| Grower | 3 (33%) |
| Water Source^a | |
| Municipal | 5 (55%) |
| Well | 2 (22%) |
| Surface | 4 (44%) |
| Farm Items Produced/Sold^a | |
| Organic Fruits | 3 (33%) |
| Organic Vegetables | 4 (44%) |
| Conventional Fruits | 2 (22%) |
| Conventional Vegetables | 5 (55%) |
| Beef/Poultry | 2 (22%) |
| Flowers | 3 (33%) |
| Primary Method of Sale^a | |
| Farmers' Market | 4 (44%) |
| CSA | 3 (33%) |
| Local Store | 3 (33%) |
| Farm Stand | 2 (22%) |
| Wholesale | 2 (22%) |
| GAPs Audit Participation | |
| Yes | 2 (22%) |
| No | 7 (88%) |

^aUnaided response- Totals sum to more than 100 percent because respondents could enter multiple responses

Producer Interview Summary

Semi-structured interviews were conducted with nine producers and lasted an average of 15 minutes (range, 8-25 min). In order to identify the potential drivers for adopting GAPs, a series of questions were asked about producers' requirements and current practices regarding on-farm food safety. In addition, future participation and interests in fresh produce audit verification programs were assessed (Table 4.2). Four out of nine producers were required to provide handling or documentation of food safety practices to their buyers. Specific information requested by produce buyers was organic standards, packing specifications, lot numbers (for traceability), temperature logs, and for two producers, proof of GAPs audit participation. Providing this information to produce buyers strengthens business connections and keeps all parties up to date on current on-farm practices for food safety. Open and transparent communication between buyers and sellers can help identify and mitigate food safety risks encountered on the farm (Chapman, 2005b). Five producers indicated they had been asked to detail their production methods to their buyers. Two of the producers indicated this was a necessity to ensure proper practices for the production of organic fruits and vegetables. However, the remaining producers noted this conversation was typically brief and occurred when the purchase agreement was made but did not necessarily include specific information about on-farm food safety. Providing verification of proper agricultural practices to buyers, both for food safety purposes and the co-management of land, can demonstrate the adopted program or set of standards is achieving its intended goals (Chapman, 2005b).

A majority of producers (67%) indicated their employees are required to participate in some sort of food safety training, prior to starting work. However, the

methods mentioned indicate a majority of producers (80%) do not have a structured food safety training curriculum and rely on on-the-job training to educate their employees. Only one producer mentioned the use of a science-based, food safety training video that included information on personal hygiene and produce handling. Two other producers, who were also processors of value-added fruits products such as cider and jam, had at least one employee on-site who had completed a food handler's ServSafe training during daily production. Insufficient training of food handlers on proper food safety and handling practices is a primary underlying cause contributing to the spread of foodborne illness (Medeiros et al., 2001). Lack of worker personal hygiene is also an important factor resulting in contaminated produce reaching the end consumer. The degree of an employee's personal hygiene can have a direct impact on the transmission of pathogenic bacteria to produce being harvested (Todd et al., 2009).

Both quantitative and qualitative losses occur in horticultural crops between harvest and consumption (Kader, 2005). Seventy-eight percent of producers responded they were aware of these issues surrounding post-harvest operations. Although temperature is primarily utilized to extend shelf-life by slowing down metabolic processes and retarding the growth of spoilage bacteria, it also plays a significant role in maintaining the safety of food. It has been shown that pathogenic and spoilage bacteria can proliferate at warmer temperatures, therefore resulting in an increased microbial load on the produce (McEvoy et al., 2009). In order to minimize the growth of harmful bacteria, if present, producers must take into account the perishability of their produce from the time of harvest through cooling, storage, and delivery.

Colorado producers' interest in learning more about food safety on the farm can be supported by a positive, 78% response rate for interest to participate in the educational webinars described in this project, *Farm to Table Food Safety for Colorado Producers*. In a 2010 report detailing producers, trainers, and regulatory agents' perspectives on GAPs curriculum, trainers and auditors most frequently cited that a lack of skilled staff and a shortage of money to provide educational trainings was a major barrier in producers' access to GAPs education (Butte, 2010). Furthermore, small growers were particularly at a disadvantage because of lack of financial support to implement farm-specific food safety plans. Most often, small producers were using farm food safety plans or templates that were originally created for large produce productions. The webinar series developed through this research project can address both the financial and educational accessibility barriers encountered by small producers in Colorado.

Table 4.2: Producer telephone interview responses.

| Survey Responses: Producers | Survey Responses (n=9) | |
|--|-----------------------------------|-----------|
| | Yes | No |
| <p>Have any of your commercial buyers required specific handling or food safety practices before delivery of your products?</p> <p>Note: Specifications included- organic standards (2), packing specification (1), lot number (3), temperature specifications (3), GAPs Audit Certification (2)</p> | 4 (44%) | 5 (55%) |
| <p>Are your employees required to participate in any food safety training prior to starting work?</p> <p>Note: Specifications included- ServSafe (2), on-the-job training (4), food safety video (1)</p> | 6 (67%) | 3 (33%) |
| <p>Does the perishability of your produce affect your post-harvest or transportation methods?</p> <p>Note: Specifications included- refrigerated storage (4), refrigerated transportation (3), first-in/first-out methods (2), removal of field heat (1)</p> | 7 (78%) | 2 (22%) |
| <p>Are you required by your consumers or commercial buyers to provide information about the type of production methods that were used?</p> <p>Note: Specifications included- organic standards (2)</p> | 5 (55%) | 4 (44%) |
| <p>If a series of hour long online training webinars on GAPs was available at no cost, would you be interested in participating?</p> | 7 (78%) | 2 (22%) |

Producer Barriers and Drivers for Adoption of GAPs

Table 4.3 outlines the reported producer benefits and barriers to adopting GAPs. Only two out of seven of the interviewed producers had participated in a GAPs audit. The two producers who had experienced a GAPs audit were satisfied with how their programs were functioning, both as a marketing tool and method to assure food safety practices on the farm for reduced liability. Although a few of the remaining un-audited producers described having “food safety plans,” “operating procedures,” or “standard practices,” 44% generally reviewed their current practices as sufficient with no need or strong desire to participate in a fresh produce audit verification program. Instead, these producers described specific practices, such as not using raw manure to fertilize their crops, as methods they believed would reduce the potential for a foodborne illness outbreak to originate on their farm.

Producers noted they did not always see the value of adopting specific GAPs, in terms of real risk reduction. GAPs trainers and auditors have cited this is one of the most common issues they encounter while performing or educating producers about audits (Butte, 2010). One auditor noted that changing the culture of traditional farming methods for those who have been in business for 50 or 60 years is difficult, but can be done by encouraging producers to consider the overall management of their farms. Many requested scientific evidence regarding which GAPs were proven effective. One producer voiced his concern that he felt GAPs were not based on common metrics, for instance, why producers have been instructed to locate vegetable production areas no less than *a mile* from a feedlot. Growers tended to express more concern about the sources of contamination they viewed as being “outside of their control”, such as contamination from wildlife, flooding, or run-off from a neighboring farm. Time constraints, confusing

guidelines, and ever-changing regulations were also described as barriers to the adoption of GAPs. In response to these concerns, the webinars were launched at a convenient time of the year for producers and content was developed to address current and future regulations in the industry, such as the recently passed Food Safety Modernization Act (FDA, 2011).

The cost of program implementation was cited as the second most common barrier to the adoption of GAPs. Half of the producers interviewed considered themselves small farms and indicated they were already optimizing their productions to be more cost effective in tight economic times. Three producers provided suggestions to help alleviate the economic burden of participating in third party audits including sponsoring cost-shared opportunities for growers or providing additional grant money. In Colorado, the estimated cost of participating in a GAPs audit for a small producer is \$368-\$552 annually (Vanderpool, 2011). This estimate includes the cost per hour for auditor services (typically 4-6 hours total) as well as potential changes that need to be made to become compliant with GAPs. The costs of GAPs adoption may vary widely depending on the type of crop grown, acres in production, and type of production system, prior to the adoption of GAPs. For example, a large, 47 acre strawberry farm located in California has an estimated cost of \$8,000 for GAPs implementation. This amount is likely too large for most of the growers in the study, but is manageable for a larger-scale producer (Woods & Thornsby, 2005).

The telephone interviews with producers suggest that current food safety goals and activities on the farm are primarily driven by the desire to protect their financial interests. The risk of large economic losses, such as a plummet in sales (especially if the

produce is traced to a specific farm operation), damage to a producer's reputation, and potential law suits, may be reduced with adoption of GAPs practices and third-party auditing (Buckley & Reid, 2010; Butte, 2010; GAPsNET, 2009). With a rise in the number of foodborne illness outbreaks associated with produce in the past 20 years, more produce buyers are requiring their suppliers to have methods in place for food safety. As an added benefit to audit participation, producers may experience improved market access to meet the demands and desires of major super market chains, school systems, restaurants, and other market outlets (Rejesus, 2009).

Another recurring theme of the telephone interviews was that media attention due to produce outbreaks is detrimental to the integrity of fresh fruit and vegetable production in the United States. Public concern and discussion of food safety and food-related risks has increased in recent years. For consumers in the United States, most knowledge of food safety issues is obtained through media outlets (Chapman, 2005). With each reported outbreak, there is potential for the erosion of trust in the safety of fruits and vegetables and the credibility of the industry that produces them. Several producers did see the value of GAPs in the event of a publicized foodborne illness outbreak; producers noted that having a system in place to reduce foodborne illness helps to increase consumer and buyer confidence that their produce is safe.

Table 4.3: Producer perceived barriers and drivers for the adoption of GAPs (n=9).

| Survey Responses: Producers | Frequency (%) |
|---|---------------|
| What do you think are the key barriers to implementing GAPs? | |
| <i>Barrier^a</i> | |
| Current practices work, no need for implementation | 4 (44%) |
| Cost of implementation | 4 (44%) |
| Time constraints | 3 (33%) |
| One Size Does Not Fit All | 3 (33%) |
| Ever-changing regulations | 3 (33%) |
| Guidelines are confusing | 2 (22%) |
| Need feasible, credible standards | 2 (22%) |
| | |
| What do you think are the key drivers to implementing GAPs? | |
| <i>Driver^a</i> | |
| Protect financial interest | 3 (33%) |
| Commodity specific guidelines | 3 (33%) |
| Customer expectation/requirement | 2 (22%) |
| Public knowledge of outbreaks/media attention | 1 (11%) |
| Land stewardship | 1 (11%) |
| Shared responsibility | 1 (11%) |

^aUnaided response- Totals sum to more than 100 percent because respondents could enter multiple responses

Produce Buyer/Distributor Demographics

Demographic information was collected from five commercial producer buyers who completed the telephone interview. Buyers were classified as individuals who serve in a management capacity for organizations that purchase produce from growers. These organizations may sell produce as retail, package the produce, or transport the produce to other retail customers. Five produce buyers and distributors agreed to participate (63% response rate) and were then sent a confirmation e-mail with the date and time of their telephone interview. All five produce buyers and distributors were interviewed at the scheduled date and time. Table 4.4 shows the demographic distribution of participants by gender, type of produce buyer, and primary sources of fresh produce. As shown, most interviews were conducted with males; three were quality control specialists and two held

produce manager positions. All five participants worked for large, nationally-based grocery chains. Buyers purchased the majority (80%) of their produce from large farms or wholesale distributors.

Table 4.4: Demographic distribution for produce buyer/distributor needs assessment participants (n=5).

| Category | Frequency (%) |
|---|---------------|
| Gender of interview subject | |
| Male | 4 (80%) |
| Female | 1 (20%) |
| Type of Produce Buyer/Distributor | |
| Large grocery chain | 5 (100%) |
| Primary Sources of Fresh Produce^a | |
| Large Farm | 4 (80%) |
| Large Wholesaler | 4 (80%) |
| Small Farm | 2 (40%) |
| International | 2 (40%) |

^aUnaided response- Totals sum to more than 100 percent because respondents could enter multiple responses

Produce Buyer Interview Summary

Semi-structured interviews were conducted with five produce buyers that lasted an average of 18 minutes (range, 15-25 min). In order to identify the potential drivers for adopting GAPs, a series of questions were asked about the buyers’ requirements for their suppliers regarding on-farm food safety. In addition, future participation and interests in fresh produce audit verification programs was assessed (Table 4.5).

Table 4.5: Produce buyer telephone interview responses.

| Survey Responses: Produce Buyers | Survey Responses (n=5) | |
|---|---------------------------|----------|
| | Yes | No |
| Do you require documentation of food safety, harvesting, or temperature management upon receipt of your fresh products? | 4 (80%) | 1 (20%) |
| Do you require your producers to participate in Good Agricultural Practices (GAPs) certification or other fresh produce audit verification programs? | 2 (40%) | 3 (60%) |
| Does your company help with the cost of third party audit certification, if required? | 0 (0%) | 5 (100%) |
| Are you planning to participate in these fresh produce audit verification programs in the future? | 5 (100%) | 0 (0%) |
| If a series of hour long online training webinars on GAPs was available at no cost, would you be interested in participating? | 5 (100%) | 0 (0%) |

In the wake of the recently passed Food Safety Modernization Act, many producers were concerned about impending mandatory regulations for on-farm food safety. However, for small producers, exemptions from these proposed regulations exist. Farmers with total sales of less than \$500,000 are exempt from requirements as long as half of sales are directly to "qualified end users," such as in-state consumers, restaurants, or grocery stores or to out-of-state locations if they are less than 275 miles from the farm (FDA, 2011). Despite these exemptions, all of the produce buyers interviewed indicated they have been moving toward GAP requirements, if they have not already mandated third-party audits for their suppliers. Only two of the interviewed produce buyers required their suppliers to participate in GAPs audits annually. However, four out of five

produce buyers required some type of food safety documentation to be provided. Most often cited by buyers for documentation was produce washing methods and temperature management logs.

As identified in the producer telephone interviews, the economic costs must be weighed against the potential benefits of GAPs adoption for small producers. The produce buyers interviewed in this study did not provide additional aid in sharing the cost of the GAPs audit process with their suppliers. However, some states have adopted cost-share programs to help shoulder the cost of third-party audits (Rejesus, 2009). While produce buyers may not always be willing to share the cost of third-party audits with their suppliers, all interview participants indicated that they were interested in obtaining additional education for themselves or their supplier to assist in completing a successful audit.

Produce Buyer Barriers and Drivers for Adoption of GAPs

Historically, producers and retailers have been hesitant to communicate their risk reduction strategies to consumers. By acknowledging that the producer or retailer is utilizing a risk reduction strategy may cause consumers to believe that there is something wrong with the product, in turn causing them to choose a product that does not acknowledge risks (Powell & Chapman, 2007). However, due to the increase in the number of foodborne illness outbreaks associated with fresh produce in the last 20 years, national attention has been directed towards grower practices and produce handling (Rangarajan, 2002). Although buyers noted that producers often have negative perceptions about GAPs audits being onerous, they noted that audits will be necessary to maintain market share in the future in response to the increased number and awareness of

foodborne illness outbreaks. Table 4.6 details buyers' perception on the barriers and benefits to participation in GAPs audits.

Table 4.6: Produce buyers perceived barriers and drivers for the adoption of GAPs (n=5).

| Survey Responses: Produce Buyers | Frequency (%)^a |
|--|--------------------------------------|
| What do you think are the key barriers to implementing GAPs? | |
| <i>Barrier</i> | |
| 'One size does not fit all' | 3(60%) |
| Cost of implementation | 2(40%) |
| Time Constraint | 2(40%) |
| Producer belief that GAPs are unproductive | 1(20%) |
| What do you think are the key drivers to implementing GAPs? | |
| <i>Driver</i> | |
| Buyer expectation/requirement | 3(60%) |
| Marketing strategy | 3(60%) |
| Protect financial interests | 2(40%) |
| Maintain product quality and safety | 1(20%) |
| Commodity specific guidelines | 1(20%) |
| Are there specific crops you feel are of higher priority to be GAPs audited? | |
| <i>Commodity</i> | |
| Leafy Greens | 4(80%) |
| Tomatoes | 4(80%) |
| Peppers | 3(60%) |
| Melons | 3(60%) |
| Berries | 2(40%) |
| Root Vegetables | 2(40%) |
| What type of information might help better prepare your suppliers for an audit? | |
| <i>Response</i> | |
| On-site visits | 3(60%) |
| Clear expectations from buyer | 2(40%) |
| Classroom training | 1(20%) |
| Printed guides | 1(20%) |
| Web-based materials | 1(20%) |

In 2000, following the release of FDA's Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables (1998), many major retailers communicated the requirement of participation in GAPs as overseen by approved third party auditors for fresh fruits and vegetables (Suslow, 2000). Produce buyers in this study indicated that standardized audits and regulations were not easily adapted to different types and sizes of farms. The "one size fits all" approach to on-farm audits for food safety should not enable growers to become automatically GAP certified. Instead, growers must be properly educated on the science-based principles that are the foundation to GAPs in order to tailor food safety plans to their farm (Rejesus, 2009). As discussed in the producer interviews, time constraints as well as the cost of implementation were listed as potential barriers by produce buyers.

Sixty percent of produce buyers said that buyer expectations and marketing strategies were the major drivers for the adoption of GAPs. Industry guidelines have driven the major reform regarding food safety in the produce industry within the last decade. The California Leafy Green Market Agreement, Produce Marketing Associations' Commodity Specific Guidelines for the Melon Supply Chain, and the Colorado Potato Administrative Committee are just a few examples of commodity specific food safety and GAPs guidelines put in place for producers of fruits and vegetables (Osterholm et al., 2009). Through partnership with industry associations, improved market opportunities exist for growers who are able to assure their buyers that they have followed the appropriate food safety practices on their farms (Bihn & Gravani, 2006). One of the primary incentives for on-farm food safety programs is to maintain

market share and strengthen relationships with customers and consumers by enhancing trust through proactive food safety programs (Chapman, 2005).

Although GAPs is a holistic approach to food safety and can apply to a variety of crop types, specific commodities have been shown to be at higher risk for foodborne illness outbreaks (Brackett, 1999). Coincidentally, when buyers were prompted to indicate which crops they believed were of higher importance to be GAPs audited, leafy greens, tomatoes, peppers, melons, and berries were listed. Repeated outbreaks have been associated with specific fruits and vegetables; including, but not limited to: tomatoes, melons, and leafy greens such as lettuce and spinach (FDA, 1998). Lastly, buyers were asked what type of materials might be of use to help prepare their suppliers to successfully pass a GAPs audit. On-site visits were mentioned most frequently, however this method is quite costly and may not be practical for smaller producers (Powell et al., 2002). Instead, clear expectations between buyer and producer, formal classroom training, and printed or web-based materials were suggested to improve grower knowledge and participation in GAPs.

Produce Fact Sheets

A total of 100 different reviewers were chosen to participate in the evaluation of the produce fact sheets. Ten different reviewers for each fact sheet were asked to rate their knowledge of the overall fact sheet topic (apples, berries, broccoli, leafy greens, melons, peaches, peppers, potatoes, squash, and tomatoes) as well as their broad knowledge of food safety, unrelated to the fact sheet topic, before and after reading the material. In addition, the reviewers were asked to rate the usefulness of the major topics incorporated into the fact sheet including: (a) introduction, background, and history, (b)

produce handling and storage, (c) nutritional information and recipes, (d) preservation, (e) fun facts and helpful hints, and (f) the overall usefulness of the fact sheet.

Pre to post-knowledge survey scores and mean change were evaluated for the first two questions in Tables 4.7 and 4.8 using paired t-tests. Appendix N details the self-reported pre and post knowledge score frequencies for each of the individual fact sheets that were rated on a five point Likert scale, where 1= No knowledge and 5=Advanced knowledge . The overall knowledge of the fact sheet topic (one of ten produce items) indicated that reviewers had a basic or slightly above average knowledge of the topic prior to reading the fact sheet (Table 4.7). For all fact sheets, positive score changes from before to after reading indicate that participants gained enough knowledge by reading the fact sheets to rate their perceived knowledge higher after reading. The apple, berry, and pepper fact sheets had the greatest positive mean change and significance from pre to post scores.

In Table 4.8, reviewers indicated that their perceived knowledge of food safety, preservation, storage, and handling of that particular produce item after reading the fact sheet was higher than before reading the fact sheet. Also notable in Table 4.8, the melon, peach, and potato fact sheets had the lowest mean change in scores. This may be due in part to the fact that Colorado is a national leader in the production of those specific crops. Colorado residents may be more familiar with these commodities because of their local presence and national recognition, for instance peaches from the Western Slope, potatoes from the San Luis Valley, or cantaloupes from Rocky Ford. The results of Tables 4.7 and 4.8 indicate the educational fact sheets are an effective tool to teach consumers about the safe handling of fresh produce.

Table 4.7: Mean scores for self-reported knowledge before and after reading the fact sheet (n=100).

| | | Apple | Berry | Broccoli | Leafy Green | Melon | Peach | Pepper | Potato | Squash | Tomato |
|--|------------------------|-----------------------|--------------------|----------|-------------|----------|----------|--------------------|--------------------|----------|----------|
| Please rate your knowledge of the fact sheet topic, before and after reading.¹ | Mean Pre-Score | 3.0±0.94 ² | 3.1±1.3 | 3.4±1.07 | 3.6±1.5 | 3.1±1.37 | 3.5±1.72 | 3.4±0.70 | 3.9±0.74 | 3.4±0.97 | 3.6±1.26 |
| | Mean Post-Score | 3.9±0.74 | 3.8±0.79 | 3.5±0.52 | 4.2±0.79 | 3.7±0.94 | 4.1±0.88 | 4.1±1.0 | 4.3±0.82 | 3.4±0.97 | 4.1±0.73 |
| | Mean Change | +0.9 | +0.7 | +0.1 | +0.6 | +0.6 | +0.6 | +0.7 | +0.4 | 0.0 | +0.5 |
| | t Value | -2.59 ^c | -3.28 ^b | -0.43 | -1.96 | -2.25 | -1.96 | -4.58 ^a | -2.45 ^c | 0.00 | -2.24 |

¹ Mean questionnaire score on a scale of 1-5; 5=Advanced knowledge and 1= No knowledge

p<0.005^a, p<0.01^b, p<0.05^c

² ± Standard Deviation

Table 4.8: Mean scores for knowledge of food safety, preservation, and produce storage and handling before and after reading (n=100).

| | | Apple | Berry | Broccoli | Leafy Green | Melon | Peach | Pepper | Potato | Squash | Tomato |
|---|------------------------|-----------------------|--------------------|--------------------|--------------------|--------------------|----------|--------------------|--------------------|--------------------|--------------------|
| Please rate your knowledge of food safety, preservation, and produce storage and handling, before and after reading.¹ | Mean Pre-Score | 3.1±1.52 ² | 2.8±1.48 | 2.6±1.78 | 3.0±1.15 | 3.4±0.97 | 3.6±0.97 | 2.3±1.06 | 3.5±0.97 | 2.7±0.67 | 2.7±0.82 |
| | Mean Post-Score | 4.1±0.74 | 3.6±0.97 | 3.7±0.82 | 3.7±1.06 | 4.0±0.82 | 3.7±0.95 | 3.9±0.88 | 4.1±1.1 | 3.7±0.48 | 4.1±0.88 |
| | Mean Change | +0.9 | +0.7 | +1.0 | +0.7 | +0.6 | +0.1 | +1.6 | +0.6 | +1.0 | +1.4 |
| | t Value | -3.87 ^a | -4.00 ^a | -3.50 ^b | -3.28 ^b | -3.67 ^b | -0.56 | -9.80 ^c | -2.71 ^d | -6.71 ^c | -6.33 ^c |

¹ Mean questionnaire score on a scale of 1-5; 5=Advanced knowledge and 1= No knowledge

p<0.005^a, p<0.01^b, p<0.001^c, p<0.05^d

² ± Standard Deviation

Table 4.9 summarizes reviewers' mean scores for the usefulness of the major fact sheet content topics. Of the six major topics incorporated into each fact sheet, nutritional and recipe information scored the highest (4.21) for usefulness. The handling and storage section was also of particular interest to reviewers, receiving an average score of 4.07. Reviewers indicated that the fun facts and helpful hints section of the fact sheets were the least useful (3.02). In response to these survey results, the fact sheets were edited appropriately to reflect the preferences of the reviewers on content. Overall, reviewers rated the fact sheets with a mean score of 4.34 for usefulness. The finalized fact sheets were shared with a group of Colorado Master Food Safety Advisors as well as a group of local growers at a Gardening Network meeting.

Table 4.9: Mean scores for usefulness of major fact sheet (10) content topics (n=100).

| Fact Sheet Content Usefulness | Mean Score ± St. Dev¹ |
|---|---|
| Please rate the material included in the introduction, background, and history of the fact sheet. | 3.73±1.0 |
| Please rate the material included in the handling and storage section. | 4.07±1.5 |
| Please rate the material included in the nutritional and recipe section. | 4.21±0.7 |
| Please rate the material included in the preservation section. | 3.51±1.0 |
| Please rate the material included in the fun facts and helpful hints section. | 3.02±1.2 |
| Please rate the overall usefulness of the fact sheet after reading. | 4.34±1.0 |

¹ Mean questionnaire score on a scale of 1-5; 5=Extremely useful and 1= Not useful

These produce fact sheets may be used to facilitate the promotion and safe use of fresh fruits and vegetables by utilizing science-based commodity information. It has been shown consumer perception of the reliability of convenient materials, like supermarket brochures or fact sheets, can be enhanced by including statements from reliable sources (Bruhn & Schutz, 1999; Macfarlane, 2002). Producers may utilize the fact sheets to promote and maintain the quality of their produce items by informing their customers' on proper handling and storage techniques. Consumers may also benefit from the provided recipes, preservation instructions, and nutritional information as a value added to their produce purchase.

The safety of consumer handling of fresh produce from the time of purchase to the plate should be emphasized not only at home during meal preparation, but also during transportation and storage after the produce has been purchased. Studies have shown most consumers believed foodborne illness was caused by food prepared somewhere other than home. The researchers found 65% of consumers attributed foodborne illness to food prepared at a restaurant, 17% thought mishandling occurred at the supermarket and 17% at home (Bruhn & Schutz, 1999). In contrast, food safety experts believe sporadic cases and small outbreaks at home are far more common than those cases constituting recognized outbreaks.

Educational outreach should target specific subpopulations, men, college graduates, higher-income households, and people younger than 65 years because of their higher frequency of unsafe handling and washing practices. In addition, six percent of the consumers responded they seldom or never wash fresh produce, and more than 35% indicated they do not wash melons before preparation (Li-Cohen & Bruhn, 2002). These

survey results illustrate the usefulness of credible, science-based commodity information which can be adequately addressed through the use and dissemination of the aforementioned produce fact sheets.

Good Agricultural Practices Webinars

A series of three web-based GAPs/GHPs trainings (webinars) targeting Colorado small farm producers of fresh fruits and vegetables was developed, implemented, and evaluated. Each webinar had between 50 and 56 participants that logged on to the session. Not all participants who signed up for the webinar (a total of 114) logged onto the live session. Feedback and evaluative information was gathered using pre- and post-questionnaires (Appendix J & M). As an incentive, interested participants received a free water testing kit from the Colorado State University Environmental Water Quality Laboratory (a \$30 value).

Demographics

Participants signed up for the webinars using a Google documents survey in December of 2010. The results shown in Table 4.10 display the demographic distribution of participants who logged onto the webinars and completed the post-webinar survey. Primary participants included producers and Extension professionals/educators. Produce buyers, industry professionals, students, and government workers comprised a small percentage of the total webinar participants. Fifty-seven percent of participants were between the ages 46-65, indicating the use of web-based approaches to on-farm food safety education is well accepted by the aging population of growers in Colorado. In addition, 24% of the participants were 35 years old or younger, indicating that there is a growing interest from new farmers in becoming compliant with on-farm food safety standards.

Table 4.10: Demographic distribution for post-survey webinar participants by profession/age (n=61).

| Post-Webinar Survey Demographics | Frequency (%) | |
|----------------------------------|---------------|-------|
| Profession | | |
| Producer | 20 | (33%) |
| Educator/Extension Professional | 14 | (23%) |
| Other | 10 | (17%) |
| Produce Buyer | 5 | (8%) |
| Industry Professional | 4 | (7%) |
| Government/Regulatory | 4 | (7%) |
| Student | 4 | (7%) |
| Age | | |
| 18-25 | 5 | (8%) |
| 26-35 | 10 | (16%) |
| 36-45 | 8 | (13%) |
| 46-55 | 19 | (31%) |
| 56-65 | 15 | (26%) |
| 66+ | 4 | (7%) |

Webinar Development

Identified course objectives were assessed for interest through the pre-evaluation (Appendix J) with the intent to give participants a summary of important course concepts during three, one hour webinar sessions. These objectives were adapted from the National Good Agricultural Practices Program developed by Cornell University (2009) and the current Food and Drug Administration’s Guide to Minimize Food Safety Hazards for Fresh Fruits and Vegetables (1998). Topics were assessed for potential inclusion into the webinar series according to participant interests in Table 4.11. Topics which yielded higher interest, such as food safety basics, cooling and storage, and washing and packing operations, were addressed appropriately to place more emphasis on content.

Table 4.11: Participant interests for webinar topics (n=114).

| Webinar Topic | Frequency (%)^a |
|--------------------------------------|----------------------------------|
| Food Safety Basics | 92 (81%) |
| Cooling and Storage | 90 (79%) |
| Washing & Packing Operations | 89 (78%) |
| Food Safety Legislation | 77 (68%) |
| Liability | 73 (64%) |
| Water Quality & Irrigation Practices | 73 (64%) |
| Worker Hygiene and Training | 72 (63%) |
| Transportation | 62 (54%) |
| Manure Management | 61 (54%) |
| Traceability & Recall | 57 (50%) |
| 3rd Party Auditing Basics | 37 (32%) |
| Other | 2 (2%) |

^aUnaided response, totals may add up to more than 100%

Webinar Evaluation

Pre and post evaluations of self-reported knowledge on the specific webinar topics were assessed statistically using an unpaired t-test based on a 5-point Likert scale where 1= No knowledge and 5=Extremely knowledgeable. Table 4.12 displays the pre and post scores for self-assessed knowledge for each webinar topic.

Table 4.12: Pre and post self-reported knowledge scores for webinar topics (n=114 before, n=61 after).

| Webinar Topic | Before | After | t-value |
|--------------------------------------|---------------|--------------|----------------|
| Food Safety Basics | 2.93 ± 1.02 | 3.38 ± 1.03 | 2.83** |
| Cooling and Storage | 2.60 ± 1.03 | 3.18 ± 1.03 | 3.52*** |
| Washing & Packing Operations | 2.29 ± 0.99 | 2.77 ± 0.76 | 3.35*** |
| Food Safety Legislation | 2.18 ± 0.98 | 3.33 ± 0.67 | 8.24*** |
| Liability | 2.12 ± 1.03 | 2.70 ± 0.95 | 3.71*** |
| Water Quality & Irrigation Practices | 2.43 ± 1.06 | 3.30 ± 0.93 | 5.39*** |
| Worker Hygiene and Training | 3.10 ± 1.01 | 3.47 ± 0.82 | 2.42* |
| Transportation | 2.38 ± 1.08 | 2.71 ± 0.89 | 2.07* |
| Manure Management | 2.63 ± 1.06 | 3.31 ± 0.78 | 4.41*** |
| Traceability & Recall | 2.01 ± 0.98 | 2.91 ± 1.08 | 5.68*** |
| 3rd Party Auditing Basics | 1.75 ± 0.96 | 2.69 ± 0.93 | 6.28*** |

*p<0.05, **p<0.01, ***p<0.001

1= No knowledge and 5=Extremely knowledgeable

Webinar participants perceived their knowledge, pre-webinar, to be highest for the worker hygiene and training category. In previous studies, workers who were aware of GAPs were significantly more likely to provide hygiene-specific worker training than those who were not aware of GAPs (Jackson et al., 2007). Hygiene is relatively easy both to enforce and provide facilities and supplies with the advantage of being easily understood by farm managers and field workers. The third-party auditing basics category was ranked lowest on perceived knowledge pre-webinar and subsequently had the second most significant increase in knowledge. With ever changing food safety legislation in the United States, it is no surprise that the participants ranked their knowledge in this category prior to the webinar sessions the lowest, but reported to have gained the most knowledge after watching the presentation. Traceability and recall also showed a significant increase in perceived knowledge; these topics have recently become of greater interest to the produce industry through CDC efforts to mitigate and identify sources of foodborne outbreaks (CDC, 2011).

Webinar participants were asked to rate their overall experience with the presentation (Appendix M), including webinar activities, speaker quality, intent to view recorded sessions, and appropriateness of technology. Table 4.13 details the mean score for each of the survey questions. Appendix O contains the detailed Likert scale frequencies and percentages of responses for each question. From this data, future webinars can be designed to better fit participants' needs and desires. Although all evaluation questions had high mean scores, improving resources available to participants may aid in increasing the efficacy of future webinars.

Table 4.13: Mean scores for basic webinar evaluation questions rated on a 5-point Likert scale, 1=Strongly Disagree and 5=Strongly Agree (n=61).

| Webinar Evaluation Question | Mean Score ±St. Dev. |
|--|-------------------------|
| The presenter(s) provided quality information. | 4.56±0.62 |
| The presentation(s) was/were delivered at a comfortable pace. | 4.30±0.45 |
| The webinar topics were presented in a logical and easy to understand format. | 4.51±0.53 |
| I benefited from hearing or participating in questions at the conclusion of the session. | 4.08±0.76 |
| I plan to use the suggested resources provided at the end of the session to gain more knowledge. | 3.97±1.01 |
| The quizzes and critical thinking activities kept me engaged and interested in the presentation. | 4.38±0.33 |
| I plan to review the recorded sessions at a later date | 4.07±0.12 |
| The technology (Adobe Connect) was appropriate and easy to use. | 4.38±0.68 |

Behavioral Intent

The theory of planned behavior hypothesizes that perceived control over one's own behavior, one's attitude, and the influence of others are precursors of behavioral intention. Ball and Wilcock (2010) have used socio-psychological models to describe factors that influence implementation of food safety behaviors in commercial food processing settings, few studies have been done to predict or explain food safety behaviors on the farm (Bihn & Gravani, 2006) . Most food safety practices provide knowledge to workers with the expectation that workers will translate the knowledge into practice (Green, 2008). Unfortunately, numerous studies have been conducted that

indicate that although knowledge may be a necessary component of behavior change, it is not always sufficient to spark action. Human behavior is complex and multiple factors affect whether people may engage in a particular behavior. In this section of the project results, the researcher asked a series of profession-specific questions (Appendix M) to webinar participants to evaluate their behavioral intent as a result of participating in the webinar(s).

Producers

Producers were asked the most rigorous set of questions after participating in the webinar series. Table 4.14 summarizes producers’ intent to participate in future GAPs audits. Of the twenty producers who completed the post-webinar questionnaire, sixty percent were either likely or somewhat likely to participate in GAPs audits as a result of watching the webinar series. Only one producer reported currently being GAPs certified.

Table 4.14: Producers’ intent to participate in GAPs/food safety audits (n=20).

| Survey Question | Frequency (%) |
|---|---------------|
| After attending one or more of the GAPs webinars, how likely are you to pursue a GAPs/food safety audit for your farm?^a | |
| Very Likely | 6(30%) |
| Somewhat Likely | 6(30%) |
| Neutral | 4(20%) |
| Somewhat Unlikely | 1(5%) |
| Very Unlikely | 2(10%) |
| I already participate in GAPs audits | 1(5%) |

^aUnaided response, totals may add up to more than 100%

To delve further into producers' behavioral intent regarding on-farm food safety, a set of thirteen questions were presented during the survey and ranked on a three point scale for likelihood to participate in certain aspects of GAPs. Two additional choices were given, 'I already do this' and 'N/A', to assess whether producers already were incorporating these practices into their daily routines. The results of the producer behavioral intent questions are summarized in Table 4.15.

Table 4.15: Summary of producer behavioral intent for specific GAPs activities (n=20).

| | Likely | Neutral | Unlikely | I already do this. | N/A |
|--|---------|---------|----------|--------------------------|---------|
| Make sure worker hygiene facilities are regularly cleaned and kept stocked. | 10(50%) | 3(15%) | 0(0%) | 7(35%) | 0(0%) |
| Improve or add worker hygiene facilities (appropriate hand washing stations, toilet facilities, signage). | 10(50%) | 3(15%) | 1(5%) | 3(15%) | 3(15%) |
| Use proper composting techniques for animal manure. | 10(50%) | 3(15%) | 1(5%) | 3(15%) | 3(15%) |
| Obtain composted manure from a certified supplier. | 1(5%) | 5(25%) | 3(15%) | 3(15%) | 8(40%) |
| If using RAW animal manure, properly apply to fields to maintain a 120 day buffer zone before harvest. | 7(35%) | 1(5%) | 0(0%) | 0(0%) | 12(60%) |
| Test irrigation water sources (surface, ground, or municipal) during the growing season for harmful bacteria (fecal coliforms, <i>E.coli</i>, etc). | 15(75%) | 4(20%) | 0(0%) | 1(5%) | 0(0%) |
| Identify and reduce sources of contamination for irrigation water (ie. manure run-off, livestock access to water source). | 13(65%) | 1(5%) | 1(5%) | 2(10%) | 3(15%) |
| Modify your method of irrigation water application (ie. change from overhead to drip). | 4(20%) | 7(35%) | 4(20%) | 3(15%) | 2(10%) |
| Enforce proper post-harvest methods to reduce the chance for contamination of produce (ie. cleaning tools, machinery, and harvest bins). | 10(50%) | 1(5%) | 0(0%) | 9(45%) | 0(0%) |
| Monitor and maintain safe water quality used in cooling and washing operations (ie. testing water, chlorination, other interventions). | 6(30%) | 0(0%) | 3(15%) | 4(20%) | 7(35%) |
| Document transportation practices (ie. temperatures for pre-cooling, inspection for cleanliness). | 8(40%) | 5(25%) | 1(5%) | 3(15%) | 3(15%) |
| Develop a traceback system for your products. | 10(50%) | 6(30%) | 3(15%) | 1(5%) | 0(0%) |
| Educate your customers/buyers on how to properly handle produce for safety/quality. | 12(60%) | 3(15%) | 0(0%) | 5(25%) | 0(0%) |

Thirty-five percent of producers indicated they were already maintaining worker hygiene facilities, while 50% were planning to improve or add additional facilities for their operations. Jackson et al. (2007) cited that cost, lack of toilet suppliers in the area, proper plumbing, and low numbers of workers were major obstacles in providing adequate worker hygiene facilities. In this study, 60% of producers responded they were not using raw manure for fertilization, those who were (35%) claimed to follow the 120 day application buffer before harvest to minimize foodborne illness outbreaks. In previous studies, organic growers who were utilizing raw manure applications were more likely to suggest practices to reduce food safety risks than conventional growers. This trend may be explained by the structured record keeping requirements enforced by organic standards, in turn making producers more aware of the timing and application of manure (Rangarajan, 2000). A majority of producers were also more likely, as a result of the webinar series, to test irrigation water quality (75%) as well as identify and reduce potential sources of contamination (65%). A lack of universal water quality standards perpetuates the need for clear guidelines to be developed to improve grower's understanding and willingness to take action regarding safe sources of irrigation water (Okafo et al., 2003). Lastly, 85% of producers responded they were either planning to or currently were providing their consumers with additional food safety information. While GAPs may help reduce foodborne illness outbreaks originating on the farm, consumer education should be paramount to any fresh produce business to assure proper handling and storage are followed (Li-Cohen & Bruhn, 2002).

Produce Buyers

Produce buyer expectations have been identified as one of the primary drivers for the adoption of GAPs in Colorado (Tables 4.3 and 4.6). Of the five produce buyers who completed the post-webinar evaluation, two said they were either likely or somewhat likely to require their suppliers to participate in GAPs audits, one was already requiring GAPs audits, and two were requiring specific food safety practices to be documented but not specific to GAPs (Table 4.16). Two produce buyers were already requiring specific food safety practices to be documented by their producers, however, only one indicated that GAPs audits were mandatory.

Table 4.16: Produce buyers' intent to impose mandatory food safety/GAPs audits on their suppliers (n=5).

| Survey Question | Frequency (%) |
|---|---------------|
| After attending one or more of the GAPs webinars, how likely are you to require your suppliers to participate in GAPs or other audits for food safety on the farm? | |
| Very Likely | 1(20%) |
| Somewhat Likely | 1(20%) |
| Neutral | 0(0%) |
| Somewhat Unlikely | 0(0%) |
| Very Unlikely | 0(0%) |
| GAPs are required | 1(20%) |
| Other Food Safety Policies Required | 2(40%) |

Produce buyers were most likely to refer interested parties to the recorded webinar series as well as participate in future programming related to GAPs in effort to educate their suppliers (Table 4.17). The development of a GAPs curriculum for their business was not of high interest, most likely because other approved and available curriculum materials exist, such as those available from the Cornell National GAPs Program. A detailed summary of the survey data for this group is located in Appendix P.

Table 4.17: Produce buyers’ mean scores for behavioral intent (n=5).

| Produce Buyer Survey | Mean Score^a ±St. Dev. |
|--|---|
| After attending one or more of the GAPs webinars, how likely are you to require your suppliers to participate in GAPs or other audits for food safety on the farm? | 4.5±0.24 |
| Refer interested parties/institutions/food establishments to the taped recordings of the webinars on the Colorado State Farm to Table Website. | 4.8±0.56 |
| Use the material presented to develop your own GAPs education/curriculum for your business and suppliers. | 3.2±0.67 |
| Inform or disseminate information about GAPs to your suppliers, gardeners, farmers, or other institutions (school lunch programs, community gardens, etc.) | 4.6±0.66 |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | 4.8±0.32 |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | 4.2±0.93 |

^aBased on a 5-point Likert scale where 1=Very Unlikely and 5=Very Likely

Educators/Extension

In recent years, debate over Extension program delivery cost and the higher educational status of the typical Extension client has driven a movement to seek out and pilot new methods of providing information (Jones et. al, 2007). It has been argued that traditional methods of Extension program delivery may not be the most appropriate method to address today's more technologically advanced Extension audience. Taking advantage of the convenience of distance education to provide learning opportunities for busy or geographically dispersed learners, Extension professionals and educators have begun to adopt and offer new methods of program delivery for a range of topics in agriculture. However, these methods must first be widely accepted by the facilitators, namely Extension educators, before clientele will accept these alternative methods to education (Allred & Smallidge, 2010).

In this section of the survey, Extension professionals and other participants who considered themselves part of the educator group, were asked a series of questions regarding their intent to use, disseminate, and adopt the materials that they were presented during the webinars. Table 4.18 displays the mean scores for the likelihood to participate in certain activities surrounding on farm food safety and GAPs. This group was most likely to disseminate the information they obtained from the webinars to gardeners, farmers, and other institutions. They were least likely to develop their own GAPs curriculum. A detailed summary of the survey data for this group is located in Appendix Q.

Table 4:18: Extension Professionals and Educators’ mean scores for behavioral intent (n=14).

| Extension Professional/Educator Survey | Mean Score^a ±St. Dev. |
|---|---|
| Refer students/interested parties to the taped recordings of the webinars on the Colorado State Farm to Table Website. | 4.4±0.22 |
| Use the material presented to develop your own GAPs education/curriculum. | 3.7±0.04 |
| Inform or disseminate information about GAPs to gardeners, farmers, or other institutions (school lunch programs, community gardens, etc. | 4.6±0.57 |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | 4.4±0.27 |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | 4.2±0.65 |

^aBased on a 5-point Likert scale where 1=Very Unlikely and 5=Very Likely

Industry Professionals/Students/Regulatory/Other

The remaining webinar participants who identified themselves as students, industry professionals, regulatory agents, or other, rated their likelihood to use, disseminate, or adopt the educational materials presented during the webinars using a 5-point Likert scale. Out of all the webinar participants, this group was the least likely to develop their own GAPs curriculum. They were also less likely to use the knowledge they obtained during the webinar directly or indirectly in their profession. They did, however, indicate they had a higher likelihood to refer other interested parties to the recorded webinar sessions posted on the website. A detailed summary of the survey data for this group is located in Appendix R.

Table 4:19: Student, industry professional, and others' mean scores for behavioral intent (n=22).

| Students/Industry Professionals/Other Survey | Mean Score^a ±St. Dev. |
|--|---|
| Refer interested parties to the taped recordings of the webinars on the CSU Farm to Table Website. | 4.0±0.39 |
| Use the material presented to develop your own GAPs education/curriculum for your business. | 2.4±0.64 |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | 4.3±0.69 |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | 3.6±0.44 |

^aBased on a 5-point Likert scale where 1=Very Unlikely and 5=Very Likely

CHAPTER V: CONCLUSION AND RECOMMENDATIONS

Food safety is truly a system-based concept. Creating safe growing, handling, and food distribution systems requires all who are involved throughout the chain of production, from farm to fork. Although the concepts incorporated into Good Agricultural Practices are relatively simple, the efficacy of educational outreach materials and the subsequent adoption of these practices on the farm are somewhat unknown in the state of Colorado. In order to fill this void, this project evaluated small Colorado producers and commercial buyers perceptions' to implementing GAPs in addition to the launch of a three part webinar series containing basic GAPs curriculum materials tailored to this target audience. This research also aimed to promote a broader and more integrated food safety culture by encouraging proactive food safety attitudes and behaviors among consumers of fresh produce through a series of informative fact sheets.

This research suggests that producers' current food safety goals and activities are driven primarily by customer expectations, concern for legal and financial liability, and pending regulations. For small-scale growers, the adoption of GAPs was hindered most often by the producer perception that GAPs were unproductive and unnecessary, the financial burden of participating in audits, and the inconsistency of on farm food safety guidance across government and industry. Most of the producers in this study were motivated to implement GAPs, or its' principles to some extent, in order to meet customers' expectations and seek improved market access. Buyers of fresh produce also

identified that the ‘one size fits all’ approach to food safety on the farm is not an effective method to promote grower adoption of GAPs audits and principles. As a limitation to the study, the narrow sampling frame (focusing on small growers in Colorado) as well as the volume of non-response for the needs assessment may indicate the sample population interviewed is not representative of a broader set of growers in the region or across the country.

In order to address the growing concerns of producers and buyers regarding the increased number of foodborne illness outbreaks originating on the farm, a convenient, web-based series of presentations was provided at no cost. As a result of participating in the webinar series, producers, buyers, and Extension professionals indicated they planned to utilize the information and resources provided. Specific topics related to GAPs such as irrigation water quality, management of manure and compost, and food safety legislation were of most interest to the participants and had the most significant increases in self-reported knowledge, pre to post webinar. While factors that influence the implementation of food safety behaviors in commercial settings is well understood, few studies have been done to predict or explain food safety behaviors on the farm. Assessing producer behavior as well as buyer behavior in the fresh produce industry, more detailed and appropriate education materials can be provided to aid in the adoption of GAPs. The webinar series developed through this research project can address both the financial and educational accessibility barriers encountered by small producers in Colorado. As a result of the launch of this webinar series, the Colorado USDA voluntary GAP/GHP Audit Verification Program has experienced a reported three-fold increase in the number of inquiry calls to begin the process of GAPs certification (Vanderpool, 2011).

By participating in the webinars, producers, buyers, and Extension professionals who serve these target audiences now have a better understanding of the importance of using good agricultural and handling practices and the resources available to them. To complete the chain of food production, consumer handling of fresh produce from the time of purchase to the plate must be emphasized not only at home during meal preparation, but also during transportation and storage. The developed produce fact sheets may help address some of these issues and bring awareness to practical steps that can be taken towards a safer food supply. Future research and development of on farm food safety educational materials should have a foundation built upon credible, science-based information which can be tailored to a wide variety of fruit and vegetable producers. While the web-based materials discussed in this study were successful in providing Colorado growers with the basic information and resources needed to pursue GAPs certification, future interventions should include hands-on practical approaches to food safety such as GAPs plan writing workshops and direct interaction with growers on the farm.

REFERENCES

- Ackers, M., Pagaduan, R., Hart, G., Greene, K., Abbott, S., Mintz, E., & Tauxe, R. (1997). Cholera and sliced fruit: Probable secondary transmission from an asymptomatic carrier in the United States. *International Journal of Infectious Diseases, 1*(4), 212-214.
- Alliance for Food and Farming. (2010). Analysis of Produce Related Foodborne Illness Outbreaks. Retrieved from http://www.foodandfarming.info/docs/386Produce_Analysis_2010_Final.pdf
- Allred, S., Smallidge, P. (2010). An Educational Evaluation of Web-Based Forestry Education. *Journal of Extension, 48*(6).
- Bairstow, R., Berry, H., Driscoll, D. (2002). Tips for Teaching Non-Traditional Audiences. *Journal of Extension, 40*(6), 14-19. Retrieved from <http://www.joe.org/joe/2002december/tt1.php>
- Ball, B., Wilcock, A., Aung, M. (2010). Background Factors Affecting the Implementation of Food Safety Management Systems. *Food Protection Trends, 30*(2), 78-86.
- Batz, M.B., Doyle, M.P., Morris, J.G., Painter, J., Singh, R., Tauxe, R.V., Taylor, M.R., & Wong, D. (2005). Attributing illness to food. *Emerging Infectious Diseases, 11*(7), 993-999.
- Bauman, H. (1990). HACCP- Concept, Development, and Application. *Food Technology, 44*(5), 156-158.
- Bazzano, L. (2006). The high cost of not consuming fruits and vegetables. *Journal of the American Dietetic Association 106*(9), 1364-1368.
- Beuchat, L.R. (1996). Pathogenic microorganisms associated with fresh produce. *Journal of Food Protection, 59*(2), 204-216.
- Beuchat, L.R. (1998). Surface Decontamination of Fruits and Vegetables Eaten Raw: A review. *WHO/FSF/FOS Publication 98.2*, 44.
- Beuchat, L.R. (2002). Ecological factors influencing survival and growth of human pathogens on raw fruits and vegetables. *Microbes and Infection, 4*(4), 413-423.

- Beuchat, L.R. (2004). Difficulties in eliminating human pathogenic microorganisms on raw fruits and vegetables. In N. E. Looney (Ed.), *Horticulture: Art and Science for Life* (pp. 151-160): International Society Horticultural Science.
- Beuchat, L.R. (2006). Vectors and conditions for preharvest contamination of fruits and vegetables with pathogens capable of causing enteric diseases. *British Food Journal*, 108(1), 38-53.
- Beuchat, L.R. (2007). Managing food safety risks in the fresh-cut industry. In S. Kanlayanarat, P. M. A. Toivonen & K. C. Gross (Eds.), *Proceedings of the International Conference on Quality Management of Fresh Cut Produce* (pp. 103-114). Leuven 1: International Society Horticultural Science.
- Beuchat, L.R., & Ryu, J. H. (1997). Produce handling and processing practices. *Emerging Infectious Diseases*, 3(4), 459-465.
- Bihn, E., & Gravani, R. (2006). Role of Good Agricultural Practices in Fruit and Vegetable Safety *Microbiology of Fresh Produce*. Washington, DC: ASM Press.
- Brackett, R.E. (1999). Incidence, contributing factors, and control of bacterial pathogens in produce. *Postharvest Biology and Technology*, 15(3), 305-311.
- Bruhn, C.M., & Schutz, H.G. (1999). Consumer food safety knowledge and practices. *Journal of Food Safety*, 19(1), 73-87.
- Buckley, M., & Reid, A. (2010). *Global Food Safety: Keeping Food Safe From Farm To Table*.
- Burnett, S.L., & Beuchat, L. R. (2001). Human pathogens associated with raw produce and unpasteurized juices, and difficulties in decontamination (Reprinted from *Journal of Industrial Microbiology & Biotechnology*, vol 25, pg 281-287, 2000). *Journal of Industrial Microbiology & Biotechnology*, 27(2), 104-110.
- Butte, G. (2010). Growers' Understanding and Implementation of FDA's GAPs Guidance: Mental Models Research Report. Retrieved from <http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/FruitsVegetablesJuices/FDAProduceSafetyActivities/ucm218562.htm>
- Calvin, L. (2004). Produce, Food Safety, and International Trade: Response to U.S. Foodborne Illness Outbreaks Associated with Produce *International Trade and Food Safety* (Vol. 74): USDA Agricultural Research Service.
- Calvin, L. (2007). Outbreak Linked to Spinach Forces Reassessment of Food Safety Practices. *Amber Waves*, 5(3). Retrieved from <http://www.ers.usda.gov/amberwaves/june07/features/spinach.htm>

- Calvin, L., Avendaño, B., Schwentesius, R. (2004). The economics of food safety: The case of green onions and Hepatitis A outbreaks. *Electronic Outlook Report from the Economic Research Service*. Retrieved from <http://www.ers.usda.gov/publications/vgs/nov04/VGS30501/VGS30501.pdf>
- Center for Disease Control and Prevention (CDC). (1997). Outbreaks of Cyclosporiasis- United States and Canada, 1997. Retrieved from <http://www.cdc.gov/mmwr/preview/mmwrhtml/00047875.htm>
- Center for Disease Control and Prevention (CDC). (2003). *Hepatitis A Outbreak Associated with Green Onions at a Restaurant --- Monaca, Pennsylvania, 2003*. Retrieved from <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5247a5.htm>.
- Center for Disease Control and Prevention (CDC). (2010). Surveillance for Foodborne Disease Outbreaks - United States 2007. *Morbidity and Mortality Weekly Report*, 59. Retrieved from http://www.cdc.gov/foodborneoutbreaks/outbreak_data.htm
- Center for Disease Control and Prevention (CDC). (2011). Foodborne Outbreak Investigations. Retrieved April 5, 2011, from <http://www.cdc.gov/outbreaknet/investigations/contamination.html>
- Chang, A., Balaguero, A., Goodrich-Schneider, R., Schneider, K. (2009). Food Safety on the Farm: Good Agricultural Practices and Good Handling Practices – Traceback. Retrieved March 6, 2011, from <http://edis.ifas.ufl.edu/fs152>
- Chapman, B. (2005). *An evaluation of an on-farm food safety program for Ontario greenhouse vegetable producers; A Global Blueprint for Fruit and Vegetable Producers*. University of Guelph, Guelph, Ontario.
- Chapman, B.J., & Powell, D.A. (2005). Implementing on-farm food safety programs in fruit and vegetable cultivation. In W. Jongen (Ed.), *Improving the safety of fresh fruit and vegetables* (pp. 268-292). Cambridge: Woodhead Publishing Ltd.
- Connally, E.H., & Floyd, A.H. (2009). Good Food Safety Practices: Managing Risks to Reduce or Avoid Legal Liability. *College of Tropical Agriculture and Human Resources: Food Safety and Technology*, 32. Retrieved from <http://www.ctahr.hawaii.edu/oc/freepubs/pdf/FST-32.pdf>
- Crutchfield, S., Roberts, T. (2000). Food Safety Efforts Accelerate in the 1990's. *Food Review*, 23(3), 44-49.
- Dentinger, C.M., Cotter, S.M., Bower, W.A., Nainan, O.V., Fowler, S., Bell, B.P., Myers, G., Dubusky, L.M., & Salehi, E. (2001). An Outbreak of Hepatitis A Associated with Green Onions. *Journal of Infectious Diseases*, 183(8), 1273.
- Divine, D. (1998). Adult Learning Styles and Effective Transfer of Information. *Transportation Research Record*(1637), 9-12.

- Food and Agriculture Organization (FAO). (2007). Working Principles for Risk Analysis for Food Safety for Application by Governments. *Codex Alimentarius*, from http://www.codexalimentarius.net/web/more_info.jsp?id_sta=10751
- Food and Drug Administration (FDA). (1997). FAO Food and Nutrition Paper Number 65. *Risk Management and Food Safety*, 32. Retrieved from <ftp://ftp.fao.org/docrep/fao/w4982e/w4982e00.pdf>
- Food and Drug Administration (FDA). (1998). Guide to Minimize Food Safety Hazards for Fresh Fruits and Vegetables. Retrieved from <http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/ucm064574.htm>
- Food and Drug Administration (FDA). (2003a). *Development of a Framework for Good Agricultural Practices*. Paper presented at the Committee on Agriculture: Seventeenth Session, Rome, Italy.
- Food and Drug Administration (FDA). (2003b). *FAO's Strategy for a Food Chain Approach to Food Safety and Quality: A framework document for the development of future strategic direction* Paper presented at the Committee on Agriculture: Seventeenth Session, Rome, Italy.
- Food and Drug Administration (FDA). (2005). Letter to California Firms that Grow, Pack, Process, or Ship Fresh and Fresh-cut Lettuce. Retrieved from <http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/FruitsVegetablesJuices/GuidanceComplianceRegulatoryInformation/ucm118911.htm>
- Food and Drug Administration (FDA). (2006). FDA Notifies Consumers that Tomatoes in Restaurants Linked to Salmonella Typhimurium Outbreak Current Information Suggests Outbreak is Not Ongoing. Retrieved from <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/2006/ucm108782.htm>
- Food and Drug Administration (FDA). (2007a). FDA Finalizes Report on 2006 Spinach Outbreak. Retrieved December 5, 2010, from <http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/2007/ucm108873.htm>
- Food and Drug Administration (FDA). (2007b). Working Principles for Risk Analysis for Food Safety and Application by Governments. Retrieved from <http://www.fao.org/docrep/010/a1550t/a1550t00.htm>
- Food and Drug Administration (FDA). (2008a). Voluntary nationwide recall of Honduran Cantaloupes grown by Agropecuaria Montelibano, San Lorenzo Valle, Honduras. Retrieved from http://www.fda.gov/oc/po/firmrecalls/centralamerican03_08.html

- Food and Drug Administration (FDA). (2008b). Warnings on raw jalapeno and serrano peppers from Mexico. Retrieved from <http://www.fda.gov/consumer/updates/pepperwarnings073108.html>
- Food and Drug Administration (FDA). (2009). Hazard Analysis Critical Control Points (HACCP). Retrieved from <http://www.fda.gov/food/foodsafety/hazardanalysiscriticalcontrolpointshaccp/default.htm>
- Food and Drug Administration (FDA). (2011). Food Safety Modernization Act (FSMA). Retrieved from <http://www.fda.gov/Food/FoodSafety/fsma/default.htm>
- GAPsNET. 2009. Good Agricultural Practices Network for Education and Training. Cornell University. Available at: <http://www.gaps.cornell.edu/>
- Garrison, J., Schardt, C., Kochi, J. (2000). Web-based distance continuing education: a new way of thinking for students and instructors. *Bull Med Libr Assoc*, 88(3), 211-217.
- Garrison, J., Schardt, C., Kochi, J. (2002). Distance education or classroom instruction for continuing education: who retains more knowledge? *J Med Libr Assoc*, 90(4), 455-457.
- GovTrack.US. (2011). *S.510 FDA Food Safety Modernization Act*. Retrieved from <http://www.govtrack.us/congress/bill.xpd?bill=s111-510&tab=summary>.
- Green, L. (2008). Behavioral Science and Food Safety. *Environmental Health Services*. Retrieved from http://www.cdc.gov/nceh/ehs/Docs/JEH/2008/Sept_08_Green.pdf
- Hanning, I.B., Nutt, J. D., Ricke, S. C. (2009). Salmonellosis Outbreaks in the United States Due to Fresh Produce: Sources and Potential Intervention Measures. *Foodborne Pathogens and Disease*, 6(6), 635-648.
- Hedberg, C.W., Angulo, F.J., White, K.E., Langkop, C.W., Schell, W.L., et al. (1999). Outbreaks of Salmonellosis Associated with Eating Uncooked Tomatoes: Implications for Public Health. *Epidemiology and Infection*, 122(3), 385-393.
- Henson, S., Caswell, J. (1999). Food safety regulation: an overview of contemporary issues. *Food Policy*, 24(6), 589-603.
- Higgins, C.L., Hatfield, B.S. (2004). A systems based food safety evaluation: An experimental approach *Journal of Environmental Health*, 67(4), 9-14.
- Hilborn, E.D., Mermin, J.H., Mshar, P.A., Hadler, J.L., Voetsch, A.. (1999). A Multistate Outbreak of Escherichia coli O157:H7 Infections Associated With Consumption of Mesclun Lettuce. *Arch Intern Med*, 159(15), 1758-1764.

- Islam, M., Doyle, M.P., Phatak, S.C., Millner, P., & Jiang, X.P. (2005). Survival of *Escherichia coli* O157:H7 in soil and on carrots and onions grown in fields treated with contaminated manure composts or irrigation water. *Food Microbiology*, 22(1), 63-70.
- Jackson, C., Archer, D., Goodrich-Schneider, R., Gravani, R., Bihn, E., & Schneider, K. (2007). Determining the Effect of Good Agricultural Practices Awareness on Implementation: A Multi-state Survey. *Food Protection Trends*, 27(9), 684-693.
- Jones, R., Goheen, A., Dhuyvetter, K., Kastens, T., & Amanor-Boadu, V. (2007). Using distance education in Extension programming. *Journal of Agriculture and Applied Economics* 39(2), 265-274.
- Kader, A. (2005). Increasing food availability by reducing postharvest losses of fresh produce. In F. Mencarelli & P. Tonutti (Eds.), *Proceedings of the 5th International Postharvest Symposium, Vols 1-3* (pp. 2169-2175). Leuven 1: International Society Horticultural Science.
- Kudva, I.T., Blanch, K., & Hovde, C. J. (1998). Analysis of *Escherichia coli* O157 : H7 survival in ovine or bovine manure and manure slurry. *Applied and Environmental Microbiology*, 64(9), 3166-3174.
- Li-Cohen, A.E., & Bruhn, C.M. (2002). Safety of consumer handling of fresh produce from the time of purchase to the plate: A comprehensive consumer survey. *Journal of Food Protection*, 65(8), 1287-1296.
- Macfarlane, R. (2002). Integrating the consumer interest in food safety: the role of science and other factors. *Food Policy*, 27(1), 65-80.
- McEvoy, J.L., Luo, Y., Conway, W., Zhou, B., & Feng, H. (2009). Potential of *Escherichia coli* O157:H7 to grow on field-cored lettuce as impacted by postharvest storage time and temperature. *International Journal of Food Microbiology*, 128(3), 506-509.
- Mead, P. (1999). Food-related illness and death in the United States. *Emerging Infectious Disease*, 5(5), 5607-5625.
- Medeiros, L.C., Hillers, V.N., Kendall, P.A., & Mason, A. (2001). Food Safety Education: What Should We Be Teaching To Consumers? *Journal of Nutrition Education*, 33(2), 108-113.
- Medeiros, L.C., Kendall, P., Hillers, V., Chen, G., & Dimascola, S. (2001). Identification and Classification of Consumer Food-Handling Behaviors for Food Safety Education. *Journal of the American Dietetic Association*, 101(11), 1326-1332, 1337-1339.

- Mukherjee, A., Speh, D., Dyck, E., & Diez-Gonzalez, F. (2004). Preharvest evaluation of coliforms, *Escherichia coli*, *Salmonella*, and *Escherichia coli* O157:H7 in organic and conventional produce grown by Minnesota farmers. *Journal of Food Protection*, 67(5), 894-900.
- National Committee on the Microbiological Criteria for Foods (NACMCF). (1995). Microbiological safety evaluations and recommendations on fresh produce. *Food Control*, 9(6), 321-347.
- O'Bryan, C., Crandall, P., Shores-Ellis, K., Johnson, D., Ricke, S., & Marcy, J. (2009). Optimizing Web-Based Instruction: A Case Study Using Poultry Processing Unit Operations. *Journal of Food Science Education*, 8(8), 93-100.
- O'Hara, J. (2009). *Implications of Mandatory Safety Standards*. Paper presented at the Produce Safety Summit, Georgetown University, Washington, D.C.
- Okafo, C.N., Umoh, V.J., Galadima, M. (2003). Occurrence of pathogens on vegetables harvested from soils irrigated with contaminated streams. *Science of the Total Environment* 311(49-56).
- Osterholm, M.T., Ostrowsky, J., Farrar, J.A., Gravani, R.B., Tauxe, R.V., Buchanan, R.L., & Hedberg, C.W. (2009). A Novel Approach To Enhance Food Safety: Industry-Academia-Government Partnership for Applied Research. [Article]. *Journal of Food Protection*, 72(7), 1509-1512.
- Plotto, A., & Narciso, J. (2006). Guidelines and Acceptable Postharvest Practices for Organically Grown Produce. *Hort Science*, 41(2), 287-291.
- Powell, D., & Chapman, B. (2007). Fresh threat: what's lurking in your salad bowl? *Journal of the Science of Food and Agriculture*, 87, 1799-1801.
- Powell, D., & Luedtke, A. (2004). *Pre-Harvest Issues Related to Food Safety in Fruits and Vegetables*. Paper presented at the Food Safety: Ensuring the Safety of Fresh Produce, Toronto, Canada.
- Powell, D.A., Bobadilla-Ruiz, M., Whitfield, A., Griffiths, M.W., & Luedtke, A. (2002). Development, implementation, and analysis of an on-farm food safety program for the production of greenhouse vegetables. *Journal of Food Protection*, 65(6), 918-923.
- Qadir, M., Wichelns, D., Raschid-Sally, L.R., McCornick, P.G., Drechsel, P., Bahri, A., & Minhas, P.S. (2010). The challenges of wastewater irrigation in developing countries. *Agricultural Water Management*, 97, 561-568.
- Rangarajan, A., Bihn, E., Gravani, R., Scott, D., & Pritts, M. (2000). Food Safety Begins on the Farm: A Grower's Guide. Retrieved from <http://www.gaps.cornell.edu/Educationalmaterials/GAPsFlyer.pdf>

- Rangarajan, A., Pritts, M. P., Reiners, S., & Pedersen, L. H. (2002). Focusing food safety training based on current grower practices and farm scale. *Hort Technology*, 12(1), 126-131.
- Rejesus, R.M. (2009). GAP Certification: Is it worth it? *Good Agricultural Practices*. Retrieved from http://www4.ncsu.edu/~rmrejesu/Food_Safety_Risk/ag-709%20final%20printed.pdf
- Ruzante, J.M., Davidson, V. J., Caswell, J., Fazil, A., Cranfield, J., Henson, S. J., Anders, S. M., Schmidt, C., & Farber, J. M. (2010). A Multifactorial Risk Prioritization Framework for Foodborne Pathogens. *Risk Analysis*, 30(5), 724-742.
- Scallan, E., Griffin, P., Angulo, F., Tauxe, R., & Hoekstra, R. (2011). Foodborne illness acquired in the United States—unspecified agents. *Emerging Infectious Diseases* 1-16. Retrieved from <http://www.cdc.gov/EID/content/17/1/16.htm>
- Schamberger, G.P., Phillips, R.L., Jacobs, J. L., & Diez-Gonzalez, F. (2004). Reduction of *Escherichia coli* O157 : H7 populations in cattle by addition of colicin E7-producing E-coli to feed. *Applied and Environmental Microbiology*, 70(10), 6053-6060.
- Scharff, R. (2010). Health Related Costs from Foodborne Illness in the United States. Retrieved from <http://www.producesafetyproject.org/media?id=0009>
- Scott, A., Pope, P., & Thompson, B. (2009). Consumer's Fresh Produce Food Safety Practices: Outcomes of a Fresh Produce Safety Education Program. *Journal of Food Science*, 8, 8-12.
- Sobel, J., Griffin, P.M., Slutsker, L., Swerdlow, D.L., & Tauxe, R.V. (2002). Investigation of multistate foodborne disease outbreaks. *Public Health Reports*, 117(1), 8-19.
- Solomon, E.B., Pang, H. J., & Matthews, K. R. (2003). Persistence of *Escherichia coli* O157:H7 on lettuce plants following spray irrigation with contaminated water. *Journal of Food Protection*, 66(12), 2198-2202.
- Solomon, E.B., Potenski, C. J., & Matthews, K. R. (2002). Effect of irrigation method on transmission to and persistence of *Escherichia coli* O157:H7 on lettuce. *Journal of Food Protection*, 65(4), 673-676.
- Suslow, T. (2000). GAPs, Food Safety, and Third-Party Audits. *Perishables Handling Quarterly*(103), 11-13.
- Tauxe, R.V. (1997). Emerging foodborne diseases: An evolving public health challenge. *Emerging Infectious Diseases*, 3(4), 425-434.

- Todd, E.C., Greig, J.D., Bartleson, C.A., & Michaels, B.S. (2009). Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 6. Transmission and survival of pathogens in the food processing and preparation environment. *Journal of Food Protection*, 72(1), 202-219.
- U.S. Census Bureau. (2009). Current Population Survey. Appendix Table A, Households With a Computer and Internet Use: 1984 to 200. Retrieved March 3, 2011, from <http://www.census.gov/population/www/socdemo/computer/2009.html>
- United States Department of Agriculture (USDA). (2007). Food availability (per capita) data system. Retrieved from <http://www.ers.usda.gov/Data/FoodConsumtion>
- United States Department of Agriculture (USDA). (2010). National Organic Program Handbook: Processed Animal Manures in Organic Crop Production. 2010(October 26). Retrieved from <http://www.ams.usda.gov/AMSV1.0/ams.fetchTemplateData.do?template=TemplateR&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPPProgramHandbook&description=Program%20Handbook&acct=noppub>
- United States Environmental Protection Agency (USEPA). (2004). *Guidelines for water reuse*. USAID Document Number 625R04108.
- University of California. (2010). Good Agricultural Practices: Self Audit. Retrieved from <http://ucce.ucdavis.edu/files/filelibrary/5453/4362.pdf>
- Vanderpool, T. (2011). Personal Interview-Cost of GAPs Audits in Colorado.
- Verma, A., & Singh, A. (2010). Webinar- Education through Digital Collaboration. *Journal of Emerging Technologies in Web Intelligence*, 2(2), 131-136.
- Voetsch, A.C. (2004). FoodNet Estimate of the Burden of Illness Caused by Nontyphoidal Salmonella Infections in the United States. *Clinical Infectious Disease*, 38(3), 127-134.
- Wachtel, M.R., Whitehand, L. C., & Mandrell, R. E. (2002). Association of Escherichia coli O157:H7 with preharvest leaf lettuce upon exposure to contaminated irrigation water. *Journal of Food Protection*, 65(1), 18-25.
- Wallner, S., Kendall, P., Hillers, V., Bradshaw, E., & Medeiros, L. (2007). Online Continuing Education Course Enhances Nutrition and Health Professionals' Knowledge of Food Safety Issues of High-Risk Populations. *Journal of the American Dietetic Association*, 107(8), 1333-1338.
- Wilson, M. (2001). Cultural consideration in online instruction and learning. *Distance Education*, 22(1), 52-64.

- Wilson, R., Parker, J., Kovacs, D., Doohan, D., & Lejeune, J. (2009). Contamination Prevention and Response Related to Fresh and Fresh-cut Produce: An Expert Perspective on the Farmer Decision Making Process. *Food Protection Trends*, 29(8), 488-492.
- Woods, M., & Thornsbury, S. (2005). Costs of Adopting Good Agricultural Practices (GAPs) to Ensure Food Safety in Fresh Strawberry Production. Retrieved from <http://www.gaps.cornell.edu/FSI/FSIlessons/6-Module2/Lesson2-3/CostsofadoptingGAPstoensurefoodsafetyinfreshstrawberries.pdf>
- World Health Organization (WHO). (2009). Millenium Development Goals. Retrieved December 2, 2010, from http://www.who.int/mdg/goals/goal1/food_safety/en/index.html
- Zhang, G.D., Ma, L., Beuchat, L. R., Erickson, M. C., Phelan, V. H., & Doyle, M. P. (2009a). Evaluation of Treatments for Elimination of Foodborne Pathogens on the Surface of Leaves and Roots of Lettuce (*Lactuca sativa* L.). *Journal of Food Protection*, 72(2), 228-234.
- Zhang, G.D., Ma, L., Beuchat, L. R., Erickson, M. C., Phelan, V. H., Doyle, & M. P. (2009b). Lack of Internalization of *Escherichia coli* O157:H7 in Lettuce (*Lactuca sativa* L.) after Leaf Surface and Soil Inoculation. *Journal of Food Protection*, 72(10), 2028-2037.

APPENDIX A



Research Integrity & Compliance Review Office
Office of the Vice President for Research
321 General Services Building - Campus Delivery 2011
Fort Collins, CO
TEL: (970) 491-1668
FAX: (970) 491-2288

NOTICE OF APPROVAL FOR HUMAN RESEARCH

DATE: February 26, 2010
TO: Bunning, Maria, Food Sci. & Human Nutrition
Maly, Christopher, Food Sci. & Human Nutrition, Swiss, Evelyn, RJCRO, Wall, Gretchen, Food Science & Human Nutrition
FROM: Baker, Janell, CSU IRB 2
PROTOCOL TITLE: Farm-to-Table: Food Safety for Colorado Produce Crops: A web-based approach for promoting Good Agriculture and Handling Practices
FUNDING SOURCE: Colorado Department of Agriculture, 90824
PROTOCOL NUMBER: 10-16434
APPROVAL PERIOD: Approval Date: February 22, 2010 Expiration Date: February 16, 2011

The CSU Institutional Review Board (IRB) for the protection of human subjects has reviewed the protocol entitled: Farm-to-Table: Food Safety for Colorado Produce Crops: A web-based approach for promoting Good Agriculture and Handling Practices. The project has been approved for the procedures and subjects described in the protocol. This protocol must be reviewed for renewal on a yearly basis for as long as the research remains active. Should the protocol not be renewed before expiration, all activities must cease until the protocol has been re-reviewed.

If approval did not accompany a proposal when it was submitted to a sponsor, it is the PI's responsibility to provide the sponsor with the approval notice.

This approval is issued under Colorado State University's Federal Wide Assurance 00000647 with the Office for Human Research Protections (OHRP). If you have any questions regarding your obligations under CSU's Assurance, please do not hesitate to contact us.

Please direct any questions about the IRB's actions on this project to:

Janell Baker, Senior IRB Coordinator - (970) 491-1665 Janell.Baker@Research.Colostate.edu
Evelyn Swiss, IRB Coordinator - (970) 491-1381 Evelyn.Swiss@Research.Colostate.edu

APPENDIX B

Good Agricultural Practices Needs Assessment Survey Questions for **Producers**

Demographics

- a.) Male/Female
- b.) Size of farm
- c.) Producer profile (Grower/Shipper/Packer)
- d.) Water Source
- e.) What types of products do you sell?
- f.) What are the primary methods you use to sell your products?
(Direct markets, small stores, CSA, large stores, farm stand)
- g.) Have you ever participated in an on-farm audit related to GAPs/GHPs?
 - i. If yes, how was your experience with the audit process?

Requirements & Current Practices

- a.) Have any of your commercial buyers required specific handling or food safety practices before delivery of your products?
 - i. If yes, what specifications did they have?
 - ii. If no, have you considered providing extra information on how the produce should be treated post farm sale (ie. refrigeration, washing, or storage specifications for optimal safety and quality) of your products?

- b.) Are your employees required to participate in any food safety training prior to starting work?
 - ii. If yes, what training do they complete?
 - iii. If no, how do you ensure your employees are handling your products safely?

- c.) Are you required by your consumers or commercial buyers to provide information about the type of production methods that were used?
 - i. About where it was grown?
 - ii. About when it was harvested?

- d.) Does the perishability of your produce affect your post-harvest or transportation methods?
 - i. If yes, please provide any methods towards ensuring food safety.

- e.) In general, how far is your product transported from your point of sale to end user and who is liable for product safety?

Future Participation and Interests

- a.) Are you planning to participate in these fresh produce audit verification programs in the future?
- b.) What type of information might help you better prepare for your next audit?
 - i. Web-based, in-person training, on-farm visit
- c.) If a series of hour long online training webinars on GAPs was available at no cost, would you be interested in participating?

Barriers and Drivers of Adoption

- a.) What do you think are the key barriers to implementing GAPs?
- b.) What do you think are the key drivers to implementing GAPs?

APPENDIX C

Good Agricultural Practices Needs Assessment Survey Questions for **Produce Buyers/Distributors**

Demographics

- h.) Male/Female
- i.) Type of Buyer (wholesale, market, large store, small store)
- j.) What are your primary sources of fresh produce?
 - i. (Larger farms, smaller farms, local markets, etc.)

Requirements & Current Practices

- i. Do you require documentation of food safety, harvesting, or temperature management upon receipt of your fresh products?
- ii. Do you require your producers to participate in Good Agricultural Practices (GAPs) certification or other fresh produce audit verification programs?
- iii. Are there specific crops you feel are of higher priority to be GAPs (or food safety) certified?
- iv. Does your company help with the cost of third party audit certification, if required?
- v. What are your thoughts on mandatory vs. voluntary approach to food safety?
- vi. What actions are taken if a producer you purchase from is involved in an outbreak of foodborne illness?

Future Participation and Interests

- d.) Are you planning to participate in these fresh produce audit verification programs in the future (continuing or starting)?
- e.) What type of information might help better prepare your suppliers for an audit?
 - i. Web-based, in-person training, on-farm visit
- f.) If a series of hour long online training webinars on GAPs was available at no cost, would you be interested in participating?

Barriers and Drivers of Adoption

- c.) What do you think are the key barriers to implementing GAPs?
- d.) What do you think are the key drivers to implementing GAPs?

APPENDIX D

February 19, 2010

Dear Producer or Produce Buyer/Distributor:

My name is Gretchen Wall and I am a M.S. student in the Food Science and Human Nutrition Department at Colorado State University. My advisor, Marisa Bunning, Ph.D., Department of Food Science and Human Nutrition, and I are conducting a research project to identify perceived and operational benefits and barriers encountered by small farm producers in fresh produce audit verification programs. The title of this research project is: Farm-to-Table Food Safety for Colorado Producers: A web-based approach for promoting good agricultural and handling practices. The project is sponsored by the Colorado Department of Agriculture's Specialty Crops Competitive Grant Program and is part of my master's thesis. Dr. Bunning is the Principal Investigator for this project, and I am a Co-Principal Investigator.

As a member of the local food industry, your expertise and opinions would provide a valuable perspective for this research project. Our first step will be to conduct interviews with fruit and/or vegetable producers from various regions across Colorado as well as retail produce buyers and distributors to determine potential benefits and opportunities for participating in such an audit system. You have been selected as a good representative for the type of information we are seeking. Your name was provided to us by an Extension agent or faculty member at CSU. The project's goal is to assess the willingness of local producers and buyers to participate in a GAP/GHP Audit Verification Program to better understand the barriers and potential incentives to utilization of these food safety tools and programs.

Your experience and knowledge are very important to our understanding. We expect the interview will take about 10-20 minutes and we hope you will agree to be interviewed personally. There are no known risks to participating in this study as the information you provide will be kept confidential and will not be linked to specific individuals. Your participation in this research project is voluntary and you may decline to participate and withdraw from the interview at any time. There are no known risks or direct benefits from participating in the study but we hope you will gain knowledge about good agricultural practices and audit programs.

While there are no direct benefits to you personally, the researchers hope you see the project's long-range benefits which are to promote good agricultural and handling practices and that you will agree to participate. Participants will not be compensated for participating in interviews, but producers will have an opportunity to take part at a later date in pilot on-line training sessions and would be compensated for their participation in

that part of the study. We will obtain your consent during a phone call before contacting you to take part in future parts of the study.

We hope that you will agree to participate. A member of our team will contact you and set up a time to conduct the interview. If you would prefer to contact us first, please call Gretchen Wall at 724-777-1113. If you have any questions about your rights as a volunteer in this research, contact Janell Barker, Human Research Administrator at 970-491-1655. We look forward to hearing your ideas.

Sincerely,

Gretchen Wall
Graduate Student
gretchenwall@gmail.com
724-777-1113

Marisa Bunning, Ph.D.
Assistant Professor
mbunning@cahs.colostate.edu

Department of Food Science & Human Nutrition
Colorado State University
Fort Collins, CO 80523-1571

APPENDIX E

Produce Facts

A Guide to Colorado Grown Fruits and Vegetables



Table of Contents

| | |
|--------------|----|
| Introduction | 1 |
| Apples | 2 |
| Berries | 3 |
| Broccoli | 4 |
| Cantaloupe | 5 |
| Peaches | 6 |
| Peppers | 7 |
| Potatoes | 8 |
| Spinach | 9 |
| Squash | 10 |
| Tomatoes | 11 |

Introduction

The following informational sheets focus on the safe production and handling of a variety of Colorado grown specialty produce crops sold directly to vendors and/or consumers in the raw state. These consumer-friendly down-loadable fact sheets include articles on nutrition, safe food handling, seasonality, selection, history, preservation, and recommended storage guidelines that can be used to help promote the following selected specialty crops: apples, berries, broccoli, cantaloupe, peaches, peppers, potatoes, spinach, squash, and tomatoes.

In recent years, there has been an increase in the number of foodborne illness outbreaks associated with fresh fruits and vegetables, affecting the health of millions of consumers and resulting in negative impacts on the produce industry. Leafy greens, melons, tomatoes, and peppers are examples of crops that have recently been involved in high-profile foodborne illness outbreaks. Specific information on the safe production and handling of produce crops sold fresh could help decrease the risk of contamination and prevent future outbreaks.

The current situation in our food supply counteracts health messages regarding the benefits associated with increased fruit and vegetable consumption. To maintain confidence in the farm-to-table food supply, the science-based commodity information presented in this booklet can help educate producers, buyers, and consumers on food safety risks and proper handling methods to provide a safe, wholesome meal.

In addition to this booklet, further information regarding food safety from farm to fork can be accessed at <http://farmtotable.colostate.edu/>. The Colorado Extension website (www.ext.colostate.edu) contains information for consumers about crops, farm management, food and nutrition, gardening, insects, livestock, resources and youth development across the state.

Apple Facts



Apples have a long recorded history of consumption throughout civilization, most likely originating in an area called the Caucasus, a mountainous region between what is now the Caspian and Black Seas. With over 7,500 varieties of apples grown worldwide, apples are one of the most popular fruits around the globe. About 2,500 known varieties of apples are grown in the United States alone. From over 100 types known to be produced commercially, fifteen popular varieties account for 90% of annual U.S. production. The average American consumes an estimated 17 pounds of fresh apples and 29 pounds of processed apples, for a total of approximately 46 pounds of apple products per year.

Seasonality

In Colorado, apples are most commonly available from mid-August through mid-October, with storage lasting until June. With apple orchards located in both the Eastern and Western parts of the state, Coloradans have access to apples and apple products at a variety of locations and markets. Local apples are available almost year round due to industry use of controlled atmosphere storage.

Selection

Choose apples with the following characteristics:

- Firmness, crispness, lack of mealiness
- Free from physical or insect damage
- Good color, no bruising* or pitting

*Bruised apples are good for making apple sauce and pies. Bruised or "less perfect" apples are called seconds and can often be purchased from a grower at a lower cost.

Handling

An apple continues to live and respire, even after it is picked. Although respiration cannot be halted completely, cooling apples postharvest can extend their shelf life. Bruising is the most common defect in apples; handle fruit with care to avoid soft spots. Always wash apples before eating or preparing. Apples are threatened by over 40 types of insects; therefore many orchards practice Integrated Pest Management (IPM). Rinsing apples with fresh water also reduces the potential for foodborne illness.

Storage

Apples keep best when stored in the refrigerator in the fruit drawer. At home, apples can last from 4-6 weeks in the refrigerator. Commercially, apples may be stored in a controlled atmosphere with an oxygen content lowered from 21% to 2.5% and the carbon dioxide content increased from 0.25% to 2-5%. With this type of storage, apples maintain their freshness for up to 12 months.

Nutrition Facts

Serving Size: 1 Medium Apple (138g)

Amount Per Serving

Calories 70 Calories from Fat 0

% Daily Value*

Total Fat 0g 0%

Saturated Fat 0g 0%

Trans Fat 0g

Cholesterol 0mg 0%

Sodium 0mg 0%

Total Carbohydrate 19g 6%

Dietary Fiber 3g 12%

Sugars 14g

Protein 0g

Vitamin A 2% Vitamin C 10%

Calcium 0% Iron 0%

*Percent Daily Values are based on a diet of other people's secrets.

Your daily values may be higher or lower depending on your calorie needs:

Calories: 2,000 2,500

Total Fat Less than 65g 80g

Saturated Fat Less than 30g 35g

Cholesterol Less than 300mg 300mg

Sodium Less than 2,400mg 2,400mg

Total Carbohydrate 300g 375g

Dietary Fiber 25g 30g

Calories per gram:

Fat 9 Carbohydrate 4 Protein 4

Did you know?

- ❖ 2/3 of the fiber and many of the antioxidants in an apple are located in the skin!
- ❖ Wax sprayed on apples helps to maintain the freshness and moisture content of apples.

Colorado Apples



"An apple a day keeps the doctor away."

Nutrition

Apples are a delicious, nutritious way to boost consumption of fruits and vegetables for a healthy diet. Apples are fat free and high in fiber. Apples contain natural fruit sugars, mainly fructose. The high fiber content of an apple allows sugars to be released slowly, maintaining healthy blood glucose levels and warding off hunger. Apples are high in Vitamin C and a variety of other disease fighting antioxidants.

Why do apples turn brown after they have been cut?

Apples brown due to a compound called polyphenoloxidase. When an apple is cut, these compounds are released from the cell and cause a browning reaction on the fruit. The more Vitamin C the apple contains, the less the browning may occur. Dipping apple slices in a solution of 50% water and 50% Vitamin C rich lemon juice will help prevent extensive browning and can help maintain crispness.

Apple Cider Safety

Drinking fresh apple cider, especially if homemade, is a delicious way to enjoy your apples throughout the fall and winter months. However, fresh or unpasteurized apple juice or cider can cause foodborne illness from bacteria found on fallen apples. Follow this simple guide from the University of Georgia for safe methods to making apple cider.

<http://www.fcs.uga.edu/pubs/PDF/FDNS-E-91.pdf>

Drying Apples:

Select mature, firm apples. Wash well. Pare and core. Cut in rings or slices 1/8 to 1/4 inch thick, or cut in quarters or eighths. Dip in 50/50 water and lemon juice solution for 10 minutes. Remove from solution and drain well. Arrange in a single layer on trays. Dry in dehydrator or oven set at 140°F until soft, pliable, and leathery, with no moistness in center.

Easy Microwave Apple Sauce

6 cups of sliced, peeled apples
1/4 c water
1/3 c sugar (adjust to taste)
Cinnamon to taste (optional)

Mix all ingredients in 2-quart microwave safe baking dish. Cover and microwave on high power 8 to 8 minutes. Using a food processor or blender, blend the cooked mixture to the desired consistency. Refrigerate any leftovers.

Apple Varieties Common in Colorado

| Apple Variety | Appearance | Flavor | Dried | Sauce | Baking |
|------------------|---|---------------------------|-----------|-----------|-----------------|
| Gala | Red-orange with yellow stripes | Sweet Crisp | Good | Very Good | Good |
| Fuji | Red blush with green and yellow stripes | Sweet, Spicy Crisp | Very Good | Good | Good |
| Honey Crisp | Yellow with blush | Mildly Tart, Sweet Flavor | Excellent | Good | Good |
| Braeburn | Yellow w/ red stripes or blush | Very Firm | Fair | Good | Good |
| Jonagold | Bright red and Gold | Sweet Tart Firm | Very Good | Good | Very Good |
| Granny Smith | Green, sometimes with pink blush | Tart Crisp | Very Good | Very Good | Very Good |
| Jonathan | Light red stripes over yellow or deep red | Moderately Tart | Very Good | Excellent | Very Good |
| Red Delicious | Striped to solid red | Sweet Crisp | Good | Fair | Not Recommended |
| Golden Delicious | Yellow-green, pink blush | Sweet Crisp | Excellent | Very Good | Very Good |

Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

Berry Facts



Considering their small size, raspberries, blueberries, and strawberries pack an astonishing amount of vitamins, minerals, and flavor into their flesh. With a long list of health benefits and sweet taste, berries top the list of 'superfoods'. Traditionally utilized by Native Americans, berries have been used as medicinal supplements and dyes for centuries. Berries contain powerful antioxidants, lowering the risk of developing certain types of cancers. In addition, berries have a wide range of applications in the diet from smoothies to jams. To extend the season, berries can be frozen, dried, or canned to enjoy throughout the winter months.

Seasonality

In Colorado, the peak season for raspberries runs from August 1 to October 15. Strawberries are available a bit earlier in the season from June 1 to October 1. Berries can be purchased in season from local markets, roadside stands, and pick-your-own operations.

Growing Your Own

Strawberries and raspberries grow well in the backyard gardens throughout Colorado; however blueberries are a bit more challenging. Colorado's high pH soils prevent most blueberries from growing in the ground. Blueberries require acidic soils between 4.8 and 5.2 pH. However, research is being conducted at Colorado State University to determine whether blueberries can successfully be produced in pots containing lower pH soils. Raspberries are the hardiest of the bush fruits and can withstand temperatures of minus 35 degrees and still produce fruit the next year. Red raspberries grow well along the Front Range, while black and purple varieties do best in the milder climates of the Western Slope. If you are interested in planting your own berry patch this year, contact your local Extension agent for more information on soils, varieties, and planting times.

Harvesting

Pick strawberries every other day during the peak of the season. It is poor practice to let fruit rot on the vine, so pick even the rotted fruit. If berries are to be eaten or preserved immediately, harvest only red-ripe fruit and leave the caps on the plant. If the fruit will not be used for a few days, harvest the berries, caps and all, while still pink.

Nutrition Facts

Serving Size 1/4 cup fresh blueberries (37g)

| Amount Per Serving | | % Daily Value* |
|------------------------------|---------------------|------------------------|
| Calories 20 | Calories from Fat 0 | |
| | | Total Fat 0g |
| | | Saturated Fat 0g |
| | | Trans Fat 0g |
| | | Cholesterol 0mg |
| | | Sodium 0mg |
| Total Carbohydrate 5g | | 2% |
| Dietary Fiber 1g | | 4% |
| Sugars 4g | | |
| Protein 0g | | |
| Vitamin A 0% | | Vitamin C 6% |
| Calcium 0% | | Iron 0% |

*Percent Daily Values are based on a diet of other people's secrets. Your daily values may be higher or lower depending on your calorie needs:

| | Calories | 2,000 | 2,500 |
|--------------------|-----------|---------|---------|
| Total Fat | Less than | 50g | 65g |
| Saturated Fat | Less than | 20g | 25g |
| Cholesterol | Less than | 300mg | 300mg |
| Sodium | Less than | 2,400mg | 2,400mg |
| Total Carbohydrate | | 300g | 375g |
| Dietary Fiber | | 25g | 30g |

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Did You Know?

Strawberries are picked, sorted, and packed in the field. They are cooled to 34°F and loaded onto refrigerated trucks. The average strawberry reaches the consumer within 24-36 hours of harvest! That's berry fast!

Selection, Handling, and Storage

Choose berries that are free from visible mold, not bruised or smashed, and relatively dry. Excess moisture on the berry will accelerate the deterioration of the fruit by allowing for the growth of bacteria and molds. Keep berries refrigerated until ready to consume. Wash berries thoroughly with cold water before eating, adding to salads, or cooking.

Colorado Berries

Nutritional Benefits

Tests of almost 40 different fruits and vegetables have found that blueberries pack the most antioxidant power for few calories - 40 calories in one-half cup. Not only have berries been shown to lower the risk of cardiovascular disease and cancer, but they may also protect the brain from the effects of age-related conditions such as Alzheimer's disease and dementia. Berries are high in Vitamin A and C, as well as fiber. Eat a handful on top your cereal, yogurt, or ice cream or toss them into salads as a delicious surprise.

Food Safety

Wash berries prior to eating by rinsing with cold water. Washing berries removes dirt, insects, and potential parasites such as *Cyclospora* that can cause food borne illness. Do not eat berries which have extensive mold growth within the pack. Keep berries dry until consumption to extend their shelf life and quality.

Uses

- Pies
- Jams and jellies
- Smoothies
- Baking
- Garnishes
- Salads



Related Links

Making Jellies

<http://www.ext.colostate.edu/pubs/foodnut/09303.html>

Raspberries for the Home Garden

<http://www.ext.colostate.edu/pubs/garden/07001.html>

Food Safety Advice: Berries

<http://www.ext.colostate.edu/safefood/newsltr/v1n1s05.html>



Preservation

To freeze berries, arrange in a single layer on a cookie sheet and place in the freezer. Once frozen, pack berries into plastic freezer bags for use in baking, as toppings on cereal, or for making smoothies.

To dry berries, select clean, mold free fruit. Arrange in a single layer on the drying rack. Small berries can be dried whole. Larger berries like strawberries can be sliced to create thin 'chips' that are a healthy snack and great addition to trail mixes and morning cereal.

Berry Trio Parfait

2 cups plain yogurt
2 cups of your favorite granola
2 cups fresh berries (raspberries, blueberries, strawberries- hulled and sliced)
4 tablespoons honey

Line up four parfait cups and spoon 2-3 tablespoons of yogurt into each. Smooth yogurt and spoon 2-3 tablespoons of granola over top. Add a layer of berries and continue layering until cup is full. Drizzle honey throughout layers as desired.



Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

Broccoli Facts



Broccoli has been cultivated for 2,000 years and may have evolved from wild cabbage on the continent of Europe. Broccoli is a cool season vegetable crop that can yield over an extended period of time if properly grown and harvested. Like most fresh produce from the Brassicaceae family, broccoli florets are rich in vitamin C and a good source of vitamin A, B6, and folate. Broccoli is also good source of fiber and provides small amounts of calcium and iron.

Seasonality

As a cool season vegetable, two crops of broccoli per year (spring and fall) may be grown in most parts of the country, including Colorado. New heat tolerant varieties allow broccoli to be produced in all but the hottest parts of the season. Transplants are recommended to give the best start for spring planting. Fall crops may be direct-seeded in the garden if space allows or may be started in flats to replace early crops when their harvest ends. The edible parts of broccoli are compact clusters of unopened flower buds and the attached portion of stem. The green buds develop first in one large central head and later in several smaller side shoots. Once the buds begin to form, the harvest of broccoli can last for several weeks.

Safe Storage and Handling

Broccoli should be stored unwashed, in loose perforated bags in the refrigerator. Broccoli left unrefrigerated will quickly become woody and fibrous. Wet broccoli can become limp and soggy as well as support the growth of microorganisms, so wait to rinse it until just before eating.

Broccoli can be safely kept in the refrigerator for 3-5 days. The highest nutritional value and best flavor will result when storage time is kept short. Broccoli florets have a rough, complex surface that can harbor and support the growth of illness-causing bacteria. Use fresh, cold water to rinse broccoli before cooking and always reheat cooked broccoli before consumption.

| Nutrition Facts | |
|------------------------------|---------------------|
| Serving Size : 1 cup (88g) | |
| Amount Per Serving | |
| Calories 30 | Calories from Fat 5 |
| % Daily Value* | |
| Total Fat 0g | 0% |
| Saturated Fat 0g | 0% |
| Trans Fat 0g | |
| Cholesterol 0mg | 0% |
| Sodium 30mg | 1% |
| Total Carbohydrate 6g | 2% |
| Dietary Fiber 2g | 8% |
| Sugars 1g | |
| Protein 2g | |
| Vitamin A 10% | • Vitamin C 130% |
| Calcium 4% | • Iron 4% |

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

| | Calories: 2,000 | 2,500 |
|--------------------|-------------------|---------|
| Total Fat | Less than 65g | 80g |
| Saturated Fat | Less than 20g | 25g |
| Cholesterol | Less than 300mg | 300 mg |
| Sodium | Less than 2,400mg | 2,400mg |
| Total Carbohydrate | 300g | 375g |
| Dietary Fiber | 25g | 30g |

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Helpful Hints!

Soaking fresh locally-grown broccoli in salt water for 5-10 minutes can help in removing any unwanted garden pests.

Broccoli can come in a variety of colors- green (Calabrese), yellow-green (Romanesco), and even purple, depending on the variety!



Cooking

Broccoli can be enjoyed raw or cooked. Steaming broccoli for 3-4 minutes is the preferred method of cooking, as it results in the greatest retention of flavor and nutrients. Short time microwaving with little or no water also helps retain nutrients and flavor. Boiling results in the greatest nutrient losses. Cooked broccoli should be bright green and tender-crisp. Overcooked broccoli develops a strong sulfur odor, turns dark green and suffers nutrient loss, especially vitamin C.

Colorado Broccoli

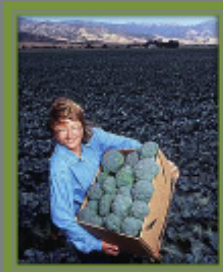
Broccoli Cheddar Soup

- 1 large head of broccoli
(12 ounces or 3/4 lb.), cut into small florets
- 2 tablespoons unsalted butter
- 1 shallot, chopped
- 1 medium onion, chopped
- 1 large potato, peeled and
cut into 1/4-inch cubes
- 2 cloves garlic, finely chopped
- 3 1/2 cups vegetable broth
- 2/3 cup freshly grated aged Cheddar,
plus more for topping
- 1-3 teaspoons whole grain mustard



Melt the butter (or olive oil) in a large saucepan over medium-high heat. Stir in the shallots, onion, and a big pinch of salt. Sauté for a few minutes. Stir in the potatoes, cover, and cook for about four minutes, just long enough for them to soften up a bit. Uncover, stir in the garlic, then the broth. Bring to a boil, taste to make sure the potatoes are tender, then stir in the broccoli. Simmer just long enough for the broccoli to get tender throughout, about 2 - 4 minutes.

Immediately remove the soup from heat and puree with an immersion blender. Add half the cheddar cheese and the mustard (a little bit at a time). Now add more water or broth if you feel the need to thin out the soup. Taste and add more salt if needed.



Related Links
Freezing Vegetables
<http://www.ext.colostate.edu/pubs/foodnut/09330.html>

Nutrition Information
<http://www.ext.colostate.edu/pubs/columnnn/n070129.html>

Home Preservation

Freezing is the best method for preserving broccoli. Select broccoli in peak condition for eating and prepare it for freezing as soon after harvesting as possible. It's important to blanch broccoli in steam or boiling water prior to freezing. Unblanched vegetables contain an active enzyme which can cause broccoli to toughen over time. Blanching stops this enzyme activity and preserves the flavor and nutrient content of the broccoli during storage.

Blanching and Freezing Steps:

1. Select tender, dark green stalks. Wash well.
2. To remove insects from heads, soak for 10 minutes in salt water (4 tsp salt/gal water). Rinse and drain.
3. Split broccoli into pieces not more than 1 ½ inches across. Trim stalks.
4. In a large pot with a tight fitting lid, bring 5 quarts of water to a rolling boil.
5. Prepare an ice bath in a 5 quart container.
6. Blanch in steam for 6 minutes or in boiling water for 4 minutes.
7. Remove broccoli with a slotted spoon or basket.
8. Submerge blanched broccoli in an ice bath for 5 minutes, or until cooled. Pat dry.
9. Pack cold broccoli into freezer containers or bags and squeeze out as much air as possible before sealing the container.
10. Label and date each container. Blanched and frozen broccoli can keep in the freezer for up to one year at 0°F or below.

Why is my broccoli so tough and chewy?

At room temperature, harvested broccoli will convert its sugar into a fiber called lignin. The more time spent at room temperature, the more lignin is produced and the more fibrous your broccoli becomes! Keep your broccoli refrigerated to extend the shelf life.

Quality Note: Broccoli is extremely sensitive to ethylene. Florets will turn yellow if exposed to high amounts. Make sure it is stored away from fruit or vegetables that produce high amounts of ethylene such as bananas, apples, or peaches.

Cantaloupe Facts



Seasonality

Cantaloupes are available August through October in Colorado. They are also produced year round in warmer climates such as Arizona and California.



Is it ok for me to eat a cantaloupe that looks 'blemished' on the outside?

This blemish is most likely the 'ground spot', or where the melon rested on the ground during its growing period. This side of the melon may look different and be slightly less ripe, however, it is still good to eat. The spot may also be caused by 'sun scald', or a side of the fruit exposed to too much sun. Sunspots on melons do not affect their quality unless it is unusually severe.

Related Links:

Cucumbers, Pumpkins, Squash and Melons

<http://www.ext.colostate.edu/pubs/garden/07609.html>

Safe Handling of Melons

<http://www.ext.colostate.edu/safefood/newsitr/v5n1s01.html>

Guide to Minimize Food Safety Hazards on Melons

<http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlantProducts/ucm174171.htm>

Cantaloupe is a type of melon characterized by a webbed surface. The scientific name of this fruit is *Cucumis melo*, also known as muskmelon. It belongs to the Cucurbitaceae family, which includes melons, squash, and cucumbers. Cantaloupes are named for the papal gardens of Cantalupo, Italy where some historians report this species of melon was first grown.

Cantaloupes have a sweet fragrance when they are ripe and the blossom end of the fruit should yield to moderate pressure.

Selection

When selecting cantaloupes, avoid those with a stem, which indicates the cantaloupe was harvested too early. Choose fragrant, symmetrical cantaloupes that are heavy for their size with no visible bruises and a yellow or cream undertone. Ripe cantaloupes will yield slightly to pressure on the blossom end. Avoid cantaloupes that have a damaged or cut outer rind, are mushy, molded, shriveled, or leaking.

Colorado Production of Cantaloupes

Colorado's melon production is centered in the Arkansas Valley around Rocky Ford, a name that is synonymous with cantaloupe melons. Since 1895, the Arkansas Valley of Colorado has been producing the highest quality cantaloupes. The U.S. commercial cantaloupe production actually began in the Arkansas Valley right near the town of Rocky Ford. Many people travel to the Arkansas Valley each year to sample the delicious Rocky Ford melons, tour the melon fields, and take a few home.

Researchers say that Rocky Ford melons are sweet because of the wide temperature swings that the region experiences during the summer. Days can reach as hot as 100 °F while nights may have lows in the 50's. The combination of warm weather and high elevation (4,000 feet above sea level) may increase sugar production. The cool Colorado nights then allow the sugars to accumulate in the melons as the growing process slows down.

Safe Handling and Preparation

Before cutting open a cantaloupe, wash the outside rind thoroughly in a clean sink under cool running water. Scrub with a clean vegetable brush to remove any soil or bacteria on the rind that might be carried from the knife blade to the flesh during slicing. Place the melon on a clean cutting board. Using a clean knife, slice open the melon and scoop out all the seeds and strings. Cantaloupe can be cut into halves, quarters, wedges, cubes, or balls.

www.ext.colostate.edu

<http://farmtotable.colostate.edu/>

Colorado Cantaloupes

Nutrition Facts

| | |
|--|------------------------------|
| Serving Size 1 cup cubed (160g) | |
| Amount Per Serving | |
| Calories 50 | Calories from Fat 5 |
| % Daily Value* | |
| Total Fat 0g | 0% |
| Saturated Fat 0g | 0% |
| Trans Fat 0g | |
| Cholesterol 0mg | 0% |
| Sodium 25mg | 1% |
| Total Carbohydrate 13g | 4% |
| Dietary Fiber 1g | 4% |
| Sugars 12g | |
| Protein 1g | |
| Vitamin A 110% | Vitamin C 100% |
| Calcium 2% | Iron 2% |
| *Percent Daily Values are based on a diet of 2,000 calories. Your daily values may be higher or lower depending on your calorie needs. | |
| | Calories: 2,000 2,500 |
| Total Fat | Less than 65g 90g |
| Saturated Fat | Less than 20g 25g |
| Cholesterol | Less than 300mg 300 mg |
| Sodium | Less than 2,400mg 2,400mg |
| Total Carbohydrate | 300g 375g |
| Dietary Fiber | 25g 30g |
| Calories per gram: | |
| Fat 9 • Carbohydrate 4 • Protein 4 | |

Nutritional Facts

Cantaloupes are rich in nutrients that fight disease, including cancer. They contain significant amounts of Vitamins A and C, are a good source of potassium and folate, and contain small amounts of many minerals. Cantaloupes are fat free and very low in sodium.

Buying Cut Melon

If purchasing a cut or diced melon, make sure that the container is stored in a chilled area, preferably a refrigerated case. If cut melon is displayed on ice, make sure the entire bottom half of the container is covered and the lid is cold to the touch.



Recipe Developed at The University of Georgia, Athens, for the National Center for Home Food Preservation. Released by Elizabeth L. Andress, Ph.D., Department of Foods and Nutrition, College of Family and Consumer Sciences. August 2003.

Cantaloupe Pickles

5 pounds of 1-inch cantaloupe cubes (about 2 medium under-ripe^a cantaloupe)
 1 teaspoon crushed red pepper flakes
 2 one-inch cinnamon sticks
 2 teaspoons ground cloves
 1 teaspoon ground ginger
 4½ cups cider vinegar (5%)
 2 cups water
 1½ cups white sugar
 1½ cups packed light brown sugar

^aSelect cantaloupe that are full size but almost fully green and firm to the touch in all areas including the stem area.

Day One:

1.) Wash cantaloupe and cut into halves; remove seeds. Cut into 1 inch slices and peel. Cut strips of flesh into 1 inch cubes. Weigh out 5 pounds of pieces and place in large glass bowl.

2.) Place red pepper flakes, cinnamon sticks, cloves and ginger in a spice bag and tie the ends firmly. Combine vinegar and water in a 4-quart stockpot. Bring to a boil, then turn heat off. Add spice bag to the vinegar-water mixture, and let steep for 5 minutes, stirring occasionally.

3.) Pour hot vinegar solution and spice bag over melon pieces in the bowl. Cover with a food-grade plastic lid or wrap and let stand overnight in the refrigerator (about 18 hours).

Day Two:

4.) Wash and rinse pint canning jars; keep hot until ready to use. Prepare lids according to manufacturer's directions.

5.) Carefully pour off vinegar solution into a large 8 to 10 quart saucepan and bring to a boil. Add sugar; stir to dissolve. Add cantaloupe and bring back to a boil. Lower heat to simmer until cantaloupe pieces turn translucent; about 1 to 1½ hours.

6.) Remove cantaloupe pieces into a medium-sized stockpot, cover and set aside. Bring remaining liquid to a boil and boil an additional 5 minutes. Return cantaloupe to the liquid syrup, and bring back to a boil.

7.) With a slotted spoon, fill hot cantaloupe pieces into clean, hot pint jars, leaving 1- inch headspace. Cover with boiling hot syrup, leaving ½-inch headspace. Remove air bubbles and adjust headspace if needed. Wipe rims of jars with a dampened clean paper towel; apply two-piece metal canning lids.

8.) Process in a boiling water canner according to the recommendations in Table 1. Let cool, undisturbed, 12-24 hours and check for properly closed seals.

Table 1: Recommended process time for Cantaloupe pickles in a boiling-water canner

| Style of Pack | Jar Size | Process time at altitudes of | | |
|---------------|----------|------------------------------|----------------|----------------|
| | | 0-1,000 ft | 1,001-6,000 ft | Above 6,000 ft |
| Hot | Pints | 15 min | 20 min | 25 min |

Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

Peach Facts



Peach Facts *Prunus persica* (L.) Batsch Rosacea Family

- Peaches originated from China where they were considered a symbol of long life.
- Colorado ranks 8th in peach production in the U.S. There are over 520,000 peach trees in Colorado.
- The prime locations for peach growing in Colorado are Mesa, Delta, Montrose, and Montezuma counties.
- Peaches account for over 75% of fruit production in Colorado.
- There are two types of peaches, freestone and clingstone. Freestone peaches are used for the fresh market, whereas clingstone peaches are typically used for canning and processing.

Helpful Hints!

To remove the peel easily for processing, blanch the peaches for one minute in boiling water and immediately place into an ice bath.

If peaches need to ripen, place them into a closed paper bag at room temperature for a day or two.

The peach industry in Colorado remains mostly a family business. Many growers live and work on farms surrounding their homes, within communities that include similar farms and families. Often, the fruit in the orchard is a staple of the family's table. This close proximity is strong motivation to use the safest tools and most up-to-date research to control pests and tree diseases on the farm. Fortunately, peaches are not typically a concern for foodborne illness, however simple precautions should be taken when canning and preserving peaches.

Picking the Right Peach

The best time to buy Colorado peaches is between August and September. Choose peaches with fuzzy skins that are firm but yield to gentle pressure. They should be yellow-orange with some red blushing. White peaches should be off-white with a few areas of red blush. Peaches with green tint may not fully ripen. Peaches with blemishes or irregularities, referred to as seconds, are less expensive and good for canning, baking, or making preserves. Avoid using peaches that show signs of spoilage or mold.

Food Preservation Tips

Canning

When selecting fruit for canning, pick fresh peaches that are firm. Use up-to date instructions adjusted for Colorado's altitude. Always check lids the next day to ensure the jars are properly sealed. The lid should be slightly concave and make a ringing high pitched sound when tapped with the bottom of a spoon. Do not eat peaches if the lid is bulging, leaking, or if the peaches have an off odor.

Freezing

Select firm, ripe fruit. Sort, wash, pit and peel. Cut in halves, quarters or slices into anti-darkening solution - 3 tablespoons lemon juice per quart of water.

Pack in 30-40 percent syrup, adding 1/2 teaspoon crystalline ascorbic acid per quart of syrup. Alternatively, sprinkle each quart of fruit with solution of 1/4 teaspoon ascorbic acid dissolved in 1/4 cup cold water. Add up to 2/3 cup sugar, mix well and pack in containers. Peaches may also be packed in cold water containing 1 teaspoon ascorbic acid per quart of water.

www.ext.colostate.edu

<http://farmtotable.colostate.edu/>

Colorado Peaches

Nutrition

Peaches are a healthy addition to any diet. They are always cholesterol, saturated fat, and sodium free, as well as a good source of Vitamin C. Comprised of more than 80 percent water, peaches are a great source of fiber. Peaches rank high among other fruits in phytochemicals and antioxidant activity, two substances that may decrease the chances of developing certain types of cancers. Peaches also provide good amounts of potassium and some iron. Although some may be turned off by the fuzzy exterior of the peach, the skin is actually a very good source of beneficial vitamins and minerals.

Nutrition Facts

| Serving Size 1 medium peach (147g) | |
|------------------------------------|---------------------|
| Amount Per Serving | |
| Calories 60 | Calories from Fat 5 |
| % Daily Value* | |
| Total Fat 0.5g | 1% |
| Saturated Fat 0g | 0% |
| Trans Fat 0g | |
| Cholesterol 0mg | 0% |
| Sodium 0mg | 0% |
| Total Carbohydrate 15g | 5% |
| Dietary Fiber 2g | 8% |
| Sugars 13g | |
| Protein 1g | |
| Vitamin A 6% | Vitamin C 15% |
| Calcium 0% | Iron 2% |

*Percent Daily Values are based on a diet of 2,000 calories. Your daily values may be higher or lower depending on your calorie needs.

| | Calories: 2,000 | 2,500 |
|--------------------|-------------------|---------|
| Total Fat | Less than 65g | 85g |
| Saturated Fat | Less than 25g | 35g |
| Cholesterol | Less than 300mg | 300mg |
| Sodium | Less than 2,400mg | 2,400mg |
| Total Carbohydrate | 300g | 375g |
| Dietary Fiber | 35g | 55g |

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Storage

If peaches were purchased while still firm, store them on the counter in a brown paper bag to promote ripening. Once peaches become ripe, they should be stored in the fruit drawer of the refrigerator and enjoyed within a few days for best flavor and eating quality. Always wash your peaches with cold water before eating.

Related Links

CSU Extension Fact Sheet-Canning fruit
<http://www.ext.colostate.edu/pubs/foodnut/09347.html>

Peach Jalapeno Jam

3 cups crushed peaches (about 2 lbs, or 4 large peaches)
 ½ cup jalapeno peppers, finely chopped (about ¼ pound, or 4-5 peppers)
 1 cup water
 ¾ cup cider vinegar
 ¾ cup lemon juice
 1 - 1 ¾ oz. package powdered pectin
 4 cups sugar

Wash, pit, and crush peaches. Wash peppers, remove stems and seeds, and chop finely. Combine peaches, peppers, water, vinegar, and lemon juice in a 5-6 quart pot. Bring to a boil, then reduce heat and simmer 20 minutes, stirring often to prevent scorching.

Add pectin to the peach/pepper mixture. Bring to a boil over high heat, stirring constantly. Add sugar, stirring well to dissolve completely. Bring to a full rolling boil, stirring constantly. Boil hard for 2 minutes. Remove from heat and skim foam, if needed.

Ladle into sterile, hot, half-pint jars, leaving ¼-inch headspace. Wipe jar rims with dampened clean paper towel. Adjust two-piece lids. Process in a boiling water bath for 10 minutes at 1000-6000 feet above sea level; 15 minutes above 6000 feet.

Yield: 4-5 half-pint jars.



Be sure to wear disposable gloves or thoroughly wash hands after cutting and handling hot peppers such as jalapeño, habanero, and other varieties. Avoid touching the eyes and face while handling peppers. If a severe reaction occurs, flush the skin and site of contact with cool water.

Pepper Facts



Be sure to wear disposable gloves or thoroughly wash hands after cutting and handling hot peppers such as jalapeño, habanero, and other varieties. Avoid touching the eyes and face while handling peppers. If a severe reaction occurs, flush the skin and site of contact with cool water.



Did you know?

Pepper pungency is rated in terms of "Scoville heat units". Capsaicin is the compound responsible for the "hot" flavor of many peppers. Jalapeno and cayenne peppers range from 2,000 to 25,000 units, whereas Tabasco peppers range between 60,000 to 80,000 units. Green Bell peppers are rated 0 on the scale because they do not contain capsaicin.

As part of the Solanaceae family, peppers are close relatives to the tomato, potato, and eggplant. Like their relatives, chili peppers, sweet peppers originated in South and Central America. The seeds of a wild variety can be dated back to 5000 BC. Spanish and Portuguese explorers carried the seeds of these fruits throughout the world after traveling through the continent. Peppers are very adaptable plants, thriving in both tropical and temperate regions. China, Europe, Turkey, Spain, Romania, Nigeria, and Mexico are currently the largest producers of peppers. A vast range of peppers may be grown in the home garden, for cooking as well as ornamental purposes. With thousands of varieties of peppers available, there is a flavor to suit everyone's taste. Peppers can be divided into two general categories, sweet peppers and chili peppers.

Seasonality

Late and early varieties of peppers are available in Colorado from July to October. Peppers are a warm season, tender vegetable often used to add flavor or 'heat' to cuisine. Peppers have tropical origin and thrive in warmer temperatures. Planting should be delayed until after the threat of frost in Colorado. Ideal temperatures are 70-80°F during the day and 60-70°F at night. Plants can be started indoors and transplanted after the threat of spring frost.

Selection

Choose peppers with the following characteristics:

- Full sized, firm, no wrinkling
- Stem partially or fully intact (to avoid internal rot)
- No extensive bruising, cuts, or wounds to the fruit
- No signs of freezing injury or sunscald

Handling

Like any other fruit or vegetable, peppers can be contaminated by bacteria from the soil, water, animals, or human sources. Wash peppers with cool, clean water prior to eating or preparing. Pat dry with a paper towel. Peppers may have a food grade wax applied to reduce moisture loss and prevent bruising during shipment and storage. Peppers can be eaten raw, roasted, grilled, or added to a variety of dishes. Drying, freezing, and pickling peppers are the most effective ways to preserve peppers after the growing season is over.

Storage

In general, peppers have a fairly short shelf life of two to three weeks. For best quality, peppers should be properly stored and eaten within one to two weeks. Cool, humid conditions, such as those of your vegetable drawer in the refrigerator, should be sufficient to keep peppers fresh during storage. However, peppers are susceptible to chilling injury and should not be stored below 40°F.

Colorado Peppers



Nutrition Facts

Serving Size 1 c chpd red bell pepper (140g)

Amount Per Serving

| | |
|-----------------------|---------------------|
| Calories 40 | Calories from Fat 5 |
| % Daily Value* | |
| Total Fat 0g | 0% |
| Saturated Fat 0g | 0% |
| Trans Fat 0g | |
| Cholesterol 0mg | 0% |
| Sodium 5mg | 0% |
| Total Carbohydrate 9g | 3% |
| Dietary Fiber 3g | 12% |
| Sugars 6g | |
| Protein 1g | |
| Vitamin A 90% | Vitamin C 320% |
| Calcium 2% | Iron 4% |

*Percent Daily Values are based on a diet of other people's secrets. Your daily values may be higher or lower depending on your calorie needs.

| | Calories | 2,000 | 2,500 |
|--------------------|-----------|---------|---------|
| Total Fat | Less than | 0g | 0g |
| Saturated Fat | Less than | 0g | 0g |
| Cholesterol | Less than | 300mg | 300mg |
| Sodium | Less than | 2,400mg | 2,400mg |
| Total Carbohydrate | 30% | 31% | |
| Dietary Fiber | 2% | 3% | |

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Nutrition

The nutritional properties of peppers range greatly depending on the variety and maturity. All peppers are a great source of Vitamin A and C. Red peppers contain lycopene and have been shown to reduce the risk for certain types of cancers. Red peppers are also an excellent source of vitamin B6. Bell peppers have a high concentration of beta-carotene which has been shown to reduce the risk for macular degeneration and cataracts. Green peppers also contain fiber, folate, and Vitamin K.

Related Links

Pickled Peppers:

<http://www.ext.colostate.edu/pubs/foodnut/09314.html>

Freezing Vegetables:

<http://www.ext.colostate.edu/pubs/foodnut/09330.htm>

Eggplant and Peppers:

<http://www.ext.colostate.edu/pubs/garden/07616.html>

Recipe

Colorado Mix (Pickled Pepper Vegetable Blend)

- 2 1/2 pounds peppers, mild or hot as desired
- 1 pound cucumbers, cut into 1/2-inch chunks
- 2 to 4 carrots, cut into 1/2-inch chunks
- 1/2 pound cauliflower, cut into 1-inch florets
- 1 cup peeled pickling onions
- 7 to 14 garlic cloves, as desired
- 6 cups vinegar
- 3 cups water
- 2 tablespoons pickling salt
- 2 tablespoons sugar, if desired

Yield: Makes 7 to 8 pints

Procedure: Wash and prepare vegetables. Slit small peppers. Core large peppers and cut into strips. Remove blossom end of cucumbers and cut into chunks. Peel and chunk carrots. Break cauliflower into florettes. Pack vegetable medley into hot, sterilized jars, leaving 1/2-inch headspace. In 3-quart saucepan, bring vinegar, water, salt and sugar to a boil. Pour hot solution over mix in jars, leaving 1/4-inch headspace. Remove air bubbles. Add liquid to bring headspace to 1/4 inch. Wipe jar rims. Add pretreated lids and process in boiling water bath. For best flavor, store jars five to six weeks before opening.

Source: CSU Extension Fact Sheet, see link below

Freezing Peppers

Select firm, crisp, thick-walled peppers. Wash and cut out stems. Cut in half and remove seeds. Cut into strips or rings, if desired. Spread in a single layer on a tray or cookie sheet. Place tray in the freezer for an hour or two. Loosen pepper pieces from tray and fill into freezer bags. Immediately place sealed bags back into the freezer. Pepper pieces will remain separated so that only a select amount can be taken at a time for cooking needs.

Caution: Although peppers packed in oil are a popular preparation technique, this method cannot be used for long term storage. Packing peppers in oil increases the risk for bacterial growth and foodborne illness, these type of peppers must be used within 1 to 2 days.

Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

Potato Facts



| Nutrition Facts | |
|--|------------------------------------|
| Serving Size 1 Medium Baked Potato (173g) | |
| Amount Per Serving | |
| Calories 160 | Calories from Fat 0 |
| % Daily Value* | |
| Total Fat 0g | 0% |
| Saturated Fat 0g | 0% |
| Trans Fat 0g | |
| Cholesterol 0mg | 0% |
| Sodium 15mg | 1% |
| Total Carbohydrate 37g | 12% |
| Dietary Fiber 4g | 16% |
| Sugars 2g | |
| Protein 4g | |
| Vitamin A 0% | Vitamin C 30% |
| Calcium 2% | Iron 10% |
| *Percent Daily Values are based on a diet of 2,000 calories per day. Your daily values may be higher or lower depending on your calorie needs: | |
| | Calories: 2,000 2,500 |
| Total Fat | Less than 65g 80g |
| Saturated Fat | Less than 20g 25g |
| Cholesterol | Less than 300mg 300 mg |
| Sodium | Less than 2,400mg 2,400mg |
| Total Carbohydrate | 300g 375g |
| Dietary Fiber | 25g 30g |
| Calories per gram: | |
| | Fat 9 • Carbohydrate 4 • Protein 4 |

The potato is the world's most widely grown tuber crop and the fourth largest food crop — after rice, wheat, and corn. Native to South America, potatoes have been cultivated for at least 1,800 years and belong to the Solanaceae family.

The potato is a versatile, carbohydrate-rich food highly popular worldwide and prepared in a variety of ways. Freshly harvested, it contains about 80 percent water and 20 percent dry matter. In addition, the potato is fat-free. Potatoes are an important source of several nutrients, especially Vitamin C. A single medium sized potato of 150 g provides nearly half the daily adult requirement (100 mg) of Vitamin C. The potato is a good source of iron and its high Vitamin C content promotes iron absorption. It's also a good source of Vitamin B6, niacin, and potassium.

Colorado Varieties

- **Russets**- make up most of the Colorado crop and are good for baking, frying, and mashing.
- **Reds**- have a smooth, moist texture perfect for soups and stews because they maintain their shape once cut throughout cooking.
- **Yellows**- have a golden flesh and creamy texture.
- **Specialties**- these include potatoes such as fingerlings, Purple Majesty, or Mountain Rose.

Selecting potatoes

- Choose potatoes that are well formed, firm, and have relatively smooth skin.
- Avoid green potatoes that have been exposed to light as they may be bitter and high in a chemical called solanine which can be harmful to eat. Trim small green areas from potatoes before cooking.
- Avoid potatoes which have large cuts, bruises, broken skin, or soft spots.

Storing potatoes

- Do not wash potatoes before storing; dampness promotes early spoilage.
- Store potatoes in a well-ventilated cool, dry, and dark place, ideally between 45-55°F.
- Do not store potatoes in a refrigerator. Temperatures below 45°F will cause the potato starches to convert to sugars, resulting in a sweeter taste and excessive darkening during cooking.

Nutrition on a Budget

One serving- a medium 5.3 ounce potato will only set you back about \$0.21! Pound for pound, potatoes are one of the best values in the produce section.



Did you know?

The average American eats 126 pounds of potatoes a year. This includes 53 pounds of frozen, 44 pounds of fresh, 16 pounds of chips, and 13 pounds of dehydrated potato products.

www.ext.colostate.edu

<http://farmtotable.colostate.edu/>

Colorado Potatoes

Potato Preparation

Potatoes are sometimes accused of being fattening. By itself, the potato is not fattening. However, frying potatoes in oil or piling them high with butter and sour cream can more than double the calories in a potato product. Another common misconception is that all of a potatoes' nutrients are located in its skin. Approximately half of the dietary fiber is found within the potato itself. As with many other vegetables, the method of cooking can affect the bioavailability of certain nutrients. Nutrient losses are greatest when boiling; water soluble vitamins and minerals will leach out into the cooking water. To maintain the highest nutrition of a cooked potato, steaming or microwaving are best.

Cooking with Potatoes

- Bake, boil, steam, or microwave cleaned potatoes with the skin on to retain nutrients.
- Use the water the potatoes were cooked in for making gravies or soups, as this water contains valuable nutrients leached from the potatoes.
- Do not allow potatoes to soak in cold water for any length of time. The water soluble nutrients will dissolve into the water.

Seasonality

Over 100 potato varieties are grown in Colorado with most production located in the San Luis Valley. At 7,600 feet, potatoes grown in the San Luis Valley are among the highest grown in the world! In Colorado, potato harvest begins in September with about 98% of the crop going into storage before being shipped.

Related Links

Storage of Homegrown Vegetables:
<http://www.ext.colostate.edu/pubs/garden/07601.html>

<http://www.coloradopotato.org/>



Food Safety Facts & Tips

- In general, potatoes are a safe food to eat. Mishandling prepared potato dishes, such as potato salad, may result in bacterial growth and cause illness.
- 90% of these cases are due to potato salad products. Potato salad provides a perfect breeding ground for harmful bacteria. With plenty of nutrients and proper temperatures, pathogens such as *Salmonella* or *Shigella* can readily grow.
- Wash potatoes thoroughly before cooking. Use clean knives and cutting boards to avoid cross contamination from other ingredients.
- When making your own potato salad, it is best to cool down the cooked potatoes to 41°F BEFORE you mix in other ingredients. Once all ingredients are mixed, place the salad back into the refrigerator immediately until ready to serve.
- Refrigerate any leftovers soon after serving. Do not allow it to stand at room temperature for more than 2 hours.
- If heating baked potatoes in foil to serve at a later time, ensure that the potato cools quickly and is stored in the refrigerator until used. Use a thermometer to reheat potatoes to 140°F before eating.

Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

Spinach Facts



Nutrition Facts

Serving Size : 1 cup (raw) (56g)

| Amount Per Serving | | Calories from Fat 0 | |
|---------------------------|------|---------------------|-----|
| | | % Daily Value* | |
| Calories | 15 | | |
| Total Fat | 0g | | 0% |
| Saturated Fat | 0g | | 0% |
| Trans Fat | 0g | | |
| Cholesterol | 0mg | | 0% |
| Sodium | 45mg | | 2% |
| Total Carbohydrate | 2g | | 1% |
| Dietary Fiber | 1g | | 4% |
| Sugars | 0g | | |
| Protein | 2g | | |
| Vitamin A | 110% | Vitamin C | 25% |
| Calcium | 8% | Iron | 8% |

*Percent Daily Values are based on a diet of 2,000 calories. Your daily values may be higher or lower depending on your calorie needs.

| | Calories: 2,000 | 2,500 |
|--------------------|-------------------|---------|
| Total Fat | Less than 65g | 90g |
| Saturated Fat | Less than 20g | 25g |
| Cholesterol | Less than 300mg | 300 mg |
| Sodium | Less than 2,400mg | 2,400mg |
| Total Carbohydrate | 300g | 375g |
| Dietary Fiber | 25g | 30g |

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Spinach Basics

Spinach is a versatile leafy green with a relatively long growing season here in Colorado. Great for use in a variety of dishes, spinach is a nutrient packed vegetable that you can incorporate into almost any meal. The cartoon character Popeye attributed his great strength to eating spinach as the nutritional benefits include high levels of iron, zinc, and vitamins such as A and C.

Varieties

Savoy: Crinkly and curly leaves, most commonly grown for local markets because they keep longer and have a more eye-catching visual appeal

Flat/smooth leaf: Flat smooth leaves, usually grown for canning and freezing because of their short time to harvest, higher yields, and ease of cleaning.

Semi-savoy: Hybrid of flat and savoy

Spinach Quality Characteristics to Look For

- Uniformly green
- Fully turgid (not wilted)
- Clean, free from visible dirt
- Free from damage (insect or handling)

Seasonality

As a cool season crop, spinach grows well in Colorado. It can be planted in early spring, about 4 weeks before the average last frost date. Ideal spinach growing weather is 50 to 60°F. You can continue sowing spinach seeds late into the fall season. If the ground freezes before the plants mature, mulch them with hay and leave them be until the temperatures warm again in spring. Remove the mulch and the plants should resume growing, resulting in an even earlier harvest.

Food Safety and Spinach

Recent outbreaks of food borne illness related to spinach have caused many consumers to become more aware of how they handle their produce after purchase or harvest. To reduce the risk for food borne illness, always wash spinach with cool water before consuming. If growing spinach in your own garden, strive to keep out any animals. By removing sources of contamination prior to harvest, the chances for a harmful pathogen to be present on the spinach in your salad will be greatly reduced.

Did you know?

Spinach is a very hardy crop and can withstand temperatures as low as 20°F. It does not tolerate hot weather well and begins to 'bolt', or go to seed- making the leaves taste bitter.

Colorado Spinach

Recipe Idea

Spinach and Sundried Tomato Quiche

*Chef Jason K. Morse, C.E.C.
Valley Country Club, Aurora, Colo.*

- 1 10" pie shell
- 10 oz. raw spinach, rough chopped
- 3 tbsp. olive oil
- 1 c sundried tomatoes, rehydrated in hot water
- 1/2 c romano cheese, grated
- 1 medium shallot, minced
- 1 clove garlic, chopped
- 1 tsp. dried basil
- 1/2 cup milk
- 10 eggs

Bake pie shell until lightly golden, remove from oven and allow to cool at room temperature. Mix all the ingredients except eggs and milk then place in the cooled pie shell. Combine the eggs and milk and mix well. Pour the egg mixture over the ingredients. Bake at 325 degrees for 15 minutes, then rotate and bake for additional 12 minutes, or until fully cooked (160°F, or until knife inserted into quiche comes out clean).

Source: Colorado Proud Website

Storage

When you bring your spinach home:

- Keep it cold – refrigerate promptly
- Store it dry
- Wash with cold, clean water before eating
- Use it fast – generally within 3-5 days

Typically, you can keep and use spinach until it shows signs of spoilage, at which point it should be thrown out.

Signs of spoilage include:

- Wilting
- Off-odors
- Yellowing
- Watery leaves



Health Benefits

Spinach provides a low calorie, nutrient dense option to add to many different recipes, or to use in a simple salad. Spinach is a good to excellent source of vitamins A, C, and folate, as well as minerals such as manganese, magnesium, calcium, zinc, and iron. It is also a good source of fiber and even contributes a small amount of protein to the diet.

Spinach also contains many lesser known antioxidant compounds such as flavonoids. Antioxidants are crucial to our body's natural defenses, helping reduce the risk of cancer.

Not enough? Spinach may play a role in the slowdown of the aging process, and help to maintain brain function. These potential health benefits, along with the proven nutritional benefits of spinach make it a must-have in your diet.

Related Links

Salad Greens: Keeping E.Coli Out of the Mix:

<http://www.ext.colostate.edu/safefood/newsltr/v11n2s01.html>

Freezing Vegetables:

<http://www.ext.colostate.edu/pubs/foodnut/09330.html>

Safe Handling of Leafy Greens:

<http://www.ext.colostate.edu/pubs/foodnut/09373.html>

Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

Squash Facts



Cutting Skills:

Most recipes using hard shelled winter squash varieties call for cutting the squash in half. To cut safely, cut off a ¼ inch from the bottom and stem end of the squash. Peel off the outer layer using a sharp vegetable peeler. Place squash upright on the cutting board and make one long cut down the middle from top to bottom. Use a small mallet or hammer to tap the knife through, if necessary.



Did you know?

Hard shelled squash varieties are unique to North America. The earliest natives cultivated them and honored them as one of the "Three Sisters", along with beans and corn. Many civilizations relied on the Three Sisters for sustenance as corn and beans made a complete protein and squash added beta-carotene and fiber to the diet.

Squash (Cucurbitaceae family) have been a staple of Native Americans and early European settlers for more than 5000 years. Available in many shapes, sizes and colors, squash are a nutritious and fun way to add color and nutrients to the diet. While some types of squash are grown on vines and others on bushes, all can be loosely grouped into summer or winter squash types. Summer squash varieties are soft skinned vegetables typically eaten soon after harvest. The fruit is picked off bush-type plants at an immature stage to prevent the formation of a hard rind. Winter squashes are harvested from low growing vines and eaten at the mature fruit stage.

Seasonality

Summer squashes are available in Colorado from August through October, whereas winter squashes are typically available from August until December. Winter squash and pumpkins require a long, warm growing season and do best at elevations below 5,000 feet. Many types of winter squashes and pumpkins can easily be stored for use throughout the winter months. Cucumbers and summer squash also require warm growing temperatures, but have a shorter growing season and shelf life than winter squash.

Selection

Choose squash with the following characteristics:

- Full sized, hard shell (winter squash)
- Heavy for their size (winter squash)
- No extensive bruising, cuts or wounds (can be an issue with soft skinned summer squash)

Handling

Summer squash is harvested when immature and may bruise or scratch easily. It can be stored in the refrigerator crisper for 3-5 days and should be kept free from moisture. Wash both winter and summer varieties under cool, running water to remove dirt and harmful bacteria before cutting. Once cut, be sure to refrigerate cut portions and discard any not used within 1-2 days.

Storage Tips for Winter Squash

Let fresh-picked winter squash sit at room temperature for 10-20 days to allow it to "cure." Then place in a cool storage room (50-55°F), no more than two fruits deep. To avoid the potential spread of mold and rot, place fruits in a single layer if space allows. A large, hard rind winter squash can be stored for up to 6 months at 50-55°F. At room temperature, winter squash can only be stored 2-3 months.

Colorado Squash



Nutrition Facts

Serving Size 1 Medium Zucchini (with skin) (195g)

Amount Per Serving

Calories 30 Calories from Fat 5

% Daily Value*

Total Fat 0g 0%

Saturated Fat 0g 0%

Trans Fat 0g

Cholesterol 0mg 0%

Sodium 20mg 1%

Total Carbohydrate 7g 2%

Dietary Fiber 2g 8%

Sugars 3g

Protein 2g

Vitamin A 8% Vitamin C 60%

Calcium 2% Iron 4%

*Percent Daily Values are based on a diet of other people's secrets.

†Your daily values may vary depending on your individual needs.

Calories: 2,000 2,500

Total Fat: Less than 65g 65g

Saturated Fat: Less than 25g 25g

Cholesterol: Less than 300mg 300mg

Sodium: Less than 2,400mg 2,400mg

Total Carbohydrate: 300g 375g

Dietary Fiber: 25g 30g

Calories per gram: Fat 9 • Carbohydrate 4 • Protein 4

Nutrition

The nutritional properties of squash range greatly depending on the variety and maturity. Winter squashes are a great source of complex carbohydrates and fiber. The flesh of orange squash, such as butternut, is high in beta-carotene which is converted to Vitamin A in the body. Vitamin A promotes healthy skin and reduces the risk for vision problems.

Summer squash contains slightly fewer nutrients than winter squash, primarily because it is harvested at an immature stage. The peel contains the most nutrients. Summer varieties are high in fiber, potassium, folate, and vitamin C. Male squash blossoms can also be eaten and are tasty when battered and fried.

Recipe

Pickled Bread-And-Butter Zucchini

- 16 cups fresh zucchini, sliced (3/16-inch thick)
- 4 cups onion, thinly sliced
- 1/2 cup canning or pickling salt
- 4 cups white vinegar (5% acidity)
- 2 cups sugar
- 4 tablespoons mustard seed
- 2 tablespoons celery seed
- 2 teaspoons ground turmeric

Yield: About 8 to 9 pints

Cover zucchini and onion with 1 inch ice water and salt. Let stand 2 hours; drain thoroughly. Combine vinegar, sugar, mustard seed, celery seed and turmeric. Bring to a boil; add zucchini and onions. Simmer 5 minutes. Fill clean pint jars with mixture and pickling solution, leaving 1/2-inch headspace. Remove air bubbles. Wipe jar rims. Adjust lids. Process in a boiling water-bath canner for 15 minutes at 6,000 feet or less; 20 minutes above 6,000 feet.

Source: <http://www.ext.colostate.edu/pubs/foodnut/09304.html>

Freezing Squash:

Winter: Wash; cut into pieces and remove seeds. Cook pieces until soft in boiling water, steam, microwave oven, pressure cooker or 350-400°F oven (cut side down). Cool. Scoop out pulp; mash, blend or put through sieve. Chill thoroughly. Place into plastic containers or bags and remove as much air as possible. Store in the freezer for up to 4 months.

Summer: Select young squash with small seeds and tender rind. Wash, cut in 1/2-inch slices. Water blanch 4 minutes. Cool and drain. Place into plastic containers or bags and place in freezer for up to 4 months.

Related Links

Cucumbers, Pumpkins, Squash and Melons

<http://www.ext.colostate.edu/pubs/garden/07609.html>

Storage of Home-Grown Vegetables

<http://www.ext.colostate.edu/pubs/garden/07601.html>

Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

Tomato Facts



Handy Tip:

Tomatoes harvested or purchased at 80-80% of their full color can be ripened in the kitchen. Ripening can be done in a paper bag with a few small holes punched into the side.



Although botanically classified as a fruit, the tomato is the most popular "vegetable" grown in home gardens across America. The tomato plant is a warm-season perennial that is grown as an annual in summer gardens across the country. In Colorado, spring and fall cool temperatures allow tomatoes a short, but typically productive growing season. The texture, flavor, and cooking characteristics of tomatoes depend on the variety, growing method, handling techniques, and overall environment. As part of the Solanaceae family, also known as the nightshade family, tomatoes are relatives of peppers, potatoes, and eggplant.

Seasonality

In Colorado, tomatoes can be a challenge to grow due to the short growing season. The dry air and cool temperatures at night often prevent the pollination of certain varieties. However, tomatoes can be found at Farmer's Market from July-October, depending on the weather during the season. Nothing tastes better than a fully vine-ripened tomato; growing your own or purchasing them fresh from the market will produce the best flavor. Colorado also operates several large greenhouses used in tomato industry, producing fresh tomatoes on a year-round basis.

Why do I need to be aware of pH when canning salsa?

Foods such as pickles or salsa need to have an acid added if they are to reach a pH level of 4.6 or lower to prevent microorganism growth and/or survival. Microorganisms such as *Clostridium botulinum*, the bacteria that causes botulism, can survive and grow in some foods at certain pH levels. Although tomatoes naturally have a low pH, adding other ingredients with higher pH values may make the product unsafe to eat. Adding lemon juice or citric acid to the recipe will lower the pH, making a safe canned product.

Selection

Choose tomatoes with the following characteristics:

- Round, full, and heavy for their size
- Free from physical or insect damage
- Rich color, no bruising* or pitting
- Flesh yields slightly to gentle pressure

*Bruised tomatoes are good for making sauces. Bruised or "less perfect" tomatoes can often be purchased from a grower at a lower cost.

Handling

Foodborne illness outbreaks caused by *Salmonella* has been linked to the consumption of raw red plum, red Roma, round red tomatoes, and items containing these raw tomatoes. Like any other fruit or vegetable, tomatoes can be contaminated by bacteria from the soil, water, animals, or human sources. Wash tomatoes with clean water prior to eating or preparing.

Did you know?

The lycopene in processed tomatoes (canned, ketchup, sauce) is actually more available to the body than that found in raw tomatoes. Heating breaks down the plant's cell walls, making the lycopene more accessible to the body. Lycopene is also better absorbed if consumed with a small amount of fat.

Storage

Whole tomatoes do not need to be stored in the refrigerator, as the flavor actually decreases upon chilling. Ripe tomatoes retain the best eating quality for 2 to 3 days, if stored at room temperature. Refrigeration does slow the ripening of tomatoes, so extra-ripe tomatoes may need to be refrigerated to keep the fruit from ripening any further. Always cover and refrigerate cut tomatoes if preparing in advance.

www.ext.colostate.edu

<http://farmtotable.colostate.edu/>

Tomato Fact Sheet



| Nutrition Facts | |
|---|---------------------|
| Serving Size 1 large (3" tomato) (182g) | |
| Amount Per Serving | |
| Calories 35 | Calories from Fat 5 |
| % Daily Value* | |
| Total Fat 0g | 0% |
| Saturated Fat 0g | 0% |
| Trans Fat 0g | |
| Cholesterol 0mg | 0% |
| Sodium 10mg | 0% |
| Total Carbohydrate 7g | 2% |
| Dietary Fiber 2g | 8% |
| Sugars 5g | |
| Protein 2g | |
| Vitamin A 30% | Vitamin C 40% |
| Calcium 2% | Iron 2% |

*Percent Daily Values are based on a diet of other people's secrets. Your daily values may be higher or lower depending on your calorie needs.

| | Calories | 2,000 | 2,500 |
|--------------------|-------------------|---------|---------|
| Total Fat | Less than 65g | 80g | 100g |
| Saturated Fat | Less than 20g | 25g | 30g |
| Cholesterol | Less than 30mg | 30mg | 40mg |
| Sodium | Less than 2,400mg | 2,400mg | 3,000mg |
| Total Carbohydrate | 30g | 37g | 45g |
| Dietary Fiber | 25g | 30g | 35g |

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Nutrition

In addition to Vitamin C, Vitamin A, fiber, and potassium, tomatoes contain large amounts of lycopene. This compound may play a role in the prevention of certain types of cancer, particularly prostate cancer. Carotenoids, such as beta carotene and lycopene, are responsible for the bright red color seen in tomatoes, watermelon, and grapefruit. Through the process of cooking, lycopene becomes more available for use within the body. Using a small amount of healthy fats, such as olive oil, in a pasta sauce will enable the body to better metabolize lycopene, a fat soluble compound.

Related Links

Canning Tomatoes and Tomato Products
<http://www.ext.colostate.edu/pubs/foodnut/09341.html>
 Gardening
<http://www.ext.colostate.edu/pubs/garden/02949.html>

Uses

Tomatoes can be used in a variety of ways; stewing, sautéing, grilling, or simply eating raw are common methods of preparation. In addition, tomatoes can be frozen, dried, or canned.

Drying: Tomatoes that are dried using a dehydrator should be packed into an air tight container and stored in the refrigerator. "Sun-dried" tomatoes can be a great flavor addition to sauces, salads, or as an appetizer- but should be done using safe drying methods.

Freezing: Frozen tomatoes are best used in dishes such as soups, stews, or sauces. To freeze, wash tomatoes. Remove the stems and cut out the core. Leave the tomato whole or cut into quarters and place in a freezer bag, leaving ½ inch of head space.

Canning: Although tomatoes are considered a high acid food, some varieties have a pH greater than 4.6. Tomatoes must either be canned using a pressure canner or acidified using lemon juice or citric acid and processed in a boiling water bath.

Roasted Corn and Tomato Quesadillas

Colorado Chef Dan Skay, Parkview Medical Center, Pueblo

3 cups roasted corn on the cob
 3 cups tomatoes, diced
 1/2 cup onion, diced
 1/2 cup green bell pepper, diced
 1 jalapeno pepper, minced
 Shredded Monterey Jack cheese

Roast corn on the cob until tender. Cut the corn from the cob and place in a container with the diced tomatoes, onion, and peppers. Mix well. Season a clean hot griddle and butter or vegetable spray a 10-inch tortilla. Place the corn-tomato mixture evenly on top of the tortilla. Cover with shredded cheese. Place another tortilla atop the cheese and butter or vegetable spray the outside of the tortilla. When the bottom tortilla begins to turn golden, turn it over being careful not to lose the flavorful filling inside. When the bottom tortilla turns golden, remove, cut into 6 triangles and serve with fresh salsa.

Source: Colorado Proud Website

APPENDIX F

How well do you know your produce?

- 1.) What causes apples to turn brown after they are cut?
- 2.) Where are the majority of nutrients located in an apple?
- 3.) How many days on average does it take a strawberry to travel from the farm to the hands of a consumer?
- 4.) What causes broccoli to become tough and chewy?
- 5.) What is the best way to remove garden pests from broccoli?
- 6.) Should you wash the outside of a melon before cutting it?
- 7.) What is the difference between a freestone peach and a clingstone peach?
- 8.) What compound is responsible for the “hot” flavor of many peppers?
- 9.) What is the world’s 4th largest food crop?
- 10.) What form of cooking results in the greatest nutrient losses of potatoes?
- 11.) Should spinach be washed before eating?
- 12.) Along with corn and beans, what vegetable crop completes the Native American trio, called the “Three Sisters”?
- 13.) How long can winter squash be stored?
- 14.) Is lycopene more available in processed tomato products or fresh tomatoes?
- 15.) Tomatoes are naturally acidic, so does that mean my salsa will be safe from harmful bacteria?

Answers

- 1.) Apples brown due to a compound called polyphenoloxidase. When an apple is cut, these compounds are released from the cell and cause a browning reaction on the fruit. The more Vitamin C the apple contains, the less the browning may occur. Dipping apple slices in a solution of 50% water and 50% Vitamin C rich lemon juice will help prevent extensive browning and can help maintain crispness.
- 2.) 2/3 of the fiber and many of the antioxidants in an apple are located in the skin!
- 3.) Strawberries are picked, sorted, and packed in the field. They are cooled to 34°F and loaded onto refrigerated trucks. The average strawberry reaches the consumer within 24-36 hours of harvest! That's berry fast!
- 4.) At room temperature, harvested broccoli will convert sugar into a fiber called lignin. The more time spent at room temperature, the more lignin is produced and the more fibrous your broccoli becomes! Keep broccoli refrigerated to extend the shelf life.
- 5.) Soaking fresh locally-grown broccoli in salt water for 5-10 minutes can help in removing any unwanted garden pests.
- 6.) Absolutely. Before cutting open a cantaloupe, wash the outside rind thoroughly in a clean sink under cool running water. Scrub with a clean vegetable brush to remove any soil or bacteria on the rind that might be carried from the knife blade to the flesh during slicing.
- 7.) Freestone peaches are used for the fresh market, whereas clingstone peaches are typically used for canning and processing.
- 8.) Capsaicin is the compound responsible for the "hot" flavor of many peppers. Jalapeno and cayenne peppers range from 2,000 to 25,000 Scoville heat units, whereas Tabasco peppers range between 60,000 to 80,000 units. Green Bell peppers are rated 0 on the scale because they do not contain capsaicin.
- 9.) After rice, wheat, and corn, potatoes rank 4th as the most widely consumed food crop.
- 10.) Nutrient losses are greatest when boiling; water soluble vitamins and minerals will leach out into the cooking water. To maintain the highest nutrition of a cooked potato, steaming or microwaving is recommended.

- 11.) Yes. To reduce the risk for food borne illness, always wash spinach with cool water before consuming. If growing spinach in your own garden, strive to keep out any animals. By removing sources of contamination prior to harvest, the chances for a harmful pathogen to be present on the spinach in your salad will be greatly reduced.
- 12.) Hard shelled squash varieties are unique to North America. The earliest natives cultivated them and honored them as one of the “Three Sisters”, along with beans and corn. Many civilizations relied on the Three Sisters for sustenance as corn and beans made a complete protein and squash added beta-carotene and fiber to the diet.
- 13.) A large, hard rind winter squash can be stored for up to 6 months at 50-55°F. At room temperature, winter squash can only be stored 2-3 months.
- 14.) The lycopene in processed tomatoes (canned, ketchup, sauce) is actually more available to the body than that found in raw tomatoes. Heating breaks down the plant’s cell walls, making the lycopene more accessible to the body. Lycopene is also better absorbed if consumed with a small amount of fat.
- 15.) No. Foods such as pickles or salsa need to have an acid added if they are to reach a pH level of 4.6 or lower to prevent microorganism growth and/or survival. Microorganisms such as *Clostridium botulinum*, the bacteria that causes botulism, can survive and grow in some foods at certain pH levels. Although tomatoes naturally have a low pH, adding other ingredients with higher pH values may make the product unsafe to eat. Adding sufficient lemon juice or citric acid to the recipe will lower the pH, making a safe canned product.

APPENDIX G

PRODUCE FACT SHEET SURVEY

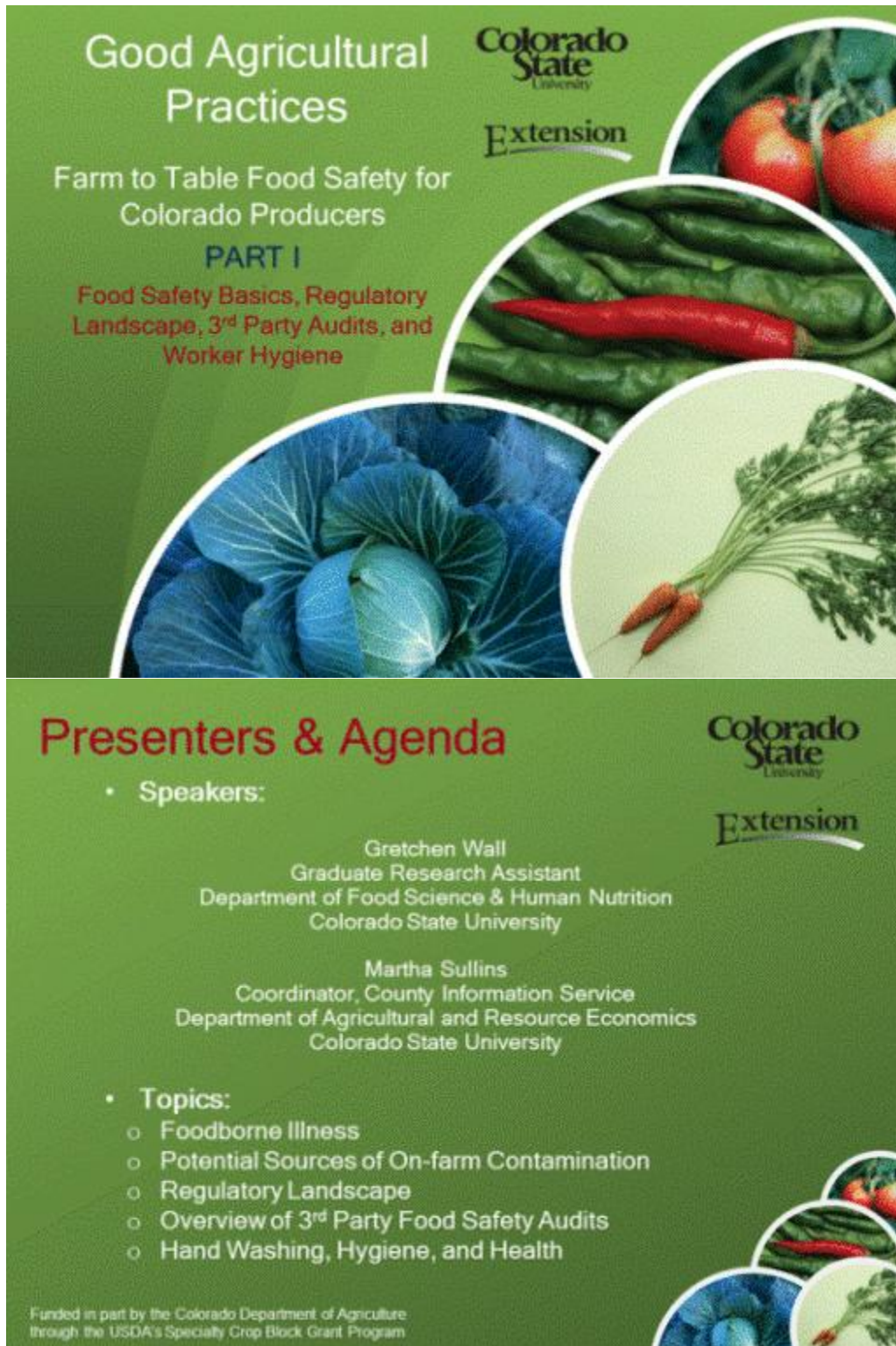
| |
|----------------------|
| Age: |
| Gender: |
| Fact Sheet Reviewed: |

For each item identified below, circle the number to the right that best fits your judgment of the question.

| Questions 1-2, please answer prior to reading the fact sheet(s). | Scale | | | | | |
|---|------------|---|---|---|---|------------------|
| | Nothing | 1 | 2 | 3 | 4 | Advanced |
| 1. Please rate your knowledge of the fact sheet topic, prior to reading. | 1 | 2 | 3 | 4 | 5 | |
| 2. Please rate your knowledge of food safety, preservation, and produce storage and handling, prior to reading. | 1 | 2 | 3 | 4 | 5 | |
| Questions 3-4, please answer after reading the fact sheet(s). | Scale | | | | | |
| | Nothing | 1 | 2 | 3 | 4 | Advanced |
| 3. Please rate your knowledge of the fact sheet topic, after reading. | 1 | 2 | 3 | 4 | 5 | |
| 4. Please rate your knowledge of food safety, preservation, and produce storage and handling, after reading. | 1 | 2 | 3 | 4 | 5 | |
| Questions 5-10, please answer the following questions regarding the usefulness of each section after reading the fact sheet(s). | Section | | | | | |
| | Not Useful | 1 | 2 | 3 | 4 | Extremely Useful |
| 5. Please rate the material included in the introduction, background, and history of the fact sheet. | 1 | 2 | 3 | 4 | 5 | |
| 6. Please rate the material included in the handling and storage section of the fact sheet. | 1 | 2 | 3 | 4 | 5 | |
| 7. Please rate the material included in the nutritional and recipe section of the fact sheet. | 1 | 2 | 3 | 4 | 5 | |
| 8. Please rate the material included in the preservation section of the fact sheet. | 1 | 2 | 3 | 4 | 5 | |
| 9. Please rate the material included in the fun facts and helpful hints section of the fact sheet. | 1 | 2 | 3 | 4 | 5 | |
| 10. Please rate the overall usefulness of the fact sheet after reading. | 1 | 2 | 3 | 4 | 5 | |

APPENDIX H

Webinar I



Good Agricultural Practices

Colorado State University
Extension

Farm to Table Food Safety for Colorado Producers

PART I

Food Safety Basics, Regulatory Landscape, 3rd Party Audits, and Worker Hygiene

Presenters & Agenda

Colorado State University
Extension

- **Speakers:**
 - Gretchen Wall
Graduate Research Assistant
Department of Food Science & Human Nutrition
Colorado State University
 - Martha Sullins
Coordinator, County Information Service
Department of Agricultural and Resource Economics
Colorado State University
- **Topics:**
 - Foodborne Illness
 - Potential Sources of On-farm Contamination
 - Regulatory Landscape
 - Overview of 3rd Party Food Safety Audits
 - Hand Washing, Hygiene, and Health

Funded in part by the Colorado Department of Agriculture through the USDA's Specialty Crop Block Grant Program

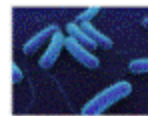
Food Safety Definitions

- Food Safety - the monitoring of food to ensure that it will not cause illness
- Foodborne Illness (FBI) - any illness resulting from the consumption of food
- Food Defense - protection from deliberate introduction of a dangerous substance
- Pathogen - disease causing microorganisms



Types of Contamination

- **Biological**
 - Microorganisms
 - bacteria, viruses, parasites
 - Natural Toxins
 - mushrooms, fish
- **Chemical**
 - Environmental Contaminants
 - mercury, pesticides
- **Physical**
 - Harmful Objects
 - glass, metal





Recent Outbreaks



2003:
Green Onions
Hepatitis A



2007:
Ground Beef
E. coli O157:H7



2004:
Roma Tomatoes
Salmonella



2008:
Cantaloupe/Peppers
Salmonella



2005:
Frozen Raspberries
Norovirus



2009:
Peanut Butter
Salmonella



2006:
Spinach
E. coli O157:H7



2010:
Eggs
Salmonella

2011:

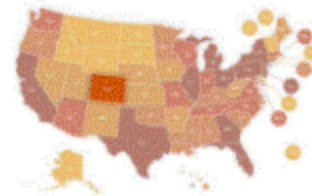


?

Foodborne Illness Statistics

| Organism | 2007 | 2008 | 2009 |
|-------------------------------|------|------|------|
| <i>Campylobacter</i> species | 816 | 763 | 756 |
| <i>Salmonella</i> species | 563 | 716 | 622 |
| <i>Giardia lamblia</i> | 580 | 562 | 500 |
| Shiga-toxin <i>E. coli</i> | 165 | 212 | 168 |
| <i>Shigella</i> species | 122 | 149 | 103 |
| <i>Cryptosporidium</i> | 216 | 113 | 138 |
| Hepatitis A | 27 | 38 | 53 |
| <i>Listeria monocytogenes</i> | 11 | 8 | 9 |
| <i>Cyclospora</i> | 1 | 1 | 0 |
| <i>Clostridium botulinum</i> | 5 | 0 | 0 |

The economic cost to society is high
U.S. estimates/year = \$152 Billion
Average cost per illness = \$1,850
Colorado estimate = \$2,336,000,000



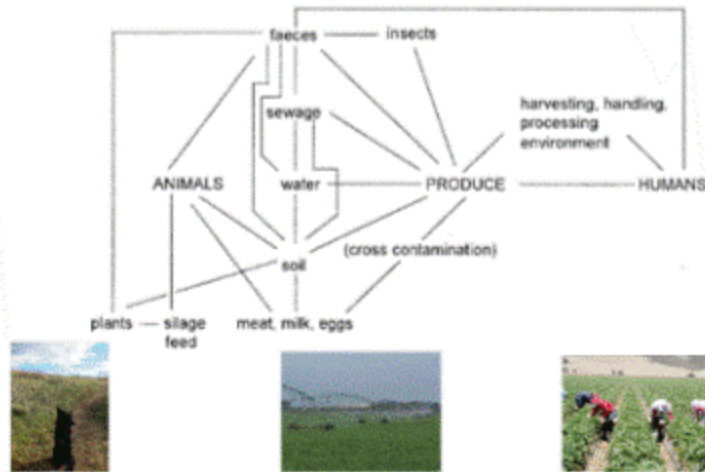


Produce Characteristics

- Grows close to soil
- Open environment
- Large surface area
- High moisture content
- Generally favorable pH
- Often consumed raw



Potential Sources of Pathogen Contamination



Source: Beuchat, 1996

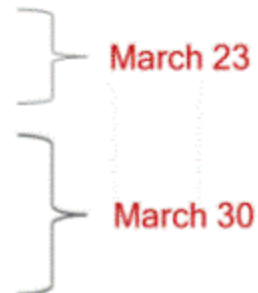
Good Agricultural Practices (GAPs)

- GAPs (Good Agricultural Practices): agricultural industry's guide to minimize and prevent contamination of fresh fruits and vegetables on the farm.
- GHPs (Good Handling Practices): focuses on best practices for packing and storing facilities, cleaning and sanitation, and transportation.



Good Agricultural Practices (GAPs)

- Elements of GAPs
 - Worker Health & Hygiene
 - Irrigation Water
 - Manure
 - Sanitary Facilities
 - Field Sanitation
 - Packing Facility Sanitation
 - Transportation
 - Traceback



Pop Quiz!

Regulatory Landscape

2011 Food Safety Modernization Act (S.510)

- ✓ Passed January 5, 2011
- ✓ Changes to occur in the next 9 months - 3 years
- ✓ Some impacts clear, some yet to be defined
- ✓ Focus on prevention, not detection of issues



New Provisions

- 1) Recall food products with potentially severe health consequences
- 2) Adopt risk-based approaches to food safety
- 3) Inspect high risk food facilities
- 4) Gain access to records
- 5) Require foreign suppliers to comply with U.S. food safety standards
- 6) Require food companies to have written food safety plans (HACCP, GAPs, GMPs)

- Some exemptions exist for small scale producers and processors

What can farmers expect?

- ✓ FDA to develop minimum safe production and harvest standards to prevent food safety hazards

Possible exemptions

- Low-risk fruits and vegetables
- Farms that:
 - ✓ Direct market more than 50% of products to qualified end users
 - ✓ Have gross sales of all food and food products of less than \$500,000
 - ✓ Sell to consumers, stores, or restaurants that are in-state or within 275 miles of where the products were harvested or processed
 - ✓ Disclose to consumers the name and address of the farm from which the food originated



What can food facilities expect?



- A variance process will give some businesses and states extra time to comply

- **Definition does not change**

- Any business that packs or holds food that is not grown, raised or consumed on that farm, or it manufactures or processes food that is not consumed on that farm [except for exempted farms, and farmers markets, roadside stands and CSAs]
- Possible exemptions for facilities that make animal food and those that store raw ag commodities (but not fruits and vegetables)

- **Requirements**

- ✓ Develop HACCP plan and written preventive controls plan to include sanitation, allergen controls, verification of suppliers, follow Good Manufacturing Practices
- ✓ Keep records of all of these plans



Tips to Remember

- ✓ State, local and county government food safety laws must still be followed for producing, harvesting, holding, transporting, and selling fresh fruits and vegetables
- ✓ Food buyers may still mandate food safety or certification programs:
 - Farm to School programs may be GAP audited
 - Retailers and institutional food service buyers may still require food safety programs



Resources:

Check FDA for updates

<http://www.fda.gov/Food/FoodSafety/FSMA/default.htm>



Types of Audits



First Party: a self audit conducted by the firm
Ex. Cornell GAPs Self Audit



Second Party: an audit performed by the buyer
Ex. Grocery chain specifications



Third Party: an audit performed by a party separate from the producer or buyer
Ex. USDA GAPs, Primus Labs, Davis Fresh, etc.

The Not-So-Scary Truth



90% of audit requirements are already being done on the farm, they just need to be documented!

The Basics: On Farm Food Safety Audit 101

- ✓ **Audit is performed only by request of auditee**
- ✓ **Valid for 1 year**
(contingent upon passing unannounced audits)
- ✓ **Prior to start, applicant must sign an "Agreement to Participate" document**
- ✓ **Program is designed for continual & consistent use**
 - Unannounced visits will confirm consistent use
- ✓ **Unannounced visits (usually <3/year) may consist of:**
 - Brief visit with contact person
 - Walk through of farm/packing operation
 - Review of any changes to food safety plan (ie. New employee training, change to standard operating procedures (SOPs))

Audit Scopes & Communication

***Key is communication between buyer and seller to understand what is expected**

- ✓ **Audit Scopes**
 - Part 1*: Farm Review
 - *All audits must begin with and pass this portion**
 - Part 2: Field Harvest and Field Packing Activities
 - Part 3: House Packing Facility
 - Part 4: Storage and Transportation
 - Part 5: Vacant
 - Part 6: Wholesale Distribution/Terminal Warehouse
 - Part 7: Preventative Food Defense Procedures



Good Agricultural Practices (GAPs)

- Elements of GAPs
 - **Worker Health & Hygiene**
 - Irrigation Water
 - Manure
 - Sanitary Facilities
 - Field Sanitation
 - Packing Facility Sanitation
 - Transportation
 - Traceback

March 23

March 30



Worker Hygiene and Training

- Pathogen transfer can occur from agricultural worker to food via several routes



Worker Hygiene and Training

Preventative Measures

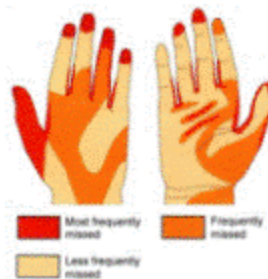
1. Educate employees
 - Training Programs
 - Documentation
2. Provide appropriate facilities
 - Hand washing
 - Toilet Facilities
3. Reinforce good hygiene practices
 - Set a good personal example
 - Monitor use
4. Maintain and service facilities
5. Reassign sick employees



Photo credits: Cornell GAP's Food Safety Begins on the Farm Grower's Guide



Hand Washing



- Use soap and warm water.
- Rub hands together to make a lather.
- Vigorous friction on areas of lathered hands and arms for at least **20** seconds.
- Use a scrub brush to clean under and around finger nails.
- Rinse well under warm water.
- Dry hands with a paper towel or hot air dryer.



Documentation: Training

| Training: Human Health & Hygiene | Documented Compliance (Yes/No) | Comments |
|--|--------------------------------|----------|
| All employees receive basic instruction in food safety. | | |
| Supervisors are trained to be familiar with the typical signs and symptoms of infectious illnesses. | | |
| All employees receive training in good personal hygiene (including bathing, hand washing, teeth brushing, wound care, etc.). | | |
| The importance of good hygiene, and regular and thorough hand washing are stressed on a consistent basis. | | |

GAPs & Impact of 2003 Hepatitis A Outbreak

Table 2—Impact of food safety outbreak on Mexican growers, by GAP status

| GAP status | Impact on: | |
|--------------------------|---------------------------------------|--|
| | Volume of green onion sales | Demand for other products |
| GAPs | Fairly constant | No impact |
| Partial GAPs | Down a bit | Some impact |
| No GAPs | Down by 50 percent | Down by about 30 percent |
| No GAPs and named by FDA | No sales and most fields plowed under | Shippers stopped selling all or almost all products from these growers |

Source: Avendaño and Calvin (2004).

The Economics of Food Safety: The Case of Green Onions and Hepatitis A Outbreaks, by Linda Calvin, Belem Avendaño, and Rita Schwenfesus, VGS-305-01, USDA, Economic Research Service, December 2004, available at www.ers.usda.gov/publications/vgs/vgs30501/



Summary

- ✓ Contamination of fresh fruits and vegetables may occur via many routes on the farm, however water, manure, and handling by employees are a significant risk factor.
- ✓ GAPs are currently NOT mandatory, but may be in the future- so plan ahead!
- ✓ Participating in 3rd Party Audits for food safety can help you develop and implement your food safety plan.
- ✓ Training, documenting, and verifying that employees are following good hygiene practices can reduce the risk for a foodborne outbreak originating on the farm.



Resources

USDA Audit Check List

<http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5050869>

USDA Audit Score Sheet

<http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5050871>

National Good Agricultural Practices Network for Education and Training, Cornell University

<http://www.gaps.cornell.edu/>

Good Agricultural Practices: A Self-Audit for Growers and Handlers, UC Davis

<http://ucce.ucdavis.edu/files/filelibrary/5453/4362.pdf>

Good Agricultural Practices, Joint Institute for Food Safety and Applied Nutrition:

<http://www.jifsan.umd.edu/training/gaps.php>



Acknowledgements

- Department of Food Science and Human Nutrition
 - Dr. Marisa Bunning, Food Safety Extension Specialist & Asst. Professor
 - Dr. Patricia Kendall, Extension Specialist and Professor
 - Mary Schroeder, Research Associate
 - Jessica Hedden, Ryan Friedman, Andrew Kester, Graduate students
- Department of Agricultural and Resource Economics
 - Martha Sullins, Coordinator, County Information Service
- College of Agricultural Sciences
 - Dr. Dennis Lamm, Extension Specialist and Professor
- Colorado Department of Agriculture
 - Tracy Vanderpool, Fruit & Vegetable Section Chief
- Colorado State Extension
 - Adrian Card, Boulder Extension Agent
 - Ruth Willson, Extension Technology




Contacts

- Marisa Bunning, Ph.D.
Assistant Professor and Extension Specialist, Food Safety
970-491-7180
mbunning@cahs.colostate.edu
- Martha Sullins
CSU Extension Coordinator, County Information Service
970-491-5706
sullins@ext.colostate.edu
- Tracy Vanderpool
Fruit and Vegetable Section Chief, CO Dept. of Ag
719-852-4749
Tracy.Vanderpool@ag.state.co.us
- Gretchen Wall
Graduate Research Assistant
Gretchen.Wall@colostate.edu



Webinar II



Good Agricultural Practices

Farm to Table Food Safety
for Colorado Producers

PART 2: Minimizing Risks During Production

Irrigation Water and Manure Management



Presenters & Agenda

- Speakers:

Marisa Bunning
Assistant Professor and Extension Specialist - Food Safety

Gretchen Wall
Graduate Research Assistant

Department of Food Science & Human Nutrition
Colorado State University

- Topics:

- Site Selection
- Manure & Pathogen Survival
- Composting Manure
- Application & Timing
- Water Contamination Routes
- Irrigation Sources & Testing

Funded in part by the Colorado Department of Agriculture
through the USDA's Specialty Crop Block Grant Program





Review of Webinars

March 16

- General On-Farm Food Safety
- Regulatory Landscape
- 3rd Party Audits
- Worker Hygiene and Health

March 30

- Post-Harvest Operations
- Packing Shed Sanitation
- Pest Management
- Cooling and Wash Water
- Transportation
- Traceback

Recordings posted on:

<http://farmtotable.colostate.edu/gap-ghp.aspx>

Risk Reduction

- **Prevention** is the key to reducing microbial contamination of fruits and vegetables *before* it occurs
- Current technologies cannot eliminate all potential food safety hazards associated with fresh produce eaten raw



"WHAT'LL IT BE — ONE LARGE RISK OR SEVERAL SMALLONES?"



Sanitation in the Field

- Site Selection
 - Land History
 - Livestock Operations
 - Worker Facilities
 - Availability of Safe Water Source



Sanitation in the Field

- Production Practices
 - **Manure Management**
 - **Manure Application**
 - **Irrigation Practices**
 - **Water Testing**
 - Harvest & Post-Harvest Operations



Photo credit: Frank Stenaker



Animal Exclusion

- Keep livestock away from irrigation water sources (direct deposition)
- Harvest workers should be trained to leave any fruit or vegetable that has been contaminated (visibly) with or in close proximity to animal feces
- Visitors, U-Pick customers, family, and friends should be instructed to leave their pets at home
- Keep deer, birds, raccoons, and household pets out as much as possible



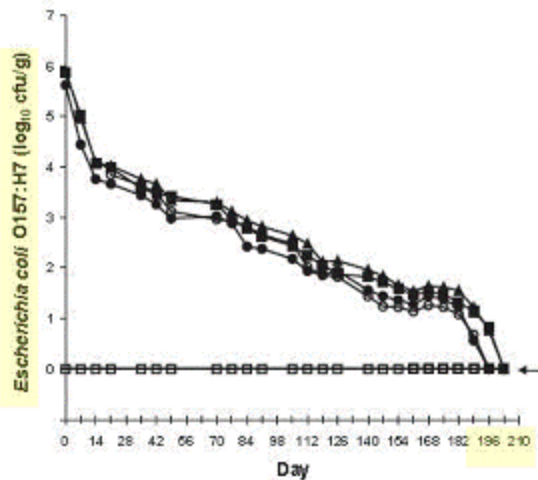
Manure as a Source of Contamination

- Why should we be concerned?
 - Pathogens can survive in soil for long periods of time
 - Fruits and vegetables may come in direct contact with soil
 - Many farm animals shed harmful pathogens naturally
 - Cattle: *Esherichia coli* O157:H7
 - Sheep: *Listeria monocytogenes*
 - Poultry: *Campylobacter*





Survival of *E. coli* O157:H7 in Soil



Islam et al., 2004. Survival of *Escherichia coli* O157:H7 in soil and on carrots and onions grown in fields treated with contaminated manure composts or irrigation water, *Food Microbiol.* 22 (2004), pp. 63-70.

Crop Selection

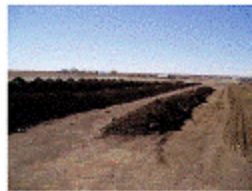
- **Root Crops:**
 - Edible portion in direct contact with soil/manure/water
- **Above Ground Crops:**
 - Tomatoes, peppers, etc.
 - Contamination may occur post-harvest via workers, packing house, handling
- **Leafy Greens:**
 - Irrigation method
 - Large surface area
 - Minimally processed (bagged greens)
- **Tree Fruit:**
 - Risk low, avoid fruit on ground
- **Grain/Forage Crops:**
 - No major risk





Manure Types

- **Types of Manure**
 - Green manure
 - Raw manure
 - Composted manure
 - Incompletely composted manure



Composting and Microbial Reduction

- **Benefits of Manure Application**
 - Improved soil structure
 - Increased uptake of nutrients by plants
 - Improved water absorption and retention
- **Benefits of Manure Composting**
 - Reduction of weed seeds
 - Substantial reduction of pathogenic microorganisms
- **How does it work?**
 - **Active Treatments**
 - Expose harmful bacteria to consistent lethal conditions
 - ie. Proper composting
 - **Passive Treatments**
 - Longer 'aging' time, not a consistent method to reduce pathogens, not to be confused with composting

Guidelines for Composting Manures

Cornell Food Safety Begins on the Farm Guidelines

- Pile achieves high temperatures between 130°F and 160°F for at least 5 days
- Compost pile is aerated and turned several times

National Organic Standards

- Composted plant and animal materials must be produced through a process that:
 1. Established an initial C:N ratio between 25:1 and 40:1
 2. Maintained a temperature of between 131°F and 170°F for 3 days using an in-vessel or static aerated pile system
 3. Maintained at a temperature between 131°F and 170°F for 15 days using a windrow composting system, during which period, materials must be turned 5 times

Handling of Manure & Compost

- Manure storage and treatment sites should be situated as far as practical from fresh produce production and handling areas.
- Store manure at least 150-200 feet from water sources- including wells and streams.
- Consider barriers or physical containment to minimize contamination from run-off, leaching, or wind.
- Minimize recontamination of finished compost



Guidelines for Application of Raw Manure

- **National GAPs Program:**
 - 120 days for all crops prior to harvest
 - 2 weeks prior to planting
- **National Organic Standards:**
 - 120 days for crops with the edible portion below the soil
 - 90 days for crops whose edible portion does not come in direct contact with the soil
 - Fall application very feasible for Colorado

If the 120-day waiting period is not feasible, such as for short season crops like lettuce or leafy greens, apply only properly composted manure

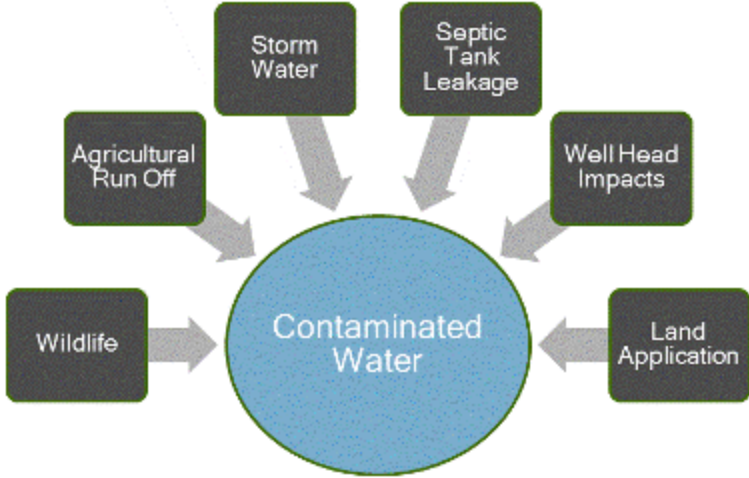


Quiz!





Water Contamination Routes



Sources of Water

-  **Surface Water**
 - Greatest Risk
 - Permanent, Cyclical, Intermittent
-  **Ground Water**
 - Moderate Risk
 - Well & Septic Maintenance
-  **Municipal Water**
 - Low Risk
 - Test Annually



Irrigation Method



Overhead,
Sprinkler



Surface,
Flood, Furrow



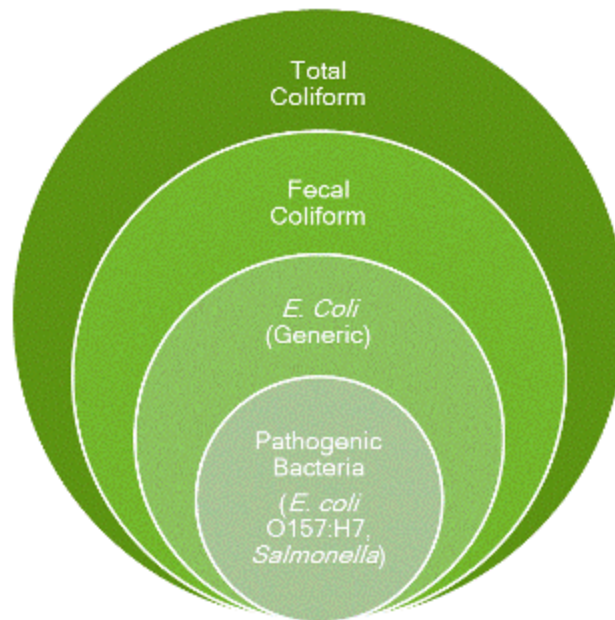
Drip, Trickle

Microbial Testing of Water Sources

- Test municipal water annually
- Test surface water 3x/season
 - Planting
 - Peak Use
 - Harvest
- Records are to be kept on file for 2 years

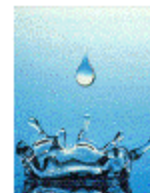


Bacterial Indicators



Irrigation Water Quality Standards

- No universally accepted standard for maximum microbial levels in irrigation water.
- ✓ EPA National Recreational Water Standards
 - ✓ 126 CFU *E. coli*/100 ml sample
- ✓ CO Recreational Water Standards
 - ✓ 126 CFU *E. coli*/100 ml sample or 200 fecal coliforms CFU/100 ml sample
- ✓ CA Leafy Greens Marketing Agreement
 - ✓ 126 CFU *E. coli*/ 100 ml sample



Solutions to Contaminated Water

Locate

- Source of Contamination

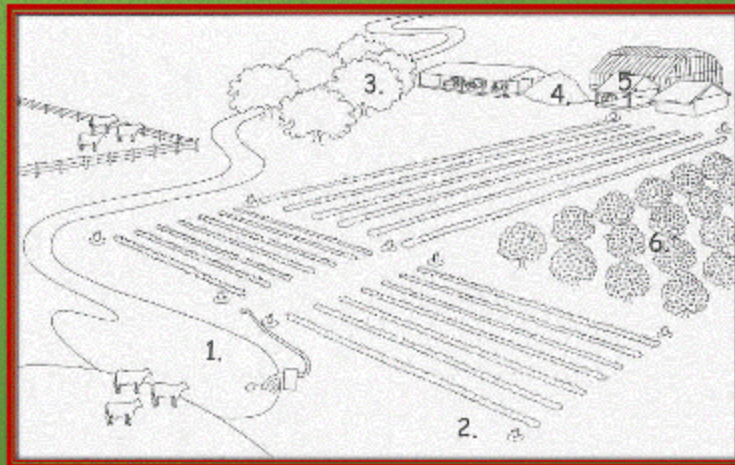
Repair

- Structures that support water sources

Identify

- Alternate water sources if contamination is present

What's Wrong With This Picture?



- 1- Surface Water Source for Irrigation
- 2- Overhead Irrigation Piping
- 3- Unmanaged Forest
- 4- Compost Heap
- 5- Vegetable Wash Station
- 6- Fruit Orchard

Brian Lapinski, Amy Simonne and M.E. Swisher. Small Farm Food Safety, Fresh Produce, Part 4. Farm Map Activity. University of Florida IFAS Extension. <http://edis.ifas.ufl.edu/y909>

Resources

USDA Audit Check List

<http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5050869>

National Good Agricultural Practices Network for Education and Training, Cornell University

<http://www.gaps.cornell.edu/>

On-Farm Composting Handbook

http://www.nraes.org/nra_order.taf?_function=detail&pr_booknum=nraes-54

Northern Plains and Mountains Regional Water Program

<http://region8water.colostate.edu/index.shtml>

Small Acreage Management – Water Guidelines

<http://www.ext.colostate.edu/sam/water.html>

Colorado Department of Health Certified Water Labs

<http://www.cdphe.state.co.us/lr/certification/sdwlist.pdf>

Acknowledgements

- Department of Food Science and Human Nutrition
 - Dr. Marisa Bunning, Food Safety Extension Specialist & Asst. Professor
 - Dr. Patricia Kendall, Extension Specialist and Professor
 - Mary Schroeder, Research Associate
- Department of Soil and Crop Sciences
 - Dr. Jessica Davis, Environmental Soils Extension Professor
 - Troy Bauder, Extension Water Quality Specialist
- College of Agricultural Sciences
 - Dr. Dennis Lamm, Extension Specialist and Professor
- Colorado Department of Agriculture
 - Traacy Vanderpool, Fruit & Vegetable Section Chief
- Colorado State Extension
 - Adrian Card, Boulder Extension Agent
 - Ruth Willson, Extension Technology

Contacts

- Dr. Marisa Bunning
Assistant Professor and Extension Specialist, Food Safety
970-491-7180
mbunning@cahs.colostate.edu
- Tracy Vanderpool
Fruit and Vegetable Section Chief, CO Dept. of Ag
719-852-4749
Tracy.Vanderpool@ag.state.co.us
- Adrian Card
Colorado State University Extension, Boulder County
303-678-6383
acard@bouldercounty.org
- Gretchen Wall
Graduate Research Assistant
724-777-1113
Gretchen.Wall@colostate.edu



Webinar III

Good Agricultural Practices

Colorado State University

Extension

Farm to Table Food Safety
for Colorado Producers

PART 3: Minimizing Risks During Harvest & Post-Harvest

Washing & Packing, Cooling & Storage,
Transportation & Traceback

Presenters & Agenda

- Speakers:

Gretchen Wall
Graduate Research Assistant
Department of Food Science & Human Nutrition
Colorado State University

Ryan Friedman
Project Manager at Sensitech Inc.
Graduate Student - Food Safety

- Topics

- Post-Harvest Operations
- Packing Shed Considerations
- SSOPs
- Cooling/Wash Water
- Cooling and Transportation
- Traceback

Funded in part by the Colorado Department of Agriculture
through the USDA's Specialty Crop Block Grant Program

Review of Webinars 1 & 2

March 16

- General On-Farm Food Safety
- Regulatory Landscape
- 3rd Party Audits
- Worker Hygiene and Health

March 23

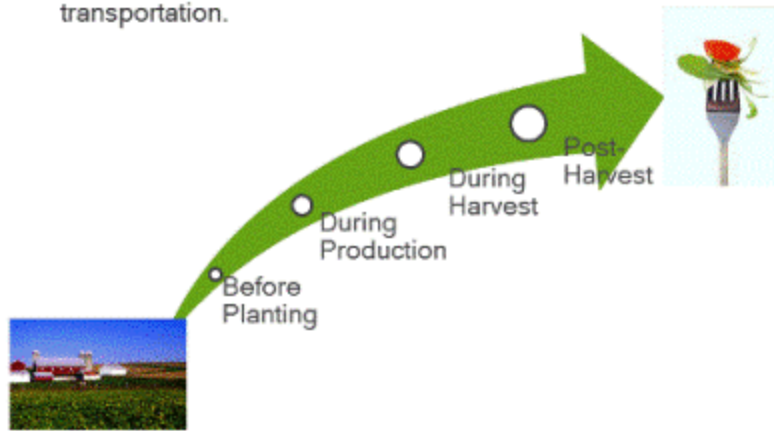
- Manure Management
- Composting Techniques
- Irrigation Water Sources
- Methods of Application
- Water Quality Standards and Testing

Recordings posted on:

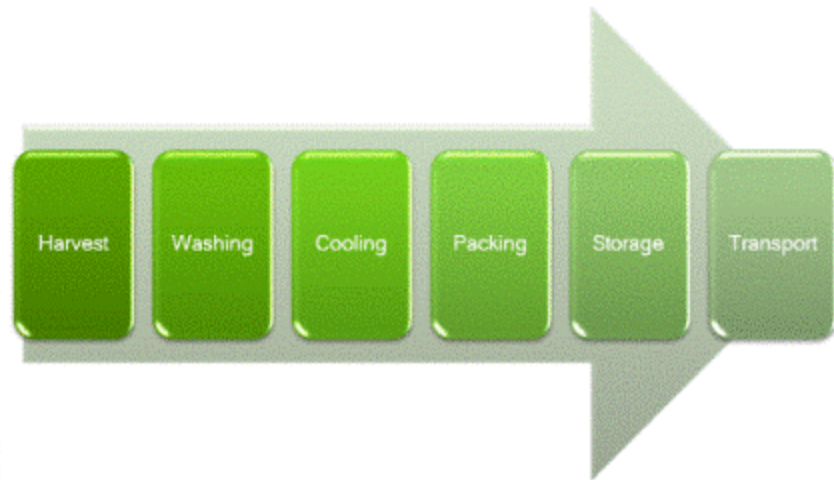
<http://farmtotable.colostate.edu/gap-ghp.aspx>

Good Agricultural Practices (GAPs)

- GAPs (Good Agricultural Practices): agricultural industry's guide to minimize and prevent contamination of fresh fruits and vegetables on the farm.
- GHPs (Good Handling Practices): focuses on best practices for packing and storing facilities, cleaning and sanitation, and transportation.



Good Handling Practices (GHPs)



- ✓ Maintain quality
- ✓ Protect food safety
- ✓ Reduce losses

Good Agricultural Practices (GAPs)

- Part 1: Farm Review
- Part 2: Field Harvesting and Field Packing Activities
- Part 3: House Packing Facility
- Part 4: Storage and Transportation
- Part 5: Vacant
- Part 6: Wholesale Distribution/Terminal Warehouses
- Part 7: Preventative Food Defense Procedures



Field Sanitation Practices at a Glance

Pre-harvest Assessment

- Sources of contamination



Sanitation Units

- Placement, number, location

Containers

- Material, condition, cleaning



Farm Equipment

- Maintenance, cleaning

Receiving

- Proper storage



Harvest Tools and Containers



- Wash, rinse, and sanitize all containers prior to each use
- Separate tools used for handling manure and tools for harvest
- Store packing materials in a covered location
- Do not stand in harvest bins or containers
- Remove dirt and debris from containers before stacking



Harvest Methods

✓ Harvest method depends on characteristics of commodity and resources available

✓ **Manual**

- Delicate commodities
- Direct contact with hands or harvest tools
- *Employee hygiene training essential*

✓ **Mechanical**

- Commodities can withstand rougher handling
- Less human contact
- *Rigorous SSOP for mechanical harvest*



Packing Shed

Major Sources of Packing Shed Contamination

1. Water/ Ice
2. Workers
3. Animals, birds, insects



Employee Field and Pack House Practices

- Do not stand in produce containers while harvesting
- Use proper restroom and hand washing facilities
- Wash hands after using the restroom, eating, or smoking
- No eating, drinking, or smoking while handling fresh produce
- Aprons are not worn to the restroom or outside



Pest Management

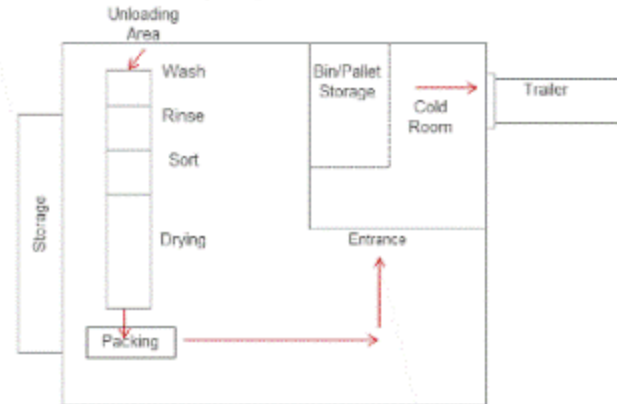


- Inspect storage and packing facilities weekly for rodents, birds, and insects
- Use pest control procedures (traps, screening, and doors)
 - Only spring loaded traps to be used inside facility
 - Bait traps may be used outside the facility
 - Apply chicken wire or netting air intake and exhaust to prevent birds
- Document pest management plan and service reports

Packing Shed Design & Flow

- **Design**

- Reduces the chance for cross contamination
- Minimal clutter
- Smooth surfaces
- Floor drains
- Pressure washing capabilities



Sanitation Standard Operating Procedures (SSOPs)

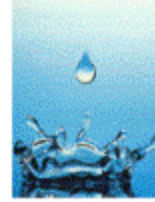
- **Purpose**

- Describe basic sanitary practices
- Provide a schedule for key activities
- Serve as a basis for training employees

- **Sanitation Standard Operating Procedures**

- Broadly defined for the fruit & vegetable industry to incorporate into GAPs & GMPs
- Includes:
 - Title
 - Statement of purpose
 - Individual responsible
 - List of materials, equipment, tools
 - Actual procedures (numbered)
 - Appropriate record sheets

Cooling & Wash Water



- ✓ Use potable water for final washes
- ✓ Sanitize and change water daily
- ✓ Chlorinate wash water
 - Monitor free chlorine levels
 - Maintain 100-150 ppm chlorine concentration
 - Maintain water pH at 6.0-7.0
- ✓ Avoid tank water temperatures more than 10°F cooler than produce temperature
- ✓ Ice must be made from potable water



Cooling & Wash Water



Photo credits: Jack Guzewich, R.S., M.P.H., U.S. Food and Drug Administration



Quiz!



Post Harvest Cooling Methods

| Cooling Type | Contamination Risk |
|------------------------|--------------------|
| Forced Air | Low |
| Vacuum | Low |
| Room Cooling (Walk-in) | Low |
| Hydro-cooling | High |
| Icing | High |

1. Cooling is important to stop post harvest *breakdown* and *preserve* food quality and safety
2. Postharvest cooling should bring the product temperature to the *ideal* temperature
3. Transportation should simply *maintain* temperature



Cooling Considerations



- ✓ **What is your product?**
 - Is it chilling sensitive?
 - What is the shelf life?
 - Other special considerations

- ✓ **Who is the end buyer?**
 - Restaurant, school district, market
 - What requirements do they have?

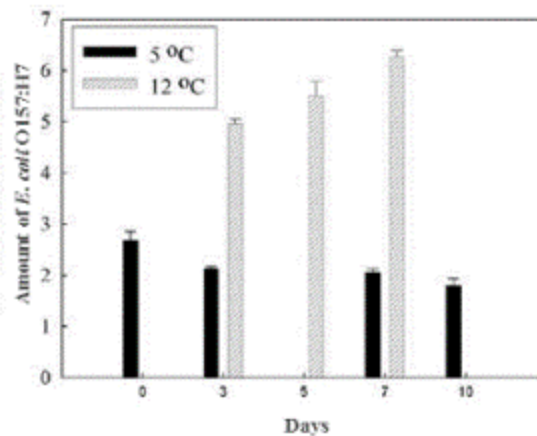
- ✓ **What are your capabilities?**
 - Equipment, resources, etc.

- ✓ **How far are your products traveling?**
 - Multiple stops
 - Route planning for efficiency

Cold Storage for Small Farms

<http://www.youtube.com/watch?v=Pkwgz-jmmP0>

Pathogen Survival During Transport



Cooler Temperatures → Slower/No Bacterial Growth

Leo, Y., He, Q., McEvey, J. Effect of Storage Temperature and Duration on the Behavior of *Escherichia coli* O157:H7 on Packaged Fresh-Cut Salad Containing Romaine and Iceberg Lettuce. *Journal of Food Science*. August 2010.

Transportation

- Inspect for cleanliness, odors, debris
- Document physical condition
 - Chutes
 - Door Seals
 - Floor channels
- Loading Practices
 - Pre-cooling
 - Docks
 - Air circulation
- Never transport fresh produce uncovered or in a vehicle that is unsanitary
 - Ex. Pick-up trucks hauling manure, then used for product delivery



Traceability

- ✓ Record keeping system designed to track the flow of product or product attributes through the production process or supply chain

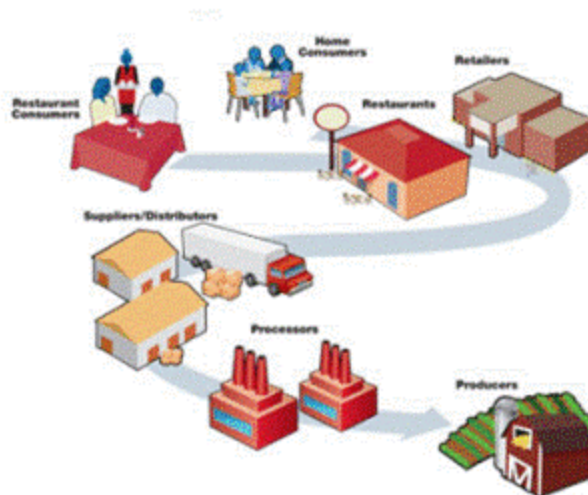
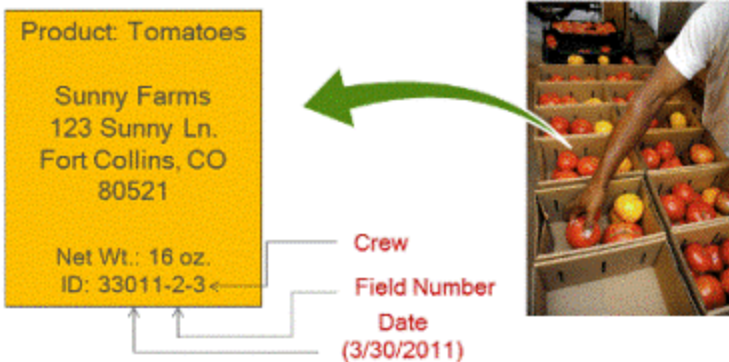


Photo credit: CDC Foodborne Outbreak Investigations,
<http://www.cdc.gov/outbreaknet/investigations/contamination.html>

Documenting Traceability on the Farm

- 1.) Map all production fields or greenhouses
- 2.) Assign numbers to identify specific growing areas
- 3.) Mark all packages with date, location, and crew members
- 4.) Put the harvest date and location ID on each invoice



The Consumer Connection

✓ Educate Consumers

- Washing produce
- Hand washing
- Proper storage
- Preservation
- Sampling



Local Food Safety

<http://farmtotable.colostate.edu/food-safety-local-foods.aspx>

Produce Fact Sheets

<http://farmtotable.colostate.edu/know-your-farmer.aspx>

Offering Samples

<http://farmtotable.colostate.edu/food-regulations.aspx>

Case Study: *Salmonella* Panama Outbreak

Date: March 23, 2011

Food Item Affected: Cantaloupes

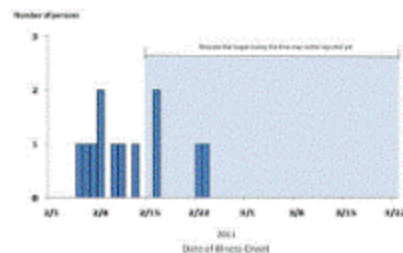
Confirmed Cases: 12 - OR, WA, CA, MD

Source: Guatemala

Possible Contamination Source: Packing house/processing water, contaminated irrigation, improper employee hygiene

Guidance: [Commodity Specific Food Safety Guidelines for the Melon Supply Chain](#)

[Guide to Minimize Food Safety Hazards of Melons](#)



Source: <http://www.cdc.gov/salmonella/panama0311/032211/index.html#investigation>

Resources

USDA Audit Check List

<http://www.ams.usda.gov/AMSV1.0/getfile?dDocName=STELPRDC5050869>

National Good Agricultural Practices Network for Education and Training, Cornell University

<http://www.gaps.cornell.edu/>

Postharvest Technology Research and Information Center

<http://postharvest.ucdavis.edu/>

UC Davis Post Harvest Chlorination

<http://postharvest.ucdavis.edu/datastorefiles/234-404.pdf>

<http://ucanr.org/freepubs/docs/7256.pdf>

Cold Storage for Small Farms

<http://www.youtube.com/watch?v=Pkwqz-immP0>

CSU Farm to Table Food Safety

<http://farmtotable.colostate.edu/>

Acknowledgements

- Department of Food Science and Human Nutrition
 - Dr. Marisa Bunning, Food Safety Extension Specialist & Asst. Professor
 - Dr. Patricia Kendall, Extension Specialist and Professor
 - Ryan Friedman, Graduate Student and Cold Chain Expert
 - Mary Schroeder, Research Associate
- College of Agricultural Sciences
 - Dr. Dennis Lamm, Extension Specialist and Professor
- Colorado Department of Agriculture
 - Tracy Vanderpool, Fruit & Vegetable Section Chief
- Colorado State Extension
 - Adrian Card, Boulder Extension Agent
 - Ruth Willson, Extension Technology



Contacts

- Dr. Marisa Bunning
Assistant Professor and Extension Specialist, Food Safety
970-491-7180
mbunning@cahs.colostate.edu
- Ryan Friedman
Project Manager at Sensitech Inc.
Graduate Student - Food Safety Colorado State University
rfriedman@sensitech.com
- Tracy Vanderpool
Fruit and Vegetable Section Chief, CO Dept. of Ag
719-852-4749
Tracy.Vanderpool@ag.state.co.us
- Gretchen Wall
Graduate Research Assistant
Gretchen.Wall@colostate.edu



Additional Info: Chlorinating Water Calculation

$$\text{Volume of NaOCl to add} = \frac{(\text{desired ppm of free chlorine}) \times (\text{total tank volume})}{(\% \text{ NaOCl in concentrate}) \times 10,000}$$

EXAMPLE

- Using 5.25 % NaOCl concentrate.
- Desire 100 ppm Cl solution.
- Total tank volume 500 gallons

$$\text{Volume of NaOCl to add} = \frac{100 \text{ ppm of free chlorine} \times 500 \text{ gallons}}{5.25 \text{ NaOCl} \times 10,000}$$

= 0.95 gallons

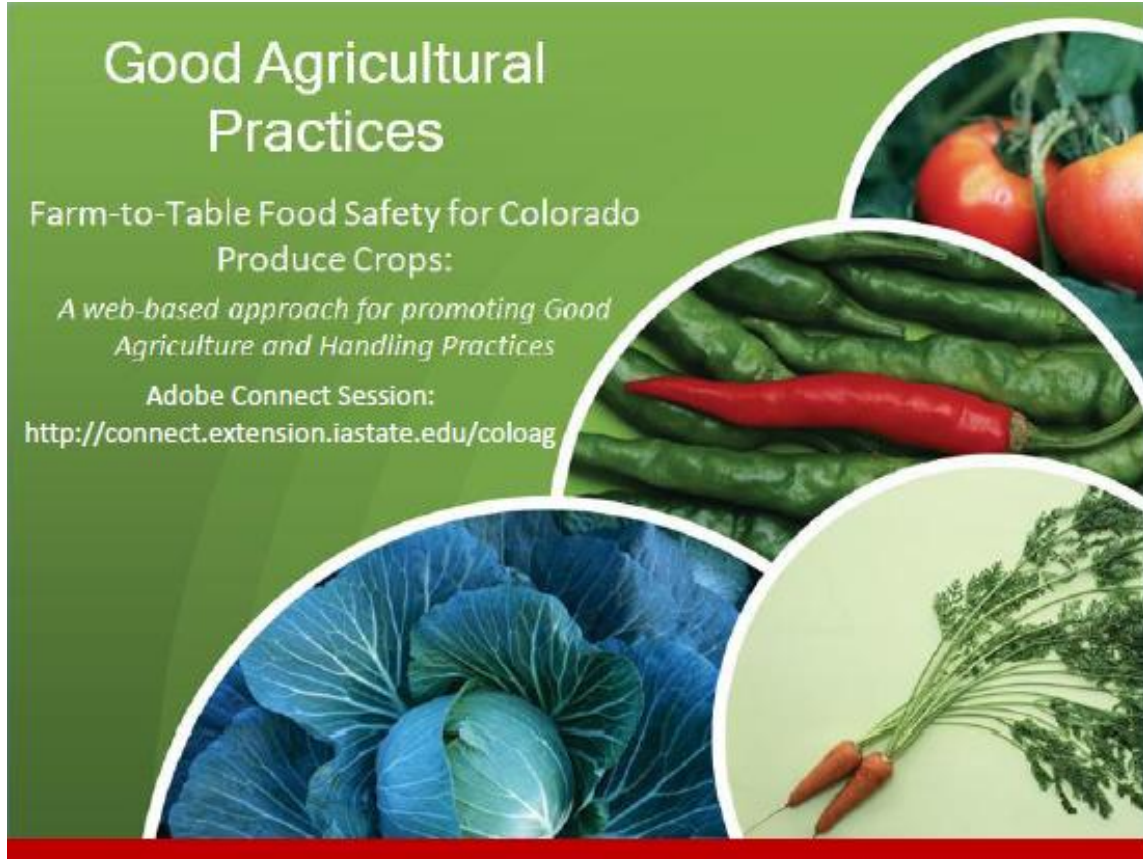
Add 0.95 gallons of 5.25% NaOCl solution to 500 gal tank

Additional Info: Chlorinating Water Calculation

| Desired ppm of Free Chlorine | Pints of 5.25% NaOCl Solution per 100 gal. of water | Pints of 12.75% NaOCl solution per 100 gal. of water | Ounces of 65% Ca(OCl) ₂ |
|------------------------------|---|--|------------------------------------|
| 50 | 0.8 | 0.3 | 1 |
| 75 | 1.1 | 0.5 | 1.5 |
| 100 | 1.5 | 0.6 | 2.1 |
| 125 | 1.9 | 0.8 | 2.6 |
| 150 | 2.3 | 0.9 | 3.1 |
| 175 | 2.7 | 1.1 | 3.6 |
| 200 | 3 | 1.3 | 4.1 |

Source: M.A. Ritenour, S.A. Sargent, J.A. Bartz. Chlorine Use in Produce Packing Lines. <http://edis.ifas.ufl.edu/ch160>

APPENDIX I



Good Agricultural Practices

Farm-to-Table Food Safety for Colorado Produce Crops:

A web-based approach for promoting Good Agriculture and Handling Practices

Adobe Connect Session:
<http://connect.extension.iastate.edu/coloag>

What: 3 Part Webinar Series
One Hour Each

When: March 16, 23, & 30, 2011
Time: 12 PM (MST)

For Who: Producers, Buyers, and all those interested in food safety and Good Agricultural Practices

Cost: Free!

Incentive: \$30 value water testing kit* & CSU GAPs & Food Safety Participation Certificate

Accessibility: Live Event through Adobe Connect
<http://connect.extension.iastate.edu/coloag>
Recordings to be posted on
<http://farmtotable.colostate.edu/>

*First 30 participants to sign up and attend all 3 sessions will be eligible

March 16

Part I: Introduction

Foodborne Illness & Potential Sources of On-Farm Contamination
Update on Pending Legislation (S.510)
Worker Hygiene & Health

March 23

Part II: Minimizing Risks During Production

In the Field: Site Selection, Field Sanitation
Manure Handling & Application
Water Quality & Testing

March 30

Part III: Minimizing Risk During Harvest & Post Harvest

Washing and Packing Operations
Cooling and Storage
Transportation & Traceback

For more information contact Gretchen Wall
E-mail: CSUGAPs@gmail.com

Sponsors: Colorado Department of Agriculture
CSU Department of Food Science and Human Nutrition
Colorado State University Extension

APPENDIX J

Good Agricultural Practices Webinars

Thank you for your interest in *Good Agricultural Practices: Farm to Table Food Safety for Colorado Producers*. Please take a few minutes to provide some information about yourself so that we may better understand our audience and interests.

To access the live webinar, please log onto <http://connect.extension.iastate.edu/coloag>. Choose "Enter As A Guest". Type in your name and enjoy the presentation!

Webinar Lunch Time Series:

March 16: 12 PM (MT) Part I: Foodborne Illness, Contamination, Regulatory Landscape, Worker Health and Hygiene

March 23: 12 PM (MT) Part II: Minimizing Risks During Production, Manure Handling & Application, Water Quality

March 30: 12 PM (MT) Part III: Minimizing Risk During Harvest & Post Harvest, Washing and Packing Operations, Cooling and Storage, Transportation & Traceback

If you have further questions, please contact Gretchen Wall at CSUGAPs@gmail.com.

*** Required**

First Name *

Last Name *

E-mail Address *

Job Title *

- Producer/Grower
- Quality Assurance
- Produce Buyer
- Educator
- Regulatory/Government
- Extension
- Other:

Company/Organization

State * Please enter the state in which you reside.

Age *

- <18
- 18-25
- 26-35
- 36-45
- 46-55
- 56-65
- 66+

Interest *

Please check all topics that are of interest to you to be covered in the webinar series

- Food Safety Basics
- Food Safety Legislation (ie. Food Safety Modernization Act S.510)
- Liability
- 3rd Party Auditing Basics
- Worker Hygiene and Training
- Manure Management
- Water Quality & Irrigation Practices
- Washing & Packing Operations
- Cooling and Storage
- Transportation
- Traceability & Recall
- Other

Additional Interests If you chose "other" in the previous question, please provide a short detail of the topic you would like to be addressed.

Knowledge *

Please rate your knowledge on each subject related to Good Agricultural Practices (GAPs).

1=Know Nothing, 5=Extremely Knowledgeable

| | Know Nothing | Slightly Knowledgeable | Somewhat Knowledgeable | Moderately Knowledgeable | Extremely Knowledgeable |
|--|-----------------------|------------------------|------------------------|--------------------------|-------------------------|
| Food Safety Basics (Pathogens, Outbreaks) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Food Safety Legislation (Food Safety Modernization Act S.510) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Liability (Risk Identification & Evaluation, Economic Loss Due to Outbreaks) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| 3rd Party Auditing Basics (Resources, Communication) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Worker Hygiene and Training (Hand Washing, Illness) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Manure Management (Composting, Application) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Water Quality & Irrigation Practices (Water Sources, Testing) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Washing & Packing Operations (Chlorinated Water, Packaging Materials) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Cooling & Storage (Product Storage, Pest Management) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Transportation (Loading Practices, Temperature Management) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Traceability & Recall (Record Keeping, Field of Origin) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

APPENDIX K

**Good Agricultural Practices & On-Farm Food Safety
Webinar Participation Certificate**

Has completed 3 hours of

**Farm-to-Table Food Safety for Colorado Producers:
*A web-based approach for promoting Good Agricultural and Handling Practices***



Sponsored by
Colorado State University
Department of Food Science & Human Nutrition
Colorado Department of Agriculture: USDA Specialty Crop Grant Program

Date: March 2011

Location: <http://farmtotable.colostate.edu/gap-ghp.aspx>



APPENDIX L

Farm to Fork Food Safety for Colorado Producers Webinar Series

WATER TESTING KIT INFORMATION

Thank you for your interest and participation in the Farm to Fork Food Safety for Colorado Producers Webinar(s). You have indicated an interest to receive a free water testing kit from the Colorado State University Environmental Quality Lab. Please read the following information regarding the receipt and proper use of your water testing kit.

Testing Kit: The water testing kit will be mailed to the address you provided in the initial e-mail. Kits will include a paid return postage label, latex gloves, water bottle, ice pack, and specific instructions for sampling water sources.

Sample Submission: Explicit instructions on when, where, and how to sample water sources on your farm will be included in the water testing kit. Samples must be overnight shipped or directly dropped off on Mondays, Tuesdays, or Wednesdays to the CSU Environmental Quality Lab.

Directions and Hours of Operation: CSU Environmental Quality Lab.

**Samples must be received by the water lab no later than 24 hours from when the sample was taken. Overnight shipping is essential if you are not directly dropping the sample off.

Please use your local UPS office to arrange overnight shipping for your sample using the pre-paid postage stamp provided in the kit.

Result Interpretation: Results of the water testing will be provided to you within 2-4 weeks of receipt of the sample. Included in these results will be instructions on how to interpret the findings and apply them to your on-farm food safety plan.

Time Line:

April 18-22: Kits will be mailed this week to the address you provided.

May 5: Deadline to return kits to the CSU Environmental Quality Lab.

Mid-Late May: Results of water testing will be mailed to you.

Participation: Your participation in this research study is voluntary and you may decline to participate at any time.

Risks/Benefits to the Participant: There is no direct risk to the participants. Information gathered from the study may benefit local producers in the future by providing tools (water testing kit) to aid in the development and implementation of Good Agricultural Practices on the farm. The local economy and health of the populace will also benefit as confidence in the safety and quality of local produce increases and more fresh produce is purchased and consumed.

Confidentiality: Information obtained in this study is strictly confidential. All data will be secured in a locked filing cabinet. Your name will not be used in the reporting of information in publications or conference presentations.

If you have any questions about the water testing kits, please contact Gretchen Wall at CSUGAPs@gmail.com. Otherwise, expect to receive your testing kit within the next 10 days.

Thank you,
Gretchen Wall

Dear Producer,

Thank you for participating in Farm to Fork Food Safety for Colorado Producers Webinar(s). We are happy to provide you with this free water testing kit for use in the development of your on-farm food safety plan. Please follow the instructions carefully.

- 1.) Identify the source of water you would like to test (surface irrigation pond, tap from well)
- 2.) Use the appropriate sampling form instructions for your chosen water source.
 - a. Use **Form A** for: Water samples from taps or faucets drawn from municipal water sources or wells.
 - b. Use **Form B** for: Water samples from surface waters, irrigation ponds, lakes, streams, or other exposed bodies of water.
- 3.) Use the CSU Environmental Quality Lab Sample Submission Sheet to fill out the contact information highlighted in yellow.
- 4.) Use the CSU Environmental Quality Lab Sample Submission sheet to label date, time, and location of where the samples were collected.
- 5.) Use the provided gloves while taking samples.
- 6.) Follow sampling instructions (either Form A or B) carefully.
- 7.) Refrigerate sample or put directly back into box with ice pack to mail or drop off at the CSU Environmental Quality Lab within 24 hours.
- 8.) Be sure to include the Sample Submission form with the water sample and ice pack prior to dropping off or mailing.
- 9.) Your results will be mailed to you with instructions on how to interpret the findings.

Included in kit

Disposable gloves

Sampling container (125 mL bottle)

Ice pack

Shipping labels (If mailing to lab)

2 sets of sampling instructions (Form A & B)

1 CSU Environmental Quality Lab Sample Submission Form

CSU Environmental Quality Laboratory

Room 154 General Service Bldg.

Fort Collins, CO 80523

970-491-4837

Lab hours: Monday-Thursday 8am-4pm.

If you have any questions, please contact Gretchen Wall at CSUGAPs@gmail.com.

FORM B

Water Sampling Protocol for Surface Waters

- 1.) Write the date, time, and collection site (water source, irrigation equipment) on the CSU Environmental Quality Lab Sheet. Verify that this information is correct before leaving the sampling site.
- 2.) Collect water sample as close to point of use as possible. This can mean from irrigation equipment in the field or in the water source, close to where irrigation equipment draws the water. Select a spot that is not filled with dense vegetation or litter, where you can collect a sample of representative water. If available, use a sampling stick. Place bottle on sampling stick and secure with strap. If you do not have a sampling stick, find a water access point where you will not disturb the bottom sediment.
- 3.) Place the provided clean gloves on your hands.
- 4.) While wearing gloves, carefully remove the lid of the bottle making certain to not stick your fingers inside the clean bottle or on the rim. Keeping the bottle clean will ensure a good sample collection. Extend the sampling stick out into the surface water source and capture a sample large enough to fill the bottle to the shoulder. Do not disturb bottom sediments. If the surface water source is very shallow, this may be a challenge.
- 5.) Place the lid back on the bottle and tighten. Check to ensure cap is tightened on bottle.
- 6.) Refrigerate samples within 15 minutes of collection.
- 7.) All samples should be delivered to the lab within 24 hours after collection or shipped for overnight delivery. If shipping more than one location/bottle to the lab in one day in the same box, be extra careful that all samples are properly labeled so that there is no confusion about the origin of the sample. Ship samples with provided chilled ice pack.

****DO NOT RINSE** the container out- the substance inside preserves the water for testing.

****DO NOT TOUCH** the inside of the lid or container – it is sterile.

****DO NOT LET THE SAMPLE FREEZE** (keep sample refrigerated until delivered to lab)

APPENDIX M

Good Agricultural Practices: Farm to Fork Food Safety for Colorado Producers

Thank you for your participation in Good Agricultural Practices: Farm to Fork Food Safety for Colorado Producers. We'd appreciate if you'd take a minute to answer a few evaluation questions so that we may better understand how we can improve for future webinars and presentations.

The recorded webinars and slides are posted on our website at:

<http://farmtotable.colostate.edu/gap-ghp.aspx>

If you have any further questions, please contact Gretchen Wall at CSUGAPs@gmail.com.

* Required

Age *

- <18
- 18-25
- 26-35
- 36-45
- 46-55
- 56-65
- 66+

Which webinar session(s) did you attend? * Choose all live Adobe Connect sessions you attended.

- Part I - March 16, 2011: Foodborne Illness, Contamination, Regulatory Landscape, Worker Health and Hygiene
- Part II - March 23, 2011: Minimizing Risks During Production, Manure Handling & Application, Water Quality & Testing
- Part III - March 30, 2011: Minimizing Risks During Harvest & Post Harvest, Washing & Packing Operations, Cooling & Storage, Transportation & Traceback

If you did not attend all three sessions, why not? Choose all that apply.

- I had a prior commitment at that specific time.
- The time (of day) did not suit my schedule.
- The time (of year) did not suit my schedule.
- I was planning to view the recording online instead.
- I was not interested in that particular topic.
- I forgot.
- Other:

How likely are you to visit the website to review a session you either attended or missed? * Choose all that apply.

- Very Likely
- Somewhat Likely
- Neutral
- Somewhat Unlikely
- Very Unlikely
- I already have
- I did not miss any

Please rate your level of agreement or disagreement with the following statements. *

| | Strongly Agree | Agree | Neither Agree Nor Disagree | Disagree | Strongly Disagree |
|--|-----------------------|-----------------------|----------------------------|-----------------------|-----------------------|
| The presenter(s) provided quality information | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| The presentation(s) was/were delivered at a comfortable pace. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| The webinar topics were presented in a logical and easy to understand format. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| I benefited from hearing or participating in questions at the conclusion of the session. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| I plan to use the suggested resources provided at the end of the session to gain more knowledge. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| The quizzes and critical thinking activities kept me engaged and interested in the presentation. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| I plan to review the recorded sessions at a later date. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| The technology (Adobe Connect) was appropriate and easy to use. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

What is your profession? *

- Producer
- Produce Buyer
- Educator/Extension Professional
- Industry Professional
- Government/Regulatory
- Student
- Other

PRODUCERS: After attending one or more of the GAPs webinars, how likely are you to pursue a GAPs/food safety audit for your farm? * If you are not a producer involved in the growing and sale of fresh produce, please click the back button to return to the main survey to choose the correct profession.

- Very likely
- Somewhat Likely
- Neutral
- Somewhat Unlikely
- Very Unlikely
- I am already GAPs certified.

PRODUCERS: As a result of attending one or more GAP webinars, please indicate the likelihood that you will participate in the following activities on your farm: *

| | Likely | Neutral | Unlikely | I already do this. | N/A |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Make sure worker hygiene facilities are regularly cleaned and kept stocked. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Improve or add worker hygiene facilities (appropriate hand washing stations, toilet facilities, signage). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Use proper composting techniques for animal manure. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Obtain composted manure from a certified supplier. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| If using RAW animal manure, properly apply to fields to maintain a 120 day buffer zone before harvest. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Test irrigation water sources (surface, ground, or municipal) during the growing season for harmful bacteria (fecal coliforms, E.coli, etc). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Identify and reduce sources of contamination for irrigation water (ie. manure run-off, livestock access to water source). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Modify your method of irrigation water application (ie. change from overhead to drip). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Enforce proper post-harvest methods to reduce the chance for contamination of produce (ie. cleaning tools, machinery, and harvest bins). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

| | Likely | Neutral | Unlikely | I already do this. | N/A |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Monitor and maintain safe water quality used in cooling and washing operations (ie. testing water, chlorination, other interventions). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Document transportation practices (ie. temperatures for pre-cooling, inspection for cleanliness). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Develop a traceback system for your products. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Educate your customers/buyers on how to properly handle produce for safety and quality. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

PRODUCER BUYERS: After attending one or more of the GAPs webinars, how likely are you to require your suppliers to participate in GAPs or other audits for food safety on the farm? * If you are not involved in the purchase fresh produce, please click the back button to return to the main survey to choose the correct profession.

- Very likely
- Somewhat likely
- Neutral
- Somewhat unlikely
- Very Unlikely
- We already require GAPs audits for our suppliers.
- We already require some other type of on farm food safety policies of our suppliers, but not specifically GAPs.

PRODUCE BUYERS: As a result of attending one or more GAP webinars, please indicate the likelihood you will participate in the following activities: * If you are not involved in the purchase of fresh produce, please click the back button and choose the correct career.

| | Very likely | Somewhat likely | Neutral | Somewhat unlikely | Unlikely |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Refer interested parties/institutions/food establishments to the taped recordings of the webinars on the Colorado State Farm to Table Website. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Use the material presented to develop your own GAPs education/curriculum for your business and suppliers. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Inform or disseminate information about GAPs to your suppliers, gardeners, farmers, or other institutions (school lunch programs, community gardens, etc). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

EDUCATORS/EXTENSION PROFESSIONALS: As a result of attending one or more GAP webinars, please indicate the likelihood you will participate in the following activities: * If you are not an educator or extension professional, please click the back button and choose the correct career.

| | Very likely | Somewhat likely | Neutral | Somewhat unlikely | Unlikely |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Refer students/interested parties to the taped recordings of the webinars on the Colorado State Farm to Table Website. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Use the material presented to develop your own GAPs education/curriculum. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Inform or disseminate information about GAPs to gardeners, farmers, or other institutions (school lunch programs, community gardens, etc). | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

GOVERNMENT/REGULATORY, INDUSTRY PROFESSIONALS, STUDENTS, AND OTHER PROFESSIONS: As a result of attending one or more GAP webinars, please indicate the likelihood you will participate in the following activities: * If you are not involved in the purchase of fresh produce, please click the back button and choose the correct career.

| | Very likely | Somewhat likely | Neutral | Somewhat unlikely | Unlikely |
|--|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| Refer interested parties to the taped recordings of the webinars on the CSU Farm to Table Website. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Use the material presented to develop your own GAPs education/curriculum for your business. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

APPENDIX N

Pre-knowledge score frequencies for each fact sheet on a.) general knowledge of the topic and b.) food safety, preservation, and storage and handling (n=10 for each fact sheet, total of n=100)

| | | Apples | Berries | Broccoli | Leafy Greens | Melons | Peaches | Peppers | Potatoes | Squash | Tomato |
|---|---|--------|---------|----------|--------------|--------|---------|---------|----------|--------|--------|
| a.) Please rate your knowledge of the fact sheet topic, prior to reading. | | | | | | | | | | | |
| Nothing | 1 | 0 | 1 | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 0 |
| | 2 | 3 | 2 | 3 | 2 | 0 | 1 | 1 | 0 | 2 | 2 |
| Basic | 3 | 5 | 4 | 1 | 1 | 5 | 2 | 4 | 3 | 3 | 4 |
| | 4 | 1 | 1 | 5 | 2 | 1 | 0 | 5 | 5 | 4 | 0 |
| Advanced | 5 | 1 | 2 | 1 | 4 | 2 | 5 | 0 | 2 | 1 | 4 |
| b.) Please rate your knowledge of food safety, preservation, and produce storage and handling, prior to reading. | | | | | | | | | | | |
| Nothing | 1 | 2 | 2 | 5 | 1 | 0 | 0 | 3 | 0 | 0 | 1 |
| | 2 | 1 | 3 | 0 | 2 | 2 | 1 | 2 | 1 | 4 | 2 |
| Basic | 3 | 4 | 2 | 1 | 4 | 3 | 4 | 4 | 5 | 5 | 6 |
| | 4 | 0 | 1 | 2 | 2 | 4 | 3 | 1 | 2 | 1 | 0 |
| Advanced | 5 | 3 | 2 | 2 | 1 | 1 | 2 | 0 | 2 | 0 | 1 |

Post-knowledge scores for each fact sheet on a.) general knowledge of the topic and b.) food safety, preservation, and storage and handling (n=10 for each fact sheet, total n=100).

| | | Apples | Berries | Broccoli | Leafy Greens | Melons | Peaches | Peppers | Potatoes | Squash | Tomato |
|--|--|--------|---------|----------|--------------|--------|---------|---------|----------|--------|--------|
|--|--|--------|---------|----------|--------------|--------|---------|---------|----------|--------|--------|

a.) Please rate your knowledge of the fact sheet topic, after to reading.

| | | | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|---|---|---|
| Nothing | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Basic | 3 | 3 | 4 | 5 | 2 | 6 | 3 | 4 | 2 | 6 | 2 |
| | 4 | 5 | 4 | 5 | 4 | 1 | 4 | 1 | 3 | 1 | 5 |
| Advanced | 5 | 2 | 2 | 0 | 4 | 3 | 3 | 5 | 5 | 2 | 3 |

b.) Please rate your knowledge of food safety, preservation, and produce storage and handling, after reading.

| | | | | | | | | | | | |
|----------|---|---|---|---|---|---|---|---|---|---|---|
| Nothing | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Basic | 3 | 2 | 4 | 5 | 4 | 3 | 6 | 4 | 2 | 3 | 3 |
| | 4 | 6 | 4 | 4 | 2 | 4 | 1 | 3 | 2 | 7 | 3 |
| Advanced | 5 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 4 | 0 | 4 |

APPENDIX O

Summary of webinar evaluation survey questions regarding intent to watch recorded sessions and reasons for missing one or more of the live webinar sessions (n=61).

| Survey Question | Frequency (%) |
|---|---------------|
| How likely are you to visit the website to review a session you either attended or missed? | |
| Very Likely | 20 (36%) |
| Somewhat Likely | 7(13%) |
| Neutral | 7(13%) |
| Somewhat Unlikely | 6(11%) |
| Very Unlikely | 1(2%) |
| I already have | 7(13%) |
| I did not miss any | 7(13%) |
| If you did not attend all three sessions, why not? | |
| Prior commitment | 17(65%) |
| Time of day did not suit schedule | 1(5%) |
| Planning to view recording | 2(10%) |

Basic webinar evaluation survey responses rated on a 5-point Likert scale with 1=Strongly Disagree and 5=Strongly Agree.

| | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
|--|----------------|---------|---------|----------|-------------------|
| The presenter(s) provided quality information. | 37(61%) | 21(34%) | 3(5%) | 0(0%) | 0(0%) |
| The presentation(s) was/were delivered at a comfortable pace. | 26(43%) | 29(48%) | 4(7%) | 2(3%) | 0(0%) |
| The webinar topics were presented in a logical and easy to understand format. | 33(54%) | 26(43%) | 2(3%) | 0(0%) | 0(0%) |
| I benefited from hearing or participating in questions at the conclusion of the session. | 22(36%) | 27(44%) | 7(11%) | 5(8%) | 0(0%) |
| I plan to use the suggested resources provided at the end of the session to gain more knowledge. | 21(34%) | 26(43%) | 8(13%) | 3(5%) | 3(5%) |
| The quizzes and critical thinking activities kept me engaged and interested in the presentation. | 29(48%) | 28(46%) | 3(5%) | 0(0%) | 1(2%) |
| I plan to review the recorded sessions at a later date | 24(39%) | 20(33%) | 14(23%) | 3(5%) | 0(0%) |
| The technology (Adobe Connect) was appropriate and easy to use. | 29(48%) | 27(44%) | 4(7%) | 1(2%) | 0(0%) |

APPENDIX P

Likelihood scores for specific behaviors of produce buyers regarding on-farm food safety practices and GAPs audits (n=5).

| | Very Likely | Likely | Neutral | Unlikely | Very Unlikely |
|--|----------------|--------|---------|----------|------------------|
| Refer interested parties/institutions/food establishments to the taped recordings of the webinars on the Colorado State Farm to Table Website. | 4(80%) | 1(20%) | 0(0%) | 0(0%) | 0(0%) |
| Use the material presented to develop your own GAPs education/curriculum for your business and suppliers. | 1(20%) | 0(0%) | 3(60%) | 1(20%) | 0(0%) |
| Inform or disseminate information about GAPs to your suppliers, gardeners, farmers, or other institutions (school lunch programs, community gardens, etc) | 3(60%) | 2(40%) | 0(0%) | 0(0%) | 0(0%) |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | 4(80%) | 1(20%) | 0(0%) | 0(0%) | 0(0%) |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | 1(20%) | 4(80%) | 0(0%) | 0(0%) | 0(0%) |

APPENDIX Q

Likelihood scores for specific behaviors of Extension professionals and educators regarding on-farm food safety practices and GAPs audits (n=14).

| | Very Likely | Likely | Neutral | Unlikely | Very Unlikely |
|--|----------------|--------|---------|----------|------------------|
| Refer students/interested parties to the taped recordings of the webinars on the Colorado State Farm to Table Website. | 9(64%) | 3(21%) | 1(7%) | 0(0%) | 1(7%) |
| Use the material presented to develop your own GAPs education/curriculum. | 7(50%) | 2(14%) | 2(14%) | 0(0%) | 3(21%) |
| Inform or disseminate information about GAPs to gardeners, farmers, or other institutions (school lunch programs, community gardens, etc. | 11(79%) | 2(14%) | 0(0%) | 1(7%) | 0(0%) |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | 8(57%) | 4(29%) | 2(14%) | 0(0%) | 0(0%) |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | 7(50%) | 5(36%) | 0(0%) | 2(14%) | 0(0%) |

APPENDIX R

Likelihood scores for specific behaviors of the remaining webinar participants (students, industry professionals, regulatory agents) regarding on-farm food safety practices and GAPs audits (n=22).

| | Very Likely | Likely | Neutral | Unlikely | Very Unlikely |
|--|----------------|---------|---------|----------|------------------|
| Refer interested parties to the taped recordings of the webinars on the Colorado State Farm to Table Website. | 9(41%) | 5(23%) | 7(32%) | 1(5%) | 0(0%) |
| Use the material presented to develop your own GAPs education/curriculum. | 2(9%) | 1(5%) | 6(27%) | 8(36%) | 5(23%) |
| Participate in future webinars or programs related to food safety on the farm and/or GAPs. | 10(45%) | 10(45%) | 1(5%) | 1(5%) | 0(0%) |
| Use the knowledge you obtained from the GAPs webinars directly or indirectly in your profession. | 7(32%) | 3(14%) | 9(41%) | 2(9%) | 1(5%) |