12-2012

ANALYSES OF CONSUMER PERCEPTIONS, FARMER CHALLENGES, POLYAMINE, AND AMINO ACID CONTENT OF ORGANIC AND CONVENTIONAL FRESH PRODUCE GROWN IN SOUTH CAROLINA

Emily Steinberg
Clemson University, esteinb@clemson.edu

ANALYSES OF CONSUMER PERCEPTIONS, FARMER CHALLENGES, POLYAMINE, AND AMINO ACID CONTENT OF ORGANIC AND CONVENTIONAL FRESH PRODUCE GROWN IN SOUTH CAROLINA

A Dissertation
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy
Food Technology

---

by
Emily L. Steinberg
December 2012

Accepted by:
Julie K. Northcutt, Ph.D, Committee Chair
Paul Dawson, Ph.D
Rose Martinez-Dawson, Ph.D
Xiuping Jiang, Ph.D

ABSTRACT

Execution of the USDA organic standards led to more support for local food as distinct from organic food. The current study was conducted to examine fresh produce perceptions and purchasing decisions of S.C. consumers. Four-hundred and eight S.C. consumers were surveyed at S.C. grocery stores. More than one-third of the S.C. consumers not knowing about the “certified S.C. grown” program suggest that the S.C. Department of Agriculture (SCDA) may want to improve the promotion of their program. Eighty-five percent of consumers indicated that they would choose local over organic. This information would be useful to local S.C. produce farmers who are contemplating whether or not to go through the USDA organic certification process.

The annual revenue from fruit and vegetable production in S.C. has been estimated to reach $161 million from the state’s reported 1,520 vegetable and 1,340 fruit farms. Farmers should be knowledgeable about the latest trends and innovations in produce farming to maintain this level of production. The current producer survey was conducted to identify their current practices, educational needs, and preferred method of information distribution. Seventy-one percent of farmers were conventional, however almost the same amount of farms were interested in receiving information on organic agriculture.

Putrescine (diamine), spermine and spermidine (polyamines), as well as cadaverine are indispensible components of living cells and are in fruits and vegetables. Diets rich in fruits and vegetables have been found to combat diseases. Leafy greens are no exception. There has been an increasing trend toward organic farming because it is perceived as healthier by consumers. Research has shown organic products to be higher than their conventional counterparts in polyamines but more controlled research was necessary to validate this finding. Therefore, USDA organic and conventional collard greens were grown in a greenhouse to examine the effect of cultivation practices on quality attributes. The organic collards weighed significantly less, were significantly lighter and had a significantly higher polyamine concentration (P-value < 0.05) than their conventional counterparts. Polyamines were found to be associated with higher yellow values within the organically grown collards, which may be a predictor of higher levels of polyamines.

DEDICATION

This dissertation is dedicated to my parents, Jeff and Marcia Steinberg who have supported me my entire life. I have been fortunate to have parents who have encouraged me to go for what I wanted regardless of the challenges. They have always said, "as long as you work hold we will be proud of you no matter what." That principle has allowed me to reach my goals.

ACKNOWLEDGMENTS

I would like to thank Clemson University, College of Agriculture, Forestry, and Life Sciences, and the Department of Food, Nutrition, and Packaging Sciences for their support. I would like to thank Kim Collins, Glenda Brown, and Krissy Boggs for all of the times they have helped me. I would like to thank Dr. Powell Smith and Mr. Roger Francis for all of their support and allowing me to participate in GAPs workshops. I would like to thank my fellow graduate students for helping me with my experiment, practicing presentations and for just being supportive. I sincerely appreciate the support from the "women of C-232." I could not have gotten through this program without them. I do not think I would have been able to go through that first harvest without the help of Dr. Michelle Parisi and, for that, I am truly grateful. I am thankful for the support I have received from my committee members: Drs. Xiuping Jiang, Paul Dawson, and Rose Martinez-Dawson. I would like to thank Dr. Jiang for the use of her greenhouse and her expertise throughout my program. I would like to thank Dr. Paul Dawson for his guidance throughout this process. I would like to thank Dr. Martinez-Dawson for the hours upon hours that she sat with me discussing statistics. I truly enjoyed it and I hope she did too. I would like to thank Dr. van den Hurk for the use of his HPLC and his time with me during my research. Words cannot express the amount of support that I received from Dr. Julie Northcutt. She has been my rock during this project and has given me so many fantastic experiences during this program. As a professor and researcher, she is truly someone I would like to emulate. I would like to thank my family

who has been supported throughout my life. Last but not least, I would like to thank my fiancé, Tyler Kelly. He has been fantastic throughout my program and I cannot wait to call him my husband!

TABLE OF CONTENTS

LIST OF TABLES

Table Page

Table (Continued) Page

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

According to the U.S. Center for Disease Control and Prevention (CDC), obesity has become an epidemic in the U.S. The CDC has estimated that 68% of adults in the U.S. are overweight or obese; with equal distribution among the categories (34% obese, 34% overweight). For adults, overweight and obesity measures are determined by using height and weight to calculate the body mass index (BMI). This index has, for most people, been a good estimate of body fat. Adults are overweight if their BMI are 25-29.9 or obese if their BMI > 30 (CDC 2012). Obesity is a significant health concern because it has been linked to a number of chronic health diseases, such as hypertension, adverse lipid concentrations and type 2 diabetes (NIH 1998). In 2008, medical costs associated with obesity were estimated at $147 billion and the medical costs for people who were obese were $1,429 higher than those people of normal weight (Finkelstein, E.A., Brown, D.S., Wrage, L.A., Allaire, B.T., and Hoerger, T.J., 2012) . Within the U.S., the highest prevalence of obesity is found in the South (29.5%) followed by the Midwest (29%), the Northeast (25.3%), and the West (24.3%). More specifically, in South Carolina the prevalence of obesity is 30.8% for adults and 15.3% for children coinciding with a national ranking of 8 and 22, respectively (Centers for Disease Control and Prevention, 2012).

There are several factors that affect obesity including genetic, behavioral, environmental, social, and economic factors. However, obesity is reflective of a calorie imbalance involving excessive caloric intake and/or inadequate physical activity (Centers for Disease Control and Prevention, 2012). Overeating and lack of physical activity are widely accepted as the most important factors contributing to the obesity epidemic (Dietary Guidelines Advisory Committee, 2010a).

There are several strategies to combat obesity that have been implemented at the national and state level. Federal programs such as “Take Action for Me,” “Take Action For My Family,” and “Take Action For My Community” have focused on planning, achieving, and maintaining a healthy weight through developing healthy eating and lifestyle habits (Centers for Disease Control and Prevention, 2012). As part of this strategy, the CDC has published several guide books, including “CDC Guide to Strategies to Increase Consumption of Fruits and Vegetables” (Centers for Disease Control and Prevention, 2012). Increased consumption of fruits and vegetables has been promoted to combat obesity by the CDC because these foods contain high levels of vital vitamins, minerals, fiber, and other beneficial nutrients (Centers for Disease Control and Prevention, 2012). Moreover, a diet rich in these fruits and vegetables has been linked to lower risks for chronic diseases, such as certain cancers (Kushi, L.H., Byers, T., Doyle, C., Bandera, E.V., McCullough, M., Gansler, T., Andrews, K.S., and Thun, M.J., 2006), cardiovascular diseases (Chen, S.T., Maruthur, N.M., and Appel, L.J., 2010; Dauchet, L., Amouyel, P., Hercberg, S., and Dallongeville, J., 2006; Griep, L.M.O., Geleijnse, J.M., Kromhout, D., Ocké, M.C., and Verschuren, W.M.M., 2010; Savica, V., Bellinghieri, G., and Kopple, J.D., 2010) , and rheumatoid arthritis (Pattison, D.J., Harrison, R.A., and Symmons, D.P.M., 2004) . Additionally, fruit and vegetable consumption has been cited by the “2010 Dietary Guidelines for Americans” as “a critical step to a healthier American” (Dietary Guidelines Advisory Committee, 2010b)

Although fruit and vegetable consumption has been cited as a recommended strategy for combating obesity, only 11% of adult consumers typically meet the USDA daily consumption guidelines for fruits and vegetables (Casagrande, S.S., Wang, Y., Anderson, C., and Gary, T.L., 2007) . From a production point of view, there is no rationale for the lower consumption of fruits and vegetables because production has not slowed. The most recent Agricultural Census (2007) stated that there were 11,481 leafy green producers with 89% of this crop being produced by small farmers (US Census Bureau, 2009). California is the leader in leafy green production, and comprise75% of its production in the U.S (US Census Bureau, 2009). The USDA estimated that the value of leafy green vegetables grown for the U.S. fresh and fresh cut market, in 2008, was $2.5 billion (US Census Bureau, 2009). Lettuce crops accounted for 79% of the U.S. leafy green production, while cabbage and spinach accounted for 15% and 7%, respectively (US Census Bureau, 2009). Other minor fresh leafy green vegetable crops, such as collards, escarole, endives, and specialty varieties of kale, are produced regionally and seasonally in California (US Census Bureau, 2009). Since 1997, U.S. production of leafy green vegetables has risen by nearly 25% (US Census Bureau, 2009). From a production aspect, the three fastest growing crops are spinach, head lettuce, and romaine (US Census Bureau, 2009). The 2007 Census had limited data for the production of minor fresh leafy greens (US Census Bureau, 2009); however, it did report that 848 mustard green farms were producing on 7,013 acres of land (US Census Bureau, 2009). Top producing states for mustard greens include California (harvesting 1,902 acres on 87 farms), Georgia (harvesting 1,585 acres on 36 farms), South Carolina (harvesting 581 acres on 35 farms), Texas (harvesting 470 acres on 61 farms), and Michigan (harvesting 308 acres on 29 farms). In the US head cabbage, leaf lettuce, and spinach are produced in every state while kale and head lettuce is grown in 44 and 45 states, respectively (US Census Bureau, 2009).

In South Carolina, the combined annual revenue from fruit and vegetable production has been estimated to approach $161 million from 1,520 vegetable farms and 1,340 fruit farms (SC department of agriculture, 2012). Moreover, these farms occupy more than 25% of the total farmland land within the state of SC (SC department of agriculture, 2012). The leafy green vegetables with the highest production South Carolina are collards, kale, turnips, and mustards (SC department of agriculture, 2012).

Among farmers and consumers, there has been an increasing trend toward organic agriculture for economic reasons as well as “health” benefits. Data suggest that consumers purchase organic food because they believe it is more nutritious and safe, as well as better for the environment, animal welfare and worker safety (Dimitri, C. and Oberholtzer, L., 2009) . Organic retail sales have risen by $17.5 billion in the past decade (Dimitri, C. and Oberholtzer, L., 2009) . Moreover, organic farming has been one of the fastest growing segments of U.S. agriculture for over a decade (National Agricultural Statistics Service (NASS), USDA, 2010). Historically, fresh produce has been the most popular organic category and it continues to be, with a steady growth of 15% between 1997 and 2007 (Dimitri, C. and Oberholtzer, L., 2009) . The $9.5 billion organic fruit and vegetable category, making up 38% of the total organic food market, continued to dominate the industry (Organic Trade Association, 2010). According to the Organic Trade Association, apples were most popular organic produce commodity and packaged salads were the most popular item within the vegetable category (Organic Trade Association, 2012).

With consumer demand for organic food, especially fresh produce, increasing at such a high rate, producers are having a difficult time meeting the demand. Therefore, the numbers of certified acres used exclusively for the production of organic produce needs to be increased. A recent survey indicated that the major barriers to become certified producers included differences in philosophical beliefs and the risk of losses due to disease, weeds, and insects with organic farming. In addition, the survey results also indicated that burden of paperwork and confusion about the organic certification process was a major barrier to farmers (Veldstra, M.D., Alexander, C.E., and Marshall, M.I., 2012) .

Fresh produce is considered organic if that product was grown under specific conditions that foster sustainability. A product may only be labeled "organic" if the product was grown without synthetic fertilizer, unapproved pesticides, sewage sludge, irradiation and genetic engineering. Consumers perceive organic products to be healthier than their conventional counterparts. Although previous studies have reported on the production patterns of conventional and organic fresh produce, little research has been conducted comparing these two production methods for farmer challenges, consumer perceptions, and produce chemical composition. Therefore, the overall goal of this project was to evaluate the quality and chemical differences between organically versus conventionally grown fresh produce. This goal was accomplished in 3 objectives, which are as follows:

1) To identify the challenges incurred by S.C. produce farmers through surveys/interviews.
2) To determine S.C. consumer perceptions of organic and conventional produce through surveys/interviews.
3) To conduct a greenhouse study of organic and conventionally grown collard greens to examine the differences in amino acid and polyamine composition.

CHAPTER TWO

LITERATURE REVIEW

2.1 U.S. FRESH PRODUCE CONSUMPTION PATTERNS

On an economic basis, the U.S. fruit and vegetable industry accounts for almost a third of the U.S. crop cash receipts and a fifth of U.S. agricultural exports. According to the U.S. Bureau of Labor Statistics (BLS), domestic consumption of fruits and vegetables accounted for about 14.6% of all at-home food expenditures in 2012. The BLS reported that Americans spent $272 per person ($679 per average household) on fresh and processed fruits and vegetables for consumption at home (U.S. Bureau of Labor Statistics, 2011) and consumed approximately 143 pounds of fresh vegetables per person annually (USDA, 2012). Per capita consumption of fruits is combined with tree nuts and were reported to be 267.9 pounds (USDA. AMS., 2012). These numbers are 10 to 20 % higher than they were 20 years ago (Perez, A., Plattner, K., and Baldwin, K., 2011) . However, Wells and Buzby (2008) found that fruit and vegetable consumption was still below the recommended daily intake in the Dietary Guidelines (Wells, H.F. and Buzby, J.C., 2008) . More recently, National Health and Nutrition Examination Survey data showed that only 2.2% of men and 3.5% of women consumed the recommended amounts of fruits and vegetables (Kimmons, J., Gillespie, C., Seymour, J., Serdula, M., and Blanck, H.M., 2009) . While there appears to be a segment of the population that does not consume the recommended daily intake of fruits and vegetables there are other consumers that focus on “health” and their food purchases reflect this. It is for this reason that interest in organic food has risen.

2.2 ORGANIC FARMING TRENDS

Organic farming has been one of the fastest growing segments of U.S. agriculture for the past decade (USDA, 2012). Organic retail sales have been reported to have risen from $3.6 billion in 1997 to $21.1 billion in 2008 (Dimitri, C. and Oberholtzer, L., 2009) . Fresh produce continues to be the most popular organic category, with a steady growth of 15% between 1997 and 2007 (Dimitri, C. and Oberholtzer, L., 2009) . Organic fruits and vegetables account for approximately 38% of the organic market, reported to be $9.5 billion in 2009 (Organic Trade Association, 2010). According to the Organic Trade Association (OTA), apples were the most popular organic produce commodity and packaged salads were the most popular for the vegetable category (Organic Trade Association, 2012). With consumer demand for organic food increasing at such a high rate, producers are having a difficult time meeting the demand. Therefore, the number of certified organic acres needs to be increased. A recent survey indicated that the major barriers for farmers to become certified for organic food production included differences personal views of organic production as wells as the risk of losses due to diseases, weeds, and insects of organic farming. The results also indicated that the financial cost of the certification process was a major barrier (Veldstra, M.D., Alexander, C.E., and Marshall, M.I., 2012) .

2.3 ORGANIC AGRICULTURE

2.3.1 Definition

The growth in the organic market has led to the development of USDA organic standards and the National Organic Program (NOP) (USDA Agricultural Marketing Service., 2012). The NOP is a regulatory program housed within the USDA Agricultural Marketing Service (AMS). This program contains standard for organically produced products to ensure the integrity of USDA organic products in the U.S. and worldwide (USDA Agricultural Marketing Service., 2012). The organic market is rapidly growing but will only continue to grow if consumers' trust the integrity of the product. This coincides with the long-standing government role of ensuring that products are not misbranded or mislabeled and consumers are not misinformed about their food.

The USDA defines a product as certified organic if "…the product has been produced through approved methods that integrate cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity." Certified organic producers are prohibited from using synthetic fertilizers, sewage sludge, irradiation, or genetic engineering. These specifications are designed to inform consumers about the items they are purchasing.

2.3.2 Economics of Organic Fruit and Vegetable Productione

The 2008 Farm Act Provisions, namely the Food, Conservation, and Energy Act of 2008, increased the mandatory funding for the Nation Organic Certification Cost-Share Program from $5 million to $22 million. This Farm Act greatly expanded support for existing organic research and regulatory programs, and provided incentives for new producers who wish to transition to organic farming (Greene, 2012). U.S. organic food and beverages sales have increased from $1 billion to $26.7 billion over the past 20 years (Organic Trade Association, 2012). Sales in 2010 represented 7.7 % growth over the sales in 2009. In 2010, organic fruits and vegetables sales experienced the highest growth, up 11.8% over 2009 sales (Organic Trade Association, 2012). ERS used the 2008 Nielsen Homescan data to estimate the average price at retail stores of an edible cup equivalent of commonly consumed fruits and vegetables. These researchers found that the average prices ranged from $0.20 to more than $2 per edible cup equivalent. They also calculated that, in 2008, it would cost $2 to $2.50 per day to meet the 2010 Dietary Guidelines for Americans. Average retail prices for vegetables ranged from $0.50/lb to over $5.00/lb. Fresh leafy greens were found to be among the most expensive fresh vegetable products ($3.92/lb) (Stewart, 2011).

Organic fruits and vegetables currently represent over 11 % of all U.S. fruit and vegetable sales. Interestingly, in 2010, mass market retailers (mainstream supermarkets, club/warehouse stores, and mass merchandisers) sold 54% of all organic food purchased while natural retailers only sold 39% of total organic food sales. Other 2010 sales occurred via export, the internet, farmers' markets/ community supported agriculture, mail order, and boutique and specialty stores (Organic Trade Association, 2012). California leads the nation in organic sales of food at $1.2 billion (National Agricultural Statistics Service (NASS), USDA, 2010). In a 2011 survey of U.S. families, the OTA, in partnership with Kiwi Magazine, found that 78% of American families reported that they purchased organic foods (Organic Trade Association, 2012). This survey also reported that four in ten families purchased more organic food than they did one year earlier. Additionally, just a decade after federal rules for the organic seal were developed, 72% of U.S. families say they are familiar with the organic label (Organic Trade Association, 2012). This is good news for organic producers. However, since this survey was conducted by an organization and a magazine that promotes organic produce consumption and production, it is important to consider the finding within the content of the intent. OTA's target audience was KIWI magazine's advisory board and a national online panel of U.S. households (obtained through a third party panel provider). A total of 763 usable responses were completed in the OTA/Kiwi survey, including 377 KIWI panelists and 386 national panelists (Organic Trade Association, 2012). Even though organic fruit and vegetable production is flourishing, fresh produce farmers have mixed outlooks on organic agriculture.

2.3.3 Comparison of Organic and Conventional Agriculture and Perceptions

There are advantages and disadvantages of organic production practices for producers. Some perceived advantages include being free from pesticides (Batte, M.T., Hooker, N.H., Haab, T.C., and Beaverson, J., 2007) and are not undergoing genetic modification (Batte, M.T., Hooker, N.H., Haab, T.C., and Beaverson, J., 2007) . It also has been suggested that organic produce may have a better flavor (Batte, M.T., Hooker, N.H., Haab, T.C., and Beaverson, J., 2007; Jolly, D.A., Schutz, H.G., Diaz-Knauf, K.V., and Johal, J., 1989; Williams, P.R.D. and Hammitt, J.K., 2000; Woese, K., Lange, D., Boess, C., and Bögl, K.W., 1997) , be produced locally (Lima, G.P.P. and Vianello, F.,

2011) , and may contain higher level of health promoting components (Robinson-O'Brien, R., Larson, N., Neumark-Sztainer, D., Hannan, P., and Story, M., 2009) ; however, this has not been proven. Consumers have stated that they purchase organic foods for a variety of reasons, namely concerns about the effects of conventional farming practices on the environment (Loureiro, M.L., McCluskey, J.J., and Mittelhammer, R.C., 2001) , human health (Magnusson, M.K., Arvola, A., Hursti, U.K.K., Åberg, L., and Sjödén, P.O., 2003) , and animal welfare (Harper, G.C. and Makatouni, A., 2002) . Some of the drawbacks of organic farming include the financial risk from lower production, higher plant health care, and lack of pesticides to control unwanted insects (Lima, G.P.P. and Vianello, F., 2011) . Concern has been expressed about the safety of produce cultivated under organic practices (Mukherjee, A., Speh, D., and Diez-Gonzalez, F., 2007) . Safety concerns relative to human health are related to the use of manure as the fertilizer of choice for organic farming. If the manure is not properly handled, it may lead to microbiological (*Escherichia. coli,* mycotoxins, coliforms, and parasites) contamination of produce. Mukherjee et al. (2004) conducted a study comparing the presence of coliforms, generic *E. coli*, *Salmonella*, and *E. coli* O157:H7 in organic, semi-organic (practicing organic without certification), and conventional produce at the farm level. These researchers collected samples from the farm during harvest and did not find a significant difference in any of the microorganisms recovered from organic and conventional produce ($P > 0.05$). Based on more than 2,600 samples of fresh fruits and vegetables collected directly from the field, *Salmonella* contamination was detected in only 2 samples (1 from organic lettuces and 1 from organic green peppers) grown by semi-organic farmers (Mukherjee, A., Speh, D., Dyck, E., and Diez-Gonzalez, F., 2004) . None of the product collected from organic or conventional farmers tested positive for *E. coli* O157:H7. Generic *E. coli* was recovered from 9.7% of the non-certified organic samples and 1.6% of the conventional samples (Mukherjee, A., Speh, D., Dyck, E., and Diez-Gonzalez, F., 2004) . In the certified organic samples this number was reduced to 4.3%. However, these bacteria are not pathogenic and are an indicator of fecal contamination. Mukherjee et al. (2004) was the group to first study the potential association between organic certification and *E. coli* prevalence. Specifically, the percentage certified organic and non-certified growers that had at least one positive sample for *E. coli* were 12% and 59%, respectively (Mukherjee, A., Speh, D., Dyck, E., and Diez-Gonzalez, F., 2004) . This study illustrates the importance of certification reflected by the association with compost time and the amount of pathogens in the manure, which is to wait at least 60 days before planting and apply the compost at least 120 days before harvest.

Winter and Davis believe it is too soon to tell whether there is a beneficial difference in vitamins, minerals, and antioxidant levels in organic versus conventional produce (Winter, C.K. and Davis, S.F., 2006) . However, Worthington (2001) found significant differences in various nutrients when comparing organic and conventional produce. Specifically, these researchers reported higher levels of vitamin C, iron, magnesium, and phosphorous, and lower levels nitrates in organic versus conventional produce (P-value < 0.01) (Worthington, 2001). Additionally, Davis et al. (2004) conducted a nutrient analysis for 43 crops between 1950 and 1999. There was a significant decrease in the level of 6 of 13 nutrients examined over time (protein, calcium, phosphorous, iron, riboflavin, and ascorbic acid. The authors suggested that the decline could be explained by changes in the cultivation practices between 1950 and 1999 (Davis, D.R., Epp, M.D., and Riordan, H.D., 2004) . The researchers also compared USDA nutrient content data published in 1950 and 1999 for 13 nutrients and water in 43 garden crops, mostly vegetables (Davis, D.R., Epp, M.D., and Riordan, H.D., 2004) . After adjusting for differences in moisture content, ratios of nutrient contents were calculated for each food and nutrient. (Davis, D.R., Epp, M.D., and Riordan, H.D., 2004) .

Since it was still unclear if organic foods are microbiologically safer or healthier than conventional alternatives, researchers at Stanford University reviewed articles from 1966 to 2011 to compare the health effects of organic and conventional foods (Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., and Stave, C., 2012). An argument often made with regard to organic produce is that there is no exposure to pesticides. However, Smith-Spangler argued that the studies that make this conclusion were not designed to assess the link between the observed urinary pesticide levels and clinical harms. They cited only one crossover study that compared urinary insecticide levels among children spending 5 days on an organic diet and 5 days on a conventional diet (Lu, C., Barr, D.B., Pearson, M.A., Walker, L.A., and Bravo, R., 2008) . This crossover study found that it was the household use of insecticides, not the diet, that proved to be a significant contributor of urinary insecticide (Lu, C., Barr, D.B., Pearson, M.A., Walker, L.A., and Bravo, R.,

2008) Another interesting finding from this Stanford review was that the study methods of the articles varied widely (Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., and Stave, C., 2012). Fifty-two percent of the studies (80 studies) were conducted on experimental farms in which potential confounding variables such as weather, geography, or plant cultivar of the relationship between cultivation method and nutrient levels were controlled while 29% of the studies (44 studies) sampled food grown on commercial farms (Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., and Stave, C., 2012). This review also found that only 2 nutrients (phosphorous and total phenols) were significantly higher in organic versus conventional produce (Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., and Stave, C., 2012). Regarding pesticide contamination, 7% of organic produce samples and 38% of conventional produce samples were contaminated (Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., and Stave, C., 2012). Based on these data, these researchers concluded that they did not have strong evidence to support that organically produced food were more nutritious than their conventional counterparts (Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., and Stave, C., 2012).

2.4 TRENDS IN LOCAL AGRICULTURE

As of 2012, there is no USDA definition of “local” to define local produce. However, some consumers have elected to define “local” to be within a certain geographical distance (i.e. 100 miles), while others have defined “local” to mean some political boundary, such as a state border. Others feel that “local” is rooted in ethics, community, and other factors not related to distance (Johnson, R., Aussenberg, R.A., and Cowen, T., 2012). There have been several surveys aimed at identifying consumer understanding of “local” relative to produce (Adams, D.C. and Adams, A.E., 2011; Adams, D.C. and Salois, M.J., 2010; Brown, 2003; Harris, B., Burress, D.A., Mercer, S.O., Oslund, P., and Rose, C.C., 2000; Hartman Group, 2008) . The Hartman Group (2008) conducted a survey in December 2007 with a sample size of 796 and found that 37% of respondents defined “local” as “made or produced in my state,” while 50% defined “local” as “made or produced within 100 miles.” The remaining 8% of the respondents was split equally between “within my region (e.g. New England)” and “in the USA” (Hartman Group, 2008). Brown (2003) conducted a survey in Missouri and asked household food buyers to define “locally grown.” This study reported that 37% of respondents said locally grown meant within the southeastern Missouri region, 23% would expand “locally grown” to include nearby southern Illinois, 14% restricted “local” to within their county, and 14% would expand “local” to include an adjacent county (Brown, 2003). Only 12% of respondents considered products from the entire state of Missouri as “locally grown” (Brown, 2003). Alarmingly, Missouri’s statewide program to promote local products has been implemented for 15 years, yet 64% of the respondents had not heard of, or seen the label that was used to denote locally grown (Brown, 2003). Harris et al. (2000) conducted focus group surveys in Kansas to identify, among other things, consumers' concepts of locally-grown produce. These researchers found that consumers' concept of locally-grown produce was not as clear as their knowledge of organic produce. Some consumers believed locally-grown meant that the produce was grown within a 100-200 mile radius, while others thought produce grown in surrounding states was locally-grown. However, some consumers said only produce grown within or near their particular city limits or county (within a 30 mile radius) should be considered locally grown (Harris, B., Burress, D.A., Mercer, S.O., Oslund, P., and Rose, C.C., 2000) . In another study, Adams and Adams (2011) gathered information from 97 consumer surveys in 2 Florida farmer's markets. This survey was conducted to identify the complex forces driving local food purchases. Adams and Adams (2011) claimed that their study highlighted the complexity of consumers' conceptualizations of local. These researchers found that the consumers they surveyed believe that local may not be defined by mileage but rather, consumers may define local as a 'value-based' descriptor. Adams and Adams (2011) found that "local" encompasses ethical, sustainable, and community factors that may vary among consumer groups or even individuals. Additionally, using cluster analysis, these researchers were able to approximate who was buying local produce and why they were buying local produce. Adams and Adams (2011) found that consumers who perceived local as least costly and easiest to access were the most frequent shoppers. However, the consumer who had the highest perception of "local" as more costly and more difficult to access also reported very frequent purchases of local food. This latter group was younger and more likely to go to alternative food stores (Adams, D.C. and Adams, A.E., 2011) . The results of this survey reflected the dichotomy of local food consumers. On one hand, there is a local food consumer who buys local because they see it as an inexpensive alternative and on the other hand there is another consumer who sees this product as more expensive but buys it to support the community and local economy (Adams, D.C. and Adams, A.E., 2011) .

Another aspect to consider while evaluating consumer perceptions of locally grown produce is the direct access of consumers to farms and farmer's markets. From 1978 to 2007, farms with direct-to-consumer food sales represented 5.5% of all farms. The number of farmers engaged in direct-to-consumer sales peaked in 1982 which was likely due to the 1976 Farmer-to-Consumer Direct Marketing Act that provided funds for activities supporting direct marketing of fresh produce (Low, S.A. and Vogel, S., 2011) . Thus, from 1992 to 2007 the number of farms participating in direct-to-consumer sales increased by 58% (Low, S.A. and Vogel, S., 2011) . More recently, the local food movement has received another significant boost. When, President Obama's stated "Local food systems work for America: when we create opportunities for farmers and ranchers, our entire nation reaps the benefit" (USDA, 2012). With President Obama's support and the 2008 Farm Bill, Tom Vilsack, U.S. Secretary of Agriculture, launched the "Know Your Food Know Your Farmer" project (USDA, 2012). Vilsack indicated that the "Know your food, know your farmer" project focuses on connecting consumers to farmers and local and regional food systems. Vilsack reported that the direct-marketing sales have increased from $551 million in 1997 to $1.2 billion in 2007 (USDA, 2012). Marketing of local foods, via both direct-to-consumer and intermediated channels grossed $4.8 billion in 2008 about four times higher than estimates based solely on direct-to-consumer sales (Low, S.A. and Vogel, S., 2011) . In their survey of the 2008 Agricultural Resource Management, showed that previous reports that focused on direct-to-consumer sales missed a large portion of the local food sales, specifically, the sale of food for human consumption to grocers and restaurants. Through this analysis, Low and Vogel (2011) discovered that gross sales of locally marketed foods are 4 times larger than the previous census. ARMS showed that most local food are marketed through intermediated channels (retailers), accounting for 50-66% of the value of all local food sales. Low and Vogel (2011) also found that local farms, marketing solely through intermediated channels, reported $2.7 billion in sales, in 2008, which is over 3 times higher than the value of local sales marketing exclusively through direct-to-consumer channels (Low, S.A. and Vogel, S., 2011) . This reflected the fact that there is more opportunity for the local food market than previously estimated. Small farms, grossing less than $50,000, accounted for 81% of local food sales and were more likely to utilize direct-to-market channels, such as farmers' markets and roadside stands, exclusively. On the other hand, large farms accounted for only 5% of all local food sales farms. Most of the local food sales conducted by large farms were from intermediated channels. Interestingly, vegetable, fruit, and nut farms comprise only 6% of the 2.1 million farms, yet accounted for 43% of all local food farms. In other words, vegetable/fruit/nut farms are 8 times more likely to sell their product locally than other farms.

The U.S. has seen a dramatic increase in consumer interest in purchasing locally grown food. As a result, there have been marked changes in the food system. For instance, from 1994 to 2012 there has been a 348% increase in the number of operating farmer's markets with an average annual increase of about 12.6% (USDA. AMS., 2012). Additionally, 26 years ago, there were only 2 Community Supported Agriculture (CSA) initiatives; however, today, there were between 6,000-6,500 CSA initiatives. (McFadden, 2012) This number was different from the 12,500 CSA initiatives that the USDA determined in their 2007 Census of Agriculture (US Census Bureau, 2009). It has been speculated that the USDA overestimated the number of CSAs because of ambiguity in the relevant question in the 2007 Census of Agriculture (Galt, 2011). The agricultural census seemed to be asking how many farms were involved with CSA rather than how many farms were in fact actual CSAs (Galt, 2011).

In 2008, Walmart demonstrated just how large the local produce movement was when they pledged to source more local fruits and vegetables for their stores. This same year, a Walmart spokesperson said that their partnerships with local farmers had grown by 50% (Walmart, 2008).

Remarkably, all 50 states have state-sponsored agricultural marketing programs to encourage consumers to buy local. For example, S.C. started their program "Certified S.C. Grown" in 2007. This program was a cooperative effort among producers, processors, wholesalers, retailers, and the South Carolina Department of Agriculture (SCDA) to brand and promote S.C. products (SC department of agriculture, 2012). The ultimate goal for this movement was to enable consumers to easily identify and purchase

S.C. products (SC department of agriculture, 2012). In S.C., the combined annual revenue from fruit and vegetable production has been estimated to approach $161 million from 1,520 vegetable farms and 1,340 fruit farms (SC department of agriculture, 2012). Moreover, these farms occupy more than 25% of the available land within S.C. (SC department of agriculture, 2012). S.C. ranks at or near the top nationally for fresh market production of leafy greens such as collards, kale, turnips, and mustard (SC department of agriculture, 2012).

2.5 LEAFY GREENS

The most recent Agricultural Census (2007) stated that there were 11,481 leafy green producers with 89% of this crop being grown by farmers. California is the leading state in leafy green production, contributing 75% of the U.S. production (US Census Bureau, 2009). The USDA estimated that the value of leafy green vegetables grown for U.S. fresh and fresh cut market was $2.5 billion in 2008 (US Census Bureau, 2009). Among leafy green production, lettuce crops accounted for 79%, cabbage accounted for 15%, and spinach accounted for 7%. Other minor fresh leafy green vegetable crops, such as collards, escarole, endives, and specialty varieties of kale, are produced regionally and seasonally. In the last 10 years, U.S. production of leafy green vegetables has risen by nearly 25%; with the three fastest growing crops being spinach, head lettuce, and romaine (US Census Bureau, 2009). The 2007 Census contained limited data for the minor fresh leafy greens; however, the census did report the national acreage and number of planting mustard greens as 7,013 and 848, respectively. Top producing states for mustard greens include California (harvesting 1,902 acres on 87 farms), Georgia (harvesting 1,585 acres on 36 farms), South Carolina (harvesting 581 acres on 35 farms), Texas (harvesting 470 acres on 61 farms), and Michigan (harvesting 308 acres on 29 farms) (US Census Bureau, 2009). All states in the U.S. produce head cabbage, leaf lettuce, and spinach (US Census Bureau, 2009). Kale is grown in 44 states and head lettuce is grown in 45 states (US Census Bureau, 2009).

2.6 BACKGROUND OF THE FAMILY: BRASSICACEAE

Among leafy green vegetables, data on collard production and consumption has not been published. Overall, leafy greens belong to the kingdom Plantae and are categorized under the order Brassicales in the family, Brassicaceae (Prakash, S. and Hinata, K., 1980). The family Brassicaceae includes 350 genera of leafy greens and about 3,500 different species (Prakash, S. and Hinata, K., 1980). The most important genus of Brassicaceae is Brassica and the most profitable species include *Brassica oleracea* L., *Brassica napus* L., and *Brassica rapa* L. Brassicas are grown as vegetables, fodder, source of oils, or condiments (Prakash, S. and Hinata, K., 1980) . The main vegetable species is *B. oleracea*, which encompasses vegetable and forage forms, such as kale, cabbage, broccoli, Brussels sprouts, cauliflower, and others (Fahey, J.W., Zhang, Y., and Talalay, P., 1997) . *B. rapa* includes vegetable forms, such as turnip, Chinese cabbage and pak choi, along with forage and oilseed types (Fahey, J.W., Zhang, Y., and Talalay, P., 1997). *B. napus* crops are mainly used like oilseed (rapeseed), although forage and vegetable types like leaf rape and nabicol are also included. The mustard group which includes three species, *B. carinata*, *B. nigra,* and *B. juncea*, may be used as a condiment while leaves of *B. juncea* are also consumed as vegetables and are used for both fresh and processed markets in Asian countries (Fahey, J.W., Zhang, Y., and Talalay, P., 1997). It is hypothesized that domestication of mustard plants originated for their medicinal properties; however their culinary uses are now wide-spread (Fahey, J.W., Zhang, Y., and Talalay, P., 1997). Leafy greens are a great source of vitamin A (carotenoids), vitamin C, folate and potassium (U.S. department of health and human services, 2008). Leafy greens within the Brassica species represented an excellent source of vitamin C, dietary fiber, and anti-carcinogenic compounds (Fahey, J.W., Zhang, Y., and Talalay, P., 1997) . Most of the time single parts of crop plants have been enhanced for domestication such as seeds, fruits, or roots. However, every part of Brassica crops have been selected to yield different crop plants such as edible oils, condiments (seeds), and vegetables (roots, leaves, stems, or inflorescences).

2.6.1 Historical Background of Brassicas

Researchers of Brassica systematics include but are not limited to Linnaeus (1753), De Candolle (1821), Roxburgh (1832), Prain (1898), Schulz (1919, 1936), Sinskaia (1927-1928), and Bailey (1922, 1930). However, there has been some confusion about the naming because of the different species within the Brassica family. The most significant contribution in the classification of Brassica came from Otto Eugen Schulz (1919), who wrote numerous papers on Cruciferae and collectively published them in Das Pflanzenreich (E. Schulz, 1919) and in Die Naturlichen Pflanzenfamilien (O. E. Schulz, 1936). It was finally determined that the crop Brassica included six species, three are basic species (*B. nigra*, *B. oleracea*, and *B.* campestri)s and the other three are amphidiploids (*B. carinata, B. juncea*, and *B. napus*) which result from any two of the basic species (Prakash, S. and Hinata, K., 1980) .

The most commonly consumed Brassica species are the Brassica oleracea. Literature from Indian, Chinese, Greek, and ancient Roman civilizations have frequently referenced these crops (Prakash, S., Wu, X.M., and Bhat, S.R., 2011) . The earliest mention of these crops can be traced to a Chinese almanac (ca 3000 BCE). *B. oleracea* has vast morphological diversity in leaf, stem, and inflorescences. As a group, they are known as cole crops, a term coined in 1901 by L.H. Bailey, an American botanist and horticulturist (Bailey, 1922). Several varieties of *B. oleracea* are extremely popular worldwide. *B. oleracea* includes at least 6 varieties. Snogerup (1980) and Dixon (2007) defined these varieties (var.). Kales (var. acephala) develop a strong main stem bearing edible foliage and include marrow stem kale, collards, and green and dwarf Siberian kale. Cabbages (var. capitata) form heads consisting of tightly packed leaves and include cabbages, brussel sprouts, and savoy cabbage (Dixon, 2007; Snogerup, S.,Tsunoda, S., Hinata, K., and Gomez-Campo, C., 1980) . Kohlrabi (var. gongylodes) is grown for its edible stem and is most common in China and Vietnam. Inflorescence kales (var. botrytis and var. italic) include cauliflower, broccoli, and sprouting broccoli. Branching bush kales (var. fruticosa) are used for edible foliage and are popular in Europe. Chinese kale (var. *B. alboglabra*) is widely cultivated in southeastern Asia and the flower bud, flower stalk, and young leaves are eaten. One of the most common leafy greens produced primarily in the southern region of the U.S. is collard greens.

2.6.2 Background of Collard Greens

Collard greens belong to the species *Brassica oleracea* var. acephala (Sauer, 1993). Acephala comes from the Greek word "akephala" meaning "without head" (Encyclopedia Britannica, 2012). This means that the leaves do not form a cohesive foundation of leaves like the leaves of cabbage. Collards are a cool season crop typically grown in spring or fall and are descendents from the wild cabbage, which was thought to be consumed since prehistoric times in Asia minor. From there, it was hypothesized to have spread throughout Europe in 600 BC and was cultivated by ancient Greek and Roman civilizations (Sauer, 1993). Cabbages and coleworts (changed to collards in the new world) were likely introduced to North and South America by the Spanish, Portuguese, and English settlers in the 1500's and 1600's (Sauer, 1993). The most common cultivars of collards include Blue Max, Flash, Hevi-Crop, Hi-Crop, Cabbage, Carolina, Champion, Georgia, Georgia Blue Stem, Green Glaze, Morris Heading, and Vates. The mean age to maturity for collards is about 71.2 days with a minimum of 60 days (Georgia Blue Stem) and a maximum of 80 days (Morris Heading) (Dixon, 2007). The most recent survey of vegetable production in the U.S. was conducted in 2001 and reported that collard production for the U.S. was 14,100 hectares with an estimated value of $36.4 million (USDA/NASS, 2001). Because of their production requirements and ability to endure hot summers, collards have flourished in the southern part of the U.S. but they may still thrive in winter (Albright, 1989). Collards have become synonymous with the South as one writer stated that collard greens, "probably more than any other food, delineate the boundary of the Mason-Dixon line" (Albright, 1989). In 2011, collard greens became the state vegetable for South Carolina. In 2001, South Carolina producers grew 264,000 pounds of collard greens within S.C. which placed the state second in U.S. for collard production, representing 16% of total U.S. collard green production. (USDA/NASS, 2001) In 2001, this crop was valued at $6,626,000 in S.C. (USDA/NASS, 2001).

2.6.3 Background of the Vates Cultivar

The Vates collard was introduced in the 1930's by the Virginia Truck Experimental Station and thus, was named VATES based on the acronym. Since its development, it has been one of the top collard varieties in the U.S. This plant was developed out of necessity during The Great Depression because it was an open-pollinated plant, and not a hybrid (Barrow, 2009). Open pollinators reproduce by either cross-pollination between two plants (via wind, insects, or water) or self-pollination (between male and female flower parts). Brassicas are cross-pollinators and therefore require isolation in the field to keep the varieties true. Older strains of open-pollinators, known as "heirlooms," are not really considered varieties as they are populations (Barrow, 2009). Individual plants within an older variety can possess a large amount of genetic variability and may even diverge in size or shape. However, plant breeders began to develop new techniques to create more uniform varieties of plants. Hybrids, on the other hand, are made from the cross or mating between two different varieties of the same plant species (Barrow, 2009). In its broadest definition, almost all vegetables are hybrids. Today, however, "hybrid" has a much narrower legal definition. To advertise and sell a vegetable as a hybrid, the parents must be known and its pollination controlled (Barrow, 2009).

2.7 ETHYLENE

One of the many biological differences between fruits and vegetables is the rate at which they conduct enzymatic oxidation or respire to produce energy. Fruits can be classified into two groups, climacteric and non-climacteric. Climacteric fruit ripen after harvest and non-climacteric fruit do not ripen after harvest. The term, climacteric, was first applied to fruit ripening in the 1920's by Kidd and West (1927). These researchers observed an increase in CO_2 levels in apples around the time of the typical harvest (Kidd, F. and West, C., 1927) . Biale and Barcus (1970) measured the respiration rate of some fruits and classified them into climacteric, non-climacteric, or intermediate on the basis of respiration rate (Table 1). Vegetables, along with non-climacteric fruit, have a slower respiration rate which means they do not continue to mature after harvest.

Table 2.1: Table of climacteric and non-climacteric fruits

Climacteric	Non-climacteric
Apple	Blueberry
Apricot	Cacao
Avocado	Caju
Banana	Cherry
Biriba	Cucumber

Breadfruit	Grape
Cherimoya	Grapefruit
Feijoa	Lemon
Fig	Lime
Guava	Olive
Jackfruit	Orange
Kiwifruit	Pepper
Mango	Pineapple
Muskmelon	Strawberry
Nectarine	Tamarillo
Papaya	
Passion fruit	
Peach	
Pear	
Persimmon	
Plum	
Sapote	
Soursop	
Tomato	
Watermelon	

In 1996, Wills found that exposing strawberries, oranges, lettuce, beans, Chinese cabbage, bak choi, choi sum, and gai lan to air containing 10-0.005ul/L of ethylene at either 0-2.5 or 20^{o}C extended the shelf-life of the produce. Ethylene is a simple compound with 2 carbons linked with a double bond (Figure 1) and naturally occurs in the gaseous form (Wills, 1996)

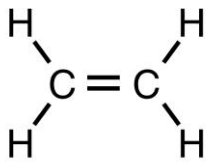

Figure 2.1-Chemical structure of ethylene

In plant tissue, ethylene is a hormone controlling a wide range of physiological processes such as the regulation of many aspects of plant development and senescence. The first indications that the presence of these gaseous materials in the air could modify the growth of plants were discovered in the mid-nineteenth century (Wills, 1996). However, it was not until the turn of the century that Neljubow (1901) identified ethylene as a causative agent of this effect. Cousins (1910) then discovered that ethylene was, in fact, produced by plant material, and could affect the growth of nearby plants. In 1934, Gane provided chemical proof that ethylene was indeed produced by mature apples. Now, it is widely known that ethylene is produced from essentially all parts of higher plants including leaves, stems, roots, flowers, fruits, tubers, and seedlings. However, some types of plants and their tissues produce more ethylene than others.

Ethylene is thought of as a plant growth regulator or plant hormone because of the large number of physiological processes that it regulates, including seed germination to organ senescence (Cousins, 1910; Gane, 1934). Among these processes, ethylene's affect on fruit ripening and vegetable senescence have been of major interest to scientists. This is because fruits and vegetables are a staple in the human diet.

Ethylene elicits both positive and negative effects during fruit ripening (Cape, 2003). Starting with the positive effects, ethylene stimulates the ripening process for climacteric fruits leading to agreeable flavors, color, and texture (quality characteristics). These fruits may also have negative effects from ethylene including over-ripe fruit (Cape, 2003). In non-climacteric fruits, ethylene is not required for the ripening process but, in these fruits, as well as vegetables, ethylene has negative effects including increased pathogen susceptibility, physiological disorders, and senescence, with a reduction in shelf-life (Cape, 2003).

Aside from the ethylene production from fruits and vegetables, there are other sources of ethylene productions. These include, biomass fermentation of some microorganisms (bacteria and fungi) and prolysis of hydrocarbons which release ethylene as a component of air pollution (Cape, 2003). To avoid these detrimental effects, it is vital to inhibit ethylene biosynthesis (Cape, 2003). To do this, it is necessary to have an understanding of the ethylene biosynthesis pathway.

2.7.1 Biosynthesis of ethylene and its regulation

Ethylene biosynthesis has been studied in depth ever since its discovery (Bleecker, A.B. and Kende, H., 2000; Deikman, 1997; John, 1997; Kieber, 1997; Sisler, 1997; Stearns, 2003) . In highly vascular plants, ethylene is synthesized from the amino acid Methionine to S-adenosylmethionine (SAM) by the addition of adenine at the expense of ATP (Kende, 1993). SAM is then converted to 1-aminocyclopropane-1-carboxylic acid (ACC) by the enzyme ACC-synthase (ACS) with the generation of the by-product 5'-methylthioadenosine (MTA) which is recycled to methionine (Yang, S.F. and Hoffman, N.E., 1984). Ethylene can be produced in high volumes even with a small pool of free methionine. Finally, ACC is oxidized to ethylene via ACC-oxidase (ACO). The rate limiting step in the formation of ethylene is ACS and the subsequent pool of ACC (Yang, S.F. and Hoffman, N.E., 1984) (Figure 2).

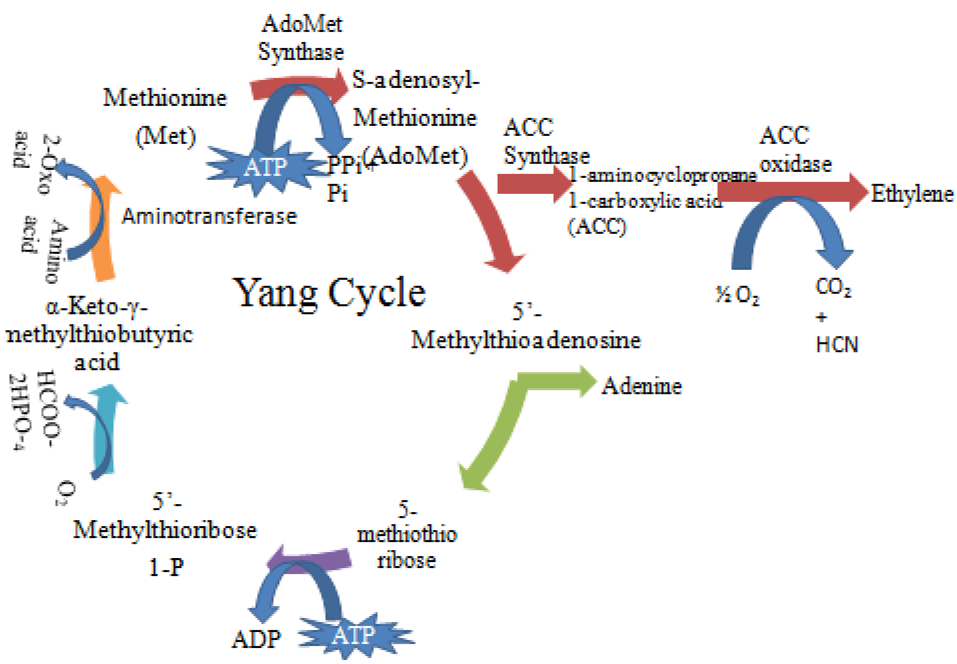

Figure 2.2-Biosynthetic pathway and regulation of ethylene

In climacteric fruit, when the ethylene is synthesized at low amounts, the internal production of ethylene increases dramatically. In other words, there is a positive feedback mechanism where ethylene promotes its own synthesis. This occurrence is known as autocatalytic ethylene production (Yang, S.F. and Hoffman, N.E., 1984) .

During the autocatalytic mechanism, ethylene binds to a receptor and the binding produces a signal that is transduced through a complex mechanism to trigger specific biological responses. Extensive research has been conducted to identify and isolate the initial receptor site using Arabidopsis as a model; however, the complete set of signaling components are still unknown (Guo, H. and Ecker, J.R., 2004) . Researchers have identified that ethylene binds to its receptors using copper as a co-factor (Guo, H. and Ecker, J.R., 2004) . Current research indicated that ethylene biosynthesis and action may be blocked by chemical compounds which differ in their structure and act at different levels, namely ACS and ACO activities, blocking receptor sites, diversion of SAM via polyamine biosynthesis, or through the removal of ethylene(Guo, H. and Ecker, J.R., 2004).

2.7.2 Ethylene Reduction Via Polyamine

Ethylene production has been altered through the exogenous treatment of polyamines. Polyamines (PA) such as putresine (PUT), spermidine (SPD), and spermine (SPN) are bioactive components of foods that have two or more amine groups. They are aliphatic amines that are essential components of all living cells and are naturally occurring in most living things including both plants and animals. Since there is competition between polyamines and ethylene through their common precursor SAM, the balance between these two opposing growth regulators is critical in slowing down or accelerating the ripening process (Pandey, S., Ranade, S.A., Nagar, P.K., and Kumar, N., 2000) . Numerous experiments have revealed the reduction of ethylene by applying exogenous polyamine during the growing season (pre-harvest) in apricots (Paksasorn ,A., Hayasaka,T., Matsui,H., Ohara,H., and Hirata,N., 1995) , peaches (Bregoli,A.M., Scaramagli, S., Costa, G., Sabatini, E., Ziosi, V. Biondi, S., and Torrigiani, P., 2002), and nectarines (Torrigiani, P., Bregoli, A.M., Ziosi,V., Scaramagli,S., Ciriaci,T., Rasori, A., Biondi, S., and Costa, G., 2004). Polyamines have also been used under post-harvest conditions to control senescence. Polyamine levels naturally decrease during fruit ripening along with an increase in senescence and paralleling the climacteric rise in ethylene production. Therefore, an exogenous application of polyamines increases the endogenous polyamine levels during storage, and sequentially extends shelf-life. Interestingly, when damaged fruit, which ordinarily have an increase in ethylene production, have been treated with exogenous polyamines, the ethylene production is inhibited. (Martinez-Romero, D., Serrano, M., Carbonell, A., Castillo, S., Riquelme, F., and Valero, D., 2004). Exogenous putrescine treatment has been found to significantly increase putrescine and spermidine (from putrescine via DC-SAM) levels, while simultaneously decreasing ethylene production in various fruits. Thus, the diversion of the DC-SAM via polyamine synthesis may explain the significant reduction in ethylene production found in putrescine treated fruit. In other words, an increased level of putrescine led to more spermidine from the putrescine via DC-SAM, thus there was less DC-SAM available to make ACC and consequently less ethylene. (Martínez-Romero, D., Guillén, F., Valverde, J.M., Bailén, G., Zapata, P., Serrano, M., Castillo, S., and Valero, D., 2007) Additionally, putrescine treated fruit had significantly higher percentages of color retention with respect to the value at harvest when compared to the control group (Martínez-Romero, D., Guillén, F., Valverde, J.M., Bailén, G., Zapata, P., Serrano, M., Castillo, S., and Valero, D., 2007).

2.7.3 ROLES OF POLYAMINES

Polyamines have a role in cellular metabolism and are engaged in many steps of protein, RNA, and DNA synthesis, ranging from control and initiation of translation (Konecki, D., Kramer, G., Pinphanichakarn, P., and Hardesty, B., 1975) ; regulation of its fidelity (Abraham,A.K., Olsnes,S., and Pihl, A., 1979) ; stimulation of ribosome subunit association (Kyner, D., Zabos, P., and Levin, D.H., 1973) via enhancement of RNA (Barbiroli, B., Corti, A., and Caldarera, CM., 1971) and DNA synthesis (Fillingame, R.H., Jorstad, C.M., and Morris, D.R., 1975) ; stabilization of the structure of tRNA (S. S. Cohen, 1978) and reduction of RNA degradation rate (Fausto, 1972); and involvement in the condensation of DNA (Anderson, N.G. and Norris, C.B., 1960) to covalent changes in proteins (Williams-Ashman H.G. and Canellakis Z.N., 1979). Polyamines have also been found to be involved with the differentiation of immune cells as well as in the regulation of inflammatory reactions (Moinard, C., Cynober, L., and de Bandt, J.P., 2005) . They also exert a suppressor effect on pulmonary immunologic and intestinal immunoallergenic responses (Hoet, P.H.M. and Nemery, B., 2000) . In a research project conducted on children, Dandrifosse et al. (2000) found that, high polyamine intake during the first year of life correlated significantly with food allergy prevention (Dandrifosse, G., Peulen, O., Khefif, N.E., Deloyer, P., Dandrifosse, A.C., and Grandfils, C., 2000). Additionally, other research has shown that spermine and spermidine exhibit a significant antiglycation effect at a physiological concentration, suggesting a new role for polylamines against diabetes (Gugliucci, A. and Menini, T., 2003) . The three primary sources for polyamines in humans are: endogenous or *de nova* biosynthesis, intestinal microorganisms, and exogenous supply through the diet. Of these three sources, the diet supplies the majority of the polyamines. Since the level of polyamine biosynthesis decreases with age, maintenance of this polyamine level is important in the elderly. However, the cell growth promoting effect of polyamines may also have a negative in relation to cancer development. In cancer patients who wish to slow down cellular proliferation, it would be advisable to minimize the intake of dietary polyamines (Bardocz, S., Duguid, T.J., Brown, D.S., Grant, G., Pusztai, A., White, A., and Ralph, A., 1995). For polyamines that are producing endogenously, intracellular PA are regulated by de nova synthesis, conversion and degradation as well as uptake of extracellular PA (Löser, C. and Fölsch, U.R., 1993; Pegg, A.E. and McCann, P.P., 1982; Seiler, 1990; Tabor, C.W. and Tabor, H., 1984) . The preface regulatory mechanisms include intracellular PA de nova synthesis via ornithine decarboxylase (ODC) as the key regulatory enzyme of PA metabolism, reconversion of PA via interconversion pathway (spermine/spermidine N^1-acetyltransferase and polyamine oxidase), and oxidative degradation of PA. (C. Löser, 2000)

In plants, PA has been found to be involved in triggering organogenesis and protection against stress. In 1998, Valero et al. studied free PA and found PA to have an anti-senescent effect on lemons from both endogenous and exogenous application. The specific effects were retarded color changes, increased fruit firmness, delayed ethylene and respiration rate emissions, induced mechanical resistance, and reduced chilling injury (CI) symptoms. In fruit, CI causes abnormal ripening, surface pitting, and internal browning; however, when fruit are exposed to low but non-freezing temperatures, there are significant increases in PUT levels in many fruit like lemons, grapefruit, zucchini, eggplant, and pepper, reflecting that PA's may protect fruits from CI owing to their ability to maintain membrane integrity. (Valero, D., Pérez-Vicente, A., Martínez-Romero, D., Castillo, S., Guillen, F., and Serrano, M., 2002) Martinez-Romero et al. (1999) found that lemons treated with PA were more resistant to mechanical stress whereas the control group had an increased concentration of PA's as a result of mechanical damage. Therefore, an increase in PA concentration may act as a good physiological marker of mechanical stress. (Martínez-Romero, D., Valero, D., Serrano, M., Martínez-Sánchez, F., and Riquelme, F., 1999) Exogenous applications of PA have been found to increase firmness in apples (Kramer, G.F., Wang, C.Y., and Conway, W.S., 1991; Wang, C.Y., Conway, W.S., Abbott, J.A., Kramer, G.F., and Sams, C.E., 1993) , strawberries (Ponappa, T., Scheerens, J.C., and Miller, A.R., 1993) , tomatoes (Law, D.M., Davies, P.J., and Mutschler, M.A., 1991) and lemons (Martínez-Romero, D., Valero, D., Serrano, M., Martínez-Sánchez, F., and Riquelme, F., 1999) . Putrescine treatment delayed the loss of firmness during storage of various fruits. The effect of PA's on fruit firmness has been quantified by their cross-linking methylesters of the pectic substances in the cell wall, producing firmness that is detectable immediately after treatment. The binding also blocks degrading enzymes such as pectinmethylesterase (PME), pectinesterase (PE), and polygalacturonase (PG), diminish the softening rate during storage (Valero, D., Martínez-Romero, D., Serrano, M., and Riquelme, F., 1999) . Polyamine treatment has also been found to improve chlorophyll breakdown in several plant organs, including fruits. This has been examined in lemons and apricots as PUT treatment delayed the color change during storage (Martínez-Romero, D., Serrano, M., Carbonell, A., Burgos, L., Riquelme, F., and Valero, D., 2002)

Bardocz et sl. (1995) measured the amount of polyamines consumed in the diet relative to the amount that actually passed through to the body. They performed this experiment using rats as models and found that a proportion of the polyamines from the diet were converted by gut enzymes to polyamine- and/or non-polyamine metabolites during the passage through the intestine. For instance, one hour after the rats were intubated with ^{14}C-labelled putrescine, only 29-39% of the ^{14}C label was found as polyamines of which putrescine contributed 11-15 %. They speculated that this putrescine breakdown was the result of diamine oxidase, the most abundant enzyme in the intestinal tissue (Bardocz, S., Duguid, T.J., Brown, D.S., Grant, G., Pusztai, A., White, A., and Ralph, A., 1995). On the contrary, 79% ^{14}C labeled spermidine and 72-74% labeled spermine remained in the rat one hour after incubation in the same form as given above. Additionally, 87-96% of the ^{14}C spermidine and 79-82 % of the ^{14}C spermine were preserved in polyamine form. The authors concluded that since spermidine and spermine were well conserved for further utilization in the body, they are the “right” polyamines to be absorbed from food as opposed to putrescine where the majority is converted to non-polyamine metabolites. The author expressed that the need for dietary polyamines may change depending on a persons’ physiological or pathological state (Bardocz, S., Duguid, T.J., Brown, D.S., Grant, G., Pusztai, A., White, A., and Ralph, A., 1995). Polyamine requirements are higher in younger people due to intensive growth. However, in the elderly, when cell proliferation slows down, dietary polyamines may also be beneficial (Bardocz, S., Duguid, T.J., Brown, D.S., Grant, G., Pusztai, A., White, A., and Ralph, A., 1995).

Diamines such as putrescine, cadaverine, and 1,3-diaminoproprane are basic nitrogenous compounds formed by decarboxylation of amino acids (L-ornithine, L-lysine, and L-1,4 diaminobutyric acid, respectively) or by amination and transamination of aldehydes and ketones (Maijala, R.L., Eerola, S.H., Aho, M.A., and Hirn, J.A., 1993) . These amines are labeled "biogenic" when they are formed by the action of living organisms through the decarboxylation process of amino acids. Amino acid decarboxylation is the most frequent means of synthesis of amines in food and aromatic amines may cause the food to be toxic. (Shalaby, 1996) They are organic bases that have a low molecular weight and are synthesized by microbial, vegetable, and animal metabolism (Ten Brink, B., Damink, C., and Joosten, H., 1990) 1990). Biogenic amines in food and beverages are formed by the microbial decarboxylation of amino acids (Halász, A., Baráth, Á., Simon-Sarkadi, L., and Holzapfel, W., 1994) . It has also been found that some of the aliphatic amines may be formed "in vivo" by amination from the corresponding aldehydes (Maijala, R.L., Eerola, S.H., Aho, M.A., and Hirn, J.A., 1993) . The chemical structure of biogenic amines may be aliphatic (putrescine, cadaverine, spermine, and spermidine); aromatic (tyramine and phenylethylamine); or heterocyclic (histamine and tryptamine). Amines like diamines (putrescine), polyamines (spermine and spermidine) and cadaverine are indispensible components of living cells and are important in the regulation of nucleic acid function and protein synthesis and in the stabilization of membranes (Bardócz, S., Grant, G., Brown, D.S., Ralph, A., and Pusztai, A., 1993; Halász, A., Baráth, Á., Simon-Sarkadi, L., and Holzapfel, W., 1994; Maijala, R.L., Eerola, S.H., Aho, M.A., and Hirn, J.A., 1993) . Diamines, such as putrescine, and polyamines such as spermidine and spermine probably occur universally in animal and plants. Also putrescine and spermidine are found in most bacteria (T. Smith, 1981). Most foods contain proteins or free amino acids and are subjected to conditions enabling microbial or biochemical active biogenic amines. (Santos, 1996) Both the nature of the food and the microorganisms present affect the total amount of different amines present (Ten Brink, B., Damink, C., and Joosten, H., 1990) . Biogenic amines are present in a wide variety of foods including fish, meat, dairy, wine, beer, vegetables, fruit, nuts, and chocolate (Ten Brink, B., Damink, C., and Joosten, H., 1990) . The factors which affect the formation of biogenic amines in foods comprise the availability of free amino acids, the presence of micro-organisms that can decarboxylate amino acids, the favorable conditional of such micro-organisms for the growth and production of their enzymes. (Shalaby, 1996)

It is well-known that the alimentary tract is an important source of polyamines and that diet as well as bacterial-derived polyamines significantly contributes to the total polyamine body pool. The intestinal mucosa has a high proliferation rate and, as a result, requires a large amount of polyamines. Rat studies conducted found that, during the third postnatal period, there is an increase in epithelial cell proliferation and differentiation leading to histological and enzymatic maturation of the small bowel epithelium. Preceding this process of epithelium maturation, there is a ten- to twentyfold increase in mucosal ODC activity and a concomitant increase in SAM-DC activity as well as polyamine content. After α-difluoromethylornithine (DFMO), a potent specific ODC inhibitor, was administered there was a significant reduction in ODC and polyamine content which was followed by a noteworthy delay in biochemical and histological maturation of the intestinal epithelium (Luk, 1992). This study indicated that ODC activity was needed for the activation of intestinal maturation, and polyamines are important intracellular messengers engaged in the maturation of the small and large intestine (C. Löser, 2000). Research on rats has shown that milk is needed to complete epithelial maturation. Dietary polyamines wield a range of direct and indirect trophic affect on the rat's immature intestine and play a vital role during intestinal maturation (Buts, J.P., De Keyser, N., Kolanowski, J., Sokal, E., and Van Hoof, F., 1993; Dufour, C., Dandrifosse, G., Forget, P., Vermesse, F., Romain, N., and Lepoint, P., 1988; Kaouass, M., Audette, M., Ramotar, D., Verma, S., De Montigny, D., Gamache, I., Torossian, K., and Poulin, R., 1997; Wery, I., Kaouass, M., Deloyer, P., Buts, J., Barbason, H., and Dandrifosse, G., 1996; Wild, G.E., Daly, A.S., Sauriol, N., and Bennett, G., 1993) . Human and cow milk contain polyamines with concentrations higher in spermine and spermidine than putrescine. There are many factors that may affect polyamine milk concentrations including mother's age, genetic influence, ethnicity, circadian rhythm of polyamine secretion, nutritional status, amount of dietary polyamine intake, duration of lactation, environment influences, amount of milk in the breast, possible bacterial contamination etc. (Buts, J.P., Keyser, N.D., Raedemaeker, L.D., Collette, E., and Sokal, E.M., 1995; Motyl, T., Płoszaj, T., Wojtasik, A., Kukulska, W., and Podgurniak, M., 1995; Wery, I., Kaouass, M., Deloyer, P., Buts, J., Barbason, H., and Dandrifosse, G.,

1996) Cow's milk has a lower concentration of polyamines compared to human milk because of the high rate of polyamine degradation in cow's milk due to the high activities of enzymes such as diamine oxidase (DOA) and polyamine oxidase (PAO) (C. Löser, 2000). After measuring PA concentration from 18 powdered infant formulas researchers found higher putrescine than both spermine and spermidine concentrations and a general PA concentration that is more than ten times lower than in natural human milk (Romain, N., Dandrifosse, G., Jeusette, F., and Forget, P., 1992) .

Limited research has been conducted to examine polyamine production in organic versus conventional produce. The few studies that have been conducted have produced conflicting results. Lima et al.(2008) found higher levels of polyamines in organic versus conventional produce. These researchers' analyzed edible parts of plants that are not typically consumed by the local Brazilian) population. The produce was purchased directly from producers grown under either conventional or organic cultivation practices. The produce was divided into lots containing 4 trials consisting of three specimens each. Even though these researchers found significant differences, it is difficult to draw major conclusions based on this research because they purchased this produce from the producers and therefore did not have all the information on the cultivation practices. They also did not specify whether the produce was USDA organic. The authors hypothesized that the high PA levels could be attributed to improved plant longevity. Alternatively, they suggested that higher PA levels may result from increased stress (Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O., 2008) due to the lack of pesticides in organic produce. Within the same lab, Rossetto et al. (2009)

were unable get a consistent pattern of polyamine contents among organic versus conventional beet samples. However, when the samples were subjected to cooking, the organic beet samples maintained a significantly higher concentration ($P < 0.05$) of polyamines compared to conventional beets. Although, this study was informative, the authors did not specify the number of samples analyzed besides the fact that triplicates were used. Additionally, this study, like the previous study, states that they purchased organic produce from certified producers but did not specify if the produce was USDA organic. Furthermore, since this produce was purchased, they did not have full control over the cultivation process. Even though this research was very informative, it is imperative to conduct further studies with larger samples sizes where the researchers have more knowledge and control over the cultivation practices.

2.8 References

Abraham,A.K., Olsnes,S., and Pihl, A. (1979). Fidelity of protein synthesis in vitro is increased in the presence of spermidine. *FEBS Letters, 101:*(1.), 93. doi: 10.1016/0014-5793(79)81302-2

Adams, D.C. and Adams, A.E. (2011). De-placing local at the farmers' market: Consumer conceptions of local foods. *Journal of Rural Social Sciences, 26:*(2.), 74.

Adams, D.C. and Salois, M.J. (2010). Local versus organic: A turn in consumer preferences and willingness-to-pay. *Renewable Agriculture and Food Systems, 25*(4), 331.

Albright, A. (1989). Collard greens. In Wilson, C. R. and Ferris, W. (Ed.), *Encyclopedia of southern culture.* (pp. 649.). New York.: Anchor Books.

Anderson, N.G. and Norris, C.B. (1960). Cell division: III. the effects of amines on the structure of isolated nuclei. *Experimental Cell Research, 19*(3), 605.

Bailey, L. H. (1922). *The cultivated brassicas.* (1st ed.). Ithaca, NY: Gentes. herb.

Barbiroli, B., Corti, A., and Caldarera, CM. (1971). The pattern of synthesis of ribonucleic acid species under the action of spermine in the chick embryo. *Biochemical Journal, 123*(1), 123.

Bardocz, S., Duguid, T.J., Brown, D.S., Grant, G., Pusztai, A., White, A., and Ralph, A. (1995). The importance of dietary polyamines in cell regeneration and growth. *British Journal of Nutrition, 73*(6), 819.

Bardócz, S., Grant, G., Brown, D.S., Ralph, A., and Pusztai, A. (1993). Polyamines in food--implications for growth and health. *The Journal of Nutritional Biochemistry, 4*(2), 66.

Barrow, M. R. (2009,). Collards: A winter staple, a local wonder.

Batte, M.T., Hooker, N.H., Haab, T.C., and Beaverson, J. (2007). Putting their money where their mouths are: Consumer willingness to pay for multi-ingredient, processed organic food products. *Food Policy, 32*(2), 145.

Besford, R.T., Richardson, C.M., Campos, J.L., and Tiburcio, A.F. (1993). Effect of polyamines on stabilization of molecular complexes in thylakoid membranes of osmotically stressed oat leaves. *Planta, 189*(2), 201.

Bleecker, A.B. and Kende, H. (2000). Ethylene: A gaseous signal molecule in plants. *Annual Review of Cell and Developmental Biology, 16*(1), 1.

Bregoli,A.M., Scaramagli, S., Costa, G., Sabatini, E., Ziosi, V. Biondi, S., and Torrigiani, P. (2002). Peach (prunus persica) fruit ripening: Aminoethoxyvinylglycine (AVG) and exogenous polyamines affect ethylene emission and flesh firmness.

Physiologia Plantarum, 114(3), 472-481. doi: 10.1034/j.1399-3054.2002.1140317.x

Brown, C. (2003). Consumers' preferences for locally produced food: A study in southeast missouri. *American Journal of Alternative Agriculture, 18*(4), 213-224.

Buts, J.P., De Keyser, N., Kolanowski, J., Sokal, E., and Van Hoof, F. (1993). Maturation of villus and crypt cell functions in rat small intestine. *Digestive Diseases and Sciences, 38*(6), 1091.

Buts, J.P., Keyser, N.D., Raedemaeker, L.D., Collette, E., and Sokal, E.M. (1995). Polyamine profiles in human milk, infant artificial formulas, and semi-elemental diets. *Journal of Pediatric Gastroenterology and Nutrition, 21*(1), 44.

Calvin, D. (2000). Corn earworm. *Corn Earworm,*

Cape, J. N. (2003). Effects of airborne volatile organic compounds on plants. *Environmental Pollution, 122*(1), 145-157.

Casagrande, S.S., Wang, Y., Anderson, C., and Gary, T.L. (2007). Have americans increased their fruit and vegetable intake?: The trends between 1988 and 2002. *American Journal of Preventive Medicine, 32*(4), 257.

Centers for Disease Control and Prevention. (2012). Overweight and obesity. Retrieved 10/21, 2012, from http://www.cdc.gov/obesity/data/facts.html

Chen, S.T., Maruthur, N.M., and Appel, L.J. (2010). The effect of dietary patterns on estimated coronary heart disease risk. *Circulation: Cardiovascular Quality and Outcomes, 3*(5), 484. doi: 10.1161/CIRCOUTCOMES.109.930685

Cheng, S.H. and Kao, C.H. (1983). Localized effect of polyamines on chlorophyll loss. *Plant and Cell Physiology, 24*(8), 1463.

Cohen, A.S., Popovic, R.B., and Zalik, S. (1979). Effects of polyamines on chlorophyll and protein content, photochemical activity, and chloroplast ultrastructure of barley leaf discs during senescence. *Plant Physiology, 64*(5), 717.

Cohen, S. S. (1978). What do the polyamines do? *Nature, 274*, 209-210.

Cook, R. L. (2011). Fundamental forces affecting US fresh produce growers and marketers. *Choices, 26*(4)

Cousins, H. H. (1910). *Annual report of the jamaican department of agriculture.* (No. 7).

Dandrifosse, G., Peulen, O., Khefif, N.E., Deloyer, P., Dandrifosse, A.C., and Grandfils, C. (2000). Are milk polyamines preventive agents against food allergy? *Proceedings of the Nutrition Society, 59*(01), 81.

Dauchet, L., Amouyel, P., Hercberg, S., and Dallongeville, J. (2006). Fruit and vegetable consumption and risk of coronary heart disease: A meta-analysis of cohort studies. *The Journal of Nutrition, 136*(10), 2588.

Davis, D.R., Epp, M.D., and Riordan, H.D. (2004). Changes in USDA food composition data for 43 garden crops, 1950 to 1999. *Journal of the American College of Nutrition, 23*(6), 669.

Deikman, J. (1997). Molecular mechanisms of ethylene regulation of gene transcription. *Physiologia Plantarum, 100*(3), 561. doi: 10.1111/j.1399-3054.1997.tb03061.x

Dettmann, R. L. (2008). Organic produce: Who's eating it? A demographic profile of organic produce consumers. Paper presented at the *Annual Meeting of the American Agricultural Economics Association,*

Dietary Guidelines Advisory Committee. (2010a). Report of the dietary guidelines advisory committee on the dietary guidelines for americans. *United States Department of Agriculture, Ed.Washington, DC: US Government Printing Office,*

Dietary Guidelines Advisory Committee. (2010b). Report of the dietary guidelines advisory committee on the dietary guidelines for americans. *United States Department of Agriculture, Ed.Washington, DC: US Government Printing Office,*

Dimitri, C. and Oberholtzer, L. (2009). *The US organic handling sector in 2004: Baseline findings of the nationwide survey of organic manufacturers, processors, and distributors* (36th ed.) U.S. Dept. of Agriculture, Economic Research Service.

Dixon, G. R. (2007). *Vegetable brassicas and related crucifers.* Cambridge, Mass.: CABI.

Dufour, C., Dandrifosse, G., Forget, P., Vermesse, F., Romain, N., and Lepoint, P. (1988). Spermine and spermidine induce intestinal maturation in the rat. *Gastroenterology, 95*(1), 112.

Encyclopedia Britannica. (2012). Acephala. Retrieved 11/29, 2012,

Fageria, N.K. and Moreira, A. (2011). The role of mineral nutrition on root growth of crop plants. *Advances in Agronomy, 110*, 251.

Fahey, J.W., Zhang, Y., and Talalay, P. (1997). Broccoli sprouts: An exceptionally rich source of inducers of enzymes that protect against chemical carcinogens. *Proceedings of the National Academy of Sciences, 94*(19), 10367.

Fausto, N. (1972). RNA metabolism in isolated perfused normal and regenerating livers: Polyamine effects. *Biochimica Et Biophysica Acta (BBA)-Nucleic Acids and Protein Synthesis, 281*(4), 543-553.

Fillingame, R.H., Jorstad, C.M., and Morris, D.R. (1975). Increased cellular levels of spermidine or spermine are required for optimal DNA synthesis in lymphocytes activated by concanavalin A. *Proceedings of the National Academy of Sciences, 72*(10), 4042.

Finkelstein, E.A., Brown, D.S., Wrage, L.A., Allaire, B.T., and Hoerger, T.J. (2012). Individual and aggregate years-of-life-lost associated with overweight and obesity. *Obesity, 18*(2), 333.

Flores, H. E. (1991). Changes in polyamine metabolism in response to abiotic stress. *Biochemistry and Physiology of Polyamines in Plants,* , 213-228.

Food Agricultual Organization. (2008). Good agricultural practices. Retrieved October/29, 2012, from http://www.fao.org/prods/GAP/

Galt, R. E. (2011). Counting and mapping community supported agriculture (CSA) in the united states and california: Contributions from critical cartography/GIS. *ACME: Int E-J Crit Geogr., 10*, 131-162.

Gane, R. (1934). Production of ethylene by some ripening fruits. *Nature, 134*(3400), 1008.

Gaskell, M. and Smith, R. (2007). Nitrogen sources for organic vegetable crops. *HortTechnology, 17*(4), 431.

Gerner, E.W. and Meyskens, F.L. (2004). Polyamines and cancer: Old molecules, new understanding. *Nature Reviews Cancer, 4*(10), 781.

Goodman, J. (2008). Grocery shopping: Who, where and when.

Greene, C. (2012). Organic agriculture: Organic market overview. Retrieved 08/29, 2012, from http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-market-overview.aspx

Griep, L.M.O., Geleijnse, J.M., Kromhout, D., Ocké, M.C., and Verschuren, W.M.M. (2010). Raw and processed fruit and vegetable consumption and 10-year coronary heart disease incidence in a population-based cohort study in the netherlands. *PLoS One, 5*(10), e13609.

Gugliucci, A. and Menini, T. (2003). The polyamines spermine and spermidine protect proteins from structural and functional damage by AGE precursors: A new role for old molecules? *Life Sciences, 72*(23), 2603.

Guo, H. and Ecker, J.R. (2004). The ethylene signaling pathway: New insights. *Current Opinion in Plant Biology, 7*(1), 40.

Gupta, S. and Gupta, N.K. (2011). Field efficacy of exogenously applied putrescine in wheat (triticum aestivum) under water-stress conditions. *Indian J. of Agric. Sci., 81*(6), 516.

Halász, A., Baráth, Á., Simon-Sarkadi, L., and Holzapfel, W. (1994). Biogenic amines and their production by microorganisms in food. *Trends in Food Science & Technology, 5*(2), 42.

Hammitt, J. K. (1990). Risk perceptions and food choice: An exploratory analysis of Organic-Versus Conventional-Produce buyers. *Risk Analysis, 10*(3), 367-374.

Harper, G.C. and Makatouni, A. (2002). Consumer perception of organic food production and farm animal welfare. *British Food Journal, 104*(3/4/5), 287.

Harris, B., Burress, D.A., Mercer, S.O., Oslund, P., and Rose, C.C. (2000). *Kaw valley focus groups on local and organic produce* University of Kansas, Institute for Public Policy and Business Research.

Hartman Group. (2008). *Consumer understanding of buying local.* ().

Hill, H. and Lynchehaun, F. (2002). Organic milk: Attitudes and consumption patterns. *British Food Journal, 104*(7), 526.

Hoet, P.H.M. and Nemery, B. (2000). Polyamines in the lung: Polyamine uptake and polyamine-linked pathological or toxicological conditions. *American Journal of Physiology-Lung Cellular and Molecular Physiology, 278*(3), L417.

Jacobs, S. (2010). Brown marmorated stink bug fact sheet. *Pennsylvania State University, College of Agricultural Sciences, Department of Entomology< Http://Ento.Psu.Edu/Extension/Factsheets/Brown-Marmorated-Stink-Bug,*

John, P. (1997). Ethylene biosynthesis: The role of 1-aminocyclopropane-1-carboxylate (ACC) oxidase, and its possible evolutionary origin. *Physiologia Plantarum, 100*(3), 583. doi: 10.1111/j.1399-3054.1997.tb03064.x

Johnson, R., Aussenberg, R.A., and Cowen, T. (2012). *The role of local food systems in U.S. farm policy.* (No. 42155).

Jolly, D. A. (1990). Determinants of organic horticultural products consumption based on a sample of california consumers. *Horticultural Economics and Marketing, XXIII IHC 295*, , 141-148.

Jolly, D.A., Schutz, H.G., Diaz-Knauf, K.V., and Johal, J. (1989). Organic foods: Consumer attitudes and use. *Food Technology, 43*(11), 60.

Kaouass, M., Audette, M., Ramotar, D., Verma, S., De Montigny, D., Gamache, I., Torossian, K., and Poulin, R. (1997). The STK2 gene, which encodes a putative ser/thr protein kinase, is required for high-affinity spermidine transport in saccharomyces cerevisiae. *Molecular and Cellular Biology, 17*(6), 2994.

Kende, H. (1993). Ethylene biosynthesis. *Annual Review of Plant Physiology and Plant Molecular Biology, 44*(1), 283-307. doi: 10.1146/annurev.pp.44.060193.001435

Kidd, F. and West, C. (1927). A relation between the concentration of oxygen and carbon dioxide in the atmosphere, rate of respiration, and length of storage life in apples. *Dept.Sci.& Indus.Res., Rept.Food Invest.Board for the Years 1925, 1926.*, , 41.

Kieber, J. J. (1997). The ethylene response pathway in arabidopsis. *Annual Review of Plant Biology, 48*(1), 277-296.

Kimmons, J., Gillespie, C., Seymour, J., Serdula, M., and Blanck, H.M. (2009). Fruit and vegetable intake among adolescents and adults in the united states: Percentage meeting individualized recommendations. *The Medscape Journal of Medicine, 11*(1), 26.

Konecki, D., Kramer, G., Pinphanichakarn, P., and Hardesty, B. (1975). Polyamines are necessary for maximum in vitro synthesis of globin peptides and play a role in chain initiation. *Archives of Biochemistry and Biophysics, 169*(1), 192.

Kramer, G.F., Wang, C.Y., and Conway, W.S. (1991). Inhibition of softening by polyamine application in golden delicious' and macIntosh apples. *Journal of the American Society for Horticultural Science, 116*(5), 813.

Kushi, L.H., Byers, T., Doyle, C., Bandera, E.V., McCullough, M., Gansler, T., Andrews, K.S., and Thun, M.J. (2006). American cancer society guidelines on nutrition and physical activity for cancer prevention: Reducing the risk of cancer with healthy food choices and physical activity. *CA: A Cancer Journal for Clinicians, 56*(5), 254.

Kuznetsov, V.V. and Shevyakova, N.I. (2007). Polyamines and stress tolerance of plants. *Plant Stress, 1*(1), 50.

Kyner, D., Zabos, P., and Levin, D.H. (1973). Inhibition of protein chain initiation in eukaryotes by deacylated transfer RNA and its reversibility by spermine. *Biochimica Et Biophysica Acta (BBA)-Nucleic Acids and Protein Synthesis, 324*(3), 386.

Law, D.M., Davies, P.J., and Mutschler, M.A. (1991). Polyamine-induced prolongation of storage in tomato fruits. *Plant Growth Regulation, 10*(4), 283.

Lima, G.P.P. and Vianello, F. (2011). Review on the main differences between organic and conventional plant-based foods. *International Journal of Food Science & Technology*, *46*(1), 1.

Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O. (2008). Comparison of polyamine, phenol and flavonoid contents in plants grown under conventional and organic methods. *International Journal of Food Science & Technology, 43*(10), 1838.

Löser, C. (2000). Polyamines in human and animal milk. *Brit.J.Nutr, 84*, 55-58.

Löser, C. and Fölsch, U.R. (1993). Importance of various intracellular regulatory mechanisms of polyamine metabolism in camostate-induced pancreatic growth in rats. *Digestion*, *54*(4), 213.

Loureiro, M.L., McCluskey, J.J., and Mittelhammer, R.C. (2001). Assessing consumer preferences for organic, eco-labeled, and regular apples. *Journal of Agricultural and Resource Economics, 26*(2), 404.

Low, S.A. and Vogel, S. (2011). *Direct and intermediated marketing of local foods in the united states.* (No. 128).United States Department of Agriculture, Economic Research Service.

Lu, C., Barr, D.B., Pearson, M.A., Walker, L.A., and Bravo, R. (2008). The attribution of urban and suburban children's exposure to synthetic pyrethroid insecticides: A longitudinal assessment. *Journal of Exposure Science and Environmental Epidemiology, 19*(1), 69.

Luk, G. D. (1992). Polyamines in normal and adaptive gastrointestinal growth. In Dowling R.H., Fölsch U.R., and Löser C. (Ed.), *Polyamines in the gastrointestinal tract.* (pp. 205). Dordrecht: Kluwer Academic Publishers.

Magnusson, M.K., Arvola, A., Hursti, U.K.K., Åberg, L., and Sjödén, P.O. (2003). Choice of organic foods is related to perceived consequences for human health and to environmentally friendly behaviour. *Appetite, 40*(2), 109.

Maijala, R.L., Eerola, S.H., Aho, M.A., and Hirn, J.A. (1993). The effect of GDL-induced pH decrease on the formation of biogenic amines in meat. *Journal of Food Protection*, *56*(2), 125.

Martínez-Romero, D., Serrano, M., Carbonell, A., Burgos, L., Riquelme, F., and Valero, D. (2002). Effects of postharvest putrescine treatment on extending shelf life and reducing mechanical damage in apricot. *Journal of Food Science, 67*(5), 1706.

Martínez-Romero, D., Valero, D., Serrano, M., Martínez-Sánchez, F., and Riquelme, F. (1999). Effects of post-harvest putrescine and calcium treatments on reducing mechanical damage and polyamines and abscisic acid levels during lemon storage. *Journal of the Science of Food and Agriculture, 79*(12), 1589.

Martínez-Romero, D., Guillén, F., Valverde, J.M., Bailén, G., Zapata, P., Serrano, M., Castillo, S., and Valero, D. (2007). Influence of carvacrol on survival of botrytis cinerea inoculated in table grapes. *International Journal of Food Microbiology, 115*(2), 144.

Martinez-Romero, D., Serrano, M., Carbonell, A., Castillo, S., Riquelme, F., and Valero, D. (2004). Mechanical damage during fruit post-harvest handling: Technical and physiological implications. In Dris, R. and Jain, S. M. (Ed.), *Production practices and quality assessment of food crops* (pp. 233). Netherlands: Springer.

McFadden, S. (2012,). Unraveling the CSA number conundrum.

Miller, S.A., Rowe, R.C., and Riedel, R.M. (1986). *Fusarium and verticillium wilts of tomato, potato, pepper, and eggplant.* (No. HYG-3122-96).Extention Factsheet. Hyg-3122-96. The Ohio State University. Columbus. p.

Mintel Oxygen Reports. (2010). *Are americans willing to pay more green to get more green?* ().

Moinard, C., Cynober, L., and de Bandt, J.P. (2005). Polyamines: Metabolism and implications in human diseases. *Clinical Nutrition, 24*(2), 184.

Motyl, T., Płoszaj, T., Wojtasik, A., Kukulska, W., and Podgurniak, M. (1995). Polyamines in cow's and sow's milk. *Comparative Biochemistry and Physiology Part B: Biochemistry and Molecular Biology, 111*(3), 427.

Mukherjee, A., Speh, D., and Diez-Gonzalez, F. (2007). Association of farm management practices with risk of escherichia coli contamination in pre-harvest produce grown in minnesota and wisconsin. *International Journal of Food Microbiology, 120*(3), 296. doi: 10.1016/j.ijfoodmicro.2007.09.007

Mukherjee, A., Speh, D., Dyck, E., and 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&# 174;, 67*(5), 894.

National Agricultural Statistics Service (NASS), USDA. (2010). *2008 organic production survey*. ().

Organic Trade Association. (2010). 2010 organic industry survey. *Reported by Meat Trade News Daily.“USA–Organic Farm Sales Gaining Market Share.” Accessed August, 5*, 2010.

Organic Trade Association. (2012). *OTA's 2012 organic industry survey*. Boulder, Co.: Nutrition business journal.

Ott, S. L. (1990). Supermarket shoppers' pesticide concerns and willingness to purchase certified pesticide residue-free fresh produce. *Agribusiness, 6*(6), 593-602.

Paksasorn ,A., Hayasaka,T., Matsui,H., Ohara,H., and Hirata,N. (1995). Relationship of polyamine content to acc content and ethylene evolution in japanese apricot fruit. *Journal of the Japanese Society for Horticultural Science, 63*(4), 761.

Pandey, S., Ranade, S.A., Nagar, P.K., and Kumar, N. (2000). Role of polyamines and ethylene as modulators of plant senescence. *Journal of Biosciences, 25*(3), 291.

Pattison, D.J., Harrison, R.A., and Symmons, D.P.M. (2004). The role of diet in susceptibility to rheumatoid arthritis: A systematic review. *The Journal of Rheumatology, 31*(7), 1310.

Pegg, A.E. and McCann, P.P. (1982). Polyamine metabolism and function. *American Journal of Physiology-Cell Physiology, 243*(5), C212.

Perez, A., Plattner, K., and Baldwin, K. (2011). Fruit and tree nuts outlook. *USDA. ERS., FTS-348*

Ponappa, T., Scheerens, J.C., and Miller, A.R. (1993). Vacuum infiltration of polyamines increases firmness of strawberry slices under various storage conditions. *Journal of Food Science, 58*(2), 361.

Prakash, S. and Hinata, K. (1980). Taxonomy, cytogenetics and origin of crop brassicas, a review. *Opera Botanica,* (55) Prakash, S., Wu, X.M., and Bhat, S.R. (2011). History, evolution, and domestication of brassica crops. In J. Janick (Ed.), *Plant breeding reviews* (pp. 19). Hoboken, N.J.: John Wiley & Sons, Inc.

Robinson-O'Brien, R., Larson, N., Neumark-Sztainer, D., Hannan, P., and Story, M. (2009). Characteristics and dietary patterns of adolescents who value eating locally grown, organic, nongenetically engineered, and nonprocessed food. *Journal of Nutrition Education and Behavior, 41*(1), 11.

Romain, N., Dandrifosse, G., Jeusette, F., and Forget, P. (1992). Polyamine concentration in rat milk and food, human milk, and infant formulas. *Pediatric Research, 32*(1), 58.

Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P. (2009). Antioxidant substances and pesticide in parts of beet organic and conventional manure. *African Journal of Plant Science, 3*(11), 245.

Santos, M. H. (1996). Biogenic amines: Their importance in foods. *International Journal of Food Microbiology, 29*(2), 213.

Sauer, J. D. (1993). *Historical geography of crop plants: A select roster* (1st ed.). Boca Raton, F.L.: CRC Press.

Savica, V., Bellinghieri, G., and Kopple, J.D. (2010). The effect of nutrition on blood pressure. *Annual Review of Nutrition, 30,* 365-401.

SC department of agriculture. (2012). South carolina department of agriculture. Retrieved October/29, 2012, from http://agriculture.sc.gov/fruitsandvegetables

Schulz, E. (1919). Cruciferae-brassica. In A. Engler (Ed.), *Das pflanzenreich* (pp. 137)

Schulz, O. E. (1936). Cruciferae. In K. P. A. Engler (Ed.), *Die natürlichen pflanzenfamilien* (2nd ed., pp. 227). Wilhelm Engelmann: Leipzig.

Scotts company. (2009). Miracle-gro® potting mix 0.21-0.07-0.14 with micromax® [Abstract].

Scotts company. (2010, Miracle-gro® organic choice® potting mix, 0.10-0.05-0.05.

Seiler, N. (1990). Polyamine metabolism. *Digestion, 46*(2), 319-330.

Serrano, M., Martinez-Romero, D., Guillen, F., and Valero, D. (2003). Effects of exogenous putrescine on improving shelf life of four plum cultivars. *Postharvest Biology and Technology, 30*(3), 259.

Shalaby, A. R. (1996). Significance of biogenic amines to food safety and human health. *Food Research International, 29*(7), 675-690.

Sisler, E. C. a. S.,M. (1997). Inhibitors of ethylene responses in plants at the receptor level: Recent developments. *Physiologia Plantarum, 100*(3), 577. doi: 10.1111/j.1399-3054.1997.tb03063.x

Smith, T.K., Mogridge, J.A.L., and Sousadias, M.G. (1996). Growth-promoting potential and toxicity of spermidine, a polyamine and biogenic amine found in foods and feedstuffs. *Journal of Agricultural and Food Chemistry, 44*(2), 518.

Smith, T. (1981). Amines in food. *Food Chemistry, 6*(3), 169-200.

Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., and Stave, C.,. (2012). Are organic foods safer or healthier than conventional alternatives? *Ann Intern Med, 157,* 348.

Snogerup, S.,Tsunoda, S., Hinata, K., and Gomez-Campo, C. (1980). The wild forms of the brassica oleracea group (2n= 18) and their possible relations to the cultivated ones. *Brassica Crops and Wild Allies.Biology and Breeding., ,* 121.

Stearns, J. C. a. G., B.R. (2003). Transgenic plants with altered ethylene biosynthesis or perception. *Biotechnology Advances, 21*(3), 193. doi: 10.1016/S0734-9750(03)00024-7

Steinberg, E.L., Martinez-Dawson, R., and Northcutt, J.K. (2013). *SC consumer survey.* Unpublished manuscript.

Stewart, H. (2011). *How much do fruits and vegetables cost?* DIANE Publishing.

Tabor, C.W. and Tabor, H. (1984). Polyamines. *Annual Review of Biochemistry, 53*(1), 749.

Ten Brink, B., Damink, C., and Joosten, H. (1990). Occurrence and formation of biologically active amines in foods. *International Journal of Food Microbiology, 11*(1), 73.

Torrigiani, P., Bregoli, A.M., Ziosi,V., Scaramagli,S., Ciriaci,T., Rasori, A., Biondi, S., and Costa, G. (2004). Pre-harvest polyamine and aminoethoxyvinylglycine (AVG) applications modulate fruit ripening in stark red gold nectarines (prunus persica L. batsch). *Postharvest Biology and Technology*, *33*(3), 293. doi: 10.1016/j.postharvbio.2004.03.008

U.S. Bureau of Labor Statistics. (2011). Consumer expenditure survey. *U.S. BLS,*

U.S. department of health and human services. (2008). *Physical activity guidelines advisory committee report, 2008.* ().

US Census Bureau. (2009). *2007 census of agriculture.* ().US.

USDA. (2012). Know your farmer know your food: Our mission. Retrieved 8/30, 2012, from http://www.usda.gov/wps/portal/usda/usdahome?navid=KYF_MISSION

USDA Agricultural Marketing Service. (2012). *Farmers market services.* (). doi: http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5080175&acct=frmrdirmkt

USDA Agricultural Marketing Service. (2012). National organic program. Retrieved November/4, 2012, from http://www.ams.usda.gov/AMSv1.0/nop

USDA. AMS. (2012). Farmers markets and local food marketing. Retrieved 08/29, 2012, from http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&ved=0CCMQFjAA&url=http%3A%2F%2Fwww.ams.usda.gov%2FAMSv1.0%2Fams.fetchTemplateData.do%3Ftemplate%3DTemplateS%26leftNav%3DWholesaleandFarmersMarkets%26page%3DWFMFarmersMarketGrowth%26description%3DFarmers%2520Market%2520Growth%26acct%3Dfrmrdirmkt&ei=knc-UImMCpPa9AT2jIHIAQ&usg=AFQjCNEgUJZGPETlhKzLiLpXGLOvsD1o3g

USDA/NASS. (2001). *Quick stats.* ().

Valero, D., Martínez-Romero, D., Serrano, M., and Riquelme, F. (1999). Polyamine roles on the post-harvest of fruits: A review. In S. G. Pandalai (Ed.), *Recent research development in agricultural and food chemistry* (pp. 39). Trivandrum, India: Research signpost.

Valero, D., Martínez-Romero, D., and Serrano, M. (2002). The role of polyamines in the improvement of the shelf life of fruit. *Trends in Food Science & Technology, 13*(6), 228.

Valero, D., Pérez-Vicente, A., Martínez-Romero, D., Castillo, S., Guillen, F., and Serrano, M. (2002). Plum storability improved after calcium and heat postharvest treatments: Role of polyamines. *Journal of Food Science, 67*(7), 2571.

Veldstra, M.D., Alexander, C.E., and Marshall, M.I. (2012). To certify or not to certify? decomposing the organic production and certification decisions. Paper presented at the *Economic and Non-Economic Concerns with Regards to Farmers' Adoption Of
organic Farming,*

Walmart. (2008). Locally grown at walmart. Retrieved 09/1, 2012, from http://az204679.vo.msecnd.net/media/documents/r_2999.pdf

Wandel, M. and Bugge, A. (1997). Environmental concern in consumer evaluation of food quality. *Food Quality and Preference, 8*(1), 19.

Wang, C.Y., Conway, W.S., Abbott, J.A., Kramer, G.F., and Sams, C.E. (1993). Postharvest infiltration of polyamines and calcium influences ethylene production and texture changes in golden delicious apples. *Journal of the American Society for Horticultural Science, 118*(6), 801.

Wells, H.F. and Buzby, J.C. (2008). *Dietary assessment of major trends in US food consumption, 1970-2005.* (No. 33).US Department of Agriculture, Economic Research Service.

Wery, I., Kaouass, M., Deloyer, P., Buts, J., Barbason, H., and Dandrifosse, G. (1996). Exogenous spermine induces maturation of the liver in suckling rats. *Hepatology, 24*(5), 1206.

Wild, G.E., Daly, A.S., Sauriol, N., and Bennett, G. (1993). Effect of exogenously administered polyamine on the structural maturation and enzyme ontogeny of the postnatal rat intestine. *Neonatology, 63*(4), 246.

Wilkins, J.L. and Hillers, V.N. (1994). Influences of pesticide residue and environmental concerns on organic food preference among food cooperative members and non-members in washington state. *Journal of Nutrition Education, 26*(1), 26.

Williams, P.R.D. and Hammitt, J.K. (2000). A comparison of organic and conventional fresh produce buyers in the boston area. *Risk Analysis, 20*(5), 735.

Williams-Ashman H.G. and Canellakis Z.N. (1979). Polyamines in mammalian biology and medicine. *Perspect. Biol. Med., 22*, 421.

Wills, R. (1996). Enhancement of senescence in non-climacteric fruit and vegetables by low ethylene levels. Paper presented at the *International Postharvest Science Conference Postharvest 96 464*, 159-164.

Winter, C.K. and Davis, S.F. (2006). Organic foods. *Journal of Food Science, 71*(9), R117.

Woese, K., Lange, D., Boess, C., and Bögl, K.W. (1997). A comparison of organically and conventionally grown foods—results of a review of the relevant literature. *Journal of the Science of Food and Agriculture, 74*(3), 281.

Worthington, V. (2001). Nutritional quality of organic versus conventional fruits, vegetables, and grains. *The Journal of Alternative & Complementary Medicine, 7*(2), 161-173.

Yang, S.F. and Hoffman, N.E. (1984). Ethylene biosynthesis and its regulation in higher plants. *Annual Review of Plant Physiology, 35*(1), 155.

Young, N.D. and Galston, A.W. (1983). Putrescine and acid stress induction of arginine decarboxylase activity and putrescine accumulation by low pH. *Plant Physiology, 71*(4), 767.

Zepeda, L. and Leviten-Reid, C. (2004). Consumers' views on local food. *Journal of Food Distribution Research, 35*(3), 1.

CHAPTER THREE

SC CONSUMER PURCHASING DECISIONS AND PRECEPTIONS OF ORGANIC AND CONVENTIONALLY GROWN FRESH PRODUCE

3.1 ABSTRACT

There has been a steady rise organic sales especially fruits and vegetables. However, execution of the USDA organic standards has led to more support for locally-grown food as distinct and separate from organic food. The current study was conducted to examine fresh produce perceptions and purchasing decisions, as well as to determine the demographics of S.C. consumers who buy locally grown or organic produce. Four-hundred and eight S.C. consumers were surveyed at four different S.C. grocery stores on 16 different days from December 2011 until April 2012. Since more than one-third of the S.C. consumers who were surveyed did not know about the “certified S.C. grown” program, this suggests that the S.C. Department of Agriculture (SCDA) may want to consider improving the promotion of their program. This becomes especially important since 85% of the organic consumers who were surveyed indicated that, if given the choice, between organic and local, they would choose local. This information would be useful to local S.C. produce farmers who are contemplating whether or not to complete the USDA organic certification process.

3.2 INTRODUCTION

Over the past 25 years, U.S. consumption of fresh fruits and vegetables has increased by 27% to 313 pounds per capita. This expansion may be credited to increased consumer attentiveness to health benefits associated with the consumption of fresh produce (Cook, 2011). There has also been a rise in organic food consumption. Organic retail sales have risen from $3.6 billion in 1997 to $21.1 billion, in 2008, (Dimitri, C. and Oberholtzer, L., 2009) . Organic farming has been one of the fastest growing segments of U.S. agriculture for the past ten years (USDA, 2012). Historically, fresh produce has been the most popular organic category and it continues to be, with a steady growth of 15% between 1997 and 2007 (Dimitri, C. and Oberholtzer, L., 2009) . In 2009, the $9.5 billion organic fruit and vegetable category, making up 38% of the total organic food market, continued to dominate the organic industry (Organic Trade Association, 2010).

The USDA-Agricultural Marketing Service has authority over the National Organic Program and monitors organic products using the National Organic Standards (USDA, 2012). These standards were introduced on October 21, 2002, approximately 12 years after they were mandated by the Organic Food Production Act of 1990. The National Organic Standards were developed to inform consumers and prevent misrepresentation of organic products by providing standards to continue to advance the development of the industry. Additionally, the industry anticipates that these standards will provide opportunities for U.S. exports of organic products by means of regulatory equivalency (USDA Agricultural Marketing Service., 2012). Even though it is too early to determine the effects of the National Organic Standards, organic sales within the U.S. have grown steadily at approximately 20 % annually (Organic Trade Association, 2012).

Despite the steady increase of organic sales, some consumers’ support for organic food declined after the implementation of the National Organic Standards. Adams and

Salois (2010) published a comprehensive review of literature on organic and local food and discovered that the implementation of the federal organic standards seems to coincide with more support for locally-grown food as distinct and separate from organic food (Adams and Salois 2010). Prior to the development of the federal organic standards, organic food was linked to small farms, improved animal welfare, sustainability, and community support. However, authors of this review found a sharp turn in the demand for locally grown food in response to the "corporate co-optation of the organic food market and the arrival of 'organic-lite'" (Adams, D.C. and Salois, M.J., 2010) .

As of 2012, there was no formal USDA definition of "local" relative to produce; however, some consumers classified "locally-grown" to be food grown within a certain geographical distance (i.e. 100 miles), while others describe "locally-grown" as some political boundary, such as a state border (Zepeda, L. and Leviten-Reid, C., 2004) . Others feel that "locally-grown" is rooted in ethics, community, and other factors not related to food miles. There have been several surveys aimed at identifying consumer understanding of "local" for food production. The Hartman Group (2008) conducted a survey of 796 U.S. consumers in December 2007. They found that 37% of these respondents' defined local as "made or produced in my state," while 50%, of these respondents defined it as "made or produced within 100 miles." The remaining 8% of the respondents were split evenly in their definition of "local" as "within my region (e.g. New England)" or "in the U.S.A." (Hartman Group, 2008). Brown (2003) conducted a survey of household food buyers in Missouri to determine their definitions of "locally grown" and found that 37% of respondents defined locally grown as within the southeastern Missouri region while 23% expanded the definition of "locally grown" to include nearby southern Illinois. Another 14% of the respondents restricted the definition to within their county, and 14% expanded it to include an adjacent county, as well as their own county. Only 12% of respondents considered products from the entire state of Missouri as "locally grown" (Brown, 2003). Disturbingly, Missouri's statewide program to promote local products has been implemented for 15 years, and yet 64% of the respondents had not heard of, or seen, the locally grown marketing *AgriMissouri* label (Brown, 2003). Harris et al. (2000) conducted focus groups in Kansas to identify, among other things, consumers' concepts of locally-grown produce. Consumers' concept of locally-grown produce was not as clear as their knowledge of organic produce. Some consumers thought locally-grown meant that the produce was grown within a 100 to 200 mile radius, while others thought produce grown in surrounding states would be locally-grown. However, others said only produce grown within or near their particular city limits or county (within a 30 mile radius) should be considered locally grown (Harris, B., Burress, D.A., Mercer, S.O., Oslund, P., and Rose, C.C., 2000) .

Adams and Adams (2011) conducted 97 surveys within two Florida farmer's markets to identify the driving force behind consumer purchase decisions. These authors claimed that their study highlights the complexity of consumers' conceptualizations of "local" as it related to commodities. In their findings, consumers reported that "local" may not be defined by mileage and instead, it was a value-based descriptor. Based on this research, Adams and Adams (2011) found that "local" encompasses ethical, sustainable, and community factors that may vary among consumer groups or even individuals. Using cluster analysis, these researchers were able to approximate who was buying local commodities and why. They found that consumers who perceived local as least costly and easiest to access were the most frequent purchasers of locally grown food. However, the consumer who viewed local as more costly and more difficult to access also reported very frequent purchases of local food since they were younger and more likely to go to purchase from alternative food stores. The study by Adams and Adams (2011) reflected the dichotomy of local food consumers- local food consumers who buy local because they see it as a cheap alternative and consumers who see this product as more expensive but buy it to support the community (Adams, D.C. and Adams, A.E., 2011) .

Another factor that has affected the image of the local food “drive” is the additional emphasis on the movement from President Obama, who stated that “Local food systems work for America: when we create opportunities for farmers and ranchers, our entire nation reaps the benefit.” The 2008 Farm Bill launched the “Know Your Food Know Your Farmer” program that focused on connecting consumers to farmers. Prior to this program, local and regional food systems and direct-marketing sales increased from $551 million in 1997 to $1.2 billion in 2007 (USDA Agricultural Marketing Service, 2012). In 2008, marketing of local foods from direct-to-consumer and intermediated channels grossed $4.8 billion (Low, S.A. and Vogel, S., 2011) . Low and Vogel (2011) also found that local farms, marketing solely through intermediated channels, reported in 2008 $2.7 billion, in sales, which is over 3 times higher than the value of local sales marketed exclusively through direct-to-consumer channels. This reflects the fact that there is more opportunity for the local food market than previously thought. Small farms, grossing less than $50,000, accounted for 81% of local food sales in the U.S. and were more likely to exclusively utilize direct-to-market channels such as farmers' markets and roadside stands. On the other hand, large farms accounted for only 5% of all local food sales farms. Most of the local food sales conducted by large farms were from intermediated channels (i.e., farmers' sales to local retail, restaurant, and regional distribution outlets). According to the 2008 ARMS, vegetable, fruit, and nut farms made up only 6% of the 2.1 million farms and yet accounted for 43% of all U.S. local food farms. In other words, vegetable/fruit/nut farms were 8 times more likely to sell their products through local channels than other farms.

All 50 states in the U.S. have state-sponsored agricultural marketing programs to promote the "buy local" movement. South Carolina (S.C.) started their state sponsored agricultural program, "Certified S.C. Grown" in 2007. This program is a cooperative effort among producers, processors, wholesalers, retailers, and the South Carolina Department of Agriculture (SCDA) to brand and promote products grown in S.C. The aim of this movement is to facilitate the identification and purchase of S.C. products by consumers. The present study was conducted as a means to meet consumer needs and ultimately help S.C. produce farmers. Consumer surveys were distributed at S.C. grocery stores to examine fresh produce perceptions and purchasing decisions, as well as to determine the demographics of S.C. consumers who buy locally grown or organic produce.

3.3 MATERIALS AND METHODS

3.3.1 Materials

The survey program Snap Surveys (Portsmouth, NH) was used to collect the data for this project.

3.3.2 Methods

Data were collected from consumers shopping in three S.C. grocery stores (BiLo, Food Lion, and Kathey's Produce) from December 2011 until April 2012 by distributing surveys to adults at least 18 years of age from 8 am until 2 pm Wednesdays, Fridays, and Saturdays. The surveys were distributed by the same person throughout the entire study to ensure uniformity in instructions. Participation in this survey was voluntary and there were no incentives provided to take the survey. Approval for this study was granted by the Institutional Review Board at Clemson University (IRB2010-324). A total of 408 surveys were completed.

3.3.2.1 Development of the survey instrument

The survey was developed by working with a statistician to ensure that the questions could be analyzed. The survey was also distributed to several Clemson University undergraduate classes to receive comments about the survey considered to improve the survey before implementation. The students were asked to give comments about how to clarify questions and then comments were to improve the questions before the survey was used in grocery stores. The survey was distributed to other university students until students expressed no concerns in understanding the survey. The survey can be found in Appendix A.

The survey consisted of two sections: purchasing decisions and demographics. The purchasing decision section included questions regarding S.C. certified produce, certified organic produce, locally grown produce, and the participant's primary grocery store. The demographic section included questions regarding age, gender, race, permanent residence, number of members in their household, highest degree of education, major (if applicable), employment status, and approximate yearly gross income.

3.3.2.2 Selection of grocery stores

BiLo of Clemson, S.C., BiLo of Seneca S.C., and Food Lion of Anderson, S.C. were selected because they are major grocery stores in upstate S.C. Kathey's Produce (Clemson, S.C.) was selected because it is a local grocery store in upstate S.C. Other major grocery stores in S.C. such as Ingles and Whole Foods Market were not selected because store policy prohibited solicitation and surveys were considered a form of solicitation. Approval from the grocery stores was received by contacting the stores' managers and grocery store headquarters and providing them with a copy of the instrument.

3.3.2.3 Distribution of surveys

Surveys were distributed by the graduate student conducting the research. The grocery store shoppers were provided with a hard copy of the survey. Every time the graduate student approached a shopper she said “Hello, my name is __________ and I am a graduate student at Clemson University working on my research which consists of surveying S.C. consumers about fresh produce. Would you have about 5 minutes to sit down and take a survey?” If the respondent agreed to take the survey, the graduate student would first provide them with the IRB information letter before taking the survey.

3.3.3 Statistical Analysis

Descriptive statistics were calculated for all the variables using procedure means within Statistical Analysis System (SAS) version 8.02 (Cary, N.C.). Procedure frequency in SAS was used to examine the distribution of whether or not the consumers purchased organic produce with various demographic variables (age, residence, education). Additionally, a chi-squared test was conducted on those variables to determine whether or not there was sufficient evidence to conclude that there is a difference in the proportion of a certain demographic that would purchase organic produce. The null hypothesis specified that there are equal proportions of the total sample for each category.

Since it is impossible to get every adult consumer in S.C. to take this survey, the survey was distributed to a sample of this population. Time constraints also prevented the distribution of this survey of consumers outside of upstate S.C. These constraints have led to a non-random, observational survey.

3.4 RESULTS AND DISCUSSION

It is not surprising that there were nearly three times the number of females as compared to males that participated in the consumer survey (Table 1). According to a report by the Time Institute, women account for nearly two-thirds of all grocery shoppers (Goodman, 2008). This report also stated that the average age of the typical shopper was 47 years old. The average age of the shoppers in the current study was either 18 to 29 years of age (40.69%) or 60+ years old (30.88%). This difference in age of the respondents in the current study as compared to the study by Goodman (2008) may be attributed to the fact that this survey was conducted near an institution of higher education. Based on the 2010 U.S. census, the median age of the U.S. population was 37.3 years of age. However, in upstate S.C., where this survey was conducted, the average median age of the population was 39.28 years of age (males and females) and 40.57 years of age for females. Respondents participating in the survey consisted primarily of Caucasian (81%) and African American (10%) people. According to the 2010 U.S. Census, this is similar to the rest of upstate S.C. (Caucasian-74% and African American-20%) and the national average (Caucasian-74% and African American-12%). Regarding the level of education, the participants of this survey were mostly college educated (78%) with a smaller percent seeking a graduate education (20%). The U.S. Census (2011) indicated that only 18% of adults over the age of 18 attained a bachelor's degree and far fewer pursue a Master's or Doctoral degree (7% and 1%, respectively). The number of college educated participants in this study was impacted by the proximity to Clemson University.

The majority of S.C. participants (58%) that responded to the survey reported purchasing S.C. certified produce; however, 38% of S.C. participants were not sure if they purchased S.C. produce (Table 2). Even though the "Certified S.C. Grown" program was implemented nearly 6 years ago, 38% of upstate S.C. participants were still unsure if they were purchasing it. Although 38% seems high, surveys in other states have had similar results, such as Missouri, which had 62% of its consumers unaware of their state's produce program after 15 years of implementation (Brown, 2003). Therefore, although S.C. should consider improving the promotion of their program, when compared to these state programs, they seem to have superior marketing. To be eligible for the "Certified South Carolina" label, producers are required to complete a free application, listing their products. The S.C. Department of Agriculture claims that this partnership will enable S.C. consumers to easily identify, find, and buy S.C. products. However, this finding reflects that S.C. participants do not know about the S.C. certified program. Nearly all of the S.C. consumers, participating in this survey, reported that they purchase produce (Table 2). Furthermore, 38% of S.C. participants who were surveyed reported that they never purchase certified organic produce.

Consumers, who indicated that they never purchase organic produce, were asked the reasons why they did not purchase organic produce using a scale of 1 to 5 (1=extremely unimportant to 5 extremely important; Table 3). "Too expensive" was the most important reason that these consumers said that they never purchased organic produce (3.9 out of 5) and "lack of transportation" was the least important reason (1.4 out of 5). Of the 62% of consumers who said they purchased certified organic produce, 50%

of them said it was because of food safety concerns. Additionally, 75% of S.C. consumers of organic produce said that the most negative aspect of organic produce is that it is "too expensive." When asked which aspect of organic farming that the respondents considered to be most important, 53% of organic produce consumers said it was because conventional pesticides were not used on organic foods. Previous survey research has found that organic consumers view chemicals and pesticides used in conventional food products as being associated with harmful long-term health effects on health (Hammitt, 1990) and environmentally harmful, whereas organic foods are believed to be healthy (Magnusson, M.K., Arvola, A., Hursti, U.K.K., Åberg, L., and Sjödén, P.O., 2003; Wandel, M. and Bugge, A., 1997) , nutritious (Hill, H. and Lynchehaun, F., 2002; D. A. Jolly, 1990) , and environmentally friendly (D. A. Jolly, 1990; Ott, 1990; Wilkins, J.L. and Hillers, V.N., 1994) .

Table 4 shows the purchase decisions of S.C. organic produce consumers that responded to the survey. Nearly 69% of S.C. organic consumers who were surveyed believe that by buying organic produce they were supporting local farmers. These findings demonstrated that most S.C. organic consumers are misinformed about the definition of organic produce. Nearly three quarters of the respondents who purchase organic produce reported that they would still buy organically grown produce even if it was not locally grown. However, if they were given a choice between buying local conventionally-grown or non-local organically grown produce, a majority (85%) of the respondents indicated that they would choose local over organic.

During a typical shopping trip, 70% of the participants of this study who purchased organic produce, indicated that they did not spend more than $20 on organic produce. The 2010 Consumer Expenditure Survey (CES), conducted by the Bureau of Labor Statistics (BLS), found that U.S. consumers spend on average $6,129 per year on food and $679 per year on fruit/vegetables. Based on a household that that goes food shopping twice a week, U.S. consumers spend approximately $59 for food and $6.53 for fruits and vegetables, during a typical shopping trip. The participants in the CES indicated that they spent over three times this amount on organic fruits and vegetable (U.S. Bureau of Labor Statistics, 2011). However, according to Mintel's latest report on green living, after the recession in 2009, only 21% of organic food buyers have reduced or eliminated organic purchasing, while 20% have switched to less expensive organic options. More than 48% of the participants in this survey reported buying as much or more organic food as they purchased before the recession. Mintel suggested that this reflected the fact that organic food is a core life-style element and they will cut spending in other areas of their budget before cutting out organic food (Mintel Oxygen Reports, 2010). This may explain the higher spending for organic produce compared to produce that is not considered organic.

Beginning with age, the percentage of participants in the adult (18-39 years), middle-age (40-59 years) and senior (60+ years) categories were 40.7%, 28.4% and 30.9%, respectively (Table 5). There is insufficient evidence to conclude that there is an association in the proportion of different age groups (adults, middle age, senior citizen) who would purchase certified organic produce (data not shown; P-value=0.1358). This means that there is insufficient evidence from this study to conclude that there is significant association in the proportion of a certain age of S.C. consumers who will purchase organic produce. There was also not enough evidence to predict if S.C. consumers will purchase organic produce based on their permanent residence (P-value = 0.0949). There was a significant association in the income level of respondents who reported purchasing certified organic produce (P-value=0.0357). Of the S.C. respondents who have an annual income of over $75,000, 70% of them indicated that they purchase organic produce. Whereas, only 36% of the respondents who were "not sure" of their income level, indicated that they purchase organic produce. There was also a significant association in the proportion of respondents that purchase organic produce and level of education (P-value=0.0009). S.C. participants who claimed they purchased certified organic produce were mostly high school educated or had completed a graduate degree. When these data were analyzed by age group, adults (18-39 years) and senior (60-70+ years) were found to have a significant association in the proportion of level of education who will purchase organic produce (P-value = 0.0276 and 0.0455, respectively). Within the adult age group, the consumers with "some high school" or a "college diploma" or higher were more likely than other educational levels to purchase organic produce. Within the senior age group, the consumers with "some high school" or "graduate or professional degree" were more likely than other educational levels to purchase organic produce.

The present study demonstrated that upstate S.C. produce consumers surveyed prefered to purchase local products to support local farmers and if aware of these products, they would purchase them over organic produce. Furthermore, this information is invaluable to local S.C. produce farmers who are contemplating whether or not to complete the USDA organic certification process. On average, the organic farming certification process takes 3 years for a farm can become certified organic. Additionally, the cost of certification has been found to be a barrier, especially for producers operating small-sized farms (Veldstra, M.D., Alexander, C.E., and Marshall, M.I., 2012) . Thus S.C. produce farmers may meet consumer demand by advertising “certified S.C. grown,” a free certification without the additional expense of the organic certification process.

Table 3.1: Demographic comparison of the study sample.

Subject	**Number**	**Percent**
Number of respondents	408	
Gender		
Male	112	27.5
Female	294	72.1
None reported	2	0.49
Total[1]	408	
Current Age		
18-29	109	26.7
30-39	57	14.0
40-49	57	14.0
50-59	59	14.5
60-69	80	19.6
70+	46	11.3
Total[1]	408	
Race		
American Indian or Alaskan Native	5	1.23
Asian or Pacific Islander	12	2.95
Black	43	10.6
White (Causasian)	333	81.8
Other	14	3.44
Total[1]	407	
Permanent Residence		
Urban	56	13.8
Suburban	230	56.7
Rural	120	29.6
Households With Members by Age		
Under 10	69	
ten to fourteen	48	
fifteen to seventeen	38	

At least 18	397	
Education		
Some high school	11	2.75
High school diploma	76	19.0
Some college	129	32.3
College diploma	104	26.0
Graduate or professional degree	80	20.0
Total[1]	400	
College Major[2]		
Agriculture, Forestry, and Life Science	25	8.28
Architecture, Arts, and Humanity	33	10.9
Business and Behavioral Sciences	85	28.2
Engineering and Science	43	14.2
Health, Education, and Human Development	116	38.4
Total[1]	302	

[1]Number of people who responded to each question.

[2]Only answered by respondents who went to college or schools of higher education.

Table 3.2: SC consumer purchase decisions regarding fresh produce.

Question	Number of respondents indicating "NO"	Number of respondents indicating "YES"	Number of respondents indicating "NOT SURE"
Purchase certified SC produce	15	236	157
Purchase conventional produce	5	403	n/a[1]
Purchase certified organic produce	155	250	n/a[1]

[1]These questions did not have "not sure" as an option.

Table 3.3: Reasons surveyed consumers never purchased organic produce and subsequent mean rankings.

Question[1]	Mean (Median) Ranking (1 =extremely unimportant; 5 =extremely important)
Too Expensive	3.9 (4.0)
Not available where I shop	2.1 (2.0)
Not convinced of the benefits	2.9 (3.0)
Not always sure if it is labeled properly	2.9 (3.0)
Lack of transportation	1.4 (1.0)
Lack of information	2.3 (2.0)

[1]Why do you not purchase organically grown produce? For each of the following reasons, please select the level of importance on a scale of 1 to 5 (1=Extremely unimportant and 5=extremely important)

Table 3.4: S.C. organic consumer purchase decisions regarding organic produce[1].

Question	Number of respondents indicating "NO"	Number of respondents indicating "YES"	Number of respondents indicating "NOT SURE"
Organic = Local	39	173	39
Still buy organic if not local	24	186	41
Choose local	37	214	n/a

[1]N = 251 organic produce consumers

Table 3.5: Respondents organic produce purchases based on different categories.

Category	Category	No (%)	Yes (%)	P-value[1]
Income Level	Less than $25,000	31.6	68.4	0.0357
	$25,000-$50,000	41.7	58.3	
	$50,001-$75,000	39.2	60.8	
	More than $75,000	29.7	70.3	
	Prefer not to answer	46.7	53.3	
	Not sure	63.6	36.4	
Permanent Residence	Urban	33.9	66.1	0.0949
	Suburban	34.9	65.1	
	Rural	46.2	53.8	
Education	Some high school	27.3	72.7	0.0009
	High school diploma	59.5	40.5	
	Some college	35.7	64.3	
	College diploma	34.6	65.4	
	Graduate or professional degree	28.8	71.3	
Education controlling for age "Adult"	Some high school	20.0	80.0	0.0276
	High school diploma	56.5	43.5	
	Some college	37.1	62.9	
	College diploma	22.2	77.8	
	Graduate or professional degree	19.1	81.0	

Education controlling for age "Middle Age"	Some high school	33.3	66.7	0.3760
	High school diploma	58.3	41.7	
	Some college	31.3	68.8	
	College diploma	42.4	57.6	
	Graduate or professional degree	43.5	56.5	
Education controlling for age "Senior"	Some high school	33.3	66.7	0.0455
	High school diploma	63.0	37.0	
	Some college	37.0	63.0	
	College diploma	46.2	53.9	
	Graduate or professional degree	25.0	75.0	

[1]Chi-squared test statistical significance at 5% level of significance

3.5 References

Adams DC, Adams AE. 2011. De-placing local at the farmers' market: consumer conceptions of local foods. Journal of Rural Social Sciences 26(2):74-100.

Adams DC, Salois MJ. 2010. Local versus organic: A turn in consumer preferences and willingness-to-pay. Renewable Agriculture and Food Systems 25(04):331-4.

Brown C. 2003. Consumers' preferences for locally produced food: A study in southeast Missouri. Am.J.Alternative Agric. 18(4):213-24.

Cook RL. 2011. Fundamental forces affecting US fresh produce growers and marketers. Choices 26(4):

Dimitri C, Oberholtzer L. 2009. The US organic handling sector in 2004: baseline findings of the nationwide survey of organic manufacturers, processors, and distributors. Available at SSRN 1354172

Goodman J. 2008. Grocery shopping: who, where and when.

Hammitt JK. 1990. Risk Perceptions and Food Choice: An Exploratory Analysis of Organic-Versus Conventional-Produce Buyers. Risk Analysis 10(3):367-74.

Hartman Group. 2008. Consumer understanding of buying local. Pulse Report

Hill H, Lynchehaun F. 2002. Organic milk: attitudes and consumption patterns. Br.Food J. 104(7):526-42.

Jolly DA. 1990. Determinants of organic horticultural products consumption based on a sample of California consumers. Horticultural Economics and Marketing, XXIII IHC 295 141-8.

Low SA, Vogel S. 2011. Direct and intermediated marketing of local foods in the United States. Economic Research Report

Magnusson MK, Arvola A, Hursti UKK, Åberg L, Sjödén PO. 2003. Choice of organic foods is related to perceived consequences for human health and to environmentally friendly behaviour. Appetite 40(2):109-17.

Mintel Oxygen Reports. 2010. Are Americans willing to pay more green to get more green?

Organic Trade Association. 2010. 2010 Organic industry survey. Reported by Meat Trade News Daily.“USA–Organic farm sales gaining market share.” Accessed August 52010.

Organic Trade Association (OTA). 2012. OTA's 2012 organic industry survey.

Ott SL. 1990. Supermarket shoppers' pesticide concerns and willingness to purchase certified pesticide residue-free fresh produce. Agribusiness 6(6):593-602.

U.S. Bureau of Labor Statistics. 2011. Consumer expenditure survey. U.S. BLS

Know your farmer know your food: our mission [Internet]. : USDA; 2012 [Accessed 2012 8/30]. Available from: http://www.usda.gov/wps/portal/usda/usdahome?navid=KYF_MISSION

Veldstra MD, Alexander CE, Marshall MI. 2012. To certify or not to certify? Decomposing the organic production and certification decisions.

Wandel M, Bugge A. 1997. Environmental concern in consumer evaluation of food quality. Food quality and preference 8(1):19-26.

Zepeda L, Leviten-Reid C. 2004. Consumers' views on local food. Journal of Food Distribution Research 35(3):1-6.

CHAPTER FOUR

NEEDS ASSESSMENT OF S.C. PRODUCE FARMERS

4.1 ABSTRACT

Farmland occupies a little more than 25% of the available land within S.C., with crops making up 43.6% of S.C. agriculture. The combined annual revenue from fruit and vegetable production has been estimated to reach $161 million from the state's reported 1,520 vegetable farms and 1,340 fruit farms and, it is this production, which has enabled S.C. to rank 33, nationally, for crop production. S.C. farmers should be knowledgeable about the latest trends and innovations in produce farming to maintain this level of production. Thus, the current survey was conducted to identify S.C. farmers' current practices, educational needs, and preferred method of information distribution. Most of the farmers (71%) who were surveyed were conventional; however most of those farms (68%) were interested in receiving information on organic agriculture. Despite this interest, these farmers were "not sure" if they needed additional educational training on farming practices from Clemson University, reflecting that the current workshops at Clemson University may not be fulfilling the farmers' needs.

4.2 INTRODUCTION

Farmland occupies slightly more than 25% of the available land within S.C. S.C. ranks at or near the top nationally in fresh market production of leafy greens such as collards, kale, turnips, and mustard (SCDA 2012). Therefore, in order to maintain these ranking, S.C. farmers need to have educational resources readily available including information on the latest trends and innovations in produce farming.

One of the emerging production trends is organic farming, which has increased significantly in the past decade. According to the Organic Trade Association (OTA), the sales of U.S. organic foods and beverages have increased from $1 billion in 1990 to $26.7 billion in 2010. In 2010, sales of organic food and beverages grew by 7.7 % over the previous year's sales-the largest growth of the decade. Revenue from organic fruits and vegetables had the highest growth in sales during 2010, which was 11.8% higher than the 2009 sales (Organic Trade Association, 2012). In 2010, the majority of the market growth (54%) in organic food was not through health food retailers or all natural stores (39%) but was through mass market retailers (mainstream supermarkets, club/warehouse stores, and mass merchandisers). Organic fruits and vegetables currently represent over 11 % of all U.S. fruit and vegetable sales. Natural retailers sold 39% of total organic food. Other sales occur via export, the Internet, farmers' markets/ Community Supported Agriculture, mail order, and boutique and specialty stores (Organic Trade Association, 2012).

Meeting consumer demand for organic food, especially produce, has proven to be difficult for organic produce farmers. Therefore, the number of certified organic acres of farmland needs to increase to assist farmers with meeting consumer demands. In response to the increased demand for organic produce, the USDA implemented the 2008 Farm Act Provisions, namely the Food, Conservation, and Energy Act of 2008. This provision increased the mandatory funding for the National Organic Certification Cost-

Share Program to $22 million (a 340% funding increase). This Farm Act expanded the support for existing organic research, regulatory programs, and provided incentives for conventional producers to transition to organic farming (Greene, 2012). A recent survey found the major barriers for producers to get their farms certified for organic production included, philosophical beliefs, the certification process, and the risk of losses due to plant disease, weeds, and insects (Veldstra, M.D., Alexander, C.E., and Marshall, M.I., 2012) .

USDA defines a product as certified organic if the "…product has been produced through approved methods that integrate cultural, biological, and mechanical practices that foster cycling of resources, promoting ecological balance, and conserving biodiversity." Certified organic producers are prohibited from using synthetic fertilizers, sewage sludge, irradiation, or genetic engineering. According to the USDA, Agricultural Marketing Service (AMS), a product may be labeled "100% Organic" if 100% of the ingredients are organically cultivated, "Organic" requires the use of 95% or more organic ingredients, while "Made with Organic Ingredients" requires that at least 70% organic ingredients are used, "Less than 70% Organic Ingredients" must be on the label if less than 70% organic ingredients were used in the product (USDA 2012).

The U.S. has also seen a rise in consumer interest for purchasing local food. Consequently, the local food movement has been one of the fastest growing production and marketing areas that the food industry has seen in recent years (USDA, 2012). From 1994 to 2012, there has been a 348% increase in the number of operating farmers' markets (USDA, 2012; USDA. AMS., 2012). Moreover, in 1986, there were only two

Community Supported Agriculture (CSA) initiatives in the U.S. and this has increased to 6,000-6,500 CSA initiatives in 2012 (McFadden 2012). Retail giant Walmart, provided evidence of just how large the local food movement has grown when they pledged to source more local fruits and vegetables for their stores (Walmart, 2008). A Walmart spokesman further stated that partnerships with local farmers had grown by 50% (Walmart, 2008).

All 50 states and 4 territories currently have state-sponsored agricultural marketing programs to encourage consumers to buy local customer goods. S.C. started their CSA program “Certified S.C. Grown,” in 2007, as a cooperative effort among producers, processors, wholesalers, retailers, and the S.C. Department of Agriculture (SCDA) to brand and promote S.C. products. The ultimate goal of this movement was to enable consumers to easily identify and purchase S.C. products.

It is evident that both organic and local produce are popular among consumers. However, meeting production demands depends upon farmers. Therefore, a survey of local produce farmers was conducted in S.C. to identify their current practices, educational needs, and preferred method of educational information distribution. Identification of farmers’ needs is the first step in the development of programs to assist farmers with increased productivity.

4.3 Materials and Methods

4.3.1 Materials

The survey program Snap Surveys (Portsmouth, NH) was used to collect the data for this project.

4.3.2 Methods

Data were collected from farmers during Good Agricultural Practices (GAPs) workshops in SC from December 2011 until April 2012 and were distributed to adults (18+) only and by the same person during the entire study. Participation in this survey was voluntary and there were no incentives provided to participate in the survey. Approval for this study was granted by the Institutional Review Board at Clemson University (IRB2010-324). A total of 31 surveys, representing 31 different farms, were completed.

4.3.2.1 Development of the survey instrument

The survey was developed by working with a statistician to ensure that the questions were worded correctly and analyzed to provide practical information. Prior to distribution, the survey was also given to several Extension Associates at Clemson University who are experts in the produce industry to receive comments about how to improve survey clarity. The final survey instrument is in Appendix B. The survey consisted of 4 sections: farming practices, profitability and marketing, educational/informational needs, and demographics. The farming practices section included questions regarding problem weeds, nutrient deficiencies, plant disease, insects, and crops that the farmers cannot grow due to these problems. The profitability and marketing section included questions regarding challenges influencing profitability, sale outlets, advertising, pricing, and location of sale. The educational/informational needs section included questions regarding primary source of produce information, preferred source of educational information, and additional educational training needs. The demographic section included questions regarding the county of the farm, if they are farming organically, number of acres they farm, water source, and crops. When the farmers were asked to rate the level of importance of specific attributes, the following scales were used: 1=extremely unimportant 3=important 5= extremely important.

4.3.2.2 Selection of produce farmers

The surveys were distributed at GAPs workshops. Therefore, the sample was non-random and may influence the results. Identifying methods to improve farming practices was one of the goals of this survey; thus, these farmers were of particular interest to the study.

4.3.2.3 Distribution of surveys

Surveys were distributed by the graduate student conducting the research. The farmers were able to choose to take the survey online (Snap Survey Software) or receive a hard copy of the survey. The graduate student introduced the survey by stating that it was part of her research to determine the needs of produce farmers in S.C. At that time, the farmer would either agree or disagree to take the survey. If the farmer agreed to take the survey, the graduate student would first provide them further information with the IRB information letter, and then they would take the survey.

4.3.3 Statistical analysis

Descriptive statistics were calculated for all the variables using procedure means within Statistical Analysis System (SAS) version 8.02 (Cary, N.C.). Frequency tables were created to compare the responses of the participants.

4.4 Results and Discussion

Of the 31 farmers who agreed to take this survey (Appendix B), 86% of them were from the counties in the lower region of S.C. and the rest of the farms were from the ccounties in the Midlands (Table 1). Of the S.C. 71% of all the farmers that participated in the survey indicated they were conventional farmers and were not farming organically (Table 2). However, 68% of these producers said they needed more information about organic or biological control products which suggested that they might consider alternative farming methods. This response also suggested that many S.C. produce farmers are not certified organic. It is not surprising that producers want more information about organic products because organic retail sales have risen by 486% ($3.6 to 21.1 billion) in the past decade (2000-2009) and these farmers have noticed the organic trend (Dimitri, C. and Oberholtzer, L., 2009) . Historically, fresh produce has been the most popular organic commodity, and it continues to be, with a steady growth of 15% between 1997 and 2007 (Dimitri, C. and Oberholtzer, L., 2009) . However, it may be informative for S.C. produce farmers to know that a recent S.C. consumer survey found that, when given a choice between local or organic, 85% of the organic produce consumers would choose to purchase local produce instead of organic produce (Steinberg, E.L., Martinez-Dawson, R., and Northcutt, J.K., 2013) .

When farmers were asked if they needed additional educational training on farming practices, 62% of respondents reported that they were "not sure" (Table 2). Based on their previous response regarding needs for organic produce information, these farmers may be "unsure" about their need for additional training because the current training may not be fulfilling the needs of the producer. Responses suggest that an organic farming workshop or training resources might be well received by S.C. farmers.

S.C. produce farmers in the current survey indicated that "labor" or adequate work force was the largest challenge affecting their long term success and they ranked this challenge with a mean score of 3.48 out of 5 (1=extremely unimportant; 5=extremely important; Table 4). Other challenges and subsequent ranking include land prices (3.4), GAPs certification (3.3), and rainfall/moisture (3.3) using the same scale. While there is little that can be done to control land prices and rainfall, extension associates have recently developed educational trainings on Good Agricultural Practices (GAPs) certification. GAPs are guidelines developed by the food industry, producer organizations, and the government to ensure food safety and quality of produce in the food chain (Food Agricultual Organization, 2008). In 2011, the Federal Food Safety Modernization Act (FFSMA) was signed into law and it redirected FDA's attention to the food safety of specific commodities, including fresh produce based on the risk of human food borne illness. This law specifically targeted fresh produce, and it requires farmers to implement “safety measures” for ensuring food safety such as GAPS food safety plans. GAPs cover growing, harvesting, sorting, packing, and storage operations through the development of science-based minimum standards related to soil amendments, hygiene, packaging, temperature controls, animals in the growing area, and water. Developing a food safety program such as GAPs that meets the FFSMA is a new requirement for farmers and may be a frightening task especially for small farmers. The FFSMA does provide an exemption for small farms; however, without a food safety plan these farmers cannot be competitive with larger producers.

During the present survey, farmers were asked to identify the major fruit and vegetable insects and to indicate the severity of this problem using a scale of 1 to 5 (1=extremely unimportant and 5=extremely important; Table 4). The majority of fruit and vegetable insects were not a problem for the participating farms (mean ranking < 3.00). However, two of the vegetable insects “stink bug” and “corn ear worm”, did receive a mean ranking of 3.5 and 3.4, respectively. This suggests that these two insects posed more severe problems for the farmers surveyed and reduced their crop yield. The “brown marmorated stink bug” or commonly known as the “stink bug”, was introduced to the U.S. with the first specimen collected in 1998. It has become a serious problem pest for fruits, vegetables, and farm crops of the mid Atlantic region. These pests feed on a wide variety of host plants rendering them unmarketable (Jacobs, 2010). The “corn earworm” is a moth in the insect family *Noctuidae*. It is a common pest of sweet corn but may also be a pest to tomato, cotton, sorghum, or vetch (Calvin, 2000). The only plant disease that presented a challenge for farmers participating in this survey (mean ranking

>3.0) was fusarium wilt (3.2). Fusarium wilt is a disease caused by a fungus and is known to infect tomato, sweet potato, legumes, cucurbits, and bananas (Miller, S.A., Rowe, R.C., and Riedel, R.M., 1986) . While these data demonstrate that S.C. farmers have had success with common challenges, there are still some educational needs that must be addressed. Prevention is always the best way of handling these challenges. This is why it is extremely important for extension associates to continue to research and educate farmers on the best preventative measures.

More than half of the survey participants indicated that they sold they products locally within their county as opposed to within the state or region (Table 5). Many of the S.C. farmers participating in this survey (71%) indicated that they sold their produce at farmer's markets (Table 3). A farmer's market is a venue that allows consumers to have direct access to locally produced food and allows small farmers sell their products to their neighbors (USDA. AMS., 2012). There are 120 farmer's markets in S.C.

Thirty-one percent of the producers who were surveyed said their primary source of educational information was extension agents and specialists while 41% said that workshops were their primary source (Table 5). When asked their preferred source of training or information distribution, 68% of the S.C. produce farmers who were surveyed said they prefer workshops which provide traditional hands-on training. Only 12% of the respondents said that a preferred source of education was online training. However, this may be because the farmers have never been exposed to online resources as an educational tool. Online trainings offer new avenues reaching diverse and broad audiences typically at minimal cost investment. The number of farmers who prefer online trainings as an educational source may increase in the next few years as this method becomes an affordable option for bringing together specialists with diverse expertise.

The survey participants were asked to identify how they advertise their product and provide the level of importance using a scale of 1 to 5 (1=extremely unimportant and 5=extremely important; Table 3). Nearly 84% of the respondents reported that they depend on word of mouth to advertise their products and that word of mouth is extremely important to them (level of importance = 4.6 out of 5). Since these farmers rely so much on word of mouth, it is imperative to make sure that consumers can identify the product and associate it with a farm. Producers can choose to advertise their product as “certified S.C. grown” for free by registering with the S.C. Department of Agriculture (SCDA) to brand and promote their products. However, a recent consumer survey found that 38% of S.C. consumers were unaware of the “certified SC grown” program (Steinberg, E.L., Martinez-Dawson, R., and Northcutt, J.K., 2013) . Thus, until the SCDA gains more support to market the “certified SC grown” program, farmers would be remiss if they did not utilize additional methods for product advertising.

The results of the present survey found that the participating S.C. produce farmers would benefit from having a workshop on USDA organic certification, as well as additional GAPs trainings. These farmers also indicated that they would benefit from receiving training on the preventative measure they can take against certain fruit and vegetable insects and plant diseases. Data collected during the present survey also reflected that SCDA could assist S.C. producers market their product through “Certified S.C. grown” and this marketing strategy needs to be clearly conveyed to the producers.

Data from this survey was limited because only farmers located in the lower and middle region of S.C. participated in the survey. Farmers in the Upstate of S.C. may experience different challenges and have different educational needs than those in the other regions of S.C.; however, the survey does demonstrate areas that could be addressed to assist farmers in the regions that participated in the survey.

Table 4.1-Demographics of producer survey[1]

Counties of SC where farm is located[2]	# of farms
Low	24
Midlands	4
Upstate	0

[1]N=28 responses; 3 participants did not report farm location.
[2]Low counties = Beaufort, Colleton, Hampton, Jasper; and Midlands counties =Calhoun, Fairfield, Kershaw, Lexington, Orangeburg, Richland, Saluda, and Sumter; Upstate counties=Abbeville, Anderson, Cherokee, Greenville, Greenwood, Laurens, Oconee, Pickens, Spartanburg, and Union.

Table 4.2- Summary of cultivation practices and training needs reported by S.C. producers.

Question	No (# of farms)	Yes (# of farms)	Not Sure (# of farms)	# of farms
Are you farming organically?	20	8	0	28
Do you need more information about organic or biological control products?	8	21	2	31
Do you need additional educational training from Clemson University?	4	7	18	29
Do you practice soil testing annually?	8	21	0	29

Table 4.3- Summary of the sale and marketing of S.C. produce farms[1]

	Selection	Number of participating farms who made this selection	Mean (Median) level of Importance[2] (if selected)
Please select where you sell your produce	Retail	16	3.75 (4.00)
	Restaurant	7	3.29 (4.00)
	Farmer's Market	22	4.04 (4.00)
	Wholesale	8	2.75 (2.50)
	Other	3	3.67 (4.00)
Please select how you advertise	Word of mouth	26	4.60 (5.00)
	Magazine	10	2.30 (2.00)
	Internet	18	3.40 (3.50)
	Newspaper	15	3.60 (3.00)
	Other	3	5.00 (5.00)

[1]N=31 farms [2] On a scale of 1 to 5 where 1=extremely unimportant and 5=extremely important; Mean value for the level of importance based on the number of people that made the selection.

Table 4.4- Summary of the challenges incurred by S.C. produce farmers[1]

Question[2]		# of farms	Mean (Median) level of Importance[3] (if selected)
Challenges affecting long term success	Weeds	24	3.00 (3.00)
	Soil nutrients	21	3.00 (3.00)
	Rainfall/moisture	23	3.30 (3.00)
	Land prices	18	3.39 (4.00)
	Labor	23	3.48 (4.00)
	GAPs[4]	4	3.33 (4.00)
Please select fruit insects that reduce crop yield	Beetles	12	2.17 (2.50)
	Peach Tree Borer	10	2.10 (1.50)
	Caterpillars	11	1.73 (2.00)
	Curculio	8	1.88 (1.00)
Please select vegetable insects that reduce crop yield	Aphids	23	2.61 (3.00)
	Ants	23	2.83 (3.00)
	Beetles	20	2.25 (2.00)
	Cutworms	21	2.19 (2.00)
	Cowpea Curculio	15	1.93 (1.00)
	Caterpillars	22	2.36 (2.00)
	Grubs	21	2.29 (2.00)
	Harlequin Bug	18	2.33 (2.00)
	Mites	3	1.67 (1.00)
	Two-spotted Spider Mites	18	2.33 (2.00)
	Maggots	18	1.78 (1.50)
	Stinkbugs	23	3.48 (4.00)
	Nematodes	19	2.68 (3.00)
	Corn Ear Worm	20	3.35 (3.00)
Please select plant diseases that reduce crop yield	Anthracnose	18	2.22 (2.50)
	Black Rot	18	2.50 (3.00)
	Botrytis fruit rot	16	2.63 (3.00)
	Mosaic	16	1.94 (2.00)
	Rust	20	1.80 (2.00)
	Fungal wilt	20	2.70 (3.00)
	Bacterial wilt	18	2.78 (3.00)
	Bacterial spot	5	2.80 (3.00)
	Downy mildew	8	2.57 (3.00)
	Powdery mildew	11	2.90 (3.00)
	Fusarium wilt	9	3.22 (3.00)

[1]N=31 farms
[2]Choices within each category were given to the producers
[3] On a scale of 1 to 5 where 1=extremely unimportant and 5=extremely important
[4]Good Agricultural Practices (GAPs)

Table 4.5-Summary of where S.C. farmers reported selling produce and preferred educational sources.

		Number of producers	Percentage of responding producers
What is the furthest location where your product is sold?	In-state	11	37.9
	Local (County)[1]	15	51.7
	Regional[2]	3	10.3
Primary source of information on produce	Magazines	7	24
	Extension agents and specialists	10	35
	Workshops	12	41
Preferred source of educational information	Workshops	23	68
	Online	4	12
	Roundtable discussion	7	20

[1]Local= within the county in which the farm is located.
[2]Regional=includes multiples states (i.e. Southeast U.S.)

4.5 References

Calvin D (2000) Corn earworm. Corn earworm

Dimitri C, Oberholtzer L (2009) The US organic handling sector in 2004: baseline findings of the nationwide survey of organic manufacturers, processors, and distributors. Available at SSRN 1354172

Food Agricultual Organization (2008) Good Agricultural Practices. In: Food Agricultural Organization. FAO. http://www.fao.org/prods/GAP/. Accessed October/29 2012

Greene C (2012) Organic agriculture: organic market overview. In: . USDA ERS. http://www.ers.usda.gov/topics/natural-resources-environment/organic-agriculture/organic-market-overview.aspx. Accessed 08/29 2012

Jacobs S (2010) Brown Marmorated Stink Bug Fact Sheet. Pennsylvania State University, College of Agricultural Sciences, Department of Entomology< http://ento.psu.edu/extension/factsheets/brown-marmorated-stink-bug

Miller SA, Rowe RC, Riedel RM (1986) Fusarium and Verticillium wilts of tomato, potato, pepper, and eggplant

Organic Trade Association (OTA) (2012) OTA's 2012 organic industry survey

Steinberg EL, Martinez-Dawson R, and Northcutt JK (2013) SC consumer survey

USDA (2012) Know your farmer know your food: our mission. In: Know your farmer know your food. USDA. http://www.usda.gov/wps/portal/usda/usdahome?navid=KYF_MISSION. Accessed 8/30 2012

USDA. AMS. (2012) Farmers markets and local food marketing. In: USDA. USDA. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&ved=0CCMQFjAA&url=http%3A%2F%2Fwww.ams.usda.gov%2FAMSv1.0%2Fams.fetchTemplateData.do%3Ftemplate%3DTemplateS%26leftNav%3DWholesaleandFarmersMarkets%26page%3DWFMFarmersMarketGrowth%26description%3DFarmers%2520Market%2520Growth%26acct%3Dfrmrdirmkt&ei=knc-UImMCpPa9AT2jIHIAQ&usg=AFQjCNEgUJZGPETlhKzLiLpXGLOvsD1o3g. Accessed 08/29 2012

Veldstra MD, Alexander CE, Marshall MI (2012) To certify or not to certify? Decomposing the organic production and certification decisions.

Walmart (2008) Locally grown at walmart. In: . walmart. http://az204679.vo.msecnd.net/media/documents/r_2999.pdf. Accessed 09/1 2012

CHAPTER 5

GREENHOUSE STUDY TO EXAMINE THE EFFECT OF CULTIVATION PRACTICES ON THE QUALITY ATTRIBUTES OF COLLARD GREENS OF THE VATES VARIETY

5.1 ABSTRACT

Amines such as diamines (putrescine and cadaverine) and polyamines (spermine and spermidine) are important in the regulation of nucleic acid function, protein synthesis and the stabilization of membranes including fruits and vegetables. Diets rich in fruits and vegetables have been found to combat a variety of diseases such as cancer, heart disease, and diabetes. Additionally, there has been an increasing trend toward organic farming because its products are perceived as healthier by consumers. Previous research has shown organic products to be higher in certain nutrients than their conventional counterparts. However, more controlled research was necessary to validate this finding. Therefore, USDA organic and conventional collard greens were grown in a greenhouse to examine the effect of cultivations practices on quality attributes. The organic collards weighed significantly less (P-value < 0.05) than their conventional counterparts and were significantly brighter (P-value < 0.05) than the conventional collards over the entire course of the experiment. When the collards were grown during the summer, the organic collards had a significantly higher (P-value < 0.05) polyamine concentration compared to their conventional equivalent. Polyamines were found to be associated with higher yellow values within the organically grown collards, which may be able to be used as a predictor of higher levels of polyamines.

5.2 INTRODUCTION

Consumption of leafy greens provides an excellent source of nutrients, primarily because they are high in vitamin A (carotenoids), vitamin C, folate, and potassium (U.S. department of health and human services, 2008). From a botanical aspect, leafy greens belong to the kingdom Plantae, the order Brassicales, and the family Brassicaceae. The most important genus of Brassicaceae is Brassica and the most commonly consumed Brassica species are the *Brassica oleracea* . *B. oleracea* have vast morphological diversity in leaf, stem, and inflorescences . As a group, they are known as cole crops, a term coined by L.H. Bailey, an American botanist and horticulturist, in 1901 .

Collard greens, which belong to the species *Brassica oleracea* var. acephala, are a cool season crop typically grown in spring or fall. The most common cultivars of collards include Blue Max, Flash, Hevi-Crop, Hi-Crop, Cabbage, Carolina, Champion, Georgia, Georgia Blue Stem, Green Glaze, Morris Heading, and Vates. Collard production in the U.S. is infrequently estimated but has been recorded to be 14,100 hectares (ha) and valued at $36.4 million. Collards have flourished in the southern part of the U.S. because of the plant's ability to endure hot summers but still thrive in mild winters. In fact, in 2011, collard greens became South Carolina's state vegetable. South Carolina producers grow approximately 264,000 pounds of collard greens, ranking the state 2nd in the U.S. for collard green production. S.C. produces 16% of the total collard greens grown in the U.S. which is valued at $6,626,000 . Among the possible varieties of collards, the Vates variety has been one of the top collard varieties in the country, and this is the most common collard grown in S.C.

Collard greens have been classified as ethylene sensitive and will turn yellow when stored with ethylene producers. Ethylene, an important chemical substance in plants is a naturally-occurring hormone. It regulates many aspects of plant development and senescence. Ethylene is produced from essentially all part of higher plants including leaves, stems, roots, flowers, fruits, tubers, and seedlings. Due to its effect on fruit ripening and vegetable senescence, ethylene has been of major interest to scientists since it has both positive and negative effects during fruit ripening. Starting with the positive effects, ethylene stimulates the ripening process for climacteric fruits (apple, apricot, avocado, banana, peach, plum, and tomato) leading to agreeable flavors, color, and texture (quality characteristics). On the other hand, ethylene may produce over-ripe fruit. In non-climacteric fruits such as citrus, eggplant, grape, pepper, and strawberry, ethylene is not required for the ripening process but, in these fruits, as well as in vegetables, ethylene has negative effects including increased pathogen susceptibility, physiological disorders, and increased rate of senescence, with an associated reduction in shelf-life. Aside from the ethylene production from fruits and vegetables, there are other sources of ethylene productions. These include biomass fermentation of some microorganisms (bacteria and fungi) and prolysis of hydrocarbons which release ethylene as a component of air pollution. In order to avoid these detrimental effects, it is vital to understand ethylene biosynthesis inhibition.

In highly vascular plants, ethylene is synthesized from the amino acid methionine to S-adenosylmethionine (SAM) by the addition of adenine at the consumption of ATP. SAM is then converted to 1-aminocyclopropane-1-carboxylic acid (ACC) by the enzyme

ACC-synthase (ACS) with the generation of the by-product 5'-methylthioadenosine (MTA), which is recycled to methionine. Therefore, ethylene can be produced in high volumes even with a small pool of free methionine. Finally, ACC is oxidized to ethylene via ACC-oxidase (ACO). The rate limiting step in the formation of ethylene is ACS and the subsequent pool of ACC. Current research shows that ethylene biosynthesis and action may be blocked by chemical compounds which differ in their structure and act at different levels, namely ACS and ACO activities, blocking receptor sites, diversion of SAM via polyamine (PA) biosynthesis, or through the removal of ethylene. Ethylene production has been altered through the exogenous treatment of polyamines. Amines like diamines (putrescine), polyamines (spermine and spermidine), as well as cadaverine are indispensible components of living cells and are important in the regulation of nucleic acid function and protein synthesis. They are also involved in the stabilization of membranes. Diamines, such as putrescine, and polyamines spermidine and spermine may occur universally in animal and plants. Putrescine and spermidine are also found in most bacteria and thus could be introduced through soil containing bacteria. Most food contains proteins or free amino acids and may be subjected to conditions enabling microbial or biochemical active biogenic amines. Both the nature of the food and the microorganisms present on it will affect the total amount of different amines present . Biogenic amines are present in a wide variety of foods including fish, meat, dairy, wine, beer, vegetables, fruit, nuts, and chocolate. The factors which affect the formation of biogenic amines in foods comprise the availability of free amino acids, the presence of micro-organisms that can decarboxylate amino acids, and the favorable conditional of such micro-organisms for the growth and production of their enzymes.

Since there is competition between polyamines and ethylene through their common precursor SAM , the balance between these two opposing growth regulators is critical in slowing down or accelerating the ripening process . Numerous experiments on apricots, peaches, and nectarines have revealed the reduction of ethylene by applying exogenous polyamine during the growing season (Bregoli,A.M., Scaramagli, S., Costa, G., Sabatini, E., Ziosi, V. Biondi, S., and Torrigiani, P., 2002; Paksasorn ,A., Hayasaka,T., Matsui,H., Ohara,H., and Hirata,N., 1995; Torrigiani, P., Bregoli, A.M., Ziosi,V., Scaramagli,S., Ciriaci,T., Rasori, A., Biondi, S., and Costa, G., 2004) . Polyamines also have been used under post-harvest conditions (Martínez-Romero, D., Serrano, M., Carbonell, A., Burgos, L., Riquelme, F., and Valero, D., 2002; Martínez-Romero, D., Valero, D., Serrano, M., Martínez-Sánchez, F., and Riquelme, F., 1999; Martinez-Romero, D., Serrano, M., Carbonell, A., Castillo, S., Riquelme, F., and Valero, D., 2004; Serrano, M., Martinez-Romero, D., Guillen, F., and Valero, D., 2003; Valero, D., Martínez-Romero, D., Serrano, M., and Riquelme, F., 1999; Valero, D., Pérez-Vicente, A., Martínez-Romero, D., Castillo, S., Guillen, F., and Serrano, M., 2002) . Polyamine levels naturally decrease during fruit ripening along with an increase in senescence and paralleling the climacteric rise in ethylene production. Therefore, an exogenous application of polyamines increases the endogenous polyamine levels during storage, and sequentially extends shelf-life (Valero, D., Martínez-Romero, D., and Serrano, M., 2002) . Interestingly, when damaged fruit, which ordinarily has an increase in ethylene production, has been treated with exogenous polyamines, the ethylene production is inhibited (Martinez-Romero, D., Serrano, M., Carbonell, A., Castillo, S., Riquelme, F., and Valero, D., 2004). Exogenous putrescine treatment has been reported to significantly increase putrescine and spermidine (from putrescine via DC-SAM) levels, while decreasing ethylene production in various fruits (Martinez-Romero, D., Serrano, M., Carbonell, A., Castillo, S., Riquelme, F., and Valero, D., 2004). Thus the diversion of the DC-SAM via polyamine synthesis could explain the significant reduction in ethylene production found in putrescine treated fruit. In other words, an increased level of putrescine led to more spermidine from the putrescine via DC-SAM, thus there was less DC-SAM available to make ACC and consequently less ethylene (Martínez-Romero, D., Guillén, F., Valverde, J.M., Bailén, G., Zapata, P., Serrano, M., Castillo, S., and Valero, D., 2007). Additionally, putrescine treated fruit had significantly higher percentages of color retention with respect to the value at harvest when compared to the control group (Martínez-Romero, D., Guillén, F., Valverde, J.M., Bailén, G., Zapata, P., Serrano, M., Castillo, S., and Valero, D., 2007).

In plants, PA has been found to be involved in triggering organogenesis and providing protection against stress. Lima et al. (2008) found higher levels of polyamines in organic versus conventional produce. This is reflected in the fact that high polyamine levels leads to improved plant longevity. Additionally higher polyamine levels may result from increased levels of stress (Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O., 2008) . Stress may result from the lack of pesticide treatment in organic produce. The study by Lima et al. (2008) also compared a wide variety of plant species (zucchini squash, banana, potato, eggplant, orange, lime, mango, passion fruit, radish, broccoli, carrot, collard, cassava, grape and spinach). However, these researchers had small samples sizes and purchased their produce directly from producers rather than growing it themselves. Therefore, they did not have control over the product during production. In the current study, USDA organic and conventional collard greens of the same variety were grown in a controlled atmosphere in a greenhouse to examine the effect of cultivations practices on quality attributes.

5.3 MATERIALS AND METHODS

5.3.1 Materials

Trichloroacetic acid (Fisher Scientific; CAS 76-03-9), sodium carbonate (Fisher Scientific; CAS 497-19-8), dansyl chloride 10% in acetone (TCI America; CAS 605-65-2), L-proline (Sigma-Aldrich; CAS 147-85-3), toluene (Fisher Scientific; CAS 108-88-3), HPLC grade acetonitrile (Fisher Scientific; 75-05-8), putrescine dihydrochloride (Sigma; CAS 333-93-7), spermine tetrahydrochloride (Sigma; CAS 306-67-2), spermidine trihydrochloride (Sigma; CAS 334-50-9), osterizer 12-speed blender (Oster; Boca Rotan, FL.; Model 564A), Vates cultivar USDA organic seeds (Seeds of Change; Rancho Dominguez, CA) , Vates cultivar seeds (Southern Exposure Seed Exchange; Mineral, VA), Nitrogen gas (Air Gas; Taccoa, GA),

5.3.2 Sample Procurement

5.3.2.1 Planting

For organic and conventional processes, 24 pots (12 organic and 12 conventional) were filled with 8 liters of USDA Certified Organic Miracle Gro Potting Soil or 8 liters of Miracle Gro Potting Soil, respectively. The USDA certified organic 'Seeds of Change' vates seeds and the 'Southern Exposure Seed Exchange' vates seeds were buried 0.635 cm deep within the certified organic soil and the conventional soil, respectively. Each pot received 50 ml of tap water after planting. Every day following the planting,160 ml of tap water were poured on the soil of each plant. Water was measured into clean containers using a Wheaton unispense and was transported to the greenhouse for watering (Millville, NJ; CAT 374301).

5.3.2.2 Greenhouse Conditions

Throughout the experiment, relative humidity, temperature, and global light energy were monitored and recorded using a hygromter/thermometer. These measurements were taken every 15 minutes, which allowed us to observe the change in these values over the course of this experiment. Since both treatments were in the same controlled environment, these measurement did not contribute to the variables. However, these data may be found in Appendix C.

5.3.2.3 Harvest

Whole plants were harvested and measured to determine growth. Half of the organic and half of the conventional collards were randomly selected and harvest on day

75. The randomly selected plants were pulled from the root and placed into labeled Ziploc bags. Within thirty minutes of harvesting, the leaves were separated, placed into Whirl-Pak® bags and refrigerated overnight (4^{0}C). The next day, the samples were placed into a -80^{o}C freezer, where they remained, until they were extracted for polyamine analysis. The remaining portions of the plants were harvested on day 91-96.

5.3.3 Measurements

Plants were measured every week for width and height to calculate growth rate. After the plants were harvested, the weight of the entire plant, including the root (minus adhering soil), was taken. Additionally, stem diameter and plant length were measured. Plant length was determined to be the length from the tip of the highest leaf to the point where the root started. Leaf color was measured for C.I.E. L*a*b* values using a Konica Minolta colorimeter (Ramsey, NJ; CR-300; Model 85D8). The L* value is on a scale from 0 (black) to 100 (white). The a* and b* values are on a scale from "–"(green and blue, respectively) to "+" (red and yellow, respectively).

5.3.4 Polyamine Analysis

5.3.4.1 Sample Extraction

Samples were removed from the -80^{o}C freezer and immediately placed on dry ice. Ten grams of each sample was weighed and the remainder of the sample was freeze dried for amino acid analysis. To each 10 g sample, 100 mL of deionized water was added. These samples were then blended for 1 min in a blender (Oster; Boca Rotan, FL.; Model 564A). One milliliter of homogenized sample was transferred to microcentrifuge tubes, in triplicate. To each of these samples, 100 ul of 25% trichloroacetic acid was added. Samples were then vortexed for 2 min, placed on ice for 15 min, and centrifuged at 3000 RCF for 5 min. After centrifugation, 200 ul of the acid soluble extracts were transferred into clean micro centrifuge tubes, and 50 ul of sodium carbonate was added to each tube to derivitize the polyamines. These samples were then vortexed for ~15 sec to mix them thoroughly. Five hundred ul of dansyl chloride in acetone was added to the derivitized protein extract to react with 1^o and 2^o amino acids and phenols to form yellow fluorescence. Samples were incubated overnight in a shaking water bath at 25-37^{o}C. After removing the samples from the water bath, they were vortexed for ~ 15 sec and 125 ul of L-proline was added to each sample to remove excess dansyl chloride. The samples were then vortexed 2-4 times and then left to sit for 15-30 min or until the solution turned pale yellow/colorless. Five hundred ul of toluene were added to each sample, to extracted dansylated polyamines, and each sample was vortexed 2-3 times for ~15 sec/tube. The samples were then centrifuged at 3000 RCF for 2-3 min. The upper layer of each samples were transferred to a new tube and evaporated under nitrogen to concentrate the polyamines. The dried polyamines were then solubilized with 200 ul of HPLC grade-acetonitrile, followed by vortexing: samples were transferred into a new microcentrifuge tube and centrifuged at 3000 xg for 2-3 min. Finally, 150 ul of the samples was pipetted into HPLC vials, sealed and analyzed using the HPLC.

5.3.4.2 HPLC Method

HPLC analysis was conducted on a C18 column. Twenty ul of each sample was injected into the HPLC with a gradient elution set to a flow rate of 1 mL/min. Mobile phases were 40% acetonitrile (Solvent A) and 100% acetonitrile (Solvent B). The elution gradient was 0-5 min: 0% solvent B, 5-20 min: 0-100% solvent B, 20-22 min: 100% solvent B, 22-22.01 min: 0-100% solvent B, 22.01-27 min: 0% solvent B. A fluorescence detector was used to quantify the polyamines with an excitation of 320 nm and an emission of 523 nm.

5.3.5 Amino Acid Analysis

5.3.5.1 Total Nitrogen

One quarter to one gram of sample were placed into a digestion flask and 15 g K_2SO_4, 0.04 g anhydrous $CuSO_4$, 0.5-1.0 g alundum granules, and 20 ml of H_2SO_4 was added to digest the sample. The flask was heated to a rolling boil until dense white fumes cleared the bulb. The flaskes were gently swirled and heated for 90 min. Samples were then cooled to room temperature by slowly adding 250 mL H_2O. The titration beaker was prepared by adding previously measured volume of standard acid so that the condenser tip was immersed. Three-4 drops of indicator solution was added to the titration. The flask, containing the sample was connected to the distillation apparatus, mixed completely, and distilled at ca 7.5 min boil rate until ≥150 ml distillate was collected in the titration beaker. The excess standard acid was titrated in distillate with NaOH solution. The %N was calculated using the following formula:

When standard HCl was used:

N, %(w/w)=$[(M_{acid})(ml_{acid})- (ml_{bk})(M_{NaOH})- (ml_{NaOH})(M_{NaOH})][1400.67]$/mg test portion

When standard H_2SO_4 was used:

N, %(w/w)=[(M_{acid})(2)(ml_{acid})- (ml_{bk})(M_{NaOH})- (ml_{NaOH})(M_{NaOH})][1400.67]/mg test portion

Where ml_{NaOH} = ml standard base needed to titrate distillate; ml_{acid}= ml standard acid used for distillate; ml_{bk}= ml standard base needed to titrate 1 ml standard base minus ml standard base needed to titrate reagent blank carried through method and distilled into 1 ml standard acid; M_{acid}= molarity of standard acid; M_{base}= molarity of standard base.

The % crude protein was then calculated by 6.25 * %N.

(AOAC 2007)

5.3.5.2 Arginine Analysis

One tenth of one gram of sample was placed into a hydrolysis tube, and 10 ml of 6 M HCl was added. The mixture was mixed, and then frozen in dry ice-alcohol bath. A vacuum (≤ 50 mm) was drawn on the sample for 1 min. The sample was then hydrolyzed for 24 h at $110^0 \pm 1^0$C. Following hydrolysis, the sample was cooled and filtered through Whatman No.1 paper. The filtrate was rinsed 3 times with H_2O and each rinse was filtered. The filtrate was dried at 65^0C under vacuum. The dry hydrolysate was dissolved using a buffer (1.96% Sodium citrate dihydrate solution with 1% thiodiglycol, pH 2.0). This hydrolysate was used to determine the concentration of arginine according to the formula:

$$ARGg(uncorrected)/16gN = [\frac{nmolesAA * initialtestsolutionvolume(ml) * MWaa]}{volumetestsolutioninjected(ml) * testportionweight(g) * \%Nfortestportion * 6.25x10^5}$$

(AOAC 2007)

5.3.5.3 Methionine Analysis

One tenth of one gram of sample was placed into a hydrolysis tube, and 2 mL cold performic acid was added. This mixture was allowed to sit overnight at 4^{o}C to oxidize the sample. The next day, 3 mL cold HBr + 0.04 ml 1-octanol (antifoam) was added to the mixture and the solution was immediately mixed for 30 sec in an ice water bath followed by evaporation to dryness at 40^{o}C under vacuum. Samples then received 10 ml 6M HCl for acid hydrolysis followed by freezing in dry ice-alcohol bath. Samples were sealed under vacuum (≤50 mm hg, 1 min) and allowed to continue hydrolysis for 24 hr at 110^{o}C. After hydrolysis, the samples were cooled, opened, and filtered through Whatman No. 1 paper. Filtrates were rinsed 3 times with distilled H_2O and the rinse was filtered as before. The filtrate was dried at 65^{o}C under vacuum, and was then resuspended in a buffer containing 1.96% sodium citrate dihydrate solution with 1% thiodiglycol, pH 2.0. This acid hydrolysis treatment quantitatively converted methionine to methionine sulfone which was analyzed to determine total methionine content using the HPLC (AOAC 2007).

Methionine was calculated based on the formula:

$$METg(uncorrected)/16gN = [\frac{nmolesAA * initialtestsolutionvolume(ml) * MWaa]}{volumetestsolutioninjected(ml) * testportionweight(g) * \%Nfortestportion * 6.25x10^5}$$

(AOAC 2007)

5.3.6 Trials

There were 2 trials of this study conducted. The first trial went from February (planting) to May (2nd harvest). The second trial went from May (planting) to August (2nd harvest).

5.3.7 Statistical Analysis

Descriptive statistics were calculated for all the variables using procedure means within Statistical Analysis System (SAS) version 8.02 (Cary, N.C.). Within SAS, procedure generalized linear model (glm) was conducted to examine if the organic collards were significantly (P-value < 0.05) different from the conventional collards for size, soil minerals, color, polyamines, or amino acids. Additionally procedure correlation was conducted, within SAS, to examine the relationship of polyamines with various quality parameters. The statistical analyses were conducted separately for each trial because significant differences (P-value < 0.05) were found in both organic and conventional collards regarding several variable between the two trials. Statistical significance was determined at a 5% level.

5.4 RESULTS AND DISCUSSION

5.4.1 Collard Production

During the first replication, organic collards grew at a faster rate than conventional, as evidenced by the increased plant height (1.78%/day 2.30%/day, respectively) and plant width (0.94%/day and 1.12%/day for organic and conventional, respectively). The opposite occurred during the second trial where the conventional collards grew at a faster rate than the organic group (height =14.85% vs 10.45%/day; width 27.87% vs 15.95%/day, respectively for conventional and organic). One of the possible explanations for the differences in growth may have been weather. The collards were grown in a greenhouse where the temperature and humidity were controlled however, temperature fluctuations may still occur. Furthermore, organic may have grown at a faster rate than conventional in trial 1, but, in both trials, the conventional was larger (height) than the organic. In fact, the collards had to be harvested at 2 different times (days) because the organic collards were so much smaller in size than the conventional collards. This could be related to soil nutrients in the organic versus as the conventional planting material. The only measure that was not significantly different for conventional versus organic collards, in trial 1, was stem diameter in harvest 1 (Table 1). The remaining measurements (weight, length, and stem diameter harvest 2) were significantly ($P < 0.05$) higher for the conventional compared to the organically grown collard greens. The weight and length for collards in trial 2 and harvest 2 were significantly higher ($P < 0.05$) for conventional versus organic collards. However, the height, for harvest 1, in trial 2 did not show the same pattern ($P > 0.05$).

The lower growth rate (trial 2) and smaller size at harvest of organic compared to conventional collards could be explained by the lower levels of nitrogen in the organic soil (Gaskell, M. and Smith, R., 2007) . Nitrogen is typically the most limiting nutrient to efficient and profitable vegetable production (Gaskell, M. and Smith, R., 2007) .

Organic growers are limited to organic or naturally occurring sources of nitrogen. Soil organic matter make up most of the nitrogen in organic vegetable production. Other important sources come from legumes included as a cover crop, compost, or organic fertilizers (Gaskell, M. and Smith, R., 2007) . In the current study, the soil used for both the conventional and organic collards was left unaltered from the original commercial state with no fertilizers (organic or conventional) added. This may explain why there was such a large difference in growth and size. The nitrogen-phosphorous-potassium percentage of the weight of the bags were found within the original mix in the organic (.1 - .05 - .05) and conventional (.21-.07-.10) potting soils (Scotts company, 2009; Scotts company, 2010). These differences would account for conventional collards larger size and faster growth rate compared to their organic counterparts.

Soil nutrient analysis was performed after each harvest and the significant results are shown in Table 2. During the first trial and the first harvest time, the organic soil was significantly higher (P value <0.05) than the conventional soil in boron while the conventional soil was significantly higher (P value <0.05) than the organic soil in phosphorous, calcium, magnesium and manganese. However, after the second harvest (trial 1), there were no significant differences (P value > 0.05) in the soil nutrients, within the soils. During the first harvest of trial 2, potassium, copper, boron, and sodium were all significantly higher ($P < 0.05$) in the organic soil versus the conventional soil. In the same trial, after the second harvest, potassium, zinc, boron, and sodium were significantly higher (P value < 0.05) in the organic versus conventional potting soil, while calcium, manganese, and copper were significantly higher (P value < 0.05) in the conventional versus organic potting soil. There are 17 nutrient needed for plant growth and development and these include carbon, hydrogen, oxygen, nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, zinc, chlorine, and nickel (Fageria, N.K. and Moreira, A., 2011) . Approximately, 95% of the plant's weight is carbon, hydrogen and oxygen and the remaining 5% is the other 14 nutrients (Fageria, N.K. and Moreira, A., 2011) .

5.4.2 Color

Color of collards was measured because it is the most common attribute used by consumers to make their purchasing decisions and excessive yellowing or discoloration is associated with reduced quality. The L*, a*, and b* are tristimulus color values used for objective colorimetry. In trial 1, a significant difference ($P < 0.05$) was observed in the L* value (50.48 vs 46.97) but not the a* (-5.97 vs -4.98) and b* (6.74 vs 4.61) values ($P > 0.05$) when comparing organic versus conventionally grown collard greens. The organic collard greens were significantly higher in the L* values (50.48 vs 46.97), which means that the organic collards were lighter.

Trial 2 was grown during the summer months and, while the collards were in a controlled atmosphere, there were increased levels of direct sunlight. Since collards are a cool-season plant, this was not the optimal environment for collard production. Therefore, it provided a stressful environment where the researchers could observe how the organic versus conventional collards performed under stress. In trial 2, the a* values were still negative or low and the b* values were still positive. However, in trial 2, all of the values were significantly different when comparing the conventional versus organic collard greens. Similarly to trial 1, the organic collards had a significantly ($P<0.05$) higher L* value than the organic collards signifying that the organic collards were lighter in color than the conventional collards. The organic collards also had significantly ($P<0.05$) higher a* and b* values than the conventional collards. This shows that the organically grown collards are more green and yellow as compared to their conventional counterparts. The fact that the organic collards are lighter and greener than their conventional equivalent could be associated with higher quality. However, the fact that the organic collards are more yellow would be viewed negatively by consumers. The reason for this effect could be the time period at which the collards were grown. This research shows that the conventional collards were more resilient (less yellow) to higher temperatures than the organic collards. These findings are important to producers as they would make their planting decisions.

5.4.3 Polyamine analysis

Regarding the polyamine analysis, there were no significant differences (P value > 0.05) between organic versus conventional collards in polyamine levels during the first trial of this study. The only significant difference within trial 1 occurred during the second harvest (day 91) which overall, produced collards with significantly higher (P value < 0.05) putrescine than collards harvested on day 75. In trial 2, the organic collards were found to contain significantly higher (P value < 0.05) putrescine and spermine than the conventional collards. However, in the same trial, the organic collards were significantly lower (P value < 0.05) than the conventional collards for spermidine. Within trial 2, harvest 2 was significantly lower (P value < 0.050) compared to harvest 1 (data not shown) for both spermine and spermidine but were significantly higher (P value < 0.050) for putrescine. The significant increase in the polyamines for the organic versus conventional collard greens concurs with previous research (Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O., 2008; Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P., 2009) . Lima et al. (2008) found higher levels of polyamines in organic versus conventional produce when they analyzed peels (zucchini squash, banana, potato, eggplant, orange, lime, mango, passion fruit and radish), leaves (zucchini squash, broccoli, carrot, collard, cassava, radish and grape), stalks (broccoli, collard and spinach) and zucchini seeds. The researchers divided the produce was divided into lots containing 4 trials, consisting of three specimens each (N = 12). Even though these researchers found significant differences in polyamine levels in fresh produce, it is difficult to draw major conclusions from on this research because the researchers purchased produce directly from the producers with no record of the organic standards or information on the cultivation practices (Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O., 2008) . Rossetto et al. (2009) were unable get a consistent pattern of polyamine contents among organic versus conventional beet samples. However, when the samples were subjected to cooking, the organic beet samples had a significantly higher concentration ($P < 0.05$) of polyamines compared to conventional beets. Although, this study was informative, the authors did not describe the number of samples analyzed other than to report that triplicate samples were used (Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P., 2009) . Additionally, the article by Rossetto et al. (2009) does, like the previous one, state that they purchased organic produce from certified producers but did not specify if the produce met the same standards as described for USDA organic. Furthermore, since this produce was purchased, they did not have full control over the cultivation process (Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P., 2009) .

Since the collards in the current study were grown during different seasons (winter and summer), the 2 different seasons could be compared for differences in polyamine levels and how that impacted the results. Significant differences in the polyamine levels were not found in organic versus conventional collards during the typical growing periods (winter). However, when the collards were grown during the summer months, the organic collards had significantly higher levels of polyamines (P value < 0.05) than the conventional collards. The differences among the collard greens when they were grown during the summer could be explained by increased stress levels on the collard greens. Lima et al. (2008) hypothesized that stress leads to increased levels of polyamines because polyamines often correlated with the improvement of plant tolerance (Kuznetsov, V.V. and Shevyakova, N.I., 2007) . This information is very important, especially for people suffering from cancer because polyamines have been found to increase proliferation of cells, which has been associated with enhanced tumor growth (Bardocz, S., Duguid, T.J., Brown, D.S., Grant, G., Pusztai, A., White, A., and Ralph, A., 1995). Therefore, cancer patients should be advised not to consumer foods with high levels of polyamines (Gerner, E.W. and Meyskens, F.L., 2004) .

5.4.3 Pearson Correlation

5.4.3.1 Organic collard greens

Review of the current literature shows that no study has investigated the relationship of naturally occurring polyamines and different quality attributes of food. Table 6 presents the Pearson correlation coefficients of individual parameters in relation to putrescine, spermidine, and spermine levels for the organic collard greens. Only the significant Pearson correlation coefficients were reported based on P-value < 0.05. The contents of putrescine, spermidine, and spermine were linearly correlated with each other and with methionine as expected from their physiological relationship. Putrescine is synthesized from ornithine via the amino acid arginine, and is further transformed into spermidine and spermine by successive transfers of aminopropyl groups. Spermidine and spermine are also synthesized from the amino acid methionine. Levels of arginine in organic collards were only significantly correlated with spermidine (r = 0.856; Table 6). This positive correlation means that the levels of arginine and spermidine move in the same direction together.

Putrescine, spermidine and spermine were all closely related to the b* color values with a Pearson's correlation of 0.594, 0.68, and 0.738, respectively. These results suggest that as the levels of these polyamines increase in the tissue, there is a corresponding increase in yellowing of the collard greens. This may be occurring because of the breakdown of chlorophyll to pheophytin. These results are significant because yellowness could be used as a means of predicting higher levels of polyamines-something critical to cancer patients if they are trying to avoid foods with high levels of polyamines. These findings disagree with previous research that found that polyamines can prevent the loss of chlorophyll (Cheng, S.H. and Kao, C.H., 1983; Cohen, A.S., Popovic, R.B., and Zalik, S., 1979) ; however; conversion to brown-yellow pheophytin does not translate into chlorophyll loss. Another study conducted by Besford and others (1993) found that treatment of spermidine and spermine prevented the loss of chlorophyll via the preservation of the thylakoid membranes at the site of the chlorophyll-protein complexes. However, in the same study, putrescine was associated with the loss of chlorophyll (Besford, R.T., Richardson, C.M., Campos, J.L., and Tiburcio, A.F., 1993) .

Higher levels of putrescine, spermidine and spermine were associated with lower pH values in collards. This agrees with previous studies that found that putrescine content rose with low pH values (5.0 or below), or higher hydrogen ion concentration (Young, N.D. and Galston, A.W., 1983) . This occurs because the ADC-mediated pathway of putrescine is activated under low pH which stimulates production (Flores, 1991). As stated previously, spermidine and spermine are highly correlated (P-value = 0.0002 and <0.0001, respectively) with putrescine because they are synthesized from putrescine. Potassium, phosphorous, and sodium within the soil of the organic collards were found to be positively correlated with spermidine and spermine levels. Putrescine, spermidine, and spermine were positively correlated with calcium, magnesium, zinc, manganese, and boron within the soil of the organic collards. Spermidine concentrations were negatively correlated with weight of collards. This finding agrees with previous research that found feeding spermidine to chicks, at high concentrations (0.4%), depressed chick growth because the spermidine becomes toxic to the chicks (Smith, T.K., Mogridge, J.A.L., and Sousadias, M.G., 1996) .

5.4.3.2 Conventional collard greens

Table 7 shows the Pearson correlation coefficients of individual parameters with putrescine, spermidine, and spermine for the conventional collard greens. The only significant parameter (P value <0.05) for the conventional collard greens was stem diameter which correlated with putrescine and spermidine with spermine (Table 7). Putrescine had a positive relationship (0.631) with stem diameter and spermidine had a positive relationship (0.833) with spermine in conventional collards. Exogenous putrescine has been shown to enhance plant size (Gupta, S. and Gupta, N.K., 2011) and the positive relationship between spermidine and spermine has been discussed earlier.

5.5 CONCLUSION AND FUTURE RESEARCH

The current research found that conventional collard greens grow at a faster rate and to a larger finishing size than their organic counterparts. However, collards evaluated in this study were not given any additional fertilizer besides what was already in the soil. Growth parameters may have been different if certified organic fertilizer had been given to the organic collard greens. Overall the organic collards were lighter in color as compared to the conventional collards. However, during the summer months, when the collards were under more stress, the organic collards became more yellow in color. This signifies that the organic collards may not maintain their quality when exposed to environmental stressors. Significant differences between the polyamine concentrations of organic versus conventional collards were not found during the typical growing season (winter). However, during the summer production, the organic collards contained significantly higher levels of putrescine and spermine than the conventional collards but significantly lower for spermidine. The fact that the current research shows a difference in the levels of polyamines, depending on the growing season is very informative for producers. The current research also found a significant relationship of higher levels of polyamines contributing to a more yellow collard green. This would be an excellent way for cancer patients, who are told to have a diet low in polyamines, to screen for collards that may be high in these compounds. Additionally, the current research shows that the growing season is a major factor in polyamine concentration. Previous research has shown that cooking can also significantly increase polyamine levels in organic versus conventional beets (Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P., 2009) . Future studies could be conducted to compare raw and cooked organic/conventional collards for polyamine concentrations. The present study was strengthened by its' larger sample sizes and by evaluating one type of produce-collard greens. However, it would be interesting to conduct similar greenhouse studies on different types of fruits and vegetables provided the sample size could be large enough to detect statistically significant differences. There has been a great deal of work on the exogenous treatment of polyamines and their effect on plant oxidation, but additional research is needed to examine the differences in the naturally occurring antioxidant abilities of organic versus conventional collards.

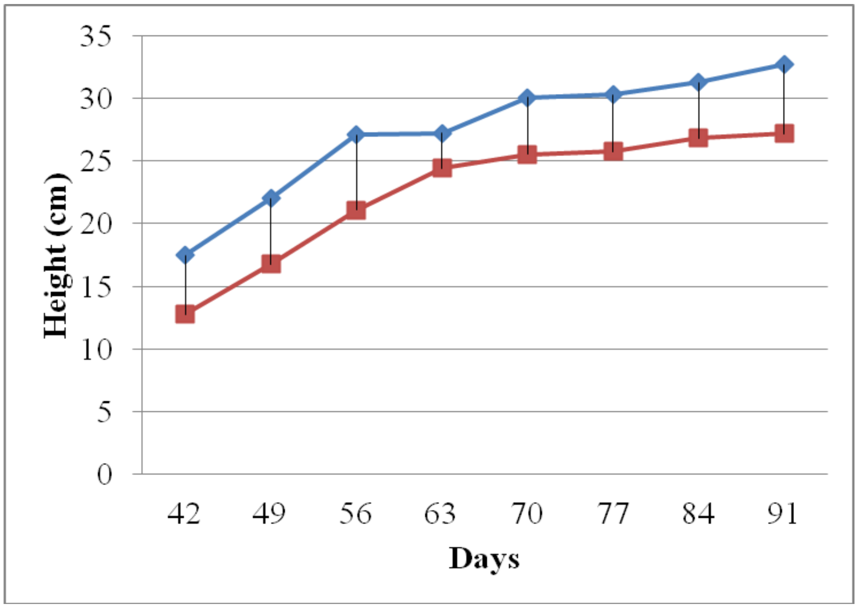

Figure 5.1-Height change of organic (□) versus conventional (◊) collards over time in trial 1.

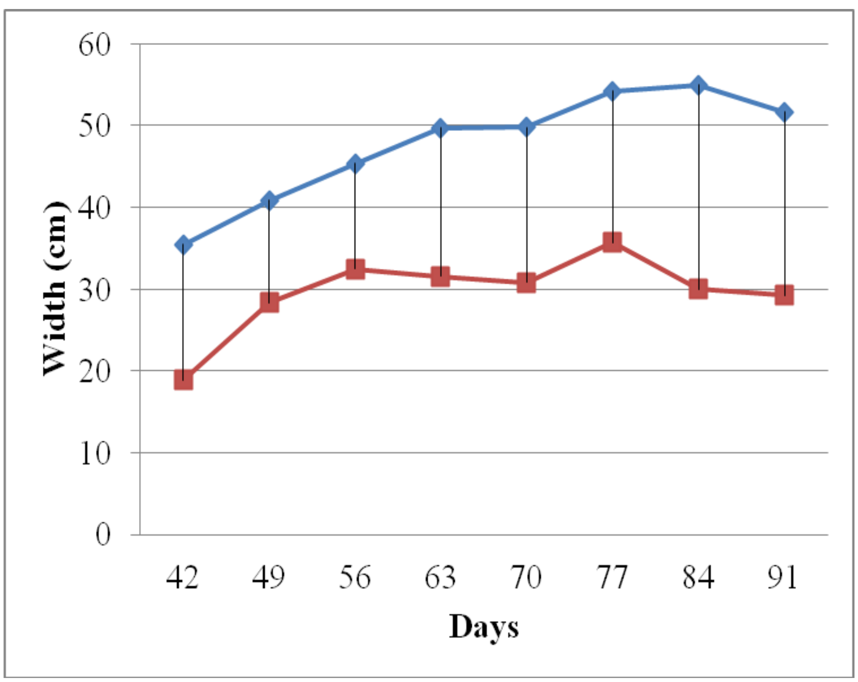

Figure 5.2-Width change of organic (□) versus conventional (◊) collards over time in trial 1.

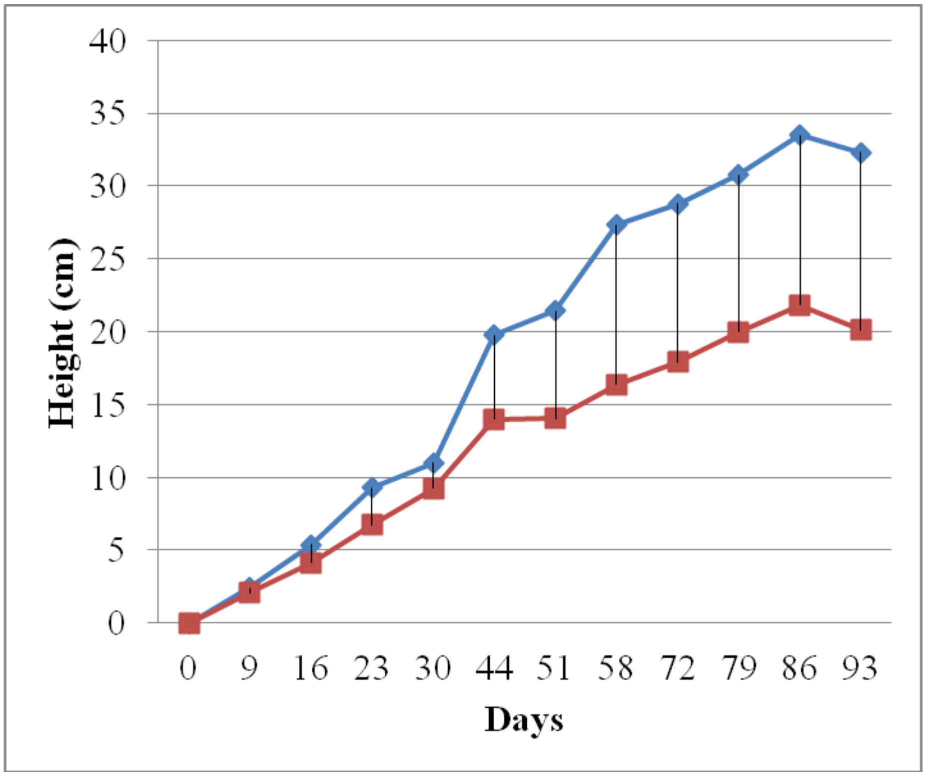

Figure 5.3-Height change of organic (□) versus conventional (◊) collards over time in trial 2.

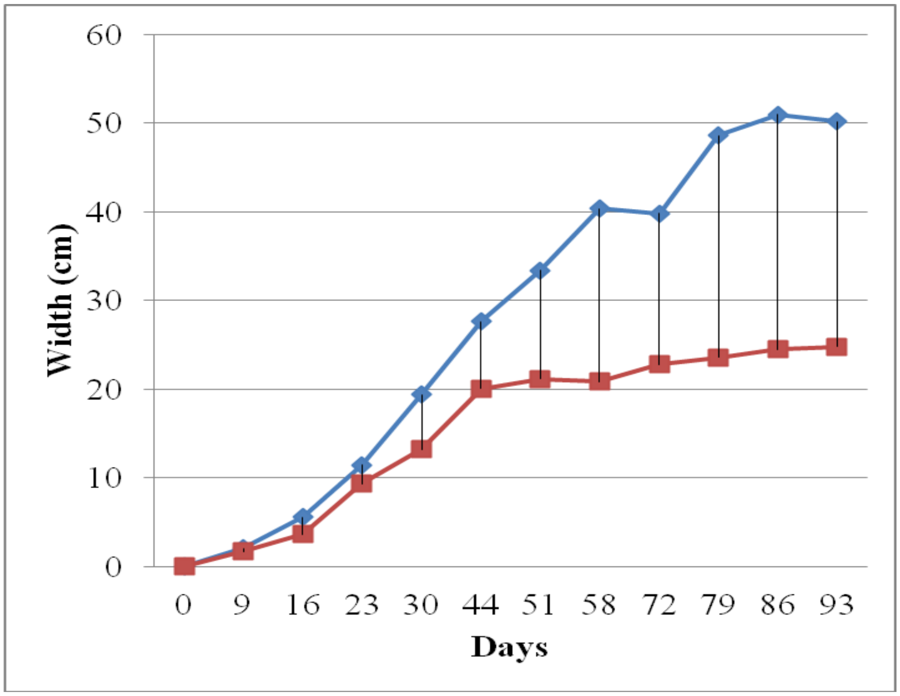

Figure 5.4-Width change of organic (□) versus conventional (◊) collards over time in trial 2.

Table 5.1-Measurements of organic and conventional collards greens at harvest[1,2]

	Trial 1[3]					
	Harvest 1			Harvest 2		
	Weight (g)	Length (cm)	Stem Diameter (cm)	Weight (g)	Length (cm)	Stem Diameter (cm)
Conventional	130.0±15.1 b	13.75±0.19 b	0.617±0.13 a	130.1±15.6 b	15.87±0.72 b	0.740±0.04 b
Organic	41.55±12.1 a	10.54±1.03 a	0.307±0.04 a	46.66±1.94 a	11.87±0.43 a	0.520±0.02 a
	Trial 2[3]					
	Harvest 1			Harvest 2		
	Weight (g)	Length (cm)	Stem Diameter (cm)	Weight (g)	Length (cm)	Stem Diameter (cm)
Conventional	144.9±8.96 b	10.58±3.47 a	0.477±0.129 a	159.0±15.0 b	37.62±2.25 b	0.507±0.017 a
Organic	10.72±1.58 a	8.320±0.22 a	0.223±0.027 a	17.42±1.11 a	25.18±0.94 a	0.217±0.205 a

[1]Mean±SE

[2]Within each harvest of each trial N =12 plants

[3]Means with different letters within columns indicate a significant difference (P-value<0.05)

Table 5.2-Analysis of organic and conventional soil minerals (1bs/acre) at harvest[1,2]

	Trial 1[3]				
	Harvest 1				
	P	Ca	Mg	Mn	B
Conventional	163.8±7.92 a	2606±56.3 a	473.6±12.2 a	30.00±3.45 a	1.920±0.09 a
Organic	209.7±10.7 b	3013±96.5 b	603.3±22.3 b	51.67±1.58 b	1.320±0.05 b

	Trial 2[3]										
	Harvest 1			Harvest 2							
	K	Cu	B	Na	K	Ca	Zn	Mn	Cu	B	Na
Conventional	1247 ±60.0 a	2.775 ±0.20 a	2.200 ±0.09 a	329.5 ±10.0 a	976.0 ±61.0 a	2975 ±72.8 a	18.97 ±0.38 a	35.67 ±2.24 a	1.400 ±0.08 a	1.650 ±0.06 a	276.8 ±10.0 a
Organic	812.3 ±83.4 b	1.467 ±0.03 b	1.725 ±0.15 b	208.0 ±20.8 b	699.4 ±86.0 b	3227 ±57.2 b	16.93 ±0.45 b	55.38 ±1.82 b	2.525 ±0.04 b	1.413 ±0.09 b	207.0 ±32.3 b

[1]Mean±SE
[2]Within each harvest of each trial N =12 plants
[3]Means with different letters within each column indicate a significant difference (P-value<0.05)

Table 5.3-Color of collard greens at harvest[1,2]

	Trial 1[3]					
	Harvest 1			Harvest 2		
	L*[4]	a*[4]	b*[4]	L*[4]	a*[4]	b*[4]
Conventional	46.97±0.69 a	-4.98±0.39 a	4.61±0.35 a	44.81±0.32 a	-5.51±0.26 a	5.75±0.31 a
Organic	50.48±0.62 b	-5.57±0.93 a	6.74±0.88 a	50.73±1.14 b	-6.49±0.44 a	6.84±1.20 a

	Trial 2[3]					
	Harvest 1			Harvest 2		
	L*[4]	a*[4]	b*[4]	L*[4]	a*[4]	b*[4]
Conventional	45.60±0.69 a	-4.74±0.16 a	4.24±0.35 a	46.21±1.11 a	-5.58±0.38 a	5.51±0.610 a
Organic	53.40±0.71 b	-7.35±0.25 b	8.08±0.38 b	54.99±1.31 b	-7.71±0.11 b	8.80±0.172 b

[1]Mean±SE
[2]Within each harvest of each trial N =12 plants
[3]Means with different letters within each column indicate a significant difference (P-value<0.05)
[4]lightness (L*), redness (a*), yellowness (b*)

Table 5.4-Putrescine, spermine, and spermidine (nmol/g of fresh sample) in collard greens grown under conventional and organic production systems[1,2]

	Trial 1[3]					
	Harvest 1			Harvest 2		
	Putrescine	Spermidine	Spermine	Putrescine	Spermidine	Spermine
Conventional	46.85±2.87 a	10.78±3.49 a	46.73±9.77 a	96.01±15.4 a	13.04±8.64 a	57.05±31.0 a
Organic	52.57±11.8 a	10.97±0.79 a	49.89±4.17 a	75.32±10.0 a	13.56±4.86 a	63.50±27.0 a
	Trial 2[3]					
	Harvest 1			Harvest 2		
	Putrescine	Spermidine	Spermine	Putrescine	Spermidine	Spermine
Conventional	76.12±16.6 a	21.21±2.70 a	61.29±5.33 a	30.81±2.71 a	6.827±1.57 a	38.24±6.90 a
Organic	192.2±31.3 b	52.62±4.76 b	183.2±7.20 b	41.39±11.7 a	18.30±9.12 a	55.62±15.3 a

[1]Mean±SE
[2]Within each harvest of each trial N =12 plants
[3]Means with different letters within each column indicate a significant difference (P-value<0.05)

Table 5.5- Methionine and Arginine (g $100g^{-1}$) in collard greens grown under conventional and organic production systems[1,2]

	Trial 1[3]			
	Harvest 1		Harvest 2	
	Methionine	Arginine	Methionine	Arginine
Conventional	0.277±0.18 a	0.727±0.05 a	0.273±0.01 a	0.743±0.06 a
Organic[2]	0.220±0.03 a	0.520±0.01 b	0.163±0.01 b	0.417±0.03 b
	Trial 2[3]			
	Harvest 1		Harvest 2	
	Methionine	Arginine	Methionine	Arginine
Conventional	0.317±0.04 a	0.870 ±0.11	0.223±0.02 a	0.610±0.07 a
Organic	0.377±0.03 a		0.240±0.06 a	0.617±0.16 a

[1]Mean±SE
[2]Within each harvest of each trial N =12 plants
[3]Means with different letters within each column indicate a significant difference (P-value<0.05)

Table 5.6- Pearson correlation (P-value) of individual parameter with diamine (putrescine) and polyamines (spermidine and spermine) within organic collard greens[1]

	Putrescine	**Spermidine**	**Spermine**
Spermidine	0.879 (0.0002)		0.947 (<0.0001)
Spermine	0.900 (<0.0001)	0.947 (<0.0001)	
b*	0.594 (0.0418)	0.680 (0.0150)	0.738 (0.0062)
Methionine	0.733 (0.0067)	0.905 (<0.0001)	0.803 (0.0016)
Arginine		0.856 (0.0067)	
Soil Ph	-0.622 (0.0309)	-0.790 (0.0022)	-0.707 (0.0101)
Soil Buffer Ph	-0.612 (0.0346)	-0.635 (0.0265)	-0.724 (0.0077)
Soil Phosphorous		0.628 (0.0286)	0.635 (0.0266)
Soil Potassium		0.679 (0.0152)	0.715 (0.0090)
Soil Calcium	0.708 (0.0100)	0.751 (0.0049)	0.818 (0.0011)
Soil Magnesium	0.738 (0.0062)	0.784 (0.0025)	0.842 (0.0006)
Soil Zinc	0.655 (0.0209)	0.684 (0.0142)	0.766 (0.0037)
Soil Manganese	0.775 (0.0031)	0.787 (0.0024)	0.860 (0.0003)
Soil Boron	0.594 (0.0418)	0.680 (0.0150)	0.738 (0.0062)
Sodium		0.607 (0.0363)	0.663 (0.0188)
Weight		-0.642 (0.0245)	

[1]Only significant correlations are displayed (P-value < 0.05).

Table 5.7- Pearson correlation (P-value) of individual parameter with diamine (putrescine) and polyamines (sperminidine and spermine) within conventional collard greens[1]

	Putrescine	Spermidine
Stem diameter	0.631 (0.0277)	
Spermine		0.833 (0.0008)

[1]Only significant correlations are displayed (P-value < 0.05).

5.6 References

Bardocz S, Duguid TJ, Brown DS, Grant G, Pusztai A, White A, Ralph A (1995) The importance of dietary polyamines in cell regeneration and growth. Br J Nutr

Besford R, Richardson C, Campos J, Tiburcio A (1993) Effect of polyamines on stabilization of molecular complexes in thylakoid membranes of osmotically stressed oat leaves. Planta

Bregoli AM, Scaramagli S, Costa G, Sabatini E, Ziosi V, Biondi S, Torrigiani P (2002) Peach (Prunus persica) fruit ripening: aminoethoxyvinylglycine (AVG) and exogenous polyamines affect ethylene emission and flesh firmness. Physiol Plantarum. doi: 10.1034/j.1399-3054.2002.1140317.x

Cheng SH, Kao CH (1983) Localized effect of polyamines on chlorophyll loss. Plant and cell physiology

Cohen AS, Popovic RB, Zalik S (1979) Effects of polyamines on chlorophyll and protein content, photochemical activity, and chloroplast ultrastructure of barley leaf discs during senescence. Plant Physiol

Fageria N, Moreira A (2011) 4 The Role of Mineral Nutrition on Root Growth of Crop Plants. Adv Agron

Flores HE (1991) Changes in polyamine metabolism in response to abiotic stress. Biochemistry and Physiology of polyamines in plants

Gaskell M, Smith R (2007) Nitrogen sources for organic vegetable crops. HortTechnology

Gerner EW, Meyskens FL (2004) Polyamines and cancer: old molecules, new understanding. Nature Reviews Cancer

Gupta S, Gupta N (2011) Field efficacy of exogenously applied putrescine in wheat (Triticum aestivum) under water-stress conditions. Indian J Agric Sci

Kuznetsov VV, Shevyakova NI (2007) Polyamines and stress tolerance of plants. Plant Stress

Lima GPP, Da Rocha SA, Takaki M, Ramos PRR, Ono EO (2008) Comparison of polyamine, phenol and flavonoid contents in plants grown under conventional and organic methods. Int J Food Sci Tech

Martínez-Romero D, Serrano M, Carbonell A, Burgos L, Riquelme F, Valero D (2002) Effects of postharvest putrescine treatment on extending shelf life and reducing mechanical damage in apricot. J Food Sci

Martínez-Romero D, Valero D, Serrano M, Martínez-Sánchez F, Riquelme F (1999) Effects of post-harvest putrescine and calcium treatments on reducing mechanical damage and polyamines and abscisic acid levels during lemon storage. J Sci Food Agric

Martinez-Romero D, Serrano M, Carbonell A, Castillo S, Riquelme F, Valero D (2004) Mechanical damage during fruit post-harvest handling: technical and physiological implications. Production practices and quality assessment of food crops

Martínez-Romero D, Guillén F, Valverde JM, Bailén G, Zapata P, Serrano M, Castillo S, Valero D (2007) Influence of carvacrol on survival of Botrytis cinerea inoculated in table grapes. Int J Food Microbiol

Paksasorn A, Hayasaka T, Matsui H, Ohara H, Hirata N (1995) Relationship of polyamine content to acc content and ethylene evolution in Japanese apricot fruit. J Jpn Soc Hortic Sci

Physical Activity Guidelines Advisory Committee (2008) Physical activity guidelines advisory committee report, 2008. Washington, DC: US Department of Health and Human Services

Rossetto MRM, Vianello F, da Rocha1and SA, Lima GPP (2009) Antioxidant substances and pesticide in parts of beet organic and conventional manure. African Journal of Plant Science

Scotts Company (2010) Miracle-Gro® organic choice® potting mix, 0.10-0.05-0.05

Scotts Company (2009) Miracle-Gro® potting mix 0.21-0.07-0.14 with micromax®

Serrano M, Martinez-Romero D, Guillen F, Valero D (2003) Effects of exogenous putrescine on improving shelf life of four plum cultivars. Postharvest Biol Technol

Smith TK, Mogridge JAL, Sousadias MG (1996) Growth-promoting potential and toxicity of spermidine, a polyamine and biogenic amine found in foods and feedstuffs. J Agric Food Chem

Torrigiani P, Bregoli AM, Ziosi V, Scaramagli S, Ciriaci T, Rasori A, Biondi S, Costa G (2004) Pre-harvest polyamine and aminoethoxyvinylglycine (AVG) applications modulate fruit ripening in Stark Red Gold nectarines (Prunus persica L. Batsch). Postharvest Biol Technol. doi: 10.1016/j.postharvbio.2004.03.008

Valero D, Martínez-Romero D, Serrano M (2002) The role of polyamines in the improvement of the shelf life of fruit. Trends Food Sci Technol

Valero D, Pérez-Vicente A, Martínez-Romero D, Castillo S, Guillen F, Serrano M (2002) Plum storability improved after calcium and heat postharvest treatments: role of polyamines. J Food Sci

Valero D, Martínez-Romero D, Serrano M, Riquelme F (1999) Polyamine roles on the post-harvest of fruits: a review

Young ND, Galston AW (1983) Putrescine and Acid Stress Induction of Arginine Decarboxylase Activity and Putrescine Accumulation by Low pH. Plant Physiol

CHAPTER SIX

CONCLUSION

Americans are eating more of all food groups, including fruits and vegetables. However, Wells and Buzby (2008) found that fruit and vegetable consumption was still below the recommendation in the 2005 Dietary Guidelines. In order to meet these recommendations, Americans need to consume less added fats, refined grains, and added sugar and increase their consumption of fruits and vegetables (Wells, H.F. and Buzby, J.C., 2008) . Health conscious and environmentally aware consumers have contributed to the unprecedented growth of the organic produce sector (Dettmann, 2008). Fresh produce continues to be the most popular organic category with a steady growth of 15% between 1997 and 2007 (Dimitri, C. and Oberholtzer, L., 2009) . Organic producers are actually having a difficult time meeting this demand and this reflects the need for more certified organic acres. Recently, after the establishment of the USDA organic standards, there has been a shift in the demand for organic foods. A food that was originally linked to small farms, improved animal welfare, sustainability, and community support was now being called "organic lite" because of the "corporate co-optation of the organic food market" (Adams, D.C. and Salois, M.J., 2010) . Therefore, it is not surprising that many of these organic consumers turned to local food following the development of the USDA organic standards. The present study was conducted not only to identify consumer produce purchase decisions, and challenges incurred by SC produce farmers, but also to examine the differences in various chemical and quality attributes of organic versus conventional collard greens grown in a greenhouse.

During the present study, findings from the SC consumer survey agreed with previous work from Adams and Salois (2010) who found that many of the organic consumers have shifted their support from organic food to local food after the development of the USDA organic standards. The present survey found that 85% of the organic consumers who were surveyed indicated that if they were given a choice they would purchase local produce over organic produce if given a choice. In other words, if these consumers were made aware of these local products they would purchase the local alternative. The current study also found that 38% of the SC consumers were not aware of the certified SC grown program. Even though this statistic seems disappointing, other states with similar programs reported that 62% of their consumers were not aware of their state produce program (Brown, 2003). Furthermore, 38% of these SC consumers indicated that they never purchase certified organic produce. Of these consumers, the most important reason for not purchasing certified organic produce was that it is "too expensive." Of the SC consumers who said that they purchased certified organic produce, 75% of them indicated that the most negative aspect of this product was its' expense. Additionally, 50% of these organic consumers stated that they chose to purchase organic produce because they perceived it to have a higher level of food safety than conventional produce.

Although these findings are informative, it is important to state that this sample was non-random. Time constraints prevented the survey from being distributed to more grocery stores around S.C. Therefore, conclusions can only be drawn based on the non-random sample that was collected and conclusion cannot be made about all U.S. consumers or all S.C. consumers.

The needs assessment survey of SC produce farmers found that 71% of these farmers were using conventional production methods. However, 68% of these farmers indicated that they needed more information about organic and biological control products. Despite this need for information on organic agriculture, 62% of the farmers stated that they were "not sure" if they needed additional educational training on farming practices from Clemson University. This may reflect that current training may not be fulfilling the needs of the producer and that an organic farming workshop or training resources might be well received by SC farmers. Additionally, with the recent signing of the Federal Food Safety Modernization Act (FSMA), the farmers would benefit from more Good Agricultural Practices (GAPs) trainings as well as trainings on the preventative measures they can take against various plant diseases.

Although these findings are informative, it is important to state that this sample was non-random. Time constraints prevented the survey from being distributed to more produce farmers around S.C. Therefore, conclusions can only be drawn based on the non-random sample that was collected and conclusion cannot be made about all S.C. produce farmers.

During a greenhouse study that compared the quality of organic versus conventionally grown collard greens, the overall size of the organic collards were significantly smaller (P-value < 0.05) than the conventional collards. In fact, the collard greens were harvested on two different days (75 and 91-96 days post-planting) to allow the organic collards more time to grow to determine if they would reach the same size as the conventional collards. However at every harvest time during two replications, the weight of the conventional collards was significantly higher (P-value < 0.05) than the weight of the organic collards. This means that organic farmers with the same acreage and number of plants will produce overall yield of product that is lower than conventional farmers. The organic collards were significantly lighter in color (P-value < 0.05) than the conventional collards over the entire course of the experiment. Level of polyamines recovered from collard leaves was not significantly different during the first trial and these data disagree with that reported in previous research (Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O., 2008; Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P., 2009) . However, polyamines were found to be significantly higher in the organic collards compared to the conventional collards when the collards were grown during the summer (second replication). This may be due to the fact that growing collards during the summer causes stress and stress has been shown to increase levels of polyamines in plant tissue. (Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O., 2008; Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P., 2009) suggested that the higher levels of polyamines may result from the increased stress because organic standards do not allow pesticide application. Thus, presence of pests will lead to higher levels of stress in organic cultivars. The present study is the first research study to correlate levels of polyamines with different quality attributes of organic versus conventional collard greens. Within the organic collard greens, the polyamines were positively related to soil minerals and negatively correlated with soil pH. Additionally, the polyamine spermidine was negatively correlated (P-value < 0.05) with weight of the collard plants. This finding agrees with previous research which shows feeding high concentrations (0.4%) of spermidine, depressed chick growth because the spermidine becomes toxic to the chicks (Smith, T.K., Mogridge, J.A.L., and Sousadias, M.G., 1996) . Future research projects could be conducted using certified organic fertilizer and determining the impact of the additional nutrients on the growth of the organic collards to determine if the size would approach that of their conventional counterparts. Another study comparing raw and cooked collards for polyamine concentrations would also show if cooking affects the level of polyamines in the plant tissue.

The current study was strengthened by its' larger sample sizes because the researchers only examined collard greens. However, it would be interesting to conduct similar greenhouse studies on different types of fruit and vegetables. Several projects have been conducted on the exogenous treatment of polyamines and their effect on plant oxidation, but it would be valuable to examine the differences in the naturally occurring antioxidant abilities of organic versus conventional collards.

References

Adams, D.C. and Salois, M.J. (2010). Local versus organic: A turn in consumer preferences and willingness-to-pay. *Renewable Agriculture and Food Systems, 25*(4), 331.

Brown, C. (2003). Consumers' preferences for locally produced food: A study in southeast missouri. *American Journal of Alternative Agriculture, 18*(4), 213-224.

Dettmann, R. L. (2008). Organic produce: Who’s eating it? A demographic profile of organic produce consumers. Paper presented at the *Annual Meeting of the American Agricultural Economics Association,*

Dimitri, C. and Oberholtzer, L. (2009). *The US organic handling sector in 2004: Baseline findings of the nationwide survey of organic manufacturers, processors, and distributors* (36th ed.) U.S. Dept. of Agriculture, Economic Research Service.

Lima, G.P.P., Da Rocha, S.A., Takaki, M., Ramos, P.R.R., and Ono, E.O. (2008). Comparison of polyamine, phenol and flavonoid contents in plants grown under conventional and organic methods. *International Journal of Food Science & Technology, 43*(10), 1838.

Rossetto, M.R.M., Vianello, F., da Rocha, S.A., and Lima, G.P.P. (2009). Antioxidant substances and pesticide in parts of beet organic and conventional manure. *African Journal of Plant Science, 3*(11), 245.

Smith, T.K., Mogridge, J.A.L., and Sousadias, M.G. (1996). Growth-promoting potential and toxicity of spermidine, a polyamine and biogenic amine found in foods and feedstuffs. *Journal of Agricultural and Food Chemistry, 44*(2), 518.

Wells, H.F. and Buzby, J.C. (2008). *Dietary assessment of major trends in US food consumption, 1970-2005.* (No. 33).US Department of Agriculture, Economic Research Service.

APPENDIX A

S.C. CONSUMER SURVEY

The following questions are part of a graduate student's program to identify consumer purchase preference of produce in SC. For each question, please indicate the answer(s) that you feel best represent(s) your household.

Do you purchase South Carolina certified produce?

- ☐ No
- ☐ Yes
- ☐ Not sure

How often do you purchase fresh conventionally grown produce (uncooked fruits or vegetables that you normally find at the grocery store and are not certified organic)?

- ☐ Never
- ☐ Daily
- ☐ Weekly
- ☐ Monthly
- ☐ Yearly

How often do you purchase organically labeled produce (or produce grown without using most conventional pesticides, petroleum-based fertilizers, or sewage sludge-based fertilizers)?

- ☐ Never
- ☐ Daily
- ☐ Weekly
- ☐ Monthly
- ☐ Yearly

How much (in dollars) do you pay for organic produce during a typical shopping trip?

- ☐ <$10
- ☐ $10-$20
- ☐ $20-$30
- ☐ $30-$40
- ☐ >$40
- ☐ Not sure

Do you buy organically grown produce to support local farmers?

- ☐ No
- ☐ Yes
- ☐ Not sure

Would you still buy organically grown produce even if it is not locally grown?

- ☐ No
- ☐ Yes
- ☐ Not sure

If you had to choose between buying local conventionally grown produce OR buying organically grown produce not grown locally, which would you choose?

- ☐ Local conventionally grown produce

☐ Organically grown produce not grown locally

Why do you purchase organically grown produce? For each of the selected attributes nplease select the level of importance on a scale of 1 to 5 (1 = extremely unimportant, 2 = unimportant 3 = somewhat important, 4 = important 5 = extremely important)

	Extremely unimportant	Unimportant	Somewhat important	Important	Extremely important
Safe (incidence of disease)	☐	☐	☐	☐	☐
Nutritious	☐	☐	☐	☐	☐
Environmentally Friendly	☐	☐	☐	☐	☐

Of the attributes listed below, which one is the most important to you?

☐ Safe (incidence of disease)
☐ Nutritious
☐ Environmentally friendly
☐ None of the above

Please specify what attribute is most important to you.

Please select what you consider to be the most negative aspect of organic produce.

☐ Too expensive
☐ Not available
☐ Poor quality (appearance)
☐ None of these are negative attributes

Which aspect of organic farming is most important to you? Select only one.

☐ No conventional pesticides (fungicides and insecticides) are used.
☐ No fertilizers made with synthetic ingredients (chemicals) and sewage sludge (mix of water and whatever wastes from domestic and industrial life) are used.
☐ No bioengineering (food that has had a gene from a different species of plant or other organism introduced to produce desired traits) are used.
☐ No ionizing radiation (process used to destroy microorganisms, bacteria, viruses, or insects that might be present in the food) are used.

Why do you not purchase organically grown produce? For each of the following reasons, please select the level of importance on a scale of 1 to 5 (1 =Extremely unimportant, 2 = unimportant 3 = somewhat important, 4 = important 5 = extremely important).

	Extremely unimportant	Unimportant	Somewhat important	Important	Extremely important
Too expensive	☐	☐	☐	☐	☐
Not available where I shop for food	☐	☐	☐	☐	☐
Not convinced of the benefits for organic produce	☐	☐	☐	☐	☐
Not always sure that the produce labeled organic is actually organic	☐	☐	☐	☐	☐
Lack of transportation	☐	☐	☐	☐	☐
Lack of information	☐	☐	☐	☐	☐

How knowledgeable (informed) are you about organic produce?

- ☐ Not very knowledgeable
- ☐ Knowledgeable
- ☐ Very knowledgeable
- ☐ I do not care

Are there types of organic produce (apples, broccoli, etc.) that you want to purchase but cannot find in your local area?

- ☐ No
- ☐ Yes

Please specify the types of produce (apples, broccoli, etc.) you want to purchase but cannot find in your area.

Would you buy organic produce with the following defects?

	Definitely buy	Probably buy	Might or might not buy	Probably not buy	Definitely not buy
Insect holes	☐	☐	☐	☐	☐
Bruising/soft spots	☐	☐	☐	☐	☐

Please select your primary grocery store (you may select more than one).

- ☐ Ingles
- ☐ Whole Foods Market
- ☐ Bi Lo
- ☐ Food Lion
- ☐ Publix
- ☐ Warehouse stores (Costco, Sam's Club etc.)
- ☐ Walmart
- ☐ Other

If other, please identify

Current age

- ☐ 18-29
- ☐ 30-39
- ☐ 40-49
- ☐ 50-59
- ☐ 60-69
- ☐ 70+

Gender

- ☐ Male
- ☐ Female

What is your racial background?

- ☐ American Indian or Alaskan native
- ☐ Asian or Pacific Islander
- ☐ Black
- ☐ White (Caucasian)
- ☐ Other

If Other, please specify

Permanent residence

- ☐ Urban (50,000+ people)
- ☐ Suburban (less dense residential areas surrounding cities)
- ☐ Rural (large and isolated areas of an open country with < 2,500 people)

Including yourself, how many of these members are living in your permanent residence?

	0	1	2	3	4	>4
Children under 10 years of age	☐	☐	☐	☐	☐	☐
Children 10 to 14 years of age	☐	☐	☐	☐	☐	☐
Children 15 to 17 years of age	☐	☐	☐	☐	☐	☐
Adults 18 years of age or older	☐	☐	☐	☐	☐	☐

What is the highest degree or level of school you have completed?

- ☐ Some high school
- ☐ Earned high school diploma
- ☐ Some college
- ☐ Earned college diploma
- ☐ Earned graduate or professional degree

What is/was your major?

- ☐ Agriculture, Fore sty, and Life Science
- ☐ Architecture, Arts, and Humanity
- ☐ Business and Behavioral Sciences
- ☐ Engineering and Science
- ☐ Health, Education, and Human Development

What is/was your major?

- ☐ Agriculture, Fore sty and Life Science
- ☐ Architecture, Arts and Humanity
- ☐ Business and Behavioral Sciences
- ☐ Engineering and Science
- ☐ Health, Education and Human Development

What is/was your major?

- ☐ Agriculture, Fore sty and Life Science
- ☐ Architecture, Arts and Humanity
- ☐ Business and Behavioral Sciences
- ☐ Engineering and Science
- ☐ Health, Education and Human Development

What is your current employment status?

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Not employed

Your approximate yearly gross income (includes work pay, financial assistance, financial aid).

- ☐ Less than $25,000
- ☐ $25,000 to $50,000
- ☐ $50,001 to $75,000
- ☐ More than $75,000

- ☐ Prefer not to answer
- ☐ Not sure

APPENDIX B

S.C. PRODUCE FARMER SURVEY

The following questions are part of a graduate student's program to identify types of farming in SC and farmer-needs. For each question, please identify the answer that you feel best represents your farm.

Farming Practices

1. **Please select your problem weeds and for each selected weed select the level of severity on a scale of 1 to 5 (1 = not very severe, 3 = somewhat severe, 5 = extremely severe).**

- ☐ Carolina geranium
- ☐ Chickweed
- ☐ Galinsoga
- ☐ Henbit
- ☐ Lambsquarters
- ☐ Pigweed
- ☐ Purslane
- ☐ Ragweed
- ☐ Morning glory
- ☐ Nutsedge
- ☐ Johnson grass
- ☐ Vetch
- ☐ Smartweed
- ☐ Field Sandbur
- ☐ Wild mustard
- ☐ Broadleaf Signalgrass
- ☐ None

For each problem weed, please select the level of severity on a scale of 1 to 5 (1 = not very severe, 3 = somewhat severe, 5 = extremely severe).

	1	2	3	4	5
Carolina geranium	☐	☐	☐	☐	☐
Chickweed	☐	☐	☐	☐	☐
Galinsoga	☐	☐	☐	☐	☐
Henbit	☐	☐	☐	☐	☐
Lambsquarters	☐	☐	☐	☐	☐
Pigweed	☐	☐	☐	☐	☐
Purslane	☐	☐	☐	☐	☐
Ragweed	☐	☐	☐	☐	☐
Morning glory	☐	☐	☐	☐	☐
Nutsedge	☐	☐	☐	☐	☐
Johnson Grass	☐	☐	☐	☐	☐
Vetch	☐	☐	☐	☐	☐

	1	2	3	4	5
Smartweed	☐	☐	☐	☐	☐
Field Sandbur	☐	☐	☐	☐	☐
Wild Mustard	☐	☐	☐	☐	☐
Broadleaf Signalgrass	☐	☐	☐	☐	☐

2. **Do you have difficulties with nutrient deficiencies on your farm?**
   - ☐ No
   - ☐ Yes
   - ☐ Not sure

   If yes, please type which nutrient deficiencies you are having difficulty with on your farm?
   ____

3. **Do you practice soil testing annually?**
   - ☐ No
   - ☐ Yes
   - ☐ Not sure

4. **Please select the plant diseases or viruses that reduce your crop yield.**
   - ☐ Anthracnose
   - ☐ Black rot
   - ☐ Botrytis fruit rot
   - ☐ Mosaic
   - ☐ Rust
   - ☐ Fungal wilt
   - ☐ Bacterial wilt
   - ☐ Bacterial spot
   - ☐ Downy mildew
   - ☐ Powdery mildew
   - ☐ Fusarium wilt
   - ☐ Other
   - ☐ None

   For each problem plant diseases or viruses, please select the level of severity on a scale of 1 to 5 (1 = not very severe, 3 = somewhat severe, 5 = extremely severe).

	1	2	3	4	5
Anthracnose	☐	☐	☐	☐	☐
Black rot	☐	☐	☐	☐	☐
Botrytis fruit rot	☐	☐	☐	☐	☐
Mosaic	☐	☐	☐	☐	☐
Rust	☐	☐	☐	☐	☐
Fungal wilt	☐	☐	☐	☐	☐
Bacterial wilt	☐	☐	☐	☐	☐
Bacterial spot	☐	☐	☐	☐	☐
Downy mildew	☐	☐	☐	☐	☐
Powdery mildew	☐	☐	☐	☐	☐
Fusarium wilt	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

5. **Please select the insects that reduce your crop yield.**

- ☐ Aphids
- ☐ Ants
- ☐ Beetles
- ☐ Cutworms
- ☐ Cowpea Curculio
- ☐ Caterpillars
- ☐ Grubs
- ☐ Harlequin bug
- ☐ Mites
- ☐ Twospotted Spider Mites
- ☐ Maggots
- ☐ Stinkbugs
- ☐ Nematodes
- ☐ Corn ear worm
- ☐ Other
- ☐ None
- ☐ Do not grow vegetables

For each problem insect, please select the level of severity on a scale of 1 to 5 (1 = not very severe, 3 = somewhat severe, 5 = extremely severe).

	1	2	3	4	5
Aphids	☐	☐	☐	☐	☐
Ants	☐	☐	☐	☐	☐
Beetles	☐	☐	☐	☐	☐
Cutworms	☐	☐	☐	☐	☐
Cowpea Curculio	☐	☐	☐	☐	☐
Caterpillars	☐	☐	☐	☐	☐
Grubs	☐	☐	☐	☐	☐
Harlequin bug	☐	☐	☐	☐	☐
Mites	☐	☐	☐	☐	☐
Twospotted Spider Mites	☐	☐	☐	☐	☐
Maggots	☐	☐	☐	☐	☐
Stinkbugs	☐	☐	☐	☐	☐
Nematodes	☐	☐	☐	☐	☐
Corn ear worm	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

6. **Please select the fruit insects and other pests that reduce crop yield.**

- ☐ Beetles
- ☐ Peach tree borer
- ☐ Caterpillars
- ☐ Curculio
- ☐ None
- ☐ Do not grow fruit

For each problem insect, please select the level of severity on a scale of 1 to 5 (1 = not very severe, 3 = somewhat severe, 5 = extremely severe).

	1	2	3	4	5
Beetles	☐	☐	☐	☐	☐
Peach tree borer	☐	☐	☐	☐	☐
Caterpillars	☐	☐	☐	☐	☐
Curculio	☐	☐	☐	☐	☐

Profitability and Marketing

7. **Please list crops you would grow but cannot because of problems such as disease, weeds, pest pressures, or cost.**

____

8. **Please select the biggest challenges affecting your long term profitability.**

☐ Weeds
☐ Soil nutrients
☐ Rainfall/moisture
☐ Land prices
☐ Labor
☐ GAPs-Farm food safety
☐ Other Please specify _________________________

For each selected challenge, please select the level of severity on a scale of 1 to 5 (1 = not very severe, 3 = somewhat severe, 5 = extremely severe).

	1	2	3	4	5
Weeds	☐	☐	☐	☐	☐
Soil nutrients	☐	☐	☐	☐	☐
Rainfall/moisture	☐	☐	☐	☐	☐
Land prices	☐	☐	☐	☐	☐
Labor	☐	☐	☐	☐	☐
GAPs-Farm food safety	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

9. **Please select where you sell your produce.**

☐ Retail
☐ Restaurants
☐ Farmers Markets
☐ Wholesale/broker
☐ Other, please specify ____________________

For each selected location, please select the level of importance on a scale of 1 to 5 (1 = not very important 3 = somewhat important, 5 = extremely important).

	1	2	3	4	5
Retail	☐	☐	☐	☐	☐
Restaurants	☐	☐	☐	☐	☐
Farmers Markets	☐	☐	☐	☐	☐
Wholesale/broker	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

10. **Please select how you advertise**

- ☐ Word of mouth
- ☐ Magazine
- ☐ Internet
- ☐ Newspaper
- ☐ Other, please specify ___________________
- ☐ Do not advertise

For each selected advertising method, please select the level of importance on a scale of 1 to 5 (1 = not very important 3 = somewhat important, 5 = extremely important).

	1	2	3	4	5
Word of mouth	☐	☐	☐	☐	☐
Magazine	☐	☐	☐	☐	☐
Internet	☐	☐	☐	☐	☐
Newspaper	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐

11. **Please list your crops and indicate how they are packaged**

Product	New Container	Reusable container	None	Other
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐
	☐	☐	☐	☐

12. **Are you currently receiving what you consider to be an average price for your products?**

- ☐ No
- ☐ Yes

If no, please specify if you are receiving above or below the average price for your produce.

- ☐ Above
- ☐ Below
- ☐ Do not wish to answer.

13. **What is the furthest location where your product is sold?**

- ☐ Local (County)
- ☐ In-State
- ☐ Regional (Southeast)
- ☐ National
- ☐ Out of Country

14. **Do you use a packhouse?**

- ☐ No
- ☐ Yes

If yes, is the packhouse owned or at another facility?

- ☐ Owned
- ☐ At another facility

Educational/Informational Needs

15. **What is the primary source of your information on produce farming? Indicate one.**
    - ☐ Extension agents and specialists
    - ☐ Magazines
    - ☐ Workshops/meetings
16. **What is the preferred source of educational information?**
    - ☐ Workshops
    - ☐ Online classes
    - ☐ Round table discussions with other farmers
    - ☐ Extension-Meetings, demonstrations, field day
    - ☐ Other
17. **Do you need any additional educational training from Clemson University on farming (for example GAPs (Good Agricultural Practices) –For Farm Food safety)**
    - ☐ No
    - ☐ Yes
    - ☐ Not sure
18. **Do you need more information about organic or biological control products?**
    - ☐ No
    - ☐ Yes
    - ☐ Not sure

Demographics

19. **In which county is your farm located?**

    ____
20. **Are you farming organically?**
    - ☐ No
    - ☐ Yes

    If yes, how many years have you been farming organically?
    - ☐ Less than 1.
    - ☐ 1-3.
    - ☐ 4-6.
    - ☐ 7-9.
    - ☐ More than 9.
21. **How many acres do you farm?**
    - ☐ <10 acres
    - ☐ 10 - 50 acres
    - ☐ 51 - 100 acres
    - ☐ > 100 acres
22. **What percent of the farm is irrigated?**
    - ☐ 0 %
    - ☐ 25 %
    - ☐ 50 %
    - ☐ 75 %
    - ☐ 100 %

23. **Please select your water source.**

- ☐ Municipal
- ☐ Pond
- ☐ Stream
- ☐ Well
- ☐ Other, please specify ____________________________

24. **Please list your crops and the percent of farm allocated to each of these crops (These numbers should add up to 100)**

Thank you for participating in this survey! I appreciate your input. If you have any additional ideas or comments, please contact me at esteinb@clemson.edu.

APPENDIX C

MEAN ± STANDARD ERROR OF TEMPERATURE (^{0}C), RELATIVE HUMIDITY (%), GLOBAL LIGHT ENERGY (w/m2) IN THE GREENHOUSE

	Temperature (^{0}C)	Relative Humidity (%)	Global Light Energy (W/m2)
February (N=2112)	21.58 ± 0.09	36.93 ± 0.33	142.21 ± 4.95
March (N=2972)	23.8 ± 0.09	48.17 ± 0.34	200.03 ± 5.29
April (N=2880)	24.46 ± 0.09	48.06 ± 0.35	251.5 ± 6.16
May (N=2976)	26.66 ± 0.10	55.61 ± 0.35	263.8 ± 9.43
June (N=2880)	27.68 ± 0.07	56.67 ± 0.25	293.2 ± 6.64
July (N=2976)	29.22 ± 0.04	63.78 ± 0.17	277.9 ± 6.36
August (N=2304)	27.83 ± 0.07	64.06 ± 0.23	236.35 ± 6.55