CONSUMER ACCEPTABILITY OF HEIRLOOM TOMATOES

by

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(Under the Direction of ROBERT L. SHEWFELT)

ABSTRACT

Consumers have been dissatisfied with tomato flavor for decades. With a grassroots movement to bring back the full flavored tomatoes of the past, heirloom tomatoes have emerged as a specialty niche in the tomato industry. Focus group discussions, organized by approximate age, revealed the young demographic have grown up eating commercial tomatoes and have little reference to garden fresh tomatoes. It was also discovered that the young group desires tomatoes with a sweet taste while the middle aged and elderly demographics want a tomato with an acid and bite taste. Consumer evaluations did not rank heirlooms as having a more superior flavor than commercial tomatoes. However, consumers did rank commercial tomatoes as least preferred than heirloom varieties. Descriptive sensory analysis showed astringency was the only descriptor of significant difference between heirloom and commercial tomatoes.

INDEX WORDS: Heirloom tomatoes, Consumer acceptability, Consumer testing, Focus group, Tomato flavor, Consumer evaluation, Acceptance scales, Descriptive Sensory Analysis.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

Heirloom Tomatoes

When most people think back to their childhood, things were all around bigger and better. Houses were bigger, people were nicer, and food tasted so much better! Well, the bigger house sizes may not be the case, but better tasting foods may not be a myth when it comes to tomatoes.

Consumers have been dissatisfied with fresh tomato fruit for at least the past 30 years (Handy et al., 1975). Since the start of centralized agriculture in the 1940's when seed companies started breeding hybrid plant varieties, fruits and vegetables have been designed and grown for the producer, not the consumer (Wu, 2004; Watson, 1996; DeMuth, 1999). Tomatoes are no exception. In general, commercial tomato fruit is no longer grown seasonally at local or regional farms, but is now grown year-round in Florida, California, or Mexico and shipped across the nation.

The bulk of fresh commercial tomatoes are harvested at the mature green or breaker stage of maturity (Auerswald et al., 1999; Boukobza et al., 2002; Peet, 2005). These tomatoes are completely green or show less than 10-percent of a yellow, pink, or red color. Most are treated with ethylene gas to induce ripening and kept at cool temperatures to extend shelf life as long as possible. They are then shipped across states, regions, nations, or oceans to their destination and our tables.

The rapid popularity of tomatoes has pushed the commercial tomato producer to develop cultivars that are designed to withstand considerable physical stress imposed by the industry's picking, packing, and shipping techniques (Vavrina et al., 2003). However, in the course of improvement, not much attention was paid to the study of flavor characteristics (Petro-Turza, 1987). Tomato research has mainly focused on the selection of new varieties to increase firmness of the fruit and storage regimes to increase their shelf life (Boukobza et al., 2002) Tomatoes have

been and still are one of the most popular vegetables in North America with the average American consuming a projected 18.7 pounds a year (USDA, 2004). At the retail level only potatoes and lettuce surpass them. But despite their popularity, fresh tomato flavor is one of the leading sources of consumer dissatisfaction amid major produce items (Bruhn et al, 1991). Now, people are discovering that there are alternatives to the sub-par retail tomato. Consumers are rediscovering their heritage.

Since the 1970's, a grassroots movement of home gardeners, preservationists, and small regional seed companies from around the world has begun to bring back the heirloom fruits and vegetables of past generations. Taylor's Guide to Heirloom Vegetables defines an heirloom as, 1) being at least 50 years old, 2) being an open-pollinator, and 3) having a history of its own (Watson, 1996). But there are several versions of this heirloom classification.

All heirloom aficionados agree that an heirloom plant must be an open-pollinating variety. Open-pollinators are pollinated naturally by the wind, birds, and insects and produce seeds true to type that replicate the parent plant (Elliot, 2000; Demuth, 1999). These standards or non-hybrid varieties are genetically stable and breed true to type (DeMuth, 1999). Hybrid plants differ as they are manufactured from F_1 hybrids which result from deliberate crossing of two distinct, highly inbred parent lines. Since their genetic makeup has been manipulated they are highly uniform and tend to have improved yield and field performance. Most are sterile but those that do have viable seed usually bear highly variable plant offspring. Therefore hybrid growers must return to the seed company each year to get the same variety (DeMuth, 1999).

While few would argue with the arbitrary number of 50 years old, there are those that believe that there should be more to this classification than just a number (DeMuth, 1999; Elliot, 2000; James, 2005; Male, 1999; Watson, 1996). Some growers believe seeds must have never

been commercially available and only those passed down through a family or community should earn the title of heirloom (Elliot, 2000; Male, 1999). Watson (1996) and others feel the seed companies have played an important role through out the years in preserving and making available plants that would other wise be forgotten.

Historical significance is also important in making an heirloom. Tomatoes actually originated and grew wild in the high coastal regions of Chile and Peru (Male, 1999). Spanish conquistadors were the first to record seeing tomatoes being cultivated for food in Mexico in the 16th century. Tomato seeds were then dispersed to the Philippines, the Caribbean, Italy, and Spain and from there to the rest of continental Europe and Southeast Asia (Male, 1999). Most tomato varieties were brought back to North America from Europe with the first settlers of the New World. The first tomatoes were not recorded as the typical red color familiar to modern tomatoes, but they were described as being yellow. Some heirloom tomato lineages can be traced back into the early 1800's and most are surrounded by stories about families and cultures. The names of most heirloom tomatoes reflect their history. Radiator Charlie's 'Mortgage Lifter' variety helped him escape financial ruin and paid off his mortgage as he sold 1,000 plants at one dollar a piece (Male, 1999). The oldest tomato variety is 'Moneymaker,' an English variety between 250 and 300 years old that was the first English variety grown for market sale (James, 2005).

There are more than 8,000 varieties of heirloom tomatoes available from one of the world's largest seed preservation organizations, Seed Savers Exchange (James, 2005; Watson, 1996). No matter what stipulations are placed on plants, heirlooms are simply those that have survived the test of time. And no matter what the environmental or political trend may be, the driving force behind the popularity of heirloom tomatoes is the flavor (Elliot, 2000). The

varieties that have survived the generations did so because they were suitable for the region in which they grew and they produced desirable fruit, full of flavor. Those that were not good producers or had bad flavor are no longer with us. Gardner (2005) states that heirloom tomatoes may have better flavor because of the high ratio of foliage to fruit. Heirloom tomatoes are indeterminate plants, which grow all season long and will continue to grow and produce fruit until cut back or killed off by frost or disease. The foliage manufactures substrates that go into producing acid and sugar levels for the fruit. The more foliage available per fruit, to an extent, the more substrate is available to produce a more flavorful tomato. Most hybrid or commercial tomato varieties are determinate plants and stop growing once fruit has been produced. Superior flavor can also be linked to cultivation practices (Gardner, 2005). Commercial tomato producers typically grow their plants in sandy soil and use lots of irrigation. Producers of heirlooms often grow their tomatoes in heavier clay soils under conditions of higher moisture stress. The combination of fertilizer elements, high salt levels from the soil, and moisture stress can lead to a tomato with increased sugar levels that is synonymous with better flavor (Gardner, 2005).

Heirloom tomatoes do have some characteristics that keep them out of the mainstream commercial industry. The qualities of hybrid tomatoes that are important in large-scale commercial operations such as maximum yield, uniform shape and size, pest resistance, and uniform ripening, are the same qualities that prevent heirloom tomatoes from being leaders in the industry. Vavrina et al. (2003) tested fifteen heirloom varieties to evaluate their ability to withstand handling in the Florida gassed-green market. He concluded that none of the varieties in that trial could withstand the picking, packing, and shipping rigors of the Florida market because their physical defects would render them unmarketable. However, there were a few varieties noted for the vine ripened specialty market. Many heirloom varieties have thin tomato walls that

make them fragile, enable concentric, calyx, or radial cracking, and promote a shorter shelf life. Heirloom tomato plants are many times less productive than hybrid varieties and productivity can waver from year to year. They are very finicky plants. Unlike hybrid varieties with fruit of a uniform shape and size that ripen generally at the same time, many heirloom tomato varieties have staggered ripening dates intrinsic of indeterminate plants (Gardner, 2005) and fruits that vary from small (~ 1-oz) to extra large (> 10-oz) (Vavrina et al., 2003). While the lower productivity is not always desirable, the backyard heirloom grower or small farmer needs a tomato that will ripen on an ongoing basis. The biggest problem with heirloom tomatoes is that most lack the disease resistance bred into hybrids (Elliot, 2000). Leaf blights, wilts, and nematodes are more likely to cause problems unless precautions are taken (Mullins, 2004). An heirloom tomato passed down through generations within a particular geographic area adapts to the dangers of that area and may be very resistant to certain indigenous rusts or wilts. But out of that area the same heirloom may not be able to withstand the weather or disease dangers (Elliot, 2000).

Then why bother with growing heirloom tomatoes? Some heirloom producers are concerned with maintaining the genetic diversity of our food crops. The importance of crop plant biodiversity was first demonstrated in the 1840's Irish potato famine. The epidemic happened because all the varieties of potatoes grown in Europe at that time were derived from two parent varieties (Strickland, 1998). They produced reliable potato yields in the climate of Northern Europe but they had never encountered blight and simply had no resistance to it. In our own country in the 1970's southern leaf blight wiped out more than 15-percent of the entire United States corn crop (Elliott, 2000; Watson, 1996). It was determined that a gene inserted into all the common commercial corn varieties was highly susceptible to the blight (Watson, 1996).

Maintaining genetic diversity is important to help combat new pests and diseases that may develop in the future. Since 1902, 80-percent of the vegetable varieties once available in the U.S. have been lost (Martin, 2003).

Other heirloom producers are simply rediscovering the backyard tomatoes of years gone by. The typical commercial tomato is thought to be red and round. But the heirloom tomato is not one to be contained in a stereotype. Heirloom varieties come in a rainbow of colors from red to black, white to green, and are often found in irregular or unusual shapes with strips or other colorful markings. With these vibrant shapes and colors come very distinct flavors that are full and robust. Flavor characteristics vary, depending on the variety, but some of the descriptions include ‘meaty texture,’ ‘sweet, slightly spicy flavor,’ ‘super sweet,’ ‘mild,’ ‘low acid taste,’ ‘complex flavor,’ and ‘slightly lemony but non-acidic flavor’ (Cheney, 2004). With over 8,000 varieties to choose from, gardeners can find virtually any flavor characteristic, size, and color they desire. Heirloom tomato flavor can vary within a variety, from garden to garden, and year to year. Soil type, weather, and climate can profoundly affect a tomato’s flavor (Male, 1999).

Tomato Flavor

Flavor is typically defined as the combination of the taste and aroma of a food based on its composition. The major components that contribute to the taste of fresh tomatoes are a complex mixture of total soluble solids that are reducing sugars, organic acids, amino acids, and minerals (Baldwin et al., 1991). Tomato flavor is thought to be a delicate balance of sugars and acids (Malundo et al., 1995). While this is a widely accepted theory, there is still no known ratio in which to produce best possible flavor. Van Lieshout (1993) reports that for optimum fresh tomato flavor sugar levels must be high, suggesting no sugar limit, but that there is a maximum

level for acid levels. Acid levels beyond the maximum level lead to decreased consumer acceptability (Malundo et al., 1995).

Aroma compounds are proposed to have a significant effect on the human perception of tomato flavor (Petro-Turza, 1987). Aroma is a result of the release of volatile compounds. Over 400 volatile compounds have been identified in tomatoes with the use of gas chromatography-mass spectrometry (Petro-Turza, 1987). Of these, only 30 have odor thresholds over 1 ppb (Buttery et al., 1987, Buttery et al., 1989) and less than 20 have odor units great enough to contribute to flavor (Buttery and Ling, 1993; Maul et al., 1998). There are approximately 15 volatiles that have been reported in the literature to be very important in fresh tomato flavor including acetaldehyde, pentanal, hexanal, *cis*-3-hexenal, *trans*-2-hexenal, *trans*-2-*trans*-4-decadienal, acetone, 1-penten-3-one, 6-methyl-5-hepten-2-one, β-ionone, geranylacetone, methanol, *cis*-3-hexenol, 2 + 3-methyl-butanol, and 2-isobutylthiazole (Baldwin et al., 1991). Still, no single chemical compound has been identified as a flavor impact compound for tomato (Petro-Turza, 1987).

Segmentation. Research has been conducted on tomatoes and tomato flavor for decades but there is still not a clear answer as to what gives a tomato its unique flavor or how to predict tomato flavor. Tomato connoisseurs debate as to what constitutes ‘ideal tomato flavor.’ However, based on the number of people and opinions there are in existence it would be unreasonable to believe one choice will satisfy them all. Several researchers have suggested consumer segmentation in which to base acceptance of tomato flavor (Moskowitz, 1993; Shewfelt, 2000a, West, 2000).

Pursuit of an average consumer is of little use in the marketability of a product (Shewfelt, 2000a). The average consumer provides an answer without an understanding of the population

(Shewfelt, 2000a). Consumer studies (Bruhn et al., 1991; van Lieshout, 1993; Auerswald et al., 1999) have shown that segmentation of consumers based on characteristic preferences provides more useful information to producers and breeders (West et al., 2005). By providing items that meet consumers' expectations for flavor acceptability, an increase in consumer satisfaction is anticipated (Moskowitz, 1993; Shewfelt, 2000). Moskowitz (1993) states that recognizing individual differences and niche marketing is the future of sensory science. Where scientists would "train out" individual differences during descriptive analysis, they need to capture those differences in order to research and identify the segments in mass consumer markets.

Through the implementation of focus groups and consumer panels, West et al. (2005) concluded five possible consumer segments for tomato flavor including 'vine ripened,' 'sweet,' 'not bland,' 'tart,' and 'sweet and tart.' Malundo (1996) also used focus group discussions to determine possible consumer segments for peach and mango fruit based on degree of ripeness preferred at point of consumption.

Focus Group Discussions. As evidenced with the previous examples, focus group discussions are one way to identify consumer segments. Focus groups are a qualitative measuring technique where consumers are able to convey their likes and dislikes. These techniques are some of the most important and widely used tools in marketing research to address consumer attitudes and motivations (Cohen, 1990). The information gathered enables producers and tomato breeders to understand the thinking of consumers (Cohen, 1990). Unlike trained panelists, consumers do not identify sensory descriptive notes that are the fundamental units of flavor quality (West, 2005). Instead consumers integrate all sensory input to form a general impression. Color may mean different things to different consumer groups. Brumfield et al. (1993) reports many consumers consider some tomatoes with pink or green coloration as vine

ripened and see it as an indication of good flavor. Focus groups allow a comfortable atmosphere in which to have a guided discussion to obtain information from a number of individuals of a similar interest (Cohen, 1990). In these groups, researchers can explore individuals' beliefs, opinions, and perceptions about the product or service of interest. Careful and systematic analysis of the discussions provides insights into how a product is perceived (Casey and Krueger, 1994).

Consumer Testing. The use of consumer panels is another way of measuring consumer preference and acceptability. These panels help identify attributes significant to consumer acceptance and are important in quality research (Brumfield et al., 1993) as consumers ultimately define and determine quality and acceptance (Shewfelt, 2000b). Yet there have been relatively few consumer studies conducted where consumers actually evaluated tomatoes at the time of study (West, 2000). Auerwald et al. (1999) regards consumers as not as sensitive as trained panelists. They cannot detect some flavor differences that trained panels detect. However, it has been shown that in paired comparison tests including duplicate samples, consumers scored the same samples accurately (Eytan, 1990). Their ability to evaluate foods accurately was also evidenced in consumer testing by Shewfelt (1999) who states that long time consumers of tomatoes can detect subtle differences in textural properties. A sample of trained panelists is not appropriate for predicting consumer preference or acceptability by untrained consumers (O'Mahoney, 1995).

When choosing the population of consumers, the goal of the study must be kept in mind. Whatever consumer testing is carried out at this stage, it is critical that it be conducted with potential consumers of the product. If the potential product will appeal to a broader range of consumers then a broad range should be tested (Meiselman, 1994). Often long-term users of a

product can better detect small changes in sensory characteristics of a product than a casual consumer (O'Mahoney, 1995).

Methodology. When performing consumer studies, it is useful to 1) select consumers that are naïve and represent target segments of the consuming population, 2) adapt terminology from the consumer, and 3) mimic the typical eating conditions in the test environment to increase external validity (Henderson, 2002). The types of tests used with consumers must also be carefully considered to gain the most statistically relevant information without overwhelming them with samples, ranking scales, and lofty words. Consumers are not trained test takers and have no standardized language or internally calibrated scales (O'Mahoney, 1995). Therefore consumer methods should be simple to perform with no hidden demands or characteristics. Tests that have been used with consumer panels include difference or triangle tests, preference tests, ranking tests, survey questionnaires, and individual interviews.

Henderson (2002) evaluated the appropriateness of three scales for determining consumer acceptability comparing the 3-point unbalanced consumer acceptability scale, the 5-point willingness-to-purchase scale, and the 9-point Hedonic liking scale. The three-point scale is designed to mirror the "gut response" of consumers to products and offers a clearer insight into consumer desires than the five-point willingness-to-purchase or the traditional nine-point Hedonic scales (Henderson, 2002). Of the acceptance scales, the nine-point Hedonic scale developed by Peryam and Giraridot (1952) is commonly accepted to measure consumer acceptance (Dubost, 2003). Generally ranging from the anchors "Like Extremely" to "Dislike Extremely," the Hedonic scale makes assumptions about consumer acceptability by interpreting levels of "liking" due to its internal validity (Henderson, 2002). However, it is believed to have flaws from end effects to unequal intervals that may cause to be it statistically invalid (Dubost,

2003; Henderson, 2002; O'Mahony, 1991; Moskowitz, 1994). The five-point willingness-to-purchase scale is thought to provide a more direct answer to intended consumer behavior and acceptability (Henderson, 2002; Moskowitz, 1994).

Dubost (2003) states to overcome the deficiencies of the nine-point Hedonic scale and provide better external validity, a three-point acceptability scale has been described at the possible expense of internal validity. This scale is more balanced with the descriptors "tastes great", "acceptable", and "unacceptable" (Shewfelt 1997) than the "exceeds expectations," "meets expectations," and "does not meet expectations" evaluation. One-on-one interviews with consumers found the latter scale to be very confusing, diverting their attention away from evaluating the product (Dubost, 2003; Henderson, 2002). Shewfelt (2000b) designed this scale by observing the typical consumers of today who tend to have other things on their mind when they eat. Dubost (2003) states the unequal intervals of the scale do not cause a problem since they are not presented as means on the three-point scale. They are presented as a percentage distribution for each category or combination of more than one category (Dubost, 2003; Shewfelt, 2000b). When consumers evaluate a product, the scales used can affect the results and thus the conclusion. Adoption of more appropriate scales of consumer preferences will provide more meaningful consumer data in evaluating new products and product concepts than the now widely used nine-point Hedonic scale (Henderson, 2002).

Descriptive Sensory Analysis. Measuring the sensory properties and determining the importance of these properties as a basis for predicting acceptance by the consumer represent major accomplishments for sensory evaluation and for those with the ability to exploit this knowledge (Stone and Sidel, 1993). Descriptive sensory analysis is the most sophisticated tool available to the sensory scientist (Abegaz, 2000). Here the attributes of a food are identified,

described, and quantified using human subjects who have been specifically trained (Lawless et al., 1991). Several descriptive sensory "systems" have been published, including the Quantitative Descriptive Analysis (QDA©), Flavor Profile, and Spectrum™ Method. Chambers and Wolfe (1996) report that there are many variations of these methods used as scientists tailor the technique to fit their unique situations. These descriptive analysis systems can be implemented to check product attributes for quality assurance or to compare differences among similar products. Stone and Sidel (1993) recommend descriptive panels be carefully selected and trained by a sensory analysis professional with extensive experience using the method. The panel is an instrument that measures samples of food so that inferences can be made about the population (O'Mahoney, 1995). Trained panelist must be able to communicate sensations using a common language (Abegaz, 2000; O'Mahoney, 1991). A panel can develop a list of terms of characteristics they perceive from the product in taste, aroma, texture, or mouth feel. These are deemed "expert panels" as they become finely tuned instruments to detect subtle differences in products and are in continuous training and calibration. An "experienced panel" consists of tasters that have experience with a product but were not specifically trained for sensory methods (Lawless, 1984; Meiselman, 1994). With the use of either the expert or experienced panel, a list of product attributes is developed, a score sheet is designed based on test objectives, and panelists determine the intensity of each attribute present in the sample (Abegaz, 2000; Chambers and Wolfe, 1996).

Consumer Acceptance. Since moving to a more centralized form of tomato production, many theorize that while breeders were selecting tomatoes with superior yields, uniformity, and disease resistance that could withstand the rigors of harvest and shipping, tomato flavor was inadvertently selected out (Petro-Turza, 1987). It is a common practice among tomato producers

to harvest tomatoes at the mature green stage or breaker stage (Auerswald et al., 1999; Baldwin et al., 1993; McGlasson, 1989; USDA, 2001). This is done in order to obtain firmer fruits suitable for transport and in order to be able to sell them over a longer period of time (Auerswald et al., 1999). Shewfelt (1999) counters this product-oriented view of quality and maintains that the longer the tomato shelf life the poorer the quality of the produce delivered to the consumer. Baldwin et al. (1998) found that early harvest and treatment of stored tomatoes prevents full flavor development and is a cause of poor tomato flavor. This observation is supported by the findings of Maul et al. (1998) in that tomatoes harvested green had decreases in six of the 15 volatile concentrations believed to be important in fresh tomato flavor. It was also reported that there were significant differences in gas-chromatography aroma profiles of ripe fruit and those treated with ethylene. Maul et al. (1998) concluded that ripe tomato flavor might be affected by maturity at harvest. The overemphasis on a product orientation to quality has dominated the American market in fresh fruits and vegetables and has bred an over-reliance on appearance at a sacrifice of flavor (Shewfelt, 1999).

Nevertheless, while the literature and research findings are very impressive, consumers are not interested in the numbers of volatiles that make up tomato flavor or at how flavor works. All consumers are interested in are acquiring tomatoes full of flavor that meet their criteria for ripeness. People use all their senses when eating foods, but buy with their eyes (Von Alvesleben and Meier, 1990). If something appears to be good, one is more likely to try it or purchase it. Modern tomatoes are required to be large, smooth, nearly round, and bright red when ripe (Hobson et al., 1989; McGlasson, 1989). These are the external qualities consumers look for when purchasing tomatoes in supermarkets worldwide. However, McGlasson (1989) found that shoppers selected fruit that was firm and well colored but frequently found the fruit had poor

texture and lacked flavor. Consumers report that they are most satisfied with fresh items where the purchase signals of quality are an accurate predictor of consumption quality (Shewfelt, 1999). Dissatisfaction with fresh tomatoes appears to be the result of a faulty linkage between purchase and consumption attributes. Much of this dissatisfaction can be traced to the cultivation practices of tomato producers and the tomato industry. Van Lieshout (1993) states that we are in a consumer-oriented market were the producers must satisfy the consumer. A failure of the produce industry to be responsive to consumer wants and needs could lead to a decline in fruit and vegetable consumption (Shewfelt, 1999). This consequence can already be seen in the California and Florida tomato markets where the product mix has changed as the share of mature green tomatoes has decreased in favor of vine ripe, roma, and specialty tomatoes such as heirloom and grape tomatoes (USDA, 2001).

Brumfield et al. (1993) believes consumers are not able to separate individual perception factors such as freshness, flavor, nutrition, and overall perception. Most consumers group these attributes when making their fresh tomato purchasing decisions rather than relying on a single attribute. Many of the consumers that are grumbling about poor tomato flavor, or have experienced the tomato varieties before they became heirlooms, were involved in tomato production and are familiar with the growing cycle and different stages of ripeness. This trend has changed greatly. As consumers become several generations removed from agriculture and do not experience tomato production in home gardens, they often are not familiar with natural ripening and prefer the more uniform color of gassed tomatoes (Brumfield et al., 1993) thereby not knowing there is superior flavor to be acquired.

With the rapid growth of tomato popularity, tomato breeders have produced new cultivars with good appearance, high yields, uniform ripening, disease resistance, and good mechanical

properties suitable for mechanized harvesting (Petro-Turza, 1987). The demand for fresh market tomatoes has led to handling techniques that prolong storage of tomato fruit, allowing long-distance shipping (Boukobza et al., 2002). As mentioned previously these tomatoes are normally harvested before they become fully ripened. These green or light pink fruits are kept under controlled conditions such as dark, cool storage areas with reduced levels of oxygen to prevent premature ripening (Boukobza et al., 2002). Storage of immature tomatoes in low temperatures was found to alter the ratio of sugars to acid (Auerswald et al., 1999; Boukobza et al., 2002; Kader et al., 1978; Maul et al., 2000). When it is time for them to go to the retail market, fruits are treated with exogenous ethylene gas to induce ripening. While tomatoes continue to ripen after harvest, their sensory characteristics are not of optimum quality.

Petro-Turza (1987) reported that tomatoes picked table-ripe are much sweeter with fuller flavor and are much more desirable than artificially ripened tomatoes. Maybe this is the route in which the tomato industry should head. Continuing to grow tomatoes with the producer in mind instead of the consumer's desires will continue to cause a shift in tomato purchase and consumption. With the use of interdisciplinary studies on tomato flavor that incorporate their nutrition, consumer perception, descriptive flavor analysis, and gas chromatography- mass spectrometry, one day the great tomato mystery and consumer quandaries will be solved.

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CHAPTER 2

PURCHASE AND CONSUMPTION PREFERENCES OF TOMATO CONSUMERS[1]

[1] Bland, S.E. and R.L. Shewfelt. 2005. To be submitted to Journal of Food Quality.

ABSTRACT

Scientists struggle with determining what makes a tomato taste like a tomato. Much research has been conducted and many phenomenal findings have been discovered; yet no one knows exactly which volatiles give the tomato its unique taste or what ratio of sugars to acids constitutes the ideal tomato. Consumers, on the other hand, know exactly what they want in fresh tomatoes and how it should taste. For this reason, three focus groups were conducted about the critical purchase and consumption attributes for tomatoes and consumer willingness to experience heirloom tomatoes that challenge the appearance of the typical round, red commercial tomatoes. Each group represented a different age demographic of young (median age 23), middle aged (median age 46) and elderly (median age 67). Many of the young demographic have grown up eating commercial tomatoes and do not have a taste reference for “garden fresh” tomatoes that are genuinely ripened on the vine. They do not know there are different tomato flavor characteristics available. It was discovered that the young focus group desires a more sweet tasting tomato while the middle aged and elderly groups are looking for a tomato with more acid and bite.

INTRODUCTION

It used to be that tomatoes were a sign that summer was in full swing. Now tomatoes do not necessarily have a season, as producers are able to offer them year round. The question is, has the convenience of having fresh tomatoes year round compromised the flavor of fresh tomatoes.

Tomatoes are one of the most popular produce items though they have one of the highest consumer dissatisfaction rates. For years there has been increasing consumer concern about the eating quality of commercial tomatoes, including poor taste and texture (Batu, 2004). Marketing tools such as focus group discussions are one way to discover the root of consumer opinions, beliefs, and dissatisfaction with tomato flavor.

Focus group interviews are qualitative research tools carefully designed to obtain perceptions on a specific area of interest (Krueger, 1994; Malundo, 1996). They seek to (1) obtain information from a number of individuals who have similar usage habits, needs, and interests (2) discover factors which motivate these persons to act in a certain way and (3) explore individual beliefs, opinions, and perceptions about the products and services that these consumers use (Cohen, 1990). In a comfortable setting, participants are able to freely engage in a guided discussion of a specific topic. These discussions are highly organized with analysis of participants' personalities, seating placement of personalities to ensure the most participation from all involved, and carefully crafted questions to obtain the most amount of information in the least invasive manner possible (Casey and Krueger, 1994; Cohen, 1990). Since there are only eight to eleven participants in a focus group, the data obtained from these discussions should not be used to provide statistical information rather these discussions are to gather insight about

preferences, generate ideas, and suggest barriers all from the panelists' point of view (Casey and Krueger, 1994).

There is only one known published report to date using focus groups to better understand tomato flavor. West (2000) engaged focus group participants to generate possible taste segmentations for tomato flavor. The objective of this study is to identify consumer attitudes and opinions of tomatoes and to determine consumers' willingness to consume and purchase heirloom tomatoes.

MATERIALS AND METHODS

Experimental Materials

Three focus group sessions about tomato quality and preference were conducted at the University of Georgia Food Science and Technology building in Athens, Georgia and at a residence in Tifton, Georgia. All sessions contained between nine and eleven panelists. Each focus group represented a separate age group roughly categorized as "young" (18-25 years old, median age 23), "middle-aged" (25 to 60 years old, median age 46), and "elderly" (23 to 80 years old, median age 67). Participants were recruited based on regular consumption and/or purchase of fresh tomato fruit. As the panelists arrived, they were given the chance to have refreshments and encouraged to talk to other panelists for a 10 to 15 minute period as recommended by Krueger (1994). Based on the moderator's observations, panelists were seated based on their personalities around an octagonal table. More outspoken panelists were seated to the left and right sides of the moderator while softer-spoken panelists were seated within the eye line of the moderator to encourage discussion (Krueger, 1994). As the session began, the

moderator gave some introductory remarks to create a relaxed, accommodating atmosphere, to set ground rules, and to set the tone of the discussion. All panelists were asked to introduce themselves and the moderator stressed the uniformity of the group. A tape recorder was placed in the middle of the table to record the discussion of the panelists. The moderator asked questions based on a previously outlined set of questions but did not follow a script. Each panelist was encouraged to respond to each question. When further explanation was needed, the moderator then engaged the panelists for more information. Each focus group was conducted so that there was more discussion rather than simply answering questions. Panelists were compensated for their time with either a meal or refreshments.

RESULTS AND DISCUSSION

With the focus groups represented by different age groups, discussion length and content varied. Overall, the young focus group was more hesitant to participate in a discussion at first and did not appear to have the amount of knowledge and experience to draw from as compared to the middle aged and elderly focus groups.

When asked to describe the perfect tomato, the young focus group seemed to prefer a more sweet taste in contrast to the middle aged and elderly groups that preferred a tomato with a more acidic taste (Table 2.1). The two older groups desired tomato fruit with more bite and a stronger flavor as it reminded them of the tomatoes they grew up with. The young group wanted a “balance between sweetness and flavor” but prefers sweet to tart. Overall each group gave indication that the ideal tomato should be a deep or bright red with no green or yellow discoloration. This supports Batu (2004) in that color is one of the most important indicators to

consumers of tomato quality. Tomato texture and firmness were differentiated in the groups. Each group wants a tomato that is “firm but not too firm.” The ideal tomato would have some give when it is touched or squeezed. The texture of the tomato should be smooth, not grainy or gritty. One of the comments from the elderly group was that now commercial tomatoes are mealy with the texture and firmness like an apple. Batu (2004) found texture is influenced by flesh firmness and skin strength. Commercial tomatoes must be able to endure the rigors of harvest, shipping, and storage and therefore are bred to have tougher skin and firmer flesh. All participants desired tomato fruit that was juicy. Upon further examination of the term “juicy,” consumers differentiated between juicy and watery. Malundo (1996) conducted focus groups on peach quality and found that peach consumers make a distinction between juiciness and watery. Tomato consumers are no different. Juiciness is the amount of liquid expressed as the consumer bit or cut into the fruit. Lack of flavor was usually associated with watery fruits while acidity or sweetness was often associated with juiciness (Malundo, 1996). The elderly focus group pointed out that the tomato juice left on the plate after it had been cut used to be red but is mainly water with a little pink color (Table 2.3). This may be caused by a decrease in the number of substrates and volatiles produced in the tomato as a result of harvesting at earlier stages of ripeness (Petro-Turza, 1987). The middle aged group expressed a dislike in the amount of “core” or columella (Rost, 1996) there was in commercial tomatoes. They described the core as hard and white that made the tomato appear unripe. Both the middle aged and elderly groups stressed the importance of seeing the seeds in the tomato. It was communicated that the presence of seeds surrounded by a clear gelatinous coating is associated with full flavor and juiciness. The elderly group feels that commercial tomatoes no longer have the smooth gelatinous seeds and ‘goop’ that they associate

with the ideal tomato. The seeds of the commercial tomato now have the consistency of cottage cheese in that the seeds are hard and the seed coatings are very opaque (Table 2.3).

Focus group participants discussed that they do like the overall appearance of commercial tomatoes (Table 2.2). Group members commented in approval that retail tomato fruit was red and round and had very little blemishes. The majority of focus group contributors liked the year round availability and broad selection of tomato varieties. Though there were some participants in the elderly group that only ate tomatoes either picked from their gardens or during the local growing season (data not shown). The young focus group's description of commercial tomatoes was "very ripe," uniform in color, "uniform in the pack," and "basically tastes like a home grown tomato" contradicts the beliefs of the middle aged and elderly groups. It also supports the conclusions of Brumfield et al. (1993) that many consumers recognize tomatoes with the uniform coloration of gassed tomatoes as vine ripened. From these findings it can be concluded that the young group is most likely several generations removed from agriculture, do not have experience with producing tomatoes, and are not familiar with the natural ripening process (Brumfield et al., 1993). One participant summed up the differences in the age groups by stating she had "grown up eating store bought tomatoes and she did not know there was a difference" (Table 2.3) in commercial and garden tomatoes. It is also notable that this young demographic was the only one to mention tomatoes "in a pack" or packaged in any way indicating there has been little if any exposure to non-commercially available tomatoes.

All focus group participants agreed on the poor texture and hardness often associated with commercial tomatoes (Table 2.2). The young demographic described the tomatoes as being bitter while the middle aged and elderly complained about the lack of acidic taste. It can be concluded that the younger demographic may be associating the lack of sweet taste (Table 2.1)

with the “bitter” descriptor. The elderly group described the taste of commercial tomatoes as bad and did not think commercial tomatoes tasted like tomatoes. One commented that these tomatoes are simply “sandwich fillers.” Flavor and textural changes develop during ripening (Bruhn et al., 1991). With commercial tomatoes being harvested early, the fruits do not have adequate time to build up optimum flavor or textural qualities. The older groups both commented on the thickness of the tomato skin and believed it caused the tomato to be hard to peel. This may have been important to these demographics because they are more involved in food preparation for their families and larger social gatherings. These consumers confirmed the findings of Auerswald et al. (1999) that after seven days of post harvest storage the peel was found to be harder. Heirloom tomatoes have thinner skin that may be desirable for the consumer but would allow cracking and scaring of the fruit and would not allow for a long shipping or shelf life (Vavrina et al., 2003). Lack of commercial tomato ripeness was expressed by the middle aged and elderly groups. This was perpetuated with their dislike of having a “huge”, “white core in the middle of the tomato.” Many thought it was simply a lot of wasted tomato. The middle aged participants were the only group to mention the high price of tomatoes as a purchase criteria (Table 2.2).

All tomato consumers in these focus groups would have memories of tomatoes during the past ten years. When asked if they felt tomato quality had diminished in that time, all age demographics answered with an enthusiastic yes. Everyone agreed that tomato flavor has decreased with comments such as “no flavor” or “not as much acid” (Table 2.3). Even the young focus group confirmed that the tomato texture has become gritty or “like Styrofoam.” One participant in the elderly group mentioned that they would not be willing to “have a tomatoey-taste with a mealy texture” (data not shown). Shewfelt (1999) believes that today’s consumers are much more sensitive to subtle differences in texture than flavor. These comments of the

mouth-feel of commercial tomatoes also supports the suggestion of Auerswald et al. (1999) that textural properties are hardly noticed when neat expected properties, but become reason for rejection when differing. The middle aged and elderly groups seemed to have had more opinions of why tomato flavor quality had diminished. They believe that commercial tomatoes are grown differently. The lack of time left on the vine to ripen and build flavor was felt to be one of the main reasons for the decreased quality (Table 2.3). These consumers' opinions echoed the report of Baldwin et al. (1998) that one of the main reasons for poor tomato flavor is that early harvest and treatment of stored tomatoes prevents full flavor development. Middle aged focus group members felt that tomato producers were simply looking for the quickest, cheapest way to get tomatoes ripe and flavor was not a priority. This was echoed by the elderly group in the comment "producers blow them up with fertilizer." These opinions confirm the findings of Bruhn et al. (1991) were some consumer's complained that the ease of shipping and harvesting practices has taken precedents over eating quality.

Once focus group participants were asked what connotations came to mind with the term "heirloom tomato" or "heirloom fruit," most responded with "antique," "old," "original with no changes," and "trusted for years" (data not shown). Most thought that heirloom varieties could simply be a marketing scheme however they felt these varieties were legitimate. Each group was given a general overview of what heirloom tomatoes are and their legendary characteristics of coming in a multitude of colors from white to black, green to purple and a variety of shapes including one shaped like an accordion. Participants were then polled as to their possible willingness to consume and purchase heirloom tomatoes. The young, middle aged, and elderly group participants confirmed that they would all be willing to try them though some said they would be hesitant (Table 2.4). Most participants would want to sample the heirloom tomatoes

before purchase and the availability of product and flavor descriptions would be very helpful. Often preference is influenced not only by tomato perception, but also by product information or image factors such as ripening method or production method (Brumfield et al. 1993; Johansson et al., 1999; Von Alvesleben and Meier, 1990). The elderly group wanted some sort of identification to distinguish heirloom tomatoes from others. The middle aged demographic was again the only group to mention the concern of price as a purchase attribute. Most of the middle aged and elderly groups indicated that a recommendation of the flavor or some type of proof of superior quality would be desired. They suggested having several heirloom varieties available might ease consumer hesitance enabling consumers to try a red heirloom variety then venture to the more non-stereotypical looking varieties (Table 2.4).

We conclude that the young demographic prefers sweet tasting tomatoes while the older groups desire a more acidic tasting tomato. We also found that the young group does not have any other flavor reference for tomatoes other than commercial tomatoes. We concluded that tastes preferences may be changing as a new generation of consumer tastes is emerging. Texture, firmness, and color were discovered to be some of the most important attributes affecting consumer consumption and purchase. Consumers want a bright red tomato that is firm yet has some give when squeezed and they are not satisfied with the apparent grittiness of commercial tomatoes. These participants would be willing to consume and purchase heirloom tomatoes on the condition of definite superior flavor. Most would like a product and flavor description available at location of purchase and indicated that a reliable recommendation of flavor from a trusted source would help in their decision.

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TABLES

TABLE 2.1
ATTRIBUTES OF FOCUS GROUP PARTICIPANTS' IDEAL TOMATO

	Young[1]	Middle Aged[2]	Elderly[3]
Flavor	Prefers sweet over tart	Slightly acidic, not sour	Strong flavor, acid, bite and tart
Color	Bright red with no green	Bright red	Red-red, not yellow
Texture	Not gritty	Smooth, not grainy	Now tomatoes are mealy, the texture of an apple
	Firm with a give when squeezed	Firm, but not too firm and not soft	Firm but has a little give when you squeeze it
	Juicy	Not too much "core"	Juicy
		Must have seeds	I like to be able to see the seeds

Ages roughly categorized.
[1] Young: 18-25 years old, median age 23.
[2] Middle-age: 25 to 60 years old, median age 46.
[3] Elderly: 23 to 80 years old, median age 67.

TABLE 2.2
FOCUS GROUPS' OPINION ON FRESH COMMERCIAL TOMATO FRUIT ATTRIBUTES

	Young[1]	Middle Aged[2]	Elderly[3]
Good Attributes	Look like a typical tomato	Looks like a tomato	Their look
	Juicy	Availability	Availability
	Very ripe		
	Uniform color on the single fruit or in the pack	Not bruised	Color
	Basically tastes like a home grown tomato		
Bad Attributes	Texture is too gritty	Grainy	Texture of an apple
	Bitter	No taste, lack of flavor	Taste is bad
	Too firm	No acid	Doesn't taste like a tomato
		Have thick, rubbery peel	No acid taste
		Not ripe	No taste, bland
		Not red, more pink in color	Hard to peel
		Have a "white core" - seen as unripe	Never really ripe
		No seeds	Huge core or stem in the middle of the tomato
		Lesser Quality	Hard
		Expensive	

Ages roughly categorized.
[1] Young: 18-25 years old, median age 23.
[2] Middle-age: 25 to 60 years old, median age 46.
[3] Elderly: 23 to 80 years old, median age 67.

TABLE 2.3
FOCUS GROUPS' OPINION OF HOW COMMERICAL TOMATOES HAVE DIMINISHED IN PAST 10 YEARS

Young[1]	Middle Aged[2]	Elderly[3]
No flavor	Flavor not as rich	Quality is less
Texture is like Styrofoam	Less acidic	Texture is almost like a watermelon
Very watery	Not as mature on the plant must affect the flavor	Not as much flavor
Very gritty	Not enough time to ripen and build flavor	Not much acid
Color seems fake	Grown differently	Now, most people don't know the difference
Can never tell of grittiness	Producers looking for the quickest, cheapest way to get them ripe	Producers "blow them up with fertilizer"
I don't know there is a difference. I have grown up with store bought tomatoes.		The seeds and juice on the inside is just cloudy
		Insides are like the consistency of cottage cheese
		Juice used to be red, now it is just watery
		Very pulpy!

Ages roughly categorized.
[1] Young: 18-25 years old, median age 23.
[2] Middle-age: 25 to 60 years old, median age 46.
[3] Elderly: 23 to 80 years old, median age 67.

TABLE 2.4
FOCUS GROUP PARTICIPANTS' WILLINGNESS TO CONSUME AND PURCHASE HEIRLOOM TOMATOES THAT MAY NOT BE RED OR ROUND

Young[1]	Middle Aged[2]	Elderly[3]
Would purchase heirlooms if they had better flavor	Yes, I would be willing to try it	Yes, but I wouldn't know what to think
Would want to try it first	Would depend on the price	Would want some type of identification of heirloom tomatoes
Would be hesitant	Must be convinced of increased quality and flavor	Would want a trusted recommendation
Would want product and flavor descriptors	Would be hard to get over the difference because we are so conditioned to red and round tomatoes	Must be convinced that they were tomatoes
	May help consumer accept heirlooms if multiple varieties were available	Maybe try the red heirlooms first and then venture from there.
		I would need samples

Ages roughly categorized.
[1] Young: 18-25 years old, median age 23.
[2] Middle-age: 25 to 60 years old, median age 46.
[3] Elderly: 23 to 80 years old, median age 67.

CHAPTER 3

CONSUMER ACCEPTABILITY OF HEIRLOOM AND COMMERICAL TOMATOES[1]

[1] Bland, S.E, Limpawattana, M., Nazarea, V., and Shewfelt, R.L. 2005. To be submitted to Journal of Food Distribution Research.

ABSTRACT

Consumers are becoming more health conscious and new information about the health benefits of tomatoes is making them a highly sought after fruit. Yet, with all its popularity, tomatoes have one of the highest rates of consumer dissatisfaction due to its poor flavor characteristics. A grassroots movement to bring back tomatoes of the past has ushered in heirloom tomato varieties that are renown to have superior flavor and believed to be an answer to poor commercial tomato flavor. Consumers (n=152) were polled to determine their tomato purchasing and consumption criteria and to rank heirloom and commercial tomato flavor. Statistically, commercial tomatoes did not receive a higher superior rating than the heirloom varieties used in this study. However, commercial tomatoes were ranked as the least preferred tomato sample among the population surveyed.

INTRODUCTION

Since the start of planting hybrid seeds for commercial production, tomatoes have been grown and designed with the producer, not the consumer in mind (Watson, 1996; DeMuth, 1999). The conveniences of increased crop yields, uniform ripening and fruit size, and built in pest resistance has revolutionized the commercial tomato operation. However, in the process of creating a better harvesting tomato, not much attention was paid to flavor characteristics (Petro-Turza, 1987).

Tomatoes are one of the most popular produce items on the market, but they have also acquired one of the highest rates of consumer dissatisfaction (Bruhn et al, 1991). This dissatisfaction stems from poor flavor that may be caused by cultivation and storage conditions (Baldwin et al., 1998). In the past several decades, a grass-roots effort has begun to bring back the varieties of the past. Many believe these tomatoes have better and fuller flavor than those that are commercially available today. Taylor's Guide to Heirloom Vegetables defines an heirloom as, 1) being at least 50 years old, 2) being an open-pollinator, and 3) having a history of its own (Watson, 1996). These tomato varieties come in a multitude of shapes, colors, and flavors. However, studies show that the very characteristics of heirlooms that make them fit the desires of consumers prevent them from dominating the commercial industry. In a study by Vavrina et al. (2003) it was found that heirloom tomato fruit size varies from small (>1 ounce) to extra large (<10 ounces). They also exhibited blossom end scars and radial, concentric and calyx cracking taking away from their appearance. Vavrina et al. (2003) tested fifteen heirloom tomato varieties and none were found that could withstand the rigors of the commercial tomato industry. However there were some varieties that were recommended for the specialty market.

Consumer acceptance is hinged upon shoppers acquiring tomatoes full of flavor that meet their criteria for ripeness. People use all their senses when eating foods, but buy with their eyes (Von Alvesleben and Meier, 1990). Tomatoes are often purchased that have the characteristics believed to portray ripeness and desired quality yet they do not deliver the expected flavor (Bruhn et al., 1991; McGlasson, 1989). Segmentation of consumers has been offered as a solution to combat poor consumer acceptance of tomatoes. Basing consumer segments on characteristic preferences would provide consumers tomatoes that encompass the flavor qualities they desire (Auerswald et al., 1999; Bruhn et al., 1991; van Lieshout, 1993; West et al., 2005). By providing items that meet consumers' expectations for flavor acceptability, an increase in consumer satisfaction is anticipated (Moskowitz, 1993; Shewfelt, 2000b).

With the use of consumer surveys and sensory evaluation the objectives of this study are to determine consumer acceptability of two heirloom tomato fruit and reasons for acceptance and rejection of these varieties.

MATERIALS AND METHODS

Experimental Materials

Two heirloom tomato varieties were grown under the Lewis Taylor Farms, Inc. standard agricultural practices at Lewis Taylor Farms in Tifton, GA. The heirloom tomatoes where chosen based on availability and history from the Southern Seed Legacy seed bank at the University of Georgia. Heirloom tomatoes were harvested at approximately the same stage of maturity, red-ripe (USDA, 1975). Tomatoes were transported back to the University of Georgia campus within one-day of harvest. Commercial tomatoes were purchased from a local retail grocery chain.

Standard, single, big red tomatoes were purchased on the basis of ripeness and color. All tomatoes were stored at room temperature (20°C) until the evaluation period.

Consumer Testing

Consumer testing was performed in Athens and Tifton, Georgia. Tomato samples were cut into halves or wedges, approximately 8 g in size, placed into 4 oz. soufflé cups and capped. Sets of three samples, one of each tomato variety, were labeled with 3-digit random numbers and served in random order to panelists. Panelists completed questionnaires consisting of three sections (1) evaluation of each sample's flavor using a 3-point acceptability scale of "tastes great," "acceptable," and "unacceptable" (Abegaz, 2000; Dubost et al., 2003; West, 2000), (2) ranking the samples in order of flavor preference, and (3) evaluation of their selection and preference of tomatoes. Each panelist was given a small treat for his/her participation.

One hundred fifty two naïve panelists participated in the consumer test where all panelists evaluated the two heirloom varieties and the commercial tomato variety. Consumer panel evaluations of all tomatoes were conducted on the same days as the sensory-panel evaluations.

Sensory Evaluation

All sensory evaluations were conducted in partitioned booths under red light at the Food Research and Development Laboratory in the Food Science Department of the University of Georgia. An experienced panel familiar with descriptive analysis was used in the sensory evaluation of one commercial tomato variety and two heirloom tomato varieties. Seven panelists (6 students and 1 staff from The University of Georgia Department of Food Science and

Technology) were given a set of 11 descriptors, which were derived from the previous studies conducted in our Laboratory: 4 taste, 5 aroma, and 2 chemical sensations (Abegaz, 2000; Meilgaard et al., 1991; Civille and Lyon, 1996) These panelists then evaluated the samples. The terms for taste were sweet, sour, salty, and bitter, and for aroma they were fruity, tomato-like, overripe, earthy/musty, and green/grassy. Chemical feeling factors were astringency and bite. Panelists scored each of the eleven attributes for each tomato using 150mm unstructured line scales which were anchored 12.5 mm from both ends (12.5 and 137.5 respectively) with the intensity scores of reference standards being identified. Reference standards were provided for proper assessment of each characteristic. Treatments were prepared as described above and coded with three-digit random numbers. Panelists were given water and unsalted saltine crackers to clear their palates in between samples. Expectoration cups were also provided.

Statistical Analysis

Demographic characteristics of consumer panelists were analyzed by percentage. The consumer acceptability and descriptive analysis data were statistically analyzed using analysis of variance (ANOVA) using SAS v.6.12 software package. Panelists were treated as repeated measures. Multiple mean comparisons were carried out by Duncan's Multiple-Range test at $p<0.05$.

RESULTS AND DISCUSSION

The majority of the survey participants were in the age range of 18 to 25 years old as shown in Table 3.1. There were no significant differences in the ratings of superior fruit ("tastes

great") between heirloom and commercial tomatoes (Table 3.2). Commercial tomatoes were found to be more acceptable ("tastes great" plus "acceptable") than both heirloom varieties. These data suggest that while a little more than one-fourth of the consumers found each item to have a superior flavor, the population tested felt more comfortable with the commercial product.

The commercial tomatoes may not have received a higher superior ranking because of cultivation practices not allowing longer ripening on the vine (Baldwin et al., 1998; Maul et al., 1998) and storage conditions (Auerswald et al., 1999; Boukobza et al., 2002; Kader et al., 1978; Maul et al., 2000). However, the commercial tomatoes most likely had more consistent quality, textural and flavor attributes than the heirloom varieties, explaining a higher acceptable ranking. Lack of expected superior and acceptable ratings of the heirloom varieties may be due to the fact they were produced in the fall. Puig and Casado (1983) found fall and winter tomatoes have a lower degree of acceptability. This observation may stem from the shorter days during these seasons which leads to a lower synthesis of substrates for sugars, acids, and carotenoids which contribute to tomato flavor (Petro-Turza, 1987). Standard commercial tomatoes are produced in sandy soils with ample irrigation. Heirloom tomatoes are typically grown in heavier clay soils under higher moisture stress. The combination of minerals and salts from the soil and fertilizers coupled with higher moisture stress is believed to be one reason heirloom tomatoes are thought to have more flavorful fruits (Gardner, 2005). The heirloom tomatoes for this study were grown in a commercial tomato operation. These heirloom tomatoes may not have had the optimum flavor qualities typical of these varieties due to cultivation practices and time of year grown and harvested.

The same consumers ranked the three tomato samples from most preferred to least preferred. There were no significant differences in the ranking of most preferred between

commercial and heirloom varieties (Table 3.2). Fewer consumers rated the red heirloom tomato as least preferred than the other treatments.

With the data from the focus groups in Chapter 2, a new hypothesis was formed that the young population (18-25 years old) prefers more sweet tasting tomatoes and the older population (26-65+ years old) prefers a more acidic tasting tomato with a bite. Once this new hypothesis was formed the consumer data was partitioned by age (18-25 years old and 26-65+ years old) as shown in Tables 3.3 and 3.4. The young data set did not offer much explanation as none of the commercial and heirloom tomato varieties were found to be significantly different for percent superior, percent acceptable, or most preferred (Table 3.3). More consumers in the younger demographic rated the commercial tomato as least preferred over both heirloom varieties and fewer consumers rated the red heirloom as least preferred. This data concurred with the overall ratings of percent least preferred as shown in Table 3.2. In the young population it was found that the heirloom varieties were differentiated as a larger number of consumers rated the yellow heirloom tomato as least preferred between the two varieties and a smaller number of consumers rated the red heirloom least preferred.

There were more differences found in the older data set as shown in Table 3.4. The commercial and red heirloom tomatoes were not found to be significantly different. However the red heirloom was rated as having a higher superior rating than the yellow heirloom tomato. Consumer ratings for percent most preferred followed a similar pattern where the commercial and red heirloom tomatoes were not found to be statistically different, yet they both received a higher rating of most preferred to the yellow heirloom tomatoes. The commercial and yellow heirloom tomatoes were not found to be significantly different for percent acceptable, however

the commercial variety was given a higher acceptance rating than the red heirloom. No significant differences were found between the three tomato varieties for least preferred.

It cannot be concluded from these data that the younger population prefer a sweeter tasting tomato while the older population prefers a more acidic tasting tomato with a bite. It appears that the older population has a more sensitive taste palate, as they were able to distinguish differences in taste among the commercial, red, and yellow heirloom tomato varieties. Based on the observations of Chapter 2, the acidity of the heirloom varieties may have contributed to these differences.

The majority of consumers do not buy a particular variety or brand of fresh tomato fruit (data not shown). Coupled with the observation that over 80% of consumers surveyed purchase tomatoes at grocery stores or supermarkets (Table 3.3), it can be concluded that when people purchase tomatoes they do not have a specific tomato reference in mind. There is no brand or variety loyalty for fresh tomato fruit. Consumers are simply looking for any fresh tomato that satisfies their requirements for quality. Color, firmness, no deformities, and size are the four main attributes affecting purchase decision (Table 3.4). This closely resembles the three most important attributes of the consumers surveyed ideal tomato fruit that are color, flavor, and firmness. Color and firmness are in the top three of purchase decision and ideal attributes, but flavor is considerably lower in purchase decision at 10% (data not shown). Brumfield et al. (1993) concludes flavor may not be as significant because flavor cannot be determined at time of purchase. As flavor is the main factor of consumer dissatisfaction with tomatoes, the faulty link between purchase and consumption attributes must be determined and corrected (Shewfelt, 1999). Color is the main characteristic consumers use to gauge ripeness and ultimate flavor (Brumfield et al., 1993). The deeper and brighter the red color, the more flavor is expected in the

fruit. It has been documented that consumers purchase tomatoes with the desired physical characteristics of roundness, firmness, and color, however the flavor expectation is often not met (McGlasson, 1989).

Of those that do purchase particular tomato brands or varieties, premium tomatoes are the main tomato types purchased (data not shown). Consumers are looking for fresh tomato fruit that tastes like a tomato, are full of flavor, and are vine-ripened (Table 3.5). Petro-Turza (1987) found that tomatoes that stay on the vine longer develop more flavor and are more desirable. The sweet characteristic is rated much higher than the acidic or sour attribute. Keeping the age range of the majority of the surveyed population in perspective (Table 3.1), this supports the findings of the focus groups (Chapter 2) that the younger population (median age 23) desires a more sweet taste while the middle aged (median age 46) and elderly (median age 67) populations desire a more acidic bite to their tomatoes.

Descriptive sensory analysis of the heirloom and commercial varieties also offers some explanation to the lower expected superior rating of the heirloom varieties. The three varieties do not differ much in their descriptions however, it is important to note that the descriptor, astringency, was significantly higher in the heirloom varieties than the commercial tomatoes (Figure 3.1). The astringency note is closely related to acidity. Again, as the younger demographics prefer a sweeter tasting tomato over sour, this may account for the higher acceptance of commercial tomatoes over heirloom (Table 3.1). This data also supports older populations complaining that commercially produced tomatoes do not favor the tomatoes they grew up with as discovered in the focus groups (Chapter 2). Garden fresh tomatoes and heirloom tomatoes that ripen on the vine longer appear to have a higher acid content than the tomato fruits available commercially (Petro-Turza, 1987).

A very small percentage of consumers indicate that commercial fresh tomato fruit is superior and needs no improvements (Table 3.6). This percentage is approximately the same as consumers who believe commercial tomatoes are unacceptable or horrible. These low numbers support the literature evidence that consumers shy away from the extreme descriptors and use primarily moderate ones (O'Mahoney, 1991). The majority of the population believes commercial tomatoes are acceptable. Approximately half of that segment believes commercial tomatoes are satisfactory while the other half believes commercial tomatoes need improvement. This observation also supports the findings of the focus groups of the previous chapter that the younger generations have grown up with commercially purchased tomatoes and do not have a "taste reference" to garden or fully vine ripened tomatoes. As consumers become several generations removed from agriculture and do not experience tomato production in home gardens, they often are not familiar with natural ripening and prefer the more uniform color of gassed tomatoes (Brumfield et al., 1993) thereby not knowing there is fuller flavor to be acquired.

Since many heirloom tomatoes do not exhibit the typical red and round attributes that comprise most commercial tomatoes, consumers were asked their likeliness of purchasing fresh tomato fruit that was a different color and shape from the traditional red, round, mass-market tomato. The majority of consumers had never heard of or eaten heirloom tomatoes (Table 3.7) however most showed a high probability of purchasing different looking tomatoes if they knew they had good flavor (Table 3.8). Many commented that they would want to sample the tomatoes before purchase (data not shown). There were 23% that indicated they would not be willing to purchase different looking tomatoes. The availability of a product description including flavor and texture attributes would benefit most consumers (Table 3.9). However a small part of the population would not be aided by product descriptors, as they know what they like or

commented they “would not believe the hype” (data not shown). Most of the population perceives heirloom tomatoes as those from an old variety (Table 3.10). Their perception is that heirlooms have better flavor, are of better quality, and are probably grown organically. Only a small percentage of consumers believe heirloom tomatoes to be a marketing scheme. Survey data not shown found that an overwhelming majority of consumers purchase tomatoes all year long.

Overall, the heirloom tomatoes evaluated in this study were not statistically more superior to commercial tomatoes in flavor. However, the surveyed population rated the commercial variety the least preferred tomato. A comment made by one of the survey participants was “[the commercial tomatoes] taste like a tomato should.” Much of the population no longer has ties to agriculture and has grown up eating commercially produced and purchased tomatoes. These consumers do not understand the ripening stages of a tomato and only know the flavor of those that have been picked at breaker stage and treated with ethylene gas. Heirloom tomato varieties would do well in the specialty tomato market or farmers market. Their future in the mass-produced commercial industry may not be as open, as the attributes that make them different from commercially produced tomatoes also prevent them from surviving commercial harvest and storage. Heirlooms would be a great tomato in which to begin the variety loyalty that is lacking in the tomato industry. While they would most likely not be able to be purchased all year long, studies show that consumers are receptive to additional cultural information such as the way and location in which produce is grown (von Alvensleben and Meier, 1990). Coupling the history of an heirloom tomato with a product description of its flavor attributes may prove to be a new niche market for the tomato industry.

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TABLES

TABLE 3.1
SURVEYED CONSUMERS' AGE AND GENDER

	Range	Percentage
Age	18-25	59
	26-35	6
	36-45	10
	46-55	14
	56-65	6
	65+	5
Gender	Female	60
	Male	40

TABLE 3.2
CONSUMER ACCEPTANCE AND PREFERENCE OF COMMERCIAL, YELLOW HEIRLOOM, AND RED HEIRLOOM FRESH TOMATO FRUIT

Tomato Type	Acceptability		Preference	
	% Superior[1]	% Acceptable[2]	% Most Preferred	% Least Preferred
Commercial	23.6[a]	82.4[a]	29.7[a]	38.5[a]
Yellow Heirloom	27.5[a]	74.5[b]	36.2[a]	34.2[a]
Red Heirloom	27.5[a]	77.9[b]	33.6[a]	28.9[b]

[1] Tastes Great. [2] Tastes Great and Acceptable. Numbers with different letters are significantly different (α=0.05). Consumer values expressed as percentages.

TABLE 3.3
YOUNG (18-25 YEARS OLD) CONSUMER ACCEPTANCE AND PREFERENCE OF COMMERCIAL, YELLOW HEIRLOOM, AND RED HEIRLOOM FRESH TOMATO FRUIT

Tomato Type	Acceptability		Preference	
	% Superior[1]	% Acceptable[2]	% Most Preferred	% Least Preferred
Commercial	25.6[a]	83.3[a]	31.1[a]	37.8[a]
Yellow Heirloom	28.3[a]	84.8[a]	35.6[a]	31.1[b]
Red Heirloom	28.3[a]	84.8[a]	33.6[a]	21.1[c]

[1] Tastes Great. [2] Tastes Great and Acceptable. Numbers with different letters are significantly different (α=0.05). Consumer values expressed as percentages.

TABLE 3.4
OLDER (26-65+ YEARS OLD) CONSUMER ACCEPTANCE AND PREFERENCE OF COMMERCIAL, YELLOW HEIRLOOM, AND RED HEIRLOOM FRESH TOMATO FRUIT

Tomato Type	Acceptability		Preference	
	% Superior[1]	% Acceptable[2]	% Most Preferred	% Least Preferred
Commercial	18[ab]	78.7[a]	41[a]	31.1[a]
Yellow Heirloom	13.1[a]	75.4[ab]	24.6[b]	32.8[a]
Red Heirloom	22[b]	69.5[b]	35[a]	36.7[a]

[1] Tastes Great. [2] Tastes Great and Acceptable. Numbers with different letters are significantly different (α=0.05). Consumer values expressed as percentages.

TABLE 3.5
PRIMARY PURCHASE LOCATION OF FRESH TOMATO FRUIT

Location	Percentage
Supermarket/Grocery Store	80
Garden	10
Roadside Stand	5
Farmer's Market	3
Other	2

TABLE 3.6
CRITICAL ATTRIBUTES OF CONSUMERS' IDEAL TOMATO AND PURCHASE DECISION OF FRESH TOMATO FRUIT

Purchase Attributes	Ideal Tomato Attributes
Color	Color
Firmness	Flavor
Free of Deformity	Firmness
Size	Quality
Quality	Free of Deformity
Flavor	Price
Price	Size
Shape	Shape
Brand	Way it's Grown
Way it's grown	Brand

TABLE 3.7
MOST IMPORTANT TASTE CHARACTERISTICS OF FRESH TOMATO FRUIT

Attributes	Percentage
Tastes like a tomato	24
Full of flavor	24
Vine-ripened	22
Sweet	19
Acidic or sour	6
Sweet and sour	4
Other	1
Bland, no flavor	<1

TABLE 3.8
CONSUMERS' RATING OF FRESH COMMERCIAL TOMATO FRUIT

Rating	Percentage
Tastes great	6
Acceptable, they are satisfactory	42
Acceptable, but need improvement	39
Unacceptable	6
Horrible	1
I don't care	5

TABLE 3.9
PERCENTAGE OF CONSUMERS WHO HAVE HEARD OF OR EATEN HEIRLOOM TOMATO FRUIT

	Heard	Eaten
Yes	23	13
No	77	87

TABLE 3.10
CONSUMERS' LIKELIHOOD OF PURCHASING FRESH TOMATO FRUIT THAT IS A DIFFERENT COLOR OR SHAPE FROM TRADITIONAL ROUND RED MASS-MARKETED TOMATOES

Response	Percentage
Yes, if had good flavor	64
Yes, I like to try different things	12
No	23
Other	1

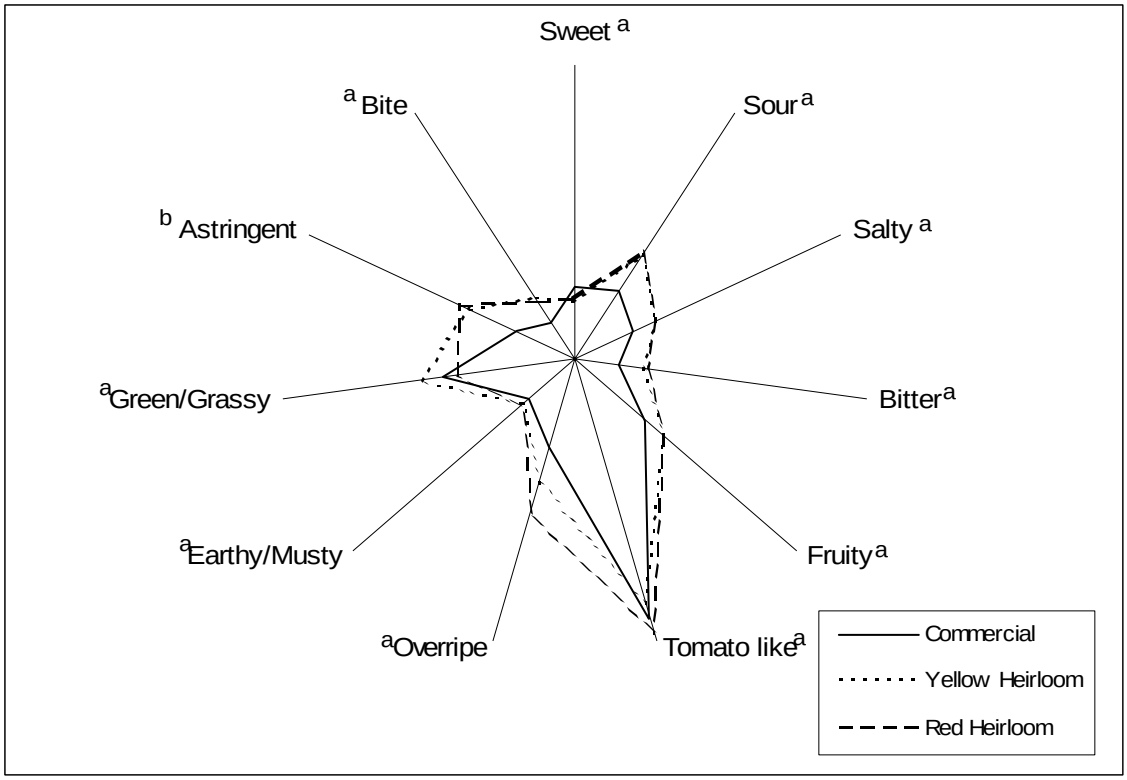
TABLE 3.11
CONSUMER OPINIONS ON THE USEFULNESS OF PRODUCT/FLAVOR DESCRIPTORS AVAILABLE AT TIME OF PURCHASE

Response	Percentage
Yes, it would help	85
No, would not help	9
No, I know what I like	6
Other	<1

TABLE 3.12
CONSUMERS' PERCEPTION OF HEIRLOOM TOMATOES

Perception	Percentage
Old Variety	49
Better flavor	10
Organically grown	10
Better quality	10
Just a marketing scheme	6
Weird or different looking	7
Other	8

FIGURE 3.1
DESCRIPTIVE SENSORY ANALYSIS OF COMMERICAL, YELLOW HEIRLOOM AND RED HEIRLOOM TOMATOES



Numbers with different letters are significantly different (α=0.05).

CHAPTER 4

SUMMARY AND CONCLUSIONS

Heirloom tomatoes have emerged onto the produce market with a reputation of having superior flavor qualities than those of commercial tomatoes. These old varieties offer a range of colors, shapes, and flavors yet the very qualities that make them unique keep them from surviving the rigors of the tomato industry.

In Chapter 2 with the use of focus groups categorized by approximate age range, it was found that consumers in the young demographic prefer sweet tasting tomatoes while the older groups desire a more acidic tasting tomato. It was also revealed that the young group does not have any other flavor reference for tomatoes other than commercial tomatoes. Participants would be willing to consume and purchase heirloom tomatoes on the condition of definite superior flavor and recommendations from trusted sources or friends would be most beneficial

In Chapter 3 consumer evaluations of heirloom tomato fruit did not elicit the superior flavor rating over commercial tomatoes that was expected. However, the surveyed population rated the commercial variety the least preferred tomato. The data was then partitioned by age as young (18-25 years old) and older (26-65+ years old) to test the hypothesis that the younger demographic prefers a sweeter tasting tomato while the older population prefers a more acidic tomato. This hypothesis cannot be concluded from these data. Much of the population no longer has ties to agriculture and has grown up eating commercially produced and purchased tomatoes. These consumers do not understand the ripening stages of a tomato and only know the flavor of those that have been picked at breaker stage and treated with ethylene gas. Heirloom tomato varieties would do well in the specialty tomato market or farmers market. It was found that there is no variety or brand loyalty in the tomato market. Heirlooms could be the tomato with a history in which to begin the variety loyalty that is lacking in the tomato industry. While they would most likely not be able to be purchased all year long, studies show that consumers are receptive

to additional cultural information such as the way and location in which produce is grown. Coupling the history of an heirloom tomato with a product description of its flavor attributes may prove to be a new niche market for the tomato industry. Sensory descriptive analysis revealed that the only descriptor that differed between the heirloom varieties and the commercial variety was astringency.

This research supports the theory of flavor segmentation. With the integration of sensory analysis, consumer acceptability and evaluation, and focus groups, a great understanding of the tomato will ensue.