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# Development Of A Sensory Descriptive Lexicon For Calamondins (Citrus Mitis Blanco) And Consumer Acceptance Of Calamondin Yogurt

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# DEVELOPMENT OF A SENSORY DESCRIPTIVE LEXICON FOR CALAMONDINS (*Citrus mitis Blanco*) AND CONSUMER ACCEPTANCE OF CALAMONDIN YOGURT

By

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DEVELOPMENT OF A SENSORY DESCRIPTIVE LEXICON FOR CALAMONDINS (*Citrus mitis Blanco*) AND CONSUMER ACCEPTANCE OF CALAMONDIN YOGURT

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The objectives of this research were to establish a semi-descriptive sensory language that describes the attributes of calamondin fruit and develop yogurt products flavored with calamondin and test consumers' acceptance of the products. A total of 89 sensory terms were established by trained panelists to describe calamondins. Yogurt products were developed with 0%, 5%, 10%, and 15% calamondin pulp. Results demonstrated that no significant difference (P>0.05) occurred for consumers' acceptance of yogurt appearance and texture, and significant differences (P<0.05) occurred for consumers' acceptance of yogurt flavor and overall liking. Generally, the yogurt with 10% honey and the yogurt with 10% honey and 5% calamondin pulp were well accepted by consumers. The consumers were grouped into 6 clusters based on their prefences. The

majority (60%) of the consumers liked moderately yogurts with 10% honey, and 0% and 5% calamondin pulp respectively.

# DEDICATION

To my parents, for you always trusting me. If there ever is a motivation that pushes me going forward, I believe it is that I always want to prove to you that I am worthy of your trust.

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# CHAPTER I

# INTRODUCTION

According to the projections from the U.S. Department of Agriculture, the United States will harvest approximately 12.7 million tons of citrus fruit during the 2007-2008 season (Pollack and Perez, 2007a). The unique flavors provided by citrus are among the most preferred in the world, and it is increasingly evident that citrus not only tastes good, but is also good nutritionally. Perhaps the most remarkable contribution of citrus fruits to the human diet is attributed to their high content of vitamin C. It is believed that the consumption of one serving of citrus fruit can fulfill a human's daily requirement for vitamin C (Ting, 1980). Citrus fruits also contain other vitamins, sugars, amino acids and minerals, many of which are essential in human nutrition (Ting, 1980).

Calamondin (*Citrus mitis Blanco*), or kalamansi is one kind of citrus fruit that is believed to be a hybrid of *Citrus reticulata* Blanco x *Fortunella* spp. It is widely distributed and cultivated in tropical (Philippines, Central America) and subtropical (China, Japan, Florida) areas (Hodgson, 1967; Mabesa, 1990; Morton, 1987). Although expanded production of calamondin in the United States does not appear to be of great demand probably due to the availability of many other citrus fruits (Crane and Campbell, 1990), it is popularly used in the Philippines primarily for its juice and as a substitute for lemon (Nisperos et al., 1982). Research has covered the post-harvest physiology, handling, and processing of calamondin fruits, chemical and nutritional changes during processing and storage of juice as well as the volatile compounds and organic acids in the juice (Mabesa, 1990; Mendoza and Pantastico, 1979; Nisperos-Carriedo et al., 1992; Nisperos et al., 1982).

Sensory attributes are analyzed to monitor the quality as well as the culinary value of a product. Yet the full determination of sensory attributes, such as flavor, of calamondin has not been reported. The focus of this research is to outline the sensory attributes as well as to develop a semi-descriptive sensory language for calamondin.

Quantitative descriptive sensory analysis (QDA) (Stone et al., 1980), as one of the most comprehensive and informative tools, will be applied in this research to fully understand the sensory properties of calamondin. Descriptive sensory analysis techniques are performed in three essential steps. Initially, the panelists must be trained to overlook specific flavors, aromas, etc. using standards. Panelists should be screened for long-term availability and should have a keen interest in citrus fruits. Then the panelists' reproducibility and consistency will be evaluated. The panelists will then be asked to generate descriptor standards needed to describe differences among the calamondin. After trained panelists develop precise descriptors, they will subsequently quantify the degree to which these attributes are present in the product. The trained panelists will then be ready to begin sessions of descriptive analysis on the calamondin (Meilgaard et al., 1999).

Today, many consumers continually search for new and unique food products while trying to maintain healthy eating habits. Calamondins could provide pleasant aroma and flavor, as well as nutritional value. Although fresh and processed calamondin product is not well introduced to the market in the United States yet, other citrus fruits, such as grapefruits, lemons and oranges have gained nation-wide popularity. Orange juice consumption is greater than those of all other fruit and vegetable juice combined (Pollack and Perez, 2007b). Lemons are served as a garnish of dishes, and lemon yogurt is highly demanded (Tamime and Robinson, 1999). Since calamondin is used as a substitute for lemon in the Philippines, there is much potential that the flavor of calamondin yogurt will be well accepted by consumers in the United States. Furthermore, an important staple to Middle Easterners for the past 5,000 years, yogurt is now becoming a popular healthy snack food in the U.S. (Foss, 2000). According to the USDA, yogurt production reached 60.7 million gallons in 2007 (United States Department of Agriculture, 2008). Therefore, it is likely that calamondin flavored yogurt will attract the attention of yogurt and citrus fruit consumers in the U.S. market. In this work, a calamondin flavored yogurt will be developed. The calamondin pulp will be mixed with plain yogurt at different levels along with sweeteners. Consumer panels will also be conducted to investigate how consumers accept the calamondin flavored yogurt.

The primary objective of this research is to determine, through descriptive analysis, scientific sensory attributes that describe calamondin by building a sensory lexicon. Secondary objective is to quantify by descriptive analysis the sensory attributes for calamondin. The third objective is to develop a calamondin flavored yogurt. And the last objective is to investigate the consumers' acceptance of the yogurt.

This research was approved by the Institutional Review Board (IRB 08-106) for research with human subjects at Mississippi State University (Apendix A).

# CHAPTER II

# REVIEW OF LITERATURE

## Citrus Fruits

### *History*

The history of citrus fruits dates back to ancient civilizations. Citrus fruits originated in China, Cochin China, the Malayan Archipelago and Southeast Asia. The ancient dynasties of China regarded citrus fruits as prized tributes. During the reign of Ta Yu (about 2205-2197 B.C.), tributes of mandarins and pummelos, wrapped in ornamental silks, were sent to the imperial court of Ta Yu when specifically ordered (Nagy and Attaway, 1980). The orange and lemon were introduced into the Mediterranean countries when the Romans navigated from the Red Sea to India. From Europe, they were introduced to America and finally to Africa and Australia (Tolkowsky, 1938).

Today, citrus fruit has been spread to most tropical and subtropical regions. The world citrus producing areas include Southern Asia, Mexico, Southern United States, especially California and Florida (National Agricultural Statistics Service, 2007), the Mediterranean region of southern Europe, northern Africa and most of the Australian continent (Ting and Rouseff, 1986). Due to its highly perishable nature, most citrus was consumed as fresh fruit until the middle of the twentieth Century. In the early 1940s, the frozen concentrated orange juice was developed in Florida. And because of this, the use of citrus fruit, especially oranges, dramatically increased in the U.S. after World War II (Florida Citrus Processors' Association, 1978). The citrus fruits in both processed and fresh forms are widely enjoyed by people in the producing regions and other regions. In the United States, the consumption of citrus juices has exceeded those of all other fruit and vegetable juices combined, due to their attractive color, distinctive aroma, and pleasing taste (Market Research Corporation of America, 1979; Pollack and Perez, 2007b).

*Culinary Usage*

Citrus fruits are used in both fresh and processed forms. In fresh form, citrus fruits can be consumed directly and also served as a garnish on plates, or used as flavor additives. Lemon is one of the common citrus fruits usually served with drinks and foods in restaurants for color and taste. In China, the peel of some citrus fruits is added into tea and other drinks not only for its flavor but also medicinal value (Xu et al., 2008).

While a significant quantity of citrus is consumed as fresh fruit, much of the crop is being consumed in the form of processed products such as juices, canned and dried products. Since the introduction of frozen concentrated orange juice, consumption of citrus products has raised several folds. Today, the consumption of citrus juices is greater than those of all other fruit and vegetable juices combined. According to United States Department of Agriculture (USDA), citrus juice accounted for 59 percent of juice consumption in 2006, down from 69 percent in 2000/01 (Pollack and Perez, 2007b). Unfortunately, citrus juices have problems from processing. Although they taste just fine when freshly squeezed from the fruits, they will turn bitter in a few hours at ambient temperature, or overnight when refrigerated. This so called "delayed bitterness", and this problem has been a target of a number of research efforts in the United States, China, Brazil, Spain, Italy and other areas where citrus is commercially grown (Berhow et al., 2000).

According to USDA, demand for most canned-fruit products, including canned-citrus products, has been declining since 2000/01, as consumers have shown increased preference for fresh and other processed fruit products such as juices and some dried fruit (Pollack and Perez, 2007b). In the United States, the dried fruits are mainly raisins. Raisins accounted for about two-thirds of dried fruit consumption, rising to almost 70 percent of the total in 2006 (Pollack and Perez, 2007b). The dried peel of some citrus fruits, called Chenpi by Chinese people, has been widely used as a culinary seasoning and tea ingredient for centuries in China (Liu et al., 2006).

Although citrus fruits are nearly universally accepted, some care should still be taken of citrus product consumption because of the chemical nature of the citrus. For example, the acid present in citrus may affect consumers adversely, especially when the citrus is not taken with a meal. Another possible problem is that certain individuals may have an allergy to citrus (Fellers, 1980).

*Dietary Value*

Besides being a favorite food, citrus fruits have been shown to possess many constituents which have important effects on human health: Vitamin C, Vitamin B1, carotenoids, folic acid, flavonoids, limonoids, potassium, soluble fiber, and others (Hasegawa et al., 2000; Ting, 1980).Perhaps the most remarkable contribution of citrus fruits to the human diet is attributed to their high content of vitamin C. Citrus fruits are among those few fruits and vegetables that highly contain vitamin C and it is believed that the consumption of one serving of citrus fruits can fulfill a human's everyday need for vitamin C (Ting, 1980). Deficiency of such vitamin would cause scurvy and other issues (Ting, 1980). Citrus fruits, juices and their other products are one of the largest suppliers of dietary vitamin C in America (Nagy, 1980). However, there still seems to be a lot of potential that we can make a better use of the vitamin C in citrus fruits, because it is reported that nearly 75% of all vitamin C in an orange and more than 80% in a grapefruit is found in the peel (Atkins et al., 1965).

Citrus juice is an ideal source of vitamin C in the diet. Vitamin C in citrus juice is remarkably stable during the short period it is generally kept after extracted from the fruit. Freshly extracted orange and grapefruit juices retained about 98% of their original vitamin C at 21.1°C for 3 days. At 4.4°C , orange and grapefruit juices retained 96% and 99%, respectively, of the original amount for one week storage (Moore et al., 1944). If orange juice is heated to boiling for 15 min, it still retains about 96% of the vitamin C (Lopez et al., 1967).

In addition to vitamin C, citrus fruits contain other important nutrients and phytochemicals that provide health benefits to consumers. Citrus juice, in particular orange juice, has been reported to be a good source of dietary folate. Orange juice contains more folate than many other fruit juice (White et al., 1991). Folate (vitamin B9) is necessary for the production and maintenance of new cells and is especially important during periods of rapid cell division and growth such as infancy and pregnancy (Kaman, 1997). Deficiency of this vitamin could result in weakness, sore tongue, headaches, heart palpitations, irritability, and behavioral disorders (Haslam and Probert, 1998). Flavonoids have been referred to as "nature's biological response modifiers" because of strong experimental evidence of their inherent ability to modify the body's reaction to allergens, viruses, and carcinogens. They show anti-allergic, anti-inflammatory, anti-microbial and anti-cancer activity (Yamamoto and Gaynor, 2001). In addition to possessing antioxidant activity and beneficial effects on capillary permeability and blood flow, the flavonoids in citrus fruits also exhibit some of the anti-cancer and anti-inflammatory benefits of tangeretin and rutin (Benavente-Garcia et al., 2007). At present, most flavanones-containing supplements are prepared from citrus fruit extracts, marketed mostly as citrus bioflavonoids complex and often mixed with vitamin C and a blend of other flavonoids such as flavonols (Espina et al., 2007).

Potassium is the most abundant mineral of citrus juices and other citrus products, amounting to 40% of the total ash. In 100 ml of orange juice, 150 to 240 mg of potassium may be available. In contrast, citrus fruits are low in sodium, generally less than 1 mg/100 ml in juice (Benk, 1965). Calcium and magnesium are the two major divalent cations of citrus fruits, but both occur in relatively low amounts in the juice ranging between 6 to 15 mg per 100 ml (Shaw et al., 1977). Phosphorus is related to the two bivalent cations in human nutrition as in structural formation. Orange juice and grape juice may contain between 15 to 20 mg per 100 ml. However, when calculated on the basis of caloric intake, citrus juices provide these three nutrients (phosphorus, calcium and magnesium) near or above their caloric contribution (Ting, 1980).

*Market and Sales*

The acceptance of fruit as a staple in the human diet has only been practiced in the past century because of their perishability as fresh produce. With the advent of canning and other preservation industries and with the better knowledge of nutrition, the use of fruits as staple foods has become more prevalent, especially in developed countries (Ting, 1980). Among the fruits, the importance of citrus fruits and their products as human food is underscored by the fact that more citrus is consumed than any other kind of fruit (Pollack and Perez, 2007b). Citrus fruits, being subtropical and tropical products, were not as popular as other fruits, such as apples. The locations of the citrus production were usually no near the world population centers and they were very perishable during storage (Ting, 1980). The technique of frozen concentrated orange juice (FCOJ) overcame the shortcomings of the citrus fruits and increased the use of them, especially oranges, dramatically after World War II in the United States (Florida Citrus Processors' Association, 1978).

Today, the demand of citrus fruits is strong and constant. Based on data from USDA, the production of citrus fruits during the past decades has been high (Figure 2.1) (National Agricultural Statistics Service, 2007). The decrease in the recent 3 years was caused by the hurricane and disease, such as citrus canker and citrus greening (Pollack and Perez, 2007b). However, the supply shortage will stimulate the unit price, which offsets the decrease of the production. Therefore, the value of the citrus production each year appears constant (Figure 2.2) (National Agricultural Statistics Service, 2007).

In the United States, the total fruit and tree nut production in 2006 season was 30.2 million tons, with the value reaching a record high at 16.7 billion dollars. Citrus fruits alone made up nearly half of the harvest, at 11.7 million tons, with the value of 2.7 billion dollars (Pollack and Perez, 2007b). Florida is the largest citrus production center in United States. Florida accounted for 70 percent of total U.S. citrus production. California totaled 25 percent, while Texas and Arizona produced the remaining 5 percent.

Citrus fruits may be dried, canned and squeezed to juice. They do not serve as froze products. Only berries, strawberries in particular, make up the bulk of frozen fruit. In dried products, raisins account for about two-thirds of dried fruit consumption, rising to almost 70 percent of the total in 2006. Demand for canned- citrus fruit products has been declining since 2000/01, as consumers have shown increased preference for fresh and other processed-fruit products such as juices. Citrus juices accounted for 59 percent of juice consumption in 2006, down from 69 percent in 2000/01, and orange juice was still the main fruit juice consumed in the United States (Pollack and Perez, 2007b).

The 2007/08 citrus crop is forecast at 12.7 million tons. The results of the March crop survey released by the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) forecasts 10 million tons of oranges, 68,000 tons of tangelos, and 434,000 tons of tangerines this season. A smaller crop is forecast for grapefruit, at 1.5 million tons, and the lemon crop is forecast to be 703,000 tons (Pollack and Perez, 2007a).

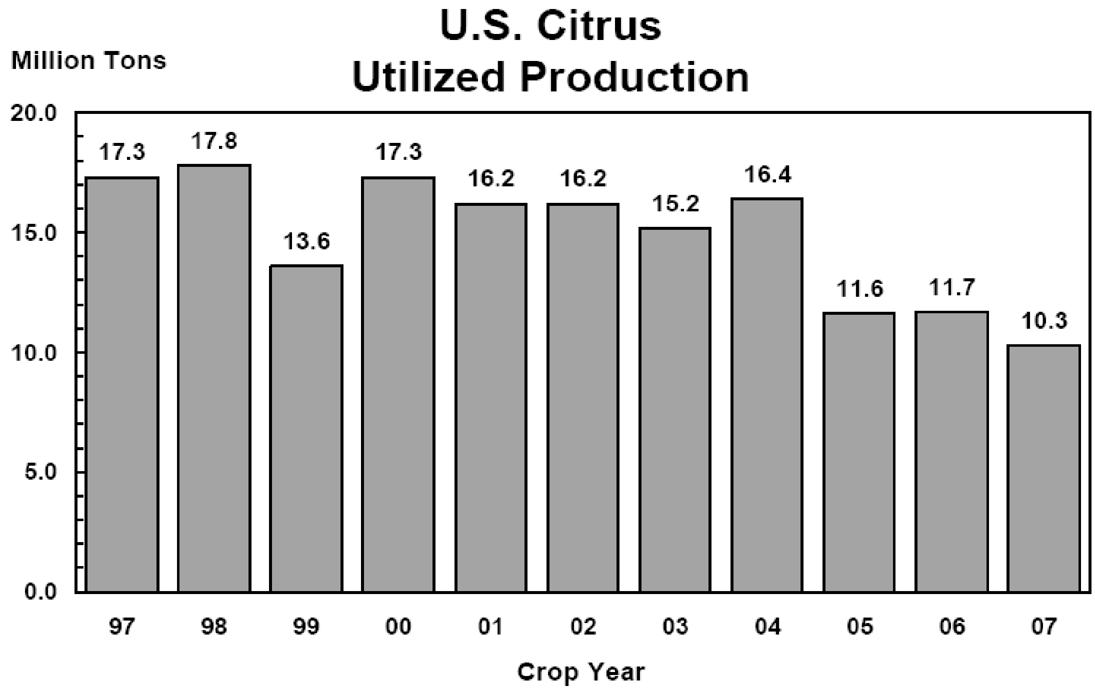


Figure 2.1 The production of citrus fruits during the past decades

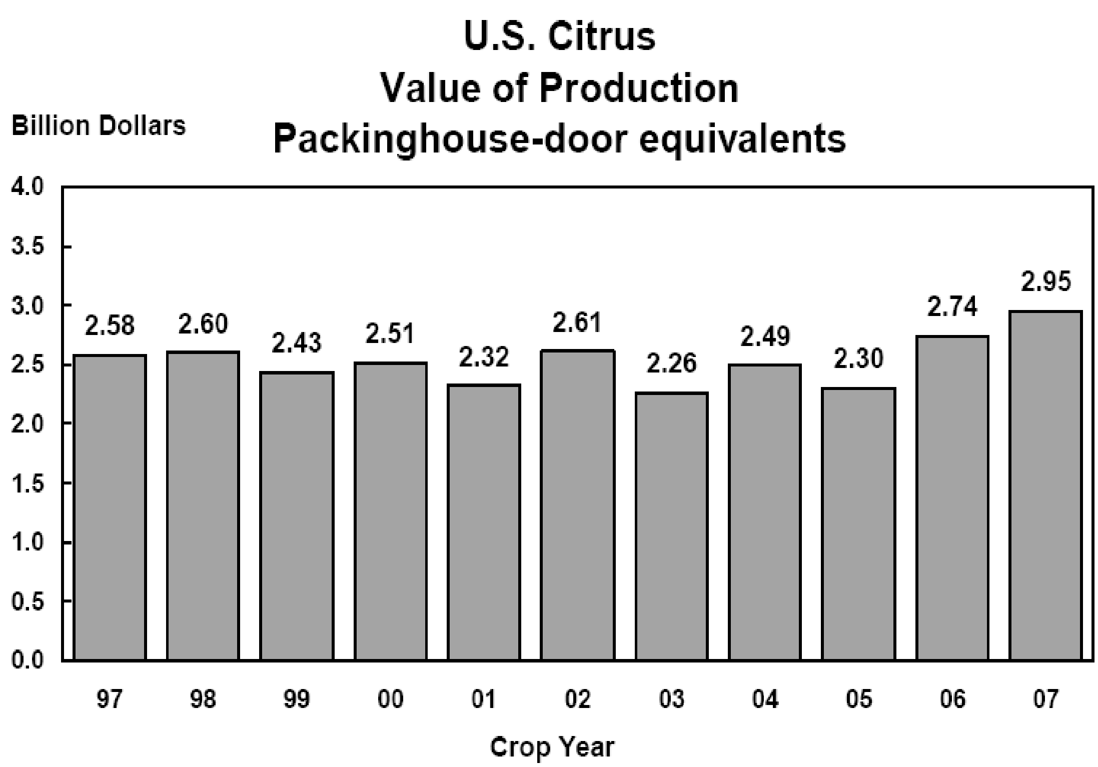


Figure 2.2 The value of production of citrus fruits during the past decades

## Calamondin

Calamondin (*Citrus mitis Blanco*) is one kind of citrus fruit that is believed to be a hybrid of Citrus reticulata Blanco x Fortunella spp. It is widely distributed and cultivated in tropical (Philippines, Central America) and subtropical (China, Japan, Florida) areas (Hodgson, 1967; Mabesa, 1990; Morton, 1987). There are many common names for this species, including calamondin, kalamondin, kalamunding, kalamansi, calamansi, limmonsito and agridulce, with calamansi being the most common in the Philippines, and calamondin in Taiwan (Yo and Lin, 2004). Although expanded production of calamondin in the United States does not appear large probably due to the availability of many other citrus fruits (Crane and Campbell, 1990), it is popularly used in the Philippines primarily for its juice and as a substitute of lemon (Nisperos et al., 1982). Also, it is valued for making acid beverages, frozen and powdered concentrates, candies, and wine. It is rich in phosphorous, calcium, iron, and vitamin C. Peel oil is used in making perfumes, soap, deodorizing agents, flavoring, petrochemicals, and pharmaceutical products (Prudente et al., 2003). The researches on calamondin as a food material were very limited. So far, the papers have covered the chemical and nutritional changes during processing and storage of juice as well as the volatile compounds and organic acids in the juice and peels (Mabesa, 1990; Moshonas and Shaw, 1996; Nisperos-Carriedo et al., 1992; Nisperos et al., 1982; Yo and Lin, 2004) .

In 1982, Nisperos, et al. studied the chemical changes of calamondin juice after various processing operations and lengths of storage. They found that the ascorbic acid in calamondin juice was very stable. Homogenization and pasteurization did not significantly affect ascorbic acid content of the juice. However, homogenization significantly reduced the color and the provitamin A. Tetratable acidity, pH, soluble solids and dry matter would be changed by homogenization as well. To the sensory point of view, pasteurization did not result in the development of cooked flavor. The differences of the sensory qualities and off-flavors such as stale flavor were not detected in the juice stored for up to one and a half years.

The application of Gas-Chromatography (GC) to calamondin and its products had been practiced since as early as 1980 when Mina identified 5 volatile compounds in fresh calamondin juice. In 1992, Nisperos, et al. developed the GC methods and identified as well as quantified 20 volatile compounds. Also, ascorbic, dehydroascorbic, and other organic acids were determined by HPLC in their work. Moshonas and Shaw (1996) analyzed the volatile compounds of calamondin peel oil by GC- Mass Spectrometry (MS) and 56 constituents were found. Similar work had been done by Takeuchi, et al. (2005). They employed GC-MS to analyze the volatile compounds. As a result, 58 and 98 compounds were identified from the peel and juice volatile concentrates, respectively. Furthermore, the characteristic flavor components of calamondin were examined by GC-olfactometry. They found that Limonene, cis-linalool oxide, linalool, α-terpineol, (E,E)-2,4-decadienal, and methyl N-methyl anthranilate had high flavor dilution factors. GC technique was also utilized to compare the difference of the calamondins. Prudente, et al. (2003) compared the ripe and unripe calamondins. They concluded that both ripe and unripe calamondins contain the same 30 volatile compounds, but the quantity made those two products differ from each other. Yo and Lin (2004) compared the calamondins cultivate in the Philippines and Taiwan. Fifty-eight volatile compounds were identified in both fruits but the quantities varied. The key components were β-pinene, β-cubebene, nonyl alcohol and linalyl alcohol.

Sensory attributes are analyzed to monitor the quality as well as the culinary value of a product. To the best of reported knowledge, the full determination of sensory attributes, such as flavor, of calamondin has not been reported.

## Yogurt

There are no reliable records regarding the origin of yogurt, but the belief in its beneficial influence on human health and nutrition has existed in many civilizations over a long period of time. According to Persian tradition, Abraham owed his longevity to yogurt and, in more recent times, Emperor Francis I of France was said to have been cured of a debilitating illness by consuming yogurt made from goat's milk (Rosell, 1932). It is likely, however, that the origin of yogurt was the in Middle East, and the evolution of this fermented product through the ages can be attributed to the culinary skills of the nomadic people living in that area (Tamime and Robinson, 1999).

Although there are numerous fermented milks produced on a local basis around the world, only yogurt has achieved a truly international distribution. Many varieties have been developed as yogurt was introduced and adopted into different areas. Generally, it comes in low fat and fat-free, creamy, set-style, stirred style, frozen, drinkable and others (Haque et al., 2001). Yogurt is generally characterized as a smooth, viscous gel with a characteristic taste of sharp acid and a green apple flavor (Bodyfelt et al., 1988). Some yogurts show a heavy consistency which closely resembles custard or milk pudding, and they are classified as set-style yogurts. Other yogurts, in contrast, are purposely soft-bodied and essentially drinkable, which are called stirred-style (Connolly et al., 1984).

The unique gel-like texture of yogurts can be appealing to consumers. Yogurt gels are formed by the protein structure. In yogurt production, milk is normally heated at a high temperature. Pasteurization not only inhibits microorganisms that will compete with starter bacteria, but also denatures and coagulates whey proteins to enhance the viscosity. During the fermentation, the pH of yogurt will decrease to around 4.6 and the attraction of caseins will increase as they approach their isoelectric point. Caseins along with denatured whey proteins build the network leading to the gelation (Lee and Lucey, 2004). In set-style yogurt, stabilizer is utilized to promote stability and desirable texture and consistency. Guar gum, gelatin, xanthan gum and locust bean gum are commonly used as thickening, stabilizing and gelling agents that increase firmness and prevent syneresis (El-Sayed et al., 2002; Fiszman et al., 1999; Kumar and Mishra, 2004). The rheological properties of stirred yogurt is the result of both acid aggregation of casein micelles and production of exopolysaccharides during incubation (Cerning, 1995). In contrast to set-style yogurt, the gel structure of stirred yogurt is broken by agitation and pumping during cooling (Beal et al., 1999).

The proteins in milk are of great biological quality and both the caseins and whey proteins are well endowed with essential amino acids. The protein content of yogurt is often elevated by concentration or addition of skimmed milk solids, producing an excellent source of protein in addition to liquid milk (Tamime and Robinson, 1999). The consumption of around 200-250ml of yogurt per day can easily provide an individual with the minimum daily requirement of protein (Cheeseman, 1991). Yogurt is also served as a good source for calcium, and calcium supplied by yogurt may be better absorbed and utilized than calcium made available in other forms (Rasic, 1987).

## Sensory analysis

*Sensory Evaluation*

Sensory evaluation has been defined as a scientific method used to evoke, measure, analyze, and interpret those responses to products as perceived through the senses of sight, smell, touch, taste, and hearing (Stone and Sidel, 1993). The field of sensory evaluation has grown rapidly in the second half of the $20^{th}$ century, along with the expansion of the processed food and consumer products industry. Sensory evaluation comprises a set of techniques for accurate measurement of human responses to foods and minimizes the potentially biasing effects of brand identity and other influences on consumer perception (Lawless and Heymann, 1998). Like other analytical test procedures, sensory evaluation is a science of measurement, it is concerned with precision, accuracy, sensitivity, and avoiding false positive results (Meiselman, 1993).

Sensory evaluation attempts to isolate the sensory properties of foods themselves and provides important and useful information to product developers, food scientists, and quality controllers, about the sensory characteristics of their products (Lawless and Heymann, 1998). Its most important function is to conduct valid and reliable research that will supply essential data for sound business decisions. In addition to the obvious uses in product development, sensory evaluation may provide information to other areas. Sensory criteria for product quality may become an integral part of a quality control program. Results from blind-labeled sensory consumer tests may need to be compared to concept-related marketing research results. Academic research on foods and materials and their properties and processing will often require sensory tests to evaluate the human perception of changes in the products (Lawless and Klein, 1989).

The sensory technique chosen for a particular test is determined by the objective of the study. When testing for acceptability of a product, consumer groups should be used instead of trained panels. Even though trained panels tend to provide more reproductive and reliable data, they can not represent the consumers as a whole. When testing for descriptive data, consumer groups should not be used. The subjects must be trained to get familiar with the products, as well as to perform constantly, before the descriptive analysis is conducted. A method of training panelist to correctly respond their perception and identify the key attributes of a product is through a method developed at Stanford Research Institute by Stone and others, called Quantitative Descriptive Analysis (Stone et al., 1980).

*History of Descriptive Analysis*

The name and the technique of Flavor Profile (FP) are trademarked to Arthur D. Little Co., Cambridge, Massachusetts. This technique was developed in the late 1940s and early 1950s at Arthur D. Little by Loren Sjostrom, Stanley Cairncross, and Jean Caul (Cairncross and Sjostrom, 1950; Caul, 1957; Sjostrom, 1954). Flavor Profile was first used to describe complex flavor systems measuring the effect of monosodium glutamate on flavor perception, which has been referred to as the start of the descriptive sensory analysis techniques (Powers, 1988).

Descriptive methods are defined as those methods that provide a word description for a product or a set of products (Stone et al., 1980). Descriptive analyses are generally useful in any situation where a detailed specification of the sensory attributes of a single product or a comparison among several products is desired (Gillette, 1984). It is a division of sensory evaluation in which a trained panel rates specified attributes of a product on scales of perceived intensity. Since the development of the Flavor Profile, new methods have evolved such as Quantitative Descriptive Analysis, the Spectrum Descriptive Analysis Method, Texture Profile, and Free-Choice Profiling (Lawless and Heymann, 1998). The use of these methods in the sensory evaluation of various types of products is well-documented in both academic research and industrial work.

Since its development, descriptive analysis has been successfully used in quality control to maintain sensory quality characteristics of products, in comparison of product prototypes, in understanding consumer responses in relation to product sensory attributes, in exploring the marketplace by sensory mapping so that gaps and opportunities in the map can be examined for potential development of new products, and in product matching which is useful for claims substantiation and product improvement (Gacula, 1997).

*Quantitative Descriptive Analysis*

The Quantitative Descriptive Analysis (QDA) was developed at Stanford Research Institute by Stone and others (Stone et al., 1980) to address the predicament of quantifying sensory description. In contrast to FP, the data are not generated through consensus discussions, panel leaders are not active participants, and unstructured line scales are used to describe the intensity of rated attributes. The linear graphic scale, a line that extends beyond the fixed verbal endpoints, was chosen because it was found that such a scale may reduce the tendency of panelists to use only the central part of the scale avoiding very high or very low ratings (Stone et al., 1980).

Panelists are selected based on availability and willingness to commit to the research project and each of them must demonstrate important qualifications. Some of the most important qualifications include good health, ability to discriminate character differences among products, ability to discriminate differences in the intensity of the characteristics, ability to verbalize and think analytically (Meilgaard et al., 1999).

Training sessions are a must in QDA. Several judges, usually 10 to 12, are exposed to many possible variations of the product to facilitate accurate concept formation. The panelists generate a set of terms that describe differences among the products. Then through consensus, panelists develop a standardized vocabulary to describe the sensory differences among the samples. The panelists will decide on the reference standards and verbal definitions that should be used to mark the descriptive terms as well. Late in the training sequence, a series of trial evaluations are preformed which allows the panel leader to evaluate individual judges based on statistical analysis of their performance relative to that of the entire panel. Evaluations of panelist performance may also be performed during the evaluation phase of the study (Lawless and Heymann, 1998). The basic features of the technique are described in Table 2.1 (Gacula, 1997).

Table 2.1 Quantitative descriptive analysis basic features

| **Technique Features** | **Explanation** |
|---|---|
| Development of the Language | A group process with the panel administrator providing leadership and guidance but not actively participating in the product evaluation |
| Subject Selection | Based on performance with test products, without using model systems |
| Repeated Judgments | As many as 12-16 are collected from each subject to monitor individual and panel performance |
| Subject Performance | Determine if individual subjects are responding consistently. If not, more training maybe required |
| Scale Performance | Individual scales producing consistent results and adequately discriminating differences |
| Product performance | The extent to which products differ on the specific attributes judged |

The resulting data can be analyzed statistically using analysis of variance (ANOVA) and multivariate statistical techniques (MANOVA). It is necessary for panelists to replicate their judgments, up to 6 times in some cases, to allow the sensory scientist to check the consistency of individual panelists and of the whole panel. Replication also allows one-way analysis of variance of individual panelists across the products, which allows the sensory specialist to determine whether the panelists can discriminate among products or need additional training (Lawless and Heymann, 1998).

*Development of Attributes*

An attribute is a quality or characteristic that specifically describes a product. We tend to perceive the attributes of a food item in the following order: 1) appearance; 2) odor/aroma/fragrance; 3) consistency and texture; 4) flavor (aromatics, chemical feeling, taste) (Meilgaard et al., 1999). The attributes of a product are usually determined through reference standards. A reference standard is any chemical, spice, ingredient, or product which can be used to characterize or identify an attribute or attribute intensity found in any class of products that is being evaluated by the judges. An ideal reference standard is one which is easily understood, reproducible, and identifies only one term (Lawless and Heymann, 1998).

Reference standards are useful tools in the training of a sensory evaluation panel because they help panelists develop terminology to properly describe products, determine intensities, show action of an ingredient and interaction of ingredients, shorten training time, document terminology, and provide useful discussion tools to be used with the project team for planning new product development, product maintenance, product improvement and cost reduction programs (Rainey, 1986). In descriptive sensory techniques, reference materials are used to establish a common vocabulary for various aromas and flavors (Krasner, 1995).

CHAPTER III

# DESCRIPTIVE ANYLYSIS OF CALAMONDINS

## Introduction

Calamondin, or kalamansi is a citrus fruit that is believed to be a hybrid of *Citrus reticulata* Blanco x *Fortunella* spp. It is widely distributed and cultivated in tropical (Philippines, Central America) and subtropical (China, Japan, Florida) areas (Hodgson, 1967; Mabesa, 1990; Morton, 1987). Although expanded production of calamondin in the United States does not appear to be of great demand probably due to the availability of many other citrus fruits (Crane and Campbell, 1990), it is popularly used in the Philippines primarily for its juice and as a substitute for lemon (Nisperos et al., 1982).

Sensory evaluation is a process of determining the flavor and acceptability of a food product. Sensory evaluation relies upon product evaluation by our senses, i.e. through sight , smell, taste, touch and sound (Jellinek, 1985). Sensory attributes are evaluated to monitor the quality as well as the culinary value of a product. A means of determining the sensory attributes, such as flavor, aroma, or appearance of a food product is through descriptive sensory analysis. Quantitative descriptive sensory analysis (QDA) (Stone et al., 1980) is one of the most comprehensive and informative scientific tools used in sensory analysis. Descriptive analysis is generally useful in any situation where a detailed specification of sensory attributes of a single product is desired. The technique of descriptive analysis, combined with univariate and/or multivariate statistics is used to profile the descriptive attributes of food products. This technique allows for the quantitative characterization of perceived sensory attributes.

Research of this type has not been previously performed with calamondins. The objectives of this research were to determine, through descriptive analysis, scientific sensory attributes that describe calamondin by building a sensory lexicon and to quantify, by descriptive analysis, the sensory attributes of calamondins.

## Materials and Methods

### *Delivery of Calamondins*

Calamondins were purchased from Rising C Ranches Inc. in California. Calamondins were packed with paper flock and placed into cardboard boxes labeled with producer's name and product's name. All the fruits were shipped the same day they were harvested. Calamondins arrived via UPS 2-day delivery to the Garrison Sensory Evaluation Laboratory in the Department of Food Science, Nutrition & Health Promotion at Mississippi State University.

*Storage of Calamondins*

Delivered calamondins were immediately placed for storage into an industrial refrigerator (Krack Corp Model# DT3S-550-DXAA-RH) at the Garrison Sensory Evaluation Laboratory with an average temperature of 3°C. Calamondins were kept in the original cardboard boxes with an additional label of project name and receiving date. The average storage time was approximately one week.

*Preparation of Calamondins*

Calamondins were selected based on intactness of body. All unselected calamondins were repacked and stored in the refrigerator for further use. All selected calamondins were placed into a plastic bowl (Packerware Model# H111524OP1) and were thoroughly rinsed by with hot water for 1 min. The fruits then were placed in 2 ounce (60 ml) plastic cups with lids on (Sweetheart Plastic Cup, Inc.). Panelists evaluated the fruits immediately after being placed in cups.

*Panel*

Both panelist training and formal analysis sessions were performed at the Garrison Sensory Laboratory in the Department of Food Science, Nutrition & Health Promotion at Mississippi State University. Training and formal analysis sessions were performed in a room specifically designed for descriptive work and utilized a round-table. Calamondins were placed before each panelist on light blue trays (Prolon Model#

K1014), along with a descriptive analysis instrument (score sheet), a No. 2 pencil (Atlas Pen & Pencil Corp., Hollywood, FL), a 16 ounce (473 ml) Styrofoam expectorant cup (Sweetheart Plastic Cup, Inc.), a 8 ounce (237ml) clear plastic cup (Sweetheart Plastic Cup, Inc.) of filtered water, a white quarter fold napkin (Scott Brand, Kimberly-Clark Global Sales Inc., Neenah, WI), a plastic fork (Sweetheart Plastic Cup, Inc.), and two empty sniff bottles (Nalge Company, Rochester, NY). Corresponding standards and references might be employed in the evaluation were put on two other light blue trays and placed in the center of the round-table for the panelists' convenience.

*Panelists*

Eight panelists were recruited based on their willingness to participate and volunteer their time. The panelists, including male and female, were trained in use of Quantitative Descriptive Analysis (Stone et al., 1980) through a round-table discussion. The training session was performed for one and a half months period (~ 20 hours). Training focused on the use of the instrument (score sheet), sensory attributes and standards. All the panelists were affiliated with the Department of Food Science, Nutrition & Health Promotion at Mississippi State University.

*Panelist Training*

Training consisted of determining calamondin attribute categories as well as intensity ratings on a standard 15cm anchored line scale for each descriptor, where 0 =

attributes not detected, and 15 = attributes extremely detected. Color attributes for the appearance were also determined and scored on the basis of presence on a 100% line scale. The size of the fruit was obtained by measuring the fruit directly with a 15-point scale where each block represented 1cm (Appendix B). The attribute categories included appearance, hand held texture, overall aroma (unpeeled), hand held peel aroma (peeled), peel aroma in sniff bottle (peeled), hand held fruit aroma (peeled), fruit aroma in sniff bottle (peeled), oral fruit texture, fruit flavor, fruit-in-mouth feeling factor, oral peel texture, peel flavor, peel-in-mouth feeling factor and physical properties. Within each category, panelists identified the attributes though the use of a round-table discussion, and rated each of the attributes based on intensity levels. During each training session, panelists were encouraged to provide additional descriptors in the extra spaces at the end of each category of attributes. These additions were discussed by all the panelists and were added to the instrument before the next training session if applicable.

Training sessions were conducted through the use of food and other commercially available products as references. The use of references and the corresponding intensity of each reference were determined and discussed by the panelists.

*Testing Area*

Testing was performed in a room specifically designed for descriptive analysis work. The room had positive air pressure. Both temperature and lighting was controlled electronically. The test room was isolated from the preparation area and had a separate air conditioning and filtration system. The test was performed via round table. Room temperature was held constantly at approximately 22°C.

*Selection of Descriptive Terms and Preparation of Corresponding Standards*

Attributes and descriptors employed in the Quantitative Descriptive Analysis of calamondins were generated by panelists through training. Calamondins were evaluated for appearance, hand held texture, overall aroma (unpeeled), hand held peel aroma (peeled), peel aroma in sniff bottle (peeled), hand held fruit aroma (peeled), fruit aroma in sniff bottle (peeled), oral fruit texture, fruit flavor, fruit-in-mouth feeling factor, oral peel texture, peel flavor, peel-in-mouth feeling factor and physical properties. The same procedure was repeated in all training sessions. At each training session, panelists were asked to reevaluated the descriptors and standards in an attempt to eliminate any which were determind to be redundant or unnecessary. Upon discussion of the calamondins and standards evaluated, a consensus was reached on a final set of 89 attributes.

*Use of the Sniff Bottle*

Panelists were trained to evaluate the aroma of calamondin fruit and peel through the use of sniff bottles. Panelists were asked to evaluate the aroma of the peeled fruit and peel separately. After the hand held aroma evaluation of both fruit and peel, the panelists were asked to place one session of the fruit and two pieces of the peel into two different sniff bottles and put on the lids. The peel piece was obtained by panelists cutting the peel using a borer (16mm Diameter, Fisher Scientific, Pittsburgh, PA). Before the assessment was performed, panelists were asked to shake each of the sniff bottles moderately for 10 seconds in an attempt to obtain a constant result.

Attributes with the standards determined by panelists are listed in Tables 3.1 through 3.16.

Table 3.1 Appearance attributes of calamondin as determined by panelists

| **Attribute** | **Descriptor** | **Reference (Intensity)** |
|---|---|---|
| Pore Coverage | Percentage of Pore Area Covered on the Entire Fruit Surface | Visual Estimation |
| Color Uniformity | Degree of Uniformity on Fruit Color | Visual Estimation |
| Visual Smoothness | Visual Quality Rating of Fruit Surface Smoothness | Wood Stick (12) |

Table 3.2 Hand held texture attributes of calamondin as determined by panlists

| **Attribute** | **Descriptor** | **Reference (Intensity)** |
|---|---|---|
| Firmness | Force Required to Compress between Fingers | Rubber Eraser (11) |
| Springiness | Degree of Recovery after Compression | Gummi Saver (7) |
| Smoothness | Quality Rating of Surface Smoothness | Wood Stick (13) |
| Leather Like Feeling | Degree of Similarity of the Fruit Surface to the Leather | Leather Cloth (10) |

Table 3.3 Overall aroma attributes of unpeeled calamondin as determined by panelists

| Attribute | Descriptor | Reference (Intensity) |
| --- | --- | --- |
| Overall Intensity | Overall Intensity as Determined by Panelists | 9g Onion in Sniff Bottle (10);<br>5g Pineapple in Sniff Bottle (5) |
| Overall Citrus | Overall Aroma Intensity that Associated with General Citrus Fruits | Freshly Cut Lemon, Lime or Orange |
| Rosemary | Aroma Associated with Rosemary Leaves | Ten Rosemary Leaves in Sniff Bottle (10) |
| Lemonbalm | Aroma Associated with Lemonbalm Leaves | Five Lemonbalm Leaves in Sniff Bottle (13) |
| Grapefruit | Aroma Associated with Freshly Cut Grapefruit | 6g Grapefruit in sample cup (10) |
| Mint | Aroma Associated with Mint Leaves | Five Mint Leaves in Sniff Bottle (8) |
| Floral | Aroma Associated with Flowers | Freshly Cut Flowers |
| Green | Aroma Associated with Freshly Cut Leaves, Grass or Green Vegetables | Freshly Cut Grass |

Table 3.4 Hand-held peel aroma attributes of calamondin as determined by panlists

| Attribute | Descriptor | Reference (Intensity) |
|---|---|---|
| Overall Intensity | Overall Intensity as Determined by Panelists | 9g Onion in Sniff Bottle (10); 5g Pineapple in Sniff Bottle (5) |
| Overall Citrus | Overall Aroma Intensity that Associated with General Citrus Fruits | Freshly Cut Lemon, Lime or Orange |
| Rosemary | Aroma Associated with Rosemary Leaves | Ten Rosemary Leaves in Sniff Bottle (10) |
| Lemonbalm | Aroma Associated with Lemonbalm Leaves | Five Lemonbalm Leaves in Sniff Bottle (13) |
| Grapefruit | Aroma Associated with Freshly Cut Grapefruit | 6g Grapefruit in sample cup (10) |
| Mint | Aroma Associated with Mint Leaves | Five Mint Leaves in Sniff Bottle (8) |
| Floral | Aroma Associated with Flowers | Freshly Cut Flowers |
| Green | Aroma Associated with Freshly Cut Leaves, Grass or Green Vegetables | Freshly Cut Grass |
| Play-Doh® | Aroma Associated with Play-Doh® | Play-Doh® in Original Box (6) |

Table 3.5 Held-in-sniff-bottle peel aroma attributes as determined by panelists

| Attribute | Descriptor | Reference (Intensity) |
|---|---|---|
| Overall Intensity | Overall Intensity as Determined by Panelists | 9g Onion in Sniff Bottle (10); 5g Pineapple in Sniff Bottle (5) |
| Overall Citrus | Overall Aroma Intensity that Associated with General Citrus Fruits | Freshly Cut Lemon, Lime or Orange |
| Rosemary | Aroma Associated with Rosemary Leaves | Ten Rosemary Leaves in Sniff Bottle (10) |
| Lemonbalm | Aroma Associated with Lemonbalm Leaves | Five Lemonbalm Leaves in Sniff Bottle (13) |
| Grapefruit | Aroma Associated with Freshly Cut Grapefruit | 6g Grapefruit in sample cup (10) |
| Mint | Aroma Associated with Mint Leaves | Five Mint Leaves in Sniff Bottle (8) |
| Floral | Aroma Associated with Flowers | Freshly Cut Flowers |
| Green | Aroma Associated with Freshly Cut Leaves, Grass or Green Vegetables | Freshly Cut Grass |
| Wine | Aroma Associated with Wine | Cooking Wine |
| Play-Doh® | Aroma Associated with Play-Doh® | Play-Doh® in Original Box (6) |

Table 3.6 Hand-held fruit aroma attributes as determined by panelists

| Attribute | Descriptor | Reference (Intensity) |
|---|---|---|
| Overall Intensity | Overall Intensity as Determined by Panelists | 9g Onion in Sniff Bottle (10); 5g Pineapple in Sniff Bottle (5) |
| Overall Citrus | Overall Aroma Intensity that Associated with General Citrus Fruits | Freshly Cut Lemon, Lime or Orange |
| Rosemary | Aroma Associated with Rosemary Leaves | Ten Rosemary Leaves in Sniff Bottle (10) |
| Lemonbalm | Aroma Associated with Lemonbalm Leaves | Five Lemonbalm Leaves in Sniff Bottle (13) |
| Grapefruit | Aroma Associated with Freshly Cut Grapefruit | 6g Grapefruit in sample cup (10) |
| Mint | Aroma Associated with Mint Leaves | Five Mint Leaves in Sniff Bottle (8) |
| Floral | Aroma Associated with Flowers | Freshly Cut Flowers |
| Green | Aroma Associated with Freshly Cut Leaves, Grass or Green Vegetables | Freshly Cut Grass |
| Play-Doh® | Aroma Associated with Play-Doh® | Play-Doh® in Original Box (6) |

Table 3.7 Held-in-sniff-bottle fruit aroma attributes as determined by panelists

| **Attribute** | **Descriptor** | **Reference (Intensity)** |
|---|---|---|
| Overall Intensity | Overall Intensity as Determined by Panelists | 9g Onion in Sniff Bottle (10); 5g Pineapple in Sniff Bottle (5) |
| Overall Citrus | Overall Aroma Intensity that Associated with General Citrus Fruits | Freshly Cut Lemon, Lime or Orange |
| Rosemary | Aroma Associated with Rosemary Leaves | Ten Rosemary Leaves in Sniff Bottle (10) |
| Lemonbalm | Aroma Associated with Lemonbalm Leaves | Five Lemonbalm Leaves in Sniff Bottle (13) |
| Grapefruit | Aroma Associated with Freshly Cut Grapefruit | 6g Grapefruit in sample cup (10) |
| Mint | Aroma Associated with Mint Leaves | Five Mint Leaves in Sniff Bottle (8) |
| Floral | Aroma Associated with Flowers | Freshly Cut Flowers |
| Green | Aroma Associated with Freshly Cut Leaves, Grass or Green Vegetables | Freshly Cut Grass |
| Play-Doh® | Aroma Associated with Play-Doh® | Play-Doh® in Original Box (6) |

Table 3.8 Oral fruit texture attributes as determined by panelists

| **Attribute** | **Descriptor** | **Reference (Intensity)** |
|---|---|---|
| Stringiness | Amount of Tissue Fibers Present when Chewed | Celery (13) |
| Firmness | Force Required to Compress between Tongue and Palate | American Cheese (4.5) |
| Juiciness | Amount of Perceived Moister Expelled when Chewed | Canned Sliced Mushrooms (8) |

Table 3.9 Fruit flavor attribute as determined by panelists

| **Attribute** | **Descriptor** | **Reference (Intensity)** |
|---|---|---|
| Sweetness | Taste Associated with Sugar or Sucrose | Sucrose in water |
| Sourness | Taste Stimulated by Acids | Citric Acid in water |
| Bitterness | Taste Stimulated by Caffeine | Caffeine in water |
| Rosemary | Taste Associated with Rosemary Leaves | Rosemary Leaf (9) |
| Green | Taste Associated with Fresh Green Vegetables and Underripe Fruits | Freshly Cut Grass |
| Mint | Taste Associated with Mint Leaves | Mint Leaf (12) |

Table 3.10 Fruit-in-mouth feeling factor attributes as determined by panelists

| Attribute | Descriptor | Reference (Intensity) |
|---|---|---|
| Numbing | Numbing Loss of Sensation in the Mouth | Orajel® (12) |
| Burn | Feeling Factor Associated with High Concentrations of Irritant Chemicals | Lemon Juice |
| Astringency | Shrinking or Puckering of the Tongue Surface | Grape Juice (6.5) |
| Tooth Pain | Amount of Tooth Pain Perceived when Chewing Fruit for 5 sec | Subjective Measurement |
| Jaw Muscle Response | Amount of Jaw Muscle Discomfort Perceived when Chewing Fruit for 5 sec | Subjective Measurement |

Table 3.11 Peel flavor attribute as determined by panelists

| Attribute | Descriptor | Reference (Intensity) |
|---|---|---|
| Sweetness | Taste Associated with Sugar or Sucrose | Sucrose in water |
| Sourness | Taste Stimulated by Acids | Citric Acid in water |
| Bitterness | Taste Stimulated by Caffeine | Caffeine in water |
| Rosemary | Taste Associated with Rosemary Leaves | Rosemary Leaf (9) |
| Green | Taste Associated with Fresh Green Vegetables and Underripe Fruits | Freshly Cut Grass |
| Mint | Taste Associated with Mint Leaves | Mint Leaf (12) |

Table 3.12 Oral peeling texture attributes as determined by panelists

| Attribute | Descriptor | Reference (Intensity) |
|---|---|---|
| Crispness | The Perceived Relative Force used by Crunching the Peel in the Mouth | Club Cracker (5) |
| Chewiness | Amount of Mastication Required | Caramel (15) |
| Fracturability | Force Applied to Cause the Peel to Break or Fracture | Graham Cracker (4.2) |
| Juiciness | Amount of Perceived Moisture Expelled when Chewed | Canned Sliced Mushroom (8) |
| Sound when Chewing | Amount of Sound Perceived When Chewed | Club Cracker (8) |

Table 3.13 Peel flavor attributes as determined by panelists

| Attribute | Descriptor | Reference (Intensity) |
|---|---|---|
| Sweetness | Taste Associated with Sugar or Sucrose | Sucrose in water |
| Sourness | Taste Stimulated by Acids | Citric Acid in water |
| Bitterness | Taste Stimulated by Caffeine | Caffeine in water |
| Rosemary | Taste Associated with Rosemary Leaves | Rosemary Leaf (9) |
| Green | Taste Associated with Fresh Green Vegetables and Underripe Fruits | Freshly Cut Grass |
| Mint | Taste Associated with Mint Leaves | Mint Leaf (12) |

Table 3.14 Peel-in-mouth feeling factor attributes as determined by panelists

| **Attribute** | **Descriptor** | **Reference (Intensity)** |
|---|---|---|
| Numbing | Numbing Loss of Sensation in the Mouth | Orajel® (12) |
| Burn | Feeling Factor Associated with High Concentrations of Irritant Chemicals | Lemon Juice |
| Astringency | Shrinking or Puckering of the Tongue Surface | Grape Juice (6.5) |
| Cooling | The mouth Feel Associated with Coolness | Menthol |

Table 3.15 Physical property attributes as determined by panelists

| **Attribute** | **Descriptor** |
|---|---|
| Fruit Size Latitude | The Length between the Stem Mark and the Navel of the Fruit |
| Fruit Size Longitude | The Length between Fastest Two Points on the Fruit Equator |
| Seed Count | Amount of Seeds Observed in the Fruit |
| Section Count | Amount of Fruit Sections Observed |

Table 3.16 Reference standards for calamondin

| Reference | Reference Manufacturer/Broker |
|---|---|
| Wood Stick | Loew-Cornell, Inc., Englewood Cliffs, NJ |
| Rubber Eraser | Pentel Stationery Co., Taiwan |
| Gummi Saver | Wrigley Company, Peoria, IL |
| Leather Cloth | Wal-Mart Stores, Inc., Bentonville, AR |
| Onion | Kroger Company, Cincinnati, OH |
| Pineapple | Kroger Company, Cincinnati, OH |
| Grapefruit | Kroger Company, Cincinnati, OH |
| Rosemary | Fresh Herb |
| Lemonbalm | Fresh Herb |
| Mint | Fresh Herb |
| Play-Doh® | Hasbro, Inc., Pawtucket, RI |
| Cooking Wine | Inter-American Products, Inc., Cincinnati, OH |
| Celery | Kroger Company, Cincinnati, OH |
| American Cheese | Kraft Foods Global, East Hanover, NJ |
| Canned Sliced Mushroom | General Mills Sales Inc., Minneapolis, MN |
| Orajel® | Del Pharmaceuticals, Inc., Uniondale, NY |
| Grape Juice | Welch’s, Concord, MA |
| Club Cracker | Kellogg Sales Co., Battle Creek, MI |
| Caramel | Kraft Foods Global, East Hanover, NJ |
| Graham Cracker | Kraft Foods Global, East Hanover, NJ |
| Sucrose | Kroger Company, Cincinnati, OH |
| Citric Acid | Archer Daniels Midland, Decatur, IL |
| Caffeine | Sigma Chemical Co., St. Louis, MO |

*Statistical Analysis*

SAS® Version 9.1.3 (SAS, 2006) was utilized to analyze the data. Individual analyses of variance (ANOVA) were run on each attribute rated by panelists through the use of SAS® procedure, General Linar Model (GLM). A difference of 0.05 was considered significant. Means on each attribute rated by panelists were obtained from SAS® and used to generate graphical representations of the results.

## Results and Discussion

*Color*

There were significant differences (P<0.05) for orange, yellow and brown. The results showed no significant (P>0.05) difference for green (Table 3.17). The brown color occurred only when there were scars on the fruits. The color varied mostly due to the differences in ripeness.

The results indicated that the color of calamondin should be mostly orange with tones of yellow, brown and green. As illustrated in Figure 3.1, the color orange averaged up to 60%, and yellow color took about a quarter of the total color of the calamondin.

*Appearance*

Results showed significant differences (P<0.05) for pore coverage and color uniformity. Results showed no significant difference (P>0.05) for visual smoothness.

Overall appearance of calamondin should be visually appealing. As represented in Table 3.18, the pore area should cover average 77% of the entire fruit surface. The overall color should be moderately uniform and the visual smoothness should be moderately smooth.

*Hand Held Texture*

Results showed significant difference ($P<0.05$) for firmness, springiness, smoothness and leather-like feeling (Table 3.19). The hand held texture varied mostly due to the ripe stage differences of fruits.

Overall hand held texture of calamondin should be slightly firm, slightly springy and very smooth. It also should moderately have a leather-like feeling. The results are graphically represented in Figure 3.2.

*Overall Aroma (Unpeeled)*

Results showed significant differences ($P<0.05$) for overall intensity, overall citrus, rosemary, lemonbalm and green. Results showed no significant difference ($P>0.05$) for grapefruit, mint and floral (Table 3.20).

As represented in Figure 3.3, the overall intensity and overall citrus of the fruit should not be strong. And there should be detectable rosemary, lemonbalm, grapefruit, mint, floral and green aroma associated with the fruit.

*Hand Held Peel Aroma after Peeling*

Results showed significant differences ($P<0.05$) for overall intensity, overall citrus, rosemary, lemonbalm, mint, floral, green and play-doh. No significant difference ($P>0.05$) was found for grapefruit (Table 3.21).

Compared with hand-held unpeeled fruit aroma, which was basically the outside of the peel aroma, the hand held peel aroma had stronger average intensity for all the attributes and detectable Play-Doh® aroma. That was because of the exposure of the inside of the peel. The results are graphically represented in Figure 3.4.

*Peel Aroma in Sniff Bottle*

Results showed significant differences ($P<0.05$) for overall intensity, overall citrus, rosemary, lemonbalm, mint, floral, green and Play-Doh®. No significant difference ($P>0.05$) was found for both grapefruit and wine (Table 3.22).

The usage of sniff bottles was targeted to explore more aroma attributes of samples, by enhancing the concentration of the aroma. Compared with the hand held peel aroma attributes, the wine attribute was detected. The results are graphically represented in Figure 3.5.

*Hand Held Peeled Calamondin Fruit Aroma*

Results showed significant differences ($P<0.05$) for overall intensity, overall citrus, rosemary, mint and green. Results showed no significant difference ($P>0.05$) for lamonbalm, grapefruit, floral and Play-Doh® (Table 3.23).

As demonstrated in Figure 3.6, the overall intensity and overall citrus of the fruit should be easily detected but not strong. And there were detectable rosemary, lemonbalm, grapefruit, mint, floral, green and Play-Doh® aroma associated with the peeled fruit.

*Peeled Calamondin Fruit in Sniff Bottle Aroma*

Results showed significant differences ($P<0.05$) for overall intensity, overall citrus, rosemary, lemonbalm, grapefruit and mint. Results showed no significant differences ($P>0.05$) for floral, green and Play-Doh® (Table 3.24).

The results are graphically represented in Figure 3.7. There was no other attribute detected by the usage of sniff bottle.

*Oral Fruit Texture*

Results showed significant differences ($P<0.05$) for stringiness, firmness and juiciness (Table 3.25).

As represented in Figure 3.8, the fruit should be moderately stingy and juice, but not very firm.

*Fruit Flavor*

Results showed significant differences ($P<0.05$) for bitter, rosemary, green and mint. Results showed no significant difference ($P>0.05$) for sour and sweet (Table 3.26).

As indicated in Figure 3.9, the fruit should be extremely sour. Other than sourness, the there were detectable sweetness, bitterness, rosemary, green and mint attributes in the fruit.

*Fruit-in-mouth Feeling Factor*

Results showed significant differences ($P<0.05$) for numbing, tooth pain and jaw muscle discomfort. No significant difference ($P>0.05$) occurred for astringency and burn (Table 3.27).

The fruit-in-mouth feeling factor highly depends on individual condition. But generally speaking, the fruit should have astringent and burn mouth feeling. Some of the panelists might have numbing feeling, touch pain and jaw muscle discomfort. The results were represented in Figure 3.10.

*Oral Peel Texture*

Results showed significant differences ($P<0.05$) for crispness, chewiness, fracturability, juiciness and sound when chewing (Table 3.28).

As indicated in Figure 3.11, the calamondin peel was slightly crispy, chewy, juicy and easy to break into pieces. Also, there was a detectable sound when chewing the peel as when chewing crackers.

*Peel Flavor*

Results showed significant differences ($P<0.05$) for sour, bitter, rosemary and green. No significant difference ($P>0.05$) occurred for sweet and mint (Table 3.29).

Attributes detected for the peel flavor were the same as for the fruit flavor. Compared with fruit, peel should have a more appealing flavor. The level of sourness should be balancing pleasantly with sweetness, bitterness, rosemary, green and mint. The results are represented in Figure 3.12.

*Peel-in-mouth Feeling Factor*

Results showed significant differences ($P<0.05$) for astringent, numbing, burn and cooling (Table 3.30).

The peel-in-mouth feeling factor highly depends on individual condition, as the with fruit-in-mouth feeling factor. But generally the peel had astringent and burn mouth feeling. Some of the consumers should experience numbing and cooling feel while chewing the peel. The results were represented in Figure 3.13.

*Physical Properties*

The fruit should have an average of 3.4cm for latitude and 3.1cm for longitude. The seed count varies from 1 to 6. Two and 3 were mostly observed counts. The section count varies from 5 to 9. Eight was the mostly observed counts.

## Conclusion

A total of 89 attributes were established by the panelists. These attributes were divided into 14 categories, which were appearance, hand held texture, overall aroma (unpeeled), hand held peel aroma (peeled), peel aroma in sniff bottle (peeled), hand held fruit aroma (peeled), fruit aroma in sniff bottle (peeled), oral fruit texture, fruit flavor, fruit-in-mouth feeling factor, oral peel texture, peel flavor, peel-in-mouth feeling factor and physical properties. All these attributes were used to describe the calamondins.

Significant differences ($P<0.05$) occurred in the results, which were probably due to the various stages of the ripeness of the fruits. Additional research needs to be performed on calamondin under different storage times. This may explain a portion of the differences. Also, further research needs to be conducted on calamondin from different regions, which would provide a detailed description from the sensory standpoint as to how the region affects the characteristics of calamondins.

Table 3.17 Calamondin color presence method analysis

| Color | Mean Score | Significance |
|---|---|---|
| Orange | 60.2 | 0.0143* |
| Yellow | 24.8 | 0.0039* |
| Brown | 3.6 | <0.0001* |
| Green | 11.4 | 0.2235 |

* There were significant differences (P<0.05) in the results.

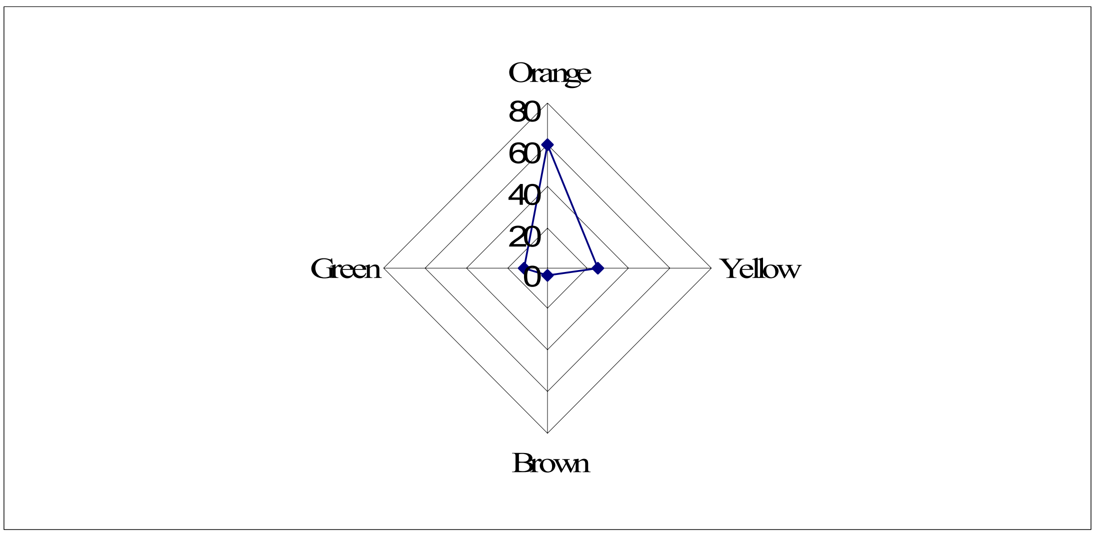


Figure 3.1 Graphical representation of calamondin color

Table 3.18 Calamondin appearance analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Pore Coverage | 77.7 | 0.0130* |
| Color Uniformity | 6.9 | 0.0020* |
| Visual Smoothness | 6.1 | 0.6187 |

* There were significant differences (P<0.05) in the results.

Table 3.19 Calamondin hand held texture analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Firmness | 5.6 | 0.0119* |
| Springiness | 4.4 | 0.0022* |
| Smoothness | 9.8 | 0.0003* |
| Leather-like Feeling | 6.7 | <0.001* |

* There were significant differences (P<0.05) in the results.

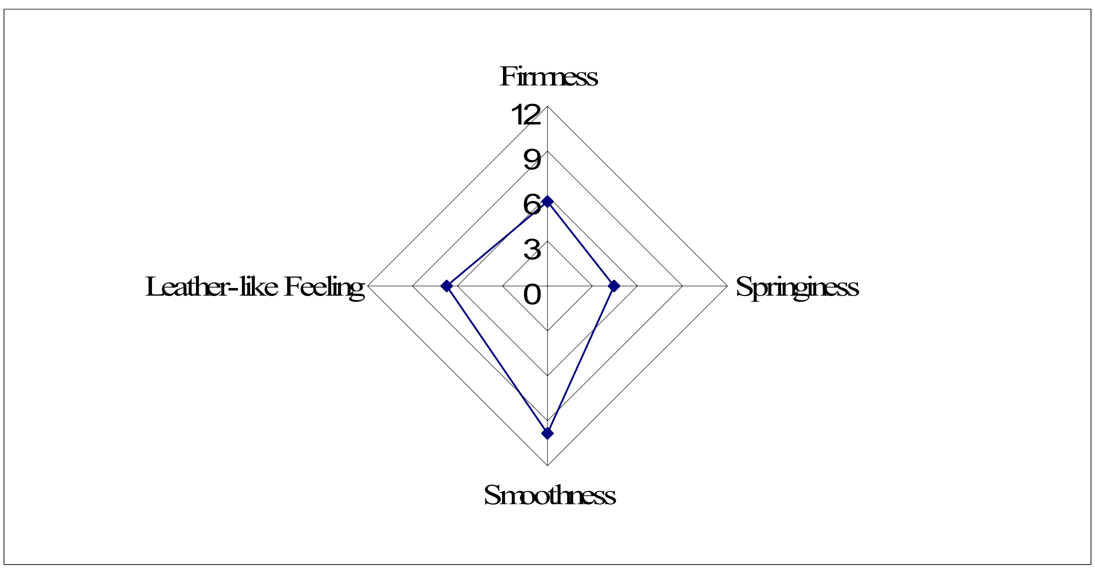


Figure 3.2 Graphical representation of calamondin hand held texture

Table 3.20 Calamondin hand held aroma analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Overall Intensity | 3.2 | 0.0013* |
| Overall Citrus | 2.9 | <0.0001* |
| Rosemary | 1.0 | 0.0005* |
| Lemonbalm | 1.1 | 0.0099* |
| Grapefruit | 1.0 | 0.0582 |
| Mint | 0.7 | 0.2922 |
| Floral | 1.0 | 0.2834 |
| Green | 0.9 | 0.0463* |

* There were significant differences (P<0.05) in the results.

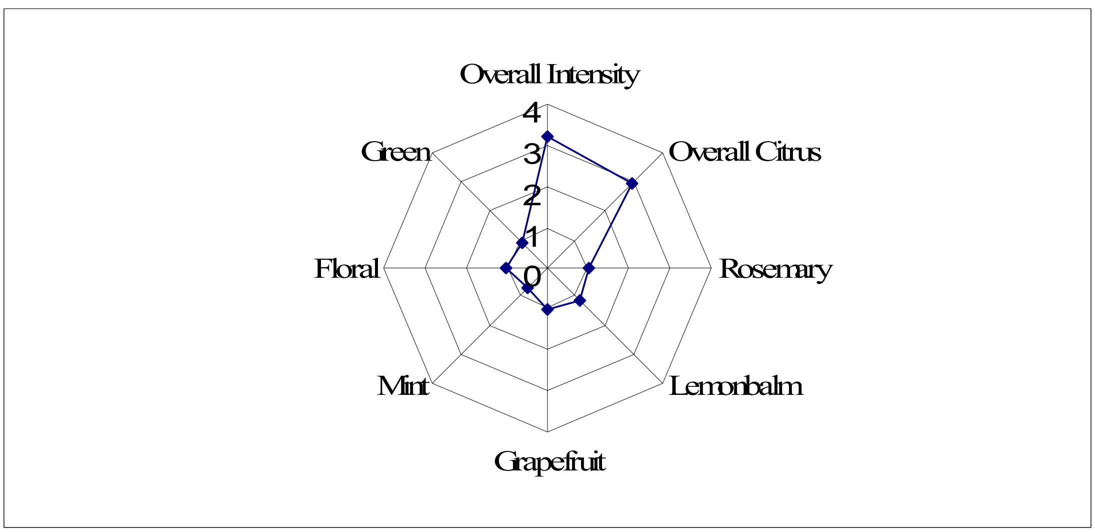


Figure 3.3 Graphical representation of calamondin hand held aroma

Table 3.21	Calamondin peel hand held aroma analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Overall Intensity | 5.1 | 0.0325* |
| Overall Citrus | 3.8 | <0.0001* |
| Rosemary | 1.7 | <0.0001* |
| Lemonbalm | 2.1 | 0.0007* |
| Grapefruit | 1.7 | 0.2840 |
| Mint | 1.3 | 0.0001* |
| Floral | 1.7 | 0.0010* |
| Green | 1.6 | 0.0019* |
| Play-Doh® | 0.8 | 0.0012* |

* There were significant differences (P<0.05) in the results.

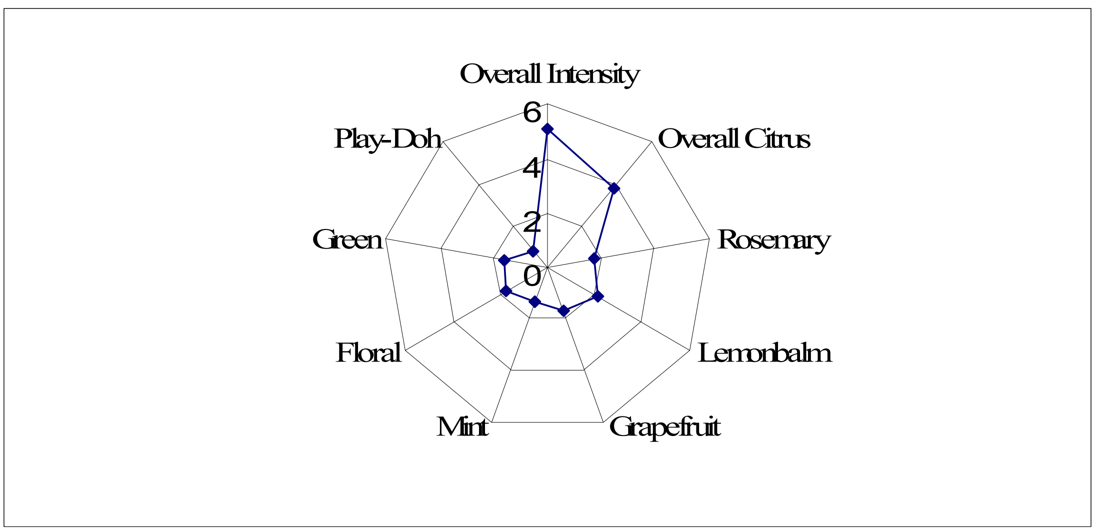


Figure 3.4	Graphical representation of calamondin peel hand held aroma

Table 3.22 Calamondin peel in sniff bottle aroma analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Overall Intensity | 4.1 | 0.0003* |
| Overall Citrus | 3.8 | <0.0001* |
| Rosemary | 1.4 | <0.0001* |
| Lemonbalm | 1.8 | 0.0002* |
| Mint | 1.1 | 0.0306* |
| Grapefruit | 1.5 | 0.3634 |
| Floral | 1.6 | 0.0473* |
| Green | 1.7 | 0.0202* |
| Wine | 0.4 | 0.2012 |
| Play-Doh® | 0.6 | 0.0006* |

* There were significant differences (P<0.05) in the results.

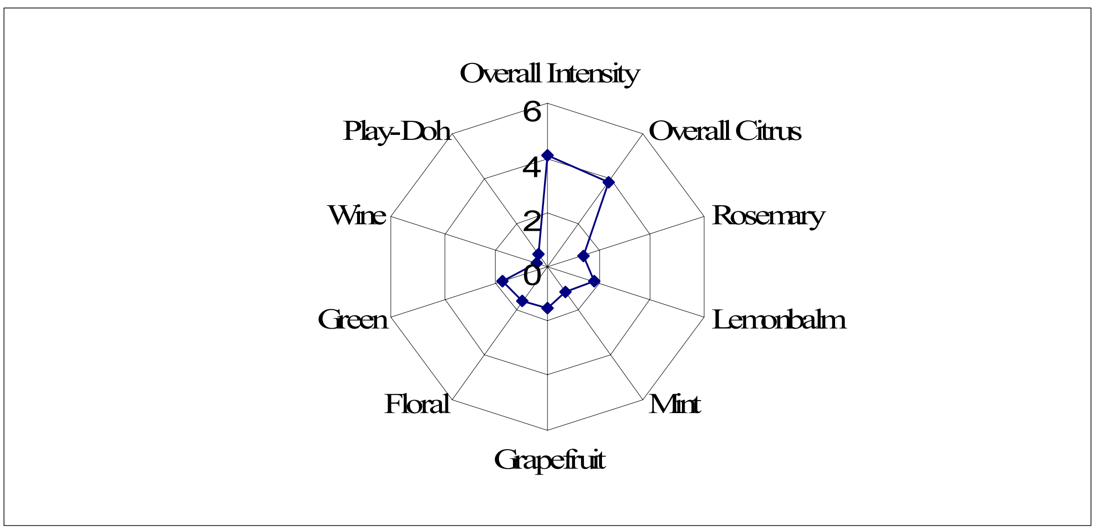


Figure 3.5 Graphical representation of calamondin peel aroma in sniff bottle

Table 3.23 Hand held peeled calamondin fruit aroma analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Overall Intensity | 3.8 | <0.0001* |
| Overall Citrus | 2.9 | <0.0001* |
| Rosemary | 1.1 | <0.0026* |
| Lemonbalm | 1.4 | 0.2795 |
| Grapefruit | 1.6 | 0.2426 |
| Mint | 0.8 | 0.0245* |
| Floral | 1.1 | 0.1629 |
| Green | 1.2 | <0.0001* |
| Play-Doh® | 0.6 | 0.1846 |

* There were significant differences (P<0.05) in the results.

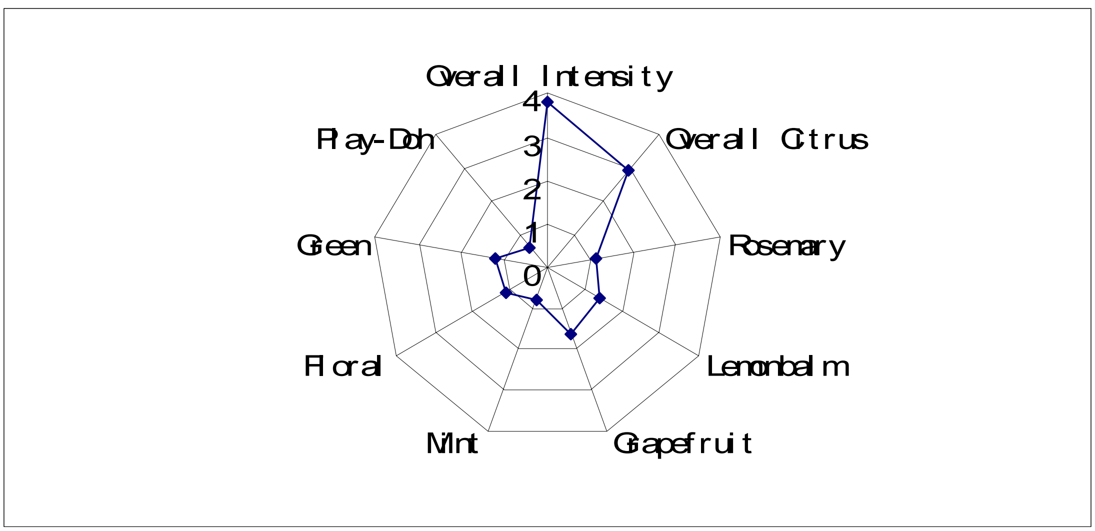


Figure 3.6 Graphical representation of peeled calamondin fruit aroma

Table 3.24 Peeled calamondin fruit in sniff bottle aroma analysis

| **Attribute** | **Mean Score** | **Significance** |
|---|---|---|
| Overall Intensity | 4.1 | 0.0003* |
| Overall Citrus | 3.4 | <0.0001* |
| Rosemary | 0.8 | <0.0001* |
| Lemonbalm | 1.1 | <0.0001* |
| Grapefruit | 1.2 | 0.0248* |
| Mint | 0.5 | 0.0146* |
| Floral | 1.3 | 0.0550 |
| Green | 1.3 | 0.1318 |
| Play-Doh® | 0.5 | 0.0739 |

* There were significant differences (P<0.05) in the results.

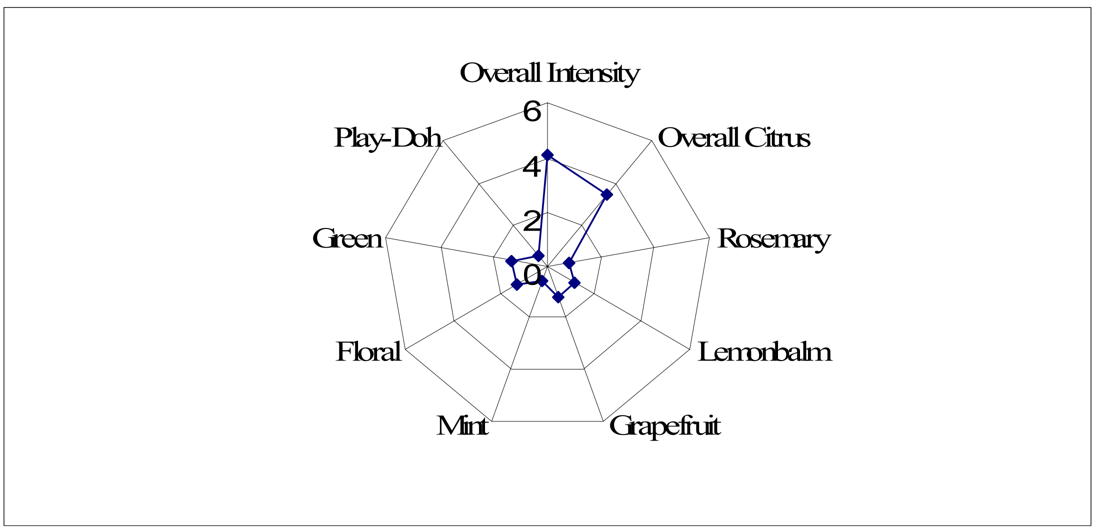


Figure 3.7 Graphical representation of peeled calamondin fruit aroma in sniff bottle

Table 3.25 Calamondin fruit oral texture analysis

| **Attribute** | **Mean Score** | **Significance** |
|---|---|---|
| Stringiness | 5.6 | 0.0027* |
| Firmness | 2.2 | 0.0270* |
| Juiciess | 5.1 | 0.0116* |

* There were significant differences (P<0.05) in the results.

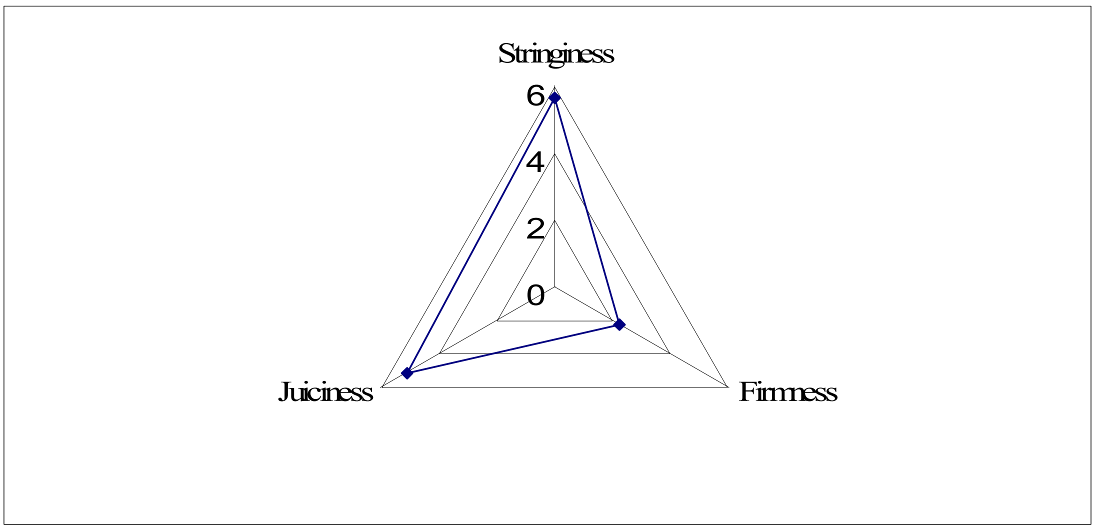


Figure 3.8 Graphical representation of calamondin fruit oral texture

Table 3.26 Calamondin fruit flavor analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Sour | 60 | 0.2063 |
| Sweet | 1.9 | 0.3697 |
| Bitter | 2.2 | 0.0026* |
| Rosemary | 1.1 | <0.0001* |
| Green | 1.3 | 0.0145* |
| Mint | 0.9 | 0.0102* |

* There were significant differences (P<0.05) in the results.

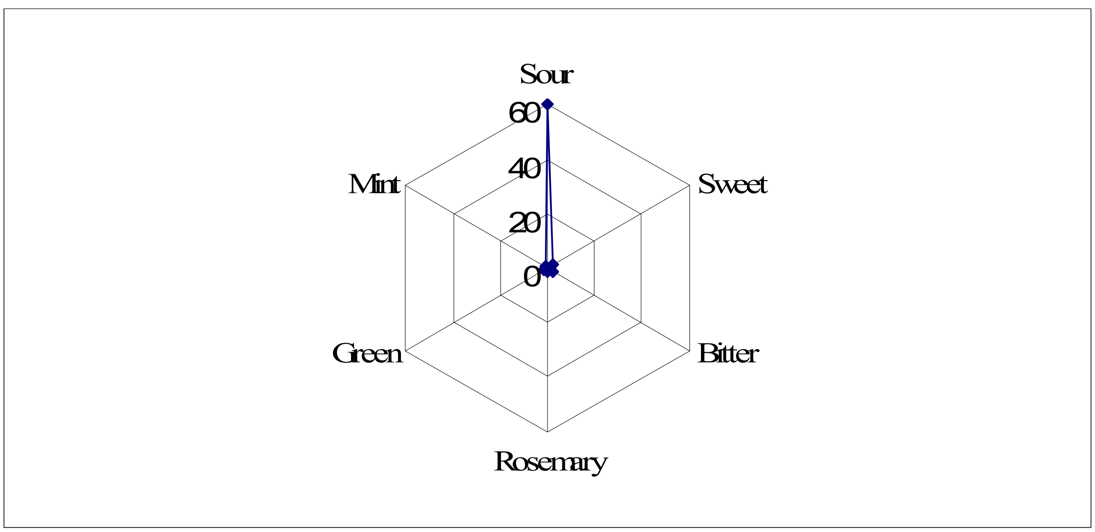


Figure 3.9 Graphical representation of calamondin fruit flavor

Table 3.27 Calamondin fruit-in-mouth feeling factor analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Numbing | 2.6 | 0.0002* |
| Burn | 1.0 | 0.1142 |
| Astringency | 3.1 | 0.2160 |
| Tooth Pain | 0.3 | <0.0001* |
| Jaw Muscle Discomfort | 1.4 | 0.0014* |

* There were significant differences (P<0.05) in the results.

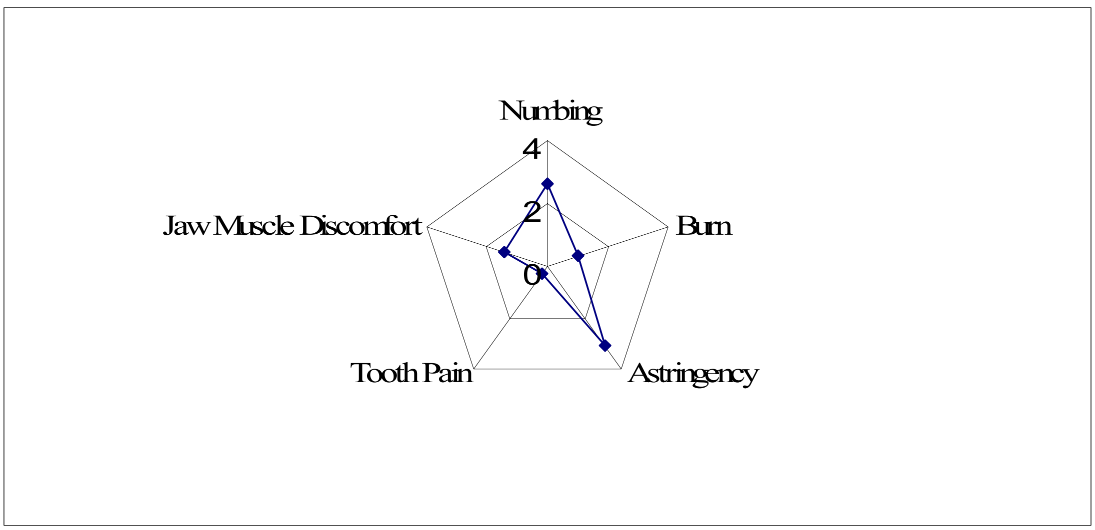


Figure 3.10 Graphical representation of calamondin fruit-in-mouth feeling factors

Table 3.28 Calamondin oral peel texture analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Crispness | 2.8 | 0.0053* |
| Chewiness | 2.8 | <0.0001* |
| Fracturability | 1.9 | 0.0149* |
| Juiciness | 2.1 | 0.0001* |
| Sound when Chewing | 3.5 | 0.0002* |

* There were significant differences (P<0.05) in the results.

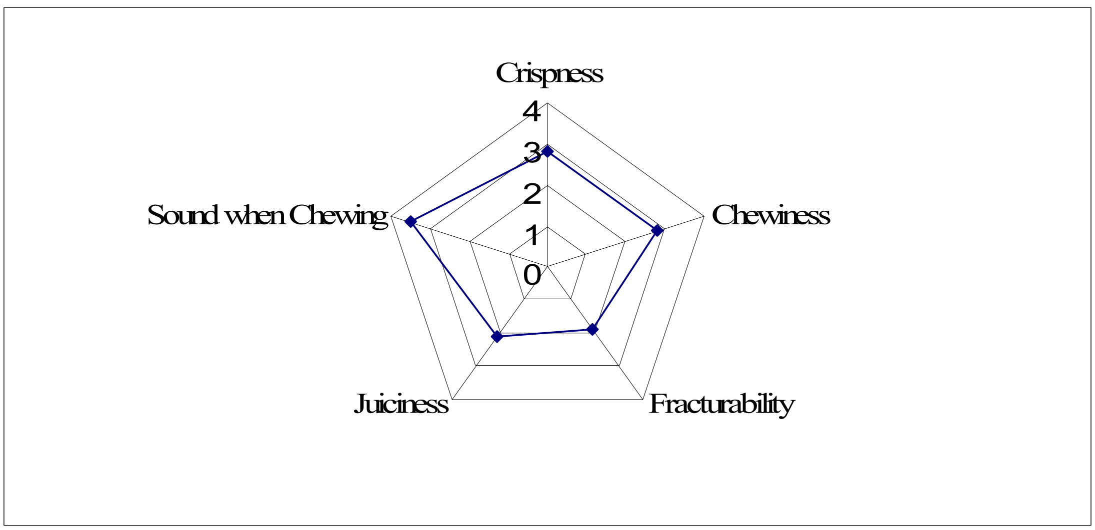


Figure 3.11 Graphical representation of calamondin peel texture

Table 3.29 Calamondin peel flavor analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Sour | 2.6 | <0.0001* |
| Sweet | 1.8 | 0.5303 |
| Bitter | 4.6 | <0.0001* |
| Rosemary | 1.9 | <0.0001* |
| Green | 1.6 | 0.0062* |
| Mint | 1.3 | 0.0548 |

* There were significant differences (P<0.05) in the results.

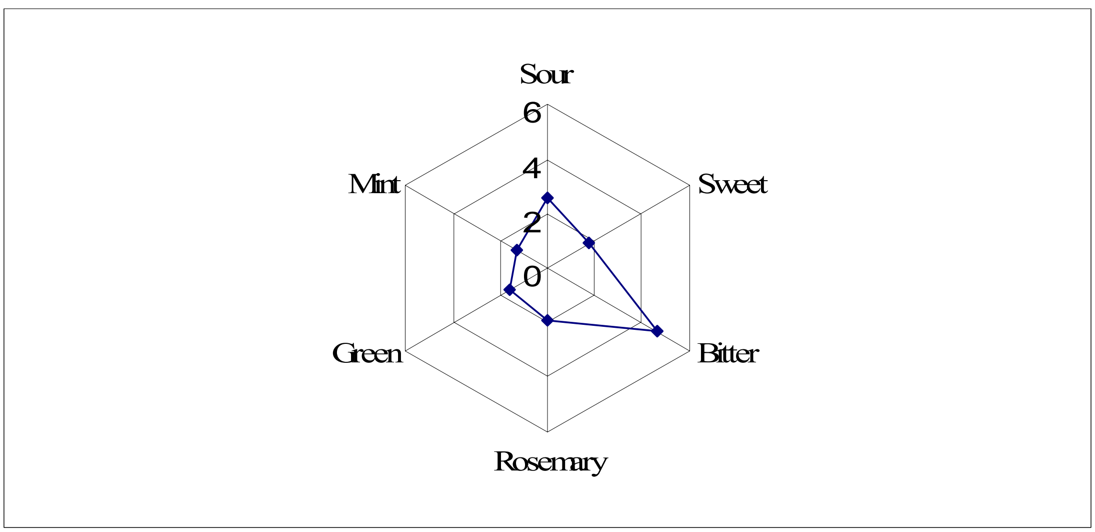


Figure 3.12 Graphical representation of calamondin peel flavor

Table 3.30 Calamondin peel-in-mouth feeling factor analysis

| Attribute | Mean Score | Significance |
|---|---|---|
| Astringency | 4.6 | 0.0047* |
| Numbing | 3.2 | <0.0001* |
| Burn | 1.9 | <0.0001* |
| Cooling | 2.2 | 0.0031* |

* There were significant differences (P<0.05) in the results.

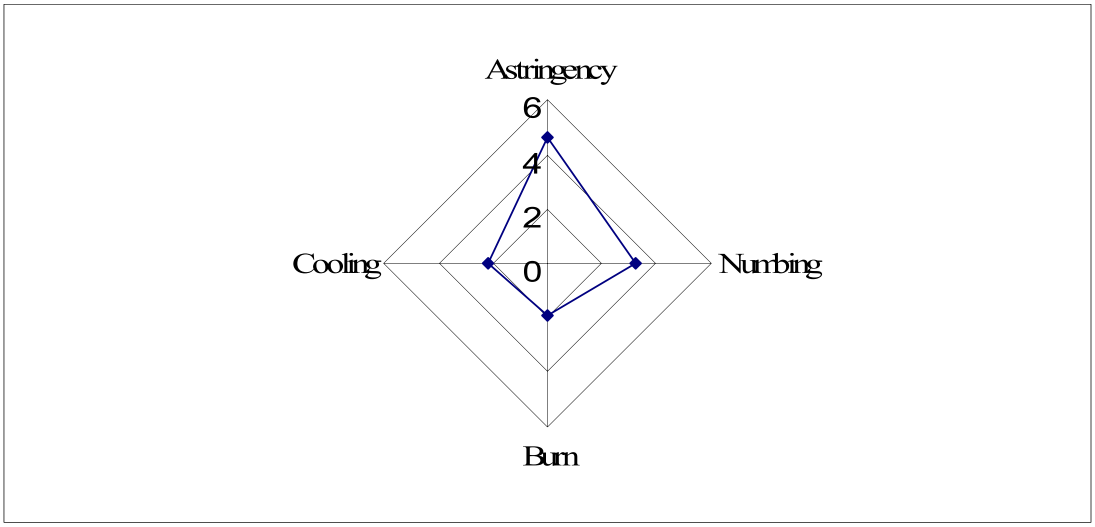


Figure 3.13 Graphical representation of calamondin peel-in-mouth feeling factor

# CHAPTER IV

# DEVELOPMENT AND CONSUMER ACCEPTABILITY OF YOGURT FLAVORED WITH CALAMONDIN

## Introduction

Calamondins provide pleasant aroma and flavor, as well as nutritional value and they are popularly used in the Philippines primarily for its juice and as a substitute for lemon (Nisperos et al., 1982). They can be served fresh and as a garnish of the plate as well. Although fresh and processed calamondin products are not well introduced to the market in the United States, other citrus fruits, such as grapefruits, lemons and oranges have gained nation wide popularity. Orange juice consumption is greater than those of all other fruit and vegetable juice combined (Pollack and Perez, 2007b). Lemons are served as a garnish of dishes, and lemon yogurt is highly demanded (Tamime and Robinson, 1999). Since calamondin is used as a substitute for lemon in the Philippines, there is potential that calamondins will be very well accepted by consumers in the United States.

Although there are numerous fermented milks produced on a local basis around the world, only yogurt has achieved a truly international distribution. Started 5,000 years ago by Middle Easterners, yogurt is now becoming a popular healthy snack food in the

United States (Foss, 2000). According to the USDA, yogurt production reached 60.7 million gallons in 2007 (United States Department of Agriculture, 2008). Today, consumers continually search for new and unique food products while trying to maintain healthy eating habits. Since lemon yogurt is highly demanded and calamondin serves as a substitute for lemon in the Philippines, there is potential that calamondin flavored yogurt will attract the attention of yogurt and citrus fruit consumers in Ameican market.

The development of yogurt with calamondin has not been previously reported. In this work, the primary objective is to develop a calamondin flavored yogurt. The second objective is to study the consumers' acceptance of the yogurt.

## Materials and Methods

*Delivery of Calamondins*

Calamondins were purchased from Rising C Ranches Inc. in California. Calamondins were packed with paper flock and placed into cardboard boxes labeled with producer's name and product's name. All the fruits were shipped the same day they were harvested. Calamondins arrived via UPS 2-day delivery to the Garrison Sensory Evaluation Laboratory in the Department of Food Science, Nutrition & Health Promotion at Mississippi State University.

*Preparation of Calamondins Pulp*

All the calamondins were selected based on intactness of body immediately upon arrival. Unselected calamondins were discarded, while the selected ones were placed into a plastic bowl (Packerware Model# H111524OP1) and were thoroughly rinsed by hands with hot water for 1 min. The fruits, as a whole, were then juiced with a juice machine (Juiceman JR., Model # JM-1C, MT. Prosepct, IL) to a 4000 ml steel beaker (Vollrath Model# 84000), and the residues were discarded. Heat a pot (8 Quarter, Emerilware, All-Clad Metalcrafters) of water to boil, then place the beaker containing the juice into the pot and let the juice heat up to 90°C for 30 sec while stirring (Braddock, 1999). Take the beaker out of the boiling water, and let it cool down for one and half hour. The pasteurized juice then was poured into a zip lock plastic bag (Bitran Model# 4745-7, Com-Pac Inc.) and placed in the freezer (Tappan Model# TRT21PNB) in the Garrison Sensory Laboratory.

*Yogurt Production*

The yogurt mix was composed of skim milk, cream, nonfat dry milk, honey and stabilizer. The mix was formulated by adjusting skim milk to 1% butter fat using 38% cream. Nonfat dry milk was added at rate of 4%, along with 10% honey (wt/wt) and 2.5% (wt/wt) stabilizer. All ingredients were heated to 50°C and homogenized with two-stage homogenizer at 10.395 and 3.43 MPa (Tamine and Robinson, 1985). Then, the yogurt milk was heated to 85°C, held for 30 min in a stainless steel vat (Walker, Newlisbon, WI) and cooled to 42°C in an ice water bath before inoculating with yogurt culture containing strains of *Streptococcus thermophilus* and *Lactobacillus delbrueckii ssp. Bulgaricus* at manufacturer's recommended rate. The yogurt was incubated until pH reached 4.7, and then cooled to 10°C. The yogurt was stirred in the vat. The details of the ingredients used are listed below.

Table 4.1 Ingredients utilized for the yogurt production

| **Ingredient** | **Manufacturer/Broker** |
|---|---|
| Cream | Custer Dairy Processing Plant, Mississippi State University |
| Skim Milk | Custer Dairy Processing Plant, Mississippi State University |
| Nonfat Dry Milk | Custer Dairy Processing Plant, Mississippi State University |
| Honey | Sysco Corporation, Houston, TX |
| Stabilizer | TIC Gums, Belcamp, MD |
| Culture | Yo-fast 20, Hanson, Milwaukee, WI |

*Yogurt Treatment*

The frozen calamondin pulp was thawed to liquid in the industrial refrigerator (Krack Corp Model# DT3S-550-DXAA-RH) at the Garrison Sensory Evaluation Laboratory with an average temperature of 3°C. The experimental yogurt samples were split evenly into 4 batches. And they were mixed with calamondin pulp by 0%, 5% (wt/wt), 10% (wt/wt) and 15% (wt/wt) respectively, setting the yogurt with 0% calamondin pulp as control.

*Yogurt Storage*

The camamondin flavored yogurt samples were filled in 5.5 oz (162 ml) plastic cups (Sweetheart Plastic Cup, Inc.) and closed with the lids provided with the cups. Each batch was assigned with a random 3-digit number and each cup was labeled before the filling. All samples were stored in well ventilated industrial refrigerator (Krack Corp Model# DT3S-550-DXAA-RH) at the Garrison Sensory Evaluation Laboratory with an average temperature of 3°C.

*Titratable Acidity and pH Measurement*

Titratable acidity (TA) was measured according to International Dairy Federation Standard (IDF, 1991). It is expressed as grams of lactic acid per 100 grams of the product, using the equation:

$$\text{Titratable acidity} = V \times 9/M,$$

Where V = volume (ml) of 1N sodium hydroxide solution required to titrate a sample of yogurt to a pH of 8.3, M = mass (g) of the test portion, and 9 is the conversion factor for lactic acid (Salvador and Fiszman, 2004).

Nine grams of yogurt were measured and placed in an 8 ounce (237ml) clear plastic cup (Sweetheart Plastic Cup, Inc.). Eighteen grams of filtered water were added to the cup and mixed thoroughly with yogurt. 0.5 ml of phenolphthalein indicator was applied to each sample. All samples were titrated with 1N sodium hydroxide until the first permanent color change to pink (30 seconds).

The pH was obtained by direct measurement with a portable electronic pH probe.

*Viscosity Measurement*

Prior to viscosity measurements, the yogurts were stirred manually. The gel was broken at 4°C with a stainless steel stick by 15 up and down movements in the original plastic cup moving in rotation for 30 sec. Texture was determined at 4°C by using the digital viscometer (Brookfield, Stoughton, MA Model# LVTD) with T-bar spindle. The spindle was inserted in the middle of yogurts approximately 10 mm under the surface. The rotation speed was adjusted so that the instrument reading would not exceed its maximum range before the formal measurement. The instrument readings were converted to final results according to the manufacturer's instruction.

*Consumer Acceptability*

Consumer panels were conducted at Garrison Sensory Laboratory, Mississippi State University. The primary investigators were certified by the Institutional Review Board of Regulatory Compliance and all test procedures were in compliance with human subject testing regulations. The consumer evaluations consisted of 3 replications with a minimum of 50 participants for each replication. Participants were recruited from Mississippi State University and surrounding community. Each participant received a light blue tray (Prolon Model# K1014). 4 yogurt samples in 5.5oz (162 ml) plastic cups with lids on, as previously mentioned, were placed on the tray, along with a sensory analysis instrument (score sheet), a No. 2 pencil (Atlas Pen & Pencil Corp., Hollywood, FL), a 16 ounce (473 ml) Styrofoam expectorant cup (Sweetheart Plastic Cup, Inc.), an 8 ounce (237ml) clear plastic cup (Sweetheart Plastic Cup, Inc.) of filtered water, a white quarter fold napkin (Scott Brand, Kimberly-Clark Global Sales Inc., Neenah, WI), a plastic spoon (Sweetheart Plastic Cup, Inc.). Samples were labeled with random 3-digit numbers and the order of samples was randomized on the score sheets. Panelists were asked to expectorate and rinse their mouths with water between each sample. The score sheets (Appendix C) directed panelists to evaluate the yogurt samples on the attributes of "appearance", "flavor", "texture", and "overall liking" using a 9-point hedonic scale (Meilgaard et al., 1999), where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like a little, 5 = either like nor dislike, 4 = dislike a little, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely.

*Testing Area*

The testing area is specifically designed for consumer evaluations. The room had positive air pressure, filtered air. Both temperature and lighting were controlled electronically. Room temperature was held constantly at approximately 22°C. Dim lightening was applied when consumer tests were conducted. Each participant was seated in an individual booth. The samples were passed to and from the participants through breadbox-type hatches. The hatches connected the testing area and sample preparation area.

*Statistical Analysis*

A randomized complete block design with 3 replications was utilized to analyze the consumer acceptability on calamondin flavored yogurts. SAS® Version 9.1.3 (SAS, 2006) was utilized to perform multivariate analysis of variance. The Least Significant Difference (LSD) test was utilized to separate means when differences occurred. A difference of 0.05 was considered significant. Clustering analysis (XLSTAT 2006) was performed to cluster consumers together based on their liking of the yogurts.

## Results and Discussion

*Titratable acidity and pH*

Titratable acidity is valuable for measuring the extent of growth of acid-producing bacteria in dairy products. The mean value of titratable acidity and pH for each yogurt product is shown below. The pH value of yogurt products deceased, as the concentration of the calamondin pulp increased, which was a result of the high acidity of the calamondin pulp (Calamondin pulp had a pH value of approximately 2.9) (Figure 4.1).

And the titratable acidity value increased, as the concentration of the calamondin pulp increased (Figure 4.2).

Table 4.2 Titratable acidity and pH value of the yogurt with different calamondin pulp concentration

| Treatment | Titratable Acidity (grams of lactic acid per 100 grams of yogurt) | pH |
|---|---|---|
| 0% pulp | 0.93 | 4.72 |
| 5% pulp | 1.08 | 4.58 |
| 10% pulp | 1.17 | 4.31 |
| 15% pulp | 1.31 | 4.12 |

*Viscosity*

The mean score of the viscosity value for each yogurt product is shown below. The texture of yogurt was more jell-like and the calamondim was basically liquid. Due to their texture difference, the calamondin pulp would dilute the yogurts. Therefore, the yogurt products became thinner as the concentration of pulp went up.

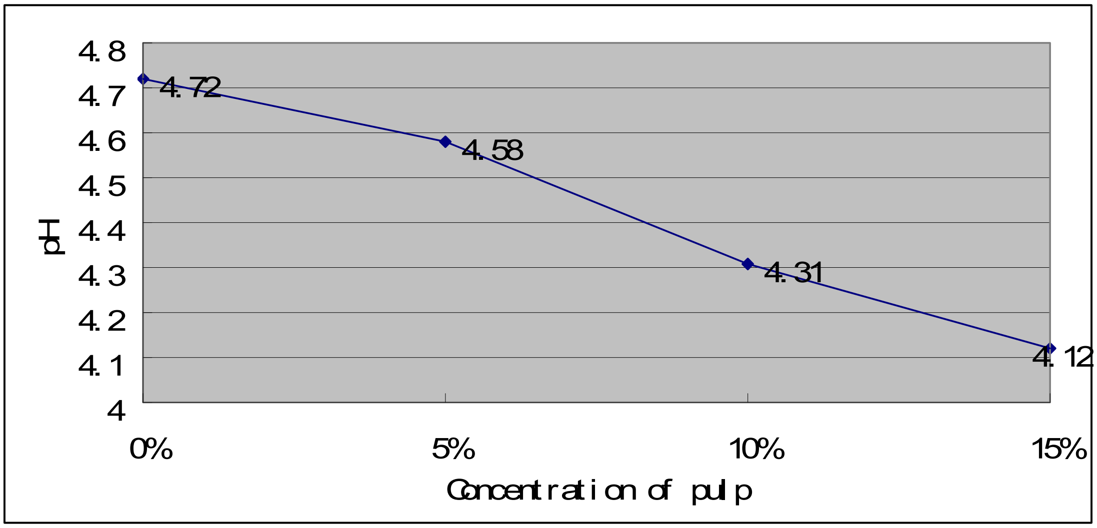


Figure 4.1 pH value of the yogurt with different calamondin pulp concentration

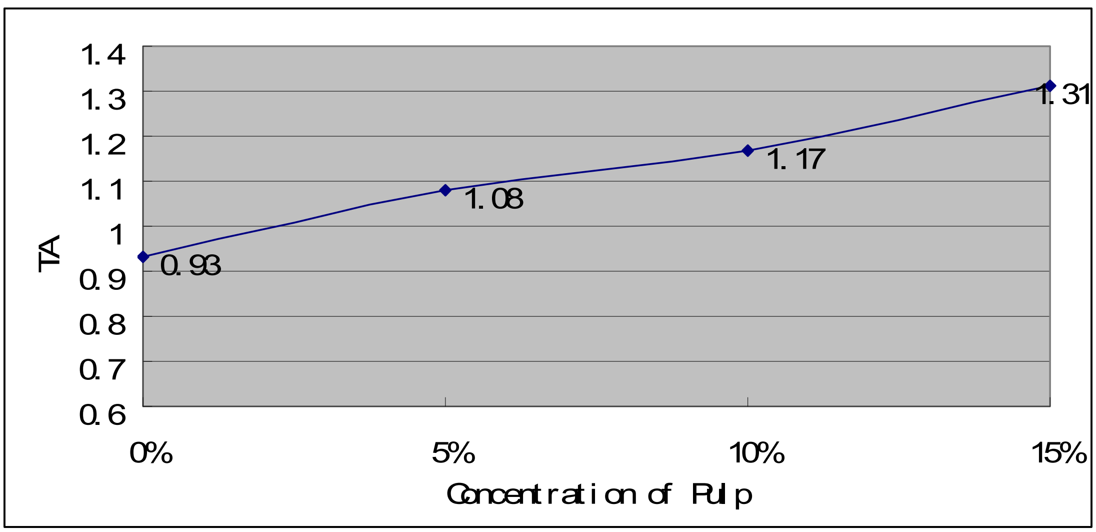


Figure 4.2 Titratable acidity value of the yogurt with different calamondin pulp concentration

Table 4.3 Viscosity value of the yogurt with different calamondin pulp concentration

| **Treatment** | **Viscosity (Pa·s)*** |
|---|---|
| 0% pulp | 6208.8 |
| 5% pulp | 5803.2 |
| 10% pulp | 5335.2 |
| 15% pulp | 3946.8 |

* The unite is pascal x second

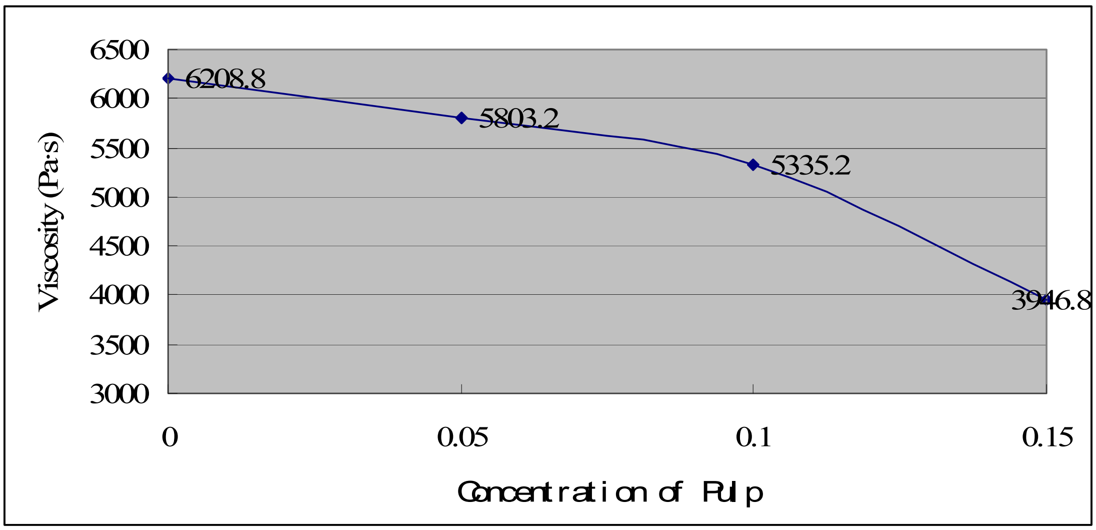


Figure 4.3 Viscosity value of the yogurt with different calamondin pulp concentration

*Consumer Acceptability*

No significant difference (P>0.05) occurred among yogurt treatments for consumer acceptability on appearance. The yogurts with 0%, 5%, 10% and 15% calamondin pulp received mean scores of 7.2, 7.1, 7.1 and 7.0, respectively, which would be categorized between “like moderately” and “like very much” on the 9-point hedonic scale.

No significant differences (P>0.05) were found in consumer’s evaluation of texture among yogurt samples. Yogurts with 0% and 5% calamondin pulp received mean scores of 7.3 and 7.0, respectively, in texture which would be categorized between “like moderately” and “like very much” on the hedonic scale. Yogurts with 10% and 15% calamondin pulp received mean scores of 6.8 and 6.5, respectively, which correspond to between “like slightly” and “like moderately” on the hedonic scale.

No significant difference (P>0.05) were found in consumers’ evaluation of flavor between yogurts with 0% and 5% calamondin pulp. While significant differences were observed among 0% and 5%, 10% and 15% calamondin pulp yogurts in flavor. Yogurt with 0% calamondin pulp received the highest mean sore of 7.2 in flavor, which falls between “like moderately” and “like very much” on the hedonic scale. That indicated consumers preferred a sweet taste. Yogurts with 5% and 10% calamondin pulp received the mean scores of 6.7 and 6.1 respectively, which both would be categorized between “like slightly” and “like moderately”. Yogurt with 15% calamondin pulp received the lowest mean score of 5.0 which corresponds to “neither like nor dislike” on hedonic scale.

Significant differences (P<0.05) were observed among yogurt treatments for overall consumer acceptability. Yogurt with 0% calamondin pulp received the highest mean score of 7.2 for overall acceptability, which falls in between “like moderately” and “like very much”. Yogurt with 5% and 10% calamondin pulp received the mean score of 6.7 and 6.2 respectively, which corresponds to between “like slightly” and “like moderately”. Yogurt with 15% calamondin pulp received the mean score of 5.2 for overall acceptability, which corresponds to between “neither like nor dislike” and “like slightly”. Both 0% and 5% calamondin pulp yogurt were very well accepted by the consumers. As the concentration of the calamondin pulp in yogurt increases, the overall consumer acceptability would decrease.

Panelists were grouped into 6 clusters based on their liking of yogurt products (Table 4.4). Cluster 1 (12% of the panelists) liked yogurt without calamondin pulp moderately and disliked the other products. Cluster 2 (13% of the panelists) liked moderately yogurts with 5% and 10% calamondin pulp, but neither liked nor disliked the other two products. Cluster 3 (26% of the panelists) liked yogurt with 0% and 5% calamondin pulp moderately, liked yogurt with 10% pulp slightly and disliked the yogurt with 15% pulp. Cluster 4 (34% of the panelists) liked the yogurt without calamondin pulp very much and liked the rest of the products moderately. Cluster 5 (12 % of the panelists) liked the yogurt without calamondin pulp moderately, liked the yogurt with 5% calamondin pulp slightly, but did not like the rest two products. Cluster 6 (3% of the panelists) did not like any of the yogurt products.

Table 4.4 Mean scores for consumer acceptability of yogurt with different calamondin pulp concentration*

| Treatment | Appearance Acceptability | Texture Acceptability | Flavor Acceptability | Overall Acceptability |
|---|---|---|---|---|
| 0% pulp | $7.2^{a}$ | $7.3^{a}$ | $7.2^{a}$ | $7.2^{a}$ |
| 5% pulp | $7.1^{a}$ | $7.0^{a}$ | $6.7^{a}$ | $6.7^{b}$ |
| 10% pulp | $7.1^{a}$ | $6.8^{a}$ | $6.1^{b}$ | $6.2^{c}$ |
| 15% pulp | $7.0^{a}$ | $6.5^{a}$ | $5.0^{c}$ | $5.2^{d}$ |

abcd Means in each column with unlike superscripts are different (p<0.05).
* Mean scores were evaluated using a nine point hedonic scale where 1 represents dislike extremely, 5 represents neither like nor dislike, and 9 represents like extremely.

Table 4.5 Mean scores for overall consumer acceptability of yogurt samples according to different clusters of consumer segments using a hedonic scale*

| Cluster | Consumers (N) | 0% pulp | 5% pulp | 10% pulp | 15% pulp |
|---|---|---|---|---|---|
| 1 | 19 | $6.8^{a}$ | $3.8^{b}$ | $4.1^{b}$ | $2.3^{c}$ |
| 2 | 20 | $4.8^{b}$ | $6.6^{a}$ | $6.3^{a}$ | $5.4^{b}$ |
| 3 | 41 | $7.7^{a}$ | $7.3^{a}$ | $6.7^{b}$ | $5.0^{c}$ |
| 4 | 53 | $8.1^{a}$ | $7.7^{b}$ | $7.7^{b}$ | $7.5^{b}$ |
| 5 | 19 | $7.4^{a}$ | $6.5^{b}$ | $3.4^{c}$ | $2.3^{d}$ |
| 6 | 5 | $3.0^{a}$ | $3.0^{a}$ | $2.6^{a}$ | $3.8^{a}$ |

abcd Means in each row with unlike superscripts are different (p<0.05).
* Mean scores were evaluated using a nine point hedonic scale where 1 represents dislike extremely, 5 represents neither like nor dislike, and 9 represents like extremely.

## Conclusion

Consumers showed no significantly different ($P>0.05$) preferences for appearance and texture of the yogurt samples. Consumers showed significantly different ($P<0.05$) preferences for flavor and overall liking of the yogurt samples. Consumers were divided into 6 groups based on their overall preference of the yogurt samples. Majority of the consumers liked the yogurt without calamondin pulp and the yogurt with 5% calamondin pulp moderately.

Calamondin pulp had a much lower pH than yogurts Therefore the calamondin pulp had an adverse relationship with both yogurt pH and yogurt titratable acidity. Also, the calamondin pulp had a adverse relationship with yogurt viscosity.

Additional research is needed to be performed to substitute honey in the yogurt product, which would cut the price of the products. Further research also needs to be conducted to study the shelf life of the yogurt. That would provide both manufactures and consumers more details of the yogurts product.

CHAPTER V

# SUMMARY AND CONCLUSION

A set of sensory lexicons were established through Quantitative Descriptive Analysis (QDA) for calamondin fruit. The lexicons contained 89 attributes in total, covering 14 categories which were appearance, hand held texture, overall aroma (unpeeled), hand held peel aroma (peeled), peel aroma in sniff bottle (peeled), hand held fruit aroma (peeled), fruit aroma in sniff bottle (peeled), oral fruit texture, fruit flavor, fruit-in-mouth feeling factor, oral peel texture, peel flavor, peel-in-mouth feeling factor and physical properties. Significant differences ($P<0.05$) were observed in the results, most likely due to the various ripe stages of the fruits. Future research should be preformed to address how storage conditions and regions may affect the characteristics of the calamondins.

Four treatments of yogurts were developed. No significant difference ($P>0.05$) occurred for consumer's preferences on appearance and texture of the yogurts. Significant differences ($P<0.05$) were observed for consumers' preferences on flavor and overall liking of the yogurts. Consumers were grouped into 6 clusters based on their overall preferences of the yogurts. The Majority (60%) of consumers liked moderately the yogurt without calamondin pulp and the yogurt with 5% calamondin pulp. Instrumental results revealed that the yogurt pulp had an adverse relationship with yogurt pH, TA and viscosity. Further research is needed to be conducted to study the substitution of the honey and the yogurt shelf life.

Ultimately, this research revealed the potential of the calamondin fruits to the American market. Also, this research provides a basis and index for future research with calamondin fruits.

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APPENDIX A

IRB APPROVAL

Mississippi State UNIVERSITY

April 7, 2008

Ye Tian
Mail Stop 9805

RE: IRB Study #08-106: Research Project for Descriptive Analysis of Calamondins (Cross citrus fruits between Mandarin orange kumquat)

Dear Tian:

The above referenced project was reviewed and approved via administrative review on 4/7/2008 in accordance with 45 CFR 46.101(b)(6). Continuing review is not necessary for this project. However, any modification to the project must be reviewed and approved by the IRB prior to implementation. Any failure to adhere to the approved protocol could result in suspension or termination of your project. The IRB reserves the right, at anytime during the project period, to observe you and the additional researchers on this project.

Please refer to your IRB number (#08-106) when contacting our office regarding this application.

Thank you for your cooperation and good luck to you in conducting this research project. If you have questions or concerns, please contact irb@research.msstate.edu or 325-3294.

Sincerely,

Katherine Crowley
Assistant IRB Compliance Administrator

cc: Dr. Patti Coggins

**Office for Regulatory Compliance**
P. O. Box 6223 • 70 Morgan Avenue • Mailstop 9563 • Mississippi State, MS 39762 • (662) 325-3294 • FAX (662) 325-8776

RECEIVED
MAY 13 2008

# **Procedural Modification/Addendum Request Form**

*Please note: This form may NOT be used for personnel changes or time extensions. Please complete a Personnel Modification form for personnel changes or a Continuing Review Request form for time extension requests.*

**IRB Docket #** **08-106**

**Principal Researcher/Investigator:** **Ye Tian**

**Research Title: Research Project for Descriptive Analysis of Calamondins and Consumer Liking Analysis of Calamondin Yogurt ( Calamondins are cross citrus fruits between Mandarin orange and kumquat).**

**1. Summarize / Itemize requested changes and justification for each.**
**In addition to the descriptive analysis of calamondins, consumer liking analysis of plaint yogurt flavored with calamondin pulp is applied. The plaint yogurt is purchased from grocery store and mixed with calamondin pulp at different level. Consumers are required to taste the yogurt samples and evaluate the samples based on their acceptability.**

**2. Do changes require a REVISED CONSENT statement or procedure?** ***If so, attach revised form and procedures. Yes, the revised form and procedures are attached behind.***

**3. Do changes require revisions to the assessment of risk of harm to the subjects?** ***If so, attach revisions. Yes, the revisions are attached behind.***

**4. Do changes require revisions to the methods of ensuring anonymity or confidentiality?** ***If so, explain. No.***

Tian Ye

**Signature of Researcher/Investigator:** **Date:** 05/12/08

Patti C. Coggins May 12, 2008

**Signature of Advisor (if student):** **Date:**

*******************************************************************(For office use)*

***Type of Approval:*** ✓ ***Administrative***
__ ***Expedited***
__ ***Full Board*** ***Date of meeting:***

***Authorized IRB Representative:*** ***Date:***

Kathrin Crawley 5-15-08

Version February 2005

1244

# APPENDIX B

# DESCRIPTIVE SCORESHEET

**Sensory Evaluation of Calamondin**

**Panelist Code:** _______________ **Gender:** **M** **or** **F**
**Date:** ___________ **Time:** ___________

## Appearance

**Orange**
|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____| _____
0 10 20 30 40 50 60 70 80 90 100

**Yellow**
|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____| _____
0 10 20 30 40 50 60 70 80 90 100

**Brown**
|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____| _____
0 10 20 30 40 50 60 70 80 90 100

**Green**
|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____| _____
0 10 20 30 40 50 60 70 80 90 100

**Estimate Pore Coverage Per Unit**
|_____|_____|_____|_____|_____|_____|_____|_____|_____|_____|
0 10 20 30 40 50 60 70 80 90 100

**Color Uniformity**
Not Uniform Extremely Uniform
|___|___|___|___|___|___|___|___|___|___|___|___|___|___|___|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Visual Smoothness** (Wood Stick 12)
None Extreme
|___|___|___|___|___|___|___|___|___|___|___|___|___|___|___|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Fruit Size: Latitude**
|___|___|___|___|___|___|___|___|___|___|___|___|___|___|___|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Fruit Size: Longitude**
|___|___|___|___|___|___|___|___|___|___|___|___|___|___|___|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

1

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Hand Held Texture

**Firmness** (Rubber Eraser 11)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Springiness** (Gummi Saver 7)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Smoothness** (Wood Stick 13)

Resistance Smoothness

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Leather Like Feeling** (Leather Cloth 10)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Overall Aroma (Unpeeled)

**Overall Intensity** (Onion 10, Pineapple 5)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Overall Citrus**

None Extreme

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Rosemary** (Rosemary 10)

None Extreme

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Lemonbalm** (Lemonbalm 13)

None Extreme

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Grapefruit** (Grapefruit 10)

None Extreme

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Mint** (Mint 8)

None Extreme

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Floral**

None Extreme

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Green**

None Extreme

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Grapefruit** (Grapefruit 10)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Mint** (Mint 8)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Floral**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Green**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Play-Doh** (Play-Doh 6)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Section Count** (Whole Fruit Base)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Fruit Aroma in Sniff Bottle (Peeled)

(Put **one** section of fruit in sniff bottle, shake moderately for 10 sec.)

**Overall Intensity** (Onion 10, Pineapple 5)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Overall Citrus**
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Rosemary** (Rosemary 10)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Lemonbalm** (Lemonbalm 13)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Grapefruit** (Grapefruit 10)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Mint** (Mint 8)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Floral**
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Green**
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Play-Doh** (Play-Doh 6)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Oral Fruit texture

**Stringy** (Celery 13)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Firmness** (American Cheese 4.5)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Juiciness** (Canned Mushrooms 8)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Seed Count** (Whole Fruit Base)

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Fruit Flavor

**Sweet**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Sour**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 6 12 18 24 30 36 42 48 54 60 66 72 78 84 90

**Bitter**
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Rosemary** (Rosemary 9)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Green**
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Mint** (Mint 12)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Fruit-in-Mouth Feeling Factor

**Numbing** (Oral Jell 12)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Burn**
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Astringent** (Grape Juice 6.5)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Tooth Pain** (Fruit in Mouth for 5 sec)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Jaw Muscle Response** (Fruit in Mouth for 5 sec)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Oral Peel Texture

**Crispness** (Club Cracker 5)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Chewiness** (Caramel 15)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Fracturability** (Graham Cracker 4.2)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Juiciness** (Canned Mushroom 8)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Sound when Chewing** (Club Cracker 8)
None Extreme
|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Peel Flavor

**Sweet**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Sour**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Bitter**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Rosemary** (Rosemary 9)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Green**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Mint** (Mint 12)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

## Peel-in Mouth Feeling Factor

**Astringent** (Grape Juice 6.5)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Numbing** (Oral Jell 12)

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Burn**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Cooling**

None Extreme

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Other**

|____|____|____|____|____|____|____|____|____|____|____|____|____|____|____|
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

**Thank You Very Much For Your Participation!!!**

APPENIX C

CONSUMER SCORESHEET

**Product: Yogurt with Calamondin** **Date:_______**

Please taste each sample in the order provided below. Rate each sample for each of the attributes. Rinse between samples with the water provided. Each column should have only one check mark.

| 658 | 745 | 360 | 821 | **APPEARANCE** |
|---|---|---|---|---|
| | | | | Like extremely |
| | | | | Like very much |
| | | | | Like moderately |
| | | | | Like slightly |
| | | | | Neither like nor dislike |
| | | | | Dislike slightly |
| | | | | Dislike moderately |
| | | | | Dislike very much |
| | | | | Dislike extremely |

| 658 | 745 | 360 | 821 | **TEXTURE** |
|---|---|---|---|---|
| | | | | Like extremely |
| | | | | Like very much |
| | | | | Like moderately |
| | | | | Like slightly |
| | | | | Neither like nor dislike |
| | | | | Dislike slightly |
| | | | | Dislike moderately |
| | | | | Dislike very much |
| | | | | Dislike extremely |

| 658 | 745 | 360 | 821 | **FLAVOR** |
|---|---|---|---|---|
| | | | | Like extremely |
| | | | | Like very much |
| | | | | Like moderately |
| | | | | Like slightly |
| | | | | Neither like nor dislike |
| | | | | Dislike slightly |
| | | | | Dislike moderately |
| | | | | Dislike very much |
| | | | | Dislike extremely |

| 658 | 745 | 360 | 821 | **OVERALL LIKING** |
|---|---|---|---|---|
| | | | | Like extremely |
| | | | | Like very much |
| | | | | Like moderately |
| | | | | Like slightly |
| | | | | Neither like nor dislike |
| | | | | Dislike slightly |
| | | | | Dislike moderately |
| | | | | Dislike very much |
| | | | | Dislike extremely |

**Thank You for your participation!!!**

Comments: ______________________________________________

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