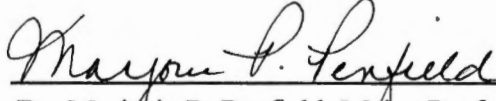
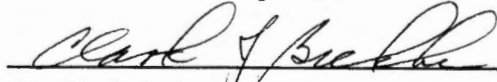


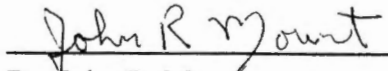
To the Graduate Council:

I am submitting herewith a thesis written by Christina A. J. Perry entitled "Sour and Sweet Taste Identification and Intensity Perception as Affected by Oral Rinses of Various Alcohol Contents and Wait Period." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science with a major in Food Science and Technology.


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**Sour and Sweet Taste Identification and
Intensity Perception as Affected by
Oral Rinses of Various Alcohol Contents
and Wait Period**

A Thesis

**Presented for the Master of Science Degree
The University of Tennessee, Knoxville**

Christina Ann Jolleen Perry

May 1999

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Thesis
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DEDICATION

This thesis is dedicated to those who gave me the encouragement to pursue my degree,
my parents Judith and Vernon Perry, my mother-in-law to be Jean Jolly and
especially my fiancé and best friend, Chris Moscone.

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I would like to express my utmost appreciation to the people that have made this thesis possible:

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ABSTRACT

Oral rinses are commonly used by consumers. Although menthol and alcohol are common ingredients in over-the-counter oral rinses, their sensory properties alone and in combination have not been studied extensively. The objective of this sensory study was to evaluate the effects that oral rinses have on a panelist's ability to identify tastants at their thresholds after rinsing and waiting a set period of time. The oral rinses evaluated were water, 3 alcohol concentrations—9, 18 and 27%. Tastant recognition and intensity were evaluated after 15, 30 or 60 min. Listerine® was the oral rinse of choice because it is the only American Dental Association (ADA) approved oral rinse. Before the panelists participated in this study they took part in a test to determine their recognition thresholds of all four basic tastes. Twenty-four panelists evaluated 24 oral rinse treatment combinations.

Oral rinse used and the length of wait period can play a role in panelists' ability to identify sweet and sour tastants correctly. Chi-square statistics showed that there are relationships prevalent in the oral rinse used and the length of wait period. As the alcohol concentration of the oral rinse increased, the panelists' ability to identify the samples decreased for both the sweet and sour tastant. The length of wait period had an influence on the ability of panelists to correctly identify the sour tastant. Analysis of variances of both the sweet and sour tastants found no significant differences ($p>0.05$) in the intensity levels assigned by panelists to correctly identified samples attributable to wait times, alcohol concentrations, or their interactions. With the sweet tastant, panelists perceived a second sample (above threshold) to be equal in intensity to the first sample (threshold).

For the sour tastant results indicated panelists perceived the intensity of the second sample to be more intense than the first with means of 66.4 and 42.4, respectively. It was concluded that oral rinses used within 60 min of a sensory test may influence results. Therefore, directions to the panelists should be changed to include instructions not to use mouth care products before participating in a sensory panel.

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CHAPTER 1

INTRODUCTION

Consumer acceptance is the ultimate goal for all products. Consumers evaluate products using a combination of factors such as availability, prices, familiarity, and personal preferences. In the food industry, consumers also evaluate product quality by using the five senses of touch, sight, sound, smell, and taste. The sensory qualities are very important to the acceptance or failure of a food product. There is a wide selection of specialized instruments available for the evaluation of the sensory properties of food products, but nothing can replace the human judge.

Ideally, the Sensory Scientist would like to receive the same responses from a human judge as from an instrument like sensitivity, reliability, and reproducibility. However, many extrinsic factors can affect the sensory perception and cause differences. Sensory Scientists have studied and examined ways to minimize factors that can influence human judgements. From these evaluations and studies certain suggestions have been made to reduce human variability. It has been highly recommended that human judges or consumer panelists not eat, drink, chew gum or smoke 30-60 min before taking part in a sensory study (Amerine et al., 1965). These external factors can leave residual flavors in the saliva which can interact with or influence the perceived taste of a product being evaluated. Each panelist has individual differences but reproducibility with each panelist can be maximized by following the above recommendations.

One area that has not been notably researched is the use of mouth-care products such as toothpaste, breath mints, and/or oral rinses and their effects on a panelist's ability

to identify the four basic tastes. The marketing, sales, and shelf space of over-the-counter (OTC) oral rinses have increased over the past few years (Pader, 1994). As Americans reexamine their dental hygiene practices to reflect concerns about plaque, tooth decay and gum disease, they have increased their use of oral rinse products. The increased use of oral rinses introduces a new consideration for Sensory Scientists to evaluate.

Research has shown that some of the common ingredients added to most oral rinses can have an effect on or influence sensory perception. According to the Code of Federal Regulations (CFR, 1997) 21.355.50, all types of oral rinses must be able to freshen the breath and oral cavity and generally rid the mouth of loose debris with a refreshing flavor in a liquid medium. Common ingredients of an oral rinse follow: a flavorant up to 2% (usually an essential oil with mint being the most popular), color which is mainly used to indicate flavor, a surfactant can be used up to 2% to stabilize flavor and provide a foaming action (sodium lauryl sulfate is commonly used because it can also act as an anti-plaque agent), and a humectant up to 2% is used to provide body and inhibit crystallization. Water makes up the bulk of the solution. The most variable ingredient in oral rinses is the alcohol. This can range from 0 to 27% of the solution. Alcohol is added to enhance flavor, give a perceived cleansing effect due the astringency and stimulate a feeling of freshness. It has a minimal contribution to the cleaning power of the mouthwash. Some oral rinses may have special ingredients added such as fluoride depending on the marketing or scientific claim of the product (Pader, 1994).

Menthol is the most common flavoring ingredient added to oral rinses, toothpaste, chewing gum and many other oral products, because of its ability to produce a thermal

sensation of cooling in the nasal and oral cavities (Gwartney and Heymann, 1995). L-menthol is the isomer that occurs most often in nature and is the one implied when using the name menthol. This isomer gives an intense peppermint aroma, bitterness, and nasal and oral cooling sensation (Eccles, 1994). Menthol affects the thermally sensitive neurons on the tongue (Lundy and Contreras, 1993). Menthol has been shown to reside in the oral cavity up to 70 min and possibly longer (Huessein et al., 1983). Menthol, along with capsaicin, has been studied extensively as an oral irritant. Menthol is used extensively as an artificial cooling agent; its possible influence on tasting perception has not been studied in detail. It has been shown that menthol combined with an alcohol concentration increases the burn and irritation in the oral cavity.

Ethanol is one to the most common chemical oral irritants (Green, 1988). It is used in various concentrations in oral rinses. The intensity of irritation varies with the concentration (Bolanowski et al., 1995). Its irritating effects are mediated by some of the same nerve fibers that mediate heat pain in the oral cavity (Green, 1988). Ethanol can desensitize the tongue but the duration of these effects have not been thoroughly researched.

The current study was designed to evaluate the effects oral rinses have on the panelists' ability to identify tastants at their own thresholds after rinsing and waiting a set period of time. Oral rinses were evaluated at 3 alcohol concentrations—9, 18 and 27%. Listerine® was the oral rinse of choice because it is the only American Dental Association (ADA) approved oral rinse. Listerine® was diluted with plastic bottled spring water (Mountain Valley, Hot Springs, AR) to give the three concentrations of alcohol containing

oral rinses. Tastant recognition and intensity were evaluated after a 15-, 30- or 60-min wait period. Basic tastes used in this study included sucrose ($C_{12}H_{22}O_{11}$), and citric acid ($C_6H_8O_7$), both of analytical grade purity. Before the panelists participated in this study they took part in a test to determine their recognition thresholds of all four basic tastes. The objectives of this study were to investigate if oral rinses affected a panelist's ability to taste the basic tastants of sweet and sour at their threshold levels and to determine if the oral rinses change the perceived intensity of the two basic tastants.

CHAPTER 2

REVIEW OF LITERATURE

I. Science of Sensory Evaluation

Sensory Evaluation is the evaluation of a product that requires the use of a least one or all of the five senses. Sensory evaluation is defined as . . .

“a scientific discipline used to evoke, measures, analyze and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing”

(Sensory Evaluation Division IFT, 1981).

The information obtained from a sensory evaluation test is very important to the success or failure of any consumer product.

There has always been sensory evaluation. Humans have developed likes and dislikes for foods and products since the beginning of time. Over the years, industry and academia have been developing methods to learn how to use the human senses and perceptions to predict the acceptance and/or failure of products (Peryam, 1990). Product development in any industry is ultimately dependent upon consumer satisfaction (Moskowitz, 1988). Sensory Science has developed into a very important tool of the food industry. Over the years there have been many influential people and developments in the success of Sensory Evaluation.

The evolution of Sensory Evaluation dates back to the early 1800s. Primitive rating scales have been used since the early 1800s. The first occurrence of psychometrics was about 1840 when Ernst Weber investigated the ability of human beings to detect

differences among strengths of physical stimuli. In 1880 Francis Galton, a British psychologist, worked with subjects conducting simple sensory and motor tests such as thresholds and reaction time. He developed extensive rating scales and originated the rank order method. He also invented various new statistical tools such as median and standard scores (Peryam, 1990). The development of statistical methods provided the scientist with a way to deal with naturally occurring variability.

Several noteworthy scientists from diverse disciplines have aided in furthering Sensory Science. The beginning of modern Sensory Science can be seen in the early 1930s. Dairy specialists at the Cornell Agricultural Experiment Station, Trout and Sharp, published research concerning thresholds for the basic tastes, how to evaluate oxidized flavor in milk and the reliability of judges (Peryam, 1990). In 1940 Scandinavian scientists developed the triangle test and other differential methods to analyze food products (Jellinek, 1985). Seagram's prime investigator, Edward Scofield, who was a psychologist, made several contributions to methodology by initiating variations of triangle difference and dou-trio tests to be used in quality control systems (Peryam, 1990).

Arthur D. Little set another milestone with the development of the flavor profile method. Today there are various qualitative systems but flavor profiling set the guidelines. Alina Szczesniak and coworkers at General Foods Corp. conducted extensive research in the classification of food texture and development of descriptive terminology and corresponding physical attributes (Pangborn, 1989). Refinements of these applications have been researched and examined in several industrial and academic institutions.

Various professional groups and organizations have aided in the development of Sensory Science. In 1946 the Kroger Food Foundation developed an in-house taste test program to support product research (Garnatz, 1952). Housewives were recruited and participated in consumer tests of preferences and opinions. Data were statistically analyzed. The U.S. Army Quartermaster Food and Container Institute also became involved with the development of methodology and applying the methods to solve food problems. The Institute is best known for refining the 9-point hedonic scale (Peryam and Pilgrim, 1957). Various segments of the USDA employed sensory work included small trained, in-house panels doing difference testing and pair-preference testing and some quality scaling (Peryam, 1990). Many valuable guide books and publications have been published by the American Society Testing Materials (ASTM), the International Standards Organization, the Society of Chemical Industry and the American Chemical Society to identify a few associations.

Today academia plays an important role in the widespread use of sensory evaluation. Food science departments offer classes in sensory analysis to prepare future food scientists for the food industry. Many books have been written by prominent scientists to aid in teaching this discipline. The first well-known sensory text was *The Principles of Sensory Evaluation of Foods* (Amerine et al., 1965).

Most industries have incorporated sensory evaluation as a part of product development and refining. The food industry is realizing that consumers are influenced by the sensory aspects of foods in making purchase decisions. Sensory research and development have played a key role in present day product development and will continue

to play a key role as long as consumers purchase and consume foods and beverages (Ennis, 1996).

II. Taste System

Taste and smell are two of the five most important senses to food quality. The combination of smell and taste results in the sensory attribute of flavor. Smell is defined as the ability “to perceive the scent of something by means of the olfactory nerves”(Berube, 1982). Taste is defined as the ability “to distinguish the flavor of by taking into the mouth, it is the sense that distinguishes the sweet, sour, salty and bitter qualities of dissolved substances in contact with the taste buds on the tongue” (Berube, 1982). Taste is initiated by contact of an aqueous solution of a chemical with the taste buds on the surface of the tongue and adjacent areas of the oral cavity and throat (Amerine et al., 1965).

Taste originates with the taste receptors, found in the special end organs called taste buds. Taste buds are found in the oral cavity on the epithelial surfaces on the tongue, soft palate, nasoincisor duct and epiglottis (Mistretta, 1991). There are 4 kinds of papillae on the human tongue: foliate, circumvallate, fungiform and filiform (Amerine et al., 1965). Three of these are specialized structures that contain taste buds. The fungiform papillae are large and round and mushroom-like in appearance and are located on the anterior two-thirds of the tongue. Each fungiform papilla's crevice contains 1-20 taste buds (Amerine et al., 1965; Mistretta, 1991). Most of the taste buds are found in the foliate and circumvallate papillae; both are larger structures that contain hundreds of taste buds. There is one foliate papilla on both posterior lateral sides of the tongue made up of a series of crevices. There are 8-12 circumvallate papillae located on the posterior

dorsal border between oral and pharyngeal tongue arranged in a V-shaped formation (Mistretta, 1991).

Taste buds contain 50-150 individual taste cells. There are four types of taste cells, basal, dark (type I), intermediate, and light (type II) (Murray, 1971; Mistretta, 1991). The basal cell is believed to be the stem cell from which taste cells originate. They can be small and round or oblate cells found at the basolateral margin of the taste bud (Mistretta, 1991). The other three cells are elongated bipolar cells that extend from the base of the bud to the surface of the epithelium from which microvilli extend in the environment through the taste pore (Schultz et al., 1967; Kinnamon and Getchell, 1991).

Taste buds are innervated by 3 branches of 3 cranial nerves. The chorda tympani innervates the fungiform papillae and the anterior walls of the foliate papillae, lingual branches of the trigeminal nerve innervates all papillae, and the lingual branch of the glossopharyngeal nerve innervates buds on the posterior wall of the foliate papillae (Kinnamon and Getchell, 1991). The taste cells are innervated by sensory axons that form the facial, glossopharyngeal and vagal cranial nerves. (Amerine et al., 1965; Murray, 1971; Kinnamon and Getchell, 1991). The chorda tympani and glossopharyngeal nerves send impulses to the brain from the taste buds on the tongue. Definite areas in the brain are stimulated by the sensory input (Amerine et al., 1965; Price and Desimone, 1977).

Taste buds respond to certain chemical stimuli present in the oral cavity which aids in the recognition of food (Amerine et al., 1965). Most taste stimuli are water soluble and nonvolatile. Placing a sapid solution in the oral cavity results in a taste sensation

which includes the quality and intensity of the stimulus (Miller and Bartoshuk, 1991; Price and Desimone, 1977).

When a stimulus is placed in the oral cavity, the first physiological response is the secretion of saliva. This response plays an extensive role in the oral cavity and in taste perception (Fischer et al., 1994). During mastication hydrophilic tastants such as weak acids (sour), salts, sucrose (sweet) and lipophilic tastants such as caffeine and quinine (bitter) are dispersed in the saliva. During this process the tastants pass through the mucus layer covering the taste pores and reach the microvilli (Miller and Bartoshuk, 1991).

Experiments on the effects of narcotics in the late 1800s presented evidence that there are four basic tastes (Amerine et al., 1965; Pfaffmann et al., 1971). The four basic tastes are bitter, sweet, sour and salty. The tongue responds to each basic taste at distinct areas of the tongue (Fig. 1). Sweet and salty are sensed on the tip of the tongue, sour is sensed on the edges of the tongue, and bitter is sensed on the back of the tongue. Each of the basic tastes stimulates the taste receptors through different chemoreceptive mechanisms. It is accepted that the sweet taste receptor involves a receptor protein which is distinct from other taste receptors (Price and Desimone, 1977). Studies have shown that the presence of the hydrogen ions in acids that elicit the sour taste is induced by the binding of the hydrogen ion to the gustatory receptor membrane (Koyama and Kurihara, 1972; Gardner, 1980). Cell membrane models suggest that there is an anion/cation inhibition/stimulation of salt taste receptors by the initiated by sodium ions (Price and

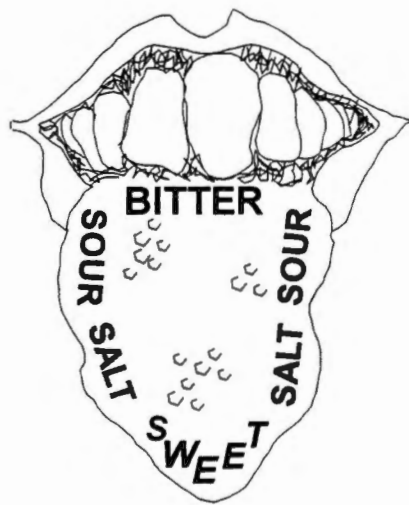


Fig. 1. Response areas of the four basic tastes (USDA, 1979).

Desimone, 1977). There is evidence that suggests that bitterness is related to the lipophilicity of the compound (Gardner, 1979). Threshold evaluations are the most common methods used to measure individual taste perception of the four basic tastes (Amerine et al., 1965).

III. Menthol

Menthol is a naturally occurring compound of plant origin. This compound gives plants of the *Mentha* species a minty smell and flavor (Eccles, 1994). Menthol can be extracted from flowering parts of the mint plants such as peppermint and spearmint plants. The use of these plants dates back to the Middle ages. Mint plants were used in various ways from curing tooth and stomach aches to being thrown in the streets to welcome triumphant gladiators. Today menthol is a common food and drug additive that can be found in chewing gums, confections, ice cream, cordials, tobacco products, tooth pastes and mouthwashes (Farrell, 1990; Lundy and Contreras, 1995; Green, 1986). The addition of menthol increases the attractiveness of a product by the elicitation of a cool sensation upon the products application or use. The cooling effect of menthols is the most noticeable sensation (Lundy and Contreras, 1994). It is the cooling action of menthol which has been most studied. Physiological studies of menthol's sensory effects are sparse.

Menthol ($C_{10}H_{20}O_1$) is a cyclic terpene. It has 3 asymmetric carbon atoms in its cyclohexane ring. Menthol is an optically active molecule and occurs as 4 pairs of optical isomers (Eccles, 1994). Some optically active isomers are known to be capable of producing different sensory impacts. L-menthol is the isomer that occurs most often in

nature. L-menthol or a combination of l-menthol and d-menthol are commonly used commercially (Green, 1985).

Green (1985) found that l-menthol enhances a cold sensation more strongly than d-menthol. Gwarthney and Heyman (1994) found similar results as Green; however, they also indicate that l-menthol has a greater maximum intensity and a longer duration of cooling and burning sensation, and as concentrations increase bitterness increases.

Menthol is a lipid-soluble substance. There are 4 characteristics that give menthol a cooling effect. It has a hydrogen bonding group, a compact hydrocarbon skeleton, a hydrophilic/hydrophobic balance and a molecular weight between 150 and 350 (Green, 1985; Eccles, 1994). The perceived cooling effect of menthol in the oral cavity is not due to evaporation or vasodilation but to a specific action menthol has on the sensory nerve endings (Eccles, 1994).

Menthol has a complex sensory effect in the oral cavity. It influences both the activity of the gustatory and temperature receptors. Besides the cooling effect of menthol evokes at certain concentrations, it may also elicit a taste, a tingling sensation and/or a burning sensation (Lundy and Contreras, 1995). The physiological effects menthol generates in the oral cavity are complex involving temperature, touch and chemical sensitivity. The chorda tympani nerve is extremely sensitive to chemical stimulation but weakly sensitive to tactile and thermal stimulation, whereas, the lingual nerve is highly sensitive to thermal, tactile and nociceptive stimulation and weakly sensitive to chemical stimulation (Lundy and Contreras, 1993). Lundy and Contreras (1994) found that the lingual nerve in rats requires a 25-100x stronger taste stimulus concentration than the

chorda tympani nerve for activation. They also discovered that taste receptors and the lingual neurons may use different mechanisms to detect and/or transduce menthol stimulation.

In studies conducted by Green (1985,1986) at the Monell Chemical Senses Center, researchers found that menthol affects thermal modalities. In the 1985 study it was found that allowing menthol to stimulate the tongue for periods of time increases the cooling sensation and causes any ingested material to feel cooler. It was found that a 5-10 min exposure to menthol in the oral cavity strongly enhanced the sensation of cold from cold water and reduced the sensation of warmth from warm water. The 1986 study showed that menthol desensitizes warm receptors and long exposure to l-menthol inhibits the perception of warming. In both studies the effects of menthol were discovered to last at least 30 min and sometimes longer.

A similar study conducted by Lundy and Contreras (1993) at Florida State University also showed that a mixture of menthol and water introduced into the oral cavity for 5 to 10 min strongly enhanced the sensation of the cold from cold water but reduced the sensation of warmth from the warm water. They additionally found that taste receptors adapted quickly to menthol stimulation, leaving the taste receptors in a state of insensitivity. In their experiment the chorda tympani nerve failed to respond to salty, sweet, sour and bitter tasting stimuli for at least 10 min after menthol stimulation. Rinsing the tongue with water for as long as 10 min failed to bring receptors back to their prestimulated state. This may be explained by the study performed by Hussien and coworkers (1983) at Life Savers Inc. In this study menthol residuals of 6.7-11.0 μg were

found in the oral cavity 10 min after one or two sticks of peppermint gum had been chewed for 5 min. Analysis after 20 min showed that 5.8 μg of menthol was still retained in the oral cavity.

IV. Ethanol

Ethanol (ethyl alcohol, $\text{CH}_3\text{CH}_2\text{OH}$) is the most common alcohol and is prepared by the fermentation of sugars. Ethanol is highly soluble in water. Research has shown that ethanol is a common oral chemical irritant, but little is known about the nature of the sensation it produces in the oral cavity or the effects it can have upon basic taste. Some studies indicate that the sensory responses to capsaicin and ethanol are mediated at least in part by the same population of receptor fibers (Green, 1988).

An experiment by Green (1988) showed that when ethanol covers the tongue an irritation appears first at the tip. The sensation then spreads to less sensitive areas along the sides and back of the tongue. As the ethanol reaches more receptors, neural activity is integrated and sensory intensity grows as a full impression of the ethanol "burn" develops. This experiment also found that ethanol's irritating effects are mediated by some of the same nerve fibers that mediate heat pain, allowing it to give a perception of both warmth and heat pain "burn."

The human taste thresholds to alcohol (ethanol) consist of two sensations. At low concentrations (4%) a sweet taste is perceived, as the concentrations increase the sweet taste increases up to a point. At this point (20-21%) a burning taste is perceived (Wilson et al., 1973). The amount of pain (burn) perceived is directly dependent on the amount of ethanol and the duration it is in the oral cavity. The pain rating increases with increasing

ethanol concentration (Bolanowski et al., 1995). Ethanol can desensitize the tongue but the lengths of these effects have not been thoroughly researched.

V. Oral Rinses

All oral rinses (mouth rinses/mouth washes) have many features in common. According to the Code of Federal Regulations 21.355.50 (CFR,1997) all types of oral rinses must be able to freshen the breath and the oral cavity and generally rid the mouth of loose debris with a refreshing flavor in a liquid medium. Common ingredients of oral rinses follow: a flavorant up to 2% (usually an essential oil with mint being the most popular), color which is mainly used to indicate flavor, a surfactant can be used up to 2% to stabilize flavor and provide a foaming action (sodium lauryl sulfate is commonly used because it can also act as an anti-plaque agent), and a humectant up to 2% is used to provide body and inhibit crystallization. Water makes up the bulk of the solution. The most variable ingredient in oral rinses is the alcohol. This can range from 0 to 27% of the solution. Alcohol is added to enhance flavor, give a perceived cleansing effect due the astringency and stimulate a feeling of freshness. It has a minimal contribution to the cleaning power of the mouthwash. Some oral rinses may have special ingredients added such as fluoride depending on the marketing or scientific claim of the product (Pader, 1994). The most commonly sold oral rinses have a mint flavor (Pader, 1994).

Reports have indicated those oral rinses with high amounts of alcohol can induce oral pain (Bolanowski et al., 1995). In a study conducted at the Institute for Sensory Research (Bolanowski et al., 1995) it was found that oral rinses which contained less than 10% ethanol failed to induce significant pain while those with higher amounts did. These

researchers looked at 25 oral rinses that contain various ethanol concentrations. Results showed that if an oral rinse was a water/ethanol mixture or another commercial oral rinse containing ethanol, pain ratings increased with increasing ethanol concentrations. Another important discovery was that marketed oral rinses tended to induce greater amounts of pain than water/ethanol mixture of the same concentrations. This finding indicates that ethanol does play a role in producing pain but that other ingredients present in oral rinses can also contribute to this effect. Although mouthwashes are commonly used consumer products, containing both ethanol and menthol, the effect they can have on taste perceptions has not been widely investigated.

CHAPTER 3

MATERIALS AND METHODS

A consumer panel of 24 (13 female, 11 male) volunteers at The University of Tennessee, Agriculture Campus was selected to participate in this sensory study. Panelists had to be able to recognize all four of the basic tastes (sour, salty, sweet, and bitter).

I. Recognition Thresholds

Each potential panelist participated in a test to determine her/his recognition thresholds for each of the 4 basic tastes. Nine triangle tests with increasing concentrations of the basic tastants (Appendix A) were presented to each panelist for each basic taste to determine the recognition threshold for each panelist. For each triangle there is an odd sample and the panelist is asked to detect the odd sample and identify the basic taste. The order of the 3 samples within each triangle was randomized for each judge and the order in which each judge should taste the samples was indicated by code on the samples and scorecard. A sample scorecard is in Appendix B. When the panelist was able to recognize the basic taste correctly, a recognition threshold was reached (Jellinek, 1985), and data were recorded for each panelist. The recognition threshold levels for each panelist were used for the study.

II. Oral Rinses

The objective of this sensory study was to determine if oral rinses affect a panelist's ability to identify 2 basic tastants. Two basic tastants, sucrose (sweet) and citric acid (sour), were used for this study. Listerine® was diluted with plastic bottled spring water (Mountain Valley® Spring Company, Hot Springs National Park, AR) to give 3

concentrations of alcohol-containing oral rinses (9, 18 and 27%). A spring water rinse (Mountain Valley® Spring Company, Hot Springs National Park, AR) was used as an additional oral rinse. At each session a panelist received 1 oral rinse, and the tastant at his/her threshold concentration and the same tastant at 1 level above his/her threshold to evaluate after a set time period (15, 30, or 60 min). Each panelist evaluated 4 oral-rinse samples in combination with 2 tastants and 3 set time periods for a total of 24 sessions.

Oral rinses were prepared the day prior to testing. Each 15-mL oral-rinse sample was measured out using a Repipet® Dispenser (Lab Industries, Berkeley, CA) that was calibrated daily. Listerine® dilutions were prepared by pumping 15 mL for 27%, 10 mL of Listerine® and 5 mL of water for 18%, 5 mL of Listerine® and 10 mL for 9% alcohol and 15 mL of water for water rinse. Other ingredients present in the oral rinses are likewise diluted and these ingredients in there diluted and full strength states can contribute to the effects oral rinses have on taste perception.

Oral-rinse samples were presented at room temperature in covered 1-oz clear plastic portion-control cups along with instructions. Panelists were instructed to take the entire 15-mL oral-rinse sample in the mouth and swish and hold for 30-sec (recommended time from ADA). After 30 sec, the panelist expectorated the oral-rinse sample and waited a set amount of time (15, 30 or 60 min) before tasting the tastant solutions. They were also instructed to not eat, drink or smoke during this waiting time. Each panelist was given a vibrating timer (Fisher Scientific 16-551-41, Vibrating Alarm Timers) set for their waiting time and allowed to leave the evaluation area with instructions to return at the end of their waiting period.

Sucrose and citric acid solutions were prepared daily. The compounds used were sucrose and citric acid, both of analytical grade purity (Mallinckrodt, Paris, KY). Samples (15 mL) were measured out in graduated cylinders for each threshold and above threshold concentration. Threshold samples were presented at room temperatures in 1-oz clear plastic portion control cups coded with 3-digit random numbers.

The 24 panelists evaluated 24 oral rinse treatment combinations. The 24 treatment combinations were randomized for each panelist. At each session panelists received their oral-rinse sample, instructions (as stated above) and an expectoration cup, in individual booths under soft white fluorescence lights. When panelists returned to the sensory booths, at the end of their waiting periods, they then received a tray containing their threshold and above threshold samples, an expectoration cup and a scorecard. The scorecard instructed the panelist to identify the taste of the samples and rate the intensities on an unstructured 15-cm scale anchored by the terms “not at all intense” and “extremely intense”. On the scorecard the panelists also indicated the last time they ate, drank, and/or smoked. A sample scorecard is in the Appendix B.

III. Data Analysis

The data obtained from the recognition threshold determination part of this experiment were interpreted using procedures outlined by Jellinek (1985). When a panelist could correctly identify the odd sample 3 times in a row, a recognition threshold was reached. The first triangle of the 3 is the point at which recognition is recorded. Recognition thresholds were recorded for each tastant for each panelist.

After completion of sensory data collection, each panelist's data were examined for the ability to correctly identify both samples for each treatment combination. Data were also examined for the panelists' ability to correctly identify the first sample and only the second sample. Nominal and ordinal data were analyzed separately.

Nominal data were analyzed using chi-square statistics (Gacula and Singh 1984; O'Mahony, 1985). Contingency tables were used to determine if a relationship existed between the oral rinse used and the length of waiting period. Tables of independence were analyzed to determine if correct response were influenced by oral rinse and time period interactions. Chi-square statistics for independence were performed on the oral rinses and time periods collectively and individually.

The intensity scores were converted to ordinal data. These converted scores were analyzed as directional paired comparison tests (Roessler et al., 1978).

Analysis of variance was also performed on the intensity results. Intensity data were analyzed with PROC GLM of the Statistical Analysis System (SAS Institute, Inc., Cary, NC, 1996) for differences due to oral rinse used, waiting periods, order as well as the interaction of oral rinse and waiting period. Judges were entered into the model as an additional source of variation. Analysis of variances was performed on intensity values associated with correct responses for both samples, first sample, and second sample only. Least-squares means (LSMEANS) estimates were generated for each treatment combination and the PDIFF function used to determine sources of differences. PROC UNIVARIATE was performed to check normality of the data. Means were calculated using PROC MEANS.

CHAPTER 4

RESULTS AND DISCUSSION

This experiment was designed to investigate the effects which oral-rinses containing various alcohol concentrations (0, 9, 18 and 27%) could have on a panelist's taste perception after a waiting period (15, 30, or 60 min). For this experiment Listerine® was the oral rinse of choice because it is the only American Dental Association (ADA) approved oral rinse. Listerine was diluted to produce the 3 alcohol concentrations of oral rinses. It is understood that there are other active ingredients in Listerine were also diluted. For this presentation the data will be discussed in terms of the alcohol concentration.

I. Recognition Thresholds

Recognition thresholds were determined for each panelist. Threshold concentrations and one concentration above thresholds for each panelist shown in Appendix A, were then used as the tastant levels in evaluating the oral rinse effects on tasting perception. Threshold data are summarized in Table 1. The range of the threshold values is within values reported in the literature for these ages, 19-40(Amerine et al.,1965).

II. Oral Rinses

All responses were examined for each tastant. The number of correct identifications of the sweet tastant, for all oral rinses in combination with length of wait period, was 325 out 576 samples. The sweet tastant was incorrectly identified as water 94 out 576 samples. The sour tastant was identified correctly 289 times out of 576 samples while it was incorrectly identified as bitter 129 times out 579 samples. No patterns were found for the incorrect identifications of the samples.

Table 1-Panelist's recognition thresholds^a

Tastants	Panelist
Sucrose (g/100 mL)	
0.1	1, 2, 19
0.2	16, 22
0.3	3, 6, 11, 14, 24
0.4	4, 8, 9, 12,
0.5	7, 17, 18, 21, 23
0.8	5, 10, 13, 15, 25
Citric Acid (g/100 mL)	
0.013	14, 19
0.020	6
0.025	1, 4, 7, 8, 11, 12, 13, 15, 17, 20, 21, 24,
0.030	2, 9, 10, 16, 22
0.035	3
0.040	5
0.050	18, 23

^a Jellinek, 1985.

To determine if the effect of the oral rinse concentration was independent of time periods chi-square (χ^2) statistics were performed. The results in Table 2 indicate that correctly identifying the sweet tastant of both samples, the first sample (lower intensity) or only the second sample (higher intensity) was not influenced by the oral rinse and the length of wait period interaction ($p>0.05$). The sour tastant results shown in Table 3 indicate that at least one wait period/alcohol level combination has an effect on identifying the sample when panelists correctly identified only the second sample ($p<0.05$). When observing the number of times panelists correctly identified each tastant a trend can be noted for both tastants. As alcohol percentage increases the number of samples correctly identified decreases. This is most evident in respect to correct identification of both samples in a session.

It has been reported that alcohol levels greater than 21% can generate a burning (pain) sensation (Wilson et al., 1973). At these high alcohol levels the tongue can be desensitized but the length of this effect has not been thoroughly researched (Bolanowski et al., 1995). The effects caused by the burning sensation and desensitization may explain why the number of correctly identified samples decreased as alcohol levels increased.

To determine if oral rinse used was related to correct or incorrect identifications, chi-square statistics were performed for the alcohol effect summed over all wait periods. Results for sweet and sour tastants summed over all wait periods are shown in Tables 4 and 5, respectively. Results in Table 4 indicate that the oral rinse used does not significantly influence a panelist's ability to correctly identify both samples for the sweet tastant ($p>0.05$). Results suggest that the ability of panelists to correctly identify the first

Table 2–Sweet tastant observed correct responses and χ^2 analysis ^a as affected by oral rinses and wait periods

Oral rinses	Wait period (min)			Total	χ^2
	15	30	60		
Both samples correctly identified					
Water	15	9	13	37	2.51
9% alcohol	11	12	12	35	
18% alcohol	12	13	10	35	
27% alcohol	9	6	10	25	
Total	47	40	45	132 ^b	
First sample correctly identified					
Water	19	18	15	52	1.45
9% alcohol	15	14	16	45	
18% alcohol	13	17	13	43	
27% alcohol	13	12	14	39	
Total	60	61	58	179 ^b	
Only second sample correctly identified					
Water	1	3	5	9	4.41
9% alcohol	1	4	3	8	
18% alcohol	4	2	3	9	
27% alcohol	1	1	2	4	
Total	7	10	13	30 ^b	

^a Observed χ^2 = 10.64 with 6 degrees of freedom at $p = .05$.

^b Total of 288 responses.

Table 3–Sour tastant observed correct responses and χ^2 analysis^a as affected by oral rinses after wait periods

Oral rinses	Wait period (min)			Total	χ^2
	15	30	60		
Both samples correctly identified					
Water	14	7	6	27	7.56
9% alcohol	5	7	8	20	
18% alcohol	4	10	8	22	
27% alcohol	6	6	6	20	
Total	31	30	28	89 ^c	
First sample correctly identified					
Water	14	9	7	30	7.17
9% alcohol	8	7	10	25	
18% alcohol	4	11	9	24	
27% alcohol	10	7	6	23	
Total	36	34	32	102 ^c	
Only second sample correctly identified					
Water	7	9	14	30	12.35 ^b
9% alcohol	11	10	13	34	
18% alcohol	14	8	6	28	
27% alcohol	5	15	18	38	
Total	37	42	51	130 ^c	

^a Observed $\chi^2 = 10.64$ with 6 degrees of freedom at $p = .05$.

^b $p < .05$

^c Total of 288 responses.

Table 4—Sweet tastant observed correct responses and χ^2 analysis^a as affected by oral rinses over all wait periods

Oral rinses	Responses		Total	χ^2
	Correct	Incorrect		
Both samples correctly identified				
Water	37	35	72	1.34
9% alcohol	35	37	72	
18% alcohol	35	37	72	
27% alcohol	25	47	72	
Total	132	156	288	
First sample correctly identified				
Water	52	20	72	5.24 ^b
9% alcohol	45	27	72	
18% alcohol	43	29	72	
27% alcohol	39	33	72	
Total	179	109	288	
Only second sample correctly identified				
Water	46	26	72	10.25 ^c
9% alcohol	43	29	72	
18% alcohol	44	28	72	
27% alcohol	29	43	72	
Total	162	126	288	

^a Observed $\chi^2 = 4.64$ with 3 degrees of freedom at $p = .10$; observed $\chi^2 = 6.25$ with 3 degrees of freedom at $p = .05$; observed $\chi^2 = 9.86$ with 3 degrees of freedom at $p = .01$.

^b $p < .10$.

^c $p < .01$.

Table 5–Sour tastant observed correct responses and χ^2 analysis ^a as affected by oral rinses over all wait periods

Oral rinses	Responses		Total	χ^2
	Correct	Incorrect		
Both samples correctly identified				
Water	27	45	72	1.80
9% alcohol	20	52	72	
18% alcohol	22	50	72	
27% alcohol	20	52	72	
Total	89	199	288	
First sample correctly identified				
Water	30	42	72	1.76
9% alcohol	25	47	72	
18% alcohol	24	48	72	
27% alcohol	23	49	72	
Total	102	186	288	
Only second sample correctly identified				
Water	30	42	72	3.31
9% alcohol	34	38	72	
18% alcohol	28	44	72	
27% alcohol	38	34	72	
Total	130	158	288	

^a Observed $\chi^2 = 6.25$ with 3 degrees of freedom at $p = .05$.

sample was related to the oral rinse used ($p < 0.10$). Results in this table also indicate that the ability to correctly identify the second samples only was also influenced by the oral rinse used ($p < 0.01$). In this case the number of correct responses is less for the 27% alcohol rinse than for the other oral rinses. In Table 5 it is evident that oral rinses did not influence the panelists' ability to identify the sour tastant ($p > 0.05$). The same trend with regards to the decrease in correct answers as the concentration of the oral rinse increased, observed in Tables 2 and 3 can be seen in Tables 4 and 5. This trend was evident when both tastants were correctly identified and when the first tastant was correctly identified.

Chi-square results for all responses for the sweet and sour tastant summed over all concentrations of oral rinses are shown in Tables 6 and 7, respectively. Results in Table 6 indicate that the panelists' ability to identify the sweet tastant was not influenced by the length of wait period ($p > 0.05$). Data in Table 7 indicate that correctly identifying the second sour sample only may be influenced by the length of waiting period ($p < 0.10$). There are a high number of correct responses for the 60-min wait periods as compared to the 15-min wait periods. It appears that the longer the wait period the more time the tongue has to recover from the oral rinse. Further analysis is needed at this point to determine which oral rinse is affected most by the length of the wait period.

The ability of the panelists' to correctly identify the sweet tastant for each oral rinse is shown in Table 8. The water rinse was the only rinse influenced by the length of the wait period and only for the second sample correctly identified. The panelists' ability to identify second samples correctly was influenced by the length of the wait period ($p < 0.10$).

**Table 6–Sweet tastant observed correct responses and χ^2 analysis^a
as affected by wait periods over all oral rinses**

Oral rinses	Responses		Total	χ^2
	Correct	Incorrect		
Both samples correctly identified				
15	47	49	96	1.09
30	40	56	96	
60	45	51	96	
Total	132	156	288	
First sample correctly identified				
15	63	33	96	1.43
30	55	41	96	
60	58	38	96	
Total	176	112	288	
Only second sample correctly identified				
15	7	89	96	2.01
30	10	86	96	
60	13	83	96	
Total	30	258	288	

^a Observed $\chi^2 = 4.60$ with 2 degrees of freedom at $p = .05$.

Table 7–Sour tastant observed correct responses and χ^2 analysis^a as affected by wait periods over all oral rinses

Unaffected by wait periods over all oral rises				
Wait period	Responses			χ^2
	Correct	Incorrect	Total	
Both samples correctly identified				
15	31	65	96	0.23
30	30	66	96	
60	28	68	96	
Total	89	199	288	
First sample correctly identified				
15	36	60	96	0.36
30	34	62	96	
60	32	64	96	
Total	102	186	288	
Only second sample correctly identified				
15	37	59	96	4.23 ^b
30	42	54	96	
60	51	45	96	
Total	130	158	288	

^a Observed $\chi^2= 3.22$ with 2 degrees of freedom at $p= .10$; observed $\chi^2= 4.60$ with 2 degrees of freedom at $p= .05$.

^b $p < .10$.

Table 8–Sweet tastant observed correct responses and χ^2 analysis^a for each oral rinse as affected by waiting periods

Wait period (min)	Water			χ^2	9% alcohol			χ^2	18% alcohol			χ^2	27% alcohol			χ^2
	Correct	Incorrect	Total		Correct	Incorrect	Total		Correct	Incorrect	Total		Correct	Incorrect	Total	
Both samples correctly identified																
15	15	9	24		11	13	24		12	12	24		9	15	24	
30	9	15	24	3.11	12	12	24	0.11	13	11	24	0.77	6	18	24	1.59
60	13	11	24		12	12	24		10	14	24		10	14	24	
Total	37	35	72		35	37	72		35	37	72		25	47	72	
First sample correctly identified																
15	19	5	24		15	9	24		13	11	24		13	11	24	
30	18	6	24	1.80	14	10	24	0.36	17	7	24	1.85	11	12	24	0.33
60	15	9	24		16	8	24		13	11	24		14	10	24	
Total	52	20	72		45	27	72		43	29	72		39	33	72	
Only second sample correctly identified																
15	16	8	24		12	12	24		16	8	24		10	14	24	
30	12	12	24	3.37 ^b	16	8	24	1.50	15	9	24	0.82	27	17	24	2.19
60	18	6	24		15	9	24		13	11	24		12	12	24	
Total	46	26	72		43	29	72		44	28	72		29	43	72	

^a Observed $\chi^2 = 4.60$ with 2 degrees of freedom at $p = .05$; observed $\chi^2 = 3.22$ with 2 degrees of freedom at $p = .10$.

^b $p < .10$.

This significant difference was not detected in the data (Table 6) where the results indicated that length of wait period did not influence sample identification across all concentrations of oral rinses. The ability to identify the sweet tastant was not influenced by the length of the wait period for the other oral rinses.

Waiting periods had an effect on the correct identification of the sour tastant, shown in Table 9. Results indicate that correct identification of the sample with the 9% alcohol oral rinse was not influenced by length of wait periods ($p>0.05$). A trend can be noticed for the 9 and 18% oral rinses, there are more correctly identified samples after the 60-min wait period as compared to the 15-min wait period. In these instances the menthol can be playing a role in inhibiting the panelists' ability to identify the sample. Lundy and Contreras (1993) reported that menthol left the chorda tympani nerve in a state of insensitivity in which it was unable to respond to sour stimuli for at least 10 min.

The results in Table 9 indicate that the panelists' ability to identify the second sample when the 27% alcohol oral rinse was used was influenced by the length of the wait periods ($p<0.0005$). Panelists were more successful in correctly identifying the second sour samples after 30- and 60-min wait periods than after a 15-min wait period. Inspection of these data shows that after 60 min all panelists correctly identified the sour tastant (6 from both samples correct plus 18 from second samples correct). Further observation of this oral rinse suggests that the panelists were better able to correctly identify the sample after the longer wait periods.

Results in Table 10 show that the only significant result for the sweet tastant was found in the 30-min time periods when both samples were correctly identified. Results

Table 9–Sour tastant observed correct responses and χ^2 analysis^a for each oral rinse as affected by waiting periods

Wait period (min)	Water			χ^2	9% alcohol			χ^2	18% alcohol			χ^2	27% alcohol			χ^2
	Correct	Incorrect	Total		Correct	Incorrect	Total		Correct	Incorrect	Total		Correct	Incorrect	Total	
Both samples correctly identified																
15	14	10	24	6.76 ^b	5	19	24	0.97	4	20	24	3.67 ^c	8	16	24	0.55
30	7	17	24		7	17	24		10	14	24		6	18	24	
60	6	18	24		8	16	24		8	16	24		6	18	24	
Total	27	45	72		20	52	72		22	50	72		20	52	72	
First sample correctly identified																
15	14	10	24	4.46 ^c	8	16	24	0.86	4	20	24	4.88 ^d	10	14	24	1.66
30	9	15	24		7	17	24		11	13	24		7	17	24	
60	7	17	24		10	14	24		9	15	24		6	18	24	
Total	30	42	72		25	47	72		24	48	72		23	49	72	
Only second sample correctly identified																
15	7	17	24	4.45 ^e	11	13	24	0.78	14	10	24	6.08 ^b	5	19	24	15.49 ^e
30	9	15	24		10	14	24		8	16	24		15	9	24	
60	14	10	24		13	11	24		6	18	24		18	6	24	
Total	30	42	72		34	38	72		28	44	72		38	34	72	

^a Observed $\chi^2 = 3.22$ with 2 degrees of freedom at $p = .10$; observed $\chi^2 = 4.60$ with 2 degrees of freedom at $p = .05$; observed $\chi^2 = 5.99$ with 2 degrees of freedom at $p = .025$; observed $\chi^2 = 13.82$ with 2 degrees of freedom at $p = .0005$.

^b $p < .025$.

^c $p < .10$.

^d $p < .05$.

^e $p < .0005$.

Table 10 –Sweet tasant observed correct responses and χ^2 analysis^a for each oral rinse within waiting periods

Oral rinses	15 min			χ^2	30 min			χ^2	60 min			χ^2
	Correct	Incorrect	Total		Correct	Incorrect	Total		Correct	Incorrect	Total	
Both samples correctly identified												
Water	15	9	24	3.13	9	15	24	5.14 ^b	13	11	24	0.87
9% alcohol	11	13	24		12	12	24		12	12	24	
18% alcohol	12	12	24		13	11	24		10	14	24	
27% alcohol	9	15	24		6	18	24		10	14	24	
Total	47	49	96		40	56	96		45	51	96	
First sample correctly identified												
Water	19	5	24	3.46	12	12	24	2.85	15	9	24	0.83
9% alcohol	15	9	24		14	10	24		16	8	24	
18% alcohol	16	8	24		17	7	24		13	11	24	
27% alcohol	13	11	24		12	12	24		14	10	24	
Total	63	33	96		55	41	96		58	38	96	
Only second sample correctly identified												
Water	1	23	24	4.16	3	21	24	2.23	5	19	24	1.13
9% alcohol	1	23	24		4	20	24		3	21	24	
18% alcohol	4	20	24		2	22	24		3	21	24	
27% alcohol	1	23	24		1	23	24		2	22	24	
Total	7	89	96		10	86	96		13	83	96	

^a Observed $\chi^2 = 6.25$ with 3 degrees of freedom at $p = .05$; observed $\chi^2 = 4.64$ with 3 degrees of freedom at $p = .10$.

^b $p < .10$.

suggest that the panelists' ability to correctly identify both responses was influenced by the oral rinse concentration ($p < 0.10$) for this wait period. It can be seen that there are more incorrect responses for the 27% alcohol level than for any other level during this wait period suggesting that the tongue might not have had time to recover from the oral rinse used but has had enough time to possibly change the chemical balance in the saliva inhibiting the ability to correctly identify the sample.

Oral rinses had an effect in each wait period for sour tastant. Results in Table 11 indicate that correctly identifying the samples after the 15-min wait periods was influenced by the oral rinse used for correctly identifying the sweet tastant of both samples, the first sample (lower intensity) or only the second sample (higher intensity) ($p < 0.005$, $p < 0.025$ and $p < 0.025$). It can be seen that there are more incorrect identifications for the 15-min wait periods over all oral rinses than correct responses. This trend is also noticed in the 30-min wait periods.

Analysis of variances of both the sweet and sour tastants found no significant differences ($p > 0.05$) in the intensity levels assigned by panelists to correctly identified samples attributable to wait times, alcohol concentrations, or their interactions. Oral rinses with alcohol concentrations varying from 0 to 27% had LSMEANS estimates of intensities which ranged from 39.9 to 47.3 on a 150-point scale for the sweet tastant. The LSMEANS estimates of intensities for the sour tastant ranged from 43.2 to 57.4 for the same oral rinses. LSMEANS estimates of intensity did not differ due to treatment interactions (Table 12). They reflect a trend of increasing perceived intensity with increasing alcohol concentrations for both tastants. LSMEAN estimates of intensities of

Table 11– Sour tastant observed correct responses and χ^2 analysis^a for each oral rinse within waiting periods

Oral rinses	15 min			χ^2	30 min			χ^2	60 min			χ^2
	Correct	Incorrect	Total		Correct	Incorrect	Total		Correct	Incorrect	Total	
Both samples correctly identified												
Water	14	10	24	11.58 ^b	7	17	24	5.83 ^c	6	18	24	2.57
9% alcohol	5	19	24		7	17	24		8	16	24	
18% alcohol	4	20	24		10	14	24		8	16	24	
27% alcohol	8	16	24		6	18	24		6	18	24	
Total	31	63	96		30	42	96		28	44	96	
First sample correctly identified												
Water	14	10	24	9.24 ^d	9	15	24	2.00	7	17	24	1.13
9% alcohol	8	16	24		7	17	24		10	14	24	
18% alcohol	4	20	24		11	13	24		9	15	24	
27% alcohol	10	14	24		7	17	24		6	18	24	
Total	36	60	96		34	62	96		32	64	96	
Only second sample correctly identified												
Water	7	17	24	8.58 ^d	9	15	24	4.91 ^c	14	10	24	7.90 ^d
9% alcohol	11	13	24		10	14	24		13	11	24	
18% alcohol	14	10	24		8	16	24		6	18	24	
27% alcohol	5	19	24		15	9	24		18	6	24	
Total	37	59	96		42	54	96		51	45	96	

^a observed $\chi^2 = 4.64$ with 3 degrees of freedom at $p = .10$; observed $\chi^2 = 6.25$ with 3 degrees of freedom at $p = .05$; observed $\chi^2 = 7.82$ with 3 degrees of freedom at $p = .025$; observed $\chi^2 = 4.64$ with 3 degrees of freedom at $p = .005$.

^b $p < .005$.

^c $p < .10$.

^d $p < .025$.

Table12–Sensory perception of sweet and sour tastant intensity after treatment combinations of 4 oral rinses and 3 waiting periods ^a

	Wait periods (min)					
Oral rinses	15		30		60	
<u>Sweet tastant ^b</u>						
Water	38.49	± 6.00	37.38	± 6.34	43.95	± 5.11
9% alcohol	44.34	± 5.73	41.19	± 5.47	38.35	± 5.71
18% alcohol	40.17	± 5.27	36.44	± 5.23	44.45	± 6.00
27% alcohol	42.27	± 6.46	51.02	± 7.73	48.46	± 5.99
<u>Sour tastant ^c</u>						
Water	46.64	± 5.97	43.44	± 8.81	40.54	± 9.24
9% alcohol	39.14	± 10.03	62.87	± 8.40	44.03	± 7.82
18% alcohol	52.05	± 10.86	50.80	± 7.14	52.31	± 8.02
27% alcohol	43.44	± 7.94	71.14	± 10.02	54.62	± 8.99

^a LSmeans ± std err of the values for perceived sweetness or sourness; none=0, highly intense =150.

^b LSmeans of 255 values associated with correct tastant identification.

^c LSmeans of 178 values associated with correct tastant identification.

the first and second samples differed for the sour tastant only ($p=0.0001$). The second sample, one level above the panelist's recognition threshold, was perceived to be more intense than the first sample with means of 42.4 and 66.4, respectively. This trend was not seen for the sweet tastant ($p=0.5778$). The sweet tastant samples at recognition thresholds were perceived to have the same intensity as the sample one level above recognition thresholds with means of 46.6 and 48.3, respectively.

Alcohol is reported to have a sweet taste. As the alcohol level increases the sweet taste that is perceived also increases to a point at which a burn sensation is perceived (Wilson et al., 1973). Adaptation to the sweetness in the oral rinse with alcohol might explain why there was no difference in the perceived sweetness of the two sucrose samples. Taste adaptation is due to a decline of sensitivity or subjective intensity of a taste stimulus. The adaptation occurring here would be cross-adaptation because the inducing stimulus is a different substance than the test stimulus (Ganzevles and Kroeze, 1987).

Differences among judges were shown to be significant ($p=0.001$) for the intensity scores. Variability among panelists reflects differences in how the scale was used ($p=0.0001$) for both the sweet and sour tastant. Considering the use of the scale of the 20 panelists who identified both tastants correctly for the sweet tastant, 7 panelists had a 0-50 point spread in intensity, 10 a 0-100 point spread and 3 a 0-150 point spread. Of the 23 panelists who identified both tastants correctly for the sour tastant, 8 had a 0-50 point spread, 9 had a 0-100 point spread and 6 had a 0-150 point spread in intensity perception. This demonstrates how each panelist used the scale differently.

Intensity scores were converted to ordinal data and analyzed as directionally paired comparison tests. Analysis of the sweet tastant data found no significant difference ($p>0.05$) in perceived sweetness between the two samples. Sixty-six of 126 intensity values were higher for the second sample than were for the first sample. This can possibly be explained by the alcohol effect. Alcohol is reported to have a sweet taste and this sweet taste increases as the percentage alcohol increases (Wilson et al., 1973). Alcohol could intensify the sweetness of the first sample at the same time the first sample can rinse out the residual alcohol in the oral cavity and cause the second sample to seem less sweet or as sweet as the first sample.

Analysis of the converted ordinal data for the sour tastant indicated a significant difference in perceived sourness between the two samples ($p=0.001$). One-hundred and eighty-six of 238 second samples were assigned higher intensity values than were the first sample. The combination of menthol and alcohol can be playing a role here. Both menthol and alcohol can desensitize the tongue, menthol for at least 10 min and alcohol has yet to be determined. The first sample could have rinsed the menthol and alcohol residue from the oral cavity resulting in a perception of higher intensity for the second sample.

CHAPTER 5

CONCLUSION

Although menthol and alcohol are common ingredients in over-the-counter oral rinse, their sensory properties alone and in combination have not been studied extensively. It has been reported that menthol influences the activity of the gustatory and temperature receptors. Studies have been found that menthol can leave the taste receptors in a state of insensitivity in which the receptors are unable to respond to tasting stimuli for at least 10 min (Lundy and Contreras, 1993). Ethanol has been reported to induce two sensations. It is perceived as having a sweet taste at concentrations between 4 and 21% and a burning taste above this point at which the duration of these sensations in the oral cavity has not been thoroughly researched (Wilson et al., 1973; Bolanowski et al., 1995). Bolanowski and coworkers found that pain ratings in the oral cavity increase with increasing amounts of ethanol concentrations in both over-the-counter products and in water/ethanol oral rinses. Research has shown that ethanol plays a role in the oral rinse but that other ingredients present in oral rinses also contribute. None of these studies look at the effect oral rinses have on taste perception. The emphasis has been on oral pain.

In the present study, the roles of oral rinses, with various concentrations of alcohol and the other active ingredients, and length of wait periods was examined. Results indicate that the alcohol level of an oral rinse and the length of wait period can play a role in a panelists' ability to identify a sweet or sour tastant. These effects also play a role in determining the perceived intensity of a sample. As the concentration of the ingredients increased in the oral rinse used the panelists' ability to identify the samples correctly

decreased for both the sweet and sour tastants. The length of wait period had an effect on the ability of panelists' to identify the correct sample for the sour tastant.

Trends in the data indicate that the oral rinses can influence a panelists' taste perception. As seen with the sweet tastant no significant differences were found in intensity values for the first (threshold) and second (above threshold) samples. This effect can possibly be caused by the alcohol in the oral rinse used. As reported in the literature, alcohol can have a sweet taste, therefore intensifying the sweet taste of the first sample (Wilson et al., 1973). The rinsing effect that would happen with tasting of the first sample can cause the second sample to be less sweet or just as sweet as the first.

Because both alcohol and menthol can leave sour and bitter residuals in the oral cavity (Green, 1988; Bolanowski et al., 1995) the perception of sour can be influenced. It has been reported (O'Mahony et al., 1979) that some panelists confuse the taste of bitter and sour. The number of correct identifications for all types of oral rinses in combination with length of wait periods was 289 out of 576 for the sour tastant. The sour tastant was identified as bitter 129 times out 576 samples.

In conclusion, results from this experiment provides evidence that directions to panelists should be changed to include instructions not to use mouth care products before participation in a sensory panel. Future research should investigate further the role of oral rinse effect on tasting perception. This study has presented evidence that tasting perception can be influenced by oral rinse used. Further research should include over-the-counter oral rinses that contain other ingredients that can influence taste perception.

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APPENDICES

Appendix A

Basic Taste Test Procedure

Table A1-Concentrations of solutions used
in recognition threshold test

Sucrose	Citric Acid
Concentrations (g/100 mL)	
0.05	0.005
0.10	0.010
0.20	0.013
0.30	0.015
0.40	0.018
0.50	0.020
0.60	0.025
0.80	0.030
1.00	0.035
1.20	0.040
	0.045
	0.050
	0.055

(Jellinek, 1985)

Appendix B

Score card for basic taste identification

SCORE CARD-THRESHOLD TEST

Judge number _____

Two of the three samples in each series (numbered 1-9) are identical, the third is different. Taste each sample in each series of 3 (A,B,C). DO NOT SWALLOW THE SOLUTION. (Expectorate into the Styrofoam cup). RINSE YOUR MOUTH BETWEEN SAMPLES. (Expectorate the rinse into the Styrofoam cup). Wait 20 seconds between series (Use a stopwatch or watch with a second hand to time.)

INDICATE YOUR RESPONSE BY CIRCLING THE APPROPRIATE LETTER OF THE ODD (different from the other two) SAMPLE IN EACH SERIES. Please indicate an odd sample for each series. Write the basic taste (sweet, sour, salty, or bitter) that you detect in the series. If you can not identify the basic taste write don't know.

Basic taste

1A	1B	1C	_____
2A	2B	2C	_____
3A	3B	3C	_____
4A	4B	4C	_____
5A	5B	5C	_____
6A	6B	6C	_____
7A	7B	7C	_____
8A	8B	8C	_____
9A	9B	9C	_____

THANK YOU FOR PARTICIPATING IN OUR SENSORY TEST!

Score card for sample identification and intensity scale

Judge _____

Taste first sample and identify the basic taste (sweet, salty, sour or bitter). Fill in the blanks with the basic taste you identified. After tasting the sample indicate the intensity on the scale below. Place a mark across the line (____/____) indicating the degree to which you think the basic taste is present in the sample. If it tastes like water record W. If you think it tastes different from water but cannot identify the taste record DK (don't know). Please repeat this for next sample. **DO NOT RINSE BETWEEN SAMPLES.**

Sample 1 _____

Basic taste _____
Not at all intense

Extremely intense

Sample 2 _____

Basic taste _____
Not at all intense

Extremely intense

At what time did you last,

eat _____

drink _____

smoke _____

THANK YOU FOR PARTICIPATING IN OUR PANEL

VITA

Christina (Tina) Ann Jolleen Perry was born on May 5, 1970 , in Great Lakes IL. Tina lived in Long Beach, CA, San Diego, CA, Great Lakes, IL, and Summerville, SC, during her father's naval career. She attended the high school in Summerville, SC. Tina graduated from Summerville High School in 1988. After attending East Tennessee State University and University of Tennessee, Tina graduated from The University of Tennessee with Bachelor of Science degrees in Kinesiology in 1995 and Food Science in 1996. Tina entered the masters program in Food Science at The University of Tennessee in 1996, graduating in May 1999 with a Master of Science in Food Science.

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