DETERMINATION OF VARIOUS PALATE CLEANSER EFFICACIES FOR REPRESENTATIVE FOOD TYPES

THESIS

Presented in Partial Fulfillment of the Requirements for the degree of Master of Science

in the Graduate School of The Ohio State University

By

Candice Lynn Lucak, B.S.

*****

The Ohio State University
2008

Master's Examination Committee:

Professor Mike Mangino, Advisor

Professor Sheryl Barringer

Professor Jeannine Delwiche

Approved by

_____
Advisor
Graduate Program in Food Science and Technology

ABSTRACT

Palate cleansers are used to remove residuals and prevent adaptation that may otherwise alter intensity ratings. Research examining relative efficacies of various palate cleansers on different food categories has been limited; it is unknown if any palate cleansers are more effective than rinsing with water. Seven basic food types were identified and a representative foods was selected for each, as follows: astringent - tea, fatty – smoked sausage, hot/spicy – hot tortilla chip, cooling - mint, bitter - coffee, sweet – jelly beans, and non-lingering - applesauce. Similarly, a variety of documented palate cleansers were identified, specifically table water crackers, spring water, pectin solution, whole milk, chocolate, and warm water. Every food – palate cleanser combination was assessed by 24 panelists over 12 sessions, 2 sessions for each of the 6 palate cleansers. Only table water crackers were effective at preventing significant differences across replications for all seven food types.

Dedicated to my family

ACKNOWLEDGMENTS

I wish to thank my advisor, Dr. Jeannine Delwiche for her support, encouragement, guidance, advice, and patience in correcting my thesis. I would also like to thank the other members of my thesis committee, Dr. Mangino and Dr. Barringer for their assistance and insight in creating this thesis. Furthermore, I would like to thank my lab mates, past and present, for providing a fun working environment and help on all things. Without their knowledge, assistance in preparation and data collection this research would not have been possible.

My family gave me great support without which I could not have had the education I have received. I would also like to thank my friends for being there for me and helping me through graduate school.

VITA

December 30, 1983…… Born – Hoffman Estates, Illinois

2006…… B.S. Food Science
University of Illinois Urbana-Champaign

2006 – Present...…… Graduate Research Assistant
The Ohio State University

FIELD OF STUDY

Major Field: Food Science and Nutrition

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

When conducting sensory evaluation assessments, it is both typical and desirable to evaluate more than one product in a session. When a panelist tastes and experiences the first of these products, she/he immediately begins to adapt to it. Even after swallowing or expectorating the sample, residuals of the sample remain in the mouth and adaptation to these residuals continues. In fact, before even the first product is sampled, the panelist is adapted to, and continues to adapt to, not only the residuals in the mouth from prior ingestion, but also the panelist's saliva itself ((Delwiche and O'Mahony, 1996). Thus, it is highly desirable to utilize a procedure that allows the panelist to stabilize at some baseline level of adaptation before making her/his first assessment, and then return to this same level before assessing each additional product. The use of palate cleansers is intended to do precisely that – establish and maintain a consistent baseline.

If residuals from prior samples are left in the mouth, they can via adaptation alter perceived taste intensity. As taste receptor cells signal the brain in the presence of a constant stimulus, the message becomes attenuated; this attenuation can be conceptualized as altering the taste "zero," similar to adjusting the tare on a balance (O'Mahony, 1974). To the taster, this process is perceived as a gradual reduction in the taste intensity, and for moderate intensity stimuli the taste actually vanishes (O'Mahony, 1974). Thus, it is essential to standardize the interstimulus interval (ISI) procedure. The

ideal palate cleanser or ISI procedure would minimize residuals and bring a subject's oral environments back to a baseline, allowing for accurate intensity ratings.

O'Mahony (1972a) examined the impact of several simple ISI protocols on the residuals left in the mouth by a solution. He began by collecting unstimulated saliva from nine subjects. Then he had the subjects rinse for 15 seconds with 15 ml of an equimolar mixture of 1 M sodium chloride and lithium chloride. After the 15 seconds, the subjects expectorated and continued doing so at 15 second intervals for 30 minutes. Both the unstimulated saliva before the rinse and the expectorations made at 2 minute intervals after the rinse were diluted and analyzed for sodium and lithium by flame photometry. He found that although repeated rapid expectoration was sufficient to clear the mouth of exogenous salt after an average of 15 minutes, on some occasions sodium levels had not returned to pre-experimental values after 30 minutes. The shortest time interval in which exogenous salt was removed was 10 minutes, far exceeding the typically sensory evaluation ISI (which rarely exceed 15 seconds if it is utilized at all). And while in subsequent conditions he found that five rinses with water did return the sodium concentration to the starting level, this amount of rinsing also exceeds the number of rinses typically employed in sensory evaluation. Furthermore, he found the clearance of residuals in each individual was different and it took each individual a different amount to return to their initial sodium levels.

The perceptual impact of residuals has been measured in several previous investigations using a variety of psychophysical measurements, including thresholds, intensity ratings, and magnitude estimation. Following a protocol similar to O'Mahony (1972a). O'Mahony (1972b) examined the impact of several simple ISI protocols on

threshold assessments. He presented 5 subjects with 10ml samples of sodium chloride solutions at concentrations of 10, 50, 100, 150, 200, 400, 600, 800, and 1000 mM in ten successive ascending series. Subjects indicated whether each sample was above the detection threshold. Thresholds were determined using three different interstimulus procedures: a 15 second rest, a 2 minute rest, and a 15 second rinse with one ~ 50 ml rinse of tap water followed by expectoration. He found that rinsing resulted in lower thresholds than did either a 2 minute rest or a 15 second rest.

O'Mahony and Godman (1974), measured sensitivity drift by determining detection thresholds for sodium chloride using an ascending series of 1, 5, 10, 15, 20, 40, 60, and 80 mM sodium chloride. Panelists sipped and spit sodium chloride solutions and followed a condition-dependent ISI protocol. When the ISI protocol consisted of two water rinses sipped and spit followed by a one minute rest, sensitivity drift was reduced. In contrast, when no rinses were allowed during the ISI, detection thresholds of sodium chloride showed irregular drift. Furthermore, the subject showed less adaptation as evidenced by lower mean detection thresholds when the ISI protocol included rinsing than when it did not.

O'Mahony and Wingate (1974) had five subjects assess the taste intensity of sodium chloride solutions using magnitude estimation under two conditions, one with no rinses and the other with a single rinse during the ISI. When log intensity was plotted against log concentration, the single-rinse condition yielded slightly lower exponents than did the no-rinse condition, indicating that smaller changes in sodium chloride concentration resulted in larger changes in perceived taste intensity when rinsing was allowed.

Halpern et al. (1986) investigated the degree of stimulus removal on judged taste intensity using controlled conditions that simulated different ISI procedures. Panelists assessed total taste intensity of a sodium chloride solution delivered using a flow machine (a specialized device that flows liquid across the surface of the extended tongue at a constant rate, eliminate the impact of saliva and residuals) using magnitude estimation (with a modulus = 10). The flow machine allowed continuous streams of liquid to be delivered for precise amounts of time. The device also allowed the experimenter to vary the content of the liquid without altering the flow rate. For all conditions, the stimulus began with delivery of the sodium chloride solution, and this liquid was delivered for one to two seconds, depending upon the condition. Subsequent to this initial signal, the flow was halted, or followed by water, artificial salvia, or the same sodium chloride solution. Intensity assessments were made 12.5, 24.5, 36.5, 48.5, 60.5, and 72.5 seconds after onset of the liquid delivery. Their results demonstrated that extreme conditions, which either promote maximum stimulus removal or permit no removal, produced judgments of enhanced intensity in the former and markedly decreased intensity in the latter.

Despite the tremendous impact the ISI procedure can have on sensory assessments, there is no universal standard for what this procedure should be. While a given investigator or investigative team may routinely follow a particular ISI procedure, there is no alignment across such teams. Some authors argue rinsing only introduces another stimulus and salvia is the best medium for cleansing a palate (Dahlberg and Penczek, 1941, Meiselman and Dzendolet, 1967). In contrast, others argue that rinsing with lukewarm water is necessary to ensure stability in assessments (Crocker, 1945, Lorant and Lorant, 1948, Moncrieff, 1947, Platt, 1931). However, those in this latter

group disagree on the specifics, with some advocating a strict rinsing regime with a standardized number of rinses (Bruvold and Gaffey, 1965), while others leave the number of rinses taken to the subjects' discretion (Gregson, 1966). Since leaving the ISI procedure in the hands of the subject will introduce many uncontrolled variables, this latter option seems ill-advised. In the study mentioned previously, O'Mahony (1972a) also had subjects rinse with tap water until the individual felt she/he had cleared the residuals from the mouth. At this point, a saliva sample was collected from the subject and analyzed with photometry. Results indicated that individuals were not at all accurate at judging when residuals had been cleared from the oral cavity.

Still other investigators employ the use of certain palate cleansers, often selecting specific palate cleansers for particular types of food. A plethora of such palate cleansers exist, making consideration of each a daunting task. While foods may be classified and grouped in many ways, for the consideration of palate cleansers foods can be divided into seven categories, as follows: sweet, bitter, fatty, astringent, hot/spicy, cooling, and non-lingering. Commonly used palate cleansers for each of these food categories is discussed below.

Sweet Foods and Stimuli

As shown in Table 1.1, the most commonly used palate cleansers for sweet foods are relatively bland crackers and water (Ball, et al., 1998, Duizer, et al., 1995, Kilcast and Clegg, 2002, Kremer, et al., 2007, Lavin and Lawless, 1998, Schiffman, et al., 2007, Warnock and Delwiche, 2006, Zhao and Tepper, 2007). When assessing juices, Ball et al. (1998) had subjects chew plain water cracker biscuits and rinse with water between samples. Similarly, Lavin and Lawless (1998) had subjects use water crackers and spring

water during the ISI when testing fruit beverages. Kremer et al. (2007) had subjects chew plain crackers and rinse with mineral water during the ISI when assessing waffles. For the assessment of soft drinks Zhao and Tepper (2007) had subjects follow one of the most rigid protocols, having them chew unsalted crackers and rinse with water during a 3 minute ISI.

Warnock and Delwiche (2006) had subjects rinse with water three times during the 15 second ISI when assessing sweetener solutions. When Duizer et al. (1995) assessed sweetener solutions, they had subjects chew unsalted crackers and rinse with water during a 5 minute ISI. Schiffman et al. (2007) had subjects use unsalted crackers and water during the ISI when assessing sweetener solutions. When assessing sweeteners, Kilcast and Clegg (2002) had subjects chew crackers and rinse with mineral water.

No research has been conducted to explicitly determine the best palate cleanser or ISI procedure for sweet foods. The above studies are only a sample of the full body of literature, but clearly indicate that for the assessment of predominantly sweet foods, the most common palate cleanser is water, sometimes combined with unsalted crackers.

	Food	Palate Cleansers and ISI	Publication
Sweet	Waffles	Plain crackers, mineral water	Kremer et al., 2007
	Soft drinks	Unsalted crackers, time	Zhao & Tepper, 2007
	Juice	Water crackers	Ball et al., 1998
	Fruit Beverages	Water crackers, spring water	Lavin & Lawless, 1998
	Sweetener Solutions	Unsalted crackers	Schiffman et al., 2007
	Sweeteners	Unsalted crackers, 5 minutes	Duizer et al., 1995
	Sweetener Solutions	3 rinses with water, 15 sec	Warnock & Delwiche, 2006
	Sweetener Solutions	Crackers, mineral water	Kilcast & Clegg, 2002

Table 1.1: Palate Cleansers Utilized in Previous Studies Involving Sweet Foods

Bitter Foods and Stimuli

Two recent investigations have examined the efficacy of a variety of palate cleansers on bitter foods, the stimuli and palate cleansers utilized are summarized in Table 1.2. During the assessment of twelve caffeine solutions at concentrations of 0.3 and 0.6 g/L, Brannan et al. (2001) had 24 subjects rinse with use 0.3% xanthan gum, 0.3% xanthan gum with 5% corn oil, 0.55% CMC, 0.55% CMC (carboxymethyl cellulose) with 5% corn oil, and 0.55% CMC with 10% corn oil. They found that 0.55% CMC was effective at reducing residuals, as indicated by the consistent bitterness ratings of the test stimuli.

Johnson and Vickers (2004) had 20 subjects assess five cream chesses that differed in the amount of added caffeine (0, 0.03, 0.05, 0.07, and 0.09%) while using

seven different palate cleansers. The palate cleansers examined were filtered water, sparkling water, baby cut carrots, unsalted top saltine crackers, unadulterated cream cheese, six water rinses, and a control where nothing was used. All palate cleansers, rinses, and stimuli were expectorated. The panelists were instructed to utilize the assigned palate cleanser prior to evaluating each sample. To mimic how these palate cleansers are most often used, panelists were allowed to rinse with water after using carrots, crackers, and cream cheese. The palate cleansing strategies did not differ from one another in their effectiveness for enhancing discrimination among samples (no significant interaction was found between palate cleanser and caffeine concentration) nor for minimizing adaptation or build-up (no significant taste position and palate cleanser effect). However, they did find that sparkling water diminished bitterness more so than did all other ISI procedures.

	Food	Palate Cleansers and ISI	Publication
Bitter	Caffeine in Cream Cheese	Water	Johnson & Vickers, 2004
	Caffeine in Cream Cheese	Sparkling water	Johnson & Vickers, 2004
	Caffeine in Cream Cheese	Carrots	Johnson & Vickers, 2004
	Caffeine in Cream Cheese	Crackers	Johnson & Vickers, 2004
	Caffeine in Cream Cheese	Cream cheese	Johnson & Vickers, 2004
	Caffeine in Cream Cheese	Rinsing six times	Johnson & Vickers, 2004
	Caffeine in Cream Cheese	None	Johnson & Vickers, 2004
	Caffeine Solution	Water	Brannan et al., 2001
	Caffeine Solution	0.3% xanthan gum	Brannan et al., 2001
	Caffeine Solution	0.3% xanthan gum with 5% corn oil	Brannan et al., 2001
	Caffeine Solution	0.55% CMC	Brannan et al., 2001
	Caffeine Solution	0.55% CMC with 5% corn oil	Brannan et al., 2001
	Caffeine Solution	0.55% CMC with 10% corn oil	Brannan et al, 2001

Table 1.2: Palate Cleansers Utilized in Previous Studies Involving Bitter Foods

Fatty Foods

There are a larger number of fatty foods for which a variety of palate cleansers have been documented (for a summary of the stimuli and palate cleansers, see Table 1.3). For the assessment of milk, both Chapman et al. (2006) and Wolf et al. (2007) had subjects rinse with spring water during the ISI while Richardson-Harman et al. (2000) had subjects chew water crackers and rinse with soda water. Investigators varied more in the ISI protocol for ice cream assessments with the subjects of Ishii et al. (2007b) using a

warm water rinse followed by a cold water rinse. Stampanoni Koeferli et al. (1996) had subjects rinsing with water, and Lethuaut et al. (2005) using bread and mineral water during a 15 second ISI. Several studies have evaluated the sensory properties of cheeses and the palate cleansers used by each investigative team varied. Lawless et al. (1995) used unsalted crackers and lemon water, Rétiveau et al. (2005) utilized unsalted crackers, apple slices, and carbon-filtered water, Adhikani et al. (2003) used unsalted crackers and carbonated water, and Olarte et al. (2001) used bland crackers and rinse with water.

When assessing yogurts, Saint-Eve et al. (2004) had subjects use plain crackers and mineral water and Ward et al. (1999) had subjects use tap water. For pudding evaluations, Ishii et al. (2007a) had subjects rinse with water ad-lib; Kilcast and Clegg (2002) used carrot sticks and sparkling mineral water as palate cleansers during the evaluation of chocolate mousse. For the assessment of chocolate, Janestad et al. (2000) used neutral wafers and carbonated water.

Azana et al. (2004) had subjects rinse with water during the evaluation of meat. Butler et al. (1996) had subjects chew unsalted crackers then rinse with warm water when assessing roasts. When rating sausages, Rason et al. (2007) used Melba toast and neutral water as palate cleansers, while Helgesen et al. (1998) followed a similar protocol, using neutral biscuits and water.

	Food	Palate Cleansers and ISI	Publication
Fatty	Milk	Spring water	Chapman et al., 2006
	Milk	Water	Wolf et al., 2007
	Ice Cream	Cold tap water, 2 rinses w/ warm, then cold tap water	Ishii et al., 2007
	Ice Cream	Water	Stampanoni Koeferli et al., 1996
	Ice Cream	Mineral water, bread, 15 seconds	Lethuaut et al., 2005
	Yogurt	Plain crackers	Saint-Eve et al., 2004
	Yogurt	Water	Ward et al., 1999
	Chocolate	Neutral wafers and carbonated water	Janestad et al., 2000
	Chocolate Mousse	Carrot sticks and sparking mineral water	Kilcast & Clegg, 2002
	Cheese	Unsalted crackers and lemon water	Lawless et al., 1995
	Cheese	Unsalted crackers, apple slices, carbon-filtered water	Rétiveau et al., 2005
	Cheese	Water	Olarte et al., 2001
	Cheese	Unsalted crackers and carbonated water	Adhikani et al., 2003
	Milk	Soda water and water crackers	Richardson-Harman et al., 2006
	Pudding	Water	Ishii et al., 2007
	Meat	Water	Azana et al., 2004
	Roasts	Unsalted crackers	Butler et al., 1996
	Sausage	Neutral biscuits	Helgesen et al., 1998
	Sausage	Melba toast	Rason et al., 2007

Table 1.3: Palate Cleansers Utilized in Previous Studies Involving Fatty Foods

As was the case with sweet foods, no explicit research has been conducted to determine the best palate cleanser or ISI protocol for fatty foods. The above studies represent only a sample of the full body of literature in which the sensory properties of fatty foods were assessed. Similar to sweet foods, for the assessment of fatty foods the most common palate cleanser was water, often combined with unsalted crackers. However, the use of warm water was unique to fatty foods and sparkling water was used far more frequently with fatty foods than with the other food categories.

Astringent Foods and Stimuli

Wine and alum solution are the major food/beverages tested in this category (see Table 1.4 below). When assessing wine, Nurgel and Pickering (2006) had subjects rinse with water during the ISI, Findlay et al. (2007) had subjects rinse with 5g/L pectin solution, unsalted crackers and water, and Pickering et al. (2004) simply enforced a 2-4 minute ISI. Francois et al. (2006) had subjects rinse with unsalted rusk (a neutral biscuit) and spring mineral water during the ISI when assessing beer, and similarly, King and Duineveld (1999) had subjects use crackers and water during ISI. For the assessment of tannic acid, Monteleone et al. (2004) had subjects use plain crackers and water during ISI.

Ross et al. (2007) conducted an investigation comparing the efficacy of several palate cleansers at reducing perceived astringency from red wine. Deionized water, a 1 g/L pectin solution, a 1 g/L CBMC (carboxymethlycellulose) solution, and unsalted crackers were compare by 18 panelists. To give their assessments of the wines, panelists followed a strict procedure, as follows: prerinse, palate cleanser, red wine samples 1-3, palate cleanser, and red wine samples 4-6. All red wine samples were the same and

panelists rated the perceived astringency of each. Panelists rated all palate cleansers in a randomized order, which two palate cleansers in each session. The observations showed that with successive samples, astringency ratings increased significantly with all four palate cleansers across all panelists. Overall, the unsalted cracker was found to be the most effective at reducing astringency build up while water was the least effective. Similarly, Colonna et al. (2004) found that pectin reduced astringency more effectively than water, cracker, polycose, PVP (polyvinylpyrrolidone), gelatin or ovalbumin, and CBMC. They also found unsalted crackers were more effective at reducing astringency than was water, but that the pectin rinse was more effective than crackers.

Brannan et al. (2001) used 20 panelists to test the effectiveness of gum-based rinses (with or without oil) at alleviating astringency build-up for 1 g/L alum solution. The six palate cleansers examined were deionized water, 0.3% xanthan gum, 0.3% xanthan gum with 5% corn oil, 0.55% CMC (carboxymethyl cellulose), 0.55% CMC with 5% corn oil, and 0.55% CMC with 10% corn oil. Results indicated the change in astringency intensity before and after use of a palate cleanser was largest for deionized water and smallest for 0.55% CMC. In fact, 0.55% CMC eliminated almost all astringency build-up.

The findings of Colonna et al. (2004) and Brannan et al. (2001) suggest that pectin and CMC solutions are the most effective palate cleansers for controlling astringency build-up.

	Food	Palate Cleansers and ISI	Publication
Astringent	Wine	Pectin, water, PVP, gelatin, ovalbumin	Colonna et al, 2004
	Wine	Water	Nurgel & Pickering, 2006
	Wine	Unsalted crackers, 5g/L pectin	Findlay et al., 2007
	Wine	Time (2-4 min)	Pickering et al., 2004
	Beer	Unsalted rusk and spring mineral water	Francois et al., 2006
	Beer	Crackers	King & Duineveld, 1999
	Tannic Acid	Plain crackers, water	Monteleone et al., 2004
	Alum Solution	Water	Brannan et al., 2001
	Alum Solution	0.3% xanthan gum	Brannan et al., 2001
	Alum Solution	0.3% xanthan gum with 5% corn oil	Brannan et al., 2001
	Alum Solution	0.55% CMC	Brannan et al., 2001
	Alum Solution	0.55% CMC with 5% corn oil	Brannan et al., 2001
	Alum Solution	0.55% CMC with 10% corn oil	Brannan et al., 2001
	Wine	Deionized water	Ross et al., 2007
	Wine	1 g/L pectin solution	Ross et al., 2007
	Wine	1 g/L CBMC solution	Ross et al., 2007
	Wine	Unsalted crackers	Ross et al., 2007

Table 1.4: Palate Cleansers Utilized in Previous Studies Involving Astringent Foods

Hot/Spicy Foods and Stimuli

The most commonly assessed hot/spicy foods and stimuli were Tabasco, salsa, and capsaicin solutions (for a summary, see Table 1.5). When salsa with capsaicin was assessed, Dowell et al. (2005) had subjects chew unsalted crackers and rinse with water

during the ISI, while Allison et al. (1999b) had subjects wait 7 minutes, eat tortilla chips, chew unsalted-tops saltine crackers, and rinse with water. For the assessment of cheese sauce with capsaicin, Carden et al. (1999) had subjects chew unsalted cracker tops and rinse with water. Green et al. (2004) had subjects wait 30 seconds then rinse with water during ISI when assessing capsaicin and piperine.

Allison et al. (1999a) had five subjects rate the intensity of heat for salsa containing 7.3 ppm capsaicin. In addition, they varied whether or not subjects used crackers and water, as well as the length of the ISI (30 seconds, 1, 2, 4, 8, 16 minutes). Results indicated rinsing significantly increased repeatability and increased the rate of heat decay. In addition, an ISI of 2.5 to 5 minutes induced desensitization.

Stevens and Lawless (1986) found that citric acid and sucrose solutions were better at reducing the burn of capsaicin solution than were either a salt solution or plain water. Nasrawi and Pangborn (1989) found that sucrose solution reduced the burn of a capsaicin solution, whereas solutions of citric acid, sodium chloride, and xanthan gum did not.

Allison and Work (2004) recommend using beer, milk, sour cream, chocolate, or sugar water during the ISI when assessing spicy foods. Other recommendations for palate cleansers can be found on Sensory Nexus (www.sensory.org), an internet discussion forum devoted exclusively to sensory science and its applications with over 1300 members. It was on the Sensory Nexus that Noble (2007) suggested good palate cleansers for assessments of capsaicin-containing foods were 10% sucrose solution, whole milk, 5% ethanol, and water.

	Food	Palate Cleansers and ISI	Publication
Hot/Spicy	Salsa w\ Capsaicin	Tortilla chips, 7 mins, unsalted-tops saltine crackers	Allison et al., 1999
	Salsa w\ Capsaicin	Unsalted cracker tops	Dowell et al., 2005
	Salsa w\ Capsaicin	Saltine crackers, time	Allison et al., 1999
	Salsa w\ Capsaicin	Time	Allison et al., 1999
	Capsaicin Solution	Sucrose, citric acid, salt solution, water	Stevens & Lawless, 1986
	Piperine	Water, 30 seconds	Green et al., 2004
	Cheese Sauce w/ Capsaicin	Unsalted cracker tops	Carden et al., 1999
	Spicy Foods	Beer, milk, sour cream, chocolate, sugar water	Allison & Work, 2004
	Capsaicin Solution	Sucrose, citric acid, sodium chloride solutions, xanthan gum	Nasrawi & Pangborn, 1989
	Capsaicin	10% sucrose	Noble, 2007
	Capsaicin	Whole Milk	Noble, 2007
	Capsaicin	5% ethanol	Noble, 2007
	Capsaicin	Water	Noble, 2007

Table 1.5: Palate Cleansers Utilized in Previous Studies Involving Hot/Spicy Foods

Cooling Foods and Stimuli

When assessing cooling foods and stimuli, a wide variety of palate cleansers have been documented (see Table 1.6). When assessing peppermint gum, Ovejero-Lopez et al. (2005) utilized a 5-minute ISI during which time the subjects could use crackers, cucumber, and water, while Duizer et al. (1996) had subjects simply wait for 15 minutes.

For the assessment of menthol solutions, Gwartney and Heymann (1995) had subjects wait 2-minutes while Gwartney and Heymann (1996) had subjects rinse during a 2-minute ISI.

On the Sensory Nexus, several recommendations were made for cooling foods. Green (2002) suggested pineapple/papaya sherbet be used as a palate cleanser for assessment of mint mouthwash. For the assessment of mint toothpaste, Graebe (2001) suggested using carrots, cucumbers, yogurt, or bread as the palate cleanser. When assessing mint gum, Piper (2005) suggested using chocolate. Summers (2005) concurred with Piper (2005), recommending Hershey kisses be utilized as the palate cleanser when assessing menthol-containing foods.

As with sweet and fatty foods, the studies above represent only a sample of the full body of literature in which the sensory properties of cooling foods were assessed. The use of chocolate as a palate cleanser was unique to this food category.

	Food	Palate Cleansers and ISI	Publication
Cooling	Peppermint Gum	Crackers, cucumber, 5 minutes	Ovejero-Lopez et al., 2005
	Peppermint Gum	Time	Duizer et al., 1996
	Mint Gum	Chocolate	Piper, 2005
	Menthol/Mints	Hershey kisses	Summers, 2005
	Mint Mouthwash	Pineapple/papaya sherbet	Green, 2002
	Mint Toothpaste	Carrot, cucumber, yogurt, bread	Graebe, 2001
	Menthol Solutions	2 minutes	Gwartney & Heymann, 1995
	Menthol Solutions	2 minutes, water	Gwartney & Heymann, 1996

Table 1.6: Palate Cleansers Utilized in Previous Studies Involving Cooling Foods

Non-Lingering Foods and Stimuli

A wide variety of foods fall into this category, but despite this there are relative few palate cleansers that are used for these stimuli (see Table 1.7). For the assessment of juice, Carbonell et al. (2007) had subjects rinse with water as did Park et al. (2007) for soup and Nindjin et al. (2007) for yams. For the assessment of bread and English muffins, Mialon et al. (2002) had subjects rinse with chilled spring water while Mehinagi et al. (2003) had subjects rinse with mineral water when assessing apples.

When assessing salmon, Farmer et al. (2000) had subjects use water biscuits and water. Kremer et al. (2007) used plain crackers and mineral water when assessing savory waffles. For the assessment of orange juice, Forde and Delahunty (2004) had subjects chew unsalted crackers and rinse with water. McGowan and Lee (2006) used matzo crackers and warm water when assessing chewing gum. Larsen et al. (2005) used bland

crackers and water when assessing extruded oat. Ferry et al. (2006) had subjects use plain crackers and diluted lime cordial when evaluating starch while Daillant-Spinnler et al. (1996) had subjects chew crackers and rinse with water. For the assessment of cod fillets, Esaiassen et al. (2004) had subjects use crackers and water.

When assessing tomatoes, Bern et al. (2005) had subjects chew white saltless bread then rinse with water. Krishnamurthy et al. (2007) had subjects use white sliced bread with crust removed and water when assessing beef bouillon. When assessing salmon, Green-Petersen et al. (2006) had subjects chew flat bread and rinse with water.

As with sweet, fatty, and cooling foods, these studies above are but a sample of the full body of literature involving the sensory evaluation of non-lingering foods. Similar to sweet foods and fatty foods, the most common palate cleansers was water, often combined with unsalted crackers.

	Food	Palate Cleansers and ISI	Publication
Non-Lingering	Salmon	Flat bread	Green-Petersen et al., 2006
	Salmon	Water biscuits	Farmer, et al. 2000
	Waffles (Savory)	Plain crackers and mineral water	Kremer et al., 2007
	Juice	Water	Carbonell et al., 2007
	Soup	Water	Park et al., 2007
	Yams	Water	Nindjin et al., 2007
	Beef Bouillon	White sliced bread with crust removed	Krishnamurthy et al., 2007
	Cod fillets	Crackers	Esaiassen et al., 2004
	Chewing Gum	Matzo cracker and warm water	McGowan et al., 2006
	Extruded Oat	Bland crackers	Larsen et al., 2005
	Bread, English Muffins	Chilled spring water	Mialon et al., 2002
	Orange juice	Unsalted crackers	Forde & Delahunty, 2004
	Apples	Mineral water	Mehinagi et al., 2003
	Apples	Crackers	Daillant-Spinnler et al., 1996
	Starch	Plain crackers and diluted lime cordial	Ferry et al., 2006
	Tomatoes	White saltless bread	Bern et al., 2005

Table 1.7: Palate Cleansers Utilized in Previous Studies Involving Non-Lingering Foods

The range of items utilized as palate cleansers is broad. Water, crackers, pectin solution, cucumber, sorbet, carrots, chocolate, yogurt, milk, warm water, time, gums, apple slices, rice, butter, and pineapple juice have al been documented as palate cleansers. Despite this, no study has systematically compared the efficacy of different

palate cleansers for members of different food categories, which was the goal of the investigation detailed in this thesis. The approach taken was to select a representative food from each category, a common palate cleanser for each food category, and to examine the stability of intensity ratings over repeated tastings for every food and palate cleanser combination. Specific foods and their associated palate cleansers were selected as follows: jelly beans (sweet) and table water crackers, coffee (bitterness) and water, smoked sausage (fatty) and warm water, tea (astringent) and pectin solution, spicy tortilla chips (hot/spicy) and whole milk, mints (cooling) and chocolate, and applesauce (non-lingering). No specific palate cleanser was paired with the non-lingering food since all typical palate cleansers for such foods were already being utilized. Every food and palate cleanser combination was tested by a set group of subjects in a complete block design.

CHAPTER 2

IMPACT OF SIX PALATE CLEANSERS ON SEVEN FOOD TYPES

This investigation was designed to systematically compare the efficacy of different palate cleansers for members of different food categories. A representative food was selected from each category and a representative palate cleanser was selected for all categories (excluding non-lingering foods). Every food and palate cleanser combination was tested in a complete block design overall multiple sessions, with all subjects ultimately assessing all combinations. Such a design was intended to definitively establish the relative efficacies of each palate cleanser for each food category.

Methods

Materials

A representative food was selected from each category with jelly beans, coffee, smoked sausage, hot/spicy chips, mints, and applesauce representing sweet, bitter, fatty, hot/spicy, cooling, astringent, and non-lingering stimuli respectively. Similarly, a representative palate cleanser was selected for categories except for non-lingering foods, with table water crackers, water, warm water, chocolate, whole milk, and pectin solution representing sweet, bitter, fatty, hot/spicy, cooling, and astringent stimuli respectively. Each palate cleanser was selected such that each is a recommended palate cleanser for one or more of food categories represented by the test stimuli. While every food category

was assessed with each palate cleanser, these selections were made to give each palate cleanser the greatest chance to demonstrate superiority over other palate cleansers when paired with the purportedly appropriate food.

For the sweet food, two jelly beans (Very Cherry Jelly Belly, Fairfield, CA) were served in a one ounce cup (Plastic Soufflés, Solo Cup Company, Baltimore, MS).

The bitter food was represented by coffee (Maxwell House, bold French roast, Tarrytown, NY) and it was prepared according to package directions with 1 tablespoon (~15 ml) of coffee for every 0.75 cup (~177 ml) of water (reverse osmosis water, Millipore, RiOs16, Millipore Corporation, Bedford, MA). Coffee was presented to subjects as 20 ml aliquots in one ounce translucent plastic cups (Plastic Soufflés, Solo Cup Company, Baltimore, MS).

The fatty food category was represented by a smoked sausage (Hillshire Farm, Downers Grove, IL). Sausages were cut in half inch slices that were then halved and placed in one ounce cups (Plastic Soufflés, Solo Cup Company, Baltimore, MS).

For the hot/spicy food, a spicy tortilla chip (Doritos Black Pepper, Plano, TX) was presented in a two ounce translucent plastic cup (Plastic Soufflés, Solo Cup Company, Baltimore, MS).

For the cooling food, 2 mints (Brachs white Dessert Mints, Chattanooga, TN), were placed in one ounce cups (Plastic Soufflés, Solo Cup Company, Baltimore, MS).

The astringent food was represented by tea (Lipton Regular Tea, 100% natural tea, Englewood Cliffs, NJ) made following the package directions at 1 tea bag per 8 ounces (~ 237 ml) of water (reverse osmosis water, Millipore, RiOs16, Millipore

Corporation, Bedford, MA). Tea was presented as 20 ml portions in one ounce translucent plastic cups (Plastic Soufflés, Solo Cup Company, Baltimore, MS).

Applesauce (Motts unsweetened applesauce, Stanford, CT) represented foods with minimal linger. It was presented in one half tablespoon (~7.5 ml) portions in one ounce cups (Plastic Soufflés, Solo Cup Company, Baltimore, MS).

Coffee, tea, and smoked sausage were prepared the day before testing occurred and refrigerated overnight, although all were served at room temperature. In contrast, applesauce was served cold (12.5º – 15.5ºC). The spicy tortilla chips, jelly beans, and mints were all stored and served at room temperature. All samples were labeled with a neutral 3-digit random number.

In previous investigations, plain crackers were often used as palate cleansers for sweet stimuli (Ball, et al., 1998, Duizer, et al., 1995, Kilcast and Clegg, 2002, Kremer, et al., 2007, Schiffman, et al., 2007, Zhao and Tepper, 2007). Accordingly, for the sweet food, plain crackers (Carr's Table Water Crackers, Carlisle, UK) were used as the palate cleanser. Three crackers were presented on a napkin to the panelists.

Ishii et al. (2007b) used warm water to cleanse the palate of panelists while testing ice cream samples. Since the use of warm water was unique to fatty foods and the more frequently used palate cleansers were already included in this investigation, warm water (~ 50ºC) was utilized as the palate cleanser selected for fatty food. Reverse osmosis water (Millipore, RiOs16, Millipore Corporation, Bedford, MA) was heated to 50ºC in a kettle and served in 10 ounce (~296 ml) aliquots in 16 ounce plastic cups (Plastic Drinkware, Gordon Food Service, Columbus-Hilliard, OH).

Both Pickering and Robert (2006) and Findlay et al. (2007) used a pectin solution as a palate cleanser when testing astringent wines, while Colonna et al. (2004) indicated that it was superior than water at reducing astringency build-up. Accordingly, a pectin solution at 5g/L, was used as the palate cleanser for the astringent food. It was presented in 5 ounce (~148 ml) servings in 9 ounce translucent plastic cups (Plastic Drinkware, Gordon Food Service, Columbus-Hilliard, OH). The solution was made from SureJell (100% Natural, Premium Fruit Pectin, Tarrytown, NY) with reverse osmosis water (Millipore, RiOs16, Millipore Corporation, Bedford, MA).

For hot/spicy foods, a commonly suggested palate cleanser is whole milk (e.g., Noble, 2007). Thus, whole milk (Krogers, Cincinnati, OH) was selected for use as the palate cleanser for the hot/spicy food. Cold milk was presented in 10 ounce (~296 ml) servings in 16 ounce cups.

For the assessment of cooling foods, chocolate is often used or suggested for use as the palate cleanser (Gwartney and Heymann, 1995, Piper, 2005, Summers, 2005). For this reason, chocolate (Dove Smooth Milk Chocolate Bar, Hackettstown, NJ) was selected as the palate cleanser for the cooling food. Chocolate was presented as 6 squares on a napkin.

Perhaps the most commonly utilized palate cleanser of all was water, and this seemed to be the most frequently used palate cleanser for both non-lingering and bitter foods. Thus, for these food types, spring water (Ice Mountain Water Co., Hilliard, OH) was used as the specifically selected palate cleanser. Spring water was served in 10 ounce (~296 ml) portions in 16 ounce cups.

Subjects

Volunteer participants were recruited from the Ohio State University. A total of 21 women and 3 men (ages 20-31) participated in the study. They were selected based upon their willingness to participate, availability for all 12 sessions, and an absence of allergies to or dislike of the stimuli and palate cleansers. All were non-smokers. All subjects gave informed consent and agreed to participate in a total of 12 sessions. Subjects were compensated for their time via gift certificates worth $48.

Procedures

All procedures were approved by the OSU Office of Responsible Research Practices. Date collection occurred across 12 sessions in total. The sessions were conducted twice a week for 6 weeks on separate days and each panelist attended all 12 sessions. For each session, the same 24 panelists evaluated each sample, following a complete block design. The seven foods were split up into two groups; these foods and the order in which they were presented were selected so as to minimize the possibility of carry-over effects. The first group consisted of tea, smoked sausage, and mints, presented in that order, while the second group consisted of applesauce, jelly beans, coffee, and spicy tortilla chips in that order. Within a session, only one of the two food groups was tested and only one of the six palate cleansers was used. Ultimately, each food group was assessed while using each of the palate cleansers. The order in which palate cleansers were used was counterbalanced across panelists, with each palate cleanser serving as the starting palate cleanser for four panelists of the 24 panelists. During each week, panelists assessed each food group and used the same palate cleanser in both sessions. The next week, the palate cleanser was changed. In all sessions, evaluations were made under

normal illumination (i.e., red lights were not used). Table 2.1 below shows the counterbalance plan for palate cleansers, food group and panelists.

Panelist	Food Group 1 & 2- Session 1 &2	Food Group 1 & 2- Session 3 & 4	Food Group 1 & 2- Session 5 & 6	Food Group 1 & 2- Session 7 & 8	Food Group 1 & 2- Session 9 & 10	Food Group 1 & 2- Session11 & 12
1	TWC	Pectin	Water	Milk	CHO	WWA
2	Pectin	Water	Milk	CHO	WWA	TWC
3	Water	Milk	CHO	WWA	TWC	Pectin
4	Water	Milk	CHO	WWA	TWC	Pectin
5	Water	Milk	CHO	WWA	TWC	Pectin
6	Milk	CHO	WWA	TWC	Pectin	Water
7	Pectin	Water	Milk	CHO	WWA	TWC
8	Milk	CHO	WWA	TWC	Pectin	Water
9	Pectin	Water	Milk	CHO	WWA	TWC
10	Milk	CHO	WWA	TWC	Pectin	Water
11	TWC	Pectin	Water	Milk	CHO	WWA
12	WWA	TWC	Pectin	Water	Milk	CHO
13	CHO	WWA	TWC	Pectin	Water	Milk
14	WWA	TWC	Pectin	Water	Milk	CHO
15	WWA	TWC	Pectin	Water	Milk	CHO
16	Pectin	Water	Milk	CHO	WWA	TWC
17	CHO	WWA	TWC	Pectin	Water	Milk
18	WWA	TWC	Pectin	Water	Milk	CHO
19	TWC	Pectin	Water	Milk	CHO	WWA
20	TWC	Pectin	Water	Milk	CHO	WWA
21	Water	Milk	CHO	WWA	TWC	Pectin
22	Milk	CHO	WWA	TWC	Pectin	Water
23	CHO	WWA	TWC	Pectin	Water	Milk
24	CHO	WWA	TWC	Pectin	Water	Milk

*CHO-Chocolate

*WWA-Warm Water

Table 2.1: Counterbalance Plan for Palate Cleansers, Food Group, and Panelists

During a session, the panelist followed a strict regime, as detailed below:

- Rinse twice with water

- Taste the first replication of food 1 and rate associated attributes

- Use the palate cleanser

- Rinse twice with water

- Taste the second replication of food 1 and rate the associated attributes

- Use the palate cleanser

- Rinse twice with water

- Taste the third replication of food 1and rate the associated attributes

- Use the palate cleanser

- Rinse twice with water

- Taste the first replication of food 2 and rate associated attributes

- Continue in the same pattern until food 2, food 3, (and food 4 for Group 2) are each assessed in triplicate.

For all foods, overall intensity was rated on a 9-point categorical scale, which ranged from “not at all” to “very” (see Figures 2.1-2.4). In addition, the intensities of specific attributed associated with each food were also rated on the same scale (see Figure 2.1). Once a panelist tasted a sample and rated the attribute, they were not allowed to go back and re-taste it. All scales for a sample were presented one at a time. The figures below show examples of the scales panelists used to rate the foods. Data was collected with Compusense® five version 4.6 (Compusense Inc., Guelph, ON.,Canada).

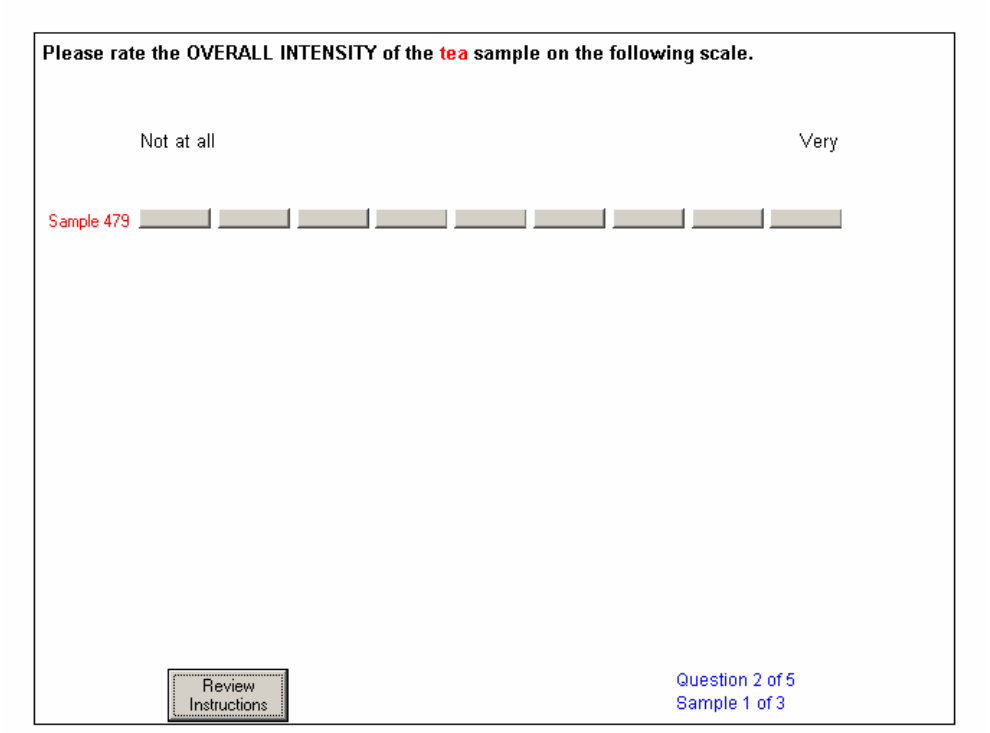

Figure 2.1: Scale Used for the Assessment of Tea Overall Intensity

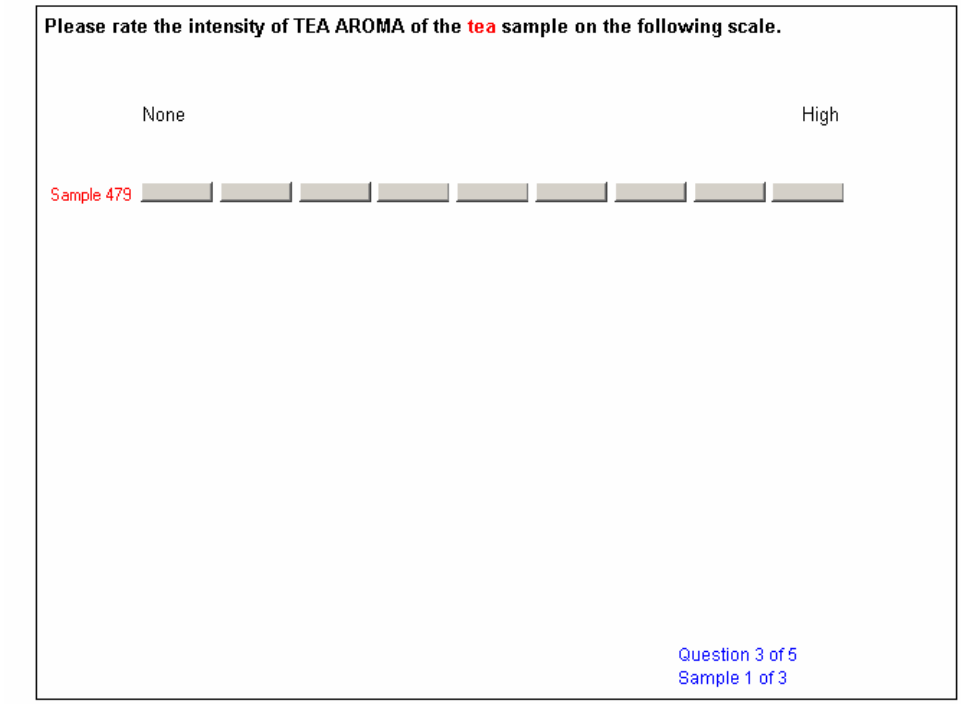

Figure 2.2: Scale Used for the Assessment of Tea Aroma

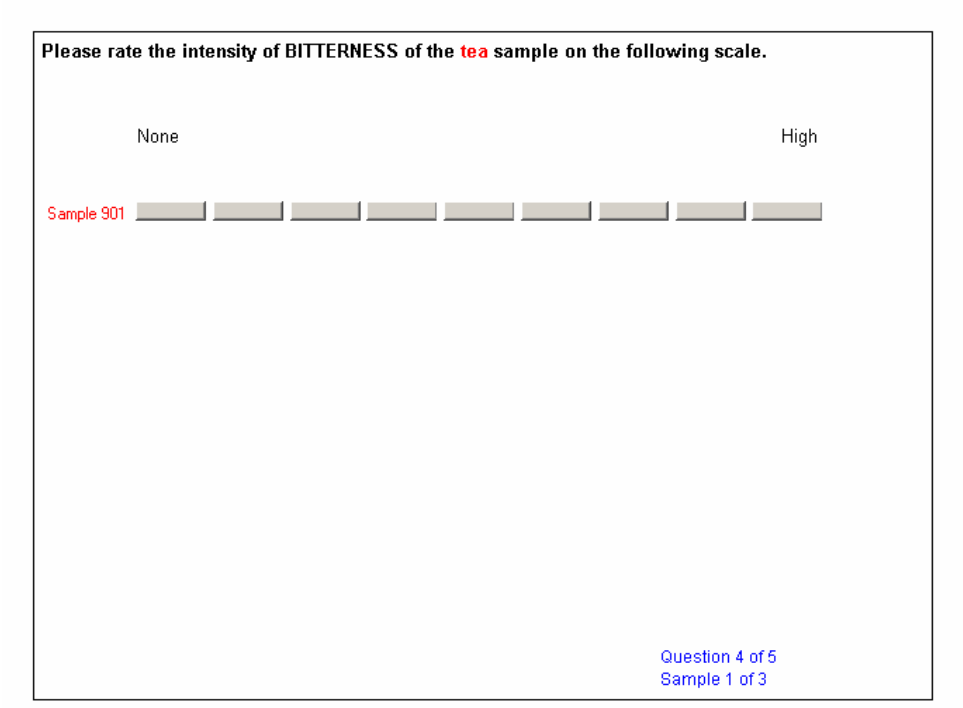

Figure 2.3: Scale Used for the Assessment of Tea Bitterness

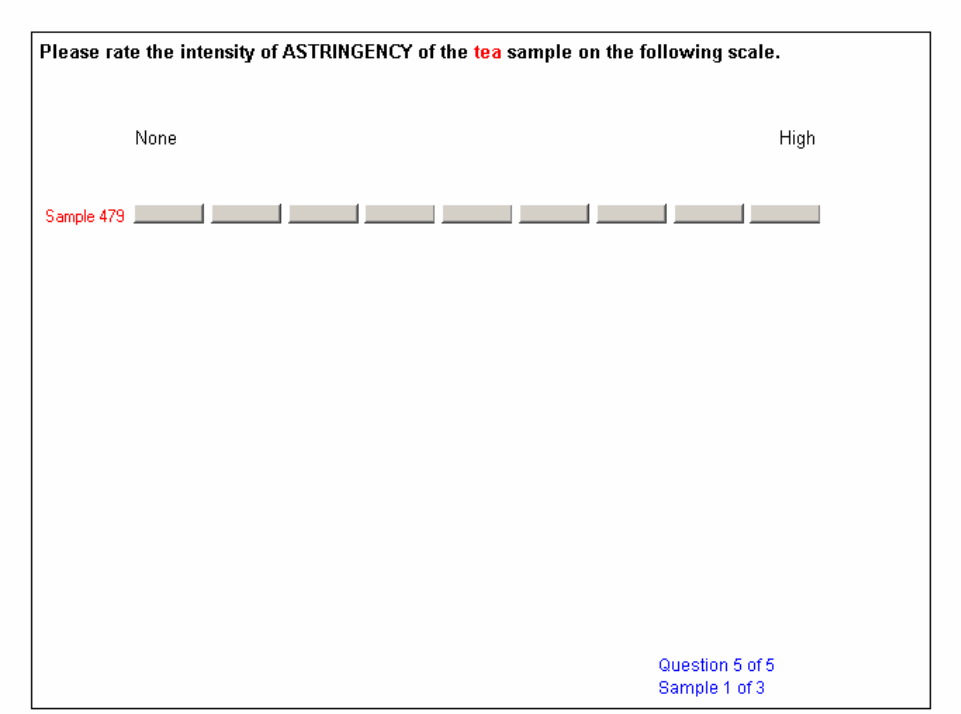

Figure 2.4: Scales Used for the Assessment of Tea Astringency

The specific attributes rated for the jelly beans were cherry aroma and sweetness. For coffee assessments were made of coffee aroma and bitterness. For smoked sausage, smoky flavor and mouth coating were rated. Tea aroma, bitterness, and astringency were rated for tea. The spicy tortilla chips were rated for cheese flavor and heat/burn. For the mints, the attributes rated were mint flavor and cooling, while applesauce was rated for sweetness and sourness.

The palate cleansing procedure varied depending upon the particular palate cleanser. For table water crackers, the panelist took a bite of the cracker then rinsed twice with spring water. For the warm water, the panelists rinsed once with warm water then twice with spring water. For the pectin solution, the panelist rinsed once with the pectin

solution then rinsed twice with spring water. For milk, the panelist took a sip of whole milk then rinsed twice with spring water. For chocolate the panelist took a bite of chocolate then rinsed twice with spring water. For the spring water palate cleanser, the panelist rinsed six times with it.

Statistical Analysis

Data was analyzed with repeated measures ANOVA. For each attribute and palate cleanser combination, the data were analyzed to see if there were any significant differences between replications. In addition, for each attribute and palate cleanser combination, the difference between replication one and three was calculated and then analyzed with repeated measures ANOVA. Also, for each attribute and palate cleanser combination, the average of replicates for each panelist was calculated and then analyzed with repeated measures ANOVA. Significant differences of the previous analyses were followed up with Duncan's post hoc analysis. All data analysis was done by using Statistica® (version 7.0, StatSoft, Inc. Tulsa, OK). Finally, efficacy of each palate cleanser was estimated from the results of the initial ANOVAs by calculating the percent of attributes tested for which significant difference was found between replications.

CHAPTER 3

RESULTS AND DISCUSSION

Results

Sweet Foods - Jelly Beans

The palate cleanser specifically selected for sweet foods was table water crackers. As shown in Tables 3.1, 3.2, and 3.3, table water crackers were effective for all attributes, with no significant difference ($p>0.05$) being found between replicates for any of the three attributes assessed (overall intensity, cherry aroma, and sweetness). The same was true for all other palate cleansers, except for the pectin rinse. When the pectin rinse was used as the palate cleanser, a significant difference in overall intensity was found between replicates ($p=0.024$). The latter replications received higher ratings than did the first, suggesting a build up with repeated tasting. No significant differences ($p>0.05$) were found across replicates for any of the palate cleansers for either cherry aroma (Table 3.2) or sweetness (Table 3.3).

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.4[a]	6.3[b]	5.7[ab]	***0.024***
Water	5.8[a]	6.1[a]	6.0[a]	*0.62*
Whole Milk	5.3[a]	5.8[a]	5.4[a]	*0.21*
Chocolate	5.3[a]	5.3[a]	5.5[a]	*0.83*
Warm Water	6.0[a]	6.3[a]	5.9[a]	*0.43*
Table Water Crackers	5.5[a]	5.5[a]	5.3[a]	*0.66*

Table 3.1: Jelly Bean Overall Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	3.9[a]	4.4[a]	4.0[a]	*0.44*
Water	4.0[a]	4.5[a]	4.5[a]	*0.29*
Whole Milk	4.0[a]	4.6[a]	4.4[a]	*0.17*
Chocolate	4.0[a]	4.3[a]	4.4[a]	*0.37*
Warm Water	4.1[a]	4.7[a]	4.2[a]	*0.07*
Table Water Crackers	3.8[a]	4.1[a]	3.8[a]	*0.46*

Table 3.2: Jelly Bean Cherry Aroma Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.5[a]	5.8[a]	5.5[a]	*0.47*
Water	6.2[a]	6.1[a]	6.1[a]	*0.99*
Whole Milk	5.8[a]	6.0[a]	5.5[a]	*0.52*
Chocolate	5.7[a]	5.4[a]	5.5[a]	*0.62*
Warm Water	6.2[a]	6.2[a]	6.0[a]	*0.78*
Table Water Crackers	6.0[a]	6.0[a]	5.9[a]	*0.78*

Table 3.3: Jelly Bean Sweetness Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

Despite the fact that only one palate cleanser allowed a significant difference between replicates as shown in Table 3.4 significant differences in overall intensity and sweetness were found between palate cleansers ($p<0.05$). The overall intensity ratings of jelly beans were significantly lower when chocolate, milk, or table water crackers were the palate cleansers as compared to when water or warm water were the palate cleanser. Similarly, the sweetness ratings were significantly lower when the pectin rinse and chocolate were the palate cleansers than when warm water and water were the palate cleansers. However, there were no significant difference ($p>0.05$) when assessing cherry aroma; none of the palate cleansers caused these mean ratings to shift.

	Overall Intensity	Cherry Aroma	Sweetness
Pectin Rinse	5.8^{ab}	4.1^{a}	5.6^{a}
Water	6.0^{b}	4.3^{a}	6.1^{b}
Whole Milk	5.5^{a}	4.3^{a}	5.8^{ab}
Chocolate	5.3^{a}	4.3^{a}	5.5^{a}
Warm Water	6.0^{b}	4.3^{a}	6.2^{b}
Table Water Crackers	5.4^{a}	3.9^{a}	6.0^{ab}
p-value	***0.008***	*0.46*	***0.019***

Table 3.4: Jelly Bean Mean Intensities (within a column, means followed by the same superscript are not significantly different at $\alpha=0.05$)

Finally, the amount of change in ratings from the first to the last replication showed no significant difference ($p>0.05$) across palate cleansers for any of the attributes (see Table 3.5).

	Overall Intensity	Cherry Aroma	Sweetness
Pectin Rinse	-0.3[a]	-0.1[a]	0.0[a]
Water	-0.1[a]	-0.5[a]	0.0[a]
Whole Milk	-0.1[a]	-0.4[a]	0.3[a]
Chocolate	-0.1[a]	-0.4[a]	0.2[a]
Warm Water	-0.1[a]	-0.1[a]	0.2[a]
Table Water Crackers	0.3[a]	0.0[a]	0.2[a]
p-value	*0.73*	*0.85*	*0.99*

Table 3.5: Jelly Bean Change in Intensities across Replicates 1 and 3 (within a column, means followed by the same superscript are not significantly different at α=0.05)

Bitter Foods – Coffee

The palate cleanser specifically selected for bitter foods was water. As shown in Tables 3.6, 3.7, and 3.8 water was effective for only two of the three attributes assessed, with a significant difference in overall intensity being found between replicates ($p=0.042$). The latter replications received lower ratings than did the first, suggesting a suppression in overall intensity due to adaptation. Warm water also showed a significant difference in overall intensity across replicates ($p=0.017$). However, when warm water was used, latter replications received both higher and lower ratings than did the first, suggesting warm water did not establish a stable baseline. No significant difference ($p>0.05$) across replicates was found with any of the remaining palate cleansers for any of the attributes (see Tables 3.6 and 3.8).

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	7.0[a]	6.9[a]	7.2[a]	*0.60*
Water	7.0[a]	7.0[a]	7.0[a]	*0.95*
Whole Milk	7.0[a]	6.6[a]	6.4[a]	*0.12*
Chocolate	6.5[a]	6.5[a]	6.3[a]	*0.85*
Warm Water	7.1[a]	7.4[a]	6.8[a]	*0.26*
Table Water Crackers	6.7[a]	6.8[a]	7.0[a]	*0.54*

Table 3.6: Coffee Overall Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.8[a]	5.5[a]	5.6[a]	*0.44*
Water	5.7[b]	5.4[ab]	5.0[a]	***0.042***
Whole Milk	5.5[a]	5.5[a]	5.3[a]	*0.84*
Chocolate	5.3[a]	5.5[a]	5.2[a]	*0.57*
Warm Water	5.5[ab]	6.0[b]	5.2[a]	***0.017***
Table Water Crackers	5.3[a]	5.5[a]	4.9[a]	*0.10*

Table 3.7: Coffee Aroma Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	7.0[a]	7.1[a]	7.1[a]	*0.93*
Water	6.9[a]	6.8[a]	7.4[a]	*0.25*
Whole Milk	6.8[a]	6.7[a]	6.8[a]	*0.88*
Chocolate	6.9[a]	6.5[a]	6.3[a]	*0.27*
Warm Water	6.8[a]	7.5[a]	6.5[a]	*0.08*
Table Water Crackers	7.2[a]	7.0[a]	7.2[a]	*0.72*

Table 3.8: Coffee Bitterness Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

There were no significant differences ($p>0.05$) found between palate cleansers for any of the attributes (see Table 3.9).

	Overall Intensity	Coffee Aroma	Bitterness
Pectin Rinse	7.0^a	5.6^a	7.0^a
Water	7.0^a	5.4^a	7.0^a
Whole Milk	6.6^a	5.4^a	6.8^a
Chocolate	6.4^a	5.3^a	6.5^a
Warm Water	7.1^a	5.6^a	3.9^a
Table Water Crackers	6.9^a	5.2^a	7.1^a
p-value	*0.17*	*0.65*	*0.43*

Table 3.9: Coffee Mean Intensities (within a column, means followed by the same superscript are not significantly different at $\alpha=0.05$)

Finally, the amount of change in ratings from the first to the last replication showed no significant difference ($p>0.05$) across palate cleansers for any of the attributes (see Table 3.10).

	Overall Intensity	Coffee Aroma	Bitterness
Pectin Rinse	-0.3^a	0.2^a	-0.1^a
Water	0.0^a	0.7^a	-0.5^a
Whole Milk	0.6^a	0.2^a	0.1^a
Chocolate	0.2^a	0.0^a	0.6^a
Warm Water	0.3^a	0.3^a	0.3^a
Table Water Crackers	-0.3^a	0.4^a	0.0^a
p-value	*0.30*	*0.43*	*0.34*

Table 3.10: Coffee Change in Intensities across Replicates 1 and 3 (within a column, means followed by the same superscript are not significantly different at $\alpha=0.05$)

Fatty Foods – Smoked Sausage

The palate cleanser specifically selected for fatty foods was warm water. As shown in Tables 3.11, 3.12, and 3.13 warm water was effective with all attributes, with no significant difference ($p>0.05$) being found between the replicates for any of the three attributes assessed (overall intensity, smoky flavor, and mouth coating). The same is true for all other palate cleansers, no significant differences ($p>0.05$) were found across replicates for any of the palate cleansers for overall intensity (Table 3.11), smoky flavor (Table 3.12), or mouth coating (Table 3.13).

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.5^a	5.8^a	5.5^a	*0.52*
Water	5.3^a	5.7^a	5.7^a	*0.31*
Whole Milk	5.6^a	5.8^a	5.6^a	*0.79*
Chocolate	5.6^a	5.7^a	5.5^a	*0.69*
Warm Water	5.7^a	6.0^a	6.2^a	*0.053*
Table Water Crackers	5.9^a	5.5^a	5.5^a	*0.21*

Table 3.11: Smoked Sausage Overall Intensities (within a row, means followed by the same superscript are not significantly different at $\alpha=0.05$)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	4.9^a	4.7^a	4.7^a	*0.78*
Water	4.7^a	5.1^a	5.0^a	*0.87*
Whole Milk	5.2^a	4.7^a	5.5^a	*0.09*
Chocolate	5.0^a	5.3^a	5.2^a	*0.83*
Warm Water	4.9^a	5.2^a	5.1^a	*0.66*
Table Water Crackers	5.3^a	5.1^a	4.9^a	*0.41*

Table 3.12: Smoked Sausage Smoky Flavor Intensities (within a row, means followed by the same superscript are not significantly different at $\alpha=0.05$)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.0[a]	5.1[a]	4.9[a]	*0.63*
Water	4.9[a]	5.4[a]	5.3[a]	*0.17*
Whole Milk	5.3[a]	5.4[a]	5.5[a]	*0.86*
Chocolate	5.0[a]	4.8[a]	4.8[a]	*0.46*
Warm Water	4.6[a]	5.1[a]	5.0[a]	*0.21*
Table Water Crackers	5.3[a]	5.0[a]	5.3[a]	*0.61*

Table 3.13: Smoked Sausage Mouth Coating Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

There were no significant differences ($p>0.05$) found between palate cleansers for any of the attributes (see Table 3.14).

	Overall Intensity	Smoky Flavor	Mouth coating
Pectin Rinse	5.6[a]	4.7[a]	5.0[a]
Water	5.6[a]	5.0[a]	5.2[a]
Whole Milk	5.7[a]	5.1[a]	5.4[a]
Chocolate	5.6[a]	5.2[a]	4.8[a]
Warm Water	5.9[a]	5.1[a]	4.9[a]
Table Water Crackers	5.6[a]	5.1[a]	5.2[a]
p-value	*0.61*	*0.72*	*0.27*

Table 3.14: Smoked Sausage Mean Intensities (within a column, means followed by the same superscript are not significantly different at α=0.05)

Finally, the amount of change in ratings from the first to the last replication showed no significant difference ($p>0.05$) across palate cleansers for any of the attributes (see Table 3.15).

	Overall Intensity	Smoky Flavor	Mouth Coating
Pectin Rinse	-0.1[a]	0.2[a]	0.1[a]
Water	-0.3[a]	-0.1[a]	-0.4[a]
Whole Milk	0.0[a]	-0.3[a]	-0.2[a]
Chocolate	0.1[a]	-0.2[a]	0.3[a]
Warm Water	-0.5[a]	-0.3[a]	-0.4[a]
Table Water Crackers	0.4[a]	0.5[a]	0.0[a]
p-value	*0.06*	*0.60*	*0.47*

Table 3.15: Smoked Sausage Change in Intensities across Replicates 1 and 3 (within a column, means followed by the same superscript are not significantly different at α=0.05)

Astringent Foods - Tea

The palate cleanser specifically selected for astringent foods was a pectin rinse. As shown in Tables 3.16, 3.17, 3.18, and 3.19, the pectin rinse was effective with all attributes, with no significant difference ($p>0.05$) being found between the replicates for any of the four attributes assessed (overall intensity, tea aroma, bitterness, astringency). The same was true for all other palate cleansers but whole milk. When whole milk was used as the palate cleanser, a significant difference in astringency was found between replicates ($p=0.046$). The latter replications received lower ratings than did the first, suggesting a suppression in ratings due to adaptation. No significant differences ($p>0.05$) were found across replicates for any of the palate cleansers for overall intensity (Table 3.16), tea aroma (Table 3.17), or bitterness (Table 3.18).

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.8[a]	5.5[a]	5.0[a]	*0.40*
Water	6.0[a]	5.8[a]	5.9[a]	*0.78*
Whole Milk	5.5[a]	5.2[a]	4.8[a]	*0.19*
Chocolate	5.7[a]	5.3[a]	5.3[a]	*0.46*
Warm Water	6.0[a]	6.2[a]	5.9[a]	*0.56*
Table Water Crackers	55[a]	5.5[a]	5.3[a]	*0.83*

Table 3.16: Tea Overall Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	4.7[a]	4.5[a]	5.0[a]	*0.43*
Water	4.6[a]	4.4[a]	4.2[a]	*0.42*
Whole Milk	4.8[a]	4.6[a]	4.1[a]	*0.08*
Chocolate	4.8[a]	4.7[a]	4.4[a]	*0.49*
Warm Water	4.7[a]	5.0[a]	4.4[a]	*0.34*
Table Water Crackers	4.6[a]	4.5[a]	4.2[a]	*0.32*

Table 3.17: Tea Aroma Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.0[a]	4.9[a]	5.0[a]	*0.97*
Water	5.2[a]	5.2[a]	5.7[a]	*0.32*
Whole Milk	5.0[a]	5.6[a]	4.7[a]	*0.10*
Chocolate	4.7[a]	4.8[a]	4.8[a]	*0.97*
Warm Water	5.5[a]	5.7[a]	5.5[a]	*0.71*
Table Water Crackers	5.1[a]	5.0[a]	4.5[a]	*0.30*

Table 3.18: Tea Bitterness Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.4^{a}	5.3^{a}	5.1^{a}	*0.64*
Water	5.0^{a}	5.1^{a}	5.6^{a}	*0.16*
Whole Milk	5.4^{b}	5.1^{ab}	4.6^{a}	***0.046***
Chocolate	4.7^{a}	4.3^{a}	4.6^{a}	*0.64*
Warm Water	5.3^{a}	5.3^{a}	5.0^{a}	*0.68*
Table Water Crackers	4.5^{a}	4.5^{a}	4.7^{a}	*0.90*

Table 3.19: Tea Astringency Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

Despite that fact that only one palate cleanser allowed a significant difference between replicates (Table 3.20), significant differences in overall intensity and astringency were found between palate cleansers ($p<0.05$). The overall intensity ratings of tea were significantly higher when water or warm water were the palate cleansers as compared to when whole milk or chocolate were the palate cleansers. Similarly, the astringency ratings were significantly higher when either the pectin rinse or water was the palate cleansers than when chocolate or table water crackers were the palate cleansers. However, there were no significant differences ($p>0.05$) when assessing tea aroma or bitterness; none of the palate cleansers caused these mean ratings to shift.

	Overall Intensity	Tea Aroma	Bitterness	Astringency
Pectin Rinse	5.5^{abc}	4.7^{a}	5.0^{a}	5.3^{b}
Water	5.9^{bc}	4.4^{a}	5.4^{a}	5.3^{b}
Whole Milk	5.2^{a}	4.5^{a}	5.1^{a}	5.0^{ab}
Chocolate	5.4^{ab}	4.6^{a}	4.8^{a}	4.5^{a}
Warm Water	6.0^{c}	4.7^{a}	5.6^{a}	5.2^{ab}
Table Water Crackers	5.4^{abc}	4.4^{a}	4.9^{a}	4.6^{a}
p-value	***0.024***	*0.74*	*0.30*	***0.038***

Table 3.20: Tea Mean Intensities (within a column, means followed by the same superscript are not significantly different at α=0.05)

Finally, the amount of change in ratings from the first to the last replication showed no significant difference ($p>0.05$) across palate cleansers for any of the attributes (see Table 3.21).

	Overall Intensity	Tea Aroma	Bitterness	Astringency
Pectin Rinse	-0.1^{a}	0.4^{a}	0.0^{a}	0.3^{a}
Water	0.0^{a}	0.4^{a}	-0.5^{a}	-0.5^{a}
Whole Milk	0.7^{a}	0.7^{a}	0.3^{a}	0.8^{a}
Chocolate	0.3^{a}	0.4^{a}	0.1^{a}	0.1^{a}
Warm Water	0.2	0.3^{a}	0.0^{a}	0.3^{a}
Table Water Crackers	0.1^{a}	0.4^{a}	0.6^{a}	-0.1^{a}
p-value	*0.61*	*0.97*	*0.30*	*0.30*

Table 3.21: Tea Change in Intensities across Replicates 1 and 3 (within a column, means followed by the same superscript are not significantly different at α=0.05)

Hot/Spicy Foods – Spicy Tortilla Chip

The palate cleanser specifically selected for hot/spicy foods was whole milk. As shown in Tables 3.22, 3.23, and 3.24, whole milk was effective for all attributes, with no significant difference ($p>0.05$) being found between the replicates for any of the three attributes assessed (overall intensity, cheese flavor, and heat/burn). The same was true for all other palate cleansers no significant differences ($p>0.05$) were found across replicates for any of the palate cleansers for overall intensity (Table 3.22), cheese flavor (Table 3.23) or heat/burn (Table 3.24).

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	6^a	6.6^a	6.2^a	*0.07*
Water	6.2^a	6.0^a	5.9^a	*0.47*
Whole Milk	5.8^a	5.7^a	5.8^a	*0.84*
Chocolate	6.4^a	6.3^a	6.1^a	*0.66*
Warm Water	6.1^a	6.4^a	6.2^a	*0.68*
Table Water Crackers	6.4^a	6.2^a	5.8^a	*0.14*

Table 3.22: Spicy Tortilla Chip Overall Intensities (within a row, means followed by the same superscript are not significantly different at $\alpha=0.05$)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	4.8^a	5.3^a	5.2^a	*0.24*
Water	5.1^a	4.8^a	4.9^a	*0.54*
Whole Milk	5.0^a	4.6^a	4.9^a	*0.31*
Chocolate	4.7^a	4.4^a	4.8^a	*0.48*
Warm Water	4.8^a	5.0^a	5.2^a	*0.44*
Table Water Crackers	4.8^a	5.0^a	5.0^a	*0.55*

Table 3.23: Spicy Tortilla Chip Cheese Flavor Intensities (within a row, means followed by the same superscript are not significantly different at $\alpha=0.05$)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	4.7[a]	5.0[a]	4.2[a]	*0.67*
Water	4.5[a]	4.5[a]	5.0[a]	*0.28*
Whole Milk	4.1[a]	4.5[a]	4.4[a]	*0.54*
Chocolate	5.2[a]	5.3[a]	4.3[a]	*0.06*
Warm Water	4.4[a]	4.9[a]	5.0[a]	*0.17*
Table Water Crackers	5.4[a]	5.3[a]	5.0[a]	*0.39*

Table 3.24: Spicy Tortilla Chip Heat/Burn Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

Even though none of the palate cleansers allowed a significant difference between replicates, significant differences ($p<0.05$) in burn were found between palate cleansers (Table 3.25). The heat/burn ratings of spicy tortilla chips were significantly lower when whole milk was the palate cleanser as compared to when chocolate or table water crackers were the palate cleansers. However, there were no significant difference ($p>0.05$) when assessing overall intensity or cheese flavor; none of the palate cleansers caused these mean ratings to shift.

	Overall Intensity	Cheese Flavor	Heat/Burn
Pectin Rinse	6.3[a]	5.1[a]	4.9[ab]
Water	6.0[a]	4.9[a]	4.7[ab]
Whole Milk	5.8[a]	4.8[a]	4.3[a]
Chocolate	6.3[a]	4.6[a]	4.9[b]
Warm Water	6.3[a]	5.0[a]	4.8[ab]
Table Water Crackers	6.1[a]	4.9[a]	5.2[b]
p-value	*0.19*	*0.39*	***0.033***

Table 3.25: Spicy Tortilla Chip Mean Intensities (within a column, means followed by the same superscript are not significantly different at α=0.05)

Finally, a significant difference ($p<0.05$) between palate cleansers was found in the change of burn from the first to the last replication (see Table 3.26). The heat/burn ratings of the spicy tortilla chip had a significantly bigger change across replications when chocolate was the palate cleanser than when warm water was the other palate cleanser. In contrast, there were no significant differences ($p>0.05$) between palate cleansers in change of overall intensity or change of cheese flavor.

	Overall Intensity	Cheese Flavor	Heat/Burn
Pectin Rinse	-0.2^{a}	-0.4^{a}	-0.2^{b}
Water	0.3^{a}	0.3^{a}	-0.2^{ab}
Whole Milk	0.0^{a}	0.1^{a}	-0.3^{ab}
Chocolate	0.3^{a}	-0.1^{a}	0.8^{b}
Warm Water	-0.1^{a}	-0.4^{a}	-0.7^{a}
Table Water Crackers	0.5^{a}	-0.2^{a}	0.4^{ab}
p-value	*0.37*	*0.59*	***0.046***

Table 3.26: Spicy Tortilla Chip Change in Intensities across Replicates 1 and 3 (within a column, means followed by the same superscript are not significantly different at $\alpha=0.05$)

Cooling Foods – Mint

The palate cleanser specifically selected for cooling foods was chocolate. As shown in Tables 3.27, 3.28, and 3.29, chocolate was effective on only one of the attributes, with a significant difference being found between replicates for both mint flavor ($p=0.001$) and cooling ($p=0.031$). The latter replications of both mint flavor and cooling were both higher and lower ratings than the initial ratings, suggesting chocolate failed to establish a stable baseline. Similarly, warm water also showed a significant difference across replicates for both overall intensity ($p=0.041$) and cooling ($p=0.041$). However, for warm water the latter replications received lower ratings than did the first

for both cooling and overall intensity, suggesting both were suppressed due to adaptation. No significant difference ($p>0.05$) across replicates was found with any of the remaining cleansers for any of the attributes (see Tables 3.27 – 3.29).

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.4^a	5.5^a	5.4^a	*0.87*
Water	5.6^a	5.6^a	5.6^a	*0.98*
Whole Milk	5.5^a	5.3^a	4.9^a	*0.15*
Chocolate	5.2^a	5.6^a	5.0^a	*0.10*
Warm Water	5.8^b	5.7^b	5.1^a	***0.041***
Table Water Crackers	5.5^a	5.7^a	5.6^a	*0.89*

Table 3.27: Mint Overall Intensities (within a row, means followed by the same superscript are not significantly different at $\alpha=0.05$)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.0^a	5.2^a	5.1^a	*0.88*
Water	5.4^a	5.0^a	5.5^a	*0.27*
Whole Milk	5.1^a	4.9^a	5.0^a	*0.85*
Chocolate	5.2^b	5.4^b	4.5^a	***0.001***
Warm Water	5.5^a	5.2^a	5.0^a	*0.42*
Table Water Crackers	5.0^a	5.5^a	5.5^a	*0.36*

Table 3.28: Mint Flavor Intensities (within a row, means followed by the same superscript are not significantly different at $\alpha=0.05$)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	4.6[a]	4.1[a]	4.2[a]	*0.22*
Water	4.2[a]	4.2[a]	4.4[a]	*0.79*
Whole Milk	4.0[a]	3.8[a]	3.9[a]	*0.64*
Chocolate	3.9[ab]	4.4[b]	3.6[a]	***0.031***
Warm Water	4.7[b]	4.4[ab]	3.9[a]	***0.041***
Table Water Crackers	4.2[a]	4.5[a]	4.1[a]	*0.29*

Table 3.29: Mint Cooling Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

There were no significant differences ($p>0.05$) found between palate cleansers for any of the attributes (see Table 3.30).

	Overall Intensity	Mint Flavor	Cooling
Pectin Rinse	5.4[a]	5.1[a]	4.3[a]
Water	5.6[a]	5.3[a]	4.3[a]
Whole Milk	5.2[a]	5.0[a]	3.9[a]
Chocolate	5.3[a]	5.0[a]	4.0[a]
Warm Water	5.5[a]	5.2[a]	4.3[a]
Table Water Crackers	5.6[a]	5.3[a]	4.3[a]
p-value	*0.38*	*0.74*	*0.47*

Table 3.30: Mint Mean Intensities (within a column, means followed by the same superscript are not significantly different at α=0.05)

Finally, a significant difference ($p<0.05$) between palate cleansers was found in the change of mint flavor (Table 3.31). The mint flavor ratings of the mint had a significantly bigger change across replications when chocolate or warm water were the palate cleansers than when table water crackers were the palate cleanser. In contrast,

there were no significant differences ($p>0.05$) between palate cleansers in change of overall intensity or cooling.

	Overall Intensity	Mint Flavor	Cooling
Pectin Rinse	0.0^{a}	0.0^{ab}	0.4^{a}
Water	0.0^{a}	-0.1^{ab}	-0.2^{a}
Whole Milk	0.6^{a}	0.1^{ab}	0.2^{a}
Chocolate	0.2^{a}	0.6^{b}	0.3^{a}
Warm Water	0.6^{a}	0.4^{b}	0.8^{a}
Table Water Crackers	-0.1^{a}	-0.4^{a}	0.1^{a}
p-value	*0.26*	***0.044***	*0.27*

Table 3.31: Mint Change in Intensities across Replicates 1 and 3 (within a column, means followed by the same superscript are not significantly different at $\alpha=0.05$)

Non-lingering Foods - Applesauce

The palate cleanser specifically selected for non-lingering foods was water. As shown in Tables 3.32, 3.33, and 3.34, water was effective for all attributes, with no significant difference ($p>0.05$) being found between the replicates for any of the three attributes assessed (overall intensity, sweetness, and sourness). The same was true for all other palate cleansers. No significant differences ($p>0.05$) were found across replicates for any of the palate cleansers for overall intensity (Table 3.32), sweetness (Table 3.33) or sourness (Table 3.34).

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	5.5[a]	6.1[a]	5.6[a]	*0.08*
Water	5.8[a]	6.1[a]	6.0[a]	*0.78*
Whole Milk	5.4[a]	5.3[a]	5.4[a]	*0.92*
Chocolate	5.5[a]	5.2[a]	5.3[a]	*0.68*
Warm Water	6.0[a]	5.8[a]	5.7[a]	*0.41*
Table Water Crackers	5.4[a]	5.4[a]	5.5[a]	*0.96*

Table 3.32: Applesauce Overall Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	4.8[a]	5.3[a]	5.1[a]	*0.37*
Water	4.0[a]	4.5[a]	4.5[a]	*0.82*
Whole Milk	4.3[a]	4.7[a]	4.6[a]	*0.64*
Chocolate	4.3[a]	4.8[a]	4.5[a]	*0.44*
Warm Water	4.6[a]	3[a]	4.7[a]	*0.09*
Table Water Crackers	4.8[a]	5.3[a]	5.3[a]	*0.21*

Table 3.33: Applesauce Sweetness Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

	Rep 1	Rep 2	Rep 3	*p-value*
Pectin Rinse	4.0[a]	3.8[a]	3.4[a]	*0.18*
Water	6.2[a]	6.1[a]	6.1[a]	*0.25*
Whole Milk	4.5[a]	3.9[a]	4.0[a]	*0.29*
Chocolate	4.0[a]	3.6[a]	3.8[a]	*0.65*
Warm Water	4.0[a]	3.7[a]	3.9[a]	*0.55*
Table Water Crackers	4.3[a]	3.6[a]	4.0[a]	*0.09*

Table 3.34: Applesauce Sourness Intensities (within a row, means followed by the same superscript are not significantly different at α=0.05)

While no significant differences were found between replicates within each palate cleanser, a significant difference ($p<0.05$) between palate cleansers were found for sourness (Table 3.35). The sourness ratings of applesauce were significantly higher when water was the palate cleanser as compared to any of the other palate cleansers. However, there were no significant difference ($p>0.05$) when assessing overall intensity or sweetness; none of the palate cleansers caused these mean ratings to shift.

	Overall Intensity	Sweetness	Sourness
Pectin Rinse	5.8	5.1^{a}	3.7^{a}
Water	6.0^{a}	4.3^{a}	6.1^{b}
Whole Milk	5.3^{a}	4.5^{a}	4.1^{a}
Chocolate	5.3^{a}	4.5^{a}	3.8^{a}
Warm Water	5.8^{a}	4.9^{a}	3.9^{a}
Table Water Crackers	5.4^{a}	5.1^{a}	4.0^{a}
p-value	*0.056*	*0.24*	***<0.0001***

Table 3.35: Applesauce Mean Intensities (within a column, means followed by the same superscript are not significantly different at $\alpha=0.05$)

Finally, the amount of change in ratings from the first to the last replication showed no significant difference ($p>0.05$) across palate cleansers for any of the attributes (see Table 3.36).

	Overall Intensity	Sweetness	Sourness
Pectin Rinse	-0.5[a]	-0.3[a]	0.6[a]
Water	0.0[a]	-0.2[a]	0.5[a]
Whole Milk	0.0[a]	-0.3[a]	0.5[a]
Chocolate	0.1[a]	-0.2[a]	0.2[a]
Warm Water	0.3[a]	-0.1[a]	0.2[a]
Table Water Crackers	0.0[a]	-0.6[a]	0.3[a]
p-value	*0.41*	*0.92*	*0.90*

Table 3.36: Applesauce Change in Intensities across Replicates 1 and 3 (within a column, means followed by the same superscript are not significantly different at α=0.05)

Overall Effectiveness

Percent effectiveness of each palate cleanser is shown in Table 3.37. From this table, it can be seen that the palate cleansers varied in effectiveness. From most to least effective the palate cleansers are as follows: table water crackers > whole milk = pectin rinse = water > chocolate > warm water. These findings suggest that table water crackers are the best palate cleanser for preventing drift in ratings across replications.

	Pectin Rinse	Water	Whole Milk	Chocolate	Warm Water	Table Water Crackers
Tea	100	100	75	100	100	100
Smoked Sausage	100	100	100	100	100	100
Mint	100	100	100	33	33	100
Applesauce	100	100	100	100	100	100
Jelly Beans	67	100	100	100	100	100
Coffee	100	67	100	100	67	100
Spicy Tortilla Chip	100	100	100	100	100	100

Table 3.37: Effectiveness of Palate Cleansers (% of attributes failing to show a significant difference between replications)

Discussion

The pectin rinse was the least effective palate cleanser for sweet foods, and allowed overall intensity to increase over replications. It is possible that the pectin rinse left residuals in the oral cavity, which allowed for the build up in overall intensity ratings. With jelly beans (the sweet food) panelists' perception of overall intensity and sweetness changed depending upon the palate cleanser, most likely due to contrast effects between the palate cleanser and the stimulus. As discussed in Chapter 1, one of the most commonly used palate cleansers for sweet foods are bland crackers and water (Ball, et al.,

1998, Duizer, et al., 1995, Kilcast and Clegg, 2002, Kremer, et al., 2007, Lavin and Lawless, 1998, Schiffman, et al., 2007, Warnock and Delwiche, 2006, Zhao and Tepper, 2007). Both of these palate cleansers appeared to be effective at preventing significant changes in ratings across replicates. Water, milk, chocolate, warm water, and table water crackers were all acceptable palate cleanser for assessing the representative sweet food.

For coffee, the representative bitter food, water and warm water were the only palate cleansers that allowed significant difference between replications. Overall intensity declined over replications when the palate cleanser was water, while intensity changed erratically over replications with warm water. The poor performance of water and warm water are in agreement with the findings of Brannan et al. (2001) that indicated water was the least effective palate cleanser for bitter stimuli. Brannan et al. (2001) suggested water was less effective than other palate cleansers because it was not as viscous as other palate cleansers they examined.

In contrast, Johnson and Vickers (2004) found water, sparkling water, carrots, crackers, plain cream cheese, rinsing six times with water, and no palate cleanser to be equally effective. This lack of difference between palate cleansers is likely due to the fact that no explicit instructions were given for the use of each cleanser. Subjects were allowed to decide whether or not to use a rinse agent more than once between samples, how much water to use in addition to the carrot, cracker, or cream cheese, how long to keep the rinse agent in the mouth, and how long to wait after expectorating the palate cleanser before proceeding to assess the next sample. As previously discussed, O'Mahony (1972a) found that individuals are not accurate at judging when residuals have been cleared from the oral cavity. Therefore, allowing subject discretion to dictate the use

of palate cleansers is ineffective and likely accounts for the discrepancy between this study and the others.

The pectin rinse, milk, chocolate, and table water crackers were all effective palate cleansers for assessing bitter foods. However, water and warm water were ineffective palate cleansers for bitter stimuli.

All palate cleansers were effective palate cleansers for fatty foods. As discussed in Chapter 1, there is a wide variety of palate cleansers being used for fatty foods such as water (Azanza, et al., 2004, Chapman, et al., 2006, Ishii, et al., 2007a, Olarte, et al., 2001, Stampanoni Koeferli, et al., 1996, Ward, et al., 1999, Wolf Frandsen, et al., 2007), crackers (Butler, et al., 1996, Saint-Eve, et al., 2004), and warm water (Ishii, et al., 2007b). All three of these palate cleansers appeared to be effective at preventing significant changes in ratings across replicates. The pectin rinse, water, whole milk, chocolate, warm water, and table water crackers were all acceptable palate cleansers for assessing the representative fatty food.

For tea, the representative astringent food, whole milk was the only palate cleanser that allowed significant difference between replications. In addition, astringency ratings declined when whole milk was the palate cleanser. In contrast, the pectin rinse, water, and table water crackers were all equally effective at preventing between replication changes. In contrast, Colonna et al. (2004), found that a pectin rinse reduced astringency more effectively than crackers or water, and that crackers were more effective than water. However, Colonna et al. (2004) did not use a repeated measures design, nor did they monitor changes over replication instead having panelist rate only a

single exposure. These differences in experimental design likely account for the discrepancy between studies.

The findings of the current investigation also conflicted with the findings of Ross et al. (2007) who reported that crackers were more effective than a pectin rinse and water. The difference in findings could be due to any of a number of key differences between the studies. First, Ross et al. (2007) had panelists used two palate cleanser in a session when assessing wine samples and each palate cleanser was used only once every three samples. Thus, astringency was allowed to build-up more in the Ross et al. (2007) investigation, allowing for greater differentiation of palate cleanser performance. In contrast, in the current investigation, such build-up was prevented. This indicates that it is not only the palate cleanser that is important, but also how it is utilized.

Brannan et al. (2001) found that water was less effective than several other palate cleansers with greater viscosity. However, none of the other palate cleansers used by Brannan et al. (2001) were included in this investigation, making direct comparison between theirs and the current investigation impossible.

Results of the current investigations indicate the pectin rinse, chocolate, water, warm water, and table water crackers were all effective palate cleansers for assessing astringent foods. However, milk was an ineffective palate cleanser for astringent stimuli and should be avoided.

For the spicy tortilla chip, the representative hot/spicy food, all the palate cleansers were effective at preventing significant differences between replication. This agrees with the findings of Allison and Work (2004), who found that both water and crackers significantly increased repeatability and increased the rate of heat decay. The

findings of Hutchinson et al. (1990) also indicated that water was just as effective as butter, rice, and pineapple juice at reducing the burn.

While Stevens and Lawless (1986) and Nasrawi and Pangborn (1989) found that sucrose solutions were better at reducing the burn of capsaicin solutions than water, sucrose solution was not included in the current investigation, making direct comparison to these studies impossible.

As discussed in Chapter 1, palate cleansers utilized with hot/spicy foods include whole milk (Noble, 2007), crackers (Carden, et al., 1999, Dowell, et al., 2005), and water (Noble, 2007). These three palate cleansers all proved to be effective at preventing significant changes in ratings across replicates. The pectin rinse, water, milk, chocolate, table water crackers, and warm water were all acceptable palate cleansers for assessing the representative hot/spicy food.

For mint, the representative cooling food, chocolate and warm water were the only palate cleansers that allowed significant difference between replications. Overall intensity and cooling declined over replications when the palate cleanser was warm water, while both cooling and mint flavor intensity changed erratically over replications with chocolate. As previously discussed in Chapter 1, there are a variety of palate cleansers used for cooling foods including crackers (Ovejero-Lopez, et al., 2005), water (Gwartney and Heymann, 1996), and chocolate (Piper, 2005, Summers, 2005). Table water crackers as well as water appeared to be effective at preventing significant changes in ratings across replicates. A pectin rinse, water, table water crackers, and milk were all acceptable palate cleansers for assessing the representative cooling food. However, chocolate and warm water are ineffective palate cleansers for cooling stimuli. This

finding is particularly notable given the frequency with which chocolate is suggested for use as a palate cleanser for cooling foods.

For applesauce, the representative non-lingering food, all the palate cleansers were effective at preventing significant differences between replication. As discussed in Chapter 1, the two most commonly used palate cleansers for non-lingering foods were bland crackers and water (Carbonell, et al., 2007, Daillant-Spinnler, et al., 1996, Esaiassen, et al., 2004, Forde and Delahunty, 2004, Kremer, et al., 2007, Larsen, et al., 2005, Mehinagi, et al., 2003, Mialon, et al., 2002, Nindjin, et al., 2007, Park, et al., 2007). Both of these palate cleansers appeared to be effective at preventing significant changes in ratings across replicates. Water, milk, pectin rinse, warm water, chocolate, and table water crackers were all acceptable palate cleanser for assessing the representative non-lingering food.

In general, effectiveness of a palate cleanser depends upon the particular attribute and food product evaluated, amount and composition the panelists' saliva, as well as how each panelist sipped or took a bite of the cracker. However, despite these variations, table water crackers were effective at preventing significant differences across replications when assessing all seven food categories, whereas water was only effective against only six of the seven.

CHAPTER 4

CONCLUSION

Certain palate cleansers were more effective at reducing rating variation over replications for particular food categories than others. Good palate cleansers to use when assessing sweet foods include water, warm water, chocolate, table water crackers, and whole milk. For the assessment of bitter foods, the pectin rinse, chocolate, whole milk, and table water crackers. The pectin rinse, water, whole milk, chocolate, warm water, and table water crackers were all acceptable palate cleansers when assessing fatty foods, non-lingering foods, as well as hot/spicy foods. Acceptable palate cleansers to use when assessing astringent foods were water, chocolate, warm water, table water crackers, and the pectin rinse. For the assessment of cooling products, water, whole milk, the pectin rinse, and table water crackers were effective palate cleansers.

Table water crackers were the only palate cleanser that was effective for all seven food types. Four of the remaining palate cleansers were effective for 6 of the 7 food types, with spring water being ineffective for bitter foods, pectin solution being ineffective against sweet foods, whole milk being ineffective against astringent foods, and chocolate being ineffective against cooling foods. Warm water was ineffective for both bitter and cooling foods. Since water was only effective for 6 of the food types, table water crackers followed by rinsing proved to be a better palate cleanser than water alone.

BIBLIOGRAPHY

Adhikari, K., H. Heymann, and H. E. Huff. 2003. Textural characteristics of lowfat, fullfat and smoked cheeses: sensory and instrumental approaches. Food Quality and Preference. 14(3):211-218.

Allison, A.-M., E. Chambers, E. Gibson, and F. M. Aramouni. 1999a. Sensory characteristics of heat-processed and fresh tomato salsa containing honey. Journal of Food Science. 64(3):560-564.

Allison, A.-M., E. Chambers, G. A. Milliken, and D. H. Chambers. 1999b. Effects of interstimulus rinsing and time on measurements of capsaicin heat in tomato salsa. Journal of Sensory Studies. 14:401-414.

Allison, A.-M. and T. Work. 2004. Fiery and frosty foods pose challenges in sensory evaluation. Pages 32-37 *in* Food Technology. Vol. 58.

Azanza, M. P. V., I. C. V. Basman, C. D. Magsuci, and R. A. Mauricio. 2004. Development of quick-cooking meat congees using multi-level sensory evaluation Food Quality and Preference. 15(4):331-340.

Ball, R. D., S. H. Murray, H. Young, and J. M. Gilbert. 1998. Statistical analysis relating analytical and consumer panel assessments of kiwifruit flavour compounds in a model juice base Food Quality and Preference. 9(4):255-266.

Bern, A. Z., J. Lammertyn, S. Buysens, C. Di Natale, and B. M. Nicolaï. 2005. Mapping consumer liking of tomatoes with fast aroma profiling techniques PostHarvest Biology and Technology. 38(2):115-127.

Brannan, G. D., C. S. Setser, and K. E. Kemp. 2001. Effectiveness of rinses in alleviating bitterness and astringency residuals in model solutions. Journal of Sensory Studies. 16(3):261-275.

Bruvold, W. H. and W. R. Gaffey. 1965. Subjective intensity of mineral taste in water. Journal of Experimental Psychology. 69:369-374.

Butler, G., L. M. Poste, D. A. Mackie, and A. Jones. 1996. Time-intensity as a tool for the measurement of meat tenderness. Food Quality and Preference. 7(3-4):193-204.

Carbonell, L., L. Izquierdo, and I. Carbonell. 2007. Sensory analysis of Spanish mandarin juices. Selection of attributes and panel performance. Food Quality and Preference. 18(2):329-341.

Carden, L. A., M. P. Penfield, and A. M. Saxton. 1999. Perception of heat in cheese sauces as affected by capsaicin concentration. Journal of Food Science. 64(1):175-179.

Chapman, K. W., K. Grace-Martin, and H. T. Lawless. 2006. Expectations and stability of preference choice. Journal of Sensory Studies. 21(4):441-455.

Colonna, A. E., D. O. Adams, and A. Noble. 2004. Comparison of procedures for reducing astringency carry-over effects in evaluation of red wines. Aust. J. Grape Wine Res. 10:26-31.

Crocker, E. C. 1945. Flavor (McGraw-Hill, New York).

Dahlberg, A. C. and E. S. Penczek. 1941. The relative sweetness of sugars as affected by concentration. Pages 2-10 *in* New York State Agricultural Experimental Station Technical Bulletin. Vol. 258.

Daillant-Spinnler, B., H. J. H. MacFie, P. K. Beyts, and D. Hedderley. 1996. Relationships between perceived sensory properties and major preference directions of 12 varieties of apples from the Southern Hemisphere Food Quality and Preference. 7(2):113-126.

Delwiche, J. and M. O'Mahony. 1996. Changes in secreted salivary sodium are sufficient to alter salt taste sensitivity: use of signal detection measures with continuous monitoring of the oral environment. Physiology & Behavior. 59(4-5):605-611.

Dowell, K. J., E. Chambers, G. A. Milliken, and D. H. Chambers. 2005. Predicting interstimulus intervals between samples for capsaicin-containing salsa with a range of heat levels. Journal of Sensory Studies. 20(3):187-199.

Duizer, L. M., K. Bloom, and C. J. Findlay. 1995. The effect of line orientation on the recording of time-intensity perception of sweetener solutions. Food Quality and Preference. 6(2):121-126.

Duizer, L. M., K. Bloom, and C. J. Findlay. 1996. Dual-attribute time-intensity measurement of sweetness and peppermint perception of chewing gum. Journal of Food Science. 61(3):636-638.

Esaiassen, M., J. Østli, E. O. Elvevoll, S. Joensen, K. Prytz, and R. Richardsen. 2004. Brining of cod fillets: Influence on sensory properties and consumers liking Food Quality and Preference. 15(5):421-428.

Farmer, L. J., J. M. McConnell, and D. J. Kilpatrick. 2000. Sensory characteristics of farmed and wild Atlantic salmon Aquaculture. 187(1-2):105-125.

Ferry, A.-L., J. Hort, J. R. Mitchell, D. J. Cook, S. Lagarrigue, and B. Valles Pamiesc. 2006. Viscosity and flavour perception: why is starch different from hydrocolloids? . Food Hydrocolloids. 20(6):855-862.

Findlay, C. J., J. S. Castura, and I. Lesschaeve. 2007. Feedback calibration: a training method for descriptive panels Food Quality and Preference. 18(2):321-328.

Forde, C. G. and C. M. Delahunty. 2004. Understanding the role cross-modal sensory interactions play in food acceptability in younger and older consumers Food Quality and Preference. 15(7-8):715-727.

François, N., C. Guyot-Declerck, B. Hug, D. Callemien, B. Govaerts, and S. Collin. 2006. Beer astringency assessed by time–intensity and quantitative descriptive analysis: influence of pH and accelerated aging Food Quality and Preference. 17(6):445-452.

Graebe, K. 2001. Subject: Mint toothpaste. http://tech.groups.yahoo.com/group/sensory/message/1529. Accessed January 10, 2007.

Green-Petersen, M. B. Ditte, J. Nielse, and G. Hyldig. 2006. Sensory profiles of the most common salmon products on the Danish market. Journal of Sensory Studies. 21(4):415-427.

Green, B. G. and J. E. Hayes. 2004. Individual differences in perception of bitterness from capsaicin, piperine, zingerone. Chemical Senses. 29(1):53-60.

Green, C. 2002. Subject: Mint mouthwash. http://tech.groups.yahoo.com/group/sensory/message/3323. Accessed January 10, 2007.

Gregson, R. A. M. 1966. Qualitative identification of the taste of weak sucrose-sodium chloride mixture stimuli. Perception and Psychophysics. 1:154-156.

Gwartney, E. and H. Heymann. 1995. The temporal perception of menthol. Journal of Sensory Studies. 10:393-400.

Gwartney, E. and H. Heymann. 1996. Profiling to describe the sensory characteristics of a simple model menthol solution. Journal of Sensory Studies. 11(1):39-48.

Halpern, B. P., S. T. Kelling, and H. L. Meiselman. 1986. An analysis of the role of stimulus removal in taste adaptation by means of simulated drinking. Physiology & Behavior. 36:925-928.

Helgesen, H., R. Solheim, and T. Næs. 1998. Consumer purchase probability of dry fermented lamb sausages Food Quality and Preference. 9(5):295-301.

Hutchinson, S. E., L. A. Trontow, and Z. M. Vickers. 1990. The effectiveness of common foods for reduction of capsaicin burn. Journal of Sensory Studies. 4(3):157-164.

Ishii, R., H.-K. Chang, and M. O'Mahony. 2007a. A comparison of serial monadic and attribute-by-attribute protocols for simple descriptive analysis with untrained judges. Food Quality and Preference. 18(2):440-449.

Ishii, R., H. Kawaguchi, M. O'Mahony, and B. Rousseau. 2007b. Relating consumer and trained panels' discriminative sensitivities using vanilla flavored ice cream as a medium. Food Quality and Preference. 18(1):89-96.

Janestad, H., K. Wendin, A. Ruhe, and G. Hall. 2000. Modelling of dynamic flavour properties with ordinary differential equations. Food Quality and Preference. 11(4):323-329.

Johnson, E. A. and Z. Vickers. 2004. The effectiveness of palate cleansing strategies for evaluating the bitterness of caffeine in cream cheese. Food Quality and Preference. 15(4):311-316.

Kilcast, D. and S. Clegg. 2002. Sensory perception of creaminess and its relationship with food structure. Food Chemistry. 13(7-8):609-623.

King, B. M. and C. A. A. Duineveld. 1999. Changes in bitterness as beer ages naturally Food Quality and Preference. 10(4-5):315-324.

Kremer, S., J. Mojet, and J. H. A. Kroeze. 2007. Differences in perception of sweet and savoury waffles between elderly and young subjects Food Quality and Preference. 18(1):106-116.

Krishnamurthy, R., A. K. Srivastava, J. E. Paton, G. A. Bell, and D. C. Levy. 2007. Prediction of consumer liking from trained sensory panel information: Evaluation of neural networks Food Quality and Preference. 18(2):275-285.

Larsen, H., P. Lea, and M. Rødbotten. 2005. Sensory changes in extruded oat stored under different packaging, light and temperature conditions Food Quality and Preference. 16(7):573-584.

Lavin, J. G. and H. T. Lawless. 1998. Effects of color and odor on judgments of sweetness among children and adults Food Quality and Preference. 9(4):283-289.

Lawless, H. T., N. Sheng, and S. S. C. P. Knoops. 1995. Multidimensional scaling of sorting data applied to cheese perception Food Quality and Preference. 6(2):91-98.

Lethuaut, L., C. Brossard, F. Rousseau, B. Bousseau, and C. Genot. 2005. Sweetness–texture interactions in model dairy desserts: effect of sucrose concentration and the carageenan type International Dairy Journal. 15(5):485-493.

Lorant, J. and G. Lorant. 1948. Taste test procedure. Food Technology Department, Oregon Agricultural Experimental Station (mimeo).

McGowan, B. A. and S.-Y. Lee. 2006. Comparison of methods to analyze time–intensity curves in a corn zein chewing gum study Food Quality and Preference. 17(3-4):296-306.

Mehinagi, E., G. Royer, D. Bertrand, R. Symoneaux, F. Laurens, and F. Jourjon. 2003. Relationship between sensory analysis, penetrometry and visible–NIR spectroscopy of apples belonging to different cultivars Food Quality and Preference. 14(5-6):473-484.

Meiselman, H. L. and E. Dzendolet. 1967. Variability in gustatory quality identification. Perception and Psychophysics. 2:496-498.

Mialon, V. S., M. R. Clark, P. I. Leppard, and D. N. Cox. 2002. The effect of dietary fibre information on consumer responses to breads and "English" muffins: a cross-cultural study. Food Quality and Preference. 13(1):1-12.

Moncrieff, R. W. 1947. The choice of flavor. Food Manufacture. 22:113-118.

Monteleone, E., N. Condelli, C. Dinnella, and M. Bertuccioli. 2004. Prediction of perceived astringency induced by phenolic compounds. Food Quality and Preference. 15(7-8):761-769.

Nasrawi, C. W. and R. M. Pangborn. 1989. The influence of tastants on oral irritation by capsaicin. Journal of Sensory Studies. 3:287-294.

Nindjin, C., D. Otokoré, S. Hauser, A. Tschannen, Z. Farah, and O. Girardin. 2007. Determination of relevant sensory properties of pounded yams (Dioscorea spp.) using a locally based descriptive analysis methodology. Food Quality and Preference. 18(2):450-459.

Noble, A. 2007. Subject: Capsaicin. http://tech.groups.yahoo.com/group/sensory/message/2473. Accessed January 10, 2007.

Nurgel, C. and G. J. Pickering. 2006. Modeling of sweet, bitter and irritant sensations and their interactions elicited by model ice wines. Journal of Sensory Studies. 21(5):505-519.

O'Mahony, M. 1972a. The interstimulus interval for taste: 1. Efficiency of expectoration and mouthrinsing in clearing the mouth of salt residuals. Perception. 1:209-215.

O'Mahony, M. 1972b. The interstimulus interval for taste: 2. Salt taste sensitivity drifts and the effects on intensity scaling and threshold measurement. Perception. 1:217-222.

O'Mahony, M. 1974. Taste adaptation: the case of the wandering zero. Journal of Food Technology. 9:1-12.

O'Mahony, M. and L. Godman. 1974. The effect of interstimulus procedures on salt taste thresholds. Perception & Psychophysics. 16(3):456-465.

O'Mahony, M. and P. Wingate. 1974. The effect of interstimulus procedures on salt taste intensity functions. Perception & Psychophysics. 16(3):494-502.

Olarte, C., E. Gonzalez-Fandos, and S. Sanz. 2001. A proposed methodology to determine the sensory quality of a fresh goat's cheese (Cameros cheese): application to cheeses packaged under modified atmospheres Food Quality and Preference. 12(3):163-170.

Ovejero-Lopez, I., R. Bro, and W. I. P. Bredie. 2005. Univariate and multivariate modelling of flavour release in chewing gum using time intensity: a comparison of data analytical methods. Food Quality and Preference. 16:327-343.

Park, J.-Y., M. O'Mahony, and K.-O. Kim. 2007. Different-stimulus' scaling errors; effects of scale length. Food Quality and Preference. 18(2):362-368.

Pickering, G. J. and G. Robert. 2006. Perception of mouthfeel sensations elicited by red wine are associated with sensitivity to 6-n-propylthiouracil. Journal of Sensory Studies. 21(3):249-265.

Pickering, G. J., K. Simunkova, and D. DiBattistaca. 2004. Intensity of taste and astringency sensations elicited by red wines is associated with sensitivity to PROP (6-n-propylthiouracil). Food Quality and Preference. 15:147-154.

Piper, D. 2005. Subject: Mint gum. http://tech.groups.yahoo.com/group/sensory/message/5059. Accessed January 10, 2007.

Platt, W. 1931. Rational methods of scoring food products. Food Industries. 3:108-111.

Rason, J., J.-F. Martin, E. Dufour, and A. Lebecque. 2007. Diversity of the sensory characteristics of traditional dry sausages from the centre of France: relation with regional manufacturing practice. Food Quality and Preference. 18(3):517-530.

Rétiveau, A., D. H. Chambers, and E. Esteve. 2005. Developing a lexicon for the flavor description of French cheeses Food Quality and Preference. 16(6):517-527.

Richardson-Harman, N. J., R. Stevens, S. Walker, J. Gamble, M. Miller, M. Wong, and A. McPherson. 2000. Mapping consumer perceptions of creaminess and liking for liquid dairy products Food Quality and Preference. 11(3):239-246.

Ross, C. F., C. Hinken, and K. Weller. 2007. Efficacy of palate cleansers for reductions of astringency carryover during repeated ingestions of red wine. Journal of Sensory Studies. 22:293-312.

Saint-Eve, A., E. P. Kora, and N. Martin. 2004. Impact of the olfactory quality and chemical complexity of the flavouring agent on the texture of low fat stirred yogurts assessed by three different sensory methodologies Food Quality and Preference. 15(7-8):655-668.

Schiffman, S., E. Sattely-Miller, and I. Bishay. 2007. Time to maximum sweetness intensity of binary and ternary blends of sweeteners. Food Quality and Preference. 18(2):405-415.

Stampanoni Koeferli, C. R., P. Piccinali, and S. Sigrist. 1996. The influence of fat, sugar and non-fat milk solids on selected taste, flavor and texture parameters of a vanilla ice-cream Food Quality and Preference. 7(2):69-79.

Stevens, D. A. and H. T. Lawless. 1986. Putting out the fire: effects of tastants on oral chemical irritation. Perception & Psychophysics. 39(5):346-350.

Summers, T. 2005. Subject: Menthol/Mints. http://tech.groups.yahoo.com/group/sensory/message/4866. Accessed January 10, 2007.

Ward, C. D. W., C. Stampanoni Koeferli, P. Piccinali Schwegler, D. Schaeppi, and L. E. Plemmons. 1999. European strawberry yogurt market analysis with a case study on acceptance drivers for children in Spain using principal component analysis and partial least squares regression. Food Quality and Preference. 10(4-5):387-400.

Warnock, A. R. and J. F. Delwiche. 2006. Regional variation in sweet suppression. Journal of Sensory Studies. 21(3):348-361.

Wolf Frandsen, L., G. Dijksterhuis, P. Brockoff, J. Nielsen, and M. Martens. 2007. Feelings as a basis for discrimination: comparison of a modified authenticity test with the same–different test for slightly different types of milk. Food Quality and Preference. 18(1):97-105.

Zhao, L. and B. J. Tepper. 2007. Perception and acceptance of selected high-intensity sweeteners and blends in model soft drinks by propylthiouracil (PROP) non-tasters and super-tasters Food Quality and Preference. 18(3):531-540.

APPENDIX A

IRB Application, Ballot, and Experimental Design

APPLICATION FOR EXEMPTION

FROM REVIEW BY THE INSTITUTIONAL REVIEW BOARD
The Ohio State University, Columbus OH 43210

All research activities involving the use of human beings as research subjects must be reviewed and approved by an Ohio State University Institutional Review Board (IRB), unless the Office of Responsible Research Practices (ORRP) determines that the research falls into one or more of the categories of exemption established by federal regulation.

Exempt research is generally **short term** in nature. It usually is performed "as written," i.e. the investigators do not plan to make changes in the research design, the selection of subjects, the informed consent process, or the instrumentation during the course of the study.

A determination that research is exempt does not absolve the investigators from ensuring that the **welfare of human subjects** participating in research activities is protected, and that methods used and information provided to gain subject consent are appropriate to the activity. **Investigators may not solicit subject participation or begin data collection until they have received approval from the appropriate Institutional Review Board OR written concurrence that research has been determined to be exempt.**

All OSU Investigators who participate in human subjects research must be appropriately trained in human subjects protection. See www.orrp.ohio-state.edu/education3.cfm for more details.

There is no deadline or timeline for submitting exempt applications for review. Applications are processed as received. Each application **must** include a research proposal. The proposal must include (at a minimum) the following items: the background literature review, the research question, a description of the research methods including sample size and data collection procedures, and a data analysis plan.

Please allow up to three weeks for processing.

If you have questions regarding the application process or the review of exempt protocols, please contact Janet Schulte, Office of Responsible Research Practices.
Phone: 688-0389 / Fax: 688-0366 / E-mail: schulte.58@osu.edu

A COMPLETE APPLICATION PACKET INCLUDES THE FOLLOWING MATERIALS:

☐ **Title page** (attached). Identifies the investigators. Lists the protocol title and the source of funding.

☐ **Screening questions** (attached). Identifies the categories of exemption and solicits responses to screening questions.

☐ **Description of the proposed research** (questions #1 through #9, attached). Includes responses to questions about the objective(s) of the research, the methodology that will be used to gain informed consent from the subjects, and the measures taken to protect the confidentiality of information obtained in research.

☐ **Research proposal** (see question #1).

☐ **Grant proposal.** Must be included when externally-sponsored funding is being sought.
☐ **Letter(s) of support** (see question #4).
☐ **Copies of surveys, instruments, questionnaires, interview questions, focus group topics, and/or data collection sheets** (see question #5).
☐ **Recruitment letter** (see question # 8).
☐ **Consent form** (see question #9).

SEND YOUR APPLICATION TO:

Office of Responsible Research Practices
300 Research Foundation Building
1960 Kenny Road
Columbus OH 43210-1063
Fax (614) 688-0366

TITLE PAGE - APPLICATION FOR EXEMPTION

FROM REVIEW BY THE INSTITUTIONAL REVIEW BOARD

The Ohio State University, Columbus OH 43210

For office use only
PROTOCOL NUMBER:

<table>
<tr><td rowspan="3"><u>►Principal Investigator</u>

University Title:
☐ Professor
☒ Associate Professor
☐ Assistant Professor
☐ Instructor
☐ Other. Please specify. (May require prior approval.)</td><td>Name: Jeannine F. Delwiche</td><td>Phone: 614-247-6756</td></tr>
<tr><td>Department or College: Food Science and Technology
Campus Address (room, building, street address):
110 Parker Food Science & Tech Building
2015 Fyffe Road
Columbus, OH 43210-1007</td><td>E-mail:
delwiche.1@osu.edu</td></tr>
<tr><td>Signature:
Date:</td><td>Fax: 614-292-0218</td></tr>
<tr><td rowspan="3"><u>►Co-Investigator</u>

University Status:
☐ Faculty
☐ Staff
☒ Graduate Student
☐ Undergraduate Student
☐ Other. Please specify.</td><td>Name: Candice L. Lucak</td><td>Phone: 614-247-6831</td></tr>
<tr><td>Campus Address (room, building, street address) or Mailing Address:
110 Parker Food Science and Tech Building
2015 Fyffe Road
Columbus, OH 43210</td><td>E-mail:
lucak.2@osu.edu</td></tr>
<tr><td>Signature:
Date:</td><td>Fax: 614-292-0218</td></tr>
<tr><td rowspan="3"><u>►Co-Investigator</u>

University Status:
☐ Faculty
☐ Staff
☐ Graduate Student
☐ Undergraduate Student
☐ Other. Please specify.</td><td>Name:</td><td>Phone:</td></tr>
<tr><td>Campus Address (room, building, street address) or Mailing Address:</td><td>E-mail:</td></tr>
<tr><td>Signature:
Date:</td><td>Fax:</td></tr>
</table>

►Co-Investigator University Status: ☐ Faculty ☐ Staff ☐ Graduate Student ☐ Undergraduate Student ☐ Other. Please specify.	Name:	Phone:
	Campus Address (room, building, street address) or Mailing Address:	E-mail:
	Signature: Date:	Fax:
►Protocol Title	**Effectiveness of palate cleansers.**	
►Source of Funding	Self-funded	

For Office Use Only

☐ **Approved.** ►	Research has been determined to be exempt under these categories: _____. Research may begin as of the date of determination listed below.
☐ **Disapproved.** ►	The proposed research does not fall within the categories of exemption. Submit an application to the appropriate Institutional Review Board for review.

Date of determination: _____ **Signature:** _____

Office of Research Risks Protection

The purpose of the Application for Exemption is two-fold: (a) to determine whether the proposed research qualifies for exemption from review and continuing oversight by an Institutional Review Board; and, if so, (b) to ensure that the informed consent process protects the rights and welfare of human subjects in research. Please respond to the following questions and provide the requested documentation.

If you have questions about the application or review process, please contact Jane Kelsey, Office of Research Risks Protection. Phone: 292-6950 / Fax: 688-0366 / E-mail: kelsey.18@osu.edu

---

Please check the categories of exemption for which you are applying. The list of categories is located at the end of this application. You may check more than one box.

EXEMPT CATEGORY: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☒

SCREENING QUESTIONS: If you check YES to any of the questions below, your research is not exempt. Do not complete the exempt application. Submit an application to the appropriate Institutional Review Board for review.

Does any part of the research require that subjects be deceived?	Yes ☐	No ☒
Will research expose human subjects to discomfort or harassment beyond levels encountered in daily life?	Yes ☐	No ☒
Could disclosure of the subjects' responses outside the research reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation?	Yes ☐	No ☒
Will fetuses, pregnant women, human *in vitro* fertilization, or individuals involuntarily confined or detained in penal institutions be subjects of the study?	Yes ☐	No ☒
For research proposed under category 2, will research involve surveys, interview procedures, or observation of public behavior with individuals under the age of 18?	Yes ☐	No ☒
For research proposed under category 4, will any of the data, documents, records, pathological specimens, or diagnostic specimens be collected or come into existence after the date you apply for exemption?	Yes ☐	No ☒
For research proposed under category 4, will any of the information obtained from data, documents, records, pathological specimens, or diagnostic specimens that come from private sources be recorded by the investigator in such a manner that subjects can be identified directly or through identifiers linked to the subjects?	Yes ☐	No ☒

IF YOU HAVE CHECKED NO TO ALL OF THE QUESTIONS ABOVE, YOUR RESEARCH MAY BE EXEMPT. PLEASE CONTINUE WITH THE EXEMPT APPLICATION.

REMINDER: If you checked YES to any of the questions above, your research is not exempt.

For purposes of this application, "research" includes the recruitment of human subjects as well as data collection and analysis. None of these research activities may begin until the investigator has received a protocol number AND has received written concurrence that the proposed research is exempt. The "date of determination" on page one of this application is assigned by the Office of Research Risks Protection; it indicates the date when research may begin.

Please describe your study clearly and completely, using a style of language that can easily be understood by someone who is not familiar with your research.

GENERAL QUESTIONS REGARDING THE PROPOSED RESEARCH

1. **Describe the purpose of the research activity to be undertaken. Describe how it involves human subjects. Respond in the space provided here, or attach a research proposal and/or grant proposal containing the requested information.**

   ☒ **Research proposal attached.**
   ☒ **Description:** The purpose of the proposed research is to determine which palate cleansers, water, pectin, chocolate, table water crackers, warm water, and whole milk, if any are effective in cleansing a consumers palate during the interstimulus interval for a certain type of food category, astringency-tea, bitterness-coffee, fatty-smoked sausage, cooling-mints, heat/burn-Doritos black pepper chips, sweetness-very cherry jelly belly, and minimal linger-applesauce.

2. **Provide a brief description of the subjects you plan to recruit and the criteria used in the selection process. Indicate whether subjects are 18 years of age or older.**

   ☐ **My response is included in the research proposal that is attached.**
   ☒ **Description:** Subjects will be recruited from volunteers over the age of 18 who are not pregnant or nursing. They will be recruited based upon availability and upon willingness to participate in the assessment of water, pectin, chocolate, table water crackers, whole milk, smoked sausage, mints, tea, coffee, Doritos, very cherry jelly belly, and applesauce.

3. **Describe how the proposed research meets the criteria for exemption from IRB review and oversight. (Refer to the criteria on the last page of this application that correspond to the category or categories you checked on the screening sheet.)**

   ☐ **My response is included in the research proposal that is attached.**
   ☒ **Description:** This research meets the criteria outlined in category #6, which includes the sensory evaluation of food that contains ingredients, chemicals and contaminants at or below the level found to be safe by the FDA or approved by the EPA or FSIS of the USDA.

4. Will your subjects be recruited through schools, employers, and/or community agencies or organizations, and/or are you required to obtain permission to access data that is not publicly available? If the answer is yes, provide a letter of support from the person authorized to give you access to the subjects or to the data in question. More than one letter may be required.

☒ **Does not apply.**
☐ **Letter(s) attached.**
☐ **Letter(s) pending and will be provided when it is obtained.**
☒ **Comments:** Subjects will be recruited from persons proximate to the Parker FST Bldg and neighboring areas.

5. Describe the means you will use to obtain data. Check all boxes that apply.

☒ **Surveys or questionnaires distributed by mail or in person. I am attaching a copy of the instrument(s).** *Data will be collected via computer terminals set up in the Parker FST Building utilizing Compusense software. A paper version of the questionnaire is attached.*

☐ **Surveys distributed through the Internet, through listservs, or through E-mail.**
I am attaching a copy of the instrument(s). Provide the Internet address:

☐ **Interviews. I am attaching a copy of the interview questions.**
☐ **Focus groups. I am attaching a copy of the questions that will shape the discussion.**
☐ **Observation of public behavior.**
☐ **Observation of activities in school classrooms.**
☐ **Audiotapes. I will obtain consent from the subjects to tape their responses.**
☐ **Videotapes. I will obtain consent from the subjects to tape their activities or responses.**
☐ **Review of existing records, including databases, medical records, school records, etc. I am attaching a copy of the data collection sheet. I am recording information in such a manner that subjects cannot be identified directly or through identifiers linked to the subjects. All of the information in the records to be reviewed exists as of the date of submission of this application.**
☐ **Tissue specimens. All of the specimens have already been collected and are "on the shelf." I am recording information in such a manner that subjects cannot be identified directly or through identifiers linked to the subjects.**

6. Indicate the date when you plan to begin research, and the date when you anticipate that data analysis will be complete.

Begin date: 03/26/07 **End date:** 03/25/08

CONFIDENTIALITY

- **Investigators are required to protect the confidentiality of the information obtained during research, unless the subjects (a) explicitly agree to be identified or quoted, and/or (b) explicitly agree to the release of material captured on audiotapes or videotapes for use in presentations or conferences.**

7. Provide a brief description of the measures you will take to protect confidentiality. Please describe how you will protect the identity of the subjects, their responses, and any data that you obtain from private records or capture on audiotape or videotape. Describe the disposition of the data and/or the tapes once the study has been completed.

☐ **My response is included in the research proposal that is attached.**
☒ **Description:** No identifying information will be collected.

INFORMED CONSENT

- **In most cases, investigators are required to obtain informed consent from their subjects before collecting data. Respond to questions #8 and #9 to indicate how you will inform your subjects about the research and how you will obtain and document their consent.**
- **Subjects must be told what they will be asked to do if they agree to participate in research, how long it will take, and how you will protect the confidentiality of the information they provide.**
- **Subjects must be told that their participation is voluntary, they can refuse to answer questions that they do not wish to answer, and they can refuse to participate or they can withdraw at any time without penalty or repercussion.**
- **With few exceptions, written consent of the child's parent(s) or guardian(s) is required if subjects are under the age of 18. In addition, children 14 years of age or older should be asked to give written assent (agreement) to participate. Children younger than 13 years of age should be asked to give verbal assent (agreement) to participate.**
- **Provide a means for subjects to contact the investigator(s) if they have questions or concerns about the research. Make it clear to the subjects that you are affiliated with The Ohio State University.**

8. What information do you plan to give to your subjects before you ask for their consent? Use a style of language that simply and clearly explains the research to your subjects. Respond in the space provided here, or attach a

copy of the information you plan to provide to your subjects and/or their parents or guardians. (Note: if you use more than one method of recruitment, you may check more than one box)

☐ **Letter(s) attached. I will give each of the subjects a copy of this letter.**
☐ **I will be contacting subjects by phone or in person. I am attaching a script that**
contains the information I will give them.
☐ **Does not apply. My data analysis is limited to existing records or tissue specimens.**
☒ Response: The nature of the experiment is to evaluate tea, coffee, water, very cherry jelly belly, pectin, chocolate, mints, smoked sausage, Doritos, applesauce, and table water crackers. There will be a total of twelve sessions, 2 sessions per week for 6 weeks lasting 30 minutes. Panelists will be compensated at the end of each session with a Target gift card. These are the increments in order $2, $2, $2, $3, $3, $3, $4, $4, $4, $5, $6, and $10. The informed consent will be present at the beginning of the questionnaire.

9. How do you plan to document informed consent? Read all of the options before checking the appropriate boxes. (A sample consent form is attached to this application.)

☐ **The subjects are 18 years of age or older. Before collecting data, I will ask**
them to sign a written consent form. I am attaching a copy of the consent form.
☐ **The subjects are 18 years of age or older. Before collecting data, I will ask**
them to give verbal consent to participate in this research study.
☐ **The subjects are 18 years of age or older. I am distributing a survey or questionnaire to the subjects. They can choose whether or not they want to**
respond. I am requesting a waiver of written consent.
☐ **The subjects are <u>under</u> the age of 18. I am attaching a copy of the consent form that I will use to obtain consent from their parents or guardians and**
assent (agreement) from subjects who are 14 years of age or older.
☐ **Some of the subjects are 18 years of age or older, and some are younger than 18.**
I have checked more than one box above to reflect the methods I will use to
document informed consent.
☐ **Does not apply. My data analysis is limited to existing records or tissue specimens.**
☒ **Other. Please explain and provide justification for your request.** The subjects are 18 years of age or older. The data collection software will be programmed in order that subjects will read information regarding the nature of the experiment and then the informed consent statement. At the end of the statement they will be asked to check the appropriate box indicating consent before starting the experiment. Failure to check the 'YES' box will end the session.
☐ **Comments:**

CONSUMER PANEL

Welcome to Sensory Testing! (Protocol #2005E####)
Jeannine Delwiche, Principal Investigator

This study is designed to look at the effectiveness of palate cleansers on different food categories. For each sample, you will rate the overall intensity as well as other attributes such as sweetness, sourness, aroma, flavor, heat/burn, cooling, astringency, and mouth coating will be rated.

Your answers will be entered directly into the computer using the mouse and/or keyboard. This should take no more than 30 minutes but you may take as long as you need. Your responses will in no way be linked to your identity and you will be compensated with a Target gift card at the end. If you have any questions, please feel free to ask the attendant at any time.

If you wish to participate, please read the following statement and indicate your consent to participate.

INFORMED CONSENT STATEMENT

I understand the purpose, procedures and time requirements of this study. All questions have been answered to my satisfaction. I may withdraw at any time without penalty. I am 18 years of age or older. I am not pregnant and not nursing. I freely and voluntarily give my consent to participate by marking 'YES' below.

YES no

Please rinse with water twice.

Please rate the overall intensity of the sample on the following scale.

	Not at all								Very
515	□	□	□	□	□	□	□	□	□

Please rate the intensity of tea aroma of the sample on the following scale.

	None								High
515	□	□	□	□	□	□	□	□	□

Please rate the intensity of bitterness of the sample on the following scale.

	None								High
515	□	□	□	□	□	□	□	□	□

Please rate the intensity of astringency of the sample on the following scale.

	Not at all								High
515	□	□	□	□	□	□	□	□	□

Please rinse with the pectin solution once (palate cleanser).

Please rinse with water twice.

*The above procedure for sample 515 will be repeated twice.

Please rinse with water twice.

Please rate the overall intensity of the sample on the following scale.

	Not at all								Very
479	□	□	□	□	□	□	□	□	□

Please rate the intensity of smoky flavor of the sample on the following scale.

	None								High
479	□	□	□	□	□	□	□	□	□

Please rate the amount of mouth coating of the sample on the following scale.

	None								Very
479	□	□	□	□	□	□	□	□	□

Please rinse with the pectin solution once (palate cleanser).

Please rinse with water twice.

*The above procedure for sample 479 will be repeated twice.

Please rinse with water twice.

Please rate the overall intensity of the sample on the following scale.

	Not at all								Very
136	□	□	□	□	□	□	□	□	□

Please rate the intensity of mint flavor of the sample on the following scale.

	None								High
136	□	□	□	□	□	□	□	□	□

Please rate the intensity of cooling of the sample on the following scale.

	None								High
136	□	□	□	□	□	□	□	□	□

Please rinse with the pectin solution once (palate cleanser).

Please rinse with water twice.

*The above procedure for sample 136 will be repeated twice.

Please rinse with water twice.

Please rate the overall intensity of the sample on the following scale.

	Not at all								Very
924	□	□	□	□	□	□	□	□	□

Please rate the intensity of sweetness of the sample on the following scale.

	None								High
924	□	□	□	□	□	□	□	□	□

Please rate the intensity of sourness of the sample on the following scale.

	None								High
924	□	□	□	□	□	□	□	□	□

Please rinse with the pectin solution once (palate cleanser).

Please rinse with water twice.

*The above procedure for sample 924 will be repeated twice.

Please rinse with water once.

Please rate the overall intensity of the sample on the following scale.

	Not at all								Very
801	□	□	□	□	□	□	□	□	□

Please rate the intensity of cherry aroma of the sample on the following scale.

	None								High
801	□	□	□	□	□	□	□	□	□

Please rate the intensity of sweetness of the sample on the following scale.

	None								High
801	□	□	□	□	□	□	□	□	□

Please rinse with the pectin solution once (palate cleanser).

Please rinse with water twice.

*The above procedure for sample 801 will be repeated twice.

Please rinse with water twice.

Please rate the overall intensity of the sample on the following scale.

	Not at all								Very
378	□	□	□	□	□	□	□	□	□

Please rate the intensity of coffee aroma of the sample on the following scale.

	None								High
378	□	□	□	□	□	□	□	□	□

Please rate the intensity of bitterness of the sample on the following scale.

	None								High
378	□	□	□	□	□	□	□	□	□

Please rinse with the pectin solution once (palate cleanser).

Please rinse with water twice.

*The above procedure for sample 378 will be repeated twice.

Please rinse with water twice.

Please rate the overall intensity of the sample on the following scale.

	Not at all								Very
239	□	□	□	□	□	□	□	□	□

Please rate the intensity of cheese flavor of the sample on the following scale.

	None								High
239	□	□	□	□	□	□	□	□	□

Please rate the intensity of heat/burn of the sample on the following scale.

	None								High
239	□	□	□	□	□	□	□	□	□

Please rinse with the pectin solution once (palate cleanser).

Please rinse with water twice.

*The above procedure for sample 239 will be repeated twice

*The same procedure for all the samples will be repeated five more times, each time using a different palate cleanser: rinse with water 6 times, take a bit out of a table water cracker then rinse with water twice, take a sip of whole milk then rinse with water twice, rinse with warm water twice then room temperature twice, and take a bit out of the dove chocolate then rinse with water twice.

Please indicate your gender.

□ Male
□ Female

Please indicate your age category.

□ 18-20 years
□ 21-25 years
□ 26-35 years
□ 36-45 years
□ 46-55 years
□ 56-65 years
□ over 65 years

Department of Food Science and Technology
Sensory Science Group
110 Parker Food Science and Technology Building
2015 Fyffe Road
Columbus, OH 43210

Phone 614-247-6864
FAX 614-292-0218

(to be posted around Ag Campus and emailed to osufst and tastetest listservs)

CONSUMER PANEL

STUDY PARTICIPANTS NEEDED!!

Date: TBD
Time: TBD
Location: Parker 122 (Sensory Booths)

Dr. J. Delwiche, principal investigator, is seeking participants to evaluate tea, coffee, water, very cherry jelly belly, pectin, chocolate, mints, smoked sausage, Doritos, applesauce, and table water crackers. Participants will be asked to attend a total of twelve sessions lasting up to 30 minutes. There will be 2 sessions per week for 6 weeks. Participants will be compensated at the end of each session with a Target gift card. The following are the gift card increments in order $2, $2, $2, $3, $3, $3, $4, $4, $4, $5, $6, and $10. Participants must be 18 years of age or older, not pregnant and not nursing.

For additional information, please contact Candice Lucak at 7-6831 or Lucak.2@osu.edu

Project: FOOD 1 - TEA Design

Plan:

Description:	All Possible Permutations
Type:	Quantitative Descriptive
Samples:	3
Presented:	3
Blocks:	6 [Base Block]
X	5 [Factor]
=	30 [Entire Block]

Options:

Blinding Codes:	Constant
Sample Randomization:	No
Block Randomization:	No
Registration:	Panelists Must Register
Sample Set Distribution	Bind Sample Sets to Panelists

Sessions:

Number of Sessions:	1

Samples:

Sample Number	*Product Code*	*Product Name*
1	1	TEa
2	2	TEa
3	3	TEa