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The Influences of Kokumi on Emotions and Satisfaction

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THE INFLUENCES OF KOKUMI ON EMOTIONS AND SATISFACTION

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An Abstract of the Thesis Presented
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Kokumi is a Japanese flavor profile that has been hailed as the sixth basic taste. Foods with kokumi are perceived as thick in consistency, rich in flavor, and well balanced with good mouthfeel. Kokumi can be found in many foods. Kokumi substances enhance mouthfulness and complexity and induce a long-lasting flavor. The calcium-sensing receptor (Ca-SR) is involved in the perception of kokumi. Kokumi compounds directly activate the Ca-SR. When activated, the Ca-SR can regulate satiety and modulate appetite, leading to the perception of a richer-tasting product and additionally, a more satisfying product. Moods and emotions also influence our food choices, and food choices can, in turn, influence moods and emotions. In this study, we examined the influence of kokumi substances on emotions.

Tomato soup was chosen as the test food for kokumi enhancement because it is a familiar food product. Campbell's® canned tomato soup was prepared according to the manufacturer's instructions. Komi™ powder (Nikken Foods USA, Inc.) was added to half of the soup to make a concentration of 0.6% Komi on a weight basis. Instrumental color and viscosity measures were made on both types of soup (0 and 0.6% Komi) from triplicate batches.

A series of sensory evaluation tests were performed. First, a triangle test was conducted to determine whether consumers could detect overall differences between the two kokumi concentrations. The sensory panelists were then given a sample of each soup coded with different three-digit numbers and asked to pick which sample they preferred. A third test investigated the acceptability of the two kokumi concentrations in tomato soup using a nine-point hedonic scale; panelists also completed demographic questions, the EsSense 25 questionnaire and the Dutch Eating Behavior Questionnaire restrained eating scale (DEBQ-R).

Twenty of the 34 panelists in the triangle test correctly identified the different sample, which was significant at $p \leq 0.01$. Equal numbers of panelists selected each kokumi level as preferred, so there was no significant difference in the paired reference test. One hundred consumers took part in the hedonic test, and 72% were female. Soup samples received mean hedonic scores of 7.0 and 6.8 for taste and overall liking respectively. The control soup had a higher liking for thickness than did the 0.6% kokumi sample (6.6 versus 6.1, $p \leq 0.05$). Soup type did not have a significant effect on any emotion category. The median restrained eating score was 26, and panelists of both genders had mean scores similar to the median.

These results could have resulted from the type of soup used in the study, the amount of kokumi, the length of the test, and panelist error. The test consisted of many questions and could have fatigued panelists. Further research is needed to determine optimal kokumi levels and foods for enhancement, and whether long-term consumption of foods with kokumi lead to great consumer satisfaction.

DEDICATION

This thesis is dedicated to my Nana who instilled my love of food. You were the spark that lit the fire that became my passion for food.

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First, I would like to thank my advisor, Dr. Mary Ellen Camire, who has provided her guidance, support, and encouragement to help me to improve as a researcher throughout this project. I would like to thank Dr. Denise Skonberg and Dr. Jennifer Perry for their guidance as committee members. I want to give a huge thank you to Zachary Bonelli, Emily Duran-Frontera, Wenshu He, Samantha Newton, Laurel Simone, and Rosanna Woodruff for all their help and support on this project. I would like to thank Peter Graf of Nikken Foods USA for donating the Komi Powder that was used in the study.

Thank you, Mom and Dad, for all that you have ever done for me. Thank you for all the sacrifices you have made to get me to where I am. Words cannot describe how grateful I am. Most of all thank you for all the support.

Thank you to the best big sister a girl could ask for! I could not have gone through this process without all of your help and support. Thank you for making me believe in myself.

Last but certainly not least, the most important thank you goes to my Nana. Thank you, Nana, for giving me my passion for food and being my first cooking show. You have been inspiring me since that first day I sat in your kitchen and watched you cook your masterpieces.

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CHAPTER 1: INTRODUCTION

Childhood and adult obesity rates have been increasing over the past few years. In the U.S., according to the Centers for Disease Control (CDC), 39.8% of adults and 18.5% of children and adolescents are obese (U.S. CDC, 2018). Though obesity rates seem to be leveling out, obesity is still a major health problem nationally and internationally. The increase in overweight and obese people worldwide in 2014 was over 2.1 billion, up from 857 million in 1980 and there is a 28% increase among adults and a 47% increase among children (Ng et al., 2014). The more significant problem of obesity is the successive health problems that it can cause. Lakerveld and Mackenback (2017) found that health and mortality effects of the obesity epidemic could be an ongoing problem for years to come and decrease U.S. life expectancy. Obesity has caused more than 3.4 million deaths, 4% of Years of Life Lost (YLL), and at least 4% of Disability-Adjusted Life Years (DALYs) globally (Djalalinia et al., 2015).

Obesity affects physical, mental, and social health. Physically obesity can lead to cancers, Type 2 diabetes, hypertension, stroke, coronary artery disease, congestive heart failure, asthma, chronic back pain, osteoarthritis, pulmonary embolism, gallbladder disease, and also an increased risk of disability (Collier, 2011). From a mental health perspective, obesity can lead to low self-esteem, mood disorder, eating disorders, impaired body image, interpersonal communication problems, sexual health issues, and decreased quality of life. All of these conditions can have drastic effects on one's social health leading to stigma, discrimination, ridicule, social bias, rejection, and humiliation. Kokumi could be added to diet food or any food and aid in portion control leading to weight loss and better eating habits. If the food was

perceived as richer and more satisfying, people This perception could make healthier food, which has a stigma of not tasting good, be more flavorful. Another major health problem is reduced appetite in older adults. As people get older, they are more likely to have chronic diseases, decreased functional ability, or cognitive decline and disability (van der Meij et al., 2015). Undernutritiois a serious health issue affecting older adults that can lead to bone and muscle weakness, immune deficiencies, prolonged hospitalization, diminished quality of life, increased mortality risks, and other problems (Agarwal et al., 2013; van der Meij et al., 2015). Nutritional strategies are needed to increase consumption of the foods that may prevent or delay the onset of these conditions and promote healthy aging. Healthy aging requires improved nutrition. Inadequate macro- and micronutrient intakes are frequent in older adults (van der Meij et al., 2015). To combat this issue, Baugreet, Hamill, Kerry, and McCarthy (2017) have suggested that enriching foods with functional ingredients, vitamins, and minerals can enhance the nutritive value of individual portions of food.

There is an urgent need for foods that are high in macro- and micronutrients as well as having good appearance, taste, flavor, texture, and consistency for older adults. Foods for older adults should contain combinations of flavors and nutrient-dense products like meat, cereal, and dairy (Baugreet et al., 2017). These researchers also suggested adding natural ingredients that are rich in umami taste. Since we lose our sense of taste as we age, the addition of kokumi to any food might make it more flavorful so people can enjoy eating and eat more healthfully. Thus, they can eat more fruits, vegetables, meat, dairy, and other foods and depend less on nutrient supplement drinks which can contain less healthful ingredients. Kokumi also intensifies flavors of food as well as increasing perceived richness and satiety, possibly leading to healthful, good tasting, and satisfying meals for older adults. There is relatively little

consumer research published on kokumi and its affects on food acceptance. Most research is focused on what kokumi is and if people can perceive it but not how it aaffects satiety. Research is lacking on whether kokumi truly affects consumers like making them feel more satisfied or feeling fuller after consumption. Kokumi could be very beneficial, but there are research gaps like its effects on satiety and emotions, types of food that it can be added to, serving size, and other facots that need to be explored.

CHAPTER 2: LITERATURE REVIEW

2.1 Kokumi

Kokumi is a Japanese flavor profile and sensorial experience. The literal translation for kokumi is rich (*koku*) taste (*mi*). Kokumi has been reported since 1990 as the sixth basic taste. The most well-known basic tastes are categorized as sweet, salty, sour, bitter, and umami (Kohyama, 2015). Foods that are thick in consistency, rich in flavor, and well-balanced with good mouthfeel can be characterized as kokumi (Kohyama, 2015). Kokumi is defined as substances that enhance mouthfulness and complexity, thereby inducing a long-lasting savory taste. However, these substances lack perceivable taste (Kohyama, 2015). Kokumi and umami are similar in that they are both taste enhancers and kokumi can also enhance umami flavors. The difference between the two taste sensations are the substances that cause each flavor profile. Umami is primarily caused by the amino acid glutamate, and ribonucleotides and kokumi sensations can be caused by peptides, calcium, protamine, glutathione, and L-histidine. Kokumi can be found in foods like cheese, milk, scallops, yeast, beans, garlic, and onions (Kuroda and Miyamura, 2015; Liu et al., 2015).

2.2 Kokumi-Containing Substances

Early studies on kokumi found that a water extract of garlic (*Allium sativum* L.) being added to common Asian soups in small amounts (0.1- 0.4% w/w) showed characteristics of kokumi flavors (Ueda et al., 1990). Ueda, Sakaguchi, Hirayama, Miyajima, and Kimizuka

(1990) found that the addition of the extract significantly strengthened the intensity of the kokumi flavor. The kokumi flavors in the garlic were found to come from the sulfur-containing constituents and alliin (Ueda et al., 1990). Sulfur-containing compounds had no taste themselves but released the flavors when dissolved in soups. Ueda, Tsubuku, and Miyajima (1994) conducted a study with a water extract of onion and found that the sulfur-containing compounds also enhanced kokumi flavor. In particular, *trans*(+) S-propenyl-L-cysteine sulfoxide (PeCSO) and its glutamate peptide (γ-Glu-PeCSO) exhibited kokumi flavors (Ueda et al. 1994).

Glutathione and several γ-glutamyl-peptides including ophthalmic acid (L-γ-glutamyl-L-α-aminobutyrylglycine (γ-Glu-α-aminobutyryl-Gly), L-γ-glutamyl alanine (γ-Glu-Ala), L-γ-glutamyl valine (γ-Glu-Val), L-γ-glutamyl cysteine (γ-Glu-Cys), and L- γ-glutamyl-valyl-glycine (γ-Glu-Val-Gly) are kokumi peptides (Ohsu et al. 2010). Miyamura, Iida, Kuroda, Kato, Yamazaki, & Muzukoshi (2014) quantified γ-Glu-Val-Gly in several kinds of fermented shrimp paste condiments and found that it enhanced kokumi flavor. An eighteen-person descriptive panel rated chicken consommé containing 5 ppm γ-Glu-Val-Gly as having significantly stronger umami, mouthfulness, and mouth coating than the control sample (Miyaki et al., 2015). This finding suggests that γ-Glu-Val-Gly can improve the flavor and mouthfeel of chicken consommé, and may improve the quality of other food products. Kokumi is a beneficial addition to low-fat foods by enhancing the flavor and perceived texture. The addition of the kokumi peptide γ-Glu-Val-Gly significantly enhanced the intensities of thick mouthfeel, aftertaste, and oiliness in reduced-fat peanut butter (Miyamura et al., 2015b). Peanut flavor was not affected by the addition of the peptide.

Kokumi substances can be found in many food and beverage products. The γ-Glu-Val-Gly peptide was found at higher concentrations in fermented foods such as fish sauces, soy sauces, and fermented shrimp paste than in scallop foods (Miyamura et al., 2014). Miyamura, Kuroda, Kato, Yamazaki, Mizukoshi, Miyano, and Eto (2015a) identified and measured γ-Glu-Val- Gly in various brewed alcoholic beverages. Hillmann and Hoffman (2016) studied tastants in parmesan cheese and identified 31 primary tastants with dose over threshold factors equal to or above 1.0; 15 kokumi-enhancing γ-glutamyl peptides, including γ-Glu-Gly, γ-Glu-Ala, γ-Glu-Thr, γ-Glu-Asp, γ-Glu-Lys, γ-Glu-Glu, γ-Glu-Trp, γ-Glu-Gln, and γ-Glu-His were identified at levels below thresholds for those compounds.

2.3 Perception of Kokumi

The human tongue is covered in papillae, which each containing one to one hundred taste buds. These taste buds hold 50 to 150 receptors (Chandrashekar et al., 2006; Brennan et al., 2014), which can perceive the well-established tastes of sweet, salty, sour, bitter and umami in addition to kokumi. Tastants are detected by the taste bud by entering through the taste pore and interacting with the taste receptors (Bailly et al., 2012; Ataseven et al., 2016). The receptor activates nerve fibers, which send signals to the brain, initiating the sensation of tasting. Each of the basic tastes has a receptor that signals a particular taste (Bailly et al., 2012; Ataseven et al., 2016).

Recent research has shown that the calcium-sensing receptor (Ca-SR) is involved in the perception of kokumi substances (Chaudhari and Roper, 2010; Demos et al., 2011; Geisler et al., 2016). The calcium-sensing receptor is a class C G-protein- coupled receptor consisting of 1078 amino acids in humans and plays a central role in extracellular calcium homeostasis in

mammals (Chaudhari and Roper, 2010; Demos et al., 2011; Geisler et al., 2016). Kokumi compounds may directly activate the Ca-SR expressed on the surface of taste cells and subsequently signal the brain via the central nervous system as well as in different organs/systems of the body to signal a taste. The Ca-SR cells are a different subset of cells from the T1R3-expressing umami or sweet taste receptor (Coetzee and Taylor, 1996). When activated, the Ca-SR can regulate satiety and modulate appetite (Amino et al., 2016). As shown by Maruyama and colleagues (2012), the kokumi-sensing cells are separate from the cells that sense sweetness and umami. The Ca-SR has a functional kokumi receptor attached. Through sensory testing, it was found that kokumi enhances sweet and umami flavors. Kokumi substances are glutamate peptides and may have a relationship to monosodium glutamate (MSG). More research is needed to determine this relationship, and if kokumi has similar physiological side effects to MSG. MSG is the sodium salt of L-glutamic acid (Glu) and is used as the first umami flavor (Populin et al., 2007). The free form of Glu, in its L-configuration, has flavor-enhancing properties, which is why it is used as a flavor enhancer in the food industry in the form of MSG. MSG can be added as yeast extracts or hydrolyzed proteins, since both containing high percentages of Glu (Populin et al., 2007).

The CaSR–activity's connection to several γ-glutamyl peptides was related to the physical conformation of those peptides (Amino et al., 2016; Amino et al., 2018). Seventeen trained sensory panelists assessed varying concentrations of γ-glutamyl peptides that were prescreened for potential kokumi effects by the CaSR activity assay. Several α- and γ-glutamyl peptides had flavor-modifying effects, and their strength varied according to composition and also CaSR activity (Amino et al., 2016; Amino et al., 2018).

2.4 Emotions and Food Choices

Today, food choices can be related to the emotions these products evoke more than basic survival needs (Gutjar et al., 2015a). Moods and emotions influence our food choices, and food choices can influence moods and emotions. Köster and Mojet suggested that these relationships involve complex physiological factors such as hunger, satiation, physiological reward mechanisms, age, memory, habit formation, and emotional coping mechanisms (Köster and Mojet, 2015) (Figure 2.4.1). Memories evoked by eating something may have strong links to significant and special moments that people have experienced at some point in their lives. Slight changes in the food, such as the addition of another ingredient or a change in texture, can be consciously detected and lead to a pleasant surprise or may evoke feelings of disappointment and dissatisfaction (Köster and Mojet, 2015).

There is no consensus for definitions of mood and emotion. Emotions have multiple components, including physiological arousal, motivation, expressive motor behavior, action tendencies, and subjective feeling (Spinelli et al., 2014). According to Gibson (2006), emotions can be defined as temporary responses to a particular event, and they can be strengthened, whereas moods are psychological states that last longer and are related to experiences like pleasure and tension.

In sensory science, “liking” (acceptance) has been the main tool used to understand the preference and food choice patterns of the consumer. Hedonic scales are used to understand the degree of liking, which differs from one consumer to another. So, to understand this food liking, many researchers use a 9-point scale that has different degrees of liking from like extremely to dislike extremely (Peryam and Pilgrim, 1957).

However, recent studies have proposed that food choice can be partly based on the

emotions evoked by the food. Spinelli and colleagues (2014) suggested that product perception is facilitated not only by emotions but also by the preferences and the nature of the subjects, their moods, and attitudes and by the feelings related to the product. Emotions can be associated with a product by the brand or by specific sensory properties like sweetness (Spinelli et al., 2014).

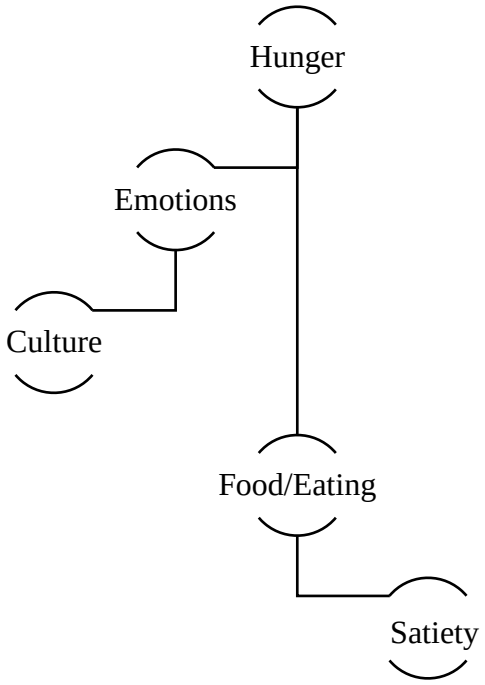

Figure 2.4.1. Influence of Food, Physiology, and Culture on Satiety and Emotions.

2.4.1 Measuring Emotions

The techniques currently used to measure emotions are physiological methods, facial recognition methods, verbal self-reporting, and visual self-reporting. Physiological methods capture the biological responses that indirectly accompany emotions, and include skin conductance and electromyography (EMG) techniques. Skin conductance measures electrodermal activity activated by emotions through the skin conductance response (SCR)(Kenney and Adhikari, 2016). Physiological methods are designed to look into the biological responses that accompany emotions. These methods include cardiovascular responses such as heart rate and blood pressure, respiratory responses like respiration rate, electrodermal responses such as skin conductance response and skin conductance level, brain responses like frontal alpha asymmetry, and pupillary responses like pupillary reflex where the pupil may dilate when pleasant items are presented (Gibson, 2006). Facial electromyography (EMG) detects the movements of two facial muscles, the corrugator muscle, which is related to positive emotions and the zygomatic muscle, which is related to negative emotions. EMG detects micro-emotional responses that make muscles tense or relax (Kenney and Adhikari, 2016). Facial recognition uses video recordings to analyze facial muscle movements in order to understand emotions being evoked. Facial recognition measures specific expressive reactions, such as facial expression, that accompany emotions (Gibson, 2006).

Questionnaires are a common method to evaluate emotional responses to foods and other consumer products. Participants are asked to rate emotions presented as terms or questions. The most well-known validated questionnaire is the EsSense Profile® which is

constructed from lists of words selected for describing emotional or feeling responses to food (Kanjanakorn and Lee, 2017).

Visual methods measure individual feelings using images instead of words to represent different emotions. Using images can be useful because it limits the rational thought process that is needed to understand verbal signals. The Self-Assessment Manikin (SAM) was the first visual method developed, with three factors, Pleasure, Arousal and Dominance (PAD), which are rated on a nine-point pictorial scale (Bestgen et al., 2015). For the pleasure scale, the figures range from smiling and happy to frowning and unhappy; the arousal scale consists of figures that range from excited and wide-eyed to relaxed and sleepy, and the dominance scale consists of figures that range from a small to a large figure (Bestgen et al., 2015). Another method is the Product Emotion Measurement Instrument (PrEmo®), with seven positive and seven negative emotions shown as animated cartoon pictures (He et al., 2016). Liking scores were only related to the valence (how good or bad) or pleasantness (enjoyment) element of emotions, not to the arousal element (He et al., 2016). Although advantageous over the verbal method, PrEmo has a low number of positive emotions and it has not been specifically modified for food-evoked emotions, which may lead to less sensitivity to differentiate between food products (He et al., 2016).

The evaluation of food-induced emotion profiles goes beyond hedonic evaluations in explaining and gauging actual food choice behaviors (Gutjar et al., 2015b). Another visual method is Image Measurement of Emotion and Texture (IMET); in this test, panelists are asked to create their own My Pictures board with images they select to represent 12 different emotions (Collinsworth et al., 2014). Panelists selecting their own images or being presented with an array of images showed less variability in responses than by just using the emotional

words questionnaires (Collinsworth et al., 2014). This test is used to evaluate the differences in emotions and texture, as well as to measure emotions naturally. The emotive projection test is another visual method in which panelists rate photographs of people for six positive and six negative personality traits after eating a food product (Mojet et al., 2015). The twelve personality traits are presented in a random order and are rated on a 7 point scale from not at all applicable (left) to very much applicable (right) (Mojet et al., 2015). The emotive projection test shows the differences in the relationship between eating and emotional feelings towards people (Mojet et al., 2015).

The EsSense 25 scale (Kanjanakorn and Lee, 2017) has been widely used. Panelists are given a sample and a list of emotions which they are asked to rate based on how they are feeling at that moment. The scale goes from "not at all" to "extremely," as shown in Table 2.4.1. The EsSense Profile contains 39 emotions and has been used recently in more research projects. Terms that consumers most clearly understood and related to food were differentiated as positive or negative (Kanjanakorn and Lee, 2017). Nestrud and colleagues (2016) found that using the 25-question version of this test did not change ratings in most cases, but important shifts in meaning occurred. The researchers concluded that results should not be compared across emotion lists. EsSense Profile incorporates emotion using a 5-point scale. Consumers typically view eating and tasting food as a positive and pleasurable experience (Kanjanakorn and Lee, 2017). Thus, researchers were not sure that one complete list of emotions would cover all types of food, but suggested that the EsSense Profile was a good starting point to study emotions and food (Kanjanakorn and Lee, 2017).

Table 2.4.1. The EsSense 25 Scale for Emotion Measurement[a]

Feeling	Not at all	Slightly	Moderately	Very	Extremely
Happy					
Pleasant					
Good					
Enthusiastic					
Joyful					
Interested					
Satisfied					
Free					
Good-natured					
Active					
Calm					
Tame					
Nostalgic					
Loving					
Understanding					
Mild					
Warm					
Secure					
Aggressive					
Adventurous					
Wild					
Guilty					
Worried					
Bored					
Disgusted					

[a] Source: Kanjanakorn and Lee, 2017.

2.4.2 Restrained Eating

Restrained eating is the term used to describe when a person restricts food intake intentionally to prevent weight gain or to lose weight. Restrained eating is related to obesity and total energy intake, and can lead people to become habitual dieters. Kemps and colleagues (2016) suggested that when restrained eaters are exposed to the sight, smell, or taste of high-calorie foods, those cues increase food intake. People prone to overeating or with weight control issues have stronger preferences for high-calorie food than do healthy-weight individuals who are not restrained eaters (van Koningsbruggen et al., 2013). Less impulsive restrained eaters who can gain self-control may be able to develop links between temptations and thoughts of dieting which helps them be effective restrained eaters.(van Koningsbruggen et al., 2013). Exposure to pleasant food stimuli activates a positive relationship to food which makes it easier for restrained eaters to control weight. Bailly et al. (2012) showed that restrained eating behavior in older people is important because this demographic group is aware of their food consumption, and malnutrition is a problem for some older adults. Malnutrition may occur in 29%–61% of the elderly population and the incidence of malnutrition increases with advanced age (Siddique et al., 2017). Diabetes, cholesterol and other common diseases that occur in older adults can also lead to restrained eating behavior (Bailly et al., 2012), thus being linked to a need to remain healthy.

There are three commonly-used restrained eating scales: the restraint scale (RS), the Dutch Eating Behavior Questionnaire (DEBQ-R), and the Three-Factor Eating Restraint (TFEQ-R). The restraint scale measures a range of chronic dieting behaviors and consists of two scales- dieting and weight fluctuations (Boyce et al., 2015). In comparison, the other two restraint scales solely measure dietary restriction. The restraint scale was not designed for

measuring dietary restriction but is being used that way nevertheless (Boyce et al., 2015). The original RS version was a five-item questionnaire, which then became an 11-item version then finally into a 10-item version (Boyce et al., 2015). Limitations of the RS scale include items that are not simple, and there is an apparent lack of agreement on the importance of dieting and weight fluctuation for weight suppression and overeating (Boyce et al., 2015). The three-factor eating restraint was used to measure mental and behavioral factors of eating in overweight populations. The TFEQ-R questionnaire consists of 51 items, divided into three scales: "Cognitive Restraint," "Disinhibition," and "Hunger" (Anglé et al., 2009). The scale is now an eighteen-item questionnaire that is reportedly easy and clear to the panelists, and able to differentiate among different eating patterns (Anglo et al., 2009). The Dutch Eating Behavior Questionnaire (DEBQ) includes a 10-item scale for restrained eating (Bailly et al., 2012). Panelists are also asked about how they feel when eating. The scale ranges from “never” to “very often” as shown in Appendix F. The DEBQ is a widely used tool for the evaluation of emotional, external and restrained eating. The DEBQ test consists of 33 items that represent three separate scales: (a) Emotional Eating,; (b) ten External and (c) the 10-item Restrained Eating scale” (Bailly et al., 2012). The questionnaire is shown in Table 2.4.2 The DEBQ is the most widely used scale for restrained eating and has good reliability and validity (Bailly et al., 2012). The assessment of the DEBQ restrained eating scale showed the highest values for consistency and had the most constant factor structure across weight categories, sexes, and random samples (Coetzee and Taylor, 1996)

Table 2.4.2. Dutch Eating Behavior Questionnaire [a]

Restrained Eating
1. If you have put on weight, do you eat less than you usually do? 2. Do you try to eat less at mealtimes than you would like to eat? 3. How often do you refuse food or drink offered because you are concerned about your weight? 4. Do you watch exactly what you eat? 5. Do you deliberately eat foods that are slimming? 6. When you have eaten too much, do you eat less than usual the following days? 7. Do you deliberately eat less in order not to become heavier? 8. How often do you ty not to eat between meals because you are watching your weight? 9. How often in the evening do you try not to eat because you are watching your weight? 10. Do you take into account your weight with what you eat?
Emotional Eating
11. Do you have the desire to eat when you are irritated? 12. Do you have a desire to eat when you have nothing to do? 13. Do you have a desire to eat when you are depressed or discouraged? 14. Do you have a desire to eat when you are feeling lonely? 15. Do you have a desire to eat when somebody lets you down? 16. Do you have a desire to eat when you are cross? 17. Do you have a desire to eat when you are approaching something unpleasant to happen? 18. Do you get the desire to eat when you are anxious, worried or tense? 19. Do you have a desire to eat when things are going against you or when things have gone wrong? 20. Do you have a desire to eat when you are frightened? 21. Do you have a desire to eat when you are disappointed? 22. Do you have a desire to eat when you are emotionally upset? 23. Do you have a desire to eat when you are bored or restless?
External Eating
24. If food tastes good to you, do you eat more than usual? 25. If food smells and looks good, do you eat more than usual? 26. If you see or smell something delicious do you have a desire to eat it? 27. If you have something delicious to eat, do you eat it straight away? 28. If you walk past the baker do you have the desire to buy something delicious? 29. If you walk past a snack bar or a cafe, do you have the desire to buy something delicious? 30. If you see others eating, do you also have the desire to eat? 31. Can you resist eating delicious foods? 32. Do you eat more than usual, when you see others eating? 33. When preparing a meal are you inclined to eat something?

[a] Bailly et al., 2012.

Allison and colleagues (1992) compared the three restraint scales and recommended the DEBQ's restraint scale for reliability and factor structure (Allison et al., 1992). However, if there is any concern that panelists might not be answering questions honestly or that there is a lack of sensitivity, then the three-factor scale is recommended because it is a less sensitive measure (Allison et al., 1992). Only the three-factor scale has items that are scored both positively and negatively. The restraint scale is slightly related to caloric intake and moderately to strongly related to scales from the Eating Disorder Inventory, the Body Shape Questionnaire and measures of relative weight and weight fluctuation (Allison et al., 1992). The restraint scale does not constantly predict whether a person tends to eat more after recently eating (counterregulatory eating). However, RS predicts counterregulatory eating only under certain circumstances (Allison et al., 1992).

Wu, Cai, and Luo (2017) found that the three DEBQ subscales showed acceptable consistency. This finding suggests that each subscale contributed to the subscale's discriminative power. The researchers also found that the DEBQ is effective in the evaluation of eating behaviors. Dutton and Dovey's (2016) study found that the DEBQ was able to distinguish between groups and proved to be a psychometrically-sound test for evaluating eating behavior.

2.5 Sensory Evaluation Methodology

2.5.1 Difference Testing

Difference tests are conducted to determine if a perceptible difference exists among samples for a specific attribute or overall (Ennis et al., 2014b). Several difference test options are available. In the 2-Alternative Forced-Choice (AFC) or paired comparison test, panelists are given one sample of X and one sample of Y and are asked to choose the sample that is stronger for the specific attribute (McClure and Lawless, 2010). In this test, the panelist is asked to focus on a specific attribute, and they have to select the product from the pair that has more of that attribute. For the 3-AFC test, panelists are given two samples that are the same and one that is different (Ennis et al., 2014b). Self-defined 2-AFC tests are more sensitive than 3-AFC because of fewer stimuli, taste adaptation, and effects of the sequence of the test (McClure and Lawless, 2010). In these tests, panelists are generally asked to select the sample that is strongest in one particular characteristic (McClure and Lawless, 2010). These tests could be more practical than the triangle and duo-trio tests because participants do not need to taste the samples many times (McClure and Lawless, 2010). However, these tests are not suitable for overall difference assessment when the type of difference among samples is not known.

In 4-AFC, panelists are given three samples that are the same and one that is different (Ennis et al., 2014a). They are asked to pick the sample that has the most of the particular attribute that is being studied, like which sample is the sweetest. The advantage of AFC tests is that panelists are asked to focus on a particular attribute as opposed to the variability of the triangle procedure which has panelists choose the odd sample out based on overall differences (McClure and Lawless, 2010). The disadvantage of these tests is that an estimate

of the difference between the products needs to be determined before the test (McClure and Lawless, 2010).

The Tetrad test presents panelists with two samples from one group and two from another group of samples in a random presentation (Ennis et al., 2014a). The panelists are then asked to match the members of each pair. The probability of correctly sorting both pairs is 1 out of 3 (Burns et al., 2018). The advantage of this test is that it is good for equivalence or intensity-related tests (Ennis and Christensen, 2014). However, having four samples could lead to panelist fatigue, which could make the panelists less sensitive to differences in the samples. The duo-trio test, in which panelists are given a reference sample with two test samples, requires panelists to select which sample is most similar to the reference (Ennis et al., 2014b). The advantage of the duo-trio test is that the reference sample that is presented to the panelist, which helps the panelists know what to look for (Ennis and Christensen, 2014b). A disadvantage is that three samples, rather than two, must be tasted which adds some confusion for the panelists (Ennis and Christensen, 2014b).

Preference tests are a version of the 2-AFC test. Panelists are given two samples and asked to pick the one they prefer. This test has two versions, one that gives the no preference option and one that does not (Christensen et al., 2014). Providing a "no preference" option may be helpful if researchers are unsure whether either sample type is actually acceptable. A no preference answer might erroneously be interpreted that samples are liked similarly. O'Mahony and Wichchukit (2017) concluded that forcing sensory panelists to select the sample that they prefer might be the best strategy. Forced choice preference tests are analyzed with simple binomial statistics, but the inclusion of a no preference answer makes calculations of significance more challenging.

The triangle test is the name commonly used for overall difference tests involving three samples (O'Mahony, 1995). During the triangle test, a panelist is given three samples- two of the same samples, and one is a different sample- and asked to choose which sample is different. In another version of the test, panelists are asked to pick the two samples that are the same (O'Mahony, 1995). In some cases, panelists are told to detect differences in a specific attribute. For samples X and Y, there are six possible combinations that should be randomized across all panelists so that equal numbers of persons receive two samples of X and Y. In a triangle test, the probability of a correct answer by chance is 1/3, and the probability of choosing an incorrect answer by chance is 2/3 (Meilgaard et al., 2007). This test is easy to use but has a few limitations. One limitation is stimulus error if there are noticeable differences which cause bias among the panelists. Other limitations include the samples not being similar in size, shape, or amount served. Statistical analysis for difference tests includes chi-squared tests and the probability of correct answers.

2.5.2 Acceptability Testing

The most commonly used test for acceptability is the 9-point hedonic scale (Wichchukit and O'Mahony 2015). The scale typically ranges from extreme dislike (=1) to extreme like (=9) (Table 2.5.1). The scale was developed by the U.S. Army Quartermaster Food and Container Institute in the 1940s and 1950s to aid in menu planning for soldiers in their canteens (Kalva et al., 2014; Wichchukit and O'Mahony, 2015). The scale was discussed by Peryam and Girardot (1952), Peryam and Pilgrim (1957), and Peryam et al. (1960). The scale was further developed based on work by Jones and Thurstone (1955) and Jones et al. (1955), using techniques from Edwards (1952) (Wichchukit and O'Mahony 2015). Panelists can be given up

to five samples and asked to taste one sample at a time from left to right. The panelists are asked to rate attributes for the liking of flavor, texture, color, and overall liking for each sample (Kalva et al., 2014). However, scientists are moving away from using acceptability tests alone to assess acceptability because there are other factors that consumers consider when purchasing products such as emotions and memories related to a certain product or brand (Gutjar et al., 2015b).

The scale can be presented as words only or numbers only to panelists (Wichchukit and O'Mahony 2015). Words-only version may be interpreted differently from the numerical scale ((Wichchukit and O'Mahony 2015). Another version of the hedonic scale is the face scale which is used for children or people whose reading comprehension skill set is not very strong (Stone et al. 2012). The scale consists of pictures or cartoons that express faces ranging from smiles to frowns and could have five, seven, or nine categories. The pictures might have phrases or descriptions attached to them as well as number ratings. Another type of scale used to measure food liking is the labeled affective magnitude (LAM) scale which uses a grouping scale that has ratio scale characteristics so liking expressions are placed along a line in a ratio relationship (Stone et al. 2012). The just-about-right (JAR) scale measures how popular a specific attribute is and can be used with hedonic scales to identify the ideal quantities of attributes in a product (Xiong and Meullenet 2006). The JAR scales have five or seven categories starting with "too little" and ending with "too much." The mid-point of the scale is categorized as "just right" or "just about right" (Xiong and Meullenet 2006). The JAR scale is recommended for consumer tests but is not useful for descriptive tests.

Table 2.5.1: The Nine-Point Hedonic Scale[a]

Hedonic Rating	Liking Score
Dislike Extremely	1
Dislike Very Much	2
Dislike Moderately	3
Dislike Slightly	4
Neither Like Nor Dislike (Neutral)	5
Like Slightly	6
Like Moderately	7
Like Very Much	8
Like Extremely	9

[a] Peryam and Pilgrim (1957).

2.6 Research Objectives and Hypotheses

2.6.1 Research Objectives

The first objective was to determine the amount of kokumi that was detectable in a familiar food, canned tomato soup. Additional objectives included testing whether added kokumi improves soup acceptability and whether kokumi can influence consumer emotion in a laboratory setting.

2.6.2 Hypotheses

1. Small amounts of added kokumi will be detectable.

2. Consumers will like tomato soup with added kokumi more than plain soup.

3. Consumers will develop greater positive emotions after consuming soup with kokumi compared with a control soup.

CHAPTER 3: MATERIALS AND METHODS

3.1 Materials

3.1.1 Ingredients

Campbell's® Classic Tomato Condensed Soup (Camden, NJ, USA) was chosen as the base medium for this study because this canned tomato soup is well-known and liked which made it easy to recruit panelists. The kokumi substance used was Komi™ powder, which was generously provided by Nikken Foods USA, Inc. (St. Louis, Missouri, USA). Mr. Peter Graf, Applications Manager from Nikken Foods USA, Inc., suggested levels of kokumi of between 0.50% (w/w) and 1% (w/w). Komi powder costs about $8.50/ kilogram. The soup and Komi powder ingredients are listed in Table 3.1.1. Soup reconstitutions were made on a weight basis, and the weight of Komi powder added for calculated based on the total weight of the batch. The soup, kokumi powder, and water were weighed out separately then mixed and heated. The soup was prepared thirty minutes before testing began.

3.1.2 Kokumi Level Determination

Different levels of kokumi substances (0.5%, 0.6%, and 0.8%) (w/w) were added to the tomato soup medium and tested by several faculty members and students in an informal test to select levels for the sensory tests. These panelists were only asked to pick which level they preferred. The 0.8% kokumi power was considered too strong, so the intermediate level was selected.

Table 3.1.1: Soup and Komi Powder Ingredients

	Campbell's® Tomato Soup[a]	Nikken Foods Komi Powder[b]
Main Ingredients	Tomato puree (water, tomato paste) High fructose corn syrup Wheat flour Water	Fermented soybean sauce (fermented soybeans, wheat, and salt) Maltodextrin
Minor (<2%) ingredients	Salt Potassium chloride Flavoring Citric acid Lower sodium natural sea salt Ascorbic acid (vitamin C) Monopotassium phosphate Celery extract	

[a] List of ingredients as appears on the Campbell's Tomato Soup Label.
[b] List of ingredients as appears on the Nikken Foods Komi powder technical data sheet.

Table 3.1.2 Calculations For The Amount of Soup Used In Testing

Test	Condensed soup can size (g)[a]	Number of family size cans used	Water added (g)	Testing size (mL)	Number of servings made
Preliminary test to choose kokumi level	660 g	3	2160 g	30 mL	15
Triangle and preference tests	660 g	2	1440 g	30 mL	240
Hedonic test	660 g	3	2160 g	60 mL	200
Color and viscosity analyses	660 g	3	2160 g	500 mL	3

[a] Individual can = 305 g, 2.5 servings; family size = 660 g, 6 servings.

3.2 Instrumental Analyses

3.2.1 Color Measurement

Color measurements were taken using the Hunter Lab Scan XE (Reston, Virginia, USA). The application notes and protocol for translucent liquids were used with a ring and disk set. EasyMatch QC software was used and the equipment set for an area view of 1.75 inches (4.44 cm) and D65/10 (illumination provided by the sun at noontime). Commission Internationale de l'Eclairage (CIE) L*a*b* readings were used, where L* represents lightness (0= black, 100 = white), +a denotes redness or green color (+a = red, -a = green), and b* indicates how yellow or blue the food is (+b = yellow, -b = blue). Tomato soup was expected to have high a* and b* values because tomatoes are an orange-red color. Tomato soup was poured into the cylinder and placed on the port. Readings were taken three times per sample,

and the cylinder was turned slightly each time. Triplicate soup batches were prepared for color and viscosity measurements.

3.2.2 Viscosity

Viscosity measurement was taken using the Brookfield DV-II Pro Programmable Viscometer (Middleboro, Massachusetts, USA). The temperature of the soup was 52°C, which was the same temperature as the soup served for sensory evaluation. The temperature was checked every five minutes. The spindle used was 0-1. Measurements were taken at 5, 10, and 20 RPM. The spindle was put in approximately 600 mL of soup, and the measurements in Pascal-seconds (Pa.s) were read directly from the viscometer.

3.3 Protection of Human Subjects

An application was sent to the Institutional Review Board for the Protection of Human Subjects (IRB) for approval for research with human subjects. The application was submitted on March 13, 2018, and approved March 26, 2018, as exempt from further review under category 6. Inclusion and exclusion criteria for this study are shown in Table 3. 3.1.

Table 3.3.1: Inclusion and Exclusion Criteria for Sensory Evaluation Panelists

Inclusions	Exclusions
At least 18 years old	Do not like tomato soup
Like tomato soup	Allergy to tomatoes or wheat or soy
	Use of tobacco or electronic cigarette products
	Take medicine that affects the senses of taste and smell.

The recruitment notices (Appendix B and Appendix E) were shared through a community email list of individuals interested in participating in sensory testing. Additional electronic notices for recruitment were placed in Announcement and Alerts on the Mainestreet campus electronic portal. Printed informed consent forms, one for the difference tests and one for the acceptability/emotions tests, were available for panelists to read upon arrival for the respective testing days, which is a standard procedure at the Sensory Evaluation Center. Participation in the test indicated panelist consent. The difference/preference test took no longer than 30 minutes to complete. As an incentive for the difference/preference tests, participants received $2.00 in cash. The acceptability/emotions test took no longer than 45 minutes to complete, and participants received $10.00.

3.4 Sensory Evaluation Methods

3.4.1 Difference (Discrimination) Testing

Firstly, an overall difference test (triangle test) was carried out to verify that the concentration of kokumi was detectable by our panelists. A paired preference test immediately followed the triangle test to measure whether panelists preferred tomato soup with kokumi. When participants arrived for the study, they were first given a triangle test (Appendix C) to identify the one sample that was different from the other two. They were given a tray with three samples, two were the same sample, and one was different as shown in Figure 3.4.1. A cup of room temperature spring water (Poland Springs, Nestle Water North America, Stamford, CT, USA), a paper napkin, and a metal spoon were also provided on each tray. Each sample was 29.6 mL (one ounce) of soup served in 59 mL white china ramekin bowls and the soup was

kept warm in one of two tabletop steam tables ((Duke Model ACTW-IM, St. Louis, MO). The soups were stirred every time samples were taken, and temperature readings were taken every half hour. Test participants evaluated the samples in one of twelve private booths with controlled lighting that included a T-8 cool light fluorescent bulb with a 3600 °K average color temperature, and a compact full-spectrum bulb with a 5900 °K average color temperature.

The SIMS program (v. 6, Sensory Computer Systems, Berkeley Heights, NJ USA) randomized and balanced the order of samples so that half of the anticipated 40 participants received two samples of the control, and the other 20 people would receive two samples of the 0.6% kokumi soup. The order of the three samples on each tray was also randomized to minimize positional order bias. The participants were then asked to pick the sample they thought was different. The triangle test required 40 participants based on calculations for the sample size for triangle tests as suggested by Meilgaard, Civille, and Carr (2007). However, we were only able to get 34 panelists due to the test being on a Wednesday, and there were many classes in session at the time of the test. Unlike the acceptability and emotions test whose monetary incentive was ten dollars, for the difference and preference tests, panelists only received two dollars. Since there is a 1 in 3 chance of guessing correctly in a triangle test (Meilgaard et al., 2007), the results were further analyzed to calculate the estimated number of people who did not guess and could actually perceive the difference.

Sample 1 = 0% Kokumi ..... Blinding Codes: 896, 597
Sample 2 = 0.6% Kokumi..... Blinding Codes: 972, 735
Tray sample order example: 896 597 972

Figure 3.4.1: Triangle Test Blinding Codes. Three-digit codes to differentiate each sample.

The triangle test was immediately followed by the paired preference test with a small delay to minimize sensory overload. Samples were given different code numbers from those used in the triangle test. Participants were given a tray with two soup samples, one kokumi soup, and one control soup, and asked to pick the one that they preferred. The 0% kokumi (control) blinding code was 198 and the 0.6% kokumi blinding code was 462; possible order combinations were 198 then 462 or 462 followed by 198. The sample size was 8mL (three ounces) of soup served in 5-ounce foam bowls. Soups were prepared the day of the test and kept warm in half hotel pans (The Vollrath Company, Sheboygan, Wisconsin) in a Duke Warming Unit (Duke Manufacturing, St. Louis, Missouri) until served. The soups were stirred every time that samples were taken and temperature readings to verify the serving temperature of 52° C were taken every half hour.

3.4.2 Hedonic and Emotion Testing

The acceptability and emotions test required a larger sample size because we wanted to relate the presence of kokumi to soup acceptability, in addition to eating emotions and behavior. The sample volume was approximately 89 mL (three ounces) of soup to ensure panelists would not get too full. SIMS© sensory software was used to conduct all tests. The test scheme is shown in Figure 3.4.2. Panelists received one sample in a 148-mL (5 ounces) expanded polystyrene bowl (Mason, Michigan) to evaluate at a time on a tray with a cup of spring water, napkin, and spoon. A monadic presentation was selected to ensure that soups were evaluated at a suitable temperature and to avoid cross-tasting between samples. Panelists assessed the degree of liking of the soups using the 9-point hedonic scale for taste, thickness, and overall

liking (Peryam and Pilgrim, 1957); the 9-points of the hedonic scale are: dislike extremely (= 1), dislike very much (= 2), dislike moderately (= 3), dislike slightly (= 4), neither like nor dislike (= 5), like slightly (= 6), like moderately (= 7), like very much (= 8), and like extremely (= 9). After rating each of the hedonic virtues for the first sample, panelists were asked to indicate how eating the soup made them feel according to the EsSense 25 questionnaire. Between samples, participants answered demographic questions and completed the DEBQ restrained eating scale questionnaire. After completing all of the questions, the participants returned their notebook computers and received their compensation.

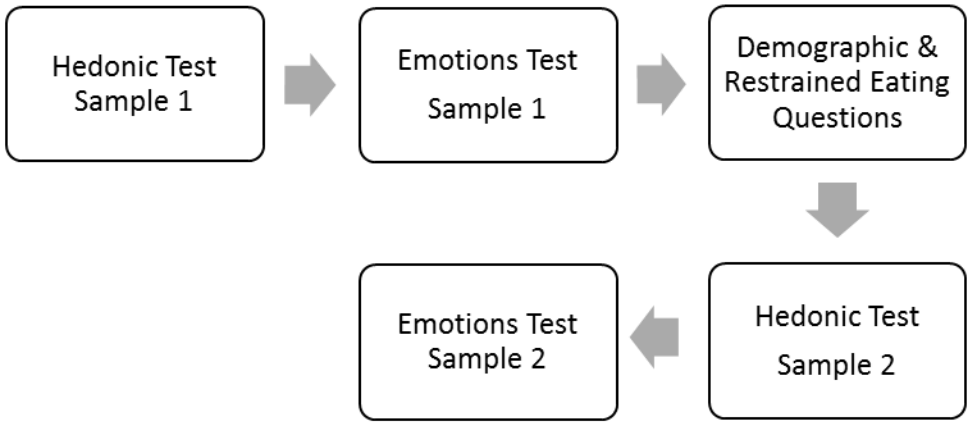

Figure 3.4.2: Acceptability and Emotions Test Scheme

3.4.3 Restrained Eating Analysis

The DEBQ restrained eating scores were summed for each participant and then divided by 10 (the number of questions); participants were further divided into low or high restrained eating groups using the median score as a division point as recommended by van Strien et al. (1997).

3.5 Statistical Analyses

A probability level of less than or equal to 0.05 was selected for all tests. XLSTAT (2018, Addinsoft and New York, NY) was used for the analysis of variance (ANOVA) of color and viscosity. Sensory statistical analyses were done using SIMS, which calculated the critical number of correct responses needed for significance at $p \leq 0.05$. The preference data were analyzed as a one-way test because we expected people to prefer the soup with kokumi. The acceptance and emotions test data except the restrained eating scores were analyzed using SAS through SIMS using ANOVA. Restrained eating scores were tabulated in Excel 2016 to calculate total scores, adjusted restrained score (total/10), and the mean total restrained score and mean scores per question.

CHAPTER 4: EXPERIMENTAL RESULTS AND DISCUSSION

The objectives of this study lie in three questions: can panelists detect kokumi in tomato soup, does adding kokumi increase tomato soup acceptability, and what are the effects of kokumi on emotions?

4.1 Color and Viscosity Measurements

CIE L*a*b* values were higher for the control soup. The 0% kokumi soup was lighter and more red and yellow than the 0.6% kokumi soup (Table 4.1.1). The Komi powder was a light orange-tan color and was not expected to have a significant impact on color at the low level of addition used in this study. Viscosity measurements were taken using the Brookfield DV-11 Pro Programmable Viscometer. The viscosity of both soups decreased with increased spindle speed. There was not a significant difference in the viscosity of the soups with and without added Komi powder. This finding is important because any perceived differences in viscosity by sensory panelists were expected to be due to the triggering of the CaSR receptor by the Komi powder.

Table 4.1.1: Soup Color [a]

% Komi	CIE color[b]		
	L*	a*	b*
0	36.23 ± 0.69 a	29.58 ± 0.13 a	36.59 ±0.34 a
0.6	33.07 ± 0.71 b	27.07 ± 0.54 b	33.66 ± 1.66 b

[a] Means ± standard deviations for triplicate samples. Three batches of each soup formulation were read in triplicate. [b] L* is lightness (0 = black, 100= white); a* is redness (+a = red, -a = green), and b* indicates degree of yellow (+b = yellow, -b = blue). Means within columns followed by different letters are significantly different ($p \leq 0.05$, Tukey's HSD test).

Table 4.1.2: Soup Viscosity (Pascal-seconds) According to Different Spindle Speeds[a]

% Komi	Spindle speed (rpm)[a]		
	5	10	20
0	845 ± 128 a	512 ± 70 a	309 ± 53 a
0.6	1125 ± 302 a	663 ± 158 a	389 ± 82 a

[a] Means ± standard deviations (n=3). Three separate batches of each soup type were tested.

Means within columns followed by the same letters are not significantly different ($p > 0.05$, Tukey's HSD test).

4.2 Sensory Overall Difference Test

There was a significant difference ($p \leq 0.01$, 99% confidence level) between the 0% and 0.6% Komi tomato soups; 58.8% of the panelists were able to detect a difference between the plain tomato soup and one that contained kokumi as shown in Table 4.2.1. The calculations for discriminators, as shown in Figure 4.2.1, indicate that only 13 out of the 34 or 38% of panelists were likely to have detected the difference in the soup. The other four persons who correctly chose the different sample may have guessed. While comments were not very conclusive, nine panelists said that the soup with 0.6% Komi powder tasted differently from the control sample. Four people found the 0.6% soup to have a stronger tomato flavor. Comments can be found in Appendix H.

Table 4.2.1: Results of the Triangle Test for Difference

	Number	Percent
Panel Size	34	100%
Correct Answers	20	58.80%
Incorrect Answers	14	41.20%
Probability of a Correct Guess		33.00 %

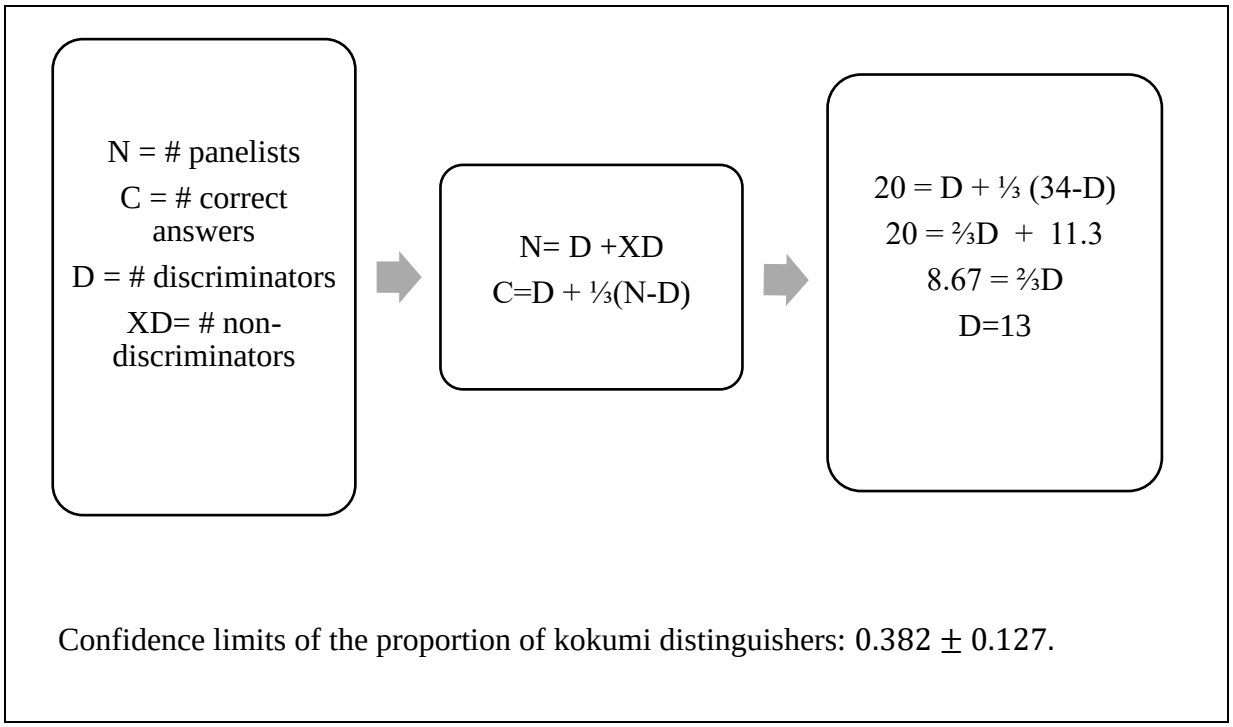

Figure 4.2.1: Calculations for Determining the Number of Actual Discriminators.

4.3 Preference Test

An equal number of panelists chose each sample, so no preference was found as shown is Table 4.3.1. A minimum of 23 persons would have had to select either soup to achieve a difference significant at $p \leq 0.05$. However, three panelists commented that the 0% soup was sweeter, more flavorful, and had more tomato flavor than the 0.6% soup. The tomato flavor had the most number of comments in this test, 5 for the 0% kokumi soup and 2 for the 0.6% kokumi soup.

Table 4.3.1: Results of the Preference Test

Soup type	Preferred sample choices	Percentage of total
0% Komi	17	50%
0.6% Komi	17	50%
Total number of panelists	34	100%

4.4 Discussion of Triangle and Preference Tests

The results for the difference test suggests that consumers could detect the kokumi. However, the degree of difference calculations demonstrates that only 13 people were able to detect the kokumi. This finding, coupled with an equal preference for both soups suggests that the level of kokumi added, was not sufficient to increase consumer liking for the kokumi-enhanced soup. DeRuyter et al. (2014) had similar results; their triangle test showed that their panelists were able to detect a difference in the samples, but some of their samples in the preference were liked equally. Comments seem to agree with the findings of Maruyama et al. (2012), who reported that kokumi enhances the sweetness and saltiness of foods. During benchtop formulation, a 0.8% kokumi soup was assessed but was found to be too salty and strong-tasting.

However, testing a higher level or multiple levels of kokumi may help determine if the kokumi influences liking.

4.5 Soup Acceptability

A total of 101 persons (27 men, 73 women, and one non-respondent) participated on April 6, 2018 (Table 4.5.1). The majority of the men's ages ranged between 19 to 25, and the women were between the ages of 19 to 36. The mean age overall was 30.7 years. The person who chose not to answer the gender question was 22 years old. Another person did not answer any demographic questions. The majority of participants (86.1%) liked tomato soup. Sixty-four women and 23 men said they liked tomato soup, and four men, nine women, and one person who refused to identify gender were neutral about tomato soup (data not shown).

There were no significant differences between the two types of soup and the acceptability test showed no significance except for thickness. Panelists slightly liked the thickness of both soups, and the thickness of the 0% kokumi soup scored higher than the 0.6% (Table 4.5.2). The panelists also positively rated all emotion attributes. There were no differences in any emotions after consuming the soups (Table 4.5.3).

Table 4.5.1: Age and Gender of Hedonic Test Participants

Age (years)	Men	Women	Did Not Specify Gender
19-25	11	41	1
26-35	10	13	
36-45	3	5	
46-55	1	7	
56-67	2	6	

Table 4.5.2 Hedonic Test Mean Scores [a]

Hedonic Attribute	**0% Komi**	**0.6% w/w Komi**	**Significance**
Taste	7.0 ± 1.3 a	7.0 ± 1.3 a	NS
Thickness	6.6 ± 1.5 a	6.1 ± 1.7 b	*
Overall	6.8 ± 1.4 a	6.8 ± 1.3 a	NS

[a] Means ± standard deviations (n=101) followed by different letters in the same row are significantly different ($p \leq 0.05$, Tukey's HSD test).

Table 4.5.3: Mean Emotion Scores [a,b]

Emotion	% Komi in Tomato Soup		Statistical Significance
	0	0.6	
Happy	3.3±0.9	3.4±0.9	NS
Pleasant	3.5±0.8	3.4±0.8	NS
Good	3.5±0.79	3.5±0.79	NS
Enthusiastic	3.0±1.1	2.9±1.0	NS
Joyful	3.0±1.0	3.0±1.1	NS
Interested	3.4±0.99	3.3±0.99	NS
Satisfied	3.5±0.89	3.3±0.90	NS
Free	2.8±1.2	2.8±1.1	NS
Good-natured	3.5±0.93	3.5±0.89	NS
Active	2.7±1.2	2.6±1.2	NS
Calm	3.3±1.0	3.4±0.89	NS
Tame	3.0±1.2	3.0±0.1.2	NS
Nostalgic	2.2±1.1	2.2±0.98	NS
Loving	2.9±1.2	2.9±1.2	NS
Understanding	3.2±1.1	3.2±1.1	NS
Mild	2.9±0.91	2.8±0.96	NS
Warm	3.2±1.0	3.2±0.91	NS
Secure	3.2±0.94	3.2±1.0	NS
Aggressive	1.2±0.71	1.2±0.65	NS
Adventurous	2.5±1.2	2.4±1.2	NS
Wild	1.6±1.0	1.7±1.1	NS
Guilty	1.2±0.63	1.2±0.52	NS
Worried	1.8±0.97	1.8±0.97	NS
Bored	1.7±0.92	1.7±0.85	NS
Disgusted	1.1±0.47	1.1±0.31	NS

[a] ESense emotion scale: 1 = not at all, 2 = slightly, 3 = moderately, 4 = very, 5= extremely.
[b] Means ± standard deviations (n =101). NS = not significant ($p > 0.05$).

4.6 Restrained Eating

The Cronbach's alpha correlation for the DEBQ-R questions in this study was only 0.694 signifying that our questions were related to each other, but the scale may not be a reliable measure. Bailey et al. reported their Cronbach's alpha as 0.71, and Dakanalis et al.'s was 0.80, indicating that the studies were satisfactory and adequate respectively. The overall median restrained eating score was 2.6, and the mean was 2.63. The range of scores was 1.2 - 4.5. Participants were considered to have low restraint if their score was less than 2.60. High restrained eaters had scores of 2.6 or higher. The one person that did not specify gender had a score of 2.8. Forty-one of the female panelists scored over 2.6, categorizing them as restrained eaters, and sixteen men were also restrained eaters (Table 4.6.1). However, there was no significant difference in restrained eating scoring based on gender. A study of 475 female university students in the Netherlands reported a mean restrained eating score of 2.70 (Anschutz, van Strien, van de Ven & Engels, 2009)

Table 4.6.1 Gender Differences in Restrained Eating Scores based on the Dutch Eating Behavior Questionnaire (DEBQ-R)[a]

Gender	Number	Mean Score ± Standard Deviation	Median Score
Female	73	2.6 ± 0.50	2.6
Male	27	2.7 ± 0.65	2.7

[a] DEBQ-R scale: 1=never, 2= seldom, 3=sometimes, 4=often, 5=very often.

Table 4.6.2 Mean Scores for Individual Questions on the Dutch Eating Behavior Questionnaire (DEBQ-R)

Question	Score [a, b]
Do you try to eat less at mealtimes than you would like to eat?	2.5 ± 1.0
Do you make any restrictions in your daily diet?	3.0 ± 1.0
Do you desire to eat when you smell or see food?	4.0 ± 0.9
I feel hungry because what I am eating is not enough.	2.5 ± 1.0
When I feel stressed I overeat.	3.0 ± 1.2
Do you leave food on your plate?	2.4 ± 1.0
When I start eating I cannot seem to stop.	2.2 ± 1.0
I do not get full easily	2.4 ± 1.0
I feel hungry because what I am eating is not enough.	2.2 ± 1.1
I get so hungry that my stomach often feels like a bottomless pit	2.1±1.1

[a] Means ± standard deviations (n=101).

[b] DEBQ-R Scale: 1=never, 2= seldom, 3=sometimes, 4=often, 5=very often.

4.7 Discussion of Acceptability and Restrained Eating Tests

The acceptability ratings for the kokumi soup were 7 for taste but 6 for thickness and overall liking. More refinements are needed to improve thickness and overall liking. Mean hedonic scores were comparable to those assigned to a standard tomato soup used in a project to examine salt reduction (Ghawi et al., 2014). Kuroda et al. (2015) found that kokumi increases the thickness of food which correlates with this study because the results show that there was a significant difference in the ratings for the thickness of the soups.

The ratings of the acceptability and emotions tests were positive. Panelists seemed to be in a very good mood, as shown by the high acceptability ratings and positive emotions rating. We

had hoped to see a difference in emotions between the two soups, specifically stronger positive emotions from the soup with the kokumi, but the results showed that the kokumi did not have the expected effect. This lack of difference again could be related to the level of kokumi tested. However, the results of these tests could be solely related to the panelists being in a good mood on the day of the test and receiving an incentive for participation. Future work should be scheduled as a cross-over experimental design with one soup one week and the second soup a week or two later.

4.8 Study Limitations

We chose tomato soup as our medium in this study because it is a common soup. Perhaps another type of soup could have yielded better results. According to Nikken Foods USA, who donated the Komi™ powder, kokumi can be added any number of products. Since kokumi is supposed to impart richness into food, a product that is rich and hearty might be a better application for the product. Some tomato soups such as bisques contain added cream for richness (Garten, 2012). We could have used other brands like Progresso, Pacific, or Heinz which might have yielded different results because of different ingredient ratios.We hypothesized that adding kokumi to canned nonfat tomato soup would create the sensation of more fat and thicker texture, but our findings did not support that idea.

In this study, we only used one level of kokumi and a control. Initially, during benchtop formulation, we tried three levels of kokumi, 0.5, 0.6, and 0.8% by weight. Before the difference/preference tests were conducted, an acceptability test should have been conducted with the three levels to see how they compared to each other. Then the top two levels could have been tested against the control to yield stronger results. Kokumi was thought to increase

emotions of happiness and comfort. A higher level of kokumi might have had a stronger effect on emotions, especially the more positive emotions.

The subjects of our panels were humans. Every human is different, and all humans are not perfect tasters. Panelists could have been in exceptionally good moods on both days of testing which might have skewed our results. The second set of testing consisted of three acceptability questions, twenty-five emotion questions, and ten retrained eating questions. That long of a questionnaire could have fatigued the panelists and resulted in them just picking the more positive answers. Panelists could have just clicked through the test and clicked the answers they felt we were expecting, as well as to get through the test and collect their compensation. The Komi Powder we used was made from fermented soybean sauce and had a reported 11% salt content (Appendix G). The panelist's comments on the saltiness of the soups suggest that we needed to test them for the ability to taste salt as well as their threshold. We could also make soup from scratch to control the salt content so we can see if the saltiness is from the soup or kokumi powder. This study had 101 panelists that included panelists who had never participated in a sensory evaluation test before and may not have been sure how to answer the questions. There is also a small possibility that panelists gave us the answers they assumed we wanted.

4.9 Future Directions

In the future, several levels of kokumi should be tested in comparison to a control. Once a level of kokumi has been determined, satiety tests should be conducted. Kokumi has been seen to increase satiety that could result in lower food consumption. This effect could be beneficial in the fight against obesity; kokumi could be added to lean and low-calorie foods,

resulting in a richer and more satisfying a feeling experience, as well as a feeling full faster and a reduction in overeating and excessive calorie intake.

Since kokumi can work as a flavor enhancer, it could be added to food catered to the geriatric population. As people age, taste perception may change, and eating can lose its excitement (Sergi et al. 2017). Reduced eating can lead to malnutrition. If kokumi can enhance the flavor and sensorial experience of foods, the older adults in the community and long-term care might be able to enjoy eating once again, be more satisfied, and have better overall health.

A drawback of kokumi is that it is a glutamate peptide and maybe possibly confused with monosodium glutamate (MSG). Many people have reservations about MSG because it has been linked to various health problems like allergies, headaches, and sensitivities, so more testing is needed to determine kokumi's relationship to MSG as well as the health side effects of kokumi. Kokumi contains allergens like soy as well as it is expensive to add. Kokumi has the potential to be a useful ingredient in the food industry. However, more testing is needed to determine its value.

CHAPTER 5: CONCLUSIONS

The objectives of this study were to determine detectable amounts of kokumi in a familiar food, canned tomato soup, testing whether added kokumi improves soup acceptability, and whether kokumi can influence consumer emotion in a laboratory setting.

The results suggest that consumers could detect the kokumi taste. However there was no significant difference in rating of emotions. Since only a small group of people were actually able to taste the kokumi and the emotion questionnaire had no significance, it can be concluded that the quantity of Komi in the soup might not have been sufficient as well the test duration. Some panelists might have need more kokumi in the soup to be able to detect the kokumi. Everyone tastes differently, and some panelists might need a larger sample to detect the kokumi. The test duration for the emotion questionnaire was quite long which could have led to panelist fatigue. A shorter test duration would not have fatigued the panelists and might have yielded better results. Testing the different soups on different days with normal portion sizes might also have yielded more useful data, Based on the data we collected, we cannot conclude that the level of kokumi was sufficient enough for the panelists to taste. During preliminary formulations, a 0.8% kokumi soup was tested but was found to be too salty and obvious that something had been added to the soup. Testing a higher level or multiple levels of kokumi may help determine if the kokumi can increase consumer liking for tomato soup with added kokumi.

Another factor to consider could be the type of kokumi used, whether it was fermented soybean base or fermented wheat protein base. Testing both types may help determine if consumer liking is due to the variety of kokumi or just kokumi itself. Studying different types of kokumi sources can determine if there is a difference in types of perception. In preliminary

testing both types were tested. However, the fermented wheat protein type was found to have a strong aroma and flavor even at small amounts.

Kokumi may be beneficial when added to diet foods. Since kokumi can enhance the richness of the food, it can be added to low-calorie foods and promoted to weight concerned consumers. The addition of kokumi could potentially help consumers eat small portions and feel satisfied like they would be eating their normal portion size. The next steps of kokumi research should be to study the effect kokumi has on satiety. If it can be proven that the addition of kokumi can create a more satisfying food, then it will be beneficial not only for diet-conscious consumers but potentially for elderly consumers. Researchers should look into the uses of kokumi in creating satisfying meals for the elderly. This is a group that struggles with the loss of appetite or loss of taste buds. Kokumi could help improve the taste of their food and help them feeling satisfied as well as enjoying their meals again. Research should also focus on the use of kokumi in frozen and ready to eat meals. Most consumers are looking for quick and healthy meals. Another topic of research should be regulation of kokumi. There is a lack of research on the side of effects of kokumi. Too much of something can be harmful so it is important to know how much kokumi is too much and the effects it can have on people. The types of kokumi powders that were sampled in this study contained soy and wheat allergens. Both are major allergens and are highly regulated by the food industry. On food labels we need to check regulations to determine if kokumi is listed as is or if each ingredient in the kokumi powder will be listed. The latter is what should be done so that consumers with allergies are aware of what they are consuming. We must figure out how to regulate the labeling of kokumi added to products. The addition of kokumi has the potential to support healthy and delicious

meal product development. Kokumi is a versatile ingredient that has the potential to be a successful tool to improve the health of so many different consumer groups.

BIBLIOGRAPHY

Agarwal, E. E., Miller, M., Yaxley, A., & Isenring, E. (2013). Malnutrition in the elderly: A narrative review. *Maturitas, 76,* 296–302. doi: 10.1016/j.maturitas.2013.07.013

Allison, D.B., Kalinsky, L.B., & Gorman, B.S. (1992). A comparison of the psychometric properties of three measures of dietary restraint. *Psychological Assessment, 4,* 391–398. doi: 10.1037/1040-3590.4.3.391

Amino, Y., Nakazawa, M., Kaneko, M., Miyaki, T., Miyamura, N., Maruyama, Y. & Eto, Y. (2016). Structure–CaSR–activity relation of kokumi γ-glutamyl peptides. *Chemical and Pharmaceutical Bulletin*, *64*:, 1181–1189. doi: 10.1248/cpb.c16-00293

Amino, Y. , Wakabayashi, H., Akashi, S., & Ishiwatari, Y. (2018). Structural analysis and taste evaluation of γ- glutamyl peptides comprising sulfur-containing amino acids. *Bioscience, Biotechnology, and Biochemistry*, *82*, 383-394. doi: 10.1080/09168451.2018.1436433

Anglé, S., Engblom, J., Eriksson, T., Kautiainen, S., Saha, M.-T., Lindfors, P., Lehtinen, M., & Rimpelä, A. (2009). Three factor eating questionnaire-R18 as a measure of cognitive restraint, uncontrolled eating and emotional eating in a sample of young Finnish females. *The International Journal of Behavioral Nutrition and Physical Activity, 6*,41. doi: 10.1186/1479-5868-6-41

Anschutz, D.J., Van Strien, T., Van De Ven, M.O., & Engels, RC. (2009). Eating styles and energy intake in young women. *Appetite, 53,* 119-122. doi: 10.1016/j.appet.2009.03.016

Ataseven, N., Yuzbasioglu, D., Keskin, A.C., & Unal, F. (2016). Genotoxicity of monosodium glutamate. *Food and Chemical Toxicology , 91*, 8–18. doi: 10.1016/j.fct.2016.02.021 [doi]

Bailly, N., Maitre, I., Amanda, M., Hervé, C., & Alaphilippe, D. (2012). The Dutch Eating Behaviour Questionnaire (DEBQ). Assessment of eating behaviour in an aging French population. *Appetite, 59,* 853–858. doi: 10.1016/j.appet.2012.08.029

Baugreet, S., Hamill, R.M., Kerry, J.P., & McCarthy, S.N. (2017). Mitigating nutrition and health deficiencies in older adults: A role for food innovation? *Journal of Food Science,* 82, 848–855. doi: 10.1111/1750-3841.13674

Bestgen, A.-K., Schulze, P., & Kuchinke, L. (2015). Odor emotional quality predicts odor identification. *Chemical Senses, 40,* 517–523. doi: 10.1093/chemse/bjv037

Boyce, J.A., Gleaves, D.H., & Kuijer, R.G. (2015). Measuring dietary restraint status: comparisons between the dietary intent scale and the restraint scale. *Frontiers in Nutrition*, *2*, 8. doi: 10.3389/fnut.2015.00008

Brennan, S.C., Davies, T.S., Schepelmann, M., & Riccardi, D. (2014). Emerging roles of the extracellular calcium-sensing receptor in nutrient sensing: control of taste modulation and intestinal hormone secretion. *The British Journal of Nutrition*, *111*, Suppl 1:16. doi: 10.1017/S0007114513002250

Burns, S.L., Penfield, M.P., Saxton, A.M., & Luckett, C.R. (2018). Comparison of triangle and tetrad discrimination methodology in an applied manner. *Food Quality and Preference*, *68*, 105–112. doi: 10.1016/j.foodqual.2018.02.009

Chandrashekar, J., Zuker, C.S., Ryba, N.J.P., & Hoon, M.A. (2006). The receptors and cells for mammalian taste. *Nature*, *444*, 288–294. doi: 10.1038/nature05401

Chaudhari, N., & Roper, S.D. (2010). The cell biology of taste. *The Journal of Cell Biology*, *190*, 285–296. doi: 10.1083/jcb.201003144

Christensen, R.H.B., Ennis, J.M., Ennis, D.M., & Brockhoff, P.B. (2014). Paired preference data with a no-preference option – Statistical tests for comparison with placebo data. *Food Quality and Preference*, *32*, 48–55. doi: 10.1016/j.foodqual.2013.06.005

Coetzee, H., & Taylor, J.R.N. (1996). The use and adaptation of the paired-comparison method in the sensory evaluation of hamburger-type patties by illiterate/semi-literate consumers. *Food Quality and Preference*, *7*, 81–85. doi: 10.1016/0950-3293(95)00039-9

Collinsworth, L.A., Lammert, A.M., Martinez, K.P., Leidheiser, M., Garza, J., Keener, M., & Ashman, H. (2014). Development of a novel sensory method: Image measurement of emotion and texture (IMET). *Food Quality and Preference*, *38*, 115–125. doi: 10.1016/j.foodqual.2014.04.011

Dakanalis, A., Zanetti, M.A., Clerici, M., Madeddu, F., Riva, G., & Caccialanza, R. (2013). Italian version of the Dutch Eating Behavior Questionnaire. Psychometric proprieties and measurement invariance across sex, BMI-status and age. *Appetite*, *71*, 187–195. doi: 10.1016/j.appet.2013.08.010

Demos, K.E., Kelley, W.M., & Heatherton, T.F. (2011). Dietary restraint violations influence reward responses in nucleus accumbens and amygdala. *Journal of Cognitive Neuroscience*, *23*, 1952–1963. doi: 10.1162/jocn.2010.21568

De Ruyter JC, Katan MB, Kas R, Olthof MR. (2014). Can children discriminate sugar-sweetened from non-nutritively sweetened beverages and how do they like them? *PLoS One* 9(12):e115113.

Djalalinia, S., Qorbani, M., Peykari, N., & Kelishadi, R. (2015). Health impacts of obesity. *Pakistan Journal of Medical Sciences*, *31*, 239-242.

Ennis, J.M., & Christensen, R.H.B. (2014). Precision of measurement in Tetrad testing. *Food Quality and Preference*, *32*, 98–106. doi: 10.1016/j.foodqual.2013.05.003

Ennis, J.M., Rousseau, B., & Ennis, D.M. (2014). Sensory difference tests as measurement instruments: A review of recent advances. *Journal of Sensory Studie*s. *29*, 89-102. doi: 10.1111/joss.12086Ina Garten. 2012. Barefoot Contessa Foolproof. New York: Clarkson Potter Publishers.

Geisler, F.C.M., Kleinfeldt, A., & Kubiak, T. (2016). Restrained eating predicts effortful self-control as indicated by heart rate variability during food exposure. *Appetite*, *96*, 502–508. doi: 10.1016/j.appet.2015.10.020

Ghawi, S. K., Rowland, I., & Methven, L. (2014). Enhancing consumer liking of low salt tomato soup over repeated exposure by herb and spice seasonings. *Appetite*, *81*, 20-29. doi:10.1016/j.appet.2014.05.029

Gibson, E.L. (2006). Emotional influences on food choice: Sensory, physiological and psychological pathways. *Physiology & Behavior*, *89*, 53–61. doi: 10.1016/j.physbeh.2006.01.024

Gutjar, S., Dalenberg, J.R., de Graaf, C., de Wijk, R.A., Palascha, A., Renken, R.J., & Jager, G. (2015a). What reported food-evoked emotions may add: A model to predict consumer food choice. *Food Quality and Preference*, *45*, 140–148. doi: 10.1016/j.foodqual.2015.06.008

Gutjar, S., de Graaf, C., Kooijman, V., de Wijk, R.A., Nys, A., ter Horst, G.J., & Jager, G. (2015b). The role of emotions in food choice and liking. *Food Research International*, *76*, 216–223. doi: 10.1016/j.foodres.2014.12.022

He, W., de Wijk, R., de Graaf, C., & Boesveldt, S. (2016). Implicit and explicit measurements of affective responses to food odors. *Chemical Senses*, *41*, 661–668. doi: 10.1093/chemse/bjw068

Huang, Y.-T., & Lawless, H.T. (1998). Sensitivity of the ABX discrimination test. *Journal of Sensory Studies*, *13*, 229–239. doi: 10.1111/j.1745-459X.1998.tb00085.x

Ishii, R., O'Mahony, M., & Rousseau, B. (2014). Triangle and tetrad protocols: Small sensory differences, resampling and consumer relevance. *Food Quality and Preference*, *31*, 49–55. doi: 10.1016/j.foodqual.2013.07.007

Kalva, J.J., Sims, C.A., Puentes, LA., Snyder, D.J., & Bartoshuk, L.M. (2014). Comparison of the hedonic general labeled magnitude scale with the hedonic 9 point scale. *Journal of Food Science*, *79*, S238-S245. doi: 10.1111/1750-3841.12342

Kanjanakorn, A., & Lee, J. (2017). Examining emotions and comparing the EsSense Profile® and the coffee drinking experience in coffee drinkers in the natural environment. *Food Quality and Preference*, *56*, 69–79. doi: 10.1016/j.foodqual.2016.09.014

Kemps, E., Herman, C.P., Hollitt, S., Polivy, J., Prichard, I., & Tiggeman, M. (2016). Contextual cue exposure effects on food intake in restrained eaters. *Physiology & Behavior*, *167*, 71–75. doi: 10.1016/j.physbeh.2016.09.004

Kenney, E., & Adhikari, K. (2016). Recent developments in identifying and quantifying emotions during food consumption. *Journal of the Science of Food and Agriculture*, *96*, 3627–3630. doi: 10.1002/jsfa.7717

Kohyama, K. (2015). Oral sensing of food properties. J*ournal of Texture Studies, 46,* 138–151. doi: 10.1111/jtxs.12099

Köster, E.P., & Mojet, J. (2015). From mood to food and from food to mood: a psychological perspective on the measurement of food-related emotions in consumer research. *Food Research International*, *76*, 180–191.

Kuroda, M., & Miyamura, N. (2015). Mechanism of the perception of "kokumi" substances and the sensory characteristics of the "kokumi" peptide, γ-Glu-Val-Gly. *Flavour*, *4*, 11. doi: 10.1186/2044-7248-4-11

Lagast, S., Gellynck, X., Schouteten, J.J., de Herdt, V., & de Steur, H. (2017). Consumers' emotions elicited by food: a systematic review of explicit and implicit methods. *Trends in Food Science & Technology*, *69*, 172–189.

Lindroos, A.K., Lissner, L., Mathiassen, M.E., Karlsson, J., Sullivan, M., Bengtsson, C., & Sjöström, L. (1997). Dietary intake in relation to restrained eating, disinhibition, and hunger in obese and nonobese Swedish women. *Obesity Research*, *5*, 175–182.

Liu, J., Song, H., Liu, Y., Li, P., Yao, J., & Xiong, J. (2015). Discovery of kokumi peptide from yeast extract by LC-Q-TOF-MS/MS and sensomics approach: Discovery of kokumi peptide from yeast extract. *Journal of the Science of Food and Agriculture*, *95*, 3183–3194. doi: 10.1002/jsfa.7058

Maruyama, Y., Yasuda, R., Kuroda., M, & Eto, Y. (2012). Kokumi substances, enhancers of basic tastes, induce responses in calcium-sensing receptor expressing taste cells. *PloS One*, *7*, e34489. doi: 10.1371/journal.pone.0034489

McClure, S., & Lawless, H.T. (2010). Comparison of the triangle and a self-defined two alternative forced choice test. *Food Quality and Preference*, *21*, 547–552. doi: 10.1016/j.foodqual.2010.02.005

Meilgaard, M.C., Civille, G.V., & Carr, B.T. (2007.) *Sensory evaluation techniques,* 4th. ed. CRC Press, Boca Raton, Fla.

Miyaki, T., Kawasaki, H., Kuroda, M., Miyamura, N., & Kouda, T. (2015). Effect of a kokumi peptide, γ-glutamyl-valyl-glycine, on the sensory characteristics of chicken consommé. *Flavour*, *4*, 1-8.

Miyamura, N., Jo, S., Kuroda, M., & Kouda, T. (2015). Flavour improvement of reduced-fat peanut butter by addition of a kokumi peptide, γ-glutamyl-valyl-glycine. *Flavour*, *4*, 1-14.

Miyamura, N., Kuroda, M., Kato, Y., Yamazaki, J., Mizukoshi, T., Miyano, H., & Eto, Y. (2014). Determination and quantification of a Kokumi peptide, γ-glutamyl-valyl-glycine, in fermented shrimp paste condiments. *Food Science and Technology Research*, *20*, 699–703.

Mojet, J., Dürrschmid, K., Danner, L., Jöchl, M., Heiniö, R.-L., Holthuysen, N., & Köster, E. (2015). Are implicit emotion measurements evoked by food unrelated to liking? *Food Research International*, *76*, 224–232. doi: 10.1016/j.foodres.2015.06.031

Naish, K.R., & Harris, G. (2012). Food intake is influenced by sensory sensitivity. *PloS One*, 7, e43622. doi: 10.1371/journal.pone.0043622

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., … Pedroza, A. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*, *384*, 766–781. doi: 10.1016/S0140-6736(14)60460-8

Ohsu, T., Amino, Y., Nagasaki, H., Yamanaka, T., Takeshita, S., Hatanaka, T., Maruyama, Y., Miyamura, N., & Eto, Y. (2010). Involvement of the calcium-sensing receptor in human taste perception. *Journal of Biological Chemistry*, *285*, 1016–1022. doi: 10.1074/jbc.M109.029165

O'Mahony, M. (1995). Who told you the triangle test was simple? *Food Quality and Preference*, *6*, 227–238. doi: 10.1016/0950-3293(95)00022-4

O'Mahony, M., & Wichchukit, S. (2017). The evolution of paired preference tests from forced choice to the use of 'No Preference' options, from preference frequencies to d′ values, from placebo pairs to signal detection. *Trends in Food Science & Technology*, *66*, 146–152. doi: 10.1016/j.tifs.2017.05.017

Peryam, D.R., & Pilgrim, F.J. (1957). Hedonic scale method of measuring food preferences. *Food Technology*, *11*, 9–14.

Populin, T., Moret, S., Truant, S., & Conte, L.S. (2007). A survey on the presence of free glutamic acid in foodstuffs, with and without added monosodium glutamate. *Food Chemistry*, *104*, 1712–1717. doi: 10.1016/j.foodchem.2007.03.034

Sergi, G., Bano, G., Pizzato, S., Veronese, N., & Manzato, E. (2017) Taste loss in the elderly: Possible implications for dietary habits. *Critical Reviews in Food Science and Nutrition*, *57*, 3684–3689. doi: 10.1080/10408398.2016.1160208

Shibata, M., Hirotsuka, M., Mizutani, Y., Takahashi, H., Kawada, T., Matsumiya, K., Hayashi, Y., & Matsumura, Y. (2017). Isolation and characterization of key contributors to the "kokumi" taste in soybean seeds. *Bioscience, Biotechnology, and Biochemistry*, *81*, 2168. doi: 10.1080/09168451.2017.1372179

Siddique, N., O'Donoghue, M., Casey, M.C., & Walsh, J.B. (2017). Malnutrition in the elderly and its effects on bone health – A review. *Clinical Nutrition ESPEN, 21*, 31–39. doi: 10.1016/j.clnesp.2017.06.001

Spinelli, S., Masi, C., Dinnella, C., Zoboli, G.P., & Monteleone, E. (2014). How does it make you feel? A new approach to measuring emotions in food product experience. *Food Quality and Preference, 37*, 109–122. doi: 10.1016/j.foodqual.2013.11.009

Stone, H., Bleibaum, R.N., & Thomas, H.A. (2012). *Sensory evaluation practices*, 4th edn. Elsevier/Academic Press, Amsterdam; Boston

Ueda, Y., Sakaguchi, M., Hirayama, K., Miyajima, R., & Kimizuka, A. (1990) Characteristic flavor constituents in water extract of garlic. *Agricultural and Biological Chemistry, 54*,163–169.

Ueda, Y., Tsubuku, T., & Miyajima, R. (1994) Composition of sulfur-containing components in onion and their flavor characters. *Bioscience, Biotechnology, and Biochemistry, 58*, 108-110.

van der Meij, B.S., Wijnhoven, H.A.H., Finlayson, G.S, Oosten, B.S.H., & Visser, M. (2015). Specific food preferences of older adults with a poor appetite. A forced-choice test conducted in various care settings. *Appetite, 90*, 168–175. doi: 10.1016/j.appet.2015.03.011

van Koningsbruggen, G.M., Stroebe, W., & Aarts, H. (2013). Successful restrained eating and trait impulsiveness. *Appetite, 60*, 81–84. doi: 10.1016/j.appet.2012.09.016

van Strien, T., Frijters, J.E.R., Bergers, G.PA., & Defares, P.B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders, 5*, 295–315. doi: AID-EAT2260050209>3.0.CO;2-T

Villegas-Ruiz, X., Angulo, O., & O'Mahony, M. (2008). Hidden and false "preferences" On the structured 9-point hedonic scale. *Journal of Sensory Studies, 23*, 780–790. doi: 10.1111/j.1745-459X.2008.00184.x

Werthmann, J., Jansen, A, & Roefs, A. (2016). Make up your mind about food: A healthy mindset attenuates attention for high-calorie food in restrained eaters. *Appetite, 105*, 53–59. doi: 10.1016/j.appet.2016.05.005

Wichchukit, S., & O'Mahony, M. (2015). The 9-point hedonic scale and hedonic ranking in food science: some reappraisals and alternatives: The 9-point hedonic scale in food science. *Journal of the Science of Food and Agriculture, 95*, 2167–2178. doi: 10.1002/jsfa.6993

Winter, S.R., Feig, E.H., Kounios, J, Erickson B, Berkowitz S, Lowe MR. (2016) The relation of hedonic hunger and restrained eating to lateralized frontal activation. *Physiology & Behavior, 163,* 64–69. doi: 10.1016/j.physbeh.2016.04.050

Xiong, R., & Meullenet, J.-F. (2006). A PLS dummy variable approach to assess the impact of jar attributes on liking. *Food Quality and Preference, 17,* 188–198. doi: 10.1016/j.foodqual.2005.03.006

Zeng, Z., & Jiang, H. (2015). Recent advances in kokumi substances. *Shipin Kexue (Beijing, China) 36,* 297–301. doi: 10.7506/spkx1002-6630-201519054

Zurawicki, L. (2015). Pleasures of the palate from the consumer marketing perspective. *Food Research International,76,* 200–206. doi: 10.1016/j.foodres.2015.05.003

(2017) Errata for Chemical and Pharmaceutical Bulletin. Chemical and Pharmaceutical Bulletin 65:603–603. doi: 10.1248/cpb.c17-e6506

Appendix A- Informed Consent for Difference/Preference Test

Hello-

You are invited to take part in a research project conducted by graduate student Tamara Stephens who is working with Professor Mary Ellen Camire of the University of Maine School of Food and Agriculture. This project studies how flavor affects food liking. You must be at least 18 years old to participate. If you do not like tomato soup or are allergic to tomatoes or wheat or soy, please do not participate in this study. Please do not take part if you use tobacco or electronic cigarette products, or if you take medicine that affects your senses of taste and smell.

What Will You Be Asked to Do?

You will be asked to taste tomato soup and answer questions about them. The test should not take more than 30 minutes to complete.

Risks

The risk is no greater risk than the normal daily eating and includes your inconvenience and loss of 30 minutes of your time.

Benefits

There are no direct benefits to you for answering this survey, but your answers may help us better understand how flavor affects food choice.

Compensation

You will receive $2.00 for completing this test upon completion of the test.

Confidentiality

Your answers will be collected and encrypted to protect your privacy. You will not be contacted for any other matter, and only the researchers will have access to your answers. The results will be stored in a secure database and will be deleted by June 1, 2020.

Voluntary

Participation in this research is voluntary.

Contact Information

If you have any questions about this project, please contact Tamara Stephens, 100 Hitchner Hall, University of Maine at (207)581-1733 (or tamara.stephens@maine.edu). If you have any questions about your rights as a research participant, please contact Gayle Jones, Assistant to the University of Maine's Protection of Human Subjects Review Board at 581- 1498 (or email UMRIC@.maine.edu)

Appendix B- Recruitment Notice for Difference/Preference Test

Hello-

You are invited to take part in a research project conducted by graduate student Tamara Stephens who is working with Professor Mary Ellen Camire of the University of Maine School of Food and Agriculture. If you are at least 18 years old and like tomato soup please help a University of Maine M.S. thesis student with her project to evaluate how flavor influences food liking.

If you do not like tomato soup or are allergic to tomatoes or wheat, please do not participate in this study. Please do not take part if you use tobacco or electronic cigarette products, or if you take medicine that affects your senses of taste and smell. The soup contains soy so please don't participate if you have a soy allergy.

The test should not take more than thirty minutes to complete. If you complete the test, you will receive $2.00 compensation.

Please refrain from eating or drinking anything other than water for at least one hour before testing.

If you are willing and able to participate, please reserve a

testing appointment: [e URL] *To be added
Testing will be held on: TBD at the Sensory Evaluation Center located in Hitchner Hall
(Room 158A and 158B) at the University of Maine near the Page Museum.

For more information, please contact Tamara Stephens at tamara.stephens@maine.edu or (207)581-1733.

Appendix C- Difference/Preference Test Questionnaire

Please take a sip of water before tasting each sample, and taste the samples in the order shown on your computer screen.

Which sample tastes different from the other two? _____
Please tell us why you thought that is was different. _____

Please open the window slightly so that the staff knows that you are done with this part of the test. A second tray will be given to you in a moment.

Please take a sip of water before tasting each sample, and taste the samples in the order shown on your computer screen.

Which sample do you like best? _____
Could you please tell us why you made that choice?
_____
_

Thank you for participating in this study. The test is now over. Please open your window again and collect your compensation from the staff in the hall

Appendix D- Informed Consent for Acceptability and Emotions Test

Hello-

You are invited to take part in a research project conducted by graduate student Tamara Stephens who is working with Professor Mary Ellen Camire of the University of Maine School of Food and Agriculture The goal of this project is to see if how flavor affects food liking. You must be at least 18 years old to participate. If you do not like tomato soup or are allergic to tomatoes, wheat or soy, please do not participate in this study. Please do not take part if you use tobacco or electronic cigarette products, or if you take medicine that affects your senses of taste and smell.

What Will You Be Asked to Do?

You will be asked to taste samples of tomato soup and answer questions about them, and to answer some questions about yourself such as your age and gender, how you feel, and your eating habits. The test shouldn't take more than 45 minutes to complete.

Risks

The risk is no greater risk than the normal daily eating and includes your inconvenience and loss of 45 minutes of your time.

Benefits

There are no direct benefits to you for answering this survey, but your answers may help us better understand how flavor affects food liking.

Compensation

You will receive $10.00 for completing this test upon completion of the test.

Confidentiality

Your answers will be collected and encrypted to protect your privacy. You will not be contacted for any other matter, and only the researchers will have access to your information. The results will be stored in a secure database and will be deleted by June 1, 2020.

Voluntary

Participation in this research is completely voluntary.

Contact Information

If you have any questions about this project, please contact Tamara Stephens, 100 Hitchner Hall, University of Maine at (207)581-1733 (or tamara.stephens@maine.edu). If you have any questions about your rights as a research participant, please contact Gayle Jones, Assistant to the University of Maine's Protection of Human Subjects Review Board at 581- 1498 (or email UMRIC@.maine.edu)

Appendix E- Recruitment Notice for Acceptability and Emotions Test

Hello-

You are invited to take part in a research project conducted by graduate student Tamara Stephens who is working with Professor Mary Ellen Camire of the University of Maine School of Food and Agriculture. If you are least 18 years old and like tomato soup please help a University of Maine M.S. thesis student with her project to evaluate how emotion influences food liking.

If you do not like tomato soup or are allergic to tomatoes or wheat, please do not participate in this study. Please do not take part if you use tobacco or electronic cigarette products, or if you take medicine that affects your senses of taste and smell/ The soup contains soy so please don't participate if you have a soy allergy.

The test should not take more than forty-five minutes to complete. If you complete the test, you will receive $10.00 compensation.

Please refrain from eating or drinking anything other than water for at least one hour before testing.

If you are willing and able to participate, please reserve a

testing appointment: [e URL] *To be added
Testing will be held on: TBD at the Sensory Evaluation Center located in Hitchner Hall (Room 158A and 158B) at the University of Maine near the Page Museum.

For more information, please contact Tamara Stephens at tamara.stephens@maine.edu or (207)581-1733.

Appendix F- Acceptability and Emotions Test Questionnaire

1. What is your current age?_____Prefer to not say_____
2. Please indicate your gender. Female_____Male_____Prefer to not say
3. Do you like tomato soup? Yes_____Neutral_____No_____

Please take a sip of water before tasting the sample.

How much do you like the taste of this soup?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neutral	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you like the thickness of the soup?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neutral	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much you like this soup overall?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neutral	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Is there anything else that you would like to say about this soup?

_____

_____

Below you will find words that describe different kinds of moods and feelings. Using the terms listed, please describe how you FEEL RIGHT Now. Please rate each feeling.

Feeling	Not at all	Slightly	Moderately	Very	Extremely
Happy					
Pleasant					
Good					
Enthusiastic					
Joyful					
Interested					
Satisfied					
Free					
Good-natured					
Active					
Calm					
Tame					
Nostalgic					
Loving					
Understanding					
Mild					
Warm					
Secure					
Aggressive					
Adventurous					
Wild					
Guilty					
Worried					
Bored					
Disgusted					

Please slightly open the window to let the staff know that you are done with this sample, then answer the next set of questions before you taste the second sample.

Do you try to eat less at mealtimes than you would like to eat?

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

Do you make any restrictions in your daily diet?

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

Do you desire to eat when you smell or see food?

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

I feel hungry because what I am eating is not enough.

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

When I feel stressed I overeat.

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

Do you leave food on your plate?

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

When I start eating I can’t seem to stop.

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

I don’t get full easily

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

I feel hungry because what I am eating is not enough.

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

I get so hungry that my stomach often feels like a bottomless pit

Never	Seldom	Sometimes	Often	Very Often
1	2	3	4	5

Please slightly open the window to let the staff know that you are done with this sample, then answer the next set of questions before you taste the second sample.

Please take a sip of water before tasting the sample.

How much do you like the taste of this soup?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neutral	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much do you like the thickness of the soup?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neutral	Like Slightly	Like Moderately	Like Very Much	Like Extremely

How much you like this soup overall?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neutral	Like Slightly	Like Moderately	Like Very Much	Like Extremely

Is there anything else that you would like to say about this soup?

_____

_____

Below you will find words that describe different kinds of moods and feelings. Using the terms listed, please describe how you FEEL RIGHT Now. Please rate each feeling.

Feeling	Not at all	Slightly	Moderately	Very	Extremely
Happy					
Pleasant					
Good					
Enthusiastic					
Joyful					
Interested					
Satisfied					
Free					
Good-natured					
Active					
Calm					
Tame					
Nostalgic					
Loving					
Understanding					
Mild					
Warm					
Secure					
Aggressive					
Adventurous					
Wild					
Guilty					
Worried					
Bored					
Disgusted					

Thank you for participating in this study. The test is now over. Please open your window again and collect your compensation from the staff in the hall.

Appendix G- Komi Powder Data Sheet

NIKKEN FOODS USA, INC.
4984 Manchester Avenue
St. Louis, MO 63110USA
Tel: (314) 881-5858
Fax: (314) 881-5850

Prepared by:
Nikken Foods USA, Inc.
4984 Manchester Avenue St.
Louis, MO 63110 USA
For inquires contact:
regulatory@nikkenfoods.com

Technical Data Sheet **PRODUCT CODE 7400**

KOMI™ POWDER

Description		Naturally and specially fermented soybean sauce spray dried on a corn maltodextrin carrier. This product provides a light tan, free flowing water-soluble powder with distinct flavor enhancement properties.	
Ingredients		Fermented Soybean Sauce (Fermented Soybeans, Wheat and Salt) and Maltodextrin.	
Applications		Soups, sauces/marinades, salad dressings, gravies, dips, seasonings, snacks, appetizers, entrees, breads/crackers, dressings/stuffings along with sodium reduction and flavor enhancement applications.	
Typical Data (reported on COA)		Moisture	6.0 % Maximum
		Salt	11.0 % ± 3.0 %
		Total Nitrogen	3.7 % Minimum
	Calculated	Protein *(Total N X 6.25)*	23.0 % Minimum
	Microbiological	Total Plate Count	< 5,000 cfu/g
		Coliforms	Negative
		E.Coli	Negative
		Yeast & Mold	< 300 cfu/g
		Salmonella	Negative
Nutritional Data (expected values)		Per 100 Grams	320 kcal
		Moisture	6.0 % Maximum
		Fat	0.2 % ± 0.2 %
		Protein	23.0 % Minimum
		Carbohydrates	55.0 % ± 3.0 %
		Ash	15.0 % ± 3.0 %

Standard Packing 20 kg (44.10 lb) net in a corrugated carton with a polyethylene liner.

Revised: 01/26/2017 SRH Supersedes: 05/26/2015 GRI

www.nikkenfoods.com

Appendix H- Comments

Triangle Test

0% Kokumi: 896,

less sweet, bit more sour

The initial taste of 972 is different but the after taste is the same. I have no idea why 896 is different as it tasted little less spicy Fuller taste

They all tasted very similar to me. Looking at all the samples I picked 972 because it was darker in color.

lighter on the tomato taste

It had a richer taste then the other two, the other two were a little more watery I think this sample is a little more flavorful than the other two.

It had a milder less hearty flavor. It also seemed less viscous

It was not as savory/salty as the other 2 samples.

The other two were more `acidic`

The color of 972 looks different. 972 doesn`t taste as acidic as the other two samples. The taste of 972 reminds me of burnt potato skin

I did not detect any difference. I chose one just to get out of the question. sorry . . .

I enjoyed sample 972 the least. I found it to be the least sweet/flavorful.

more acidic

tasted richer and saltier

I am not sure why I thought this one was different, but I would say maybe this one was a little more sour?

0.6% Kokumi: 972,735

saltier and tangier

Seemed to have less taste like watered down.

This sample tasted saltier than the other two samples. Maybe a stronger tomato taste too?!

This one tasted a little sweeter than the other two.

It tastes more tomato-y and maybe less salty

It seemed to have a bit more of a savory flavor.

The difference between the three was quite subtle.

less salt for flavoring

slightly different aftertaste

It tasted more grainy or malty.

this sample was slightly less flavorful than the other 2

It tastes like it is more watered down and bitter/acidic.

It was honestly hard for me to tell the difference. Maybe 735 was a bit less flavorful. They were all very similar to me.

735 was less tangy than the other two

very difficult!!! It seemed a tad milder in intensity....

The taste of 972 stayed longer then the tastes of 896 and 597. I liked the aftertaste of 972 sample.

896 just doesn`t have as hearty of a tomato flavor as the other two sample. It tastes a little more watered down.

It was a little bit more sour than the other two samples.

Preference Test

0% Kokumi-198
0.6% Kokum-462

462-it was a more savory, and 198 tasted more sweet. a combination of the both would be best. although I liked 462 more, it was a bit too salty and tangy. Also, the soup in both tests is cold and therefore hard to gauge taste with.

198 tasted lighter and slightly more flavorful than 462

198- While I did not like the lighter color, I preferred the flavor of this sample. The other one tasted burnt. This sample had a light tomato flavor.

198- Smoother and stronger

462 the flavor was much more robust to me. Sample 198 tasted plain and watery to me

198-thicker richer flavor. more tomato flavors

198-more of a true tomato taste

198-seems saltier

198 tastes more like tomato. 462 tastes like grains.

I liked sample 462 more because it had a heartier flavor and a darker richer color. Sample 198 seemed to have too mild of a tomato flavor to me.

Sample 462 had more of a body to the flavor. Sample 198 was more `flat` in terms of flavor.

462 reminds me of the previous sample: 972.

Overall, I prefer 198 because there isn`t a lingering flavor of the `burnt` taste. It tastes like there are crackers in 462, whereas 198 tastes more like bread

198-It was thicker and seemed heartier

198 seemed a tad sweeter.....

198 less acidic

Sample 198 has a strange viscosity to it, that sample 462 didn`t have. Sample 462 also taste more like straight tomato, in a unconcentrated soup.

I liked sample 198 because the soup tasted really balanced. However, I liked the color better in sample 462 but sample 462 was little more sour. They were really similar to me.

462- there seemed to be more taste and just a tad bit sweeter…

198 is a bit sweeter 462 bit too intense aftertaste

I like spicy food. 462 feels more spicier than 198

It had a slightly sweeter taste than 198.

462 was a little too sugary for me. 198 has more of a tomatoey taste.

462-The flavor reminded me more of a classic, creamy tomato soup. The other tasted more pure. I also think the mouth feel (not to sound too pretentious) of 198 was superior.

462 more flavorful soup, it was more tangy and rich than the first sample.

I think sample 462 has a stronger flavor than 198.

462-this sample had a thicker consistency which I prefer, and it also had a stronger flavor

462- It is less acidic, and creamier than the other soup.

462-I really couldn`t tell much of a difference, however, 198 may have been a little more flavorful I enjoyed both.

462-I feel like this one has more of a tomato flavour and would go better with bread or other sides.

Honestly, I liked both samples and all three in the other part of the test! I truly did not find detectable differences between them. Incidentally, it was great having them served very hot, and the aroma was fantastic! Now I`m hungry and must go eat my salad lunch . . .

I enjoyed 198 much more than 462. I found 198 to be more flavorful, less acidic, and more sweet tasting. I found sample 462 to taste less tomato-y.

The 462 sample had more umami and good aftertaste and the good taste and umami stayed longer in my mouth. On the other hand, I could not feel any aftertaste of sample 198. The taste was immediately disappeared after swallowing.

462- It taste lighter and fresher, less saltier. the other one left a bit of bitter after-taste.

462-I feel like that sample has a richer, deeper flavor than the other sample which was kind of weak and thin.

BIOGRAPHY OF THE AUTHOR

Tamara Stephens was born in Manipal, India on November 12, 1991. She was raised all over the world. Tamara grew up in India, Belize, and the United States which fostered her love of food. She attended Oregon State University and graduated in 2015 with a Bachelor's degree in Food Science and Technology. She then moved to Maine and entered the Food Science and Human Nutrition graduate program at The University of Maine in the fall of 2016. After receiving her degree, Tamara would like to begin her career in the field of sensory science. Tamara is a candidate for the Master of Science degree in Food Science and Human Nutrition from the University of Maine in August 2019.