SENSORY ANALYSIS FOR DETERMINING THE INFLUENCE OF VISUAL STIMULI UPON EATING EXPERIENCES

A Dissertation

Submitted to the Graduate Faculty of the Louisiana State University and Agricultural and Mechanical College in partial fulfillment of the requirements for the degree of Doctor of Philosophy

in

The School of Nutrition and Food Sciences

by
Pitchayapat Chonpracha
B.S., Kasetsart University, Thailand, 2006
M.S., Kasetsart University, Thailand, 2010
May 2019
ACKNOWLEDGEMENTS

This work would not have been possible without the advice and support from many people that I could not express the level of gratitude in words for their contributions to my time in graduate school at LSU. Most specifically, I am indebted to my advisor, Dr. Witoon Prinyawiwatkul. My life has been changed since the first day at LSU. The new chapter started in Spring 2015 after Dr. Witoon accepted my application and further allowed me to join his sensory team. On the academic level, Dr. Witoon taught me the fundamentals of conducting scientific research in the sensory areas and provided me with endless support for the project. Under his supervision, I have had an opportunity to identify a research problem, design the experiment, identify possible solutions and finally publish the results. On a personal level, Dr. Witoon inspired me by his passionate attitude of being a donor and hard–worker who worked actively to provide me with opportunities to pursue my career goals. I am very grateful to LSU AgCenter Food Incubator, especially Gay Sandoz, Director of LSU AgCenter Food Incubator, for financial support that I otherwise would not have been able to accomplish my education.

Besides, I would like to thank my dissertation committee members, Dr. Marlene Janes, and Dr. Georgianna Tuuri for their great support and valuable advice. They have provided me with professional guidance on the research context and shaped my final dissertation. I truly appreciated Dr. Philip Jung of agreeing to serve on my dissertation Dean’s Representative. The value of his comments and contributions are valuable to fulfill the goals of my research.

I would especially like to thank Ashley Gutierrez, Dr. Wannita Jirangrat and Tony Gualtieri for helping me tailor my writing skills. I could not have accomplished my experiment without the tremendous contribution of my lab mates. Thank you Dr. Damir Torrico, Dr. Wisdom Wardy, Dr.
To Kairy Pujols, Yupeng Gao, Valentina Rosasco, Jose Alonso, Ryan Ardoin and visiting scholars who supported my study. Thank you for being part of my journey.

I am also grateful to Kloytypia Chuunnaigit, Kanya Arntson, Jintana Cochran, Dr. Manoch–Laddawan Konchum, Kanitta–William Ruiz and other Thai friends for their support, trust in my foods and sharing a smile together during my time in Baton Rouge. Thanks my friends in Thailand for friendship, support, caring and understanding through all those tough times in life.

Nobody has been more important to me in the pursuit of this degree than my family. I would like to thank and dedicate this dissertation to grandma and aunts, for their endless love and continuous encouragement for whatever I have pursued. I would not have been who I am right now without them. Thank for having faith in me. Importantly, I would like to express my deepest gratitude to all distinguished supervising teachers and professors in my life for their wisdom and giving me valuable knowledge and opportunities that could expand my visions and allow me to come to this point.
# TABLE OF CONTENTS

ACKNOWLEDGEMENTS........................................................................................................... ii

ABSTRACT .................................................................................................................................... v

CHAPTER 1. INTRODUCTION ........................................................................................................ 1

CHAPTER 2. LITERATURE REVIEW ................................................................................................. 9

CHAPTER 3. THE EFFECT OF INTRINSIC AND EXTRINSIC VISUAL CUES ON CONSUMER PERCEPTIONS AND OVERALL FOOD EXPERIENCES: A CASE OF READY–TO–EAT SALAD .................................................................................. 35

CHAPTER 4. COMPARISON OF THE R0INDEX AND PARTIAL PROJECTIVE MAPPING APPROACHES FOR SENSORY DISCRIMINATION OF SALTINESS AND BITTERNESS OF SALT MIXTURES CONTAINING L–ARGININE .......................................................................................................................... 65

CHAPTER 5. THE USE OF VISUAL CUES TO ENHANCE TASTE PERCEPTION: A CASE STUDY FOR REDUCED CONSUMPTION OF SALT AND SUGAR IN FOOD MODELS ......................................................................................... 86

CHAPTER 6. SUMMARY AND CONCLUSIONS ............................................................................... 119

APPENDIX A. QUESTIONNAIRE FOR CHAPTER 3 ...................................................................... 121

APPENDIX B. QUESTIONNAIRE FOR CHAPTER 4 ...................................................................... 142

APPENDIX C. QUESTIONNAIRE FOR CHAPTER 5 ...................................................................... 144

APPENDIX D. LSU AGCENTER INSTITUTIONAL REVIEW BOARD (IRB) EXEMPTION FORM INSTITUTIONAL OVERSIGHT ......................................................................................................................... 151

APPENDIX E. SEGMENTATION OF CONSUMERS IN CHAPTER 3 ............................................. 153

VITA ............................................................................................................................................... 154
ABSTRACT

Consumers are currently more conscious about salt and sugar intake than they were in the past. Visual cues have been shown to impact consumers’ cognitive and their taste perceptions. Current research information about visual cues enhancing human’s tastes expectation of saltiness and sweetness is limited. The sophisticated sensory analysis for products containing a reduced amount of salt and sugar is undoubtedly time-consuming and costly if the sensory experiment is designed with many samples. Therefore, the following three studies were achieved: I) an examination of how intrinsic and extrinsic visual cues affect the overall consumer eating experiences; II) a comparison of non–sensory discrimination ability of R–Index (RIX) and Partial Projective Mapping (PPM) in the application of salt substitute; and III) a study of consumers’ responses to visual cues enhancing taste perceptions of saltiness and sweetness. In study I, 150 consumers visually evaluated their liking, emotion and purchase intent of ready–to–eat (RTE) salad with four different visual effects (green color, size, multicolor and package) that were nested in a given condition with or without product name. The visual factors strongly impacted consumer liking, emotion, and purchase intent. The color cues were more sensitive for distinguishing consumers liking score and emotion while the purchase intent was dependent on how well consumers liked and felt about the product, not just their liking alone.

Study II compared RIX and PPM for discrimination ability of salt substitutes containing KCl and L–Arginine (bitterness blocker). The R–Index by the ranking method was used to determine sensory discrimination. Panelists ranked three salt mixture concentrations (0.5%w/v, 1% w/v and 1.5%w/v) for saltiness and bitterness intensity; hence they participated 6 RIX sessions (2 attributes x 3 concentrations). In contrast, PPM allowed panelists to evaluate all samples simultaneously. Both RIX and PPM performed similarly for sensory discrimination with slight
differences; however, PPM took a shorter time to complete the task and may offer slightly more sensitivity to differences.

Study III, the effect of visual cues on taste expectation was divided into two parts; visual expectation of saltiness perception using chicken broth as a food model, and expectation of sweetness expectation using syrup which was added to brewed coffee. Color cue strongly influenced consumers’ eating behavior by affecting their taste expectation during the decision–making process, and this finding may alleviate overconsumption of salt and sugar.
CHAPTER 1. INTRODUCTION

1.1. Introduction

Salt and sugar are the most versatile ingredients in foods, however, much well-established evidences indicates that Americans are consuming much more than the recommended levels of salt and sugar (DiNicolantonio and others 2016). Consumers may not realize how omnipresent salt and sugar are in popular products on grocery shelves. Excessive salt intake alone was identified as the major dietary determinants of hypertension and cardiovascular disease. Recent studies have suggested that high salt intake is also indirectly associated with an increased risk for obesity because it promotes greater sugar–sweetened beverage consumption (Ma and others 2015). Given the current food environment, several approaches including crucial strategies have been applied to achieve meaningful reductions in sodium intake. The strategies take into account public education, individual dietary counseling, food labeling, coordinated and voluntary industry sodium and sugar reduction effort, government and private sector food procurement policies, and FDA regulations, as recommended by the Institute of Medicine, to modify sodium’s generally recognized as safe (GRAS) statue (Coob and others 2012).

Although reduction of salt and sugar in foods is essential for improving consumer wellness, the quality, taste and functional attributes of such products have received noteworthy consideration. Partial replacement of NaCl with potassium chloride (KCl) has been the most preferred method of reducing sodium content. However, bitter and metallic aftertaste are the most common problems encountered (Khetra and others 2016). Similarly, switching sugar to sugar alternatives or sweeteners can cause changes in consumers’ expectation, concerning sensory liking, desirable intake amounts, and functions in promoting health (Wardy and others 2017). Besides those sensory characteristics, the psychological influences due to past experiences,
product information, and cognitive factors are also influential in one’s perception of a food product. These factors often create expectations (before tasting the product) and can sway a consumer’s perception of a product when they are confirmed and disconfirmed (after tasting the product) (Teixeira Lopes and others 2018; Hurling and Shepherd 2003; Delwiche, 2012; Wan and others 2015; Urbanus and others 2014).

Visual perception of sensory intrinsic and extrinsic cues has been proven to set consumers’ expectations regarding the taste and flavor perception of foods (Symmank and others 2018; Cardello 2007; Spence 2015). The impact of color constitutes one of the most salient visual cues influencing food’s sensory properties, and can be used to modify consumer’s perception of a taste that is already presented in the mouth (Spence 2017a). Changing the color intensity or hue of food and beverage items can exert a sometimes dramatic impact on its perception. For instance, a drink that was perceived as sweet as if 10% more sugar were added (Clydesdale and others 1992). Psychologically–induced taste enhancement is indeed indistinguishable from real perception (Spence 2017b).

In the food industry, overall discrimination tests are used with untrained/naïve consumers to compare multiple test stimuli against a fixed reference (Jeong and others 2016; Bi 2015). The difficulty of that testing is reflected in the response accuracy of the measurement (Sun and Landy 2016), time required for completing the test, power of discrimination test to reliably detect differences between stimuli and even the effect of memory. These limitations could lead to panelist fatigue and a reduction in sensitivity of the methods (Enis 2012) or cause adaptation due to the experimental series progress. Rapid descriptive sensory profiling methods, the alternative method under active investigation for identifying overall differences among multiple samples, includes sorting and projective mapping (Dehlholm and others 2012). The motivation behind developing
this method is imposed by its nature, intuitive, and holistic way for consumers to describe products as if they were in front of the market shelf (Varela and Ares 2012). These discrimination methods provide researchers with scientifically valid tools for sample screening and understanding consumer preferences, without the extensive time and cost (Louw and others 2013).

1.2. Research Justification

A significance lowering of dietary salt and sugar requires a shift in two key domains: a reduction of salt and sugar in commercial foods and changes in consumer behavior. The challenge for commercial foods is to achieve further reductions in the salt and sugar content while maintaining good taste and texture stability to guarantee that consumers will like or even prefer these reformulated products (Zandstra and others 2016). The food industry has already lowered both ingredient levels in many products by gradually replacing salt with KCl (Dötsch and others 2009; Webster and others 2011) and replacing sugar with alternative sweeteners such as non-nutritive sweeteners (Dubois and Prakash 2012; Pawar and others 2013). However, there remains a pressing need for further reductions (Hendriksen and others 2014). Replacing or reducing salt or sugar can lead to undesirable taste and flavor (Morais and others 2014, Zorn and others 2014), and reduction or replacement strategies are not “one size fits all” (Wagoner and others 2018). Hence, further reductions will require the use of advanced food technology and that salt replacement ingredients are not seen as unnatural and do not negatively impact the taste.

Changes in consumer behavior regarding less salt and sugar consumption are also required to ensure that the reduced salt or sugar products are accepted and that consumers do not add them back during cooking. Consumer behavior changes in this area remain complex and have received relatively little attention. Recent studies suggest that consumers in both developing and developed countries are primarily aware of the adverse health effect of too much salt and sugar, and they
think reducing salt and sugar intake is healthy and essential (Newson and others 2013; Busch and others 2013). However, this awareness does not translate into relevant behavioral changes (e.g., reduction in salt or swapping in sugar alternatives) (Zandstra and others 2016). There is also evidence indicating that if products have lower salt and sugar intensity when compared to the regular ones, consumers start replacing the removed salt by adding salt back at the table (Liem and others 2012). Furthermore, consumers are expected to reject the product with a low salt or sugar content if those products do not meet their sensory and hedonic expectation, even if they are healthier than a regular version (Civille and Oftedal 2012).

Multisensory interactions as a combined method can be applied to a current situation of salt and sugar reduction due to their involvement in the integration of all human sense (Carvalho and Spence 2018). Sensory cues have been reported to affect human perception of taste, flavor and hedonic judgments (Spence and others 2012; Spence and Piqueras–Fiszman 2014). Taste and aroma interactions are also utilized to boost saltiness (Delwiche 2004). The type and intensity of color’s hue influence the expectations concerning flavor (Zellner and others 2018), and taste expectation such as red–colored solutions being rated sweeter than green–colored solutions or uncolored solutions, and dark red solutions being rated sweeter than light–red solutions (Wadhera and others 2014) are to be considered. Certain colors have been found to correspond with specific taste (e.g., red with sweet and green with sour) (Koch and Koch 2003).

When exploring the consumer’s response toward the reduced salt and sugar products, the selection of appropriate sensory methodology is critical. Conventional sensory descriptive analysis and sensory discrimination tests may be difficult to apply due to the time and resource needed for its implementation (Varela and Ares 2012). Considering the time spent on conventional profiling, rapid descriptive methods may offer a considerable cost saving by speeding up a project (Delholm
and others 2012), and can provide a sample map in a relatively short time (Chollet and others 2011). One of the rapid descriptive methods, Partial Projective Mapping (PPM) showed a higher correlation with conventional descriptive analysis and showed better discrimination than global projective mapping (Pfeiffer and Gilbert 2008).

1.3. Research Objectives

Giving the significance of salt and sugar reduction in public health, it is important to take into consideration the visual cues that can influence consumers’ perception and their acceptance of a food product. No research has been reported to utilize the benefits of visual cues affecting a taste perception to enhance saltiness and sweetness in reduced salt or sugar products. In addition, the existing sensory profiling methods that have been used to analyze consumers’ preference, and eventually consumers’ behaviors are costly and take an extended period for evaluation. Using rapid sensory profiling may help reduce time–process and give a better product screen during a formulation process. Specific objectives of this dissertation were to I) study the impact of product intrinsic and extrinsic cues on consumer liking, emotion, and purchase intention; II) compare sensory discrimination ability of the R–Index (RIX) by a ranking procedure and the partial projective mapping (PPM) using salt substitute as a food model; III) identify the influence of visual cues on a taste perception of saltiness and sweetness.

1.4. References


CHAPTER 2. LITERATURE REVIEW

2.1. Factors affecting consumer purchase decision

Consumers’ purchase behaviors in today’s world continue to depend on their experiences and knowledge of products. Some consumers may be able to make quick purchase decisions while others may need to get information and be more involved in the decision process before making a purchase. Increasing sophistication in technology makes it even more challenging for the consumer who expects a brand to deliver new and innovative products, putting increased pressure on manufacturers. Despite this, many new food products entering the supermarket shelves have a high failure rate resulting in substantial costs and missed opportunities for the food industry (Kemp 2013). The link between a hedonic measurement and sensory product characteristics may not be so direct, and it may be that other subjective and complex dimensions are also influencing consumer judgment (Palczak and others 2019). Many different scientific disciplines (including biology, physiology, psychology, sociology, sensory consumer and food science, marketing and economics) study consumer behavior and many different factors that interact to form consumer's perception and preferences (Asioli and others 2017). Researchers especially psychologists have long been interested in the effect of a combination of sensory stimuli, both intrinsic and extrinsic, in product evaluation (Enneking and others 2007).

Food product characteristics can be divided into two main groups of intrinsic and extrinsic attributes. Intrinsic characteristics refer to qualities that are part of the physical product (e.g., sensory characteristic, ingredients, nutritional composition), whereas the extrinsic characteristics are not part of the physical product and can be modified without changing the characteristics of the product (e.g., price, brand, package, health claim) (Olson and Jacoby 1972). Some of these extrinsic attributes such as price, layout, and brand can easily be evaluated during shopping, while
others are unobservable (e.g., health/sustainability claims) and must be believed (Fernqvist and Ekelund 2014; Northen 2000). Despite a lack of any actual effect on product quality, many extrinsic cues have been found to significantly influence consumer perception of product performance and quality (Veale and Quester 2009).

Both product characteristics related to all other aspects of the product and its presentation are important for consumer choice probability or liking of food products (Figure 2.1). For instance, studies have shown a positive effect of information about sugar and fat content (Johansen and others 2010) as well as the packaging to be critical to the food choice. Both characteristics are essential and should be taken into account in research when the objective is to understand the patterns in human perception and liking or choice probability, but they may also be highly relevant in actual industrial product development situations (Menichelli and others 2012). However, the health information is likely to affect choice on the first time purchase, while the sensory dimensions and the product experience will probably be the prime factors for repeat purchase of the product, reflecting previous intrinsic experience and memory of sensory acceptance (Schifferstein and others 2013; Kardes and others 2004), which is strongly related to expectation.

2.1.1. Role of intrinsic sensory characteristics

The Sensory Visual Cue Theory is one of the most applied frameworks to assess consumer perceptions. Involvement of intrinsic cues plays a crucial role in consumers' product appraisal of quality. This quality perception begins with an acquisition and classification of signs that are associated with the product’s intrinsic attributes such as appearance, color, and flavor, and will be increased during the process of consumption (Espejel and others 2007). The higher level of perceived quality of intrinsic attributes (e.g. sensory quality) in the long term will also increase the quality perception of the extrinsic attributes, for instance, the brands. As a consequence, the
intrinsic quality may rise the satisfaction and the loyalty toward a product. In case of a recurring purchase, the intrinsic characteristics can better contribute satisfaction toward consumers' needs than extrinsic information (Fenko and others 2009; Shifferstein and others 2013).

Figure 2.1. Flow chart of how intrinsic and extrinsic sensory attributes respond to food choice and food intake (Modified from Gutjar and others 2015).

2.1.2. Role of extrinsic sensory characteristics

In addition to product intrinsic characteristics, mainly consumers' perceptions of product sensory attributes, the extrinsic characteristics are mainly focused on marketing aspects (Stone and others 2012) including brand name, packaging price and even health claim (Meillon and others 2010). These factors are the ones consumers usually consider when purchasing. At the point of sales, extrinsic factors are leading determinants since intrinsic factors have not yet been evaluated at this stage. These extrinsic factors give rise to expectations regarding intrinsic properties. An expression is formed based on the first impression or previous experiences, and in turn, can influence present perception of the product (Tijssen and others 2017). Product name, for instance, is a powerful tool in the communication between products and consumers by creating specific sensory expectations through prior associations and experiences of consumption (Cardello 2007). Moreover, in the absence of experience or when products are difficult to evaluate (e.g., wine and perfume), consumers often evaluate quality on the bases of extrinsic cues such as packaging,
branding, and labeling (e.g., best before date, days since harvest) (Schiffman and Kanuk 2007). An extrinsic cue can provide a critical impetus for consumers' choices to help reduce the perceived risk of making a wrong choice (Carlucci and others 2015; Boncinelli and others 2019). Acebrón and Domingo (2000) studied consumer expected quality of beef using the extrinsic (price, promotion, designation of origin and presentation) quality cues. The results indicated that as far as expected quality is concerned, the most significant extrinsic cue was the price as it exerted a very positive influence on expected quality. Additionally, in a case of meat products such as beef, the types of information about production method, product nutrition, and safety are not easily known; hence, the consumer seeks extrinsic cues as a signal for quality perceptions (Telligman and others 2017). At the consumption stage, the presence of extrinsic cues did affect consumers' acceptance differently based on consumption experience, but it did not change the preference trend (Choi and Lee 2019).

2.1.3. Expectation based on sensory intrinsic and extrinsic cues

Expectation is psychological anticipation that an event will occur or be experienced at an unconscious level (Cardello 2007). Expectation affects responses, and may improve or degrade the perception of a food or beverage even before it is tasted (Deliza and MacFie 1996). An expectation of sensory characteristics can be conceptualized as a sequence of multiple neural processes (Lobanov and others 2014). In particular, our brains interpret and integrate previously experienced (and stored) information with any newly–presented cues about the food that may be available before consumption. Consequently, that information induces great expectations in our mind (Spence and Piqueras–Fiszman 2014; Woods and others 2010).

The source of expectation can be derived from both intrinsic and extrinsic properties. Previous studies demonstrated that the intrinsic attributes which induce expectation of the sensory
qualities (Silva and other 2017) affect purchase decision. For instance, studies about buying fresh pork and beef uniformly identified the importance of color of the meat and the degree of visible fat as a significant quality when purchasing meat (Grunert and others 2015). Relevant intrinsic cues that unequivocally define a given category of beef include sensory (e.g., color, visible fat, cut of the meat) and nutritional attributes (Acebrón and Dopico 2000). In addition, Cardello (1994) has pointed out that visual cues are likely to generate salient expectation about a food or drink's characteristics since they often convey the first sensory impressions of that stimulus to the perceiver. Dijksterhuis and others (2014) also suggested that expectancy effects can start from the first bite of the product and exert an influence over the consumer's experience of the remainder of food consumption period if the difference in taste is not too significant. According to Olson and Jacoby (1972), intrinsic attributes are specific to each product, disappear after it has been consumed and cannot be altered without changing the nature of the product itself.

Extrinsic product cues are made up of information that is not physically part of the food but is related to the product. Their importance lies in the expectations they elicit. Such expectations, by contrast, constitute “pre–trial beliefs about the product” and may be operated via cognitive perceived information and psychological mechanisms of knowledge and previous memories of the same or similar cue (Cardello 2007; Okamoto and Dan 2013). Changing the color of potato chip packaging when consumers are acquainted with the brand may result in a different flavor (Piqueras–Fiszman and Spence 2011). The similar effect was observed for milk desserts with respect to package shape and coloring, further stressing the importance of appropriate packaging for the product’s appearance and acceptance (Ares and Deliza 2010). Expectancy effects elicited via extrinsic cues such as written text and pictorial labeling information including health claims, can affect a person’s intake (Piqueras–Fiszman and Spence 2015) and purchase
intent. For instance, the information given to a consumer about a product’s nutritional content (i.e., number of calories, fat, and salt content) can have important consequences in terms of their expectations and beliefs about the healthiness of a product. Wardy and others (2018) also reported that raising consumer consciousness about sugar reduction in a product positively affected overall liking, purchase intent and intensities of the emotion happy and wellness.

When food or drink is consumed and its flavor, aroma, or taste evaluated the perception and eating experience is subsequently compared to the expectation, and when the hedonic evaluation of a product meets the expectation, confirmation occurs (Piqueras–Fiszman and Spence 2015). However, in the case of discrepancy or disconfirmation, the observed effects can be explained by the assimilation/contrast model proposed by Anderson (1973). Assimilation occurs when consumers adjust their perception of the product due to what was expected, attempting to minimize the discrepancy between expected and actual experiences. This assimilation predicts positive disconfirmation when expectations are less than the actual hedonic response of a product, and negative disconfirmation when expectations are higher than the hedonic appraisal of a product (Cardello 2003). As a result of discrepancy, when consumers magnify the discrepancy between expectation and experience rates shift in the opposite direction (Yeomans and others 2008).

The sensory expectation of food and beverages based on extrinsic and intrinsic cues has been studied widely. For instance, the preferences for specific beers are influenced primarily by expectation derived from different extrinsic attributes such as brand, information regarding manufacturing technology and information and timing when participants were informed about a secret ingredient added to beer rather than the tasted experience itself (intrinsic attributes) (Allison and Uhl 1964; Caporale and Monteleone 2004; Lee and others 2006).
2.2. Rapid sensory screening

Conventional sensory descriptive analysis with extensive attribute and scaling training is costly and sometimes impractical for companies when many different types of products needed to be evaluated quickly. Furthermore, creating and maintaining a well-trained, calibrated sensory panel can be quite expensive. Small food companies usually cannot afford it, and it could even mean a significant expense for large companies if they have a wide range of products that require various panels working in parallel (Valentin and others 2012). As a result, faster alternatives have gained substantial popularity in the development of new rapid methods which seek to increase the efficiency of the data collection process while maintaining the robustness of the information obtained.

Alternative methods to conventional descriptive analysis with trained sensory panels include various rapid sensory profiling techniques that use consumers and sensory panels without attribute and scaling training. These alternate methods can provide researchers with scientifically valid, efficient and flexible tools for sample screening and understanding consumer preferences.
without the extensive time and cost incurred by conventional sensory profiling methods (Louw and others 2013). These rapid methods are useful for gathering information about the sensory characteristic of food products or when performing screening tests to select products or condition for the design of a larger experiment (Varela and Ares 2012). Rapid sensory profiling methods include Flash Profile, Free Sorting, Projective Mapping (PM) and Napping and Check–All–That–Apply (CATA) (Kim and others 2018).

Examination of the product spaces obtained from conventional descriptive analysis and rapid sensory profiling methods has demonstrated that these rapid methods can provide information about the product sensory characteristics similar to those traditional sensory descriptive methods (Oppermann and others 2017; Antúnez and others 2017). When no details on the sensory characteristic of food products are required, these rapid methods offer useful information (Varela and Ares 2012). When the outcomes from different rapid methods were compared, PM provided sensory characterization of milk dessert similar to CATA (Ares and others 2010). Similarly, when evaluating a powdered orange flavored drink, Ares and others (2011) reported that CATA question, PM, sorting, and intensity scales were equivalent.

2.2.1. Projective Mapping (PM)

Projective Mapping (PM) was introduced to the field of food sensory evaluation by Risvik and others (1994). With PM, assessors are briefed about the method but no further training required. They are supplied with a paper sheet with unstructured line scales and are instructed to position samples on a bi–dimensional space according to their global similarities and differences. The samples perceived as similar are placed close to each other while the samples perceived to be more different are placed farther apart (Dehlholm and others 2012). The methodology allows assessors to evaluate similarities and differences among samples by considering more than one
characteristics at the same time which enables PM to be more spontaneous and more direct than other descriptive methods (Varela and others 2017).

Sensory characterization with PM has been applied to a wide range of product categories as it has been described as a natural, holistic way for consumers to describe products, closer to what happens in front of them of the grocery store (Ares and others 2010). It has been applied to various foods like chocolate, red wine, beer, and apple (Vidal and others 2014). Some authors used this method for complex products such as chewing gums (Delarue and Loescher 2004) or even cars (Dairou and Sieffermann 2002). However, it has mostly been used for food products with no need of prior preparation and most of the time served at room temperature; this makes the PM practices relatively easy. Furthermore, it has been applied with success to study stimuli other than sensory ones, such as the influence of packaging information and nutritional claims on consumer perceptions (Varela and Ares 2012).

The increased use of PM has led to the development of guidance regarding best practices. For example, the validation of paper's size being 60 cm x 60 cm was conducted by King and others (1998) and both unstructured and structured line scales were used later with untrained assessors. The shape of paper has also gained interest from researchers. In recent studies, the effect of square vs. rectangular (Hopfer and Heymann 2013) and rectangular vs. circular (Dehlholm and others 2012) sheets on panelist's responses toward the X and Y coordinates and the consensus product configuration were investigated. Neither study was able to conclude if the shape of the score sheet influenced the overall result (Louw and others 2015).

Although the PM method is simple, a trained panel provides a better separation of products (Kennedy and Heymann 2009). Better performance of a trained panel can be attributed to an increased focus on differences resulting from the training process, which may reduce the variation
between individual maps; however, the number of trained assessors directly affects the costs for executing the project. According to Simiqueli and others (2015), a panel of at least eight trained assessors is recommended to obtain suitable discrimination of the products to be evaluated.

In particular, when using PM with naïve consumers, the number of assessors could potentially influence the attainment of a stable consensus map. It is essential to take into account the cost associated with consumer studies which increases with the number of participants; thus, PM could be cheaper if the number of consumers used in a study is relatively low, but of course, the result may not be reliable. The number of consumers used in different studies ranges from 8 to 81 (Kennedy and Heymann 2009; Risvik and others 1997; Torri and others 2013).

Pfeiffer and Gilbert (2008) proposed the application of PM by modality or partial projective mapping (PPM), in which assessors are asked to evaluate similarities and differences in a specific pattern (as appearance, flavor, texture) as opposed to global similarities and differences. According to the previous study, PPM was proven to be a better tool for exploring consumers' perceptions when information about specific sensory modalities is needed (Marcano and others 2015). The limitations of this method are: 1) it confines the panelists to two dimensions to discriminate among samples (Mielby and others 2014) and 2) in general, a maximum of 12 products that can be tested at the same time (Pages 2005).

2.3. R–Index

The R–Index (RIX) is a signal detection measurement, which applies to measurements of slight differences between food stimuli (Villegas and others 2007). This index gives the probability that a judge can correctly distinguish a target stimulus (the signal: S) from background noise (the noise: N). If the judge cannot discriminate between the two stimuli, the judge will have to guess and the chances of correctly identifying "S" will be 50%. If the judge can discriminate correctly
between the two stimuli, the RIX will be 100%. If the judge is only partially successful at distinguishing, as happens with difference tests, the RIX will have some values between 50% and 100%; the higher the degree of difference the higher the probability of distinguishing between them (O'Mahony 1986; Argaiz and others 2005; Lee and Van 2009).

In food science, RIX has been used for various applications such as sensitivity measurement, threshold measurement for product optimization, sensory discrimination testing, quality control, and shelf–life testing, measurement of consumer preference, hedonic measurement and consumer concepts or emotions related to conceptual attributes (Lee and Van 2009). However, the method is popular for discrimination testing which distinguishes between confusable food products using rating and ranking. Lee and O’Mahony (2007) reported that the RIX values obtained from sensory experiment differed depending on the sensory testing methods used. The R–Index obtained from ranking will be higher than the one obtained from signal detection rating due to its forced choice nature (O'Mahony and others 1980) and is based on behavior rather than numerical estimation. For this reason, ranking rather than rating is the method of choice for RIX analysis.

The advantage of RIX analysis is that it can be interchanged with $d'$ (Thurstonian modeling), the measurement of a degree of difference between the products, that provides more precise numerical measuring differences. It is important to note that the computation of $d'$ takes into account the differences in cognitive strategies used in the experimental methods while the RIX tends to be a measure of panelist performance rather than a fundamental measurement of difference. Another advantage of RIX over the conventional discrimination test is the test protocol can be modified easily according to the experimental situations and product characteristics. It may
not be possible to compare between RIX values of experimental results obtained from different test protocols of different experiments (Rousseau 2007).

2.4. Consumption of salt and sugar

Table salt is a main source of sodium, and in fact, the human body needs a small amount of sodium to work properly. The vast majority of sodium consumptions comes from processed and restaurant foods. Only a small proportion of total sodium intake is from sodium inherent in foods or from salt added in home cooking or at the table (CDC 2017a). An average intake for those ages one year and older is 3,440 mg per day. Average intakes are generally higher for men than women. For adult men, the average intake is 4,240 mg, and for adult women, the average is 2,980 mg per day. The recommended sodium intake is far higher than physiologic need; the estimated average requirement of 1500 mg/d accommodates groups with extreme physiologic sodium excretion (e.g., professional athletes). If the proposed targets are met, there will be minimal change in the proportion of the population consuming less than 1500 mg/day of sodium (Lilic and others 2015).

In terms of sugar consumption, sugar–sweetened beverages (SSBs) or sugary drinks (e.g., fruit drinks, sports drinks, energy drinks, sweetened waters, and coffee and tea beverages with added sugars) are leading sources of added sugars in the American diet (CDC 2017b; Huth and others 2013). With the modern day diet, added sugars in foods and drinks account for ~15% of food energy intakes by children and young people. Adults in the United States currently obtain an average of 14.6% of their calories from added sugars (Peters and others 2018). Males, in particular, consume as much as 189 g free sugars/day, accounting for ~32% of their energy intake (NDNS 2014). Food manufacturers, restaurants, takeaways, and cafes are being challenged to reduce overall sugar content across a range of product categories by at least 20% by 2020 (Buttriss 2017).
2.4.1. Health concerns of excessive salt and sugar intake

The adverse health–related sequela of excessive salt and sugar consumption is a growing concern of consumers, and they may aware of products containing these additives that provide minimal nutritional value and therefore make a disproportionate contribution to total caloric intake (MacGregor and Hashem 2014). Malnutritious foods and soft drinks are sold and consumed worldwide, and their negative impact on global health is being noticed regarding increased rates of obesity and its comorbidities (Rao and others 2018). High salt intake is a major cause of increased blood pressure and risk for cardiovascular diseases. Recently, many studies have emerged which suggest that dietary sodium intake may be implicated in weight gain (Grime and others 2016). Studies in children and adults have reported positive associations between sodium intake and a range of adiposity outcomes including high body mass index (BMI) values or in the case of children's body mass index percentile, percent body fat and abdominal obesity (Zhu and others 2014; Yi and others 2015). A recent study by O'Connor and others (2018) revealed that dietary sugars consumed with tea, coffee, and cereal were significantly and positively associated with metabolic outcomes via weight gain through their contribution to energy intake. Sucrose or other mono/disaccharides or free sugars intake, is associated with increased blood pressure and serum lipids, independently of body fat level (Morenga and others 2014). Actions to reduce salt and sugar intake across the global population will have major beneficial effects on health along with possible cost savings for health care expenses.

2.4.2. Reducing sodium and sugar approaches

The harmful effect related to high sodium and sugar consumption has been a matter of great public and scientific interest. These adverse effects have been associated with the development of obesity and the risk of several chronic diseases. Accordingly, consumers are
demanding healthier foods with lower sodium and sugar content. As a result, various alternative methods have been extensively researched and implemented by food manufacturers. It is emphasized that success in techniques to reduce sodium levels in food is a multidimensional problem, involving the nature of the product, its composition, and the type of industrial processing (Ruusunen and Puolanne 2005). Common approaches include reducing the amount of salt added during food processing (Aaslyng and others 2014), replacement with low–sodium blend (KCl, CaCl2, or MgCl2) (Choi and others 2014; Paulsen and others 2014), used of flavor enhancer such as monosodium glutamate (Dos Santos and others 2014), slight salt reduction (Liem and others 2011) and change in the form of salt (Kilcast and den Ridder 2007).

For sugar reduction in foods, product reformulation by partially or entirely replacing sugar is the most deliberate strategy (Di Monaco and others 2018). In the US, reformulation has been mostly voluntary and initiated by the food industry (Scott and others 2017). Generally, sugar replacement requires using both alternative sweetener and bulking agents. However, reformulation may be an acceptable way of reducing sugar intake by some consumers, even though significant improvement in the sensory quality of sugar reduced product are required (Markey and others 2015).

An innovative strategy to reduce sugar content in food is the use of multisensory integration principles involved in the reduction of salt and sugar. The addition of appropriate aromas enhances the sweetness intensity of cross–modal interaction (Stieger and van de Velde 2013). For instance, an increase of both vanilla and starch concentration increased vanilla flavor and sweetness perception and reduced changes in consumer hedonic perception caused by a 20% sugar reduction in a dessert without the need to add non–nutritive sweeteners (Alcaire and others 2017). It should
also be a possible to alter taste perceptions through multisensory perceptions; however, more research is needed to better understand its correlations and consumer perceptions.

2.5. Visual Cues

Tasting food is typically the outcome of a behavioral sequence promoted by anticipatory cues. Several sensory signals, including appearance, taste, odor, texture, temperature, and flavor, affect food intake. Although taste is an essential factor regulating food intake, in most cases, the first sensory contact with food is through the eyes (Wadhera and others 2014). Color is a visual cue that can influence judgments of food acceptability by affecting expectations of food palatability which can ultimately dictate food choice and consumption (Koch and Koch 2003; Spence and others 2010). Consumers may have a preconceived idea of the taste, texture, and other sensory characteristics of the food (sensory expectations) based on visual evaluation, which influences how much they will like it before consuming it (hedonic expectations) (Tarancón and other 2014). The mere sight of food can facilitate the personal desire to eat. Visual appearance of a food provides expectation about its taste quality, flavor, and palatability and may ultimately affect its acceptance, consumption, and purchase decision.

2.5.1. Importance of visual cues

A series of visual cues impacting consumer cognitive perceptions has been reported in different contexts (Wadhera and others 2014). Visual exposure to a food before consumption can reduce neophobia and facilitate introducing new foods to children by increasing their willingness to try a novel food. This visual appeals not only can improve the desire to try new foods but encourage their consumption. Arranging foods on a plate can affect our expectations and ultimately, liking of the food. Varying the appearance of a portion was also reported to impact
perceptions of varieties of the meals, which also affects energy intake. Further, visual exposure to food elicits the physiological release of saliva and other regulatory peptides required for digestion.

2.5.2. Impact of visual cues on taste perception and food intake

Taste perceptions can change depending on visual stimuli. Altering the appearance of food can affect people’s perception of taste and food intake. Food appearance is a compound view of all the information about the product and its environment perceived by the eyes. Unfortunately, the world of color has superseded appearance as the description of the entire visual perception of foods; thus, color is concerned even more when it comes to total appearance. Indeed, it has long been recognized that color constitutes one of the most salient visual cues, affecting sensory perception of both taste and flavor of foods. Food color can be considered perhaps as the single most important intrinsic sensory cue governing consumer’s sensory and hedonic expectations of foods and drinks and the items they search for and subsequently consume.

The addition of food coloring influences sensory thresholds for certain basic tastes. Mega (1974) demonstrated that adding food coloring (green, red or yellow) to an otherwise clear solution exerted a significant effect on thresholds for the detection of certain basic taste when presented in a solution. Adding green food coloring decreased people's detection threshold for sourness, while at the same time increasing the detection threshold for sweetness. The addition of yellow coloring reduced the detection threshold for both sourness and sweetness while the addition of red coloring reduced the detection threshold for bitterness. More intensely colored food is likely to be perceived as more intensely flavored. Stevenson and others (1999) showed that paring a color or odor with a sour or sweet taste led to increased expected sourness or sweetness ratings of the associated solution. In addition to intrinsic food color, color–taste correspondences are of interest in food packaging, design, and formulation because color plays a significant role in consumer expectation
of a product. Previous research has revealed that foods such as cakes and snack foods (e.g., chocolate chip cookies or popcorn) are hedonically influenced by their containers. A salty/sweet popcorn served in a blue bowl was rated as slightly, but significantly sweeter/saltier than the same popcorn served in a white bowl (Harrar and others 2011).

Geier and others (2012) suggested that segmenting food into multiple and smaller units can promote food intake as this increases perceived sensory variety. For instance, a small size and more pieces of biscuits and chocolate bars reduce the consumption of that foods, without changing pleasantness (Marchiori and others 2011). Evidence also suggested that the size of the plate affected the overall perception of Asian noodles. The noodles served on small plates received higher familiarity, pleasantness, food plate congruency, and willingness–to–pay scores compared to noodle served on substantially larger plates. The author suggested that the small plate might lead the participants to perceive the amount of food to be larger as compared to the same portion served on a larger plate (Zhao and others 2018).

Texture is one of the food cues that has been reported to impact consumer acceptance. There are a variety of texture attributes such as firmness, crunchiness, smoothness, creaminess, and thickness (solid) and viscosity (liquid) (Szczesniak 2002). Texture also has been described as the mechanical and surface properties of food detected through the sense of vision, hearing, touch and kinesthetic. McCrickerd and Forde (2016) noted that food texture plays an important role in moderating energy intake, as many solid foods are consumed at rates of < 10 g to 100 g per min, whereas liquid beverage is consumed much faster, often 600 g per min. Viscous, chewy and hard foods are consumed more slowly and are consciously ingested in smaller quantities than foods and beverages with softer textural characteristics. More research is needed to determine the effects of
viscosity on taste perception, particularly sweetness and saltiness, as part of multisensory interaction strategies to reduce sugar and salt intake.

2.6. References


CHAPTER 3. THE EFFECT OF INTRINSIC AND EXTRINSIC VISUAL CUES ON CONSUMER PERCEPTIONS AND OVERALL FOOD EXPERIENCES: A CASE OF READY–TO–EAT SALAD

3.1. Introduction

The sensory experience of foods is one of life’s greatest pleasures and is executed through different sensory modalities (e.g., sight, smell, taste, and texture) (Gutjar and others 2015). Vision is usually the first sense contacting with food (Wadhera and Capaldi–Phillips 2014). Although people argue that taste perception is a dominant factor regulating food intakes (Glanz and others 1998; Zellner 2015), visual information typically arrives prior to the introduction of the food into the mouth. Seeing a food labeling and package triggers a brain imagination of how the food will taste and creates an expectation about the sensory intrinsic and attributes to come. This visual information may influence sensory perceptions and elicit emotional responses. Ultimately, this may alter consumer hedonic experiences of the products (Kostyra and others 2016; Schifferstein and others 2013; Hurling and Shepherd 2003; Zhang and Seo 2015).

Consumers infer product quality based on their perceived information of intrinsic and extrinsic cues. The intrinsic cues are product attributes that cannot be changed or experimentally manipulated without changing its inherent characteristics, such as taste, appearance, and texture (Olson and Jacoby 1972). Intrinsic cues influence consumer product evaluation and can affect consumer preferences and choices. By contrast, extrinsic sources of information are those that are related to the product, but are not physically a part of it, such as a product’s labeling, packaging, and any other sources of information provided by marketing communications (Piqueras–Fiszman and Spence 2015). Extrinsic cues create an expectation of the perceived sensory characteristics, driving hedonic appraisal, and food consumption. Indeed, these visual cues were intensively generated during the primary stages of product’s development in order to provide a product’
impressions to consumers (Acebrón and Dopico 2000). Various types of extrinsic cues (e.g., shape, color, variety, size, portion size, surface properties, and texture) have been reported to be involved in the expression of hedonic perceptions, and affect the consumer decision making process during a purchase stage (Wadhera and Capaldi–Phillips 2014; Levitsky and others 2012; Burger and others 2011; Morales and others 2008).

Recently published articles regarding consumer behavior revealed that emotional profiles of food products discriminate products more effectively than hedonic measurements alone. As a result, measuring of food–evoked emotions is becoming an important issue in sensory sciences (Gutjar and others 2015). Methods to assess food–elicited emotions using questionnaires have been developed by various researchers. Those measuring concepts work by either forcing participant to state their feeling when evaluating the products or searching emotions from a list (Vidal and others 2016). A set of mixed–emotion profiles was simultaneously elicited by different types of food products. Different product presentation formats such as package, food name, or tasting with or without product itself may also induce different emotions (Schifferstein and Desmet 2010; Gutjar and others 2015).

With respect to consumer demand for more ready–to–eat (RTE) foods, their portable nature makes them convenient for many people to use while on the move (Stratakos and Koidis 2015). The demand for fresh–cut or minimally processed products like fresh–cut and vegetable salads has been raised all over the world with the changes in demographics, lifestyle and eating habits (Zhang and others 2017). Consequently, the significance of consumer perspective toward consuming salads is driving beyond health benefits and basic nutrition. In the case of fruits and vegetables, color is the main visual indicator of freshness as it changes during storage. For the food industry, the visual impression of such food items is becoming increasingly important. Up to now, color
appearance has been driven by a simple question like “how does the green color make you feel?” Green is a cool color that symbolizes nature and the natural world as well as being refreshing and tranquil. Green is used in decorating for its calming effect, and as a signal for food labeling to denote healthier foods and as quality indicator of fruits and vegetables. Previous findings have shown that the chromatic and vivid color of green vegetables implied better quality compared to a dull colored vegetable (Temple and others 2011; Levy and others 2012; Canjura and others 1991; Lee and others 2013).

The current research developed a framework illustrating consumer assessment of RTE salad based on various intrinsic and extrinsic cues (e.g., different green colors, cut size, and package) that may alter consumer perceptions under the given conditions with or without attaching product name. The information will be useful for practitioners in the development of market strategies and will help by emphasizing the relevant product cues that will provide distinctive evidence beyond classic hedonic and preference information.

3.2. Materials and Methods

3.2.1. Emotion lexicon screening and development

Twelve RTE salad products from local supermarkets in Baton Rouge, Louisiana area were chosen. The justification for consideration was to cover a wide range of product variabilities based on the different types of vegetable (e.g., iceberg lettuce, green cabbage, romaine, spring mixed, and spinach), functions and conveniences (complete kit salad with and without dressing), and package (plastic bag and solid container). The products were purchased and stored in refrigerator (3–5 C°) one day before testing. To broaden the emotional dimensions, the panelists were exposed to entire product appearance including brand, package, and nutrition.
Twenty-three salad users who regularly purchased or consumed RTE salads at least twice a week were invited to participate in the evaluation using the modified individual sample description technique (Fiszman and others 2015). The users received a whole sample set at once, but they were instructed to look at samples one at a time and to write down their perceived emotion. The average evaluation time held approximately for 30–35 min (Modified from Fiszman and others 2015).

The classification of emotion terms began with a sorting process within each product. It was important to take into account the terms with similar meaning by eliminating the redundancies without altering the meaning. This term selection was based on the way consumers commonly use the language to describe salads. For instance, the term “safe” was more frequently used than “secure,” thereby the term “safe” was chosen. Then, the selected terms were pooled across different samples and the same sorting process was repeated for those combined terms. At the end of sorting process, 33 emotion terms were discovered (Table 3.2).

Those 33 terms were further collaborated with a commercial emotion lexicon (39 terms) from the EsSense Profile®. This combining resulted in 54 emotions after removing the similar terms (Table 3.3). Then, the validation step was conducted with 118 consumers in order to select the most relevant terms using online questionnaire (www.lsu.qualtrics.com).

3.2.2. Experimental stimuli

A photo of each RTE salad was captured within four different visual effects (green color, size, multicolor, and package, see Table 3.1). The visual green color varied in four shades from pale green color (PG) to darker green color (DG). The size effect was prepared using a cutting size of large (square L) versus small (shredded, S). The effect of multicolor and package were created
within two different green color models (pale green, PG) and darker green, DG). In addition, the impact of product name (with/without) was nested in those four factors.

Table 3.1. Stimuli used to determine visual cue effects.

<table>
<thead>
<tr>
<th>Visual Effects</th>
<th>RTE samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Green color</strong></td>
<td>Iceberg lettuce</td>
</tr>
<tr>
<td>With product name</td>
<td></td>
</tr>
<tr>
<td>Square Iceberg lettuce</td>
<td>Shredded Iceberg lettuce</td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>With product name</td>
<td></td>
</tr>
<tr>
<td>Sample A</td>
<td>Sample B</td>
</tr>
<tr>
<td>Green color</td>
<td></td>
</tr>
<tr>
<td>Square (L)</td>
<td>Shredded (S)</td>
</tr>
<tr>
<td>Without product name</td>
<td></td>
</tr>
<tr>
<td>Pale color (PG)</td>
<td></td>
</tr>
<tr>
<td>Single color</td>
<td>Multicolor</td>
</tr>
<tr>
<td>Dark color (DG)</td>
<td></td>
</tr>
</tbody>
</table>

3.2.3. Visual evaluation

The images were labelled with a three-digit number before uploading to Compusense® Five Software (Compusense Inc., Ontario, Canada), which facilitated displaying a photo in a
random order. One–hundred fifty salad eaters from Baton Rouge, Louisiana, USA were recruited. They were asked to rate overall liking scores regarding the visual effects using a 9–points hedonic scale. Afterward, the selected emotion terms from the emotion development study (active, bored, desired, disgusted, energetic, engaging–wellness–lifestyle, good, guilty, happy, healthy, interested, refreshing, safe, satisfied, special, and worried) were evaluated. For the emotion question, they were asked “how would the color/appearance of sample make you feel?” using a 5–points scale (not at all (1)–moderately (3)–extremely (5)). At the end, there was a question regarding purchase intent (PI) “would you like to buy this sample?” using a binomial scale (yes/no).

3.2.4 Statistical analysis

The effect of visual cues on consumer perceptions was captured using different statistical methods. A two–way analysis of variance (ANOVA) was performed on the rating of overall liking and emotion intensity. The mean differences were determined using the post hoc Tukey HSD at 5% significant level. The Logistic Regression (LR) was conducted to predict consumer purchase intent in which independence variables were overall liking and emotion elicited by visual cues. The statistical analysis software v. 9.4 (SAS, 2003) was used for the above data.

The correlation between the emotion profiles and the visual cue factors was unfolded by Principal Component Analysis (PCA). Additionally, the emotion driven consumer liking score of green color was handle by the Partial Least Squares Regression Analysis (PLSR). The standardized regression coefficient was used to further identify which of the emotion responses (Xs) influencing overall liking score using XLSTAT Software (Addinsoft Inc., 2015).

3.3. Results and Discussions

3.3.1. Emotion lexicon development
The RTE salads used in the individual sample description technique evoked both positive and negative emotions; however, the users reported the positive emotions more than the negative emotions (see Table 3.2). The term “feel healthy” was repeatedly mentioned across all samples. As such, it could imply that the first emotion impression about salads was recognized in the aspect of “wellness” which is often related to the term “feel healthy.” An explanation of how consumers connected those products to the healthy emotion would be the halo effect of eating salad and the perceived benefits. Apaolaza and others (2017) stated that an occurrence of one specific bias regarding a product attribute took place during a taste perception, which would potentially impact other product characteristics. As such, it would be relevant that the benefit of consuming salad might cover the perception of any other emotions, as a result, “feel healthy” was repeatedly mentioned. In addition, the obtained emotions also reflected different perspectives regarding the functional and convenience concepts of RTE. Hence, the term “creative,” “comfortable,” “and unique” were identified. Also, a surprising emotion of “nostalgic” and “desired” as well as the negative emotion of “mad” and “disappointed” were expressed by the users.

In term of the evaluation technique, when taking into account the emotion lists (Table 3.2), the result indicated that 16 out of 33 terms corresponded to the EsSense Profile™, which was developed by King and Meiselman (2010) and is extensively used for emotion study of various food products. This suggested that the individual sample description method was applicable for use to identify consumers’ emotion elicited by foods. With respect to the contribution of EsSense Profile™ that delivered essential information about emotions elicited by foods and the direct contextual impact achieved by the modified description methods, it is important to acknowledge both systems in this study, thereby, 54 collaborative emotion terms were subjected for the online validation study.
Table 3.2. Emotion terms for the RTE salads generated by modified individual sample description technique.

<table>
<thead>
<tr>
<th>Emotion terms</th>
<th>Emotion terms</th>
<th>Emotion terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accomplished</td>
<td>Disgusted*</td>
<td>Pleasant*</td>
</tr>
<tr>
<td>Bored*</td>
<td>Excited</td>
<td>Pleased*</td>
</tr>
<tr>
<td>Calm*</td>
<td>Feel healthy</td>
<td>Refreshing</td>
</tr>
<tr>
<td>Comfortable</td>
<td>Feel wellness</td>
<td>Safe*</td>
</tr>
<tr>
<td>Confident</td>
<td>Guilty*</td>
<td>Satisfied*</td>
</tr>
<tr>
<td>Creative</td>
<td>Happy*</td>
<td>Steady*</td>
</tr>
<tr>
<td>Curious</td>
<td>Interested*</td>
<td>Trust</td>
</tr>
<tr>
<td>Dangerous</td>
<td>Joyful*</td>
<td>Uninterested</td>
</tr>
<tr>
<td>Desired</td>
<td>Mad</td>
<td>Unique</td>
</tr>
<tr>
<td>Disappointed</td>
<td>Nostalgic*</td>
<td>Warm*</td>
</tr>
<tr>
<td>Discouraged</td>
<td>Peaceful*</td>
<td>Worried*</td>
</tr>
</tbody>
</table>

* indicated 16 emotion terms corresponding with EsSense Profile™

A criteria of 30% was used to determine the cut off frequency of term used by consumers, resulting in 9 emotions terms (e.g., feel healthy, feel wellness, safe, satisfied, active, good, happy, interested, and refreshing). The term “feel healthy” (79%) and “feel wellness” (58%) were reported most frequently and both had scores above 50%. This could be explained by the health aspect and the perceived nutritional value of salad consumption that is often associated with the subject’s past experience. In addition, Gilbert and others (2016) studied the implicit associations of color and emotion using visual evaluation. Their results suggested that the green color elicited “energized” emotion perception. Additionally, previous studies demonstrated that by using a food image to trigger individual emotions, consumers might experience their eating habits similarly to when consuming freshly prepared products, and this would typically stimulate the emotional “desire or undesired” of eating regardless of eating condition (Barthomeuf and others 2009; Maughan and others 2016). Besides, Poonnakasem and others (2016) found that the negative emotion affected the consumers’ decision–making process of eating and purchasing sponge cake, especially, the
emotions “bored, disgusted, guilty and worried” and drastically decreased the chances of the product being purchased. In fact, some negative emotions such as “fear and guilt” are related to “well-being” as it helped preventing eaters of eating unfamiliar foods (Schifferstein and others 2013; Kass 1994). It is necessary to take those additional emotion terms as it might help depicting more of consumer perceptions. Consequently, the term “energized, desired, bored, disgusted, guilty and worried” were included for the consumer study.

Table 3.3 Percentage of emotion terms elicited by RTE salads and mentioned by all consumers (N=118).

<table>
<thead>
<tr>
<th>Emotion Terms</th>
<th>Percentage</th>
<th>Emotion Terms</th>
<th>Percentage</th>
<th>Emotion Terms</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feel healthy</td>
<td>79%</td>
<td>Friendly</td>
<td>21%</td>
<td>Adventurous</td>
<td>5%</td>
</tr>
<tr>
<td>Feel wellness</td>
<td>58%</td>
<td>Worried</td>
<td>18%</td>
<td>Enthusiastic</td>
<td>5%</td>
</tr>
<tr>
<td>Safe</td>
<td>45%</td>
<td>Loving</td>
<td>15%</td>
<td>Warm</td>
<td>4%</td>
</tr>
<tr>
<td>Satisfied</td>
<td>44%</td>
<td>Peaceful</td>
<td>15%</td>
<td>Whole</td>
<td>4%</td>
</tr>
<tr>
<td>Active</td>
<td>39%</td>
<td>Joyful</td>
<td>14%</td>
<td>Glad</td>
<td>4%</td>
</tr>
<tr>
<td>Good</td>
<td>37%</td>
<td>Bored</td>
<td>14%</td>
<td>Affectionate</td>
<td>4%</td>
</tr>
<tr>
<td>Happy</td>
<td>31%</td>
<td>Calm</td>
<td>14%</td>
<td>Darling</td>
<td>3%</td>
</tr>
<tr>
<td>Interested</td>
<td>31%</td>
<td>Understanding</td>
<td>13%</td>
<td>Disgusted</td>
<td>3%</td>
</tr>
<tr>
<td>Refreshing</td>
<td>30%</td>
<td>Accomplished</td>
<td>11%</td>
<td>Merry</td>
<td>3%</td>
</tr>
<tr>
<td>Pleased</td>
<td>28%</td>
<td>Excited</td>
<td>10%</td>
<td>Tender</td>
<td>2%</td>
</tr>
<tr>
<td>Trust</td>
<td>27%</td>
<td>Feel different</td>
<td>8%</td>
<td>Tame</td>
<td>2%</td>
</tr>
<tr>
<td>Confident</td>
<td>25%</td>
<td>Free</td>
<td>8%</td>
<td>Nostalgic</td>
<td>1%</td>
</tr>
<tr>
<td>Desired</td>
<td>25%</td>
<td>Mild</td>
<td>7%</td>
<td>Polite</td>
<td>1%</td>
</tr>
<tr>
<td>Energetic</td>
<td>25%</td>
<td>Unique</td>
<td>7%</td>
<td>Dangerous</td>
<td>1%</td>
</tr>
<tr>
<td>Comfortable</td>
<td>24%</td>
<td>Eager</td>
<td>6%</td>
<td>Mad</td>
<td>1%</td>
</tr>
<tr>
<td>Feel special</td>
<td>23%</td>
<td>Curious</td>
<td>6%</td>
<td>Quiet</td>
<td>1%</td>
</tr>
<tr>
<td>Good–natured</td>
<td>22%</td>
<td>Disappointed</td>
<td>6%</td>
<td>Wild</td>
<td>1%</td>
</tr>
<tr>
<td>Pleasant</td>
<td>22%</td>
<td>Guilty</td>
<td>5%</td>
<td>Aggressive</td>
<td>0%</td>
</tr>
</tbody>
</table>

3.3.2. The effect of visual cues on consumer liking

The effect of visual color cues on consumer liking scores of green color is shown in Table 3.4. The different green color shades had a significant ($P < 0.05$) impact on the liking scores of
green color under two eliciting conditions; with/without product name. Regardless of product name, increasing green color intensity from pale to darker green color (sample A to sample D) resulted in significantly increased ($P < 0.05$) of liking scores from 4.39 to 7.28. Sample C received the highest liking score with 7.28 and showed no significant difference from sample D (7.09). This suggested that consumers liked the darker green color better than the pale green color. This might be explained by the positive impression that connected consumer past experience of eating darker green color vegetables with more nutrition and health benefit than with the pale vegetables. Schuldt (2013) suggested that the green color implied “natural” and that it might promote a healthful impression of food products, and the green color labeling of a candy bar helped increase the perceived healthfulness compared to one with a white color label. Borgogno and others (2015) endorsed that consumers’ familiarity and experience with a product category were key moderators of the role played by extrinsic cues in driving consumer preference and food choice. In fact, the hedonic scores varied with different contexts, particularly the type of products being tested. Muggah and McSweeney (2017) studied the human perception of different beer’s colors. The results indicated that a black colored beer had a significant negative effect on female choice with undesirable attribute, whereas the other colors (e.g., light golden, amber, red, light brown and golden brown) had positive correlations with female perceptions. In addition, the mean color liking scores from different objects varying in lightness and chroma were significantly different. Vegetables with higher chroma and vivid colors represented more freshness and better quality compared to a dull vegetable color (Jantathai and others 2014; Schloss and others 2012; Manninen and others 2015). Lee and others (2013) also suggested that the vivid green foods increased people’s appetites and the high chromatic color may imply an increasing chance of selecting fresher and less decomposed foods using their visual perception.
For the impact of product name, the results demonstrated that regardless of the name attached to product, the dark color samples (C & D) had significantly higher liking scores than the pale color samples (A & B). With the name attached, the dark green color sample still yielded a significantly higher liking score (C, 7.28), compared to the other two pale samples (5.75–6.00). This finding suggested that attaching a name to the dark colored product did not improve the liking score of that product ($P > 0.05$) and there were no significant differences between the liking scores of the dark color samples when compared across two eliciting conditions. Unlike the dark color samples, giving product a name could enhance the overall liking score of the pale color sample. The score for sample A, which was the palest was significantly increased from 4.39 to 5.75 when the product name was given. The result indicated that presenting the product name could help improving the color liking of the products under the condition set for this current study.

Table 3.4. Mean liking scores of green color and size of RTE salad products.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Conditions</th>
<th>RTE Samples*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W/O</td>
<td>Sample A</td>
</tr>
<tr>
<td>Green color</td>
<td>W</td>
<td>4.39c</td>
</tr>
<tr>
<td></td>
<td>W</td>
<td>5.75b</td>
</tr>
<tr>
<td></td>
<td>$P$ Value</td>
<td>0.000**</td>
</tr>
<tr>
<td>Size</td>
<td>W/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$P$ Value</td>
<td>3.82</td>
</tr>
</tbody>
</table>

* refered to Table 3.1 for sample description.

a, b, c indicated significant differences of mean scores in each row ($P < 0.05$).

ns indicated no significant differences of mean scores ($P > 0.05$).

** indicated significant differences of mean scores in each column using the Student’s $t$-test.

ND is not determined.

Regarding segments of consumers, two groups of consumers were identified according to the type of vegetable salads’ consumptions they regularly consume. One group was those who regularly consumed pale green color salads (e.g., cabbage and lettuce) and the other was those who
frequently consumed dark green color salads (e.g., spinach and spring mix), accounting for 73% and 75% of total consumers, respectively. The consumers of pale green color salads rated liking scores of green color salad for sample C (7.28) and D (7.50) higher than sample A (4.50) and B (5.96). Similarly, for consumers of dark green color salads, the dark color samples C (7.10) and sample D (7.00) had significantly higher liking scores than the pale color samples A (5.14) and sample B (4.07)) (see Appendix E). These segment results suggested that the type of vegetable salads had no impact on the liking scores of the green color, thereby, the liking score of green color reported in Table 3.4 spontaneously corresponded to perceived color effect alone.

The effects of cutting size and product name on the liking are shown in Table 3.4. The small cut salad (shredded) was more liked, but not significantly, than the larger cut salad (square). Similarly, the effect of eliciting conditions of with and without product name had no impact on improving consumer overall liking score. It is possible that, for the iceberg lettuce, cut size may not be critical for product liking. However, these responses did not agree with previous studies that found a correlation between consumers’ perceptions and specific shape/size of product. For instance, the shapes with curvature like circle and ellipse, with higher hedonic scores, would increase the sweet sensitivity, whereas angular shapes like square, rectangle, triangle and pentagram did not affect sweet sensitivity (Liang and others 2003). Olsen and others (2012) investigated children’s preferences for snack vegetables using pictures and focusing on the effect of sizes (ordinary vs. small) and shapes (whole/chunk vs. slices vs. sticks vs. figures). The results indicated that the shape influenced children’s preferences. Children clearly preferred having a vegetable cut. The size was only mattered for the whole/chunk. Moreover, children liked pictures of vegetables served in the shape of stars than when cut into slices or sticks, while adults preferred pictures of meats cut into pieces than slices (Reisfelt and others 2009). In adults, food intake
differed between small and large snack foods (Weijzen and others 2008). Likewise, adults expressed favorite shapes of pasta, and pasta shape alone was found to influence intake (Rolls and other 1982). Altogether, these findings indicate an interesting impact of size and shape of foods on liking and food intake. However, this impact may be applicable and specific to some foods and hence, should not be generalized.

Table 3.5, reflects the effect of multicolor and package of RTE salad on the overall liking score of appearance and liking score of green color within eliciting conditions (PG and DG). For PG, when a variety of color (purple/orange) was added to a single green color salad, the overall liking score for appearance and liking score of green color significantly increased. Therefore, it is possible that adding more color could enhance the attractiveness of salad compared to a monochrome salad, resulting in a higher of hedonic rating. These results were supported by previous studies, which suggested that a colorful meal increased eater’s attentions than the meal that was much less colorful (Zellner and others 2010).

Table 3.5. Overall liking score of appearance and liking score of green color for RTE salads with a single color, multicolor and package.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Overall liking of appearance</th>
<th>Liking of green color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PG*</td>
<td>DG*</td>
</tr>
<tr>
<td>Single color</td>
<td>5.28b</td>
<td>6.39ns</td>
</tr>
<tr>
<td>Multicolor</td>
<td>6.51a</td>
<td>6.56ns</td>
</tr>
<tr>
<td>Package</td>
<td>6.24b</td>
<td>6.68ns</td>
</tr>
</tbody>
</table>

* referred to Table 3.1 for sample description.
a, b, c indicated significant differences mean scores in each column ($P < 0.05$).
ns indicated no significant differences mean scores in each column ($P > 0.05$).
** indicated significant differences of mean scores between models using the Student’s $t$-test.

Rolls and others (1982) reported that an increased variety of color in a meal would influence consumer’ consumption behaviors. People might consume more when the food had more varieties in term of its color. However, it could be that viewing foods you like makes a meal more attractive than viewing foods you dislike. In addition, Jimenez and others (2015) investigated how
side dishes (vegetables/starches) affect the hedonic ratings of the main food item (meat/meat substitute) when a plate of these foods is viewed. The results showed that the main food item was hedonically rated lower when simultaneously presented with more hedonically positive side dishes than when presented with hedonically negative side dishes. This could be explained the current finding that the main single color salad was rated lower, but when presenting salad with more colors, more hedonically positive, could increase the liking scores. Similarly, the visual packaging also positively influenced the overall liking scores, especially, within the PG condition. On the other hand, both visual parameters (multicolor and packaging) had no impact on the overall liking score of appearance and liking score of green color in the DG condition ($P > 0.05$). Perhaps, it was possibly because consumers already liked the dark colored salad, subsequently, adding colorful color or package would not change the liking scores.

The comparisons across the two eliciting conditions were analyzed using the Student’s $t$-test (Table 3.5). A significance difference in the overall liking score of appearance and the liking score of green color was observed under the impact of single color and package only ($P=0.001$, $< 0.0001$ and $P < 0.029$, respectively). For a single color, the overall liking score of appearance and the liking score of green color for DG condition were significantly higher than PG, indicating that consumers desired a darker green color salad than the pale green color salad. This result confirmed the first experiment in our study (Table 3.4) that compared the effects of different green color shades on the consumer perceptions, and the darker green salads were more acceptable. For the package, there was a statistically significant result within the overall liking score of color only. Presenting the darker green color salad with package received a higher rating score than presenting the pale green color with package ($P < 0.05$). This demonstrated that the package was an important extrinsic attribute affecting consumers liking of the RTE salads.
3.3.3. The effect of visual cues on consumer emotions

The results of the emotion profiles elicited by visual cues are presented in Figure 3.1. The different green color intensity significantly affected consumers’ emotion intensity ($P < 0.05$). Regardless of an eliciting product name (Figure 3.1a), the darker green color salads (sample C & D) elicited higher emotion intensity (2.20–3.88) from positive emotions than the pale green color salads (sample A & B) (1.56–2.95). These pale green color salads, on the other hand, induced higher emotion intensity (2.37–1.36) from negative emotions than the darker green color (1.69–1.13). This finding suggested that the darker green color salads elicited the positive emotion perception, while the pale green color salads induced the negative emotion. Furthermore, eight emotion terms (active, bored, energetic, engaging wellness lifestyle, good, healthy, interested, and satisfied) showed statistically significant differences. An increase of > 0.3 units of the emotion intensity elicited by shifting from the pale green color to the dark green color was observed for those significant terms. The explanation of these results may be appearing because the green color generated the expectation and likely reflected sensory impression about salad characteristics and subsequently conveyed a memory of healthy foods, thereby influencing liking and emotions (Wardy and others 2017). Interestingly, the emotion “guilty” was not significantly different among four products in this study ($P > 0.05$). Perhaps, the nature of the product, in this case, “healthy” likely overrode the effects of pale green color on this “guilty” emotion.

The presence of product name clearly affected the emotional profiles (Figure 3.1a vs. Figure 3.1b). The impact of product name was more toward perceived emotion of pale green color salads than the darker green color salads, especially, sample A (Figure 3.1b). Giving the product significantly increased ($P < 0.05$) the positive emotion intensity of energetic, happy, healthy, interested, refreshing, satisfied and special. On the other hand, giving the product name did not
affect the negative emotion intensity of pale green color. In the absence of product name, it was possible to link the emotion responses to the liking scores in which consumers liked salad with the pale green color less than the darker green color one, therefore, consumers lower perceived positive emotional response.

In contrast, consumers rated higher scores of both liking and emotional intensity of samples with product name. Product name may elicit memories of a typical emotion experienced with the food and can improve liking score. Previous research has suggested that the influence of food item name merely affected dieters or health conscious eaters as well as people who are highly susceptible to cue (Irmak and others 2011). In other words, cues may be more pronounced with dieters or health conscious eaters than non–dieters. Kim and Kwak (2005) suggested that the pleasantness of the sample was rated higher when the subject was exposed to product information prior to tasting. Hence, it is possible that the above results may be an outcome of health conscious people since we recruited eaters who regularly consumed salad at least once a week. Eventually, giving the food name would increase their perception of healthfulness.

For the effect of size (Figure 3.2), comparisons were made across sample A (square, L) and sample B (shred, S). Without an effect of product name, consumers rated the emotion intensity of both sizes similarly ($P > 0.05$), except for the terms “healthy” and “engaging wellness lifestyle” which were rated a higher intensity with a square size than with a shredded size. On the other hand, there was a significant difference ($P < 0.05$) in the emotion intensity among an eliciting condition of product name (with/without). Consumers rated their emotions with higher intensity when a product name was present and a lower rating of emotion intensity when a product name was absent. For instance, the emotion intensity of healthy was rated with 3.12 and 2.68 with and without
product name, respectively. This suggested that giving a product name impacted rating by increasing a positive emotion intensity.

![Figure 3.1](image)

Figure 3.1. Mean emotion scores elicited by green color cues in eliciting condition (a) without product name and (b) with product name.

* indicated significant differences mean emotion scores ($P < 0.05$).
ns indicated no significant differences mean emotion scores ($P > 0.05$).
Significant effects of multicolor and packaging on consumers’ emotion were observed for pale green color salad (\(P < 0.05\)) (Figure 3.3a) but were not significant (\(P > 0.05\)) for darker green color salad (Figure 3.3b). The explanation might be that the single color of the darker green salad satisfied consumer emotions, so adding others cues such as colors or package may not produce a significant impact on emotion.

![Graph showing emotion scores](image)

Figure 3.2. Mean emotion scores elicited by product size in eliciting conditions of without product name (WO) and with product name.

For pale green color salads, half of the emotion terms (bored, energetic, engaging wellness lifestyle, good, happy, interested, refreshing, satisfied, and special) were elicited by the effect of multicolor and package (\(P < 0.05\)). The term “special” showed an increased emotion intensity > 0.4 unit with addition of multicolor and package compared to a single color. This suggested that adding color variety or presenting package may generate more positive emotional responses to the pale color product. Zellner and others (2011) reported similar results where they found that a multicolor balanced food plate was rated higher in attractiveness than a single pale color. The single color also induced a negative emotion of “bored,” and its intensity decreased after presenting
the product with multicolor and package. This suggested that the multicolor and package positively enhanced consumer emotion.

Figure 3.3. Mean emotion scores elicited by visual cues; single color, multicolor and package in a condition of (a) pale green color salad and (b) dark green color salad.

* indicated significant differences mean emotion scores ($P < 0.05$).
Hutching (2003) revealed that a dinner consisting only of a single color or white foods produces the emotion “boring.” This implies that consumers might not be satisfied with the individual component such as the pale green color in this study. Adding colors and package could induce cognitive processing such as memory and functionality of the product and generate emotional saturation if these cues meet sensory expectation of the product and the packaging elements influence the emotional evaluation of a product (Ng and others 2013; Gujar and others 2015).

Our results on food-evoked emotions confirmed the finding by Ng and others (2013) and Gujar and others (2015) where food-evoked emotions differentiated successfully among products based on different elements (taste–packaging) and the images of chocolate brownie caused significant differences in emotion response when evaluated under several conceived consumption contexts. It has been reported that the same product may elicit different emotion responses based on extrinsic product properties (colors, name, size and package).

### 3.3.4. Emotion profile across visual cue effects

Figure 3.4 showed the PCA biplot of correlation between four sensory visual cue effects (green color, size, multicolor and package) and emotion. The result showed that the sensory visual cues significantly influenced the emotion ratings; both PC components can explain the variation up to 95.34%. The differences between positive and negative emotions were heavily seen on the first PC dimension, which is accounted for 67.46% of the total variance. In the first dimension, negative emotions were on the left while ones positive on the right. The green color effect was correlated with “bored.” Conversely, most of the positive emotion terms were characterized by the multicolor and package effect. The second dimension is accounted for 27.88 of the total variance.
It can be seen that the rest of the negative emotions (disgusted, guilty, and worried) were loaded on this dimension. These emotions generally associated with the size effect.

**Biplot (axes F1 and F2: 95.34 %)**

![Biplot](image)

Figure 3.4. A PCA biplot of emotion terms elicited by four sensory visual cue effects.

### 3.3.5. Correlation between emotions and consumer liking of green color using PLSR

Figure 3.5 showed the correlation between the emotion attributes evoked by green color effect and hedonic responses for the liking of green color at a confidence interval 95%. It can be observed that the consumer acceptability score of green color salads was driven by the positive emotions. The standardized regression coefficients loaded across all variables were 0.033 to 0.097. The emotion “special” showed the highest value whereas the term “safe” showed the lowest standardized regression coefficient value. This implied that the perceived emotion “special” largely influenced a liking score of green color salads. In contrast, the negative emotions (bored, disgusted, and worried”) contributed to decrease acceptability scores. As expected, the term “bored” with a standardized regression coefficient of $-1.06$ was a majority emotion associated with
a negative liking. Indeed, the liking score would decrease if consumers rated those negative terms with higher scores. Interestingly, the term “guilty” was positively correlated with the green color liking score. To explain this finding, it might be possible that consumers consciously recognized health benefit of consuming salad and were no longer felt guilty when consuming salad, even with pale green color. Consequently, these terms had positively correlated with green color salad but did not decrease the liking score.

3.3.6. The effect of visual cues on the purchase intent (PI)

Table 3.6 presents odds of PI of the RTE salads with consumer liking score, emotion intensity and combined liking and emotion as predictors that were elicited by four visual cues (green color, size, multicolor and package). The results suggested that the change in liking scores due to the size, multicolor and package increased the PI. One unit increased on a 9–point scale of the liking score elicited by those factors would increase the probability (odds ratio) of the product being purchased by 1.5–2.7 times ($P < 0.05$). However, the liking score modulated by green color did not have an effect on the PI response ($P=0.5255$). In the case of emotion intensity, when the intensity of positive emotion is large, the odds ratio would be increased. For instance, a one–unit increase in positive emotion intensity of “active, healthy and satisfied” would potentially increase positive PI by 2.5–5.0 times. For the negative emotion, on the other hand, increasing of negative emotion intensity resulted in decreased odds ratio (e.g., the term “disgusted” the odds ratio was 0.148 for emotion intensity elicited by the green color). In other words, probability that the product would not be purchased was 6.75 times when the consumer felt more disgusted. In addition, there was no overall significant impact of emotion elicited by size on PI ($P=0.0548$).

One potentially important validity issue with regard to the combined liking score and emotion intensity was investigated. An increase of one unit in liking score and the positive emotion
intensity score elicited by green color, multicolor and package effect would raise the PI 4–13 times. The results indicated that food–evoked emotional responses contributed to food choices along with liking, and this cross–model variable strongly exerted an influence on consume purchase decision. This result pinpoints the importance of multisensory experience in making food choices based on the products’ cues. The impact of packaging on the emotion of “active” and “healthy” potentially increases the chances of a product being purchase up to 13 times. As suggested by Schifferstein and others (2013), packaging affects how food is perceived and experienced during buying. Likewise, Dalenberg and others (2014) revealed that food–evoked emotions better predicted food choice than liking alone; however, combining emotion score with liking resulted in a better prediction of choices for products tested without packaging information. It is possible that consumers use neither liking nor emotion alone to make their purchase decision.

Figure 3.5. Drivers of hedonic ratings completed by consumers and emotion attributes evoked by green color cue based on the partial least squares regression analysis (PLSR).
Table 3.6. Predicting purchase intent of the RTE salads by sensory visual cues using Logistic Regression.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sensory Visual Cues Effects</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Green color</td>
<td>Pr&gt;ChiSq</td>
<td>Odds ratio</td>
<td>Size</td>
<td>Pr&gt;ChiSq</td>
<td>Odds ratio</td>
</tr>
<tr>
<td>Liking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liking</td>
<td>0.5255</td>
<td>0.933</td>
<td>0.0076</td>
<td>1.521</td>
<td>&lt;0.0001</td>
<td>2.681</td>
</tr>
<tr>
<td>Emotion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>0.023</td>
<td>3.652</td>
<td>0.955</td>
<td>1.030</td>
<td>0.050</td>
<td>2.523</td>
</tr>
<tr>
<td>Desired</td>
<td>0.185</td>
<td>0.430</td>
<td>0.536</td>
<td>0.794</td>
<td>0.468</td>
<td>1.441</td>
</tr>
<tr>
<td>Energetic</td>
<td>0.730</td>
<td>1.243</td>
<td>0.599</td>
<td>1.319</td>
<td>0.090</td>
<td>0.360</td>
</tr>
<tr>
<td>Engaging wellness lifestyle</td>
<td>0.354</td>
<td>0.464</td>
<td>0.120</td>
<td>0.389</td>
<td>0.426</td>
<td>1.400</td>
</tr>
<tr>
<td>Good</td>
<td>0.348</td>
<td>2.324</td>
<td>0.096</td>
<td>2.883</td>
<td>0.171</td>
<td>0.440</td>
</tr>
<tr>
<td>Happy</td>
<td>0.908</td>
<td>1.079</td>
<td>0.874</td>
<td>0.913</td>
<td>0.347</td>
<td>1.767</td>
</tr>
<tr>
<td>Healthy</td>
<td>0.054</td>
<td>3.869</td>
<td>0.672</td>
<td>1.213</td>
<td>0.174</td>
<td>0.451</td>
</tr>
<tr>
<td>Interested</td>
<td>0.520</td>
<td>0.601</td>
<td>0.629</td>
<td>0.780</td>
<td>0.744</td>
<td>0.831</td>
</tr>
<tr>
<td>Refreshing</td>
<td>0.789</td>
<td>0.838</td>
<td>0.041</td>
<td>2.751</td>
<td>0.091</td>
<td>2.822</td>
</tr>
<tr>
<td>Safe</td>
<td>0.049</td>
<td>0.299</td>
<td>0.749</td>
<td>1.136</td>
<td>0.118</td>
<td>0.497</td>
</tr>
<tr>
<td>Satisfied</td>
<td>0.049</td>
<td>4.265</td>
<td>0.541</td>
<td>0.740</td>
<td>0.064</td>
<td>2.996</td>
</tr>
<tr>
<td>Special</td>
<td>0.637</td>
<td>0.721</td>
<td>0.500</td>
<td>1.401</td>
<td>0.691</td>
<td>1.191</td>
</tr>
<tr>
<td>Bored</td>
<td>0.565</td>
<td>0.832</td>
<td>0.214</td>
<td>0.566</td>
<td>0.488</td>
<td>0.766</td>
</tr>
<tr>
<td>Disgusted</td>
<td>0.034</td>
<td>0.148</td>
<td>0.555</td>
<td>1.337</td>
<td>0.034</td>
<td>0.219</td>
</tr>
<tr>
<td>Guilty</td>
<td>0.216</td>
<td>0.394</td>
<td>0.866</td>
<td>1.081</td>
<td>0.462</td>
<td>1.626</td>
</tr>
<tr>
<td>Worried</td>
<td>0.014</td>
<td>1.646</td>
<td>0.346</td>
<td>0.619</td>
<td>0.836</td>
<td>1.142</td>
</tr>
</tbody>
</table>

(Table 3.6 Continued)
Table 3.6 Continued

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sensory Visual Cues Effects</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pr&gt;ChiSq</td>
<td>Odds ratio</td>
<td>Pr&gt;ChiSq</td>
<td>Odds ratio</td>
<td>Pr&gt;ChiSq</td>
</tr>
<tr>
<td>Liking*Emotion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liking</td>
<td>0.280</td>
<td>1.256</td>
<td>0.222</td>
<td>1.354</td>
<td>0.009</td>
</tr>
<tr>
<td>Active</td>
<td>0.016</td>
<td>4.735</td>
<td>0.943</td>
<td>0.962</td>
<td>0.050</td>
</tr>
<tr>
<td>Desired</td>
<td>0.200</td>
<td>0.433</td>
<td>0.490</td>
<td>0.771</td>
<td>0.935</td>
</tr>
<tr>
<td>Energetic</td>
<td>0.914</td>
<td>1.071</td>
<td>0.700</td>
<td>1.230</td>
<td>0.480</td>
</tr>
<tr>
<td>Engaging wellness lifestyle</td>
<td>0.325</td>
<td>0.440</td>
<td>0.105</td>
<td>0.362</td>
<td>0.693</td>
</tr>
<tr>
<td>Good</td>
<td>0.358</td>
<td>2.291</td>
<td>0.113</td>
<td>2.817</td>
<td>0.090</td>
</tr>
<tr>
<td>Happy</td>
<td>0.927</td>
<td>1.063</td>
<td>0.814</td>
<td>0.869</td>
<td>0.943</td>
</tr>
<tr>
<td>Healthy</td>
<td>0.043</td>
<td>4.291</td>
<td>0.469</td>
<td>1.428</td>
<td>0.565</td>
</tr>
<tr>
<td>Interested</td>
<td>0.790</td>
<td>0.799</td>
<td>0.786</td>
<td>0.868</td>
<td>0.835</td>
</tr>
<tr>
<td>Refreshing</td>
<td>0.796</td>
<td>0.843</td>
<td>0.047</td>
<td>2.711</td>
<td>0.210</td>
</tr>
<tr>
<td>Safe</td>
<td>0.031</td>
<td>0.250</td>
<td>0.603</td>
<td>1.233</td>
<td>0.130</td>
</tr>
<tr>
<td>Satisfied</td>
<td>0.050</td>
<td>4.359</td>
<td>0.360</td>
<td>0.622</td>
<td>0.090</td>
</tr>
<tr>
<td>Special</td>
<td>0.480</td>
<td>0.603</td>
<td>0.553</td>
<td>1.357</td>
<td>0.641</td>
</tr>
<tr>
<td>Bored</td>
<td>0.695</td>
<td>0.879</td>
<td>0.272</td>
<td>0.592</td>
<td>0.684</td>
</tr>
<tr>
<td>Disgusted</td>
<td>0.023</td>
<td>0.123</td>
<td>0.385</td>
<td>1.589</td>
<td>0.070</td>
</tr>
<tr>
<td>Guilty</td>
<td>0.205</td>
<td>0.381</td>
<td>0.673</td>
<td>1.232</td>
<td>0.316</td>
</tr>
<tr>
<td>Worried</td>
<td>0.010</td>
<td>1.654</td>
<td>0.261</td>
<td>0.543</td>
<td>0.926</td>
</tr>
</tbody>
</table>
3.4. Conclusions

The current study demonstrated that visual cues (color, size, multicolor, package, and product name) could be used as a strategic tool to specially modify consumer’s experiences regarding their acceptance, emotion responses and purchase decision related to eating behaviors. The different green color shades significantly impacted the liking scores green color under eliciting conditions with and without product name. The darker green color elicited more positive emotions than the pale green color which was strongly associated with the negative emotions. Giving the product name and adding multicolor and packaging to the pale color product increased the liking score of the color and enhanced the consumers’ emotion in a positive direction; however, both cues did not improve consumer experience associated the dark color product. The effect of product size, may not be critical for product liking, and emotion. Regarding the PI, consumers neither used liking nor emotion alone to make their purchase decision; hence, changing liking scores and emotion intensity corresponding to visual cues could potentially impact PI.

3.5. References


CHAPTER 4. COMPARISON OF THE R–INDEX AND PARTIAL PROJECTIVE MAPPING APPROACHES FOR SENSORY DISCRIMINATION OF SALTINESS AND BITTERNESS OF SALT MIXTURES CONTAINING L–ARGININE

4.1. Introduction

In the fast moving world of consumer goods, the need for effective sensory discrimination and preference methods is becoming increasingly crucial for the food industry in order to achieve multiple business objectives (Bi and others 2018). For product modification and advertising claim substantiation, various sensory discrimination methods have been used (Rousseau 2015). However, a selection of the discrimination tools for each research design depends on the objective, the complexity of the product, test sensitivity, and the number of panelists (Burn and others 2018). Modern research has been taking an advantage of sense–based marketing that engages in field experiments in which untrained volunteer respondents are used to assess product characteristics and preferences (Harvard Business Review 2015). These discrimination tests completed by non–practitioners have inherent limitations that can independently lead to different interpretations, and, as a result, it is important to examine other potentially useful methods (Keith and others 2009).

R–Index (RIX) is one of the sensory discrimination methods that has been used for measuring the degree of difference or similarity between two products. The method was originally developed for use in food quality control and product development. The RIX can also be calculated from ranking data when ranking between products is practical; however, the procedure requires the samples to be ranked along a given dimension and consumers must indicates the degree of perceived difference between two samples. Panelists are simply required to indicate whether the samples are similar or different. The probability of the judges being able to distinguish between the two samples is demonstrated. The advantages of RIX include the computational simplicity of
data analysis and its flexibility in being able to use in a wide variety of test protocols (Lee and Van Hout 2009). Nevertheless, performing RIX can be costly and time-consuming if the test plan is conducted with too many samples and the results do not provide a specific direction or magnitude of differences. Fortunately, Bi (2006) proposed the RIX analysis based on the Mann–Whitney U Statistics (MWW), and subsequently the RIX can be converted to the Thurstonian’s Modeling ($d'$), a direct measure of difference. This approach has driven the use of non-parametric statistical analysis in the sensory areas which is based on a data set free of distribution assumption, and a measurement index unaffected by the decision criteria and a number of categories of ratings data.

Projective Mapping (PM) is one of the popular and fast holistic descriptive methods that has been used for gathering product information about sensory characteristics with a quick response (Dehlholm and others 2012). With this method, panelists are asked to evaluate the samples and to position them onto the paper according to the global similarities and differences among the samples (Marcano and others 2015). The positioning criteria and their importance are chosen individually by each panelist, which allows PM to be a flexible and spontaneous procedure (Ares and Varela 2014). Previous studies have reported that performing PM can be accomplished with a set of between 5–18 samples; however, the optimum number of samples to include in a PM task is 12 (Risvik and others 1994; Hopfer and Heymann 2013; Pagès 2005). One advantage of the method is its ability to provide a graphical map within a relatively short period of time. However, conducting PM can deliver a terminology disadvantage regarding the information about a specific sensory modality. Consumers may not be able to articulate the terms related to the entire sensory attributes. In order to break this hurdle, Pfeiffer and Gilbert (2008) proposed the modified version of PM, namely partial projective mapping (PPM), in which the panelists are asked to evaluate the similarities and differences of product in a specific modality (such as appearance, flavor, texture),
as opposed to global similarities and differences (Dehlholm 2014). According to these authors, the PPM demonstrated a better discrimination than the global PM and showed a higher correlation with conventional descriptive analysis (Marcano and others 2015).

In this current study, the PPM procedure was adapted from the original version in two different ways. First, the constructed line scale of the two dimensions (low–medium–high) was applied following a previous study of King and others (1998). The structured PPM would be more effective in assessing a different combination of attributes than the original line scale. Another modification was reported by Ferrage and others (2010) that the pre–named axis name of Napping resulted in a better interpretation of sensory flavor space than unnamed axis. Hence it is possible to apply a pre–named axis on PPM since the relationship between Napping and PPM are not very clear and some researchers used both terms interchangeably (Hopfer and Heymann 2013).

Widespread concern by consumers about their current eating habits and their desire to decrease sodium intake has made it an imperative goal of the food industry to reduce the sodium content in products. The reformulation of food products has been identified as one of the most cost effective strategies to reduce dietary sodium intake at the population level (Regan and others 2017). However, successful implementation of sodium reduction programs may conflict with the challenge of consumer’s innate preference for salty taste (Mennella 2014). Sodium reduction has been widely reported to cause negative changes in consumer perception of different product categories. To overcome this limitation, various approaches have been conducted over decades. The concentration of added salt (NaCl) has been lowered by replacing NaCl with other chloride salts (KCl, CaCl₂, and MgCl₂), flavoring, taste enhancers, preservatives and masking agents, and combinations of the above approaches (Brankovic and others 2015; Tahergorabi and Jaczynski 2012). Partial replacement of NaCl with KCl has been the most preferred method of reducing
sodium due to their similarity in molecular composition. Although KCl can help reduce the sodium content in foods, the use of KCl has been limited due to bitterness and off–flavors that are associated with its use (Stanley and others 2017) at more than 50% (Gillette 1985; Lilic and others 2015).

One approach which has been frequently studied is the use of bitterness blocker to inhibit taste receptor activation caused by the bitter compound (Roland and others 2016). Low molecular weight compounds, which include amino acid derivatives and peptides, are known to mask bitter taste. However, it is not clear if the mechanisms masking bitter taste act at the receptor level or on the intracellular components of the taste signalling cascade (Pydi and others 2014). Ogawa and others (2004) reported that L–Arginine (L–Arg) has the capability to block bitterness receptors when substituting NaCl with KCl at a low level. Hence, the search for ingredients that are capable of suppressing off–flavors caused by KCl is a promising approach.

The experiment was conducted due to an existing knowledge of PPM that was based on a fast holistic methodology and may be suited for gathering a quick discrimination within a set of various samples. Hence, the tested hypothesis was that PPM was able to detect the difference between mixed salt solution (KCl/NaCl/L–Arg) and provided a similar discrimination result compared to a standard discrimination test, RIX. Secondly, in an attempt to minimizing the undesirable taste (bitterness and metallic) of KCl, the current study examined the masking ability of L–Arg at a high level of KCl replacement using sensory RIX as a detective tool. Consequently, it would benefit the food industry to simply minimizing sodium content at a proper substitute level without noticeable bitterness perception.

4.2. Materials and Methods

4.2.1. Preparation of mixed salt solutions
Food Grade (FCC) NaCl and L–Arg were purchased from Voigt Global Distribution LLC (Kansas City, MO), while FCC grade KCl was obtained from EMD Chemicals INC. (Gibbstown, NJ). The Brita Water Filtration System (Brita Products Company, Oakland, CA) was purchased from a local supermarket. Four mixed salt (KCl/NaCl/ L–Arg) solutions at 0.5% w/v, 1.0% w/v and 1.5% w/v and control NaCl solution (0.5% w/v, 1.0% w/v and 1.5% w/v) were prepared (Table 4.1). The water used for solution preparation was filtered to eliminate any undesirable taste or odor. Each mixed salt solution was poured into 2 oz plastic cups (with lids) before labeling with three–digit numbers and kept at room temperature for further use. All samples were prepared one day before the testing session.

Table 4.1. The ratio of KCl/NaCl/ L–Arg in the mixed salt solutions.

<table>
<thead>
<tr>
<th>Sample</th>
<th>% KCl</th>
<th>% NaCl</th>
<th>% L–Arg</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>70</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>B</td>
<td>65</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>C</td>
<td>60</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>55</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>E (control)</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
</tbody>
</table>

4.2.2. R–Index evaluation

An untrained panel of 20 people (13 females and 7 males) volunteered for the testing. They were students, staff, and faculty from Louisiana State University, Baton Rouge, LA. Each session was conducted in the Sensory Services Laboratory of the School of Nutrition and Food Sciences at Louisiana State University. Each panelist was instructed to take the sample into his/her mouth, swirl it, and expectorate it into the cups provided. The panelist then rinsed their palate with drinking water after tasting each sample. Unsalted crackers were provided to minimize carryover effects that could be accumulated during the sessions. They were required to take a five–minute
break between each testing. Six sessions (3 concentration x 2 taste modalities), were scheduled for each panelist. Each panelist assessed the lowest concentration of saltiness and tested consecutively for three days. In each session, five salt solutions (Table 4.1) were ranked in the order of saltiness intensity (1=most intense, 5=least intense), and a tie was not allowed for the rank score. A week later, the same procedure was conducted for bitterness evaluation.

4.2.3. Projective Mapping

Fifteen samples, three concentrations and five mixed salt solutions, were randomly presented in a session. Thirty untrained panelists were provided with a white sheet of paper (60 cm x 60 cm) (King and other 1998; Kennedy and Heymann 2009; Nestrud and Lawless 2010). The sheet was constructed with a line scale range from low–high intensity (0–100). Panelists were given direction on how to perform the test before starting their own evaluation. Panelists placed the sample on the paper in accordance with the sample’s similarities/differences in bitterness and saltiness. Those samples considered similar in intensity were placed closer and vice versa.

4.2.4. Design of the experimental and Statistical Analysis

The number of significant pairs from each method was determined. For RIX, the samples are presented to the panelists as N (control, E), S_A (sample A), S_B (sample B), S_C (sample C) and S_D (sample D), see Table 4.2 (Waimaleongora-Ek 2010). In order to obtain the RIX, the Mann–Whitney U statistic was computed through the Wilcoxon Rank Sum using PROC NPAR1WAY (SAS® 9.4 2003). The RIX was then conversed to a degree of differences between two samples ($d'$) following Bi (2006).

For PPM, the coordinate of $x$ (saltiness) and $y$ (bitterness) from each panelist was determined considering the left bottom corner as the origin ($0, 0$). The ANOVA test was performed on the position of each salt solution ($x, y$ coordinate) obtained from PPM, and the differences
between treatments were tested using Tukey’s Test (HSD) at 0.05 probability level. All statistical analyses of data were performed using statistical analysis software (SAS, 2003, version 9.1).

Table 4.2. Tabulate frequencies of ranking data for RIX.

<table>
<thead>
<tr>
<th>Sample</th>
<th>1st (most intense)</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th (least intense)</th>
<th>Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_A</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>E</td>
<td>m</td>
</tr>
<tr>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>m</td>
</tr>
<tr>
<td>S_D</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>…</td>
<td>m</td>
</tr>
<tr>
<td>N</td>
<td>f</td>
<td>g</td>
<td>h</td>
<td>i</td>
<td>J</td>
<td>n</td>
</tr>
</tbody>
</table>

S_A–D indicated mixed salt solution contained KCl (Sample A, B, C and D). N indicated control (Sample E). a–j indicated cumulative rank sum from panelists. m and n indicated total number of panelists participated in each sample.

4.3. Results and Discussions

4.3.1. Detection of saltiness and bitterness by R–Index evaluation

In order to compare whether or not there were differences in sensory perception of saltiness and bitterness, the RIX and d’ value were determined. The RIX had a value range from 0 to 1 (or 0–100%). The value of 1.0 represents a perfectly distinguishable pair, whereas the value of 0 indicates a non–discrimination ability within the pair, therefore, a larger value RIX reflects better discrimination. In this study, the critical RIX value indicating significant difference between pairs was 0.57 (n=120, α=0.05) (Bi 2006). At concentration 0.5% w/v (Table 4.3), the value of RIX indicated that panelists could not differentiate the saltiness of the pairs containing KCl substitute 55%–65% (e.g., B–C, B–D and C–D). The RIX corresponding to those pairs were 0.53, 0.56, and 0.54, respectively. In contrast, panelists rather discriminated the saltiness for the pairs containing KCl substitute above 70% (e.g., A–B, A–C, A–D and A–E), all with 10% L–Arg. Therefore, it can
be concluded that the optimal KCl substitute, without a noticeable difference of saltiness perception, were 55%–65% v/w.

Robinson and others (2005) noted that there is a linear correlation between RIX and the $d'$ value. The RIX value of 0.75 (75%) is approximately equivalent to a $d'$ value of 1, an appropriate level of discrimination to determine threshold values. The closer value to zero of $d'$ indicated a similarity between the pair. Interestingly, an increase of $d'$ value was observed when the amount of NaCl in the mixed salt solution was increased. In this case, the pair A–B ($d'$=0.29) has less significant difference of saltiness perception than the pair A–C, A–D and A–E, ($d'$=0.39, 0.51 and 2.66, respectively). In addition, panelists were able to detect the significant difference of saltiness from all the pairs when increasing the salt concentration from 0.5% w/v to 1.5% w/v. It should be noted that the salt concentrations affected the threshold of discrimination ability of the panelists. Hence, an appropriate concentration for mixed salt substitute is 0.5% due to no noticeable difference of saltiness perception. Regardless of salt concentrations, the panelists perceived the highest differences in saltiness perception between the control (E, 100% NaCl) and the salt containing KCl 65–70% (A & B) with the $d'$ about 2.5, which was identical to a signified distinct differentiation, according to Lawless and Heymann (1999). However, the changes of $d'$ was not significantly noticeable when the salt concentrations were increased.

Considering the bitterness perception among the salt substitute samples (Table 4.4), panelists could not discriminate the bitter taste intensity from pair A–B, A–C, B–C, and C–D at a concentration 0.5% w/v (RIX=0.52–0.55). However, when the salt concentration was increased up to 1.5% w/v, the non-distinguishable difference of the bitter taste was only observed from pair A–B, and B–C, which had only 5% KCl differences. Panelists were able to differentiate the bitterness perception between the control (sample E) and the salt substitute solutions (RIX=0.58–0.65) with
an exception of sample D (RIX=0.53–0.57) across all concentrations. This could suggest that sample D has a bitterness intensity similar to sample E, which was free of salt substitute and had no bitter taste. This could be attributed to the use of L–Arg as a bitterness blocker in sample D. Consequently, adding 10% of L–Arg could mask the bitter taste of KCl substitute at 55% in the salt mixture.

This finding was supported by previous study of Antúnez and others (2018), who reported that an increase in the percentage NaCl replacement with KCl beyond 40% would result in the perception of bitterness and metallic flavors. In addition, Feltrin and others (2015) conducted a study using temporal dominance of sensations to assess the dynamic sensory profile of aqueous solutions of NaCl and different sodium replacers. Their results showed that the sensory profile of a 0.75% NaCl solution and that of a KCl solution equivalent in saltiness were similar. However, the differences between NaCl and KCl for bitterness were characterized during the last half of the evaluation period. With respect to those results, it is impossible for panelists to liberate those differences, unless L–Arg successfully suppressed the bitter taste. Therefore, this finding has supported the feasibility of the sodium reduction strategy and reinforced the idea that L–Arg also positively contributed a masking ability at high levels of salt concentration.

For d’, an increase in KCl substitute from 55% to 70% at 0.5% v/w resulted in a decrease of the d’ from 0.39 to 0.14, which directly reflected the tendency of bitterness discrepancy between the pair that was reduced. Hence, it could be suggested that the bitterness intensity of sample A was closer to sample B than sample C, D and E (A–B > A–C > A–D > A–E, respectively); however, these results did not accurately repeat across the entire concentrations.

Previous studies have demonstrated the use of RIX for various test objectives; for instance, Robinson and others (2005) utilized RIX for measuring the bitterness threshold by comparing to
the American Society for Testing and Material (ASTM) method. The study revealed that the RIX group threshold for the initial panel was 0.0260 g caffeine/100 ml and 0.0148 g/100 mL for the second panel. Group thresholds, using the ASTM method, were 0.0291 g/100 ml for the first panel and 0.0309 g/100 ml for the second panel.

Table 4.3. Analysis of saltiness perception of different mixed salt concentrations using RIX.

<table>
<thead>
<tr>
<th>Pairs (KCl:NaCl:L–Arg)</th>
<th>0.5% w/v</th>
<th>1% w/v</th>
<th>1.5% w/v</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (70:20:10) – B (65:25:10)</td>
<td>0.58&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.58</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>0.29&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.25</td>
<td>0.32</td>
</tr>
<tr>
<td>A (70:20:10) – C (60:30:10)</td>
<td>0.66</td>
<td>0.67</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>0.39</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>A (70:20:10) – D (55:35:10)</td>
<td>0.64</td>
<td>0.78</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>0.51</td>
<td>1.10</td>
<td>1.10</td>
</tr>
<tr>
<td>A (70:20:10) – E (0:100:0)</td>
<td>0.97</td>
<td>0.97</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>2.66</td>
<td>2.66</td>
<td>2.48</td>
</tr>
<tr>
<td>B (65:25:10) – C (60:30:10)</td>
<td><strong>0.53</strong></td>
<td>0.61</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>0.40</td>
<td>0.43</td>
</tr>
<tr>
<td>B (65:25:10) – D (55:35:10)</td>
<td><strong>0.56</strong></td>
<td>0.74</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.91</td>
<td>0.82</td>
</tr>
<tr>
<td>B (65:25:10) – E (0:100:0)</td>
<td>0.97</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>2.66</td>
<td>2.47</td>
<td>2.48</td>
</tr>
<tr>
<td>C (60:30:10) – D (55:35:10)</td>
<td><strong>0.54</strong></td>
<td>0.68</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td>0.62</td>
<td>0.39</td>
</tr>
<tr>
<td>C (60:30:10) – E (0:100:0)</td>
<td>0.95</td>
<td>0.95</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>2.48</td>
<td>2.33</td>
<td>2.10</td>
</tr>
<tr>
<td>D (55:35:10) – E (0:100:0)</td>
<td>0.94</td>
<td>0.92</td>
<td>0.93</td>
</tr>
<tr>
<td></td>
<td>2.33</td>
<td>1.99</td>
<td>2.10</td>
</tr>
</tbody>
</table>

Critical value RIX (n=120, α=0.05) =0.57 (Bi 2006).

*Bold* indicated no significant differences.

<sup>a</sup> the letters in each pair correspond to salt formulations in Table 4.1.

<sup>b</sup> corresponded to RIX value.

<sup>c</sup> corresponded to d’ value.
Table 4.4. Analysis of bitterness perception of different mixed salt concentrations using RIX.

<table>
<thead>
<tr>
<th>Pairs</th>
<th>0.5% w/v</th>
<th>1% w/v</th>
<th>1.5% w/v</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (70:20:10) – B (65:25:10)</td>
<td>0.54b</td>
<td>0.52</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>0.14c</td>
<td>0.07</td>
<td>0.14</td>
</tr>
<tr>
<td>A (70:20:10) – C (60:30:10)</td>
<td>0.55</td>
<td>0.63</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>0.21</td>
<td>0.47</td>
<td>0.36</td>
</tr>
<tr>
<td>A (70:20:10) – D (55:35:10)</td>
<td>0.58</td>
<td>0.67</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>0.29</td>
<td>0.62</td>
<td>0.54</td>
</tr>
<tr>
<td>A (70:20:10) – E (0:100:0)</td>
<td>0.61</td>
<td>0.65</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>0.39</td>
<td>0.54</td>
<td>0.36</td>
</tr>
<tr>
<td>B (65:25:10) – C (60:30:10)</td>
<td>0.52</td>
<td>0.64</td>
<td>0.54</td>
</tr>
<tr>
<td></td>
<td>0.07</td>
<td>0.51</td>
<td>0.14</td>
</tr>
<tr>
<td>B (65:25:10) – D (55:35:10)</td>
<td>0.59</td>
<td>0.68</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>0.32</td>
<td>0.66</td>
<td>0.47</td>
</tr>
<tr>
<td>B (65:25:10) – E (0:100:0)</td>
<td>0.59</td>
<td>0.64</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>0.32</td>
<td>0.51</td>
<td>0.32</td>
</tr>
<tr>
<td>C (60:30:10) – D (55:35:10)</td>
<td>0.53</td>
<td>0.56</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>0.10</td>
<td>0.21</td>
<td>0.36</td>
</tr>
<tr>
<td>C (60:30:10) – E (0:100:0)</td>
<td>0.58</td>
<td>0.60</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>0.29</td>
<td>0.36</td>
<td>0.32</td>
</tr>
<tr>
<td>D (55:35:10) – E (0:100:0)</td>
<td>0.57</td>
<td>0.55</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>0.18</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Critical value RIX (n=120, α=0.05) =0.57 (Bi 2006). Bold indicated no significant differences.

a the letters in each pair correspond to salt formulations in Table 4.1.
b corresponded to RIX value.
c corresponded to d’ value.

The results also suggested that the signal detection rating method produced an accurate threshold value with less preparation, ultimately saving time and reducing cost. In addition, Feng and O’Mahony (2017) adapted the RIX for differentiating the spacing between the various products (e.g., toothbrushes, pens and candies). When a significant difference was detected by at
least one of the two hedonic scales, it was also detected a significant majority of the times by the RIX. The method was a short, logical step to adapt for difference testing for sensory analysis (O’Mahony and others 1979).

4.3.2. Detection of saltiness and bitterness by PPM

Table 4.5 presents the saltiness and bitterness intensity of four salt substitute solutions compared to the control solution obtained by PPM. The result indicated a higher chance of significant difference of the saltiness intensity than the bitterness intensity. As expected, the control (sample E) received the highest salty intensity among the five solutions, except at 0.5% w/v. At 0.5% w/v, replacing NaCl with KCl 55% to 70% had no impact on the saltiness perception. The panelists perceived the saltiness intensity from those samples to be similar to the control ($P > 0.05$), suggesting that KCl successfully achieved the goal of providing a similar salty intensity to NaCl at 0.5% w/v. On the other hand, the saltiness intensity increased in accordance with the increasing in salt concentrations to 1.0% and 1.5% w/v ($P < 0.05$). At 1% w/v, the replacement of NaCl with KCl from 55% to 70% resulted in the noticeable difference of saltiness perception between salt substitute solutions and the control. These findings suggest that the salt concentrations impacted the saltiness perception. At a concentration 1.5% w/v, replacement with a highly restricted proportion 55% (sample D) to 60% (sample C) of KCl is required to protect the noticeable difference from the control (sample E). With respect to this finding, the appropriate ratio of KCl substitute in salt solution, regardless of a concentration, was 55% to 60%.

Unlike the saltiness, the bitterness intensity was not significantly ($P > 0.05$) affected by increasing the salt concentration but rather significantly changed by the increasing KCl substitution ($P > 0.05$). At a concentration 0.5% w/v, there was non–significant difference in bitterness perception between the salt solutions ($P > 0.05$). The possible explanation is that either
L–Arg successfully masked the bitter taste of KCl in the salt substitutes or the discrepancy between the bitterness intensities of the solutions were too small for panelists to differentiate, subsequently panelists perceived the bitter intensity similarly. At salt concentration of 1.0% w/v and 1.5% w/v, panelists were better able to discriminate the bitterness between the control and the salt substitutes, but they could not differentiate the bitterness among the salt substitutes. Therefore, it can be concluded that L–Arg masked bitterness perception of mixed solutions at low salt concentration (0.5% w/v) only.

The discrimination results obtained from the PPM can be presented using a graphical mapping (Figure 4.1). Basically, the solutions were classified into 3 groups following their concentrations. The solutions with 1.5% w/v were projected to the top right of $x,y$ space, the higher bitterness and saltiness area, while the other concentrations were located far apart by the left side. The control of 0.5% w/v, 1.0% w/v and 1.5% w/v was positioned at the bottom–left of each concentration, indicating its concentration as the lowest saltiness and bitterness intensity. This mapping depicts a visual illustration of the samples’ position across their overall differentiations which roughly provides their overall product impression.

It has been observed that the application of PPM in the current study was different from the previous studies of PM. Usually, those studies have compared PM with rapid descriptive analysis methods such as free multiple sorting, flash profiling, ultra–flash profiling, conventional profiling. Recent research has reported that PPM showed a better discrimination than global projective mapping and a higher correlation with descriptive analysis in several evaluation frames (e.g., single attribute, single modality, and multimodalities) (Kim and others 2019; Pfeiffer and Gilbert 2008).
Table 4.5. Percentage of saltiness, bitterness perception* of mixed salt solutions using PPM.

<table>
<thead>
<tr>
<th>Sample</th>
<th>KCl : NaCl : L– Arg</th>
<th>0.5%W/V</th>
<th>1.0%W/V</th>
<th>1.5%W/V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltiness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>70:20:10</td>
<td>15.38nsB</td>
<td>36.23bA</td>
<td>48.19cA</td>
</tr>
<tr>
<td>B</td>
<td>65:25:10</td>
<td>11.54nsC</td>
<td>38.60bB</td>
<td>58.11bcA</td>
</tr>
<tr>
<td>C</td>
<td>60:30:10</td>
<td>12.60nsC</td>
<td>30.75bB</td>
<td>66.61abA</td>
</tr>
<tr>
<td>D</td>
<td>55:35:10</td>
<td>13.18nsC</td>
<td>38.07bB</td>
<td>64.75abcA</td>
</tr>
<tr>
<td>Control</td>
<td>0:100:0</td>
<td>23.60nsC</td>
<td>56.94aB</td>
<td>79.27aA</td>
</tr>
</tbody>
</table>

| Bitterness |                     |         |         |         |
| A          | 70:20:10            | 37.27nsNS | 41.61aNS | 45.67aNS|
| B          | 65:25:10            | 26.32nsNS | 39.59abNS | 40.22aNS|
| C          | 60:30:10            | 33.19nsNS | 45.48aNS  | 39.03aNS|
| D          | 55:35:10            | 24.49nsNS | 30.27abNS | 40.36aNS|
| Control    | 0:100:0             | 21.87nsNS | 23.13bNS  | 17.05bNS|

a, b, c indicated significant differences mean scores in each column ($P < 0.05$).
A, B, C indicated significant differences mean scores in each row ($P < 0.05$).
NS, ns indicated no significant differences mean scores between samples and concentrations.
* based on a 0–100 scale.

4.3.3 Comparison of the discrimination method RIX and PPM.

In order to compare the discrimination ability of RIX and PPM, mixed salt substitutes were used as “teste” stimuli. The greater the number of pairs with significant differences, the higher the discrimination ability (Table 4.6). For PPM, the mean intensity deriving from the samples position on the sensory space of saltiness and bitterness was analyzed and computed using ANOVA. On the other hand, the RIX values were derived from the ranking of sample intensity. The two methods indicated similar results in terms of the appropriate ratio of salt substitute; however, the RIX technique yielded more pairs with significant difference when compared to the PPM data using ANOVA comparisons. In addition, the number of significant pairs between the RIX and PPM method was well established for saltiness rather than bitterness (27 vs. 7, and 19 vs. 6, respectively). This result implied that the saltiness perception (from NaCl and KCl) in the mixed salt solutions may suppress the perceived bitter taste, thereby, substantial differences in taste.
perception of saltiness were more prominent than those of bitterness; hence, the significant differences of saltiness perception were higher.

Figure 4.1. Graphical mapping of saltiness and bitterness intensity of four mixed salt solutions and NaCl solution at concentration of 0.5% w/v, 1.0% w/v, and 1.5% w/v obtained by PPM.

This point was in the line with Berg and other (2002) who noted that the high sensitivity of perceived “bitter” resulted in the low ability to discriminate taste perception. In addition, non–significant difference of bitterness perception was detected between sample D and the control when using RIX, (corresponding to RIX and $d'$ value) at 0.5% w/v, 1.0% w/v and 1.5% w/v, respectively. Performing PPM, by contrast, could demonstrate a masking ability of L–Arg between the sample D and the control at 0.5% w/v and 1.0 w/v only. Park and others (2007) compared the methodological differences between RIX ranking, rating and traditional 9–point hedonic rating for assessing the degree of liking of food and non–food products. The results relied on the number of non–significant differences among the stimuli and further indicated that the numbers of non–significant records of RIX and traditional hedonics were comparable, with a very slight and non–
significant advantage for the ANOVA analysis. The differences between rank–rating and traditional scaling was slight, but not for all products.

The data analysis was included as a part of this comparison investigation. The PPM data can be analyzed by parametric statistics such as ANOVA or MFA, if various attributes are constructed. Running data analysis with ANOVA or MFA can lead PPM to be a quick and simple method. It also provides an overview of visual graphical mapping of product position, which may be a benefit for identifying the specific product profile of various samples within a short time. However, one disadvantage of PPM when using a paper ballot is the time spent for data collection. Measuring the product coordinates on the sheet of each panelist was a tedious and tiresome process, particularly with a large number of consumer (Veinand and others 2011). Unlike PPM, the RIX analysis method was also simple and fast by cooperating the non–parametric statistics in the analysis before transforming % RIX into $d'$. Theoretically, considering a relationship between RIX, the Mann–Whitney U test and the Wilcoxon Rank Sums Statistic, the RIX is only slightly less powerful than the $t$–test (approx. 5%), if the underlying distributions are normal (Bi 2006). When the normal distribution assumptions do not hold, as would be expected with hedonic scaling (O’Mahony 1982; Thurstone 1954), the RIX is frequently more powerful than the $t$–test.

Regarding the number of samples, PPM can be performed with 15 products at a time, but at some points it may lead to carry over. However, with RIX, 5 samples were served to panelists, thus causing less fatigue. Additionally, the duration time spent on the evaluation can be a part of the comparison. The PPM was completed in approximately 40 min for all evaluations whereas the RIX took 4 times longer to complete all 15 samples, within 6 sessions.
Table 4.6. The number of pairs with significant differences between salt mixed solutions using RIX and PPM.

<table>
<thead>
<tr>
<th>Salt Concentration*</th>
<th>Saltiness Perception</th>
<th>Bitterness Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RIX</td>
<td>PPM</td>
</tr>
<tr>
<td>0.5% w/v</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>1.0% w/v</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>1.5% w/v</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>7</td>
</tr>
</tbody>
</table>
* based on 10 different pair comparisons for each concentration.

4.4. Conclusions

Both the RIX and PPM could be successfully used to examine discrimination of saltines and bitterness between a salt substitute and a control solution. The R–Index offered a distinctive discrimination of the pair through a non–parametric technique. The measurement of an index was unaffected by the decision criteria and number of categories of rating data. The method is potentially more sensitive to sensory differences, but may take longer time to perform the test. The PPM method, on the other hand, required that the similarity or dissimilarity of confusable product attributes be compared and the differences between those samples be projected onto a sensory space. The method provided less specific measurement related to sensory characteristics and was less sensitive to detect differences; however, the grouping/sorting was possible with less time to perform the test. This study also revealed that L–Arg and NaCl could synergistically mask the bitterness of KCl, and it would be of a great benefit to food industries to simply minimize sodium content in products at proper substitution level without bitterness effects.

4.5. References


CHAPTER 5. THE USE OF VISUAL CUES TO ENHANCE TASTE PERCEPTION: A
CASE STUDY FOR REDUCED CONSUMPTION OF SALT AND SUGAR
IN FOOD MODELS

5.1. Introduction

Present-day dietary patterns closely parallel the technological innovation that have penetrated the global food system, and increased food availability and accessibility (Wilkinson 2004). In recent years, diets have become laden with salt and sugar (Johnson and others 2007) and are described using the term “Western Diet” (Popkin 2006). Processed foods alone account for 80% of daily salt intake (Delahaye 2014) apart from daily salt added to cooking as well as those from natural sources such as meat and plant matter. It could, therefore, be inferred that high salt intake occurs frequently and individuals are often unaware of the amount of salt consumed. The recent estimate of human consumption of salt per day is about 9–12 grams, or around twice the recommended maximum level of salt intake of 1.5–2.0 grams (WHO 2016). Soft drinks and sugar–sweetened beverages are a leading source of added sugar. Before the advent of modern agriculture, less than 2% energy was derived from sugar, but today about 18%–25% energy comes from simple sugars (Gray and others 2013). Adults in the United States currently obtain an average of 14.6% of calories from added sugars (Peters and others 2018). Males, in particular, consume as much as 189 grams per day, accounting for ~32% of their energy intake (NDNS 2014). Consequently, reducing salt or sugar levels in food products is an essential motivation for research, as the general intake of these two additives by consumers is too high.

The extent of consumer awareness and exposure to salt or sugar alternatives may result in different consumer expectations concerning sensory liking, desirable intake amounts, and functions in promoting health. For instance, replacing sugar in beverages can cause changes in consumer perceptions. The use of high–intensity sweeteners that do not increase viscosity and
density results in watery products (Brandenstein and others 2014). Wardy and others (2018) demonstrated that consumers noticed the most prominent differences in sweetness intensity between sugar and stevia added in muffins, with a liking score for stevia rated 1.3 times lower than the sugar containing muffin. Also, the addition of 100% sugar alternatives as a sugar replacer in muffins resulted in harder muffins with a more compact and less aerated crumb (Gao and others 2018). Among salt substitutes, potassium chloride (KCl) provides similar properties to common salt (NaCl), but with several unwanted offensive side tastes: bitter, acrid, and metallic (Cepanec and others 2017). It was reported that the spreads containing KCl had higher bitterness and pH than spreads containing NaCl, and that saltiness intensity slightly decreased when oil concentration was increased (Torrico and Prinyawiwatkul 2017). It is important to consider that the use of salt substitutes or sugar replacement could possible produce a serious adverse side effect on overall product quality. Research to support taste-improving approaches for sugar replacement and KCl-based salt substitutes is, however, beyond this scope of the present research.

Previous findings demonstrate that visual cues associated with food products had a substantial effect on taste perceptions in particular by affecting expectations of palatability of foods which can ultimately dictate food choices and consumptions (Wadhera and others 2014). It has long been recognized that color constitutes one of the most salient of visual cues concerning the taste/flavor of foods and beverages. To date, a large body of research has demonstrated that changing the hue or intensity/saturation of the color of food and beverage items can sometimes exert dramatic impact on the expectations, and hence on the subsequent eating experiences of consumers. For instance, red and lime/lemon colored drinks having a darker color were rated as having a higher sweetness intensity (Spence and others 2010). It was suggested that pairing a color or odor with a sour or sweet taste led to increasing expected sourness or sweetness ratings of the
associated solution (Stevenson and others 2000). In a recent study, Shermer and Levitan (2014) showed that the saturation of salsas (i.e., the intensity of red color) biased participant ratings of their piquancy in taste (i.e., their spice intensity). In this respect, then, there might well be different correspondences, or even a complex network of correspondences, underlying the matching of any specific color with any particular taste associated with food products. Beyond visual color, intrinsic factors like viscosity changes remain an essential challenge for sensory expectation. Cooks and others (2003) suggested that an increase in the viscosity of liquid foods also have an impact on taste and aroma perception. Oral perception of viscosity can be correlated with the shear–stress developed in the mouth when manipulating liquid samples. However, their study examined the poorly understood phenomenon of sweetness and aroma suppression in viscous hydrocolloid solutions.

Finding strategies for salt or sugar reduction, while maintaining the salty taste of products remains a great challenge to food scientists. A few studies have been conducted on the impact of visual cues on salt or sugar content in foods. The goal of experiment 1 was to determine if the visual color could enhance the saltiness perception of “Lightly Salted” chicken soup. Experiment 2 was to evaluate the effects of visual cues (yellow/brown color and viscosity) of syrups on sweetness and bitterness perception and to determine if these visual cues could reduce consumption of syrup added to brewed coffee.

5.2. Experiment 1: The use of visual color to enhance salty taste in chicken broth.

5.2.1. Materials and Methods

5.2.1.1. Sample Preparation

Chicken drumsticks with addition of onion and water, in a ratio based on Table 5.1, were put in the stewpots. The sample was slowly heated to a boil for 90 min, then reduced the heat to
low, and simmered gently for 30 min. The chicken was lifted out of the hot liquid and the broth was strained with filter cloth. This broth was kept at the room temperature for 1 hr. and it was constituted as a chicken broth base formulation.

Table 5.1. Ingredients and its ratio used in chicken broth formula.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>% by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken drumstick (Walmart, USA)</td>
<td>1.7%</td>
</tr>
<tr>
<td>Water (Great Value™, USA)</td>
<td>98.0%</td>
</tr>
<tr>
<td>Onion</td>
<td>0.3%</td>
</tr>
</tbody>
</table>

* all ingredients other than salts used in the recipe were salt–free.

5.2.1.2. Saltiness evaluation of chicken broths

In this study, the base formulation was used as a food model for a comparison of chicken broth containing regular salt and chicken broth containing salt substitute (from Chapter 4) for an identification of saltiness perception. Therefore, NaCl (regular salt) at 1% w/v was added to 100 ml of chicken broth base formulation and it was constituted as a “control” while the one containing 1% w/v of salt substitute (55% KCl, 35% NaCl, and 10% L–Arg) was constituted as a “salt substitute” sample.

The 2–alternative forced choice (2–AFC) test was used to identify the saltiness perception of both samples. Ten milliliter of chicken broth was poured into 2 oz. plastic cups (with lids) before labelled with three digits–numbers and kept at room temperature before the testing session. Sixty consumers participated in the evaluation of two samples in the blue light controlled booth and identified which of the chicken broths was saltier. The test statistic for the 2–AFC test was based on the binomial distribution for 2–AFC following Meilguard and others (2007), corresponding to n=60 and P=0.05, critical value=39. The result showed that 46 observed responses indicated that the chicken broth containing NaCl at 1% w/v was saltier than the one with salt substitute.
5.2.1.2. Consumer visual evaluations

The chicken broth containing salt substitutes was colored with three levels of caramel color 1X (Goldcost®, USA), see Table 5.2, in order to mimic color of chicken broths in the current market (Figure 5.1). The soup color was then measured using a spectrophotometer (model CM–5, Konica, Jakarta Raya, Indonesia) and reported as L*, a*, b* values (Table 5.2).

Figure 5.1. Appearance of chicken broth and sensory testing booth with blue light control.

A consumer study was conducted with a total of eighty-five (male and female) participants. They were recruited according to their willingness to participate and with a requirement of consuming chicken soup. In the beginning, the four chicken soups were presented in the glass tubes (Figure 5.2). In a session, only sixty consumers were asked to rank those samples in the order bitterness and saltiness based on visual color perceptions, 1=least intense, 5= most intense and no tie was allowed for the rank score.
Table 5.2. Volume of caramel color added into chicken broth containing salt substitute and the color value \((L^* a^* b^*)\) obtained by instrumental measurement.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Volume of caramel color (ml) /100 ml chicken broth</th>
<th>Color parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (1% w/v NaCl)</td>
<td>-</td>
<td>49.84 1.41 8.24</td>
</tr>
<tr>
<td>LBC (Light Brown Color)</td>
<td>0.010</td>
<td>55.65 1.03 12.59</td>
</tr>
<tr>
<td>MBC (Medium Brown Color)</td>
<td>0.035</td>
<td>56.07 1.56 16.74</td>
</tr>
<tr>
<td>IBC (Intense Brown Color)</td>
<td>0.055</td>
<td>50.15 1.69 18.02</td>
</tr>
</tbody>
</table>

In the second part, consumers (85) were asked to visually evaluate their liking, expectation score of saltiness/bitterness, saltiness and bitterness intensity and purchase intent based on product color alone. They were then asked to taste the samples and answer the questions about visual testing. Liking was evaluated by using a 9–points hedonic scale, and the expectation was evaluated by a 9–points scale of 1=extremely less salty/bitter than expected, 5=same as expected, 9=extremely salty/bitter than expected). The intensity of saltiness and bitterness (JAR) was evaluated with a 5 points category scale of “not salty/bitter enough” to “too salty/bitter”, and purchase intention was evaluated with a binary scale of “yes or no”.

Figure 5.2. Color of added color chicken broth (from left; control, LBC, MBC, IBC; see Table 5.2 for color value).
5.2.1.2. Statistical Analysis

For the rank data, the analysis corresponded to Christensen and others (2006). Once ranked data were summed, the largest difference between rank sums was compared with the values in the Tables of Christensen and others (2006) to determine overall significant difference, using n=60, samples=4, \( P=0.05 \), critical value=36. If a significant difference occurred, then it was appropriate to make multiple comparisons to determine significance between all pairwise comparisons. If the difference in rank sums of 1 sample compared with another sample as equal to or exceeding the critical value listed in LSD Table (critical value=28), then the null hypothesis (e.g., the two samples are same) is rejected. It can be concluded that the samples were significantly different from each other. For data of liking and expectation, the mean scores were analyzed using ANOVA and the differences between treatments were tested using the Turkey test at 0.05 probability level. For the JAR data, the percentage of consumers in each of the 5 categories was calculated and collapsed in the three categories. All statistical analyses of data were performed using statistical analysis software (SAS, 2003, version 9.1).

5.3. Results and Discussions

The result from the ranking test indicated a significant effect of color cues on the visual expected saltiness and bitterness \( (P < 0.05) \), see Table 5.3. Among the chicken broth containing salt substitutes, IBC was ranked with the highest saltiness intensity followed by MBC and LBC, respectively. Consumers visually perceived the control as significantly less salty than MBC and IBC. Unlike the salty taste, consumers visually expected that the control was more bitter than those colored samples and IBC was ranked with the lowest bitterness intensity. With this result, it could be noted that the color cues induced an expectation of saltiness and bitterness perception.
Table 5.3. Rank sum of saltiness and bitterness in chicken soup based on visual testing.

<table>
<thead>
<tr>
<th>Sample*</th>
<th>Control</th>
<th>LBC</th>
<th>MBC</th>
<th>IBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltiness</td>
<td>124&lt;sup&gt;a&lt;/sup&gt;</td>
<td>144&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>158&lt;sup&gt;b&lt;/sup&gt;</td>
<td>164&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bitterness</td>
<td>174&lt;sup&gt;b&lt;/sup&gt;</td>
<td>155&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>142&lt;sup&gt;a&lt;/sup&gt;</td>
<td>129&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* referred to Table 5.2 and Figure 5.2 for color description.

<sup>a-b</sup> different letters within each row indicated significant differences between samples (<i>P < 0.05</i>).

The result of the visual evaluation indicated that consumers liked the colors of chicken broth differently (Table 5.4). The IBC showed significantly higher liking scores as compared with LBC and control (5.82 versus 4.27 and 3.60, respectively), but was not significantly different from MBC (5.64). It could be concluded that the color liking score increased with increasing color intensity set in this study. Huynh and others (2016) used fish sauce to reduce NaCl in chicken broth. They concluded that the broth color changed due to the brown color of fish sauce and the changes in color influenced the consumer perception of the taste of the broth.

For the taste evaluation, consumers agreed that the saltiness of chicken broths, especially, MBC and IBC did not meet their expectation which was generated by visual evaluation prior to the taste evaluation. All chicken broths were rated with “less salty than expected,” lower than neutral point, except the control that was recognized as “same as expected” to “almost slightly more than expected.” Consumers expected IBC to be saltier due to the intense brown color, but when tasted, it was not as salty as expected. On the other hand, the impact of color cues did not significantly sway a taste perception of bitterness (<i>P > 0.05</i>), suggesting that the visual brown color cues have more impact on the saltiness rather than bitterness under the color range tested in this study. It is important to acknowledge that the effect of visual color cues may vary depending on eating and particular food models (Tu and others 2016). For instance, brown M&M’S candies were rated as significantly more chocolate than green M&M’S (Shankar and others 2009) or a case of fish sauce that was associated with brown color (Rithiruangdej and Suwansichon 2007). The
color–flavor/taste congruence with food product (for example, some colors appear to correspond or “go with” certain odors while others are less appropriate) is also affected by prior experience with the stimuli of interest (Velasco and others 2015; Zellner 2013). Thus, a natural correlation between brown color and saltiness was more obvious than a correlation between brown color and bitterness. This finding confirmed the ranking results that the more intense brown color yielded higher expectation of saltiness to chicken broth than the light brown color.

In the specific case of saltiness and bitterness liking scores of chicken broths, there was no significant difference of the liking score across all chicken broths ($P > 0.05$). The sensory liking score of saltiness and bitterness were rated in the range of “disliked” level (below 4). For a purchase intent, by visual evaluation, consumers strongly intended to purchase the chicken broths with more brown color with PI increasing from 10% to 71.76%. However, the switching of their purchase decision to not buying was observed after consumers tasted the sample. Even though consumers liked the chicken broths’ appearance, taste was a driving factor of consumer purchase intent. This finding agreed with Valentin and others (2016), who demonstrated that color was not a significant factor in the sensory assessment of the wines quality, although wine color had several minor effects.

For the saltiness intensity, the results are shown in Figure 5.3. More than 50% of consumers visually rated saltiness of the control and LBC higher in the range of “not salty enough” when compared to other JAR categories but they visually rated the saltiness of MBC and IBC higher in the range of “JAR” (52.9 and 49.4) than the control. When compared to the control, only IBC was highly rated in the range of “too salty” (38.5%). This demonstrated the clear effects of visual color cues on expectation saltiness perception. Indeed, those chicken soups containing different brown color intensity have identical salt content. Therefore, the perceived saltiness intensity of those
broths should be similar by tasting, which was not the case as seen in Figure 5.3. Consumers likely expected IBC to be saltiest compared to LBC and MBC, but after tasting, they rated IBC with more “not salty enough” than MBC and LBC (52.9%, 47.1%, 43.5%, respectively). This assumption was supported by Yang and others (2016), who demonstrated that the color cues allowed people to not only identify sensory characteristics such as taste, flavor, and texture but also to expect specific intensities of sensory characteristics. Therefore, it could be reported that the different color intensity also induced differences in perceived taste intensity as seen in this study.

Table 5.4. Expected intensity, liking score of saltiness and bitterness and purchase intent of chicken broth from consumers using taste evaluation.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Responses</th>
<th>Control*</th>
<th>LBC**</th>
<th>MBC**</th>
<th>IBC**</th>
</tr>
</thead>
<tbody>
<tr>
<td>visual</td>
<td>color liking</td>
<td>3.60a</td>
<td>4.27a</td>
<td>5.64b</td>
<td>5.82b</td>
</tr>
<tr>
<td></td>
<td>purchase intent (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>20.00</td>
<td>32.94</td>
<td>71.76</td>
<td>71.76</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>80.00</td>
<td>67.06</td>
<td>28.24</td>
<td>28.24</td>
</tr>
<tr>
<td></td>
<td>expected saltiness</td>
<td>5.93c</td>
<td>4.91bc</td>
<td>4.33b</td>
<td>4.12a</td>
</tr>
<tr>
<td></td>
<td>liking of saltiness</td>
<td>4.58</td>
<td>4.28</td>
<td>4.20</td>
<td>4.28</td>
</tr>
<tr>
<td></td>
<td>expected bitterness</td>
<td>4.48</td>
<td>5.09</td>
<td>4.76</td>
<td>4.98</td>
</tr>
<tr>
<td>taste</td>
<td>liking of bitterness</td>
<td>4.88</td>
<td>4.21</td>
<td>4.62</td>
<td>4.33</td>
</tr>
<tr>
<td></td>
<td>purchase intent (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>43.53</td>
<td>25.88</td>
<td>36.47</td>
<td>35.29</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>56.47</td>
<td>74.12</td>
<td>63.53</td>
<td>64.71</td>
</tr>
</tbody>
</table>

* referred to Table 5.2 and Figure 5.2 for color description.
** referred to color of chicken broths (LBC=light brown color, MBC=medium brown color, IBC=intense brown color).

\[a-c\] different letters within each row indicated significant differences between samples \((P < 0.05)\).

ns indicated no significant differences between samples for each response \((P > 0.05)\).

With respect to bitterness intensity (Figure 5.4), the intense brown color tended to slightly induce visual expectation of bitterness more than the light brown color. For instance, consumers visually rated the bitterness intensity of MBC and IBC higher in the range of “JAR” than the
control and LBC (55.3–61.2% vs. 36.5–41.2%) of the JAR score. However, those differences in distribution of the visual expected bitterness were not clearly illustrated when compared with the results from saltiness perception. Furthermore, the outcome of that expectation did not carry over to a taste evaluation, resulting in a minimal change in the distribution frequency of the bitterness intensity. In fact, this current JAR finding is contrary to our first ranking study, which showed that consumers rated higher bitterness for the control. But the JAR result showed a higher frequency rating of “too bitter” for MBC and IBC.

![Figure 5.3](image-url)

Figure 5.3. Saltiness intensity rating (%) from four chicken broth (Control=no brown color added, LBC =light brown color, MBC=medium brown color, IBC=intense brown color) obtained by visual (V) and taste (T) perception, based on a 3–points JAR scale.

Brogaard and Gatzia (2017) proposed that color experiences are not purely perceptual, but rather depended on a variety of factors besides the spectral properties such as the intrinsic makeup of our visual system, including the environment, color–related beliefs, knowledge, and memory. Hence, in the specific condition of visual testing, it might be an atypical sensory association between chicken broth and bitter taste. Even though the chicken broths contained a bitter taste resulting from KCl substitute, consumers were not informed about KCl substitute prior to the
testing; therefore, they might not connect the bitter taste to chicken broth. Consequently, the correlation between the color experience of chicken broth and the bitter taste was not easy to establish.

Figure 5.4. Bitterness intensity rating (%) from four chicken broth (Control=no brown color added, LBC=light brown color, MBC=medium brown color, IBC=intense brown color) obtained by visual (V) and taste (T) perception, based on a 3–points JAR scale.

5.4. Experimental 2: Reducing consumption of syrup added to brewed coffee by visual cues

5.4.1. Materials

The syrups were prepared using the following ingredients: Ticalose® 400 SF Powder (TIC GUMS, MD, USA), sugar (Great Value™, WalMart, Bentonville, AR, USA), distilled water (Great Value™, Premium water, Inc., Riverside, MD, USA), artificial caramel color 1X (Gold Coast Ingredients, Inc., CA, USA). The coffee base consisted of Nescafe Taster’s Choice 100% pure coffee (Nestle professional North America Solon, OH, USA), distilled water and Coffee–mate® powdered coffee creamer (Nestle professional Beverages, Tempa, FL, USA).
5.4.2. Syrups preparation

The syrups were prepared in 2,000 mL batches. Twenty percent (w/v) of sugar was dispersed in a mixture of 0.5%, 1.4% and 2.6% Ticalose® and water, resulting in 20 °Brix of sweetness. The mixture viscosity was adjusted to 80 cP, 800 cP, and 8,000 cP, using a viscometer (model DV– II+, Brookfield Engineering Labs Inc., Middleboro, MA, USA) at 25 °C using a S62 spindle. The final mixture was blended with 50% (w/w) diluted caramel color solution in varying amounts of 10 µL, 70 µL, 150 µL, and 300 µL, resulting in a Yellow Index (YI) of 0.04, 0.08, 0.16 and 0.32, respectively, measured using a spectrophotometer (model CM–5, Konica, Jakarta Raya, Indonesia) and reported value as L*, a*, b* values. The YI was calculated according to Pathare and others (2013). Totally, there were a total of 12 syrup samples (3 viscosity x 4 concentrations).

5.4.3. Preparation of coffee

One coffee packet was mixed with 80 g of hot water (80 °C), then a powdered creamer was dissolved in the mix. The coffee/creamer solution was equally divided into 2 part of 40 g, and kept warm (70–75 °C), before serving.

5.5. Sensory analysis

5.5.1. Effect of visual cues on sweetness and bitterness perception

The visual evaluation of 12 syrups concerning sweetness and bitterness was conducted through partial projective mapping (PPM). The PPM procedure was performed using a white paper (60 cm x 60 cm) with a constructed line scale from a low to high intensity of both perceptions. Thirty panelists, male and female, participated in the visual evaluation of 12 syrups which were filled into glass tubes covered with plastic lids. Panelists were instructed to carefully look at the samples and position them on the paper according to their similarities and differences of perceived bitter and sweet taste intensity. The samples considered similar in intensity would be placed close...
to each other and vice versa. The positions of each sample were recorded as $x, y$ coordinate, where $x$ represented sweetness intensity and $y$ represented bitterness intensity.

5.5.2. Visual cues affected consumer behaviors of syrup–sweetened coffee

Seventy-eight consumers who regularly drink coffee twice a week with added syrup or sugar were recruited. Only four syrup combinations were selected following the PPM result. Ten oz of each syrup was transferred to a 16 oz plastic pump bottle. At a testing session, consumers were supplied with a set of samples (e.g., syrup, hot coffee, water, cracker, and measuring cup) in a monadic sequential design using Compusense® five software (version 5.6, Compusense Inc., Guelph, Canada). First, they visually rated the expected sweetness intensity of syrups, (Question: Please rate your expected sweetness intensity based on the color and viscosity of this syrup), using a 3 points JAR scale (1=not sweet enough, 2=just about right, 3=too sweet). They were then asked to pump syrup into a measuring cup at a satisfactory sweetness level, and record the syrup volume as first pump (1st). Afterward, the taste evaluation began once the syrup was added to hot coffee. Consumers were asked about the expected sweetness perception after the 1st pump and whether it met their expectation, sweetness intensity, and liking of sweetness intensity of the coffee. [Question: How did the coffee sweetness meet your expectation? (using a 9–points scale of 1=extremely less sweet than expected, 5=same as expected, 9=extremely sweet than expected), Question: Please rate the sweetness intensity of your coffee (using JAR scale of 1=not sweet enough, 2=just about right, 3=too sweet), Question: How do you like the sweetness of the coffee? (using a 9–point hedonic scale of 1=extremely dislike, 5=neither like nor dislike, 9=extremely like)]. Consumers were allowed to add more syrup a second time (2nd) if they were unsatisfied with the sweetness after the first pump. Then, the questions of expectation of sweetness, sweetness
intensity and liking of sweetness were repeated. The questionnaire creation including data collection were obtained by Compusense® five software.

5.6. Data analysis

In order to determine the effect of YI and viscosity on the sensory perception, a two–way ANOVA was performed on the position of each syrup (x, y coordinate) obtained from PPM, and the differences between treatments were tested using Fisher’s Least Significant Difference (LSD) test at a 0.05 probability level. For the coffee study, consumer data were segregated into two groups; consumers who performed a single pump (SP) were denoted as n while m represented those performed double pump testing (DP). The two–way ANOVA and LSD were also applied to the data regarding the volume of syrups, liking and expectation score. The JAR data were analyzed using McNemar’s–Test (Sae–Eaw and others 2007; Poonnakasem, and others 2016). All statistical analyses of data were performed using statistical analysis software (SAS, 2003, version 9.1)

5.7. Results and Discussions

5.7.1. Effect of visual cues on sweetness and bitterness perception

The analysis revealed a significant effect of color and viscosity on visual expected sweetness and bitterness perception ($P < 0.05$). Based on the mean of bitterness and sweetness intensity, few differences were observed across all syrup stimuli (Table 5.6). However, robust differences were demonstrated when comparing the intensity of the sweetness perception. By visual examination, the interaction between viscosity and YI strongly influenced the sweetness perception ($P < 0.05$). For instance, an increase of viscosity from 80 cP to 8,000 cP, resulted in an increase of sweetness intensity from 32.46 to 59.60 units and 54.53 to 73.12 units, when adjusting YI from 0.04 to 0.32, respectively. In fact, the changes in sweetness perception were more obvious with respect to YI levels than viscosity levels as shown by the larger differences of perceived
sweetness intensity when increasing YI level compared to the increasing of viscosity level. This result suggests that the differences of YI exerted significant impact on visual expected sweetness perception. The two viscosity levels, 800 cP and 8,000 cP, showed similar impact on sweetness intensity. Only the highest viscosity (8,000 cP) was kept for further study, to reduce the number of test samples (see Table 5.5).

Table 5.5. Selected syrups used in consumer study of coffee.

<table>
<thead>
<tr>
<th>Syrups</th>
<th>Defined code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syrup has viscosity 80 cP and YI 0.04</td>
<td>LC1</td>
</tr>
<tr>
<td>Syrup has viscosity 80 cP and YI 0.32</td>
<td>LC2</td>
</tr>
<tr>
<td>Syrup has viscosity 8,000 cP and YI 0.04</td>
<td>HC1</td>
</tr>
<tr>
<td>Syrup has viscosity 8,000 cP and YI 0.32</td>
<td>HC2</td>
</tr>
</tbody>
</table>

In the case of bitterness perception (Table 5.6), the mean ratings of bitterness intensity were unaffected by changes in viscosity ($P > 0.05$) for all YI levels. The samples were merely characterized by the differences in YI levels ($P < 0.05$). The most intense YI syrups (YI=0.32) were visually perceived with the highest bitter taste with 45.65 to 49.83 units. As a result, panelists rated the intense color syrup as having the highest bitter taste.

An important point to note about this study was that changing viscosity and color intensity exerted different perception patterns. The sweetness perception was strongly influenced by the interaction between color and viscosity while the bitterness perception was affected by the color alone. The implication is that color may be considered a significant contributor to taste perception. However, the evidence pertaining to the color’s influence on taste intensity would appear to be more ambiguous than its effect on flavor intensity. Not surprisingly, a number of studies have failed to demonstrate any such cross-modal effect of increasing the level of food coloring on
ratings of taste intensity (Spence 2011). Yet, the current finding has established solid evidence regarding the association between color and taste perceptions.

To explain the observed effect of color on bitter/sweet perception, an explanation would be that the panelist’s anticipation may be based on their own personal thinking and prior experience about the color and the taste of syrup. An early research indicated that brown color was positively associated with syrupy or perhaps negatively associated with sweetness (Koch and Koch 1995) and may be associated with bitterness (Doorn and others 2017). Furthermore, O’ Mahony (1983) reported the number of participants who gave the same color response on all three of the occasions on which they were tested. The highest consistent response was found with the sweet taste when matched with the color red (with 7 of the 51 participants). The tendency for participants to consistently pick brown for bitter was 2 out of 51 participants. This result showed a smaller number of the participants. As a result, the meaning of certain colors was being assessed in the absence of various contexts; therefore, its meaning might be expected to be more variable under such testing conditions. In addition, the association between taste and a particular color is dependent on food types. The pairings between tastes and colors do not count as associations between features or properties of the same kind of products but more as cross–modal correspondences, which are defined as matchings between apparently unrelated sensory features and dimensions (Deroy and Spence 2012). Similarly, Lavin and Lawless (1998) revealed that adults rated the dark–red and light–green fruit beverages higher in sweetness than the light–red and dark–green sample. It could be explained that the darker colors (i.e., green color) may psychologically mask the sweet taste thus raising their threshold or it may have been associated with a specific food.

With respect to viscosity, our results are similar to earlier studies that showed increasing viscosity may enhance sweetness and other taste attributes. For instance, Holm and others (2009)
observed an increase in sweetness with an increasing amount of pectin while Kanemaru and others (2002) found the sweetness–enhancing effects of soluble starch. Brandenstein and others (2014) investigated the effects of viscosity and different hydrocolloids on the texture and taste perceptions of low–viscosity fruit drinks. Their results indicated that the sweetness of fruit drinks was also not significantly influenced by viscosity. However, some studies argued that an increase in viscosity reportedly led to a decrease in taste perception and therefore may have reduced sweetness perception (Boland and others 2003; Malone and others 2003). These contradictory findings may be due to the differences in the test conditions as well as the high number of experimental variables in the literature. More research is needed to further explore the relationships between taste and visual color cues.

5.7.2. Visual cues affected consumer behaviors of syrup–sweetened coffee

Beginning with the visual expected sweetness perception (Figure 5.5), the single pump consumers (SP) estimated the sweetness intensity of four syrups prepared by a combination between viscosity (80 cP and 8,000 cP) and YI (0.04 and 0.32). The syrups contained identical YI, but having differences in viscosities, showed a similar sweetness intensity’ frequency ranges of “not sweet enough” of syrup LC1 (44.7%) and HC1 (37.5%) and “too sweet” of syrup LC2 (43.9%) and HC2 (48.7%). For syrups with similar viscosities, the distribution frequency ranges were demonstrated with a different pattern. A case of low viscosity syrup, for instance, the less intense YI syrup (LC1) was expected to be “not sweet enough” (44.7%) while the more intense YI syrup (LC2) was expected to be “too sweet” (43.9%). The results also demonstrated a similar trend with the high viscosity syrup, but a changing percentage of the distribution frequency range was noted.
Table 5.6. Impact of viscosity and yellowness index (YI) on visual perception of sweetness and bitterness intensity using PM.

<table>
<thead>
<tr>
<th>Attributes*</th>
<th>Viscosity (cP)</th>
<th>Yellow Index (YI)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.04</td>
<td>0.08</td>
<td>0.16</td>
<td>0.32</td>
<td></td>
</tr>
<tr>
<td>Sweetness</td>
<td>80</td>
<td>32.46 ± 4.69B&lt;sup&gt;c&lt;/sup&gt;</td>
<td>36.17 ± 3.21B&lt;sup&gt;c&lt;/sup&gt;</td>
<td>47.96 ± 3.42B&lt;sup&gt;b&lt;/sup&gt;</td>
<td>59.60 ± 4.55B&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>53.98 ± 4.75A&lt;sup&gt;b&lt;/sup&gt;c</td>
<td>50.63 ± 3.93A&lt;sup&gt;c&lt;/sup&gt;</td>
<td>64.90 ± 3.86A&lt;sup&gt;b&lt;/sup&gt;</td>
<td>76.69 ± 3.30A&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>8,000</td>
<td>54.53 ± 2.46A&lt;sup&gt;c&lt;/sup&gt;</td>
<td>53.98 ± 4.02A&lt;sup&gt;c&lt;/sup&gt;</td>
<td>65.25 ± 3.35A&lt;sup&gt;b&lt;/sup&gt;</td>
<td>73.12 ± 3.89A&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bitterness</td>
<td>80</td>
<td>32.31 ± 6.06NS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>37.08 ± 3.86NS&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>39.63 ± 3.66NS&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>49.83 ± 5.41NS&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>26.93 ± 5.09NS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30.36 ± 3.10NS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>35.60 ± 3.41NS&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>46.44 ± 5.73NS&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>8,000</td>
<td>31.13 ± 5.46NS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30.77 ± 2.86NS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>32.88 ± 3.32NS&lt;sup&gt;b&lt;/sup&gt;</td>
<td>45.65 ± 5.66NS&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*Mean ± SE from 30 panelists based on PM method.  
A–C different letters within each column indicated significant differences between viscosity levels ($P < 0.05$).  
a–c different letters within each row indicated significant differences between yellow index levels ($P < 0.05$).  
NS within each column indicated no significant differences ($P > 0.05$).
Figure 5.5. Sweetness intensity (JAR) from four syrups (L=viscosity 80 cP, H=8,000 cP, C1=YI 0.04, C2=YI 0.32) obtained by visual (V) and taste (T) perception for single pump syrup consumers (SP).

As shown in Table 5.7, significant differences in distribution scores across the syrups were observed for the visual expectation of sweetness perception. The McNemar’s–Test revealed that syrups LC1 and HC2 had a significantly different in visual expected of sweetness intensity ($\chi^2 = 6.67$). This suggests that HC2 was expected to be sweeter than LC1. Furthermore, it should be taken into account that for the syrup HC1 consumers hesitantly rated the intensity between “JAR” and “not sweet enough.” This may be the result of a lower expected sweetness intensity from the softer color than the intense color. Moreover, the impact of visual expected sweetness perception conveyed a signal of perceived sweetness intensity of syrup consumption during coffee testing.

In Table 5.8, consumers pumped the volume of each syrup significantly different ($P < 0.05$). The highest volume was recorded for LC1 (12.27 mL) whereas the volume of HC1 was not significantly different from LC2 (9.15 mL) and HC2 (7.74 mL) ($P > 0.05$). Consumers added a higher volume of the less intense color sample (LC1/HC1) when compared to the corresponding
more intense color sample (LC2/HC2). However, the effect of YI showed a non–significant influence on the pump volume of the high viscosity syrup \((P > 0.05)\).

Table 5.7. Pairwise comparison of visual expected sweetness perception of syrups using CMH and McNemar’s–Test analysis.

<table>
<thead>
<tr>
<th>Sample(^a)</th>
<th>Single pump consumer (SP)</th>
<th>Double pump consumer (DP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LC1</td>
<td>LC2</td>
</tr>
<tr>
<td>LC1</td>
<td>–</td>
<td>0.021*</td>
</tr>
<tr>
<td></td>
<td>(4.27)</td>
<td>(6.67)</td>
</tr>
<tr>
<td>LC2</td>
<td>–</td>
<td>0.079</td>
</tr>
<tr>
<td>HC1</td>
<td>–</td>
<td>0.024*</td>
</tr>
<tr>
<td></td>
<td>(3.337)</td>
<td>(9.39)</td>
</tr>
<tr>
<td>HC2</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

\(^a\) indicated syrup samples (L=viscosity 80 cP, H=8,000 cP, C1=YI 0.04, C2=YI 0.32).

\(^*\) indicated significant pairwise differences obtained by CMH analysis, the value ( ) represented as \(\chi^2\) value based on McNemar’s–Test. Critical \(\chi^2\) value=5.99 (df=2, \(\alpha=0.05\)). Data were obtained from a 3–points JAR scale (1= not enough, 2=just–about–right, 3=too much).

In terms of the taste evaluation, there were no significant differences in the distribution scores of sweet taste intensity across products \((P=0.1548)\). In order to explain how consumer perceived the sweet taste intensity, the analysis of distribution frequency ranges was employed. Considering T1 (Figure 5.5), SP consumers were satisfied with the coffee’s sweetness due to the extensive distribution of consumer in the ranges of “JAR” (55.3–78%). The interesting points were the switching of “non–JAR” distributions from visual testing to “JAR” distribution of taste testing. The coffee containing more intense YI (LC2/HC2) showed a change from “too sweet” to “JAR” while a change of “not sweet enough” to “JAR” was observed with coffee containing less intense YI. Therefore, the additional syrup after the 1\(^{st}\) pump may be unnecessary for these SP consumers.
Table 5.8. Mean volume (mL) of syrups added into coffee, consumer expectation and liking score of sweetness of coffee brewed with different syrups (single pump syrup).

<table>
<thead>
<tr>
<th>Factors</th>
<th>LC1^A</th>
<th>LC2^A</th>
<th>HC1^A</th>
<th>HC2^A</th>
</tr>
</thead>
<tbody>
<tr>
<td>(n=47)</td>
<td>(n=41)</td>
<td>(n=40)</td>
<td>(n=39)</td>
<td></td>
</tr>
<tr>
<td>Volume (mL)</td>
<td>12.27 ± 0.81a</td>
<td>9.15 ± 0.86b</td>
<td>8.90 ± 0.87b</td>
<td>7.74 ± 0.89b</td>
</tr>
<tr>
<td>Expectation</td>
<td>4.81 ± 0.23a</td>
<td>4.17 ± 0.25ab</td>
<td>4.05 ± 0.25b</td>
<td>4.23 ± 0.25ab</td>
</tr>
<tr>
<td>Liking *</td>
<td>5.98 ± 0.26</td>
<td>6.02 ± 0.28</td>
<td>5.04 ± 0.21</td>
<td>5.08 ± 0.21</td>
</tr>
</tbody>
</table>

The numbers listed within the table indicated mean ± SE from consumers. ^A indicated syrup samples (L=viscosity 80 cP, H=8,000 cP, C1=YI 0.04, C2=YI 0.32). a–b different letters within each row indicated significant differences (P < 0.05). * indicated no significant differences between syrups.

The key finding of this study was highlighted by the consumer behavior response toward visual stimuli, which created an expected sweetness perception and subsequently reduced caloric–intake of syrup consumption. The analysis of JAR distribution frequency ranges and McNemar’s–Test of visual expectation revealed an increase in expected sweetness intensity across the impact of color and viscosity. By visual evaluation, the intense color and thicker syrups were expected to be sweeter than the less intense and thinner syrups. Therefore, the visual information induced by perception was carried over into consumers’ decision–making process when adding syrup to coffee. They pumped the expected sweeter syrup in lower amounts than the expected less sweet syrup (Table 5.8). The possible explanation for this finding would be a psychological consequence of perceived color and viscosity information prior to actual eating that may bias consumers’ minds about the sweetness. Subsequently, this visual information altered eating behavior. According to Sukkwai and others (2017) increasing colorant concentration tentatively increased saltiness expectation of dipping sauce as indicated by the higher percentage of ‘too much’ responses for saltiness on a JAR scale. Another study done by Genschow and others (2012) demonstrated that color provides signals affecting consumer perception. They suggested that red color cues may reduce the amount of soft drink intake. Participants drank less from a cup with a red sticker.
compared to a cup with a blue sticker. The color may act as a subtle stop cue and thereby influence consumption behavior. This finding suggests that the informative visual expectation efficiently impacted consumption behaviors, particularly with respect to the impact of color that conveyed past experiences to the brain about what taste was to be expected (Stummerer and Hablesreiter 2010).

For double pump consumers (DP), the results confirmed the above finding that the visual color and viscosity enhanced the expected sweetness perception, but they rather expressed a robust eating behavior for adjusting the sweetness of coffee than SP consumers. From Figure 5.6, the effect of color cue influenced the visual expected sweetness perception greater than the effect of viscosity observed by a comparison of distribution frequency from LC1/LC2 and HC1/HC2. For instance, increasing YI from less intense color to intense color (LC1 vs. LC2 and HC1 vs. HC2) resulted in the switching of distribution frequency ranges from “too weak” to “too sweet” (61.3% vs. 54.1%, 44.7% vs. 59.0%). On the other hand, increasing the viscosity from a low level to a high level (LC1 vs. HC1, LC2 vs. HC2) induced a change in distribution frequency scores of both “JAR” (22.6% vs. 42.1% and 27.0 % vs. 33.3%) and “not sweet enough” (61.3% vs. 44.7% and 18.9% vs. 7.7%) at the same time. As expected, LC1 had the highest percentage of distribution frequency ranges of “not sweet enough” while the HC2 was visually rated as “too sweet.”

From the C (Table 5.7), the McNemar’s–Test indicated that four out of six pairs had a significantly different in visual expected of sweetness; LC1 vs. LC2, LC1 vs. HC2, LC2 vs. HC1, and HC1 vs. HC2 ($\chi^2 = 7.56, 14.45, 6.05$ and $9.39$, respectively). This indicates that the visual expected sweetness perception of LC1 and HC1 was not as high as LC2 and HC2. However, there were no significant differences in expected sweetness perception of LC1 vs. HC1 and LC2 vs.
HC2 ($P > 0.05$). Consequently, the color (YI) and viscosity have a significant contribution to intensify visual expected sweetness perception for the DP consumers.

![Sweetness intensity (JAR) from four syrups](image)

Figure 5.6. Sweet intensity (JAR) from four syrups (L=viscosity 80 cP, H=8,000 cP, C1=YI 0.04, C2=YI 0.32) obtained by visual (V) and taste (T1=1st pump, T2=2nd pump) perception for double pump syrup consumers (DP).

Once again, a robust relationship between visual expectation of sweetness perception and syrup volume (1st & 2nd) was illustrated (Table 5.9). Undoubtedly, for the 1st pump, the LC1 showed the highest pump volume (11.50 mL) while the lowest volume belonged to HC2 (7.31 mL). The volume of LC2 showed a parity amount to both LC1 and HC1 ($P > 0.05$). For the 2nd pump, the volume of all syrups was noted as higher than the 1st pump. The LC1 had the highest amount (15.02 mL) followed by LC2 (12.05 mL), HC1 (11.03 mL) and HC2 (10.86 mL), respectively.

Visual cues can be a reliable indicator of the actual quality of food. When there is a lack of congruence between the expectation and actual sensory quality of food, this may lead to perceptual confusion and therefore alter the sensory experience itself (Yeomans and others 2008; Anderson 1973; Cardello 2007; Piqueras–Fiszman and Spence 2015).
Table 5.9. Mean volume (mL) of syrups added into coffee, consumer expectation and liking score of sweetness of coffee brewed with different syrups (double pump syrup).

<table>
<thead>
<tr>
<th>Factors</th>
<th>LC1&lt;sup&gt;A&lt;/sup&gt; (m=31)</th>
<th>LC2&lt;sup&gt;A&lt;/sup&gt; (m=37)</th>
<th>HC1&lt;sup&gt;A&lt;/sup&gt; (m=38)</th>
<th>HC2&lt;sup&gt;A&lt;/sup&gt; (m=39)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; pump</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; volume (mL)</td>
<td>11.50 ± 1.09a</td>
<td>9.60 ± 1.00ab</td>
<td>9.71 ± 0.99ab</td>
</tr>
<tr>
<td>expectation scores</td>
<td>3.29 ± 0.27ab</td>
<td>3.68 ± 0.25a</td>
<td>3.32 ± 0.24ab</td>
<td>2.97 ± 0.24b</td>
</tr>
<tr>
<td>liking scores*</td>
<td>4.29 ± 0.28</td>
<td>4.57 ± 0.26</td>
<td>4.29 ± 0.26</td>
<td>4.26 ± 0.25</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; pump</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; volume (mL)</td>
<td>15.02 ± 1.24a</td>
<td>12.05 ± 1.13ab</td>
<td>11.03 ± 1.12b</td>
</tr>
<tr>
<td>expectation scores*</td>
<td>4.58 ± 0.25</td>
<td>4.60 ± 0.23</td>
<td>4.37 ± 0.22</td>
<td>4.46 ± 0.22</td>
</tr>
<tr>
<td>liking scores</td>
<td>5.61 ± 0.28ab</td>
<td>6.11 ± 0.28a</td>
<td>5.42 ± 0.27ab</td>
<td>5.28 ± 0.27b</td>
</tr>
<tr>
<td>Total syrup (mL)</td>
<td>26.52 ± 1.95a</td>
<td>21.65 ± 1.79ab</td>
<td>20.74 ± 1.76b</td>
<td>18.17 ± 1.74b</td>
</tr>
<tr>
<td>Sugar content&lt;sup&gt;B&lt;/sup&gt; (g)</td>
<td>5.30</td>
<td>4.33</td>
<td>4.15</td>
<td>3.63</td>
</tr>
<tr>
<td>Calories from sugar&lt;sup&gt;C&lt;/sup&gt; (kCal)</td>
<td>21.20</td>
<td>17.32</td>
<td>16.60</td>
<td>14.52</td>
</tr>
<tr>
<td>Calories reduction&lt;sup&gt;C&lt;/sup&gt; (kcal, %)</td>
<td>0 (0%)</td>
<td>3.88 (18.30%)</td>
<td>4.60 (21.69%)</td>
<td>6.68 (31.50%)</td>
</tr>
</tbody>
</table>

<sup>A</sup> indicated syrup samples (L=viscosity 80 cP, H=8,000 cP, C1=YI 0.04, C2=YI 0.32).

<sup>a–b</sup> different letters within each row indicate significant differences ($P < 0.05$).

<sup>B</sup> syrup consisted of 20 g sugar per 100 ml.

<sup>C</sup> 1 g of sugar contributed 4 kCal in foods.

* indicated no significant differences between syrups.
For this study, when the disparity between the expectation and actual experience was relatively small or was not noticed (see syrup LC1), the assimilation was likely to occur. Coffee with added syrup HC2, in turn, would be expected to induce too large of a discrepancy, and so the contrast may be observed instead.

With respect to DP consumers, there were no significant differences in distribution score of sweetness intensity across products \((P=0.6890\) of T1, and \(P=0.1614\) of T2). Consumers expressed their sweetness perception of coffee (T1) with a high distribution frequency range of “not sweet enough” with more than 85% (Figure 5.6). Also, the coffee’s sweetness intensity was below the expected level \((P < 0.05)\), particularly with regard to the HC2 (high viscosity and intense YI) that caused a disconfirmation of sweetness intensity. This finding suggests that the high viscosity and intense YI color visually made consumers perceive the syrup as sweeter. For T2, the distribution frequency’s ranges of each coffee demonstrated as “JAR” with more than 70%, except for HC1 and HC2, showing that consumers still needed more sweetness (up to 44%). As a result, consumers felt that the coffee failed to meet the expected sweetness after adding additional syrup.

Consumer acceptability scores of sweetness intensity were not significantly different with scores of 5.04 to 6.02 \((P > 0.05)\) due to an identical sugar content in each syrup (20% w/v) for SP consumers (Table 5.8). It is possible that consumers who have experienced a larger discrepancy would be unsatisfied with their coffee sweetness. When the expectation from such visual information was or was not confirmed by the first pump \(1^{st}\), the perceptions of product performance were different from preconceived expectations. When this happens, there is a disconfirmation of expectation (Deliza and others 1996). Otherwise, it is possible that the visual perception alone could not account for that effect and probably lead to smaller changes in personal perception. As proved by Wardy and others (2017), the color of the packet of sweetener has great
influence on emotional associations with sweet taste that could potentially modify an individual’s preference for sweet taste in products containing sucrose alternatives, and result in a decrease in overall calories consumed.

Jimenez and others (2015) also proposed that consumers’ visual assessments may rely on imagining and anticipating the taste and liking of the product based on prior relatable experiences. A related study on color affecting taste perception demonstrated that the color of the mug may have influenced the perceived brownness of the coffee and may also have influenced the perceived intensity (and sweetness) of the coffee (Doorn and others 2017). Furthermore, color–taste associations with frequently consumed foods have the effect of raising the individual’s basic taste threshold (Johnson and others 1982), which may, in part, explain the reason that led consumers to add additional syrup (2nd pump).

Regardless of the visual and taste perceptions, the liking scores and sweetness intensity of coffee sweetness was not affected by the viscosity and color of the syrups. This could be explained by the fact that all the syrups were prepared with the same sweetness. Therefore, consumers rated the liking score of sweetness within a similar range. Another possible explanation could be that there was incongruence between the consumer is perceived information about sweetness and visual cues that may have led to specific expectation, but then the consumer perceives other information after tasting. Therefore, the unmet expectation can reduce the liking score of the food as observed by disliking scores (Zellner and others 2014). This finding shows that the deviation of visual cue intensity shifted consumer expectation of taste perception, but it did not affect the sensory acceptability of products. A supporting study demonstrated by Sukkwai and others (2018) showed that the changes in color from off–white to light orange did not make the color unacceptable based on the color liking score, but rather influenced the expectation of salty taste. Furthermore,
Verastegui–Tena and others (2017) proposed that the hedonic evaluation of food would not be affected if the food presented to consumers matched their expectations even if a disparity between the expected experience with the product and the actual one likely occurred. The effect of color on drink intake did not mediate an increased liking for the drink. The color rather acted as a direct signal on behavior either with or without affecting perceived taste.

### 5.7.3. Calories reduction

As shown in Table 5.9, the total volume of syrup containing low viscosity and less intense YI (LC1) was significantly higher than that of high viscosity and intense YI (HC2) ($P < 0.05$). Using the visual cues of color and viscosity would reduce the consumption of syrup by 4.87–8.35 mL. This accounted for a reduction of calories between 18%–31% compared to a regular syrup. This finding could be applied to reduce sugar consumption of syrup–sweetened drinks through the use of visual cues; viscosity and intense color.

### 5.8. Conclusions

One particularly exciting finding that emerged from this study was that visual cues exerted a significant effect on changing the consumers’ expected sweetness and saltiness intensity and hence on their subsequent eating behaviors. This current study found that one color cue (brown color), but with different hue and saturation, induced different taste perceptions (e.g., the brown color induced saltiness intensity of chicken broths, and also helped strengthen the sweet taste perceptions of syrups). This research offers an approach to potentially modify consumer behavior towards reducing the consumption of salt and sugar in food products. For future research, the hurdle study in taste enhancement is required in parallel to the use of visual cues for addressing a taste issue.
5.9. References


ten–free bakery and pasta products: prevalence and quality improvement, Int J Food
Sci Technol. 53:19–32.

Genschow O, Reutner L, Wänke M. 2012. The color red reduces snack food and soft drink

salt intake and reproductive outcome in the rat: effect on growth, fertility, sex ratio, and

Holm K, Wendin K, Hermansson AM. 2009. Sweetness and texture perception in mixed pectin

Huynh HL, Danhi R, Yan SW. 2016. Using Fish Sauce as a Substitute for Sodium Chloride in

is not eating it: Hedonic context effects differ for visually presented and actually eaten

Johnson J, Clydesdale FM. 1982. Perceived Sweetness and Redness in Colored Sucrose

Johnson RJ, Segal MS, Sautin Y, Nakagawa T, Feig DI, Kang DH, et al. 2007. Potential role of
sugar (fructose) in the epidemic of hypertension, obesity and the metabolic syndrome,


Lavin JG, Lawless HT. 1998. Effects of color and odor on judgments of Sweetness among

Malone ME, Appelqvist AM, Norton IT. 2003. Oral behaviour of food hydrocolloids and

Meilgaard, M., G. V. Civile, and B. T. Carr. 2007. Sensory evaluation techniques. 4th ed. CRC
Press, Boca Raton, FL.

National Diet and Nutrition Survey (NDNS). (2014). Results from years 1 to 4 (combined)of the

121


Tu Y, Yang ZHI, Ma C. 2016. How the spiciness of food is affected by the color of the place used to serve it? *J. Senso Stu.* 31:50–60.


CHAPTER 6. SUMMARY AND CONCLUSIONS

The first study demonstrated that the visual perception of intrinsic and extrinsic sensory cues may impact consumers’ eating experiences. Both cues can be used as powerful communication tools that contributed psychological signals influencing consumer acceptance, emotion, purchase decision–making process, and likely change subsequent consumer behavior. Consumers connect their current eating behavior with their memories which could possibly trigger consumer positive and negative perceptions. The liking and emotion responses were more sensitive to the changes in color intensity than product package and size for the salads. The darker green color was well liked by consumers and was positively associated with health and wellness emotion. The pale green color, by contrast, was less liked and associated with negative emotion. A product may be less preferred if the first impression of its appearance failed to deliver consumers’ expectations; however, giving a product name was one possible way to improve impression. However, a focus on various consumption stages concerning these visual cues along with the different dieting tendency of dieters versus non–dieters should be studied further.

In the second study, the bitterness and saltiness of mixed salt solutions were successfully discriminated by both RIX and PPM. The RIX delivered a better distinctive discrimination via pairwise comparisons while the PPM sorted the differences of salt solutions into distinctive groups. The graphical mapping presented by PPM could be beneficial for future product development ideas. The RIX approach takes advantage of distribution–free, is more robust, and is unaffected by the decision criteria from data rating. The method, however, may take a longer time to perform than the PPM. The PPM, on the other hand, has less measurement specificity related to sensory differences but the sorting could be accomplished within a shorter time. Using NaCl combined with L–Arg synergistically could mask the bitterness of KCl, and this would be a benefit for food
industries for simply minimizing sodium content in products at a proper substitution level, without an adverse effect from bitterness.

For the third study, one color cue (brown color), but different hue and saturation, may induce different taste perceptions (e.g., the brown color induced saltiness intensity of chicken broths, but also strengthened the sweet taste perceptions of syrups). The visual perception of color cue significantly created consumer expected saltiness and sweetness intensity, and subsequently, impacted eating behaviors, i.e., reducing the amount of added syrup when drinking coffee or switching consumer purchase decision–making of chicken soup when its color is brown.

This dissertation research showed various effects of visual cues on consumer perceptions. Although the visual cues can help enhance taste expectation of saltiness and sweetness before the eating process, these taste perceptions failed to meet consumer expectation after the eating process. More research is needed to investigate multisensory interactions that will help food industries create healthier food products without compromising sensory quality.
APPENDIX A. QUESTIONNAIRE FOR CHAPTER 3

a. Online Survey from www.lsu.qualtrics.com

Access Link: https://lsu.ca1.qualtrics.com/ControlPanel/?ClientAction=EditSurvey&Section=SV_6mm3NPfuE9kb0ax&SubSection=&SubSubSection=&PageActionOptions=&TransactionID=1&Repeateable=0

Please express how ready-to-eat salad product affects your emotion. You can check all terms that apply from the list below.

- Accomplished
- Aggressive
- Confident
- Desired
- Eager
- Feel different
- Free
- Good-natured
- Joyful
- Mild
- Pleased
- Safe
- Tender
- Warm
- Active
- Bored
- Curious
- Disappointed
- Energetic
- Feel healthy
- Friendly
- Guilty
- Loving
- Nostalgic
- Polite
- Satisfied
- Trust
- Whole
- Adventurous
- Calm
- Dangerous
- Discouraged
- Enthusiastic
- Feel special
- Glad
- Happy
- Mad
- Peaceful
- Quiet
- Steady
- Understanding
- Wild
- Affectionate
- Comfortable
- Darling
- Disgusted
- Excited
- Feel wellness
- Good
- Interested
- Merry
- Pleasant
- Refreshing
- Tame
- Unique
- Worried
Research Consent Form

Thank you for your interest in this survey. Please read the below consent form before proceeding to the survey. This is a consent form for research participation in the research entitled “Effect of Ready-to-Eat Salad Product on Consumer Emotions using Visual Observation” which is being conducted by Pitchayapat Chonpracha, a PhD Student of the School of Nutrition and Food Sciences at Louisiana State University Agricultural Center, (225) 578–5188.

I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated on my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participation returned to me, removed from the experimental records, or destroyed. Three hundred and twenty consumers will participate in this research. For this particular research, about 15 minutes participation will be required for each consumer.

Participant's Statement

“I have read and understand the information provided about this study above (consent document). I volunteer to take part in this research. I know I can ask questions at any time by contacting the research staff via email uchonp1@tigers.lsu.edu. I understand that I can change my mind and withdraw my consent to participate by closing the website or contacting the research staff by email without penalty.”
If you agree to participate to this consumer test, please give your signature next page

Question # A

If you agree to participate in the test, please type your name

___________________________________________________________________________
___________________________________________________________________________
___________________________________________________________________________

Question # B

Please answer questions below.

• Gender:  [ ] Male  [ ] Female

• Age (years):  [ ] 18–30  [ ] 31–40  [ ] 41–50  [ ] 51–60  [ ] over 60

• Race:  [ ] African American  [ ] Caucasian  [ ] Asian  [ ] Latino  [ ] Others

• How often do you consume ready-to-eat vegetable salad?
  [ ] Daily
  [ ] 2–3 Times a Week
  [ ] Once a Week
  [ ] Once a Month or less
  [ ] Never

• Please select the main vegetable in salad you consume most often (Select only one)
  [ ] Chard  [ ] Red cabbage
  [ ] Green cabbage  [ ] Romaine lettuce
  [ ] Iceberg lettuce  [ ] Spinach
  [ ] Kale  [ ] Spring mix (tender baby lettuces and greens)
Please look at the picture of ready-to-eat salad and answer the question

Question # 1–Sample <<Sample1>>

How do you like the green color of salad?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Much</th>
<th>Like Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question # 2–Sample <<Sample1>>

How would the green color of make you feel? Please check in each box

Active

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bored

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Desired

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Disgusted

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Energetic

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Engaging wellness lifestyle

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Good

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Guilty

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Happy

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Healthy

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Interested

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Refreshing

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Safe

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Satisfied

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

### Special

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
**Question # 3**

How do you like the size of the cut pieces?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
</table>

**Question # 4**

How would the size of the cut pieces make you feel? Please check in each box

- **Active**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Bored**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Desired**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Disgusted**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Energetic**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Engaging wellness lifestyle**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Good**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Guilty**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
- **Happy**
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
Healthy

Not at all  Slightly  Moderately  Very much  Extremely

Interested

Not at all  Slightly  Moderately  Very much  Extremely

Refreshing

Not at all  Slightly  Moderately  Very much  Extremely

Safe

Not at all  Slightly  Moderately  Very much  Extremely

Satisfied

Not at all  Slightly  Moderately  Very much  Extremely

Special

Not at all  Slightly  Moderately  Very much  Extremely

Worried

Not at all  Slightly  Moderately  Very much  Extremely

Question # 5–Sample <<Sample1>>

How likely will you purchase the actual if sold in the store you normally shop?

Yes  No

Please wait for your next Sample
Please look at the picture of ready-to-eat **ICEBERG LETTUCE** and answer the question

**Question # 1–Sample <<Sample1>>**

How do you like the green color of iceberg lettuce?

- Dislike Extremely
- Dislike Very Much
- Dislike Moderately
- Dislike Slightly
- Neither Like Nor Dislike
- Like Slightly
- Like Moderately
- Like Very Much
- Like Extremely

**Question # 2–Sample <<Sample1>>**

How would the green color of iceberg lettuce make you feel? Please check in each box

- Active
  - Not at all
  - Slightly
  - Moderately
  - Very much
  - Extremely
<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bored</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desired</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disgusted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energetic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engaging wellness lifestyle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guilty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refreshing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Question # 3**

How do you like the size of iceberg lettuce the cut pieces?

<table>
<thead>
<tr>
<th>Dislike</th>
<th>Dislike Very Much</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Much</th>
<th>Like Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely</td>
<td>Very much</td>
<td>Moderately</td>
<td>Slightly</td>
<td>Not at all</td>
<td>Slightly</td>
<td>No at all</td>
<td>Not at all</td>
</tr>
</tbody>
</table>

**Question # 4**

How would the size of iceberg lettuce make you feel? Please check in each box

**Active**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Bored**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Desired**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Disgusted**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Energetic**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Engaging wellness lifestyle**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Good**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Guilty**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>
Happy

Not at all  Slightly  Moderately  Very much  Extremely

Healthy

Not at all  Slightly  Moderately  Very much  Extremely

Interested

Not at all  Slightly  Moderately  Very much  Extremely

Refreshing

Not at all  Slightly  Moderately  Very much  Extremely

Safe

Not at all  Slightly  Moderately  Very much  Extremely

Satisfied

Not at all  Slightly  Moderately  Very much  Extremely

Special

Not at all  Slightly  Moderately  Very much  Extremely

Worried

Not at all  Slightly  Moderately  Very much  Extremely

**Question # 5**

How likely will you purchase this iceberg lettuce if sold in the store you normally shop?

Yes  No

*Please wait for your next Sample*
Please look at the picture of ready-to-eat salad and answer the question

**Question # 1**–**Sample <<Sample1>>**

How do you like the overall appearance of this salad?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
</table>

**Question # 2**–**Sample <<Sample1>>**

How do you like the green color of this salad?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
</table>

**Question # 3**–**Sample <<Sample1>>**

How would the salad make you feel? Please check in each box.
<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bored</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desired</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disgusted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energetic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engaging wellness lifestyle</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guilty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refreshing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question # 4

How likely will you purchase this salad if sold in the store you normally shop?

Yes  
No  

Please look at the picture of ready-to-eat salad and answer the question

![Salad Inside]

Question # 1–Sample <<Sample1>>

How do you like the overall appearance of this salad?

Dislike Extremely  Dislike Very Much  Dislike Moderately  Dislike Slightly  Neither Like Nor Dislike  Like Slightly  Like Moderately  Like Much  Like Very Much  Like Extremely

Question # 2–Sample <<Sample1>>

How do you like the green color of this salad?
<table>
<thead>
<tr>
<th></th>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question # 3–Sample &lt;&lt;Sample1&gt;&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How would the salad make you feel? Please check in each box</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bored</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desired</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disgusted</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energetic</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engaging wellness lifestyle</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guilty</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Happy</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interested</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
<td>Extremely</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Refreshing

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Safe

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Satisfied

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Special

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Worried

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Question # 4**

How likely will you purchase this salad if sold in the store you normally shop?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

Please wait for your next Sample

Please look at the picture of ready-to-eat salad and answer the question
Question # 1–Sample <<Sample1>>

How do you like the overall appearance of this salad?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
</table>

Question # 2–Sample <<Sample1>>

How do you like the green color of this salad?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
</table>

Question # 3–Sample <<Sample1>>

How would the salad make you feel? Please check in each box

Active

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Bored

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Desired

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Disgusted

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Energetic

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Engaging wellness lifestyle

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Good

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

Guilty

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>----------</td>
<td>------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Happy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interested</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refreshing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worried</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question # 4**

How likely will you purchase this salad if sold in the store you normally shop?

Yes [ ] No [ ]

Please wait for your next Sample
Please look at the picture of ready-to-eat salad and answer the question

Salad Inside

**Question #1** – Sample <<Sample1>>

How do you like the overall appearance of this salad?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
</table>

**Question #2** – Sample <<Sample1>>

How do you like the green color of this salad?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
</table>

**Question #3** – Sample <<Sample1>>

How would the salad make you feel? Please check in each box

**Active**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
</table>

**Bored**

<table>
<thead>
<tr>
<th>Not at all</th>
<th>Slightly</th>
<th>Moderately</th>
<th>Very much</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desired</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>---------</td>
<td>------------</td>
<td>----------</td>
<td>------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Disgusted</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Energetic</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Engaging wellness lifestyle</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Good</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Guilty</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Happy</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Healthy</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Interested</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Refreshing</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Safe</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Satisfied</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
<tr>
<td>Special</td>
<td>Not at all</td>
<td>Slightly</td>
<td>Moderately</td>
<td>Very much</td>
</tr>
</tbody>
</table>
Question # 4

How likely will you purchase this salad if sold in the store you normally shop?

Yes  No
APPENDIX B. QUESTIONNAIRE FOR CHAPTER 4

a. Questionnaire for RIX Evaluation

Name: ____________________________________________ Date: ______________

Note: 1) You will be presented with the 5 labeled samples in random order.
       2) Please taste the samples in the order presented, from left to right.
       3) Rank the samples for intensity. No ties allowed!

I: Saltiness Evaluation

   – Rank the solutions in a descending order of saltiness

     _________ > _________ > _________ > _________ > _________

     Saltiest (1)   Least salty (5)

II: Bitterness Evaluation

   – Rank the solutions in a descending order of bitterness

     _________ > _________ > _________ > _________ > _________

     Most bitter (1)   Least bitter (5)
b. Questionnaire for PPM Evaluation

**Direction:** Here are 15 samples of salt solutions. **Taste them all**, then place samples with similar salty and/or bitter taste intensities closer and vice versa.”
a. Compusense® ballot – Consumer's perception of chicken soup

Welcome to the LSU Sensory Lab

Press the 'Continue' button below to begin the test.

Research Consent Form

I, _________________________, agree to participate in the research entitled “Consumer's Perception of Chicken Soup” which is being conducted by Prof. Dr. Witon Prinayawiwatkul, School of Nutrition and Food Sciences at Louisiana State University Agricultural Center, (225) 578–5188. I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated at my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participants returned to me, removed from the experimental records, or destroyed. One hundred and twenty consumers will participate in this research. The following points have been explained to me:
1. In any case, it is my responsibility to report prior to participation to the investigator any food allergies I may have.
2. The reason for the research is to gather information on human perception of chicken soup. The benefit that I may expect is the satisfaction that I have contributed to a solution and evaluation of problems relating to such examinations.
3. The procedures are as follows: four sample codes will be placed in front of me, and I will evaluate them by normal standard methods and indicate my evaluation on score sheets. All procedures are standard methods as published by the American Society for Testing and Materials and the Sensory Evaluation Division of the Institute of Food Technologists.
4. Participation entails minimal risk: “Chicken (white meat), salt, onion, carrot, and cilantro.” However, because it is known to me beforehand that the above–mentioned foods and ingredients are to be tested, the situation can normally be avoided.
5. The results of this study will not be released in any individually identifiable form without my prior consent unless required by law.
6. The investigator will answer any further questions about the research, either now or during the course of the project. The study has been discussed with me, and all of my questions have been
I understand that additional questions have been answered. The study has been discussed with me, and all of my questions have been answered. I understand that additional questions regarding the study should be directed to the investigator listed above. In addition, I understand the research at Louisiana State University AgCenter that involves human participation is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Michael Keenan of LSU AgCenter at 578–1708. I agree with the terms above.

**Question # A.**

If you agree to participate in the test, please type your name

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

**Question # 1–Sample <<Sample1>>**

**Please LOOK AT the sample <<Sample1>>, do not taste the soup**

How do you like the color of the chicken soup?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Much</th>
<th>Like Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please rate your expected saltiness intensity based on the color of this soup

<table>
<thead>
<tr>
<th>Not Salty Enough</th>
<th>Slightly Not Salty Enough</th>
<th>Just About Right</th>
<th>Slightly Too Salty</th>
<th>Too Salty</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please rate your expected bitterness intensity based on the color of this soup

<table>
<thead>
<tr>
<th>Not Bitter Enough</th>
<th>Slightly Not Bitter Enough</th>
<th>Just About Right</th>
<th>Slightly Too Bitter</th>
<th>Too Bitter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How likely will you purchase this soup based on the color?

<table>
<thead>
<tr>
<th>Yes</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Question #2–Sample "Sample 1"

Please TASTE the sample "Sample 1"

How did the saltiness of the soup meet your expectations?

Please rate the saltiness intensity of the soup

How do you like the taste of the chicken soup?

Question #3–Sample "Sample 1"

How did the bitterness of the soup meet your expectations?

Please rate the bitterness intensity of the soup

How do you like the taste of the chicken soup?

How likely will you purchase this soup based on the taste?
Welcome to the LSU Sensory Lab

Press the 'Continue' button below to begin the test.

Research Consent Form

I, _________________________, agree to participate in the research entitled “Sweetness Perception of Coffee Added with Syrup” which is being conducted by Prof. Dr. Witoon Prinyawiwatkul, School of Nutrition and Food Sciences at Louisiana State University Agricultural Center, (225) 578–5188. I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated at my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participants returned to me, removed from the experimental records, or destroyed. One hundred and twenty consumers will participate in this research. The following points have been explained to me:

1. In any case, it is my responsibility to report prior to participation to the investigator any food allergies I may have.

2. The reason for the research is to gather information on the effect of adding syrup to human perception of hot coffee. The benefit that I may expect is the satisfaction that I have contributed to a solution and evaluation of problems relating to such examinations.

3. The procedures are as follows: four sample codes will be placed in front of me, and I will evaluate them by normal standard methods and indicate my evaluation on score sheets. All procedures are standard methods as published by the American Society for Testing and Materials and the Sensory Evaluation Division of the Institute of Food Technologists.

4. Participation entails minimal risk: **Coffee Powder, Syrup (sugar, cellulose), Creamer (Corn Syrup Solids, Hydrogenated Vegetable Oil (Coconut and/or Palm Kernel and/or Soybean),**
Sodium Caseinate (a Milk Derivative), Less than 2% of Dipotassium Phosphate, Mono- and Diglycerides, Sodium Aluminosilicate, Artificial Flavor, Annatto Color. **Not a source of lactose**. However, because it is known to me beforehand that the above–mentioned foods and ingredients are to be tested, the situation can normally be avoided.

5. The results of this study will not be released in any individually identifiable form without my prior consent unless required by law.

6. The investigator will answer any further questions about the research, either now or during the course of the project. The study has been discussed with me, and all of my questions have been answered. I understand that additional questions. The study has been discussed with me, and all of my questions have been answered. I understand that additional questions regarding the study should be directed to the investigator listed above. In addition, I understand the research at Louisiana State University AgCenter that involves human participation is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Michael Keenan of LSU AgCenter at 578–1708. I agree with the terms above.

**Question # A.**

If you agree to participate in the test, please type your name

___________________________________________________________________________
___________________________________________________________________________
____________________
_____________________________________________________

There are 4 cups of hot coffee that you are going to taste.
Only one sample will be served at a time.

Please lift the hatch to request next sample.
Question # 1–Sample ______ Please look at the syrup %01

Please rate your expected sweetness intensity based on the color and viscosity of this syrup.

<table>
<thead>
<tr>
<th>Not Sweet Enough</th>
<th>Just About Right</th>
<th>Too Sweet</th>
</tr>
</thead>
</table>

Question # 2–Sample ______

Please add one packet of creamer to your coffee & pump the amount of syrup %01 would you use to sweeten your coffee into a measuring cup at the level that satisfied your sweetness.

Please record the amount of syrup you have pumped (CC/ML).

Amount of syrup ______________

Question # 3–Sample ______

Pour the syrup into your coffee, make sure to pour all syrup from the measuring cup.

How did the coffee sweetness meet your expectations?

<table>
<thead>
<tr>
<th>Extremely less sweet than expected</th>
<th>Very much less sweet than expected</th>
<th>Moderately less sweet than expected</th>
<th>Slightly less sweet than expected</th>
<th>Same as expected</th>
<th>Slightly sweet than expected</th>
<th>Moderately sweet than expected</th>
<th>Very much sweet than expected</th>
<th>Extremely sweet than expected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please rate the sweetness intensity of your coffee.

<table>
<thead>
<tr>
<th>Not Sweet Enough</th>
<th>Just About Right</th>
<th>Too Sweet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How do you like the sweetness of the coffee?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like</th>
<th>Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Much</th>
<th>Like Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question # 4–Sample ______

Do you want to add additional syrup to the coffee?

☐ Yes ☐ No

* if yes was selected, consumer will be brought to next question, if no was selected, consumer will be brought to the next samples
Question # 5– Sample ______

Please pump the amount of ADDITIONAL SYRUP %01 you would use to sweeten your coffee into a new measuring cup at the level that satisfied your sweetness.

Please record the amount of syrup you have pumped (CC/ML).

Amount of syrup __________

Pour the syrup into your coffee, make sure to pour all syrup from the measuring cup.

How did the coffee sweetness meet your expectations?

<table>
<thead>
<tr>
<th>Extremely less sweet than expected</th>
<th>Very much less sweet than expected</th>
<th>Moderately less sweet than expected</th>
<th>Slightly less sweet than expected</th>
<th>Same as expected</th>
<th>Slightly sweet than expected</th>
<th>Moderately sweet than expected</th>
<th>Very much sweet than expected</th>
<th>Extremely sweet than expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Please rate the sweetness intensity of your coffee.

[ ] Not Sweet Enough [ ] Just About Right [ ] Too Sweet

How do you like the sweetness of the coffee?

<table>
<thead>
<tr>
<th>Dislike Extremely</th>
<th>Dislike Very Much</th>
<th>Dislike Moderately</th>
<th>Dislike Slightly</th>
<th>Neither Like Nor Dislike</th>
<th>Like Slightly</th>
<th>Like Moderately</th>
<th>Like Very Much</th>
<th>Like Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Please lift the hatch to request next sample and have water and cracker to clean your palate.
APPENDIX D. LSU AGCENTER INSTITUTIONAL REVIEW BOARD (IRB)
EXEMPTION FORM INSTITUTIONAL OVERSIGHT

LSU AgCenter Institutional Review Board (IRB)
Dr. Michael J. Keenan, Chair
School of Nutrition & Food Sciences
209 Knapp Hall
225-578-1708
mkeenan@agctr.lsu.edu

Application for Exemption from Institutional Oversight

All research projects using living humans as subjects, or samples or data obtained from humans must be approved or exempted in advance by the LSU AgCenter IRB. This form helps the principal investigator determine if a project may be exempted, and is used to request an exemption.

- Applicant, please fill out the application in its entirety and include the completed application as well as parts A-E. listed below, when submitting to the LSU AgCenter IRB. Once the application is completed, please submit the original and one copy to the chair, Dr. Michael J. Keenan, in 209 Knapp Hall.

- A Complete Application Includes All of the Following:
  (A) The original and a copy of this completed form and a copy of parts B through E.
  (B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1 & 2)
  (C) Copies of all instruments and all recruitment material to be used.
  * If this proposal is part of a grant proposal, include a copy of the proposal.
  (D) The consent form you will use in the study (see part 3 for more information)
  (E) Beginning January 1, 2009: Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing and handling data, unless already on file with the LSU AgCenter IRB.

Training link: (http://grants.nih.gov/grants/policy/hum/training.htm)

1) Principal Investigator: Dr. Wittawat Prinavawatikul Rank: Professor Student? Y/N NO
Dept: School of Nutrition & Food Sciences Ph: (225)578-5188
E-mail: wprinav@lsu.edu

2) Co-Investigator(s): please include department, rank, phone and e-mail for each
   - If student as principal or co-investigator(s), please identify and name supervising professor in this space
     o Ashley Gutierrez, Research Associate, School of Nutrition & Food Sciences
     o (225)578-5423, agutierrez@agctr.lsu.edu

3) Project Title: Consumer Acceptance and Perception of New and Healthier Food Products
4) Grant Proposal? (yes or no) Y/N. If Yes, Proposal Number and Funding Agency
   Also, if Yes, either: this application completely matches the scope of work in the grant Y/N. OR
   more IRB applications will be filed later Y/N

5) Subject pool (e.g. Nutrition Students) LSU Faculty, Staff, Students and off-campus consumers
   - Circle any “vulnerable populations” to be used: (children<18, the mentally impaired, pregnant
     women, the aged, other). Projects with incarcerated persons cannot be exempted.

6) PI signature: **Date 2/23/18** (no per signatures)
   **I certify that my responses are accurate and complete. If the project scope or design is later changed
   I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-
   LSU AgCenter institutions in which the study is conducted. I also understand that it is my responsibility to
   maintain copies of all consent forms at the LSU AgCenter for three years after completion of the study. If I
   leave the LSU AgCenter before that time the consent forms should be preserved in the Departmental
   Office.

Committee Action: Exempted Y. Not Exempted IRB# HE 18-22
Reviewer: Michael Keenan Signature: Michael Keenan Date 9-5-2018

157
Research Consent Form (EXAMPLE)

I, ________________________, agree to participate in the research entitled “Consumer Acceptance and Perception of New and Healthier Food Products” which is being conducted by Dr. Witoon Prinyawiwatkul, Professor of the School of Nutrition and Food Sciences at Louisiana State University, Agricultural Center, phone number (225) 578-5188.

I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated on my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participation returned to me, removed from the experimental records, or destroyed. Up to 300 consumers will participate in this research. For this particular research, about 15-20 minutes participation will be required for each consumer.

The following points have been explained to me:

1. In any case, it is my responsibility to report prior to participation to the investigator any food allergies I may have.

2. The reason for the research is to gather information on sensory acceptability, emotion and purchase intent of new and healthier food products. The benefit that I may expect from it is a satisfaction that I have contributed to quality improvement of these products.

3. The procedures are as follows: 3-5 coded samples will be placed in front of me, and I will evaluate them by normal standard methods and indicate my evaluation on score sheets. All procedures are standard methods as published by the American Society for Testing and Materials and the Sensory Evaluation Division of the Institute of Food Technologists.

4. Participation entails minimal risk: The only risk which can be envisioned is that of an allergic reaction toward common food ingredients [red beans, bell pepper, onion, garlic, celery, thyme, cayenne pepper, bay leaf, pork products, rice and rice products, milk and dairy products, yogurt or fermented milk products, peanuts, mayonnaise products, wheat flour, tapioca flour, eggs, table sugar, vanilla, soy products, sweet potato, salt (sodium chloride) and salt substitute (potassium chloride and common amino acids such as glycine and lysine), and plain unsalted crackers]. However, because it is known to me beforehand that the food to be tested contains common food ingredients, the situation can normally be avoided.

5. The results of this study will not be released in any individual identifiable form without my prior consent unless required by law.

6. The investigator will answer any further questions about the research, either now or during the course of the project.

The study has been discussed with me, and all of my questions have been answered. I understand that additional questions regarding the study should be directed to the investigator listed above. In addition, I understand the research at Louisiana State University, Agricultural Center, which involves human participation, is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Michael Keenan, Chair of LSU AgCenter IRB, (225) 578-1708. I agree with the terms above and acknowledge.

________________________________________  ________________________________________
Signature of Investigator                                      Signature of Participant

Witness: ___________________________________________                      Date: ____________________
Table E.1. Liking score of green color salads obtained by consumers according to type of vegetable salads consumptions.

<table>
<thead>
<tr>
<th>Segment consumers</th>
<th>Sample*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sample A</td>
</tr>
<tr>
<td>Pale green color salads consumptions</td>
<td>4.50c</td>
</tr>
<tr>
<td>Dark green color salads consumptions</td>
<td>4.07b</td>
</tr>
</tbody>
</table>

*referred to Table 3.1 for sample description.
a, b, c indicated significant differences of mean scores in each row ($P < 0.05$).
VITA

Pitchayapat Chonpracha was born in September, 1983 in Bangkok, Thailand. She completed her Bachelor of Science degree in Biotechnology from Kasetsart University in 2006. She continued studying a Master degree in Product Development and earned a degree in 2009. In October of 2009, she started her first career as a research and development supervisor at Beerthip Brewery Public Company, Limited, Thailand. Her work focused on the development of beverage prototypes and maintenance of sensory quality of the existing beverage products. In May 2011, she left Beerthip Brewery and began her new career as sensory and consumer insight at V. Mane Fils, flavor and fragrance supplier. The passion for career growth and a hunger to advance her sensory practical skills inspired her to pursue a PhD. She left V. Mane Fils in December 2014 and traveled to Louisiana State University to pursue a PhD in Food Sciences concentration in January 2015. Her doctorate work has profoundly focused on Consumer and Product Understanding, and she expects to complete in May 2019.