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Development, Acceptability, and Emotional Responses of Low-Sodium Roasted Peanuts and Flavored Spreads

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DEVELOPMENT, ACCEPTABILITY, AND EMOTIONAL RESPONSES OF LOW-SODIUM ROASTED PEANUTS AND FLAVORED SPREADS

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ABSTRACT

The objective of this research was to evaluate the feasibility of developing acceptable low-sodium products by using a salt-replacement technique, an oil-in-water emulsion system, and health benefit information to improve consumers' awareness of low-sodium diets. Three experiments were conducted: (I) Sensory characteristics and optimization of low-sodium roasted peanuts by substitution of NaCl with KCl, and addition of glycine (Gly) as a bitterness blocker; (II) Rejection threshold (RjT) of KCl added to low-sodium roasted peanuts using a 2AC-test; (III) Development of acceptable low-sodium and sodium-free spreads by flavor modification and their use on turkey salad sandwiches. In study I, results showed that sodium content in peanuts decreased from 140mg/50g to 41.7mg/50g without affecting liking scores with positive purchase intent (PI) of >60%. Health messages (HM) related to high-sodium intake risks increased positive emotion responses while decreasing negative ones. The optimal range of 59-100/0-40/0-12.5 of NaCl/KCl/Gly yielded acceptable low-sodium peanuts. From Study II, up to 30-50% KCl did not significantly decrease overall liking (OL) scores, but OL scores decreased at 70-90% KCl; the same was observed for PI. Samples containing 70-90% KCl were perceived by consumers as "too salty," and was associated with mean drops of 2.2 on the 9-point OL scale. No RjT of added KCl at 90% w/w in low-sodium roasted peanuts was reached under the conditions of this study. In Study III, consumers first indicated their willingness to purchase a sodium-free mayonnaise spread containing 1% KCl after a sodium claim was stated. Three levels of KCl (0.5, 1, and 1.5%) were tested with four selected flavors in the spreads. Acceptability of the flavored spreads increased by flavor modification. Bacon flavor significantly outperformed for all sensory attributes evaluated when compared to the rest of the treatments. Bitterness intensity of the samples was not associated with the mean drops on the OL scores. Low-sodium benefits HM increased PI for 10 treatments.

Flavored spreads evaluated on turkey salad sandwiches yielded higher liking scores and PI than the spreads alone. Combination of a sodium HM and salt substitution with KCl increased liking scores, positive emotion responses and willingness to purchase low-sodium products.

CHAPTER 1. INTRODUCTION

1.1 Introduction

Sensory evaluation is an applied, multidisciplinary science which seeks to understand and interpret human responses to product properties perceived by the senses of sight, touch, smell, taste, and hearing. In a changing world, especially in the food market, sensory evaluation is widely applied to determine decisions people make regarding food, thus playing a key role in new product development (Martens, 1999; Jaeger, 2006).

For years, salt has been added to food for many functional reasons such as flavoring, preservation, texture improvement (Kilcast & den Ridder, 2008; He & MacGregor, 2009). Sodium, which mostly comes from regular table salt in human diets, is an essential nutrient with functions in the regulation of extracellular fluids. However, excessive sodium consumption has been linked to hypertension, strokes, kidney failure, and cardiovascular diseases. About one in three U.S. adults have high blood pressure, and only half of these people have their blood pressure under control (Ruusunen & Puolanne, 2005; CDC, 2015). Average sodium intake in the US is approximately 3,300 mg, which is far higher than the 2,300mg recommended per day for healthy individuals. In addition, during early stages in life (6-18 years old), U.S. children and adolescents are consuming, on average, 3000-3500mg sodium per day (CDC, 2016). Most of the sodium consumed in regular diets is in the form of salt and is present in processed and restaurant foods (CDC, 2015).

Salt reduction is considered a challenge in the food industry due to its importance to specific food characteristics. Different strategies to reduce salt levels in foods have been evaluated, such as substitution with salt-replacers (Verma *et al.*, 2010; Sinopoli & Lawless, 2012; Wu *et al.*, 2014)), flavor enhancers (Pietrasik & Gaudette, 2014), and odour-taste interaction (Lawrence *et* *al*., 2009). Partial or total salt substitution with potassium chloride is one of the most effective ways to reduce sodium in processed food. However, KCl has the disadvantage of imparting bitter and metallic after taste when added in high concentrations (Sinopoli & Lawless 2012; Pietrasik & Gaudette, 2014; Torrico & Prinyawiwatkul, 2017).

Peanuts are grown in the tropics and in temperate zones primarily as an oilseed crop. Peanuts are sold fresh, canned, frozen, roasted in-the-shell (salted and unsalted), and are also used in bakery products, peanut butter and other foods (Muego-Gnanasekharan & Resurreccion, 1993; Nepote *et al.*, 2006). Peanut kernels make an important contribution to the human diet in several countries and are considered a cheap source of protein and a good source of essential vitamins and minerals (Yeh *et al.*, 2002; Young *et al.*, 2005).

Mayonnaise, a mixture of oil, egg, vinegar, and spices, is one of the most used sauces worldwide. In North America, mayonnaise is typically used as a sandwich spread (Garcia *et al*., 2009). As a sauce, mayonnaise is used to enhance or modify the flavor of other foods, and along with salad dressings, constitutes much of the semi-solid foods market (Ma & Boye, 2013).

1.2 Research justification

Research has shown that low-sodium foods are perceived by consumers as lacking flavor and tastefulness, and that consumers' taste preferences may or may not explain acceptance of products with reduced sodium. Targeting taste, in addition to the use of sensory emotion, could increase sensory liking and modify consumer dietary sodium intake. There is a strong link between emotions and consumer behavior, and the extent of product usage has been found to be based on sensory characteristics and emotional associations consumers attach to a product. Desmet & Hekkert (2009) explained how emotions may be an important factor influencing purchase decision together with sensory liking. Appropriate health benefit information has also been reported to impact product purchase decisions (Vickers, 1993; Roininen *et al.*, 1999). Currently manufactures seek to understand the factors leading to increased consumer acceptance of low-sodium foods.

Raw and unsalted roasted peanuts as well as mayonnaise-type products do not contain high amounts of sodium; however, peanuts are more frequently consumed roasted and salted, and mayonnaise-type products are consumed in high quantities. After the roasting and salting processes, the amount of sodium in peanuts rises to 200-450mg Na/ 50g of peanuts (USDA, 2016). Mayonnaise, on the other hand, when consuming in high amounts lead to high sodium consumption. Mayonnaise is an oil-in-water emulsion. Findings from Torrico *et al*., (2015) indicate that, compared to aqueous solutions, oil-in-water emulsions exhibited bitterness-suppressing effects on KCl. Thus, the oil-in-water emulsion food system may lend itself to an effective use of KCl as a substitute for sodium chloride.

1.3 Research objectives

Main objective

The main objective of this research is to explore the feasibility of developing acceptable low-sodium products by using salt substitutes and proper health benefit information to improve consumers' awareness of low-sodium diets.

Two different phases were done to address the main objective:

Phase 1- Developing acceptable low-sodium roasted peanuts using KCl as a partial salt-replacer (a solid food system).

- **Study 1:** *Sensory Characteristics of Low-sodium Peanuts Containing Sodium Chloride, Potassium Chloride, and Glycine*

    - To evaluate how sensory liking, emotion, and purchase intent of low-sodium roasted peanuts are affected by different concentrations of NaCl/KCl/Gly and health benefit statement (HBS).
    - To optimize proportion of NaCl/KCl/Gly based on sensory liking and emotional responses of low-sodium roasted peanuts.
- **Study 2:** *Rejection Threshold of KCl Added in Roasted Peanuts*
    - To determine the RjT level of KCl applied to roasted peanuts using 2-Alternative Choices (2AC) with a no-preference option test.
    - To evaluate the effect of KCl rejection level on emotion, overall liking, and purchase intent of roasted peanuts.

Phase 2- Developing low-sodium and sodium-free mayonnaise-type spreads (an emulsion system).

- **Study 3:** *Consumer Perception, Emotion and Purchase Intent of Mayonnaise-type Spreads as Affected by Nutrient Claims for Sodium Content (low-sodium, reduced sodium, and sodium free)*
    - To evaluate the effect of salty and bitter taste imparted by NaCl and KCl, and sodium content claims on liking and purchase intent of mayonnaise-type spreads.
    - To evaluate emotional responses to sodium content claims and their effects on purchase intent of mayonnaise-type spreads.
- **Study 3.1:** *Improving Consumer Acceptance, Emotion, and Purchase Intent of Low-Sodium Spreads by Flavor Modification and its Incorporation into Turkey Salad Sandwiches*

- To identify flavors that help reduce bitterness perception of low-sodium mayonnaise-type spreads.
- To assess consumer acceptance, emotional profile and purchase intent of flavored mayonnaise-type spreads before and after consumers were given health benefit information regarding sodium content.
- To evaluate how adding flavored mayonnaise-type spreads to a final product (turkey salad sandwich) improved consumer acceptance, emotion, and purchase decision of the product.

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CHAPTER 2. LITERATURE REVIEW

2.1 Sodium chloride in food products

Sodium chloride (NaCl), commonly known as a table salt, contributes to the salty taste in foods. It has been added to food as a flavoring agent for centuries. Sodium chloride is soluble in water and is considered odorless. Salt is essential in both human' and animal' diets (Columbia Electronic Encyclopedia, 2017). Table salt serves several essential functions in food products, providing not only flavor, but also improving texture (mainly in meat and poultry products) and shelf-life (Verma & Banerjee, 2012; Inguglia *et al.*, 2017). In the meat industry, NaCl has been proven to increase water-holding capacity, improve flavor, and decrease microbial counts (Terrell, 1983). Several authors (Ruusunen *et al*., 2001; Ruusunen & Puolanne, 2005) described the noticeable increase in saltiness and sensory properties when higher amounts of salt were added to fatty products. Lowering salt content in meat resulted in lower pH, cooking yield, and emulsion stability. Reduced NaCl content in this product also negatively impacted flavor, texture, and overall acceptability of chicken nuggets (Verma *et al*., 2010). Inguglia *et al*., (2017) also described the shelf-life issue in processed meat products which was caused by salt reduction. While it was possible to control microbial growth with the introduction of lactates, the resulting flavor and texture characteristics were not acceptable to consumers due to salt reduction. Miller & Barringer (2002) explained the several functions of salt in snack food. The authors reported salt as one of the major generators of structure and color in processed snacks and as a topical tastant either alone or in combination with other flavors.

2.2 Sodium intake and health concern

Sodium is a mineral that is needed to sustain life (WHO, 2013). Sodium deficiency is not a major problem for any population, but excess sodium consumption is a global health issue due to its relation to health risks. Due to current lifestyle and poor dietary choices, the daily amount of salt consumed is, on average, 8-9 grams per person in developed countries (Mitchell, 2016). In a regular diet, it has been estimated that 75% of the sodium chloride consumed comes from industrially produced foods (Steffensen *et al.*, 2018). Based on recommendations, adults need under a teaspoon of salt, or 5 grams, per day, to meet their daily sodium requirements (WHO, 2016). The largest amount of sodium consumed comes from processed meats, breads, sauces, and others (Havas *et al.*, 2004; Capuano *et al.*, 2013). High sodium chloride intake is associated with the development of high blood pressure, which is also a risk factor for cardiovascular disease (CVD), stroke and kidney disease (Ezzati *et al.*, 2002; Havas *et al.*, 2007). Hypertension and cardiovascular disease are the primary cause of death worldwide (WHO, 2013). Primary adverse effects related to high sodium consumption are associated with the osmotic activity of sodium ions in extracellular fluids, leading to different diseases (He & MacGregor, 2010).

About 13% of deaths worldwide are due to hypertension (Stevens *et al.*, 2009). Hypertension, or high blood pressure, is defined as a systolic blood pressure higher than 140 mm Hg and a diastolic blood pressure which is greater than 90 mm Hg (WHO, 2013). Hypertension contributes to poor health and it is a prime concern around the globe due to its increasing prevalence and contribution to morbidity (Bernabe-Ortiz *et al.*, 2014). Other non-communicable conditions, such as diabetes and obesity also tend to increase the risk of hypertension, with risks of comorbidity. Salt has been proven to worsen hypertension, and this has been known and understood, and the subject of debate for about a century (O'Hare & Walker, 1923). It has been estimated that 2.5 million deaths could be prevented per year if global salt consumption were reduced to the recommended level (WHO, 2016). There are particular concerns for vulnerable groups in society, such as elderly people who are more prone to hypertension. He *et al*., (2008) investigated the effect of sodium in the diets of children and adolescents. They found that the level of salt in the diet increased every year after the age of four, resulting in measurable increases in systolic pressure which could be predicted by the daily salt intake. Laatikainen *et al*., (2006) predicted that when a 30–35% reduction in sodium intake was achieved over a 20 year period, it contributed to a 75% drop in mortality caused by coronary heart diseases in adults under 65 years of age.

2.3 Sodium reduction approach

The demand for low-sodium products is not synchronized with the health needs of populations to dramatically lower their consumption of sodium. There is strong evidence that even small reductions in blood pressure at the population level have large health benefit in terms of cardiovascular wellness (Bernabe-Ortiz *et al*., 2014). Despite this evidence, there remains continued debate regarding whether salt is the proven cause of hypertension (Omvik & Myking, 1995; Titze & Luft, 2017). The evidences regarding the health impacts of salt reduction have been stated in quantitative ways, but they all depend on a linkage between salt and systolic blood pressure. The findings that for each 2 mmHg decrease in systolic pressure, mortality from stroke and cardiovascular disease decreased by 7% to 10%, respectively, support the evidence of the current high blood pressure problems (Bernabe-Ortiz *et al*., 2014).

The most common approach to reduce sodium content in food is to replace salt with a substitute which has a salty flavor but a low-sodium content. A similar effect is achieved by simply reducing the salt without any other additions. The results differ on a product by product basis, but the main problem is the change of flavors, including bitterness due to this feature of salt substitutes. Flavor enhancers and bitterness blockers are, therefore, recommended for this strategy (Toldrá &

Barat, 2009). Sodium reduction techniques using salt replacers aim to increase saltiness perception without increasing sodium content in foods (Liem *et al.*, 2011). The food matrix is also an important factor in reducing sodium in food. Several authors have studied the feasibility of reducing sodium by modifying salt crystal size (Kilcast & Angus 2008; Rama *et al*., 2013). These authors followed the principle that by reducing the size of salt, more surface area will be covered, thus an optimized release of salt from the product to the taste receptors will be achieved. The use of small components that act as salt boosters or replacers is also applied to enhance salty perception (Busch *et al*., 2013). Monosodium glutamate is one of those flavor enhancer that has been reported to increase saltiness of a product and, thus, the palatability of low-salt foods (Kremer *et al*., 2009; Mitchell *et al*., 2009). Another promising technique through cross modal sensory interactions between tasteless odorants and saltiness perception has been reported in both water solutions (Lawrence *et al*., 2009; Prescott, 2015), and solid foods (Lawrence *et al*., 2011; Chokumnoyporn *et al*., 2015). Emorine *et al.* (2015) were able to reduce over 35% salt content without losses in the acceptability of food by combining the enhancement of saltiness with odorants and heterogeneous distribution of salt. Moreover, a study using odor-taste-taste mixtures in water solutions showed that the combination between sourness-saltiness, and odor induced saltiness can effectively enhance salty taste perception (Nasri *et al*., 2013). Food matrix systems are a significant factor when reducing sodium in products. That is, salty taste may be affected by several characteristics of the product. Some researchers have demonstrated that increasing the hardness of a product may increase salty taste release (Seuvre *et al*., 2006; Gierczynski *et al*., 2007).

Based on one of the explained techniques or a combination of them, salt reduction has been achieved in different types of products. Based on the food matrix and the method used, a variety of challenges are encountered. The removal or reduction of sodium from snack foods is challenging and requires special attention to functionality aspects of other ingredients used that may contain sodium. Recent studies have shown that reductions in sodium content of some solid foods (2–5%) were not noticeable by consumers (Drake *et al*., 2011). It has also been shown that in snacks, especially in chips, normal eating patterns would not release the majority of the added topical salt (Xian & Fisk, 2012). Another key factor is the complexity of the food matrix which is important in the perception of saltiness when aiming to reduce sodium content without significantly affecting salty taste perception (Drake *et al*., 2011).

2.4 Potassium chloride and other compounds used as salt-replacers

Potassium chloride is the most commonly known salt substitute, and it has dual positive functions. Potassium and sodium levels of the body are related to one another, and an increase in potassium reduces the negative health impacts of sodium (Kawano *et al*., 1998). While potassium chloride would seem to be an ideal replacement for salt, it tends to impart bitter aftertaste (Toldrá & Barat, 2009). Another possible drawback is that when substituting NaCl with KCl there may be negative health effects due to excessive consumption of potassium in diets. However, no evidence has demonstrated any adverse effects from increased dietary potassium in individuals with no potassium excretion problems (WHO, 2012). About 90% of dietary potassium is normally absorbed from the gut. In a regular 70 kg adult, from the total potassium absorbed, 98% is used in the intracellular fluid, and the extracellular compartment is believed to contain the remaining amount of potassium (Traeger & Wen, 2008). Hyperkalemia occurs when plasma potassium concentration rised above than 5.0 mmol/L and is mainly caused by excessive potassium intake combined with impaired renal excretion of this nutrient. On the other hand, hypokalemia is a potassium deficiency in the body (NNR, 2012; Traeger & Wen, 2008). Regardless of the concerns with potassium intake, scientific studies support that in healthy people with no renal dysfunction, the body is able to handle high intakes of potassium (Taber & Thomas, 1997).

Aburto *et al*. (2013) concluded that potassium intake appeared to be significantly related to decrease risk of stroke. In another study conducted by Larsson *et al*. (2011), a dose-response meta-analysis of prospective cohort studies on dietary potassium and risk of stroke was performed. They concluded that for every 1 g (25 mmol) increase in potassium intake, an 11% reduction was observed in the risk of strokes.

In terms of taste, researchers found that the 25% potassium chloride and 75% sodium chloride combination had flavor equivalent to regular table salt (Saavedra-Garcia, *et al*., 2015). A systematic implementation of such a salt would result in a dramatic reduction in sodium intake of up to one quarter, with systematic impacts on long-term cardiovascular health due to the reduction in risks of hypertension. The cause of the bitter perception of potassium chloride is not generally understood. It is believed that the receptor sites located on the tongue where saltiness is perceived can readily distinguish potassium from sodium, and this difference is physiologically perceived as a difference in bitterness intensity. Because of the difference in flavor between potassium chloride and sodium chloride, it is necessary to use bitterness blockers and other salty taste enhancers to minimize this flavor difference (Murray & Shackelford, 1991).

Glycine and glycine derivatives are used as antibacterial agents and as a means of blocking bitterness from salt substitutes such as potassium chloride (Toldrá & Barat, 2012). Glycine has been tested for safety, and is permissible for use as a food preservative. Other compounds that block bitterness also include sweeteners. Gaudette *et al*. (2016) described the use of bitterness blockers for improving the sensory profile of a product. Bitterness blocking to enhance saltiness cannot be reduced to a single sensation (i.e. salty taste). In particular, the researchers found that a sweetener was the single most intense substance to enhance the effect of the bitterness blocker (Gaudette *et al*., 2016). This was seen as a functional and appetizing way to formulate low-sodium foods with high consumer acceptability. Unfortunately, the addition of sweeteners does not enhance the health aspects of the product, and could be seen ultimately as simply replacing one problem component with another.

Canto *et al*. (2014) examined chemical and consumer perceptions of low-sodium restructured caiman steaks using salt replacement for flavor, and microbial transglutaminase for texture. The microbial transglutaminase did improve texture, and the salt replacements were found to improve consumer acceptance. Choi *et al*. (2014) described the effect of a combination of potassium lactate and calcium ascorbate as a salt substitute in the production of low-sodium frankfurter sausages. In this study, consumers were not able to differentiate the control versus treated frankfurters samples. The salt replacement contained 30% potassium lactate and 10% calcium ascorbate, and it was able to mimic the water retention, texture and flavor of frankfurters made ordinarily with salt. This technique is only proven to work for this product, as each food has its own requirements in relation to salt replacement.

Low-sodium products have been increasingly entering the market, fueled by calls for healthier processing and ingredients by health organizations (CDC, 2016). Consumers have been responding, but a failure to meet taste expectations can be problematic for newly developed low-sodium formulations. While there are a multitude of potential treatments and combinations, there is no single best approach, as each product has unique characteristics which determine the success of the sodium reduction approach.

There are also natural alternatives which include the *Salicornia* and *Eucheuma* plants and certain seaweeds that are composed of a proper ratio of sodium chloride to potassium chloride, with trace minerals such as calcium, magnesium, zinc and iodine. These salts tend to only contain 20%-30% sodium chloride, and further flavor enhancers can be added to further reduce the sodium content in the food formulations. These plants tend to be invasive species which in many cases are implicated in posing risks to coral reefs. There may be interesting commercial and environmental potential to using these plants to create salt substitutes, although because of the risks that these fast-growing plants can pose there would need to be careful consideration of ecological impacts (Shin & Lee, 2003; Tabarsa *et al*., 2012).

2.5 Salty taste perception

Saltiness, a sensory experience, is impacted by context, expectation and perception (Kilcast & Den Ridder, 2007). Saltiness in meat, for example, is related to the perception of texture and succulence, and without salt these perceptions are interpreted differently (Monahan & Troy, 1997). Neyraud *et al*. (2003) explained that, in terms of sensory perception, the rate of sodium and chloride ions released will depend on the structure and composition of the food as well as the mastication and salivation processes. After salt is eaten, sodium and chloride ions are released, and the ions are subsequently transported to the taste buds, either through bulk transport or through diffusion. Both ions are needed to be able to activate salt receptors (Malone *et al*., 2003). Van der Klaauw & Smith (1995) explained that taste receptors are located at the top end of the taste receptor cells. The nature of humans' salt receptor is not completely understand, but Chandrashekar *et al*. (2010) explained a possible model; basically, the mouse models indicated that there are two epithelial sodium channels (ENaCs) involved. Each one of the channels is believed to be activated differently; one activated at low-sodium concentrations, and the other at higher sodium concentrations. This latter is also reported to be activated by other cations and is thought to be responsible for the off-taste of cations. Chen *et al.* (2011) proposed that upon the salt receptors activation, a conversion to an electrical signal occurs which is sent via afferent nerve fibers to the brain, where they are thought to be encoded in a "gustotopic map" of distinct hot spots for the different taste qualities in the gustatory cortex. Besides this specific salty model perception, intra- and cross-modal interactions are well-known to impact overall taste perception of a food product (Noble, 1996; Keast & Breslin, 2002; Delwiche, 2004). Woods *et al*. (2011) added explanation on the influence of psychological factors such as expectations and experience on salt perception. Taste can be affected in two main levels: peripherally (receptor level), and centrally (brain level).

Awareness of salt and its health risk can create an impact on preference for saltiness. Creating a cognitive approach for sodium reduction can be done by promoting a need to reduce sodium in humans' diets. Switching to a different diet (e.g., low-sodium diet) can be difficult even for people with hypertension problems (Pimenta *et al*., 2009). McCance (1936) reported that salt craving is a common behavior of many animals, but the author explained that it has only incidentally been observed in humans who suffer from extreme sodium loss. The overconsumption of salt in many humans is not driven by physiological need, but by taste preference (Bertino *et al*., 1982). Bertino *et al*. (1982) studied the feasibility to reduce sodium in diets by partially reducing salt in food. After repeated exposure to low-sodium diet, subjects became more sensitive to salty taste.

Physiological aspects as well as food composition also impact the effectiveness of salt reduction. In dairy products (a complex food) the salt and fat content affected the flavor perception (Saint-Eve *et al*., 2004). Repoux *et al*. (2012) also reported that nonvolatile compounds (such as salt) could be more effectively released based on food composition. For example in cheeses, salt released during consumption of the product will be reduced with a high fat content (Phan *et al*., 2008).

Chokumnoyporn *et al*. (2016) were able to enhance the saltiness perception of oil roasted peanuts by using foam-mat salt and soy sauce odor. Torrico *et al*. (2015) examined saltiness of sodium chloride and potassium chloride, along with bitterness of potassium chloride in an oil-in-water emulsion. Sodium chloride, not surprisingly, had the highest saltiness intensity in emulsions, but saltiness was enhanced when the emulsion was made with 20% or 40% oil. Bobowski *et al*. (2015) described an experiment to compare gradual reduction of salt in products with a more dramatic salt reduction using tomato juice. The researchers noted that the most important factor affecting consumers acceptance was an individual's hedonic sensitivity to salt (determined by the extent to which responses to highest and lowest amounts of salt differed) and personal interest in reducing salt intake. While both salt reduction strategies worked, the gradual reduction was more acceptable because it did not involve a sudden drop in liking of the juice, which was observed in the sudden salt reduction strategy. Participants with the least hedonic sensitivity were the least affected by salt reduction, in terms of their acceptance of lower salt alternatives; however, those with high hedonic sensitivity have a greater difficulty regardless of the strategy used.

2.6 Emotional responses

There is more to food choice than sensory liking. Emotions can play a leading role in product experience (Cardello *et al*., 2012). Emotion measurement has recently received increasing attention in product development and consumer research. A number of questionnaires and methods have been developed to measure emotions associated with food products (Lewis *et al*., 2008). Hartwell *et al*. (2013) stated that consumption context is linked to how people feel. They explained that based on humans' feelings, perception of a food, as well as liking and enjoyment of the consumption experience could be modulated.

Mood and emotions can influence motivation to eat and even induce to change some eating behaviors (Köster & Mojet, 2015). On the other hand, food intake can modify how people feel (Jiang *et al*., 2014). Hence, there is a growing interest in understanding the role of emotions in liking, and vice versa. Spinelli *et al*. (2013) suggested that emotional profiles in response to foods can be mapped into two orthogonal dimensions, a valence dimension (positive-negative, unpleasant-pleasant) and an activation dimension (low-high). Desmet & Shifferstein's (2008) proposed five different sources of food emotions: sensory properties, experienced consequences (past experience or memories), associated (or anticipated) consequences (for example, concern about becoming fat because of eating unhealthy food), personal or cultural meanings and actions of associated agents (for example the gratification that comes from receiving compliments for dishes one has prepared). Desmet & Schifferstein (2008) also reported that consumers mainly experience positive emotions in response to food products. Kumari *et al*. (2016) noted the emotional role of eating, and proposed that these emotions in relation to food were intense enough to allow for the identification of nutritional status of patients. Even for food related with positive emotional responses, when eaten in a hospital, the food tended to elicit many negative feelings, including boredom, shame and hostility. In a hospital, while sick, there are fewer positive cues and an expectation that food will not be flavorful. The concept of comfort food captures the relationship between sentiment, food and emotions very well. The emotional aspects of food, including taste, sentiment and luxury, are related to another phenomenon, i.e., consumers appear to lie to themselves about the level of healthy and nutritious foods that they eat (Hung *et al*., 2017).

This is, in turn, related to the level of motivation to eat healthy foods, including a low-sodium diet. The impact of the type of motivation and a positive or negative orientation towards low-sodium food is likely to have an emotional-type impact.

Emotions, in contrast to a number of other functions, also seem to be well preserved with increasing age (Craik & Salthouse, 2011). It means that even when an impaired sensory perception occurs due to age, an impact on consumer behavior could be done via modulations of the emotional responses (den Uijil *et al.*, 2016). Overall, it has been confirmed that food-evoked emotions give new information beyond liking that could better help to differentiate foods based on emotion profiles as compared to liking. When measuring emotional responses, the focus (sensory or extrinsic properties) matters. Situations such as blind product presentation, package or food name could evoke different emotions varying in both, degree and kind (Cardello *et al.*, 2012). Dalenberg *et al.* (2014) demonstrated that by combining emotion scores, liking ratings, and without packaging information, a better prediction of choice for tasted products was obtained.

Within the variety of methods created to measure emotional responses, several food-specific questionnaires have been implemented. The EsSense Profile® appears to be best validated and gains influence in the field of sensory science. This method includes 39 emotion terms based on observation that people tend to describe food products using a large variety of terms (King *et al.*, 2010). The majority of instruments to measure emotions are self-report. In recent years, other new tools have also been developed to measure food-evoked emotions: self-report instruments, observational method such as facial expressions, nervous system parameters (heart rate), and affective brain function (Grabenhorst *et al.*, 2008; De Wijk *et al.*, 2012).

2.7 Health benefit statements in food consumption

Food manufacturers seek to understand the factors leading to increased consumer acceptance of low-sodium foods. The production of low-sodium products requires consumer acceptance in order to fuel production interest and investment. The search for the appropriate techniques that have a high degree of safety, affordability, ease of use and consumer acceptance is the key to successful low-sodium products; however, it has been elusive at times. Consumer acceptance is often the most challenging aspect, particularly given the widely varying salt sensitivities and a belief that healthy food does not taste good. While this would seem to be related to knowledge of health and health claims of food, it appears to be the other way around. Motivation to eat healthy foods seems to drive interest in health benefit messages on food packaging, and knowledge about what these claims mean to consumers (Hung *et al*., 2017). There are, however, several challenges with consumers' perception toward health information provided in food packages. First, when food is described as healthy, people have been shown to rate it as less tasty (Raghunathan *et al*., 2006). Another issue is that, the presence of a health statement of a food can mislead consumers to feel that they have fulfilled their health goal (known as "health halo effect") (Wilcox *et al*., 2009). Wagner *et al.* (2015) also evaluated the effectiveness of the type (subtle and explicit) of health message provided to consumers on food choice. They found that subtle messages may be more effective than the explicit ones in encouraging consumers to make a healthy snack choice.

Di Vita *et al*. (2016) examined the willingness of consumers to pay for salt-reduced bread products. Bread is one of the lesser known sources of sodium in diets, although two slices of bread provide as much as one quarter of daily recommended values according to the 2010 Dietary Guidelines for Americans (McGuire, 2011). While the potential benefit of sodium reduction is great, and consumers are interested, they found that willingness to pay more for sliced, salt-reduced bread was limited. For those consumers with significant interest, the maximum additional value in terms of willingness to pay additionally was capped at about 20%. Rodrigues *et al*. (2017) investigated the knowledge level of Brazilian consumers on the salt content of foods, and their interest in purchasing low-sodium products using a survey instrument. They found that while Brazilian consumers seemed concerned about the amount of salt in products, they thought their consumption of salt was greater than the recommended maximum daily amount. Respondents also believed that the sodium in the processed foods were different from the salt which was used in home-cooking and, at the table, and had fewer concerns about this use of salt. Most respondents did not read health statements or labels in order to determine sodium content in foods, and those who did were likely to be older and males.

A similar study in Ontario, Canada was performed to assess the knowledge of the public in relation to sodium in their diet, and found that most respondents were aware that high levels of sodium lead to health problems (Papadakis *et al*., 2010). Unfortunately, those same respondents were unable to name the popular foods in the diet which were high in sodium, even though the respondents reported that they often consume those foods. Indicating the lack of knowledge about food high in sodium. Sodium content in food was not linked to food choices, and for the most part the respondents were unaware of them even though nearly 60% claimed to be actively trying to eat healthier.

A more recent study in Victoria, Australia, was conducted by Grimes *et al*. (2017), examined the knowledge, awareness, and behavior of consumers in relation to sodium in food and a healthy level of sodium in their diets. As with other studies in other contexts, most individuals were aware that sodium carried health risks, and that the general population tended to consume too much salt. While 75% of respondents were able to identify processed foods as a common source of high sodium levels, only 29% believed that they consumed too much salt. Almost half of the respondents were concerned that it was difficult to find food that had an appropriate sodium content, and a majority thought that food laws should regulate the amount of salt which could be added to food. Overall knowledge about sodium levels was low, and people were unable to assess what an appropriate salt intake was or how to achieve it.

2.8 Peanut

The peanut (*Arachis hypogaea L*) is considered a legume which belongs to the pea and bean family. The peanut is a well-known source of high edible oil and protein (Yeh *et al.,* 2002; Young *et al.*, 2005). Also, the peanut is a rich source of essential amino acids, minerals, vitamins, and has good digestibility. Due to its nutritional value, the peanut has a potential role in fighting malnutrition, especially in developing countries (Berkman & Epstein, 2008). In addition, peanuts are a good sources of polyphenols such as catechins, porcyanides, and resveratrol. Peanuts' bioactive compounds have multiple cardiovascular benefits. Populations with risk of coronary heart disease would be expected to decrease markedly if peanuts were routinely incorporated into healthy diets (Blomhoff *et al*., 2006; Kris-Etherton *et al*., 2008). According to a USDA's report, in 2017 a total of 183 million pounds of shelled edible grade peanuts were used. The utilization by type was: 104 million pounds for peanut butter, 28.7 million pounds for peanut candy, and 43.8 million pounds for peanut snacks. Raw and unsalted roasted peanuts do not contain high amounts of sodium; however, peanuts are more frequently consumed roasted and salted. After the roasting and salting processes, the amount of sodium content in peanuts increases (USDA, 2016).

2.9 Oil-in-water emulsions

Emulsions are explained as a mixture of two immiscible liquids. In the mixture, one of the liquids is dispersed in the other. When it is specified an "oil-in-water" emulsion, it refers to a simple emulsion where oil droplets are dispersed in an aqueous phase (McClement, 2005). The liquids in an emulsion are combined by a homogenization process. Bush *et al*. (2013) explained the possibility of achieving low-sodium products by modification of the food product structure, which will improve the perception of salty taste in food products. One example of this principle is the modification of physical properties such as viscosity and the overall salt distribution in a product. Mayonnaise is an oil-in-water emulsion. Mayonnaise-- a mixture of oil, egg, vinegar, and spices-- is one of the most used sauces across the world. In North America, mayonnaise is typically used as a sandwich spread (Garcia *et al*., 2009). As a sauce, mayonnaise is used to enhance or modify the flavor of other foods, and along with salad dressings, constitutes much of the semi-solid foods market (Ma & Boye, 2013). Torrico & Prinyawiwatkul (2017) demonstrated that oil concentration in an emulsion affects consumers' taste perception as the physical properties of the emulsions changed. Torrico *et al*. (2015) also reported that oil-in-water emulsions have the potential benefit of suppressing bitter taste (specifically bitterness imparted from KCl).

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CHAPTER 3. SENSORY CHARACTERISTICS OF LOW-SODIUM PEANUTS CONTAINING SODIUM CHLORIDE, POTASSIUM CHLORIDE, AND GLYCINE

3.1 Introduction

Sensory testing generally refers to the evaluation of a product based on appearance, aroma, taste, smell, touch, and sound (Brody & Lord, 2000). Nevertheless, several studies have reported other important elements involved in sensory testing such as the emotions elicited by the product (Babin & Babin, 2001; Phillips & Baumgartner, 2002; Laros & Steenkamp, 2005) and health benefit information received (Roosen *et al.*, 2007; Van't Riet, 2013). Research has started to focus not only on basic sensory characteristics, but also on emotional responses to food and their relationship to product acceptability (Barthomeuf *et al.*, 2009; Wardy *et al.*, 2015). Emotions are becoming a critical component in designing products that meet consumers' needs and expectations. Appropriate health benefit information has also been reported to impact product purchase decisions (Vickers, 1993; Roininen *et al.*, 1999). Nowadays, manufacturers seek to understand the factors leading to increased consumer acceptance of low sodium foods.

Sodium chloride (NaCl), commonly known as table salt, is the most used food additive worldwide due to its roles as a flavor enhancer and a food preservative (He & MacGregor, 2009; Heshmati, 2014). However, high levels of salt consumption, resulting in high sodium intake, have been linked to hypertension and cardiovascular disease (Ruusunen & Puolanne, 2005). The use of 'salt substitutes,' such as potassium chloride (KCl), is one of the most common methods of reducing sodium content in foods. Although capable of imparting saltiness, KCl has been shown to have an unpleasant bitter aftertaste, so the use of a bitterness blocker or masking agent is needed (Fitzgerald & Buckley, 1985; Desmond, 2006). Glycine is an amino acid reported to be a potentially effective bitterness blocker (Khetra *et al.*, 2016)

Peanuts are grown in the tropics and in temperate zones primarily as an oilseed crop. Peanuts are sold fresh, canned, frozen, and roasted in-the-shell (salted and unsalted), and are also used in bakery products, peanut butter and other foods (Muego-Gnanassekharan & Resurreccion, 1993; Nepote *et al.*, 2006). Peanut kernels make an important contribution to the human diet in several countries and are considered an inexpensive source of protein and a good source of essential vitamins and minerals (Yeh *et al.*, 2002; Young *et al.*, 2005). Raw and unsalted roasted peanuts do not contain high amounts of sodium; however, peanuts frequently consumed roasted and salted. After roasting and salting processes, the amount of sodium in peanuts rises to 200-450mg Na/ 50g of peanuts (USDA, 2016).

Until now, studies of consumer acceptance and emotional responses to low-sodium oil-roasted peanuts have not been conducted. The objectives of this research were to evaluate how consumers' liking of low-sodium peanuts varies with different concentrations of NaCl, KCl, and Gly; to optimize the proportion of NaCl, KCl, and Gly considered acceptable to consumers; and to determine the emotion profile and PI associated with consuming low-sodium roasted peanuts, with and without a low-sodium health benefit message provided.

3.2 Materials and methods

3.2.1 Materials and mixture of salts

The materials used in this study were: raw, in-shell Valencia peanuts (purchased at Southside Produce Market, Baton Rouge, LA), canola oil (Great Value®, Bentonville, AR, USA), NaCl (Morton International, INC., Chicago, IL, USA), KCl-99% (FCC grade, Extracts & Ingredients, LTD., Union, NJ, USA), Glycine (Leico Medical, CAS#66-49-5, Glycine USP, 610823, Decatur, AL, USA). NaCl, KCl and Gly were the three components used in the salt mixtures. Each was passed separately through 0.0165-inch diameter sieve (U.S.A. Standard Test

Sieve; ASTM E-11 Specification; Fisher Scientific Company) to obtain homogenous particle size. The sifted NaCl, KCl and Gly were later mixed according to the specific proportions detailed in Table 3.1 and Figure 3.1.

Table 3.1 Ten formulations for mixed salts*

Formulation	%NaCl	%KCl	%Glycine
1	100	0	0
2	60	40	0
3	30	70	0
4	0	100	0
5	0	87.5	12.5
6	32	55.5	12.5
7	67.5	20	12.5
8	87.5	0	12.5
9	21	72	7
10	59	34	7

*Totaling 140mg of NaCl + KCl + Gly

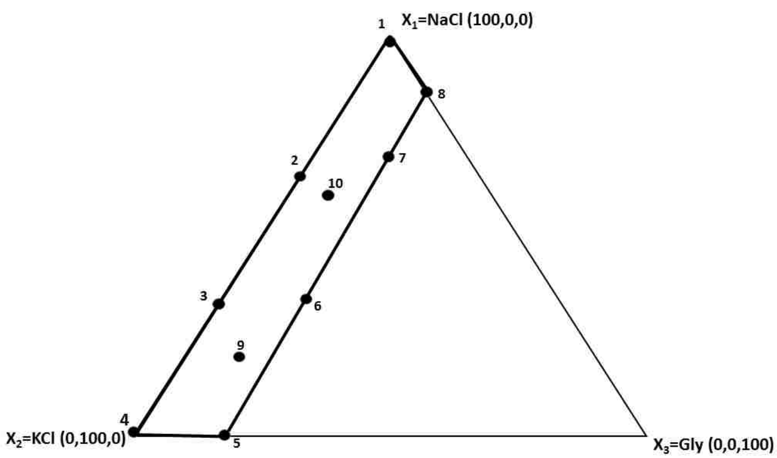

Figure 3.1 Constrained region in the simplex coordinate system (10 points=10 formulations in Table 3.1)

3.2.2 Peeling, blanching and deep frying peanuts

Peanuts were first shelled manually. The raw shelled peanuts were weighed into separate batches of 800 g each. Each batch was blanched in 7 L boiling water for 1.5 min using a kettle pot (Tramontina®, Professional Stainless Steel, 80126/527, USA), and the water was drained. The skins of the boiled peanuts were removed by hand. Seven-and-a-half L of canola oil was heated to 300ºF in a deep fryer (Frymaster, SA®, J1CSD, USA) (oil was changed after every two batches). Blanched peanuts were added to the deep fryer for 7.5 minutes, after which, peanuts were taken out, spread onto a tray and hand-sprinkled with salt mixtures while the peanuts were still warm. Peanuts were cooled to room temperature and stored in small cups to be served the next day.

3.2.3 Experimental design

The experimental design used was a three-component constrained simplex mixture design. The mixture design consisted of NaCl (X_1), KCl (X_2) and Gly (X_3), where the three component proportions summed to 1.0, or 100% (based on 140 mg NaCl+KCl+Gly). Ten formulations were obtained for use in this research (Figure 1). For this study, all formulations met "low-sodium" criteria (not more than 140mg of sodium per 50 g of sample) (21CFR101.61, CFR, 2017). A Balanced Incomplete Block Design, plan # 11.15 from Cochran & Cox (1957) (t=10, k=3, r=9, b=30, λ=2, e_2=0.74), was used where each consumer evaluated 3 samples (out of 10 formulations). Samples were randomly coded for a total of 99 replications (observations) per treatment. A total of 330 consumers were recruited for this study (b×11 = 30×11= 330 consumers).

3.2.4 Consumer testing

The research protocol for consumer testing was approved (IRB # HE15-9) by the Louisiana State University Agricultural Center Institutional Review Board. Consumer testing was conducted in the Sensory Analysis Laboratory, Animal and Food Sciences Laboratory building, Louisiana State University, Baton Rouge, LA, USA. All evaluations were performed in partitioned sensory booths with cool natural lighting. The questionnaire was electronically presented to consumers, and data were collected using Compusense® *five* (Compusense Inc., Guelph, Canada) software.

Emotion terms related to the consumption of peanuts were screened using check-all-that-apply (CATA) online survey. Emotion terms elicited by food from the EsSense Profile® (King & Meilseman, 2010) were used for the online survey, which was administered using a web link created using the QuickSurveys™ program (Toluna QuickSurveys™; Toluna SAS, Levallois-Perret, France). Emotion terms selected by at least 20% of participants were chosen for the subsequent consumer study. *Satisfied, pleased, energetic,* and *happy* were used as positive emotion terms. *Good* and *active* were not used because of similarity to *pleased* and *energetic,* respectively. *Unsafe*, *worried* and *guilty* were selected as negative emotion terms due to a possible relationship with consumption of peanuts (Desmet & Schifferstein, 2008).

After agreeing to terms outlined in a consent form, consumers were asked for demographic information and responded to general questions about knowledge of salt, salt consumption and salt substitutes. The ten different treatments shown in Table 3.1 (three per participant, based on the BIB design) were first evaluated on a 9-point hedonic scale (1-Dislike extremely, 5-Neither like nor dislike, 9-Like extremely) for liking of texture, saltiness, overall taste, and overall liking (OL). Saltiness and bitterness intensities were then evaluated on a 5-point just-about-right (JAR) scale (1-None, 2-Weak, 3- Moderate, 4-Strong, and 5-Very Strong) followed by a consumer-satisfaction question (yes/no scale) for saltiness and bitterness intensities. Emotion intensities were rated on a 5-point scale (1-Not-at-all, 5-Extremely) (King & Meiselman, 2010). Finally, consumers were asked if they would purchase the product (yes/no scale). Emotion profiles and purchase intent (PI) were evaluated twice - one before and the other after consumers were given the following low-sodium health benefit message (LSHBM): “High sodium intake is associated with heart diseases. This sample is low in sodium.”

3.2.5 Statistical analyses

All data were analyzed using SAS software 9.4 (SAS Inst. 2015). Percent frequencies were calculated for responses to general knowledge, consumer satisfaction and PI questions, and for emotion terms selected from the online survey. Analysis of variance (ANOVA) and LS-Means with the post-hoc Fisher LSD test were performed at α=0.05 significance level comparing mean differences among treatments for hedonic responses, saltiness and bitterness intensity perception, and emotion intensities. Multivariate analysis of variance (MANOVA), followed by a descriptive discriminant analysis (DDA), were used to determine attributes responsible for the underlying differences among the low-sodium peanut samples. A two-samples dependent t-test was conducted to identify significant differences between emotion scores 'before' and 'after' consumers were informed of LSHBM. The McNemar test was performed to analyze significance of changes in PI 'before' and 'after' receiving LSHBM. Logistic regression analysis (LRA) was applied to identify general knowledge questions, sensory liking attributes, and emotion terms that significantly influenced PI. Penalty (mean drop) analysis was conducted to determine if non-JAR responses for saltiness and bitterness intensities were associated with concerning mean drops in OL scores.

Response surface methodology (RSM) was used to optimize NaCl, KCl, and Gly proportions. Only those attributes and emotions contributing highly towards sample differences, with canonical correlations higher than 0.70 in the 1st canonical dimension, were included. Sensory attributes having liking scores ≥ 6 ('like slightly' on a 9-point hedonic scale) and emotion scores >2.0 ('slightly' on a 5-point rating scale) were chosen and superimposed to obtain a predicted optimum formulation range.

3.3 Results and discussion

3.3.1 General knowledge information, consumer acceptability and purchase intent

To better understand possible trends in acceptance of low-sodium products, consumers (N=330) were first asked about knowledge of NaCl and KCl, NaCl usage and willingness to reduce dietary sodium. Results are presented in Table 3.2, showing that more than 70% and 95% of the consumers had some knowledge about KCl and NaCl, respectively. A total of 86.97% of consumers reported regular use of NaCl, and 81.82% indicated willingness to reduce sodium intake in their diets after being informed that sodium is associated with cardiovascular diseases.

Table 3.2 Frequency count (%) of general information asked to consumers*

General information	Yes (%)	No (%)
Know-NaCl	95.76	4.24
Know-KCl	74.55	25.45
Consume-NaCl	86.97	13.03
Willing-to-lower-Na	81.82	18.18

* N=330 consumers

NaCl/KCl/Gly concentrations per 50g of peanuts (treatments), mean liking scores (hedonic responses) and PI are reported in Table 3.3. All treatments are considered ‘low-sodium’ (≤140mg/50g sample) according to 21CFR101.61 (CFR, 2017). Treatment 1 had the highest (though not significantly) mean liking scores for all sensory attributes (>6.47) measured, while treatments 4, 5 and 9- containing no or low amounts of sodium: 0%, 0% and 21%, respectively- yielded the lowest hedonic scores. In general, higher amounts of NaCl resulted in higher saltiness liking scores, with some exceptions. Treatment 3, for example, contained around 70% less sodium than standard ‘low-sodium’ peanuts but did not exhibit significant differences in saltiness liking scores from treatment 1 (with the highest level of sodium among all treatments). OL scores ranged from 4.84 to 6.64, with treatment 4 (100% KCl) scoring significantly lower than all other treatments. KCl has been used as a common substitute for NaCl to impart salty taste in foods without adding sodium, but is associated with bitterness and metallic off-taste at high concentrations (Albarracìn *et al.*, 2011, Cerrato Rodriguez *et al.*, 2017) and a negative association with taste liking (Torrico & Prinyawiwatkul, 2017). A similar finding in the present study may explain the lower liking of high KCl peanuts.

Table 3.3 Consumer acceptability scores$^{\beta}$ and purchase intent of low-sodium peanuts

TRT	NaCl/KCl/Gly	Na(mg)/50g peanuts*	Texture	Saltiness	Overall taste	Overall liking	PIb (%)$^{\lambda}$	PIa (%)$^{\wedge}$
1	100-0-0	138.9	6.59^{ab}	6.47^{a}	6.55^{a}	6.64^{a}	72.73	70.71
2	60-40-0	83.35	6.52^{abc}	5.84^{bc}	5.96^{b}	5.97^{bc}	56.57	57.58
3	30-70-0	41.67	6.59^{ab}	6.03^{ab}	6.08^{ab}	6.17^{abc}	60.61	65.66
4	0-100-0	0	5.73^{e}	4.95^{e}	4.77^{d}	4.84^{e}	**34.34**	**40.40**
5	0-87.5-12.5	0	6.11^{cde}	5.25^{de}	5.39^{c}	5.47^{d}	54.55	56.57
6	32-55.5-12.5	44.45	6.18^{bcd}	5.52^{cd}	5.93^{b}	5.81^{cd}	54.55	55.56
7	67.5-20-12.5	93.75	6.34^{abcd}	6.10^{ab}	6.23^{ab}	6.24^{abc}	**60.61**	**68.69**
8	87.5-0-12.5	121.55	6.62^{a}	6.33^{ab}	6.38^{ab}	6.34^{ab}	66.67	70.71
9	21-72-7	29.15	5.99^{de}	5.28^{de}	5.27^{c}	5.33^{d}	47.47	46.46
10	59-34-7	81.95	6.51^{abc}	6.17^{ab}	6.32^{ab}	6.34^{ab}	69.70	67.68
	Standard Error		0.1589	0.1802	0.1870	0.1814		

$^{\beta}$ Mean and Standard Error from 99 consumer responses based on a 9-point hedonic scale. Mean values in the same column followed by different letters are significantly different (P<0.05).
$^{\lambda}$ Statistically significant p-values in bold print (P<0.05) based on McNemar Exact probability.
$^{\wedge}$ PIb (Purchase Intent before) and PIa (Purchase Intent after), before and after, health benefit message was given to consumers. *By calculation

Higher liking scores increase willingness to purchase a product (Bower *et al.*, 2003). This trend in PI is observed in Table 3.3, where higher OL scores resulted in higher positive PI. In this study, after consumers were informed of LSHBM, PI was evaluated again. Based on the McNemar test, positive PI for treatments 4 and 7 significantly increased (from 34.34% to 40.40% and 60.61% to 68.69%, respectively) after consumers received the LSHBM. These changes support the claim that nutritional information may affect purchase decision (Tuorila & Cardello, 2002; Li *et al.*, 2015). In the present study, sodium content in peanuts was reduced from 140mg Na/50g peanuts to 41.67 mg Na/50g peanuts (treatment 3) without significantly affecting consumers' liking of the product.

3.3.2 Effect of saltiness and bitterness intensity on consumers' satisfaction and overall liking

A 5-point rating scale was used to evaluate saltiness and bitterness intensities, followed by a "yes/no" scale for saltiness and bitterness intensity satisfaction (results reported in Table 3.4). All mean scores for saltiness and bitterness intensities were between 2 (weak), and 3 (moderate). Liem *et al.* (2011) reported that higher amounts of NaCl tend to increase saltiness intensity perceptions. However, no significant differences among saltiness intensity mean scores were observed (Table 3.4). This may be attributed to additional saltiness imparted by KCl. Perceived bitterness intensity was significantly higher in treatments with a high amount of KCl (treatments 4, 5, and 9), compared to those with lower amounts. In certain foods, KCl has demonstrated less salty taste and more bitter taste than NaCl (Ambra *et al.,* 2017; Torrico *et al.,* 2015). Satisfaction responses for saltiness and bitterness intensities were reported as percent frequencies (Table 3.4), showing similar trends as observed for their respective intensities. Figure 3.2 shows the overall consumer satisfaction when consumers rated saltiness as "not enough", "JAR" or "too much", and bitterness as "none", "moderate", and "too much".

Table 3.4 Saltiness and bitterness intensity scores[λ] and satisfaction[€] of low-sodium peanuts

TRT	NaCl/KCl/Gly	Saltiness Intensity	Satisfaction (%)	Bitterness Intensity	Satisfaction (%)
1	100-0-0	2.78[NS]	71	2.14[d]	78
2	60-40-0	2.74	64	2.28[cd]	65
3	30-70-0	2.66	63	2.24[cd]	78
4	0-100-0	2.60	51	2.83[a]	45
5	0-87.5-12.5	2.55	56	2.73[ab]	63
6	32-55.5-12.5	2.61	59	2.49[bc]	66
7	67.5-20-12.5	2.75	74	2.24[cd]	73
8	87.5-0-12.5	2.72	66	2.16[d]	73
9	21-72-7	2.49	53	2.75[ab]	54
10	59-34-7	2.73	64	2.28[cd]	75
Standard Error		0.0838		0.1023	

[λ] Mean and Standard Error from 99 consumer responses based on a 5-point rating scale. Mean values in the same column followed by different letters are significantly different (P<0.05).
[€] Consumer positive satisfaction of saltiness and bitterness intensity measured on a yes/no scale after consumers rated respective intensities. [NS] No significant differences for Saltiness Intensity responses (p>0.05).

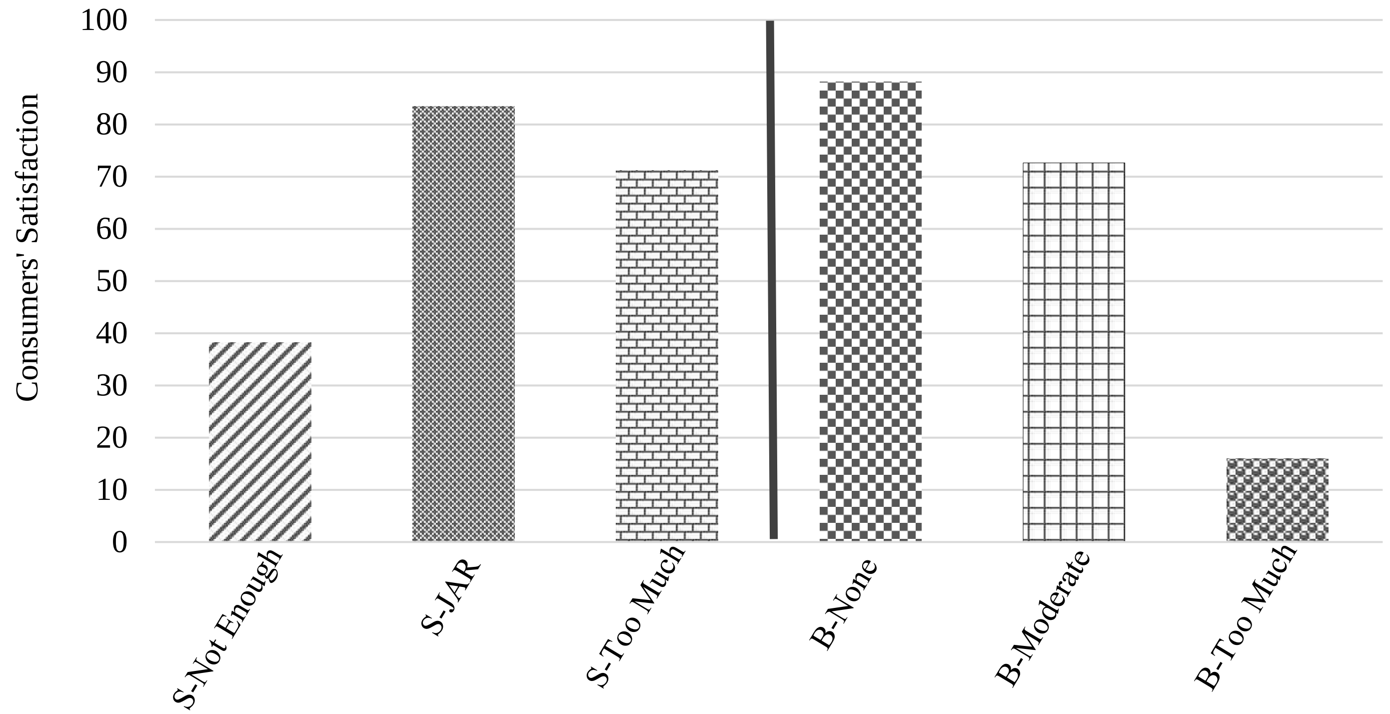

Figure 3.2 Overall frequencies (%) of consumer satisfaction (yes responses) toward intensity of Bitterness and Saltiness. S= Saltiness; B= Bitterness; JAR= Just About Right. Summary of 10 treatments.

To establish saltiness JAR categories, ratings of 'None' and 'Weak" were collapsed into the 'Not Enough' saltiness category; 'Strong' and 'Very Strong' into 'Too Much' saltiness; and 'Moderate' was designated as the 'JAR' rating for saltiness intensity. For bitterness; 'None' represented the 'JAR'/ideal category; 'Weak' and 'Moderate' were collapsed into 'Moderate' bitterness; and 'Strong' and 'Very Strong' into 'Too Much' bitterness. Collapsed saltiness and bitterness intensity categories were graphed (X axis) against corresponding consumer satisfaction frequency counts (Y axis) (Figure 3.2). In general, consumer satisfaction was higher when saltiness intensity was perceived as 'JAR' (>80% positive satisfaction rating) or 'Too Much' (>70% positive satisfaction rating). Consumers expressed less satisfaction with saltiness intensities perceived as 'Not Enough' than 'Too Much'. Congruent results can be observed among saltiness liking scores (Table 3.3), saltiness intensity (Table 3.4), and consumer satisfaction (Table 3.4), with treatments 4, 5 and 9 having the lowest mean scores for saltiness intensity and saltiness liking (4.95-5.28) and low consumer satisfaction ratings (51-53%). On the other hand, treatments with higher saltiness liking received slightly higher scores for saltiness intensity and consumer satisfaction. Although bitterness intensity was conversely related to satisfaction, 'Moderate' bitterness yielded over 70% positive satisfaction (Figure 3.2). NaCl in combination with KCl decreases perception of unpleasant bitter and metallic tastes (Sinopoli & Lawless, 2012). Satisfaction was lowest (<20%) when 'Too Much' bitterness was perceived (Figure 3.2).

Penalty (mean drop) analysis for OL scores based on saltiness and bitterness intensities are presented in Figures 3.3a (for saltiness) and 3.3b (for bitterness). Only attributes that deviated from the ideal level by more than 20% of the consumers were considered. Meaning of "mean drop" on a 9-point hedonic scale have been defined as; mean drop values from 1 to 1.49 "slightly concerning"; from 1.5 to 1.99 "concerning"; and 2.0 or greater "very concerning". Mean drop values may help consider adjusting the intensity of specific attributes on a product (Xiong & Meullenet, 2006; ASTM, 2009). Over 30% of respondents rated saltiness intensity as ‘Not Enough’ for all formulations, resulting in the largest observed OL mean drops for each treatment. More than 45% of respondents, rated treatments 4, 5, and 9 to have ‘Not Enough’ saltiness, associated with mean drops of -1.28, -1.43, and -1.17, respectively. Fewer consumers (39-41%) found treatments 2, 3, and 8 to have ‘Not Enough’ saltiness, with OL mean drops ranging from -1.31 to -1.67. These data indicate “slightly concerning penalties” for less-than-JAR saltiness levels. This is concurrent with results presented in Figure 3.2 where the ‘Not Enough’ saltiness category yielded the lowest satisfaction frequency. Although treatments 2, 3, and 8 showed “slightly concerning penalties”, their OL scores (5.97-6.34 on a 9-point hedonic scale) were all significantly higher than those for treatments 4, 5 and 9 (4.84-5.33 on a 9-point hedonic scale) (Table 3.3). Despite “slightly concerning penalties” for ‘Not Enough’ saltiness, liking scores still remained around the ‘Liked Slightly’ to ‘Liked Moderately’ levels for treatments 2, 3, and 8.

Bitterness intensity, on the other hand, showed “most concerning penalties” to OL when consumers perceived it as ‘Too Much.’ More than 20% of responses for treatments 4, 5, and 9 indicated ‘Too Much’ bitterness, resulting in concerning OL mean drops (-2.29 to -3.84). This can be attributed to the highest levels of KCl and the anticipated negative effect of its bitterness on liking (Torrico & Prinyawiwatkul, 2017). These results are also consistent with the low acceptability and PI scores for the same treatments reported in Table 3.3. For ‘Moderate” bitterness intensity, no critical or concerning mean drops were observed. In general, high bitterness and low saltiness intensities decreased liking and satisfaction.

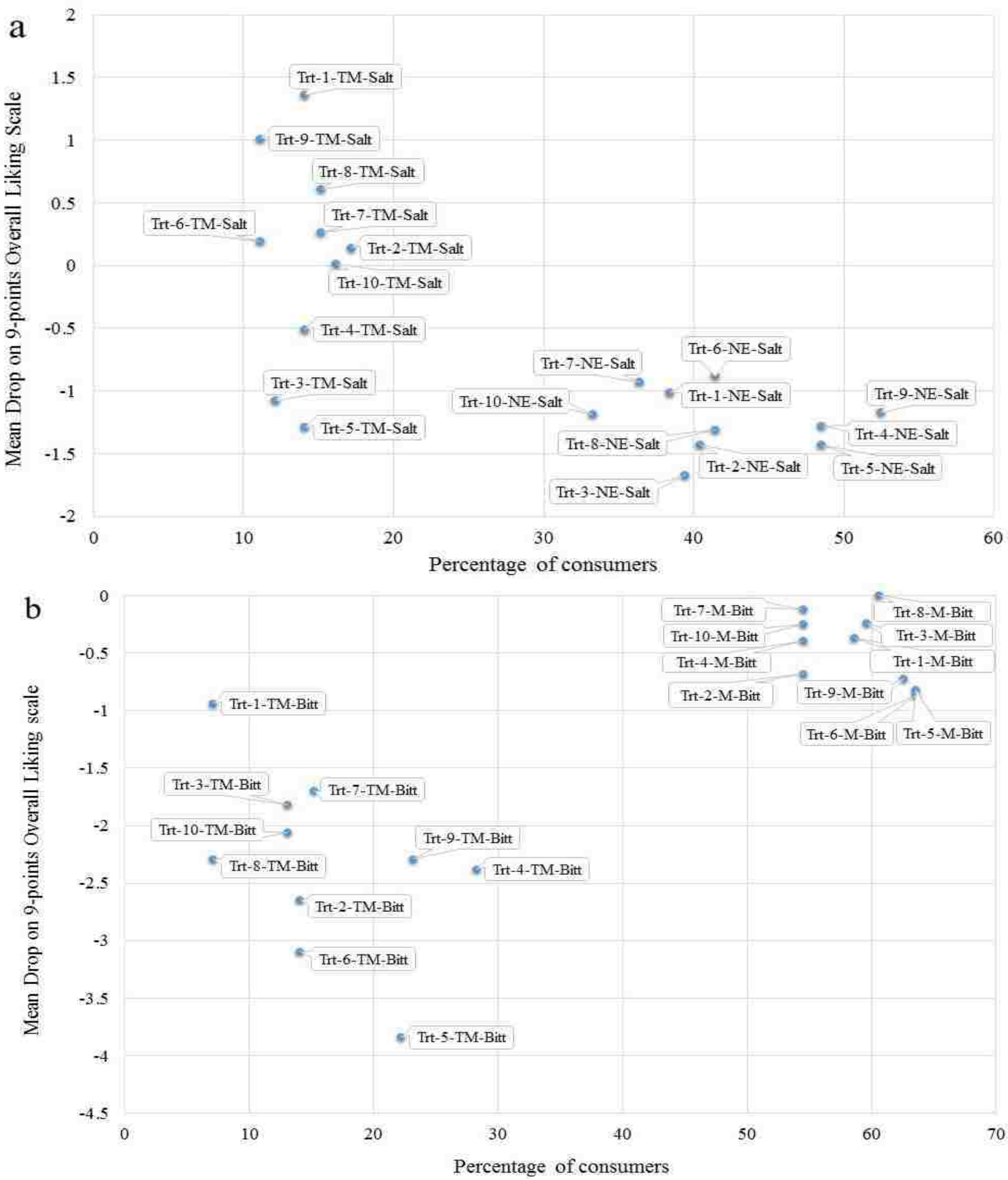

Figure 3.3 (a) Saltiness Penalty plot. NE= Not Enough Saltiness; TM= Too much Saltiness. (b) Bitterness Penalty plot. M= Moderate Bitterness; TM= Too much Bitterness.

3.3.3 Consumer emotional responses elicited by the consumption of low-sodium peanuts

Mean scores for emotions (selected from the online survey (Figure 3.4)), 'before' and' after' consumers received LSHBM, are presented in Table 3.4. Consistent with other findings (Desmet & Schifferstein, 2008; Ferrarini *et al.*, 2010), positive emotion terms were generally scored higher (1.88-2.98 'before' and 1.96-3.08 'after') than negative emotion terms (1.28-1.60 'before' and 1.16-1.42 'after') on the 5-point rating scale. Before LSHBM was presented, no significant differences in positive emotion scores were found between treatments 7, 8, and 10 (no and low KCL concentrations) and treatment 1 (100/0/0-NaCl/KCl/Gly) (Table 3.5). These results are comparable to acceptability scores (Table 3.3) where no significant effect on any of the hedonic attributes was observed comparing treatments 7, 8, and 10 to treatment 1. This demonstrates that a sodium reduction down to 81.95 mg Na/50 g peanuts (treatment 10) did not significantly affect consumer emotion or liking responses.

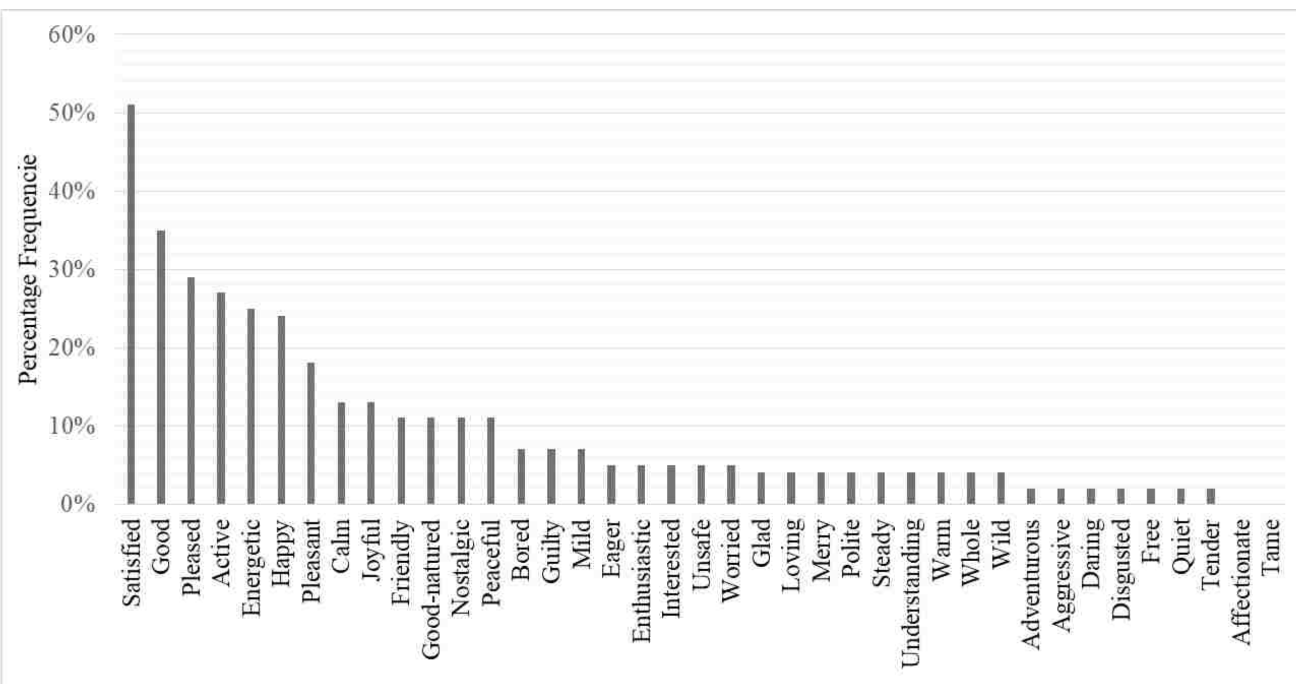

Figure 3.4 Emotion terms elicited by roasted peanuts. Online survey (N = 90 consumers)

Table 3.5 Consumer emotion scores (before and after) of low-sodium peanuts$^{\lambda}$

TRT		Energetic	Guilty	Happy	Pleased	Satisfied	Unsafe	Worried
1	Before	2.23^{NS}	1.45^{NS}	2.73^{A}	2.93^{A}	2.98^{A}	1.35^{NS}	1.29^{NS}
	After	2.37^{a}*	1.39^{NS}	2.84^{ab}	3.04^{ab}*	3.02^{ab}	1.26^{NS}	1.19^{b}
2	Before	2.09^{NS}	1.48^{NS}	2.47^{BC}	2.60^{BCD}	2.66^{B}	1.38^{NS}	1.31^{NS}
	After	2.30^{abc}*	1.39^{NS}	2.64^{bc}*	2.78^{c}*	2.81^{ab}*	1.20^{NS}*	1.22^{b}*
3	Before	1.88^{NS}	1.48^{NS}	2.40^{CD}	2.63^{BCD}	2.79^{AB}	1.30^{NS}	1.28^{NS}
	After	2.19^{abc}*	1.33^{NS}*	2.61^{bc}*	2.79^{bc}*	2.83^{ab}	1.30^{NS}	1.24^{b}
4	Before	1.91^{NS}	1.58^{NS}	2.08^{E}	2.21^{E}	2.17^{C}	1.49^{NS}	1.44^{NS}
	After	1.96^{d}	1.36^{NS}*	2.31^{e}*	2.33^{d}*	2.29^{c}	1.27^{NS}*	1.28^{ab}*
5	Before	1.95^{NS}	1.59^{NS}	2.20^{DE}	2.39^{DE}	2.39^{C}	1.37^{NS}	1.42^{NS}
	After	2.09^{cd}*	1.40^{NS}*	2.36^{de}*	2.47^{d}	2.44^{c}	1.22^{NS}*	1.27^{ab}*
6	Before	2.05^{NS}	1.60^{NS}	2.40^{CD}	2.60^{BCD}	2.65^{B}	1.42^{NS}	1.40^{NS}
	After	2.13^{bcd}*	1.38^{NS}*	2.65^{bc}*	2.80^{bc}*	2.78^{b}*	1.42^{NS}	1.41^{a}
7	Before	2.05^{NS}	1.48^{NS}	2.64^{AB}	2.77^{AB}	2.78^{AB}	1.28^{NS}	1.34^{NS}
	After	2.35^{ab}*	1.38^{NS}	2.78^{abc}*	2.90^{abc}	2.86^{ab}	1.20^{NS}*	1.16^{b}*
8	Before	2.10^{NS}	1.46^{NS}	2.59^{ABC}	2.76^{AB}	2.85^{AB}	1.28^{NS}	1.29^{NS}
	After	2.37^{a}*	1.26^{NS}*	2.90^{a}*	3.08^{a}*	3.05^{a}*	1.22^{NS}	1.21^{b}
9	Before	1.99^{NS}	1.59^{NS}	2.18^{DE}	2.44^{CDE}	2.34^{C}	1.35^{NS}	1.36^{NS}
	After	2.16^{abcd}*	1.42^{NS}	2.35^{de}*	2.43^{d}	2.41^{c}	1.35^{NS}	1.40^{a}
10	Before	2.07^{NS}	1.40^{NS}	2.53^{ABC}	2.68^{ABC}	2.74^{AB}	1.33^{NS}	1.28^{NS}
	After	2.10^{cd}	1.34^{NS}*	2.59^{cd}	2.79^{bc}	2.84^{ab}	1.22^{NS}*	1.18^{b}*
Standard Error	Before	0.0864	0.0782	0.0947	0.0991	0.0996	0.0674	0.0670
	After	0.0918	0.0671	0.0988	0.1002	0.1025	0.0598	0.0610

$^{\lambda}$ Mean and Standard Error from 99 consumer responses based on a 5-point scale per emotion term. Emotions were obtained before and after consumers had been given information about low-sodium health benefits.

$^{A\text{-}E}$ Mean values of emotions 'before' in the same column followed by different letters are significantly different ($P<0.05$)

$^{a\text{-}e}$ Mean values of emotions 'after' in the same column followed by different letters are significantly different ($P<0.05$)

* Asterisk indicates significant differences between before and after consumers had been given information about low-sodium health benefits based on a Paired t-test ($P<0.05$).

^{NS} Indicates not significant differences were observed among the treatments in that specific row (before or after) for the specific emotion term (column) ($p>0.05$).

Consumers' emotional responses may be affected by health benefit information (Canetti *et al.,* 2002). In general, positive emotion scores increased and negative emotion scores decreased after delivery of LSHBM (Table 3.5). King *et al.* (2013) reported that a mean emotional difference of ≤ 0.2 units (on a 5-point intensity scale) may not be impactful, even when statistically significant differences are observed. For *energetic*, increases of ≥ 0.2 units (0.23, 0.27, and 0.32, respectively) were only observed in treatments 3, 7, and 8. Except for treatments 1 and 10, mean *happy* scores increased significantly, but differences ≥0.2 were observed only for treatments 3, 6, and 8. *Pleased* scores for treatments 6 and 8 showed increases ≥0.2 units after LSHBM. *Satisfied* scores significantly increased for eight treatments (except treatment 4 and 10) 'after' LSHBM. Negative emotion terms tended to decrease after the LSHBM. Treatments 4 and 6 showed decreases of ≥0.2 units (0.22 and 0.24, respectively) for *guilty* scores. It may be inferred that, pertaining to consumption of roasted peanuts, a low-sodium health benefit message can increase positive emotions and decrease negative ones.

3.3.4 Overall product differences

A multivariate analysis of variance (MANOVA) was conducted to test whether treatments differed, considering separately: acceptability, emotions 'before' and emotions 'after.' Combined analysis of emotions 'before' and emotions 'after' was also conducted. The Wilks' Lambda p-value was ≤0.02 throughout, indicating an overall difference ($p<0.05$) among all treatments. Based on these results, descriptive discriminant analysis (DDA) was used to identify attributes contributing most to differences among the treatments. When only sensory attributes were considered, with 74.1% variance explained in the first canonical dimension, OL, overall taste, and saltiness contributed more (canonical correlation, cc= 0.973-0.890) to overall differences than texture (cc=0.576) (Table 3.6). These results are comparable to acceptability scores (Table 3.3), where less change in acceptability was observed for texture compared to the rest of the sensory attributes. This indicates that the salt combination treatments had more effect on taste-related attributes than texture. When emotions were evaluated separately, *satisfied* (cc=0.908), *happy* (cc=0.723), and *pleased* (cc=0.720) contributed more than other emotions to overall product differences 'before' delivery of LSHBM, with 61.5% of the variance explained in the 1st canonical dimension. In Can 2, with 77.2% variance explained, the magnitude of canonical correlation increased for *Energetic* (cc=-0.612) and decreased for the rest of the emotions. A similar trend was observed 'after' consumers received LSHBM (Table 3.6), where *satisfied* (cc=0.861), *happy* (cc=0.738), and *pleased* (cc=0.850) had a larger impact on overall treatment differences with 58.9% of variance explained in the 1st canonical dimension. In Can 2, canonical correlation increased for all negative emotions and decreased for all positive emotions. *Unsafe* (cc=0.767) and *worried* (cc=0.732) had the highest contribution to overall treatments differences with 77.3% variance explained.

In the first canonical dimension, similar trends between emotions 'before' and 'after' LSHBM, analyzed together or separately were observed (Table 3.6). *Satisfied, happy*, and *pleased* had the greatest contribution to overall product differences, with 44% of variance explained. Compared to Can 1, *unsafe* and *worried* (with 'berofe' and 'after' analyzed together) canonical correlations (cc=0.540, 0.520, respectively) increased in Can 2. With emotions 'before' and 'after' analyzed together, the magnitude of canonical correlation decreased for positive emotions, with 60.8% of variance explained in Can 2. Taste-related attributes and positive emotion terms contributed more to underlying treatments differences than did texture and negative emotions.

Table 3.6 Canonical structure r's[£] describing group differences among low-sodium peanuts

Variables	Can 1[∨]	Can 1^	Can 2[∨]	Can 2^	Can 3[∨]	Can 3^
Texture	0.576	-	0.118	-	0.715	-
Saltiness	0.890	-	-0.292	-	-0.001	-
Overall taste	0.943	-	0.299	-	0.047	-
Overall liking	0.973	-	0.115	-	0.190	-
Cumulative variance	74.1	-	86.9	-	95	-
Wilk's Lambda *P* value	<0.0001					
Energetic[B]	0.272	0.263	-0.612	-0.274	0.300	-0.230
Guilty	-0.251	-0.218	0.160	0.277	-0.012	-0.027
Happy	0.723	0.682	-0.348	-0.225	0.460	0.032
Pleased	0.720	0.672	-0.068	-0.084	0.471	0.114
Satisfied	0.908	0.856	-0.018	0.004	0.020	-0.018
Unsafe	-0.256	-0.218	-0.247	0.079	-0.177	-0.255
Worried	-0.305	-0.270	0.007	0.037	0.165	0.058
Cumulative variance	61.5	44.0	77.2	60.8	88.6	73.9
Wilk's Lambda *P* value	0.001	0.020	0.001	0.020	0.001	0.020
Energetic[A]	0.393	0.349	-0.314	-0.259	-0.496	0.189
Guilty	-0.184	-0.172	0.254	0.090	-0.108	-0.128
Happy	0.738	0.651	0.021	0.038	-0.449	0.222
Pleased	0.850	0.761	0.022	0.050	-0.165	0.099
Satisfied	0.861	0.778	-0.036	0.015	0.079	-0.028
Unsafe	-0.115	-0.129	0.767	0.540	-0.301	-0.114
Worried	-0.322	-0.310	0.732	0.520	-0.135	-0.118
Cumulative variance	58.9	44.0	77.3	60.8	89.6	73.9
Wilk's Lambda *P* value	0.003	0.020	0.003	0.020	0.003	0.020

[£] Based on the pooled within group variances.

[B] Before consumers had been given health benefits information about the product.

[A] After consumers had been given health benefits information about the product.

[∨] Calculated separately by acceptability, emotions before, or emotions after.

^Calculated from combined emotions before and after health benefits information had been given to consumers.

3.3.5 Factors affecting purchase intent predicted by logistic regression analysis (LRA)

Odds ratio estimates of PI of low-sodium roasted peanut 'before' and 'after' receiving LSHBM are presented in Table 3.7 and 3.8. Demographic information, general knowledge questions about NaCl, KCl and low-sodium, sensory attributes, and emotions 'before' were all included in the LRA model to predict PI 'before' LSHBM (Table 3.7). Gender, OL, *energetic* and *satisfied* were significant predictors of PI. Odds of purchasing low-sodium peanuts was shown to be 1.917 higher for females than males. Overall liking was significant such that a 1-unit increase in OL (on a 9-point hedonic scale) increased odds of purchase by 519.0% (odds ratio=5.190). This substantiates results relating higher OL to higher positive purchase decision (Table 3.3). A 1-unit increase (on a 5-point rating scale) in *energetic* and *satisfied* intensity increased odds of positive purchase intent by 1.374 and 1.488 times, respectively.

Table 3.7 Odds ratio estimates of consumers' purchase intent (before)[€] of low-sodium peanuts

Parameters	Pr > ChiSq*	Odds ratio
Gender	**0.0035**	**1.917**
Education	0.3238	0.586
Know NaCl	0.1074	2.609
Know KCl	0.4295	0.805
Consume NaCl	0.2449	0.701
Lowering Na	0.3065	0.753
Texture	0.0725	0.836
Saltiness	0.8123	0.976
Overall taste	0.9904	1.002
Overall liking	**< 0.0001**	**5.190**
Energetic	**0.0312**	**1.374**
Guilty	0.8925	1.024
Happy	0.8981	0.977
Pleased	0.5487	1.125
Satisfied	**0.0202**	**1.488**
Unsafe	0.8690	0.958
Worried	0.5547	0.856

*Statistically significant p-values in bold print (P<0.05).

€ Purchase intent asked **before** consumers had been given low-sodium health benefits.

For predicting PI 'after' consumers received LSHBM, demographics, general knowledge questions about NaCl, KCl and low-sodium, and emotions 'after' were included in the LRA (Table 3.8). Sensory attributes and acceptability were not considered, as they were not evaluated after providing the LSHBM. Gender remained a significant predictor (odds ratio= 1.946) of PI, where women were even more likely than men to report willingness to buy the product after LSHBM. *Energetic* became an insignificant predictor after LSHBM, but *satisfied* became more significant (odds ratio= 2.359). With a 1-unit increase in *satisfied* intensity, expected odds of purchasing low-sodium peanuts would be 2.359 time higher. *Pleased* was also a significant predictor of PI after consumers had been given LSHBM (odds ratio= 2.105). Based on these results (Table 3.8), odds of buying the product would be 2.105 times higher when *pleased* score is increased by one unit on a 5-point scale. After LSHBM, general knowledge about NaCl and KCl both became significant predictors of PI. For consumers who reported knowledge of NaCl, odds of buying the product were 2.440 times higher than for those who did not. On the other hand, when consumers reported some knowledge of KCl, odds of purchase were 0.645 times lower compared to those without knowledge of KCl, indicating some negative perception of KCl.

Table 3.8 Odds ratio estimates of consumers' purchase intent (after)[€] of low-sodium peanuts

Parameters	Pr > ChiSq*	Odds ratio
Gender	**0.0001**	**1.946**
Education	0.7463	0.873
Know NaCl	**0.0348**	**2.440**
Know KCl	**0.0301**	**0.645**
Consume NaCl	0.7060	0.912
Lowering Na	0.3305	0.810
Energetic	0.0860	1.222
Guilty	0.0756	0.777
Happy	0.4396	0.893
Pleased	**<0.0001**	**2.105**
Satisfied	**<0.0001**	**2.359**
Unsafe	0.7131	1.088
Worried	0.0754	0.654

*Statistically significant p-values in bold print ($P<0.05$).
[€] Purchase intent asked **after** consumers had been given low-sodium health benefits.

3.3.6 Sensory and emotion optimization of low-sodium peanuts

Response surface methodology was used to determine optimum salt and glycine combinations to obtain an acceptable low-sodium roasted peanut formulation. The optimal formulations were determined by superimposing a lower limit of '6' (on 9-point hedonic scale) for sensory attributes: saltiness, overall taste and OL, and lower limit of '2' (on 5-point scale) for selected emotions: *happy*, *pleased* and *satisfied* (score before and after LSHBM were included). Using the superimposed criteria, an optimization area containing treatments 1, 2, 7, 8, and 10 was obtained (Figure 3.5). It indicates that, any formulation within the range of 59-100/0-40/0-12.5 (%) of NaCl/KCl/Gly, respectively, will generate an acceptable product for consumers. Relating this to the actual Na content, it means that without significantly affecting liking and positive emotion scores, sodium content was decreased from 140 mg down to 81.95 mg/ 50 g of peanuts. This represents an additional 37% reduction past the minimum 'low-sodium' criteria.

3.4 Conclusion

Results from this research evidenced that different concentrations of NaCl, KCl, and Gly in low-sodium roasted peanuts had an effect on consumers' liking, emotional responses, and PI. No significant differences were observed among perceived saltiness intensity scores (based on a 5-point scale) among the ten treatments. Consumers expressed higher satisfaction when saltiness intensity was perceived as 'JAR' or 'Too Much', compared to 'Not Enough.' As perceived bitterness intensities increased, positive satisfaction decreased. In general, positive emotions were scored higher than negative ones. After LSHBM was provided to consumers, positive emotion terms tended to increase and negative emotion terms tended to decrease. Taste-related attributes and positive emotion scores had higher contribution toward overall product differences. Gender, OL, previous knowledge of NaCl and KCl, and the emotions *satisfied* and *pleased* were significant predictors of PI. Based on optimization data, a 37% sodium reduction past the minimum required level for “low-sodium” claim can yield acceptable low-sodium roasted peanuts without affecting liking or positive emotions.

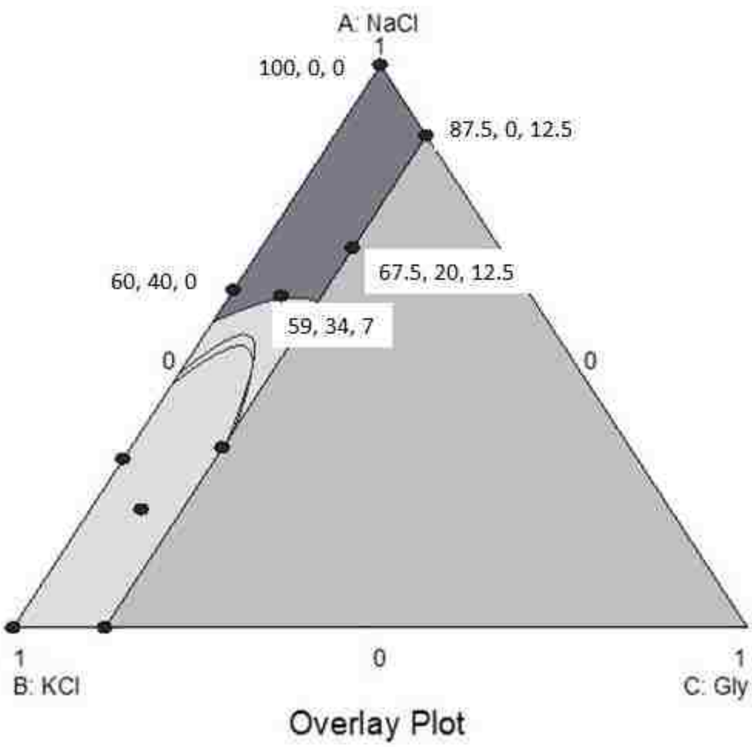

Figure 3.5 The optimization plot based on acceptability responses (scores >6 for Saltiness, Overall taste, and Overall liking) and positive emotion terms asked before and after consumers had been given information about health benefits of the product (scores >2).

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CHAPTER 4. REJECTION THRESHOLD OF KCL ADDED IN ROASTED PEANUTS

4.1 Introduction

Perceived food flavor is an integration of multiple sensory stimuli and is a key aspect in consumers' food choices and acceptance (Lawrence *et al.,* 2009). It is well known that sodium chloride (common salt) is the usual stimulus providing salty taste (Dötsch *et al.,* 2009). However, the global prevalence of cardiovascular diseases and hypertension is linked to overconsumption of dietary sodium (Toldrá & Barat, 2009). Potassium chloride (KCl) is an effective alternative to replace traditional salt and reduce sodium in processed foods. Major reasons for rejection of low-sodium products containing KCl are bitter and metallic aftertastes imparted at high KCl concentrations (Morris *et al.,* 2010; Cruz *et al.,* 2011), or when NaCl is substituted above 30-40% using only KCl (Tamm *et al.,* 2016).

Our previous research demonstrated the feasibility of producing acceptable low-sodium roasted peanuts containing up to 70% KCl substitution for NaCl. Nevertheless, consumers usually rate low-sodium products as "not salty enough." Proper addition of KCl to low-sodium products could potentially increase saltiness perception without increasing sodium content in food (Stanley *et al.,* 2017). The majority of research concerning low-sodium products aimed to address sensory liking and development of acceptable new products (Chau *et al.,* 2017; Felicio *et al.,* 2016). However, the specific KCl concentration at which consumers start to reject low-sodium samples (roasted peanuts, in this study) has not been established.

The Rejection Threshold (RjT) of a compound in a specific food is determined by product evaluations at increasing concentrations of the compound, against a control, to identify the level at which preference is diminished. Using this approach, Prescott *et al.* (2005) measured TCA RjT in wine samples, and Harwood *et al.* (2012) evaluated added bitterness flavor in chocolate. The technique aimed to determine the RjT using a standard paired preference test with a constant stimuli threshold methodology (Prescott *et al.*, 2005).

Liking of a food is a hedonic reaction; it is an affective response based on personal evaluation of the product (Berridge, 2009). From the early stages in life, taste is highly involved in acceptance or rejection pf foods, and people usually exhibit innate dislike of bitterness and show preference for sweetness (Steiner *et al.*, 2001). Specific sensory characteristics can distinguish one product from others. During consumption, consumers also experience a variety of emotions elicited via their interaction with different properties of the product (Jordan, 2000). These emotional responses have been shown to play an important role in the product-consumer experience (Prescott, 2017), and may determine rejection or acceptance of a food (Piqueras-Fiszman & Jaeger, 2014).

Peanut kernels are considered an inexpensive source of protein in many cultures (Yeh *et al.*, 2002). Peanuts do not contain high amounts of natural sodium. Nevertheless, the crop is most commonly consumed roasted and salted. After roasting and salting, sodium content may increase to 200-450mg Na/50g of peanuts (USDA, 2016). This study aimed to identify the amount of added KCl sufficient to yield consumer rejection of low-sodium roasted peanuts, based on overall taste; and to evaluate changes in overall liking, emotional magnitude responses, and purchase intent associated with increasing KCl levels.

4.2 Materials and methods

4.2.1 Materials and sample preparation

Raw in-shell Valencia peanuts were purchased at Southside Produce Market (Baton Rouge, LA). Canola oil (Great Value® Bentonville, AR, USA), sodium chloride (NaCl) (Morton International, INC., Chicago, IL, USA), and potassium chloride (KCl-99%) (FCC grade, Extracts

& Ingredients, LTD., Union, NJ, USA) were used for sample preparation. Peanuts were first manually shelled. Raw shelled peanuts were weighed into separate 800g batches. Each batch was blanched in 7 L boiling water (~212ºF) for 1.5 min using a kettle pot (Tramontina®, Professional Stainless Steel, 80126/527, USA). Water was drained, and boiled peanuts were hand-peeled to remove the skins. Seven-and-a-half L canola oil was heated to 300ºF in a deep fryer (Frymaster, SA®, J1CSD, USA). Blanched peanuts were placed in the deep fryer for 7.5 minutes, removed and spread onto a tray, and hand-sprinkled with salt mixtures while the peanuts were still warm. Peanuts were cooled to room temperature and stored in small 2-oz cups to be served the next day. Oil was changed after every two batches.

4.2.2 Experimental design

The amount of NaCl addition was fixed for all treatments (138.9 mgNa/50g peanuts), based on previous studies in our laboratory. Low-sodium (no more than 140mg of sodium per 50 g of sample, 21CFR101.61) roasted peanut treatments were prepared at increasing KCl concentrations of 30, 50, 70, and 90 % of the fixed NaCl amount. A control sample containing no KCl (0%) was also prepared. Each KCl concentration was evaluated in duplicate against the control, resulting in a total of eight sample-pairs (0-30, 30-0, 0-50, 50-0, 0-70, 70-0, 0-90 and 90-0) (Table 4.1). Two pairs of samples were served per session (a total of four samples per session) - each pair having one control and one treatment sample. Samples were coded with different 3-digit numbers in each pairing to avoid bias.

Table 4.1 NaCl and KCl concentrations used in the low-sodium roasted peanuts.

Treatment/order*	1	2	3	4
NaCl $^{\beta}$	2.778g	2.778g	2.778g	2.778g
KCl concentration$^{\Omega}$	30%	50%	70%	90%

*All KCl concentrations were served two times to each consumer. Each treatment had 139mg Na/50 g of roasted peanuts (by calculation).
$^{\beta}$ Amount of NaCl added represents 0.70% of the total product formulation and is considered "low-sodium". Based on previous studies. $^{\Omega}$ Percentage of KCl was based on total NaCl content.

4.2.3 Sensory analysis

A total of 60 consumers between 18 and 64 years of age, with no peanuts allergy, were recruited for this study. All identified themselves as regular consumers of peanuts and voluntarily agreed to participate in the study. No compensation was offered for participation. Each consumer was required to complete eight different testing sessions. An introductory meeting was conducted to inform participants about the evaluation procedures, collect demographic information, and complete consent forms prior to sample evaluation.

The research protocol for consumer testing was approved (IRB # HE15-9) by the Louisiana State University Agricultural Center Institutional Review Board. All testing was conducted in the Sensory Analysis Laboratory in the Animal and Food Sciences Laboratory Building at Louisiana State University, Baton Rouge, LA, USA. Sample evaluations were performed in partitioned sensory booths with cool natural lighting. The questionnaire was electronically presented to consumers and data collected using Compusense® *five* (Compusense Inc., Guelph, Canada) software.

4.2.4 Overall liking, JAR, emotion profile, and purchase decision

Instructions for the JAR test were provided to consumers to rate the saltiness and bitterness intensity of samples on a 3-point JAR scale. For saltiness, descriptors 'not salty enough,' 'just about right,' and 'too salty' were used; 'not bitter,' 'moderately bitter,' and 'too bitter' were used for bitterness. Following the JAR evaluation, emotional profile was assessed. Emotion terms related to the consumption of peanuts were screened using check-all-that-apply (CATA) online survey. Emotion terms elicited by food from the EsSense Profile® (King & Meilseman, 2010) were used for the online survey, which was administered using a web link created using the QuickSurveys™ program (Toluna QuickSurveys™; Toluna SAS, Levallois-Perret, France).

A total of seven prescreened (via the online survey, N=80) emotion terms, four positive (*Energetic*, *Happy*, *Pleased*, and *Satisfied*) and three negative (*Guilty (health related), Unsafe (health related), Worried (health related)),* were used. Consumers evaluated each emotion on a 5-point scale [1-Not at all, 2-Slightly, 3-Moderately, 4-Very much, 5-Extremely]. Overall liking of the product was measured using a 9-point hedonic scale. Finally, willingness to purchase the product was reported using a yes/no scale.

4.2.5 2-AC – Consumer Rejection Threshold (CRT) procedure

Rejection Threshold (RjT) of added KCl was performed using the 2AC method. All KCl concentrations were evaluated in duplicate and were presented in an ascending order. For each evaluation of the CRT, consumers tasted samples (from left to right) and reported which of the two was more preferred based on overall taste (a "no preference" option was included). Samples were served in a balanced arrangement within each session (ISO Standard 5495).

4.2.6 Statistical analyses

Analysis of Variance (ANOVA) and LS-Means with the post-hoc Fisher LSD test were performed at α=0.05 significance level, comparing mean differences among treatments for overall liking responses and emotion magnitude scores (using SAS software 9.4 (SAS Inst., 2015)). Penalty (mean drop) analysis was conducted to determine if non-JAR responses for saltiness and bitterness intensities were associated with concerning mean drops in OL scores. Criteria for the rejection point as a function of added KCl was based on the Thurstonian 2-AC tables (Ennis & Ennis 2001-IFPress 2010-) at the specific observed "no difference" proportion (%) for each section.

4.3 Results and discussion

4.3.1 Acceptability and purchase intent (PI)

Table 4.2 shows consumer acceptability scores and PI of the samples. As mentioned, all samples are classified as "low-sodium" according to the 21CFR101.61 (2017) regulations. The fixed amount of NaCl added was 2.778g (per batch of peanuts) which represents approximately 140mg Na/ 50g peanuts, and increasing KCl concentrations were added as shown in Table 4.1.

Table 4.2 Consumer acceptability scores and purchase intent (PI) of low-sodium roasted peanuts

TRT	NaCl content[µ]	% KCl added[µ]	Na (mg)/50g peanuts*	Overall liking	PI (%)
1	2.778g	0	138.9	6.33[a]	64.42
2	2.778g	30	138.9	6.20[ab]	64.23
3	2.778g	50	138.9	6.11[ab]	55.28
4	2.778g	70	138.9	5.84[b]	54.92
5	2.778g	90	138.9	5.80[b]	55.37
Standard Error			Trt 1	0.07	
			Trt 2,3,4,5	0.15	

[a-b] Mean values overall liking in the same column followed by different letters are significantly different ($P<0.05$)
[µ]The amount of NaCl added represents 0.70% of the total product formulation. All samples are considered "low-sodium". Percentage of KCl added was based on total NaCl content in the samples. *By calculation

In the present study, mean overall liking scores ranged from 5.8 to 6.2 (on a 9-point hedonic scale) and showed an inverse relationship with KCl concentration (Table 4.2)- the lower the KCl amount, the higher the mean OL scores (Table 4.2). Treatment 1 (no KCl added) exhibited the highest OL (6.33), while treatments 4 and 5 (70 and 90% KCl, respectively) had the lowest OL scores (5.84 and 5.80, respectively), which were statistically different from treatment 1. Despite the lower scores for higher KCl treatments, consumers did not express dislike of these samples (all liking scores above 5 on the 9-point hedonic scale).

Positive PI is also presented in Table 4.2. PI is highly dependent on overall liking. All positive PI frequencies were above 50%. For all treatments, more than 55% of consumers showed willingness to purchase the products. Treatments 1 and 2 (0 and 30% KCl) had the highest positive purchase intent, with 64% of consumers indicating willingness to buy the product.

4.3.2 Emotions

To identify emotions associated with consumption of roasted peanuts, an online screening was initially conducted using emotion terms listed by the EsSense Profile ® (King & Meilseman, 2010). Those terms selected by more than 20% of participants were used in the consumer study. In the consumer study, emotion intensities were rated on a 5-point scale. Scores for all treatments are presented in table 4.3.

Among all treatments, scores of positive emotions *energetic*, *happy*, and *pleased* did not show statistical differences. On the other hand, *satisfied* was scored significantly lower for treatments with higher KCl levels. Comparing *satisfied* scores for treatment 5 (2.51) to treatments 1 (2.81) and 2 (2.91), differences of 0.30 and 0.40 points, respectively, were observed. Statistical significance indicated that consumers felt more *satisfied* after tasting treatments containing ≤ 30% KCl addition (based on amount of added NaCl. Overall, mean positive emotion scores were above 2 (on a 5-point scale) for all the samples tested.

Negative emotion terms *guilty*, *unsafe,* and *worried* were also evaluated. Treatment 1 (no KCl) scored lowest across all negative emotions, compared to treatments containing KCl. Without exception, *unsafe* and *guilty* scores were significantly higher for treatments with added KCl, compared to treatment 1 (no KCl added). KCl imparts bitter taste when added to food products (Frank & Mickelsen, 1969; Toldrá & Barat, 2012). Bitter taste perceived by consumers significantly increase negative emotional responses. Historically, bitterness has been related to the presence of toxins in food products and is also associated with medicines (Beauchamp, 2016). This may explains why consumers scored negative emotion terms higher for samples containing added KCl.

Table 4. 3 Consumer emotion scores of low-sodium roasted peanuts $^{\lambda}$

TRT	% KCL	Energetic	Guilty	Happy	Pleased	Satisfied	Unsafe	Worried
1	0	2.22^{NS}	1.45^{b}	2.67 ^{NS}	2.79 ^{NS}	2.81^{a}	1.36^{b}	1.40^{b}
2	30	2.17	1.72^{a}	2.70	2.82	2.91^{a}	1.51^{a}	1.57^{a}
3	50	2.26	1.67^{a}	2.61	2.67	2.74^{ab}	1.52^{a}	1.51^{ab}
4	70	2.07	1.68^{a}	2.46	2.6	2.58^{b}	1.53^{a}	1.52^{ab}
5	90	2.17	1.68^{a}	2.47	2.54	2.51^{b}	1.60^{a}	1.66^{a}
Standard Error	Trt 1	0.06	0.04	0.05	0.05	0.05	0.04	0.04
	Trt 2,3,4,5	0.11	0.09	0.10	0.10	0.10	0.07	0.08

$^{\lambda}$ Mean and Standard Error from 122 (Trt 2, 3, 4, 5) and 488 (Trt 1-Control) consumer responses based on a 5-point scale per emotion term.
$^{a-b}$ Mean values of emotions in the same column followed by different letters are significantly different (P<0.05)
^{NS} No significant differences were observed among the treatments (P>0.05).

4.3.3 Penalty analysis

Saltiness and bitterness intensity was evaluated using a 3-point JAR scale. When the optimal level of a compound is not met, overall liking scores of the product may be negatively affected (Popper *et al.*, 2004). Figure 4.1 shows mean drops in overall liking scores when saltiness (a) intensity and bitterness (b) intensity levels were not perceived as ideal. Overall liking scores for samples 2, 3, 4 and 5 were negatively affected by non-JAR saltiness intensities. Mean drops in OL ranged from -1.74 to -2.19 units on a 9-point hedonic scale when consumers perceived samples 2, 3, 4, and 5 as “too salty” (representing more than 23% of responses). A decrease ≥ 1 units in the overall liking score is usually considered a concerning drop (Xiong & Meullenet, 2006). These results demonstrate the negative impact on overall liking scores when samples were perceived as “too salty”. Sample 1 (control with no KCl added) was perceived as “not salty enough” by 26% of consumers, decreasing overall liking scores by 1.52 units on the 9-point hedonic scale. One objective of this research was to effectively increase saltiness perception by increasing KCl concentration in the samples- without increasing sodium content. Saltiness JAR results show that increasing the amount of added KCl in low-sodium roasted peanuts may increase saltiness perception. Still, more research is needed to identify an optimal KCl level that would yield a "just right" saltiness intensity in low-sodium roasted peanuts.

As previously mentioned, one of the main concerns when decreasing sodium content in a food by the addition of KCl is bitter taste (Toldrá & Barat, 2012). This perceived bitter taste from KCl is usually associated with less acceptability of low-sodium products. In Figure 4.1 (b), a bitterness penalty plot (mean drops in overall liking when bitterness intensity did not meet the ideal level) is presented. Based on obtained results, less than 10% of consumers detected "too bitter" intensity in the samples. The upper right corner of the graph represents some "slightly concerning mean drops" on the 9-point overall liking scale when "moderately bitter" intensity was perceived (>25% of the consumers). Mean drops ranged from 0.94 to 1.39 units when samples were considered "moderately bitter." Bitter taste was expected due to the addition of KCl. Nevertheless, these results show that none of the samples had "very concerning" penalties based on "too bitter" intensity.

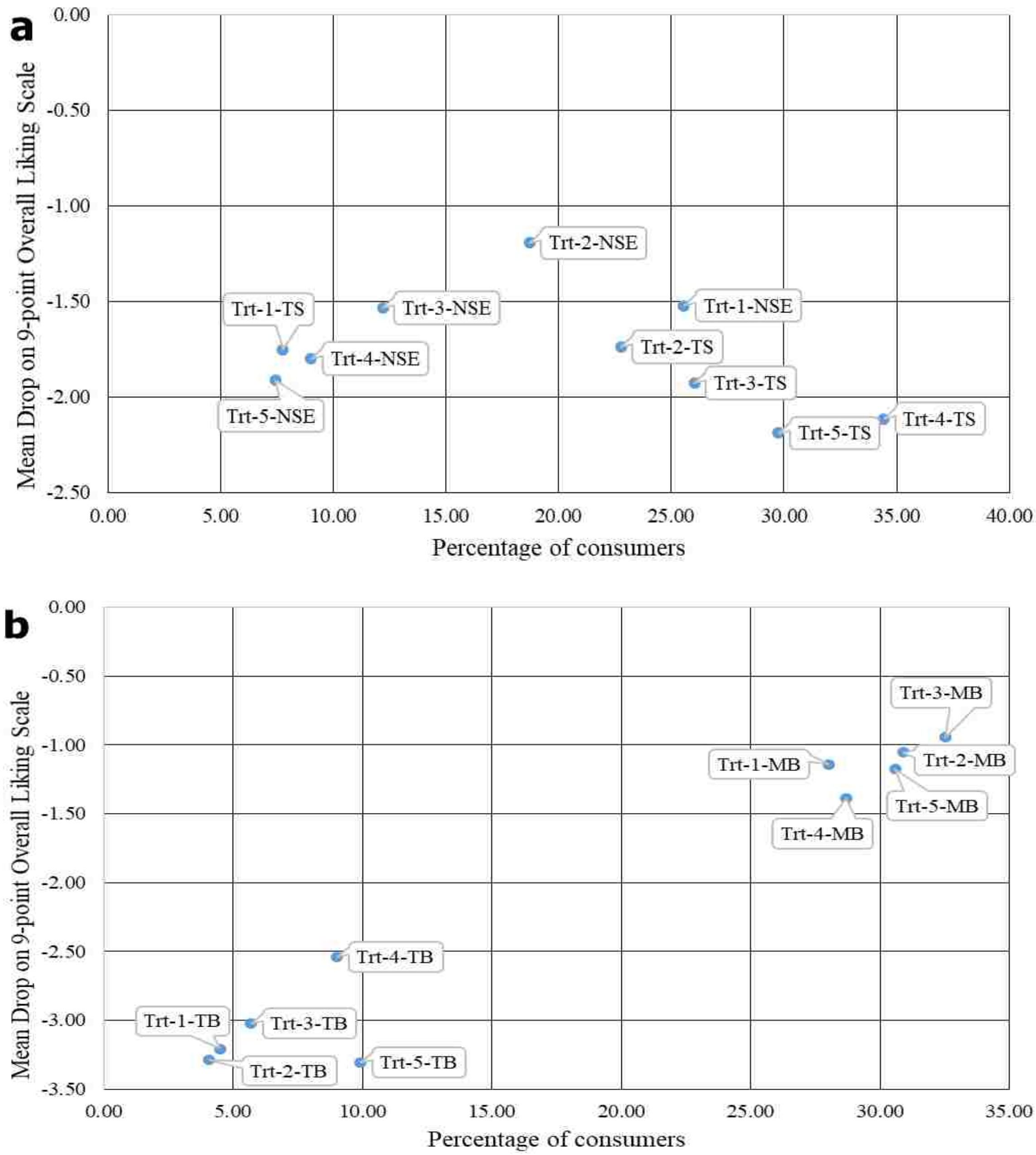

Figure 4.1 (a) Saltiness Penalty plot. NSE= Not Enough Saltiness; TS= Too Salty. (b) Bitterness Penalty plot. MB= Moderately Bitter; TB= Too Bitter (% KCl/sample = T1:0; T2:30; T3:50; T4:70; T5:90)

4.3.4 Rejection threshold

In Figure 4.2, the proportion of consumers preferring control samples (y axis) is plotted against the increasing KCl concentrations (x axis). The Thrustonian 2-AC model was used with a 5% significance criterion. These data were an average of both replicates. Nevertheless, significance was analyzed at the 5% level for all individual (N=62) and combined replicates (N=124) to confirm the results. The Thrustonian 2-AC tables (α=0.05) were used to determine if the number of consumers selecting control samples was statistically significant to achieve a KCl rejection threshold level in the low-sodium roasted peanut samples. The 2-AC method with a "no preference" option is desirable to allow for accurate reporting of equal preference between two samples, and for proper treatment of these data points. Under the conditions of this study, without exception, the "equally preferred" option was only selected by fewer than 19% of consumers.

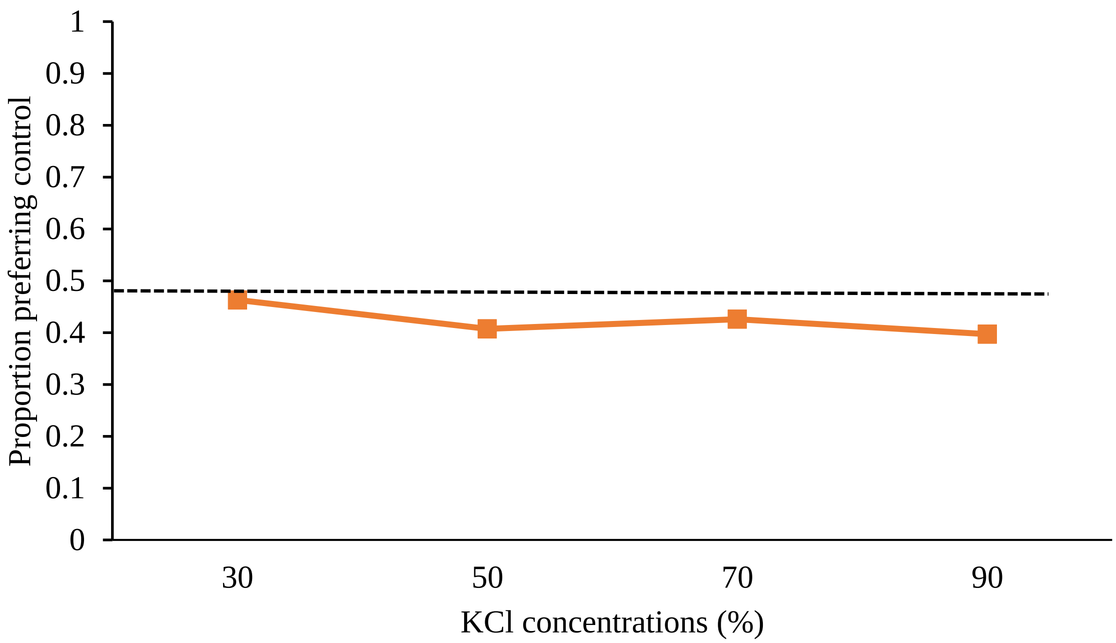

Figure 4.2 Proportion of consumers preferring control samples. Each point represents a duplicate 2-AC preference test with a no-preference option. A 5% significance criterion was used for the Thrustonian 2-AC model

After analyzing all responses and comparing test-values to the critical values obtained from the 2-AC Thrustonian tables (minimum of responses required), none of the treatments, containing increasing levels of KCl, were rejected by consumers. Even though no statistically significant KCl RjT was found in this study, overall liking scores did tend to decrease with increasing KCl addition, as depicted in Table 4.2. The maximum amount of salts (NaCl and KCl) used in the samples represent 1.30% of the total formulation (by weight of final product). Hence, due to the low amounts of KCl used, perceived bitterness intensities were not sufficient to make the products unacceptable. Further research is needed to see how consumers evaluate other types of low-sodium products following the same procedure applied to this research.

4.4 Conclusion

Addition of KCl to low-sodium roasted peanuts showed a significant impact on overall liking responses and negative emotional responses. With increasing concentration of KCl in the samples, consumers expressed less satisfaction (*satisfied* emotion) and higher levels of negative *guilty*, *unsafe*, and *worried* emotions. When more than 30% of KCl (as a proportion of NaCl amount) was added, consumers perceived samples as "too salty," producing mean drops in overall liking scores $\geq$ 1.74. Bitterness was not of high concern to overall liking scores. Under the conditions of this study, no RjT for added KCl was found in low-sodium roasted peanuts.

4.5 References

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CHAPTER 5. CONSUMER PERCEPTION, EMOTION AND PURCHASE INTENT OF MAYONNAISE-TYPE SPREADS AS AFFECTED BY NUTRIENT CLAIMS FOR SODIUM CONTENT (LOW-SODIUM, REDUCED SODIUM, AND SODIUM FREE)

5.1 Introduction

Salts influence flavor, texture, and shelf-life of food products and are the most used food additive worldwide (Heshmati, 2014). The most commonly used salt in food is sodium chloride (NaCl). Sodium chloride is also the main dietary source of sodium. As a flavoring agent, salt enhances desirable flavors in food while imparting a salty taste. Salt has also been shown to suppress bitterness perception (Breslin & Beauchamp, 1997).

In the United States, processed (65%) and restaurant foods (25%) account for most of the sodium consumed. A diet high in sodium is associated with elevated blood pressure, increasing the risk of cardiovascular disease and stroke (CDC, 2015). Evidence also links excessive sodium intake to kidney disease, osteoporosis, and stomach cancer (He & MacGregor, 2009). These health-risks associated with sodium overconsumption have made reduction of sodium in the American diet a public health priority (CDC, 2015). He & MacGregor (2009) suggested that a gradual and sustained reduction in the amount of salt added to products by the food industry can help with dietary sodium reduction. Proposed sodium reduction strategies for the food industry include stealth reduction, saltiness potentiation, multisensory application, physical modification of salt crystals, and sodium replacement (Kuo & Lee, 2014). One approach to sodium replacement is the use of a “salt substitute” such as potassium chloride (KCl). A common drawback to the replacement of NaCl in foods with KCl is that people find potassium chloride to have a bitter taste and metallic and chemical aftertastes (Torrico & Prinyawiwatkul, 2015; Sinopoli & Lawless, 2012).

Mayonnaise is simply a mixture of oil, egg, vinegar, and spices. This emulsion is one of the most used sauces across the world. In North America, mayonnaise is typically used as a sandwich spread (Garcia *et al*., 2009). As a sauce, mayonnaise is used to enhance or modify the flavor of other foods, and along with salad dressings, constitute much of the semi-solid food market (Ma & Boye, 2013). The standard identity for mayonnaise in the United States requires that the product contain at least 65% vegetable oil by weight (21CFR169.140). Increased consumer awareness of and concern about health risks due to overconsumption of ingredients such as fat, sodium, and cholesterol have led to development of healthier versions of mayonnaise and mayonnaise-type products. This interest in alternative formulations presents a challenge to product developers to formulate spreads that consumers find acceptable in regards to flavor and texture while meeting market demand for healthier products (Garcia *et al*., 2009; Ma & Boye, 2013). As described by King & Meiselman (2010), food affects the way we feel. Studies of the relationship between food and emotion can focus on: effects of people's emotions on food preferences and behavior, or the effect of food consumption on emotions experienced. Additionally, Desmet & Schifferstein (2008) pointed out direct sources (e.g., sensory characteristics) and indirect sources (e.g., anticipated health benefits) of food emotions. Mayonnaise is an oil-in-water emulsion. Findings from Torrico *et al*., (2015) indicate that, compared to aqueous solutions, oil-in-water emulsions exhibited bitterness-suppressing effects on KCl. Thus, the oil-in-water emulsion food system may lend itself to an effective use of KCl as a substitute for sodium chloride.

The objectives of this study were to evaluate the effect of salty and bitter taste (from NaCl and KCl), liking, and sodium claims on purchase intent (PI) of mayonnaise-type spreads, to evaluate emotional responses to sodium claims and their effect on PI of mayonnaise-type spreads, and to select an acceptable spread formulation to further evaluate it with flavor addition.

5.2 Materials and methods

5.2.1 Materials and mixture of salts

Five mayonnaise-type spreads were prepared according the formulations in Table 5.1. Each formulation was associated with a sodium claim (low-sodium, reduced sodium, standard recipe, or sodium free) based on the concentration of NaCl in the product. Soybean oil (Great Value™, Wal-Mart Stores, Bentonville, AR USA) and water were used as a base of the oil-in-water emulsions. Distilled white vinegar (Great Value™, Wal-Mart Stores, Bentonville, AR, USA) was used as an acidifier. Powdered whey protein concentrate (Grande Bravo® 500, Grande Custome Ingredients Group, Lomira, WI, USA) was used as an egg-replacer and for viscosity development. A commercial hydrocolloid mix (Tic Saladizer® 243 M Powder [modified corn starch, modified tapioca starch, guar gum, xanthan gum, and gum acacia]; Tic Gums Inc, Belcamp, MD USA) was used for thickening and stabilization of the emulsion. Sodium chloride (Morton Iodized Salt; Morton Salt, Inc., Chicago, IL USA) or KCl-99% (FCC grade, Extracts & Ingredients, LTD., Union, NJ, USA) was added to provide salty taste to the spreads.

Table 5.1 Mayonnaise-type spread Formulations

	Percent by Weight						
Treatments	**Oil**	**Vinegar**	**WPC**	**Gum**	**Water**	**NaCl**	**KCl**
1- Low-sodium	65%	8.90%	5.4%	0.75%	19.45%	0.5%	-
2- Reduced Sodium	65%	8.90%	5.4%	0.75%	18.95%	1.0%	-
3- Standard Recipe	65%	8.90%	5.4%	0.75%	18.45%	1.5%	-
4- Sodium Free (Lower Potassium)	65%	8.90%	5.4%	0.75%	18.95%	-	1.0%
5- Sodium Free (Higher Potassium)	65%	8.90%	5.4%	0.75%	17.95%	-	2.0%

Ingredients were weighed with an Ohaus Precision Standard balance (model TS4KS; Ohaus Corporation, Florham Park, NJ USA). Vinegar and water were mixed using a Globe model SP20 commercial food mixer (Globe Food Equipment Co.; Dayton, OH USA) for 2 minutes. Then, dry ingredients were added and blended for 5 minutes to obtain a homogenous mixture. Oil was gradually added over 10 minutes to form an emulsion, and the spread was mixed for an additional 5 minutes on a high speed. The spread samples were portioned (approximately 15g servings) into two ounce clear plastic cups with lids and labeled with blinding codes. All samples were prepared two days in advance and refrigerated at 38°F prior to testing.

5.2.2 Health benefit claims

The claim "low-sodium" was given to treatment 1 because this formulation met the criteria set forth in 21CFR101.61, that is, the food contains less than 140mg of sodium per a reference amount customarily consumed. The reference amount customarily consumed for mayonnaise, sandwich spreads, and mayonnaise-type dressings is 15g. Based on a reduction of sodium from 1.5% (in the standard recipe) to 1.0%, treatment 2 can be called a "reduced sodium" product, because it contains over a 25% reduction in sodium compared to the reference food. Treatment 3 contained the normal amount of sodium typically found in commercial mayonnaise products, and treatment 3 was used as the reference food on which the "reduced sodium" claim was made for treatment 2. Treatment 4 and treatment 5 were given "sodium free" designations, as these spreads contained less than 5mg sodium per a reference amount (21CFR101.61). For this study, treatment 4 had a lower potassium (1.0% KCl), and treatment 5 had a higher potassium (2.0% KCl).

5.2.3 Experimental design and sensory evaluation

The spreads were evaluated by consumers following a Balanced Incomplete Block Design, plan # 11.1a from Cochran & Cox (1957) ($t=5$, $k=3$, $r=6$, $b=10$, $\lambda=3$). Each consumer evaluated 3 samples (out of 5 formulations). Samples were randomly coded for a total of 66 replications (observations) per treatment. A total of 110 people were recruited for this study (b×11 = 10×11 = 110 subjects). Consumer testing was conducted in the Sensory Analysis Laboratory, the Animal and Food Sciences Laboratory building, Louisiana State University, Baton Rouge, LA, USA. All evaluations were performed in partitioned sensory booths with cool natural lighting. The questionnaire was electronically presented to consumers, and data were collected using Compusense® *five* (Compusense Inc., Guelph, Canada) software. The research protocol for consumer testing was approved (IRB # HE15-9) by the Louisiana State University Agricultural Center Institutional Review Board. Emotion terms related to the consumption of spreads were screened using check-all-that-apply (CATA) online survey. Emotion terms elicited by food from the EsSense Profile® (King & Meilseman, 2010) were used for the online survey, which was administered using a web link created using the QuickSurveys™ program (Toluna QuickSurveys™; Toluna SAS, Levallois-Perret, France). Emotion terms selected by at least 20% of participants were chosen for the consumer study. A total of thirteen emotions (*bored, calm, disgusted, eager, energetic, guilty, happy, interested, nostalgic, pleased, safe (pertaining to health), satisfied, worried*) were associated with consumption of spreads and were selected to be evaluated on a 5-point scale in the subsequent consumer study.

After agreeing to terms outlined in a consent form, consumers were asked about their demographic information. The five different treatments shown in Table 5.1 (three per participant, based on the BIB design) were first rated on a 9-point hedonic scale (1-Dislike extremely, 5-Neither like nor dislike, 9-Like extremely) for liking of saltiness, bitterness, and overall liking (OL). A 3-point JAR scale, Just About Right, was used to rate intensities of saltiness and bitterness. Emotions selected from the online survey were evaluated on a 5-point scale (1-Not-at-all, 5-

Extremely) (King & Meiselman, 2010). Purchase intent (PI) was asked on a "yes/no" scale. Three different health messages (HM) informing consumers of risks associated with excessive sodium intake and benefits of dietary potassium were presented dependent on the sample (Table 5.2). Overall liking, emotion intensities, and PI were evaluated before and after consumers were given the HM.

5.2.4 Statistical analyses

All data were analyzed using SAS software 9.4 (2015, SAS Institute Inc., Cary, NC USA). Analysis of variance (ANOVA) and the post-hoc Fisher LSD test were performed at α=0.05 to compare mean differences between treatments for hedonic responses, saltiness and bitterness intensity perception, and emotion responses. The McNemar test was performed to analyze significance of changes in PI 'before' and 'after' receiving HM. Logistic regression analysis (LRA) was used to determine whether overall liking and emotions significantly affected PI both before and after HM was presented to consumers. Penalty (mean drop) analysis was conducted to determine if the non-JAR responses for saltiness and bitterness intensities were associated with a concerning mean drop in bitterness, saltiness, and overall liking scores.

5.3 Results and discussion

5.3.1 Consumer acceptability and purchase intent (PI)

The mean liking scores (bitterness, saltiness, and overall liking) for all treatments and PI before and after HM are shown in Table 5.2. The lowest mean liking of bitterness (mean value= 4.43) was found for treatment 5. This was expected because of the higher level of KCl, which has been shown to have a bitter taste (Hooge & Chambers, 2010; Sinopoli & Lawless, 2012). This score was significantly different from those of the non-KCl treatments (1, 2, and 3). Treatment 5 also exhibited the lower mean score for saltiness liking (mean value= 4.72) and overall liking before presentation of HM (mean value= 4.74). Treatment 3, which contained the same amount of sodium typically found in commercial mayonnaise, yielded the higher mean saltiness liking (mean value= 5.53) and overall liking (mean value = 5.48) scores before presentation of HM. Consumers' decisions may vary based on the information provided. Several authors (Sabbe *et al*., 2009; Stephen *et al*., 2012; Padhi *et al*., 2015) have reported a positive impact on liking/acceptance scores when an appropriate HM is presented to consumers. Without exception, after HM claims of "low-sodium", "reduced sodium", and "sodium free", all overall liking scores increased. On the other hand, when HM claim "regular sodium content" was presented to consumers, overall liking scores (5.01-5.62) decreased (Treatment 3). However, no significant differences were found in OL mean scores "after" when comparing all the treatments.

Before consumers were presented with sodium health-risks, potassium benefits, and sodium/potassium treatment of the samples, the two KCl formulations (treatments 4 and 5) yielded the lowest PI (35.82% and 37.31% of consumers, respectively). However, after HM, the percentage of consumers who responded with positive PI of the products increased for all samples with a sodium reduction, while the standard-sodium recipe exhibited lower PI. This may be related to the phenomenon of "hedonic eating," which Canetti *et al*., (2002) described as the tendency to eat because of the pleasant taste of the food or because [in this case] the food consumed is thought to be healthy. Most notably, based on the McNemar test, the PI for the 1.0% KCl treatment significantly increased from 35.82% to 50.75% after consumers received the HM associated with this sample. These trends towards increased liking and acceptance of low-sodium, reduced sodium, and sodium free spreads once their health benefits are known may indicate a concern about healthfulness among consumers and an influence of sodium-claims upon liking and purchasing decisions.

Table 5.2 Mean consumer liking scores* and purchase intent[&] of spreads (before and after health message[^])

	Treatment	Bitterness	Saltiness	Overall liking before	Overall liking after	Purchase intent before (%)	Purchase intent after (%)
1	0.5% NaCl	5.10[a]	5.39[a]	5.42[a]	5.62[a]	44.78	49.25
2	1.0% NaCl	5.18[a]	5.21[ba]	5.33[ba]	5.52[a]	46.97	54.55
3	1.5% NaCl	5.37[a]	5.53[a]	5.48[a]	5.10[a]	40.91	37.88
4	1.0% KCl	5.94[ba]	5.29[ba]	5.10[ba]	5.58[a]	**35.82**	**50.75**
5	2.0% KCl	4.43[b]	4.72[b]	4.74[b]	5.01[a]	37.31	46.27
Standard error		0.21	0.23	0.24	0.24		

[*] Mean and Standard Error from 66 consumer responses based on a 9-point hedonic scale. Mean values in the same column followed by different letters are significantly different (P<0.05).

[&]Statistically significant p-values in bold print (P<0.05) based on McNemar Exact probability. Purchase intent was asked before and after consumers had been given health benefit information.

[^]Treatment 1 HM: "Excess sodium consumption contributes to high blood pressure, a leading cause of heart disease, kidney disease, and stroke. **This sample contains 66% less sodium than the standard recipe."**

Treatment 2 HM: "Excess sodium consumption contributes to high blood pressure, a leading cause of heart disease, kidney disease, and stroke. **This sample contains 33% less sodium than the standard recipe."**

Treatment 3 HM: "Excess sodium consumption contributes to high blood pressure, a leading cause of heart disease, kidney disease, and stroke. **This sample contains 1.5% salt, the amount commonly found in a standard commercial recipe."**

Treatments 4 and 5 HM: "Excess sodium consumption contributes to high blood pressure, a leading cause of heart disease, kidney disease, and stroke. Eating foods high in potassium may lower blood pressure and reduce the adverse health effects of sodium. **This sample is sodium free and contains potassium."**

5.3.2 Consumers' emotional responses after consumption of spreads

Health messages indicating sodium reduction or elimination generally increased positive emotion scores (*calm, eager, energetic, happy, interested*, *nostalgic, pleased*, *safe*, *satisfied*) while decreasing negative emotion scores (*bored, disgusted*, *guilty*, *worried*) (Table 5.3). In a study by Lyman (1982), participants reported greater tendency to eat healthy food when experiencing positive emotions. Emotion *safe* score decreased by 0.85 units (from 2.92 to 2.07) for the standard-sodium spread and increased by around 0.6 units (from 2.33 to 2.93 and from 2.19 to 2.78, respectively) for 1.0% and 2.0% KCl formulations. Treatment 5 had the highest *disgusted* score, which was associated with the less desirable bitterness (mean liking score= 4.43) and salty (mean liking score= 4.72) tastes. In a study of primary taste qualities (sweet, salty, sour, and bitter) and emotion, Robins *et al*. (2000) found the bitter solution to be primarily associated with emotions *anger* and *disgust*. After HM was given to the consumer, most of the positive emotion terms for the standard sodium spread decreased. In addition, Treatment 3, the standard sodium spread, had a higher mean *disgusted* score than the 1.0% KCl sodium free formulation (1.84 vs. 1.67). All positive emotion magnitudes increased for both sodium-free formulations (1.0% and 2.0% KCl) after the HM was given to consumers. The ability of health messages and nutrition claims to affect emotion was consistent with findings from Desmet & Schifferstein (2008), in which anticipated consequences as well as actions of associated food agents were proposed to elicit food emotions.

5.3.3 Factors affecting purchase intent predicted by logistic regression analysis

In order to determine the effect of gender, liking scores, and emotion magnitudes on purchase decision (before and after HM) of the product, Logistic Regression Analysis (LRA) was performed. Those attributes with statistical significance ($P \leq 0.05$) based on LRA were considered significant predictors of PI. Based on data obtained (Table 5.4), gender, overall liking scores, and *disgusted* emotion were the three most significant predictors for PI, both before and after receiving the HM. In both instances, females were found to be over two times (2.18-2.6) more likely than males to purchase the spreads. This trend may not be just related to the product, but to the fact that there is an inherent difference in the way males and females make purchase decisions (Lassen *et al.*, 2016). The only tested emotion found to be a statistically significant predictor of PI was the *disgusted* emotion. One unit decrease in *disgusted* (on a 5-point scale) would increase the odds of purchasing the product by 1.91-2.07. Increasing overall-liking score of spreads by one point (on a 9-point hedonic scale) would indicate a 2.40 and 2.66 (before and after HM, respectively) times increase in likelihood of intent to purchase the product.

Table 5.3 Odds ratio estimates of consumers' purchase intent of spreads

Parameters	Pr > ChiSq*	Odds ratio $^{\beta}$	Pr > ChiSq*	Odds ratio $^{\mu}$
Gender	**0.0362**	**2.178**	**0.0233**	**2.262**
Overall liking	**<0.0001**	**2.403**	**<.0001**	**2.662**
Bored	0.2874	0.784	0.8429	1.048
Calm	0.5788	1.142	0.6171	0.890
Disgusted	**0.0277**	**0.484**	**0.0130**	**0.523**
Eager	0.5830	1.191	0.7436	0.911
Energetic	0.9778	0.991	0.4062	1.297
Guilty	0.1361	0.644	0.6403	0.863
Happy	0.6359	0.853	0.3455	0.746
Interested	0.2869	1.289	0.9365	0.979
Nostalgic	0.0834	1.695	0.2774	1.342
Pleased	0.8082	1.080	0.1967	1.476
Safe	0.8563	1.042	0.1429	1.320
Satisfied	0.0654	1.722	0.4730	1.223
Worried	0.1357	0.619	0.1634	0.648

*statistically significant p-values in bold print ($p<0.05$)

$^{\beta}$ Purchase intent asked **before** consumers had been given low-sodium health benefits.

$^{\mu}$ Purchase intent asked **after** consumers had been given low-sodium health benefits.

Table 5.4 Consumer emotion scores (before and after)^ for spreads

	Treatment 1 0.5% NaCl		**Treatment 2 1.0% NaCl**		**Treatment 3 1.5% NaCl**		**Treatment 4 1.0% KCl**		**Treatment 5 2.0% KCl**		**Standard error**	
Emotion	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Bored	1.65[a]	1.59[A]	1.55[a]	1.54[A]	1.65[a]	1.61[A]	1.71[a]	1.65[A]	1.60[a]	1.63[A]	0.11	0.10
Calm	1.96[a]	2.01[BA]	1.83[a]	2.00[BA]	2.02[a]	1.78[B]	2.05[a]	2.15[A]	1.92[a]	2.05[A]	0.11	0.11
Disgusted	1.65[b]	1.57[BC]	1.58[b]	1.38[C]	1.61[b]	1.84[BA]	1.85[ba]	1.67[BA]	2.00[a]	1.94[A]	0.12	0.12
Eager	1.63[a]	1.71[A]	1.64[a]	1.65[A]	1.57[a]	1.61[A]	1.59[a]	1.69[A]	1.47[a]	1.79[A]	0.10	0.10
Energetic	1.61[a]	1.57[A]	1.59[a]	1.66[A]	1.67[a]	1.58[A]	1.51[a]	1.51[A]	1.46[a]	1.56[A]	0.10	0.10
Guilty	1.38[b]	1.30[B]	1.39[b]	1.36[B]	1.47[ba]	1.71[A]	1.52[ba]	1.29[B]	1.65[a]	1.33[B]	0.10	0.09
Happy	1.82[ba]	1.99[A]	1.74[ba]	1.92[A]	1.94[a]	1.95[A]	1.63[b]	1.91[A]	1.69[b]	2.00[A]	0.10	0.12
Interested	2.14[ba]	2.32[A]	2.03[ba]	2.20[BA]	2.22[a]	2.02[B]	1.95[ba]	2.41[A]	1.92[b]	2.26[BA]	0.12	0.12
Nostalgic	1.35[ba]	1.52[A]	1.37[ba]	1.38[A]	1.55[a]	1.52[A]	1.31[b]	1.35[A]	1.27[b]	1.38[A]	0.08	0.09
Pleased	2.06[ba]	2.25[A]	2.04[ba]	2.21[A]	2.18[a]	2.08[A]	2.10[ba]	2.22[A]	1.82[b]	2.05[A]	0.12	0.13
Safe	2.30[a]	2.63[BA]	2.02[b]	2.61[B]	2.92[a]	2.07[C]	2.33[a]	2.93[A]	2.19[ba]	2.78[BA]	0.12	0.13
Satisfied	2.29[ba]	2.20[A]	2.20[ba]	2.28[A]	2.33[a]	2.11[A]	2.04[ba]	2.35[A]	2.01[b]	2.22[A]	0.12	0.13
Worried	1.44[a]	1.35[B]	1.43[a]	1.35[B]	1.49[a]	1.74[A]	1.48[a]	1.30[B]	1.56[a]	1.31[B]	0.09	0.09

^ Mean and Standard Error from 66 consumer responses based on a 5-point scale. Magnitude of emotion terms was asked before and after consumers had been given health benefit information.

a-b Mean values of emotions 'before' in the same column followed by different letters are significantly different ($P<0.05$)

A-C Mean values of emotions 'after' in the same column followed by different letters are significantly different ($P<0.05$)

5.3.4 Effect of saltiness and bitterness intensity on consumers' liking

When an attribute is not at its ideal level, liking scores may be affected. Figure 5.1 shows penalty plots for the effect of non-JAR ratings of bitterness on (a) bitterness liking and (b) overall liking. The points representing responses with over 20% frequency and associated with mean drops ≥2.0 in liking scores are of concern (ASTM 2009). Over 30% of respondents detected treatment 5 to be too bitter, resulting in a mean drop of approximately -3.4 on the 9-point hedonic scale for bitterness liking. Concerning mean drops in bitterness liking (≥-3) were also found for treatment 4 (1% KCl) due to strong bitterness intensity reported by more than 20% of the consumers (Figure 5.1 (a)). Strong bitterness perception in treatment 5 (2% KCl) also had an impact on overall liking resulting in mean drops >2.5 (on the 9-point hedonic scale). Overall, the strong bitterness rating for the 2% KCl spread showed the most concerning mean drop for bitterness and overall liking scores.

Strong saltiness in treatment 5 and 3 were of concern in saltiness and overall liking. More than 30% of the subjects rated both the 2% KCl and the 1.5% NaCl treatments as too salty, producing mean drops >-2.5 (on the 9-point hedonic scales for saltiness and overall liking). However, the evidence that only 11.9% of people surveyed found treatment 5 to be "not salty enough," indicates that, in the absence of NaCl, KCl can provide saltiness intensity that meets or exceeds acceptable amounts. A majority of panelists (61.19%) reported the saltiness intensity of the 1.0% KCl spread to be in the "just-about-right" category (Figure 5.2).

5.4 Conclusion

Health message informing sodium reduction or elimination had a positive impact on overall liking scores and increased purchase intent. This may indicate the potential for consumer acceptance of a sodium-free spread, especially a 1.0% KCl spread formulation when its health benefits are known. Positive emotions generally increased and negative emotions generally decreased for low-sodium, reduced-sodium, and sodium-free formulations after a HM was given. The reverse effect was seen for a standard-sodium spread. This shows that emotional responses in consumers were related to health consequences of what they consume, and a tendency for healthful foods to be associated with higher levels of positive emotions. Gender, overall liking, and *disgusted* emotion significantly influenced consumer purchase intent of mayonnaise-type spreads before and after presentation of a HM with a sodium claim. This study demonstrated the feasibility of developing an acceptable 1% KCl (sodium free) mayonnaise-type spread.

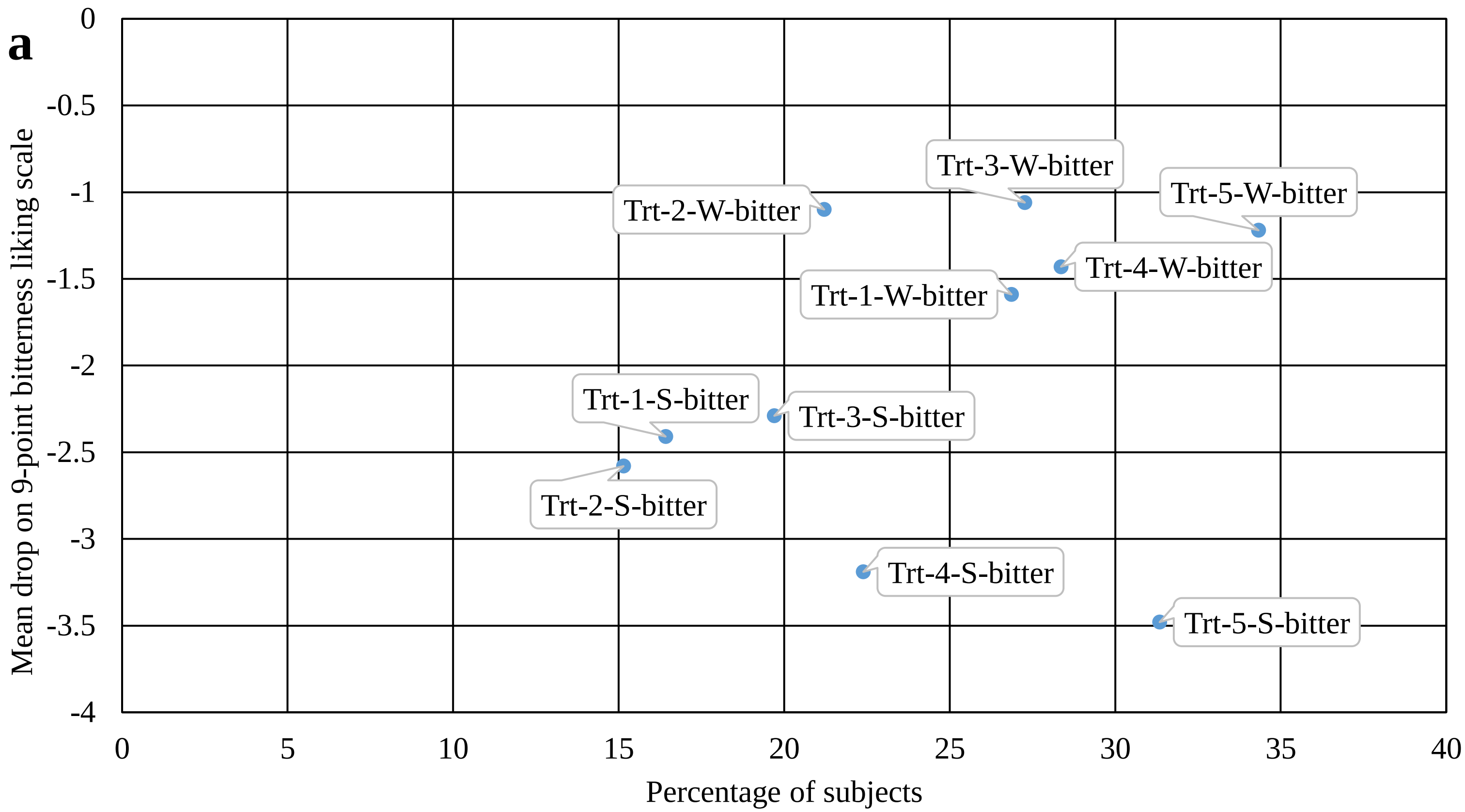
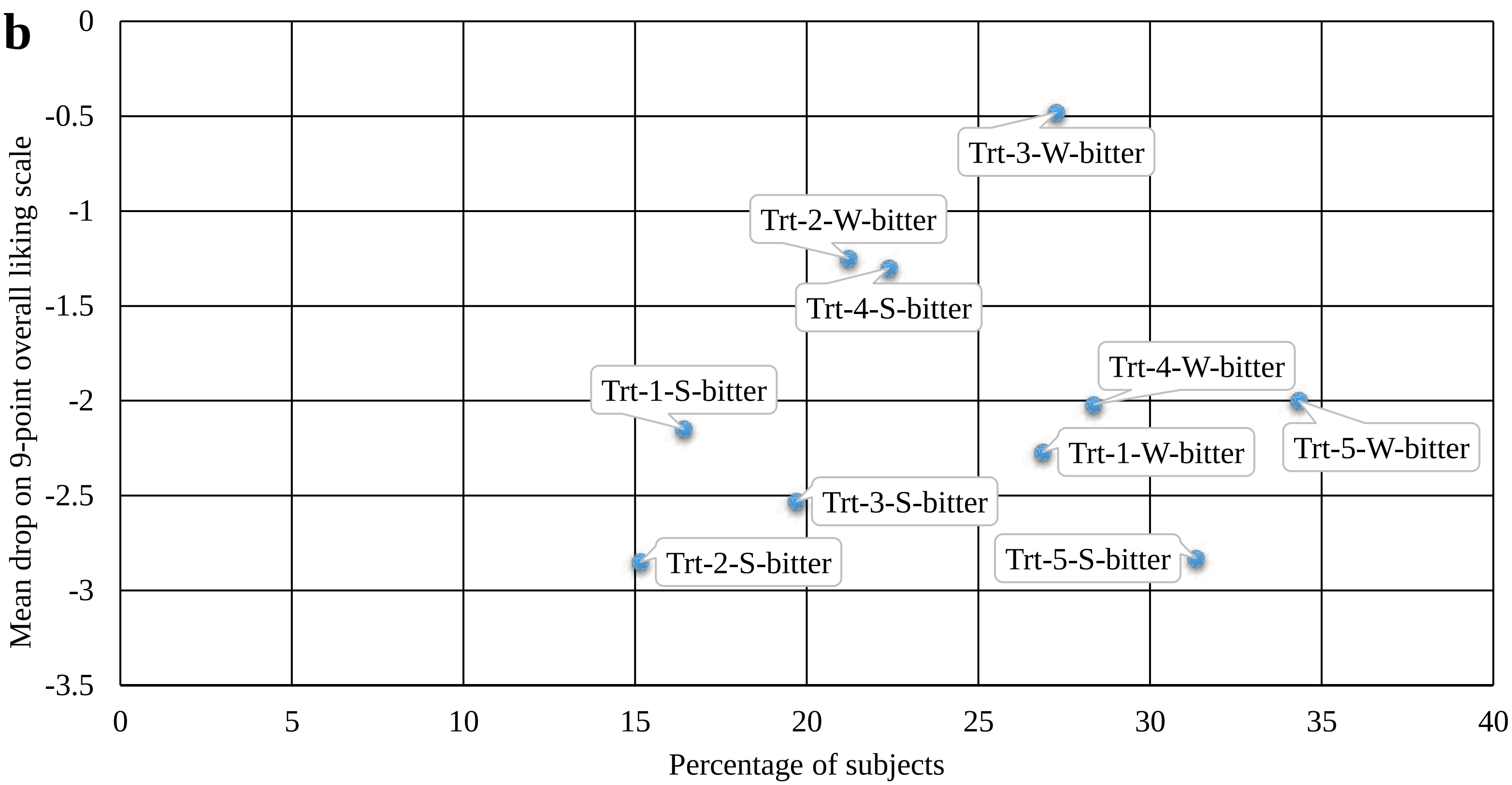


Figure 5.1 (a) Bitterness Penalty plot. S= Strong Bitterness; W= Weak Bitterness (affecting bitterness liking). (b) Bitterness Penalty plot. S= Strong Bitterness; W= Weak Bitterness (affecting overall liking)

(figure cont'd.)

b


0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Mean drop on 9-point overall liking scale
Trt-3-W-bitter
Trt-2-W-bitter
Trt-4-S-bitter
Trt-1-S-bitter
Trt-4-W-bitter
Trt-1-W-bitter
Trt-5-W-bitter
Trt-3-S-bitter
Trt-2-S-bitter
Trt-5-S-bitter
0
5
10
15
20
25
30
35
40
Percentage of subjects

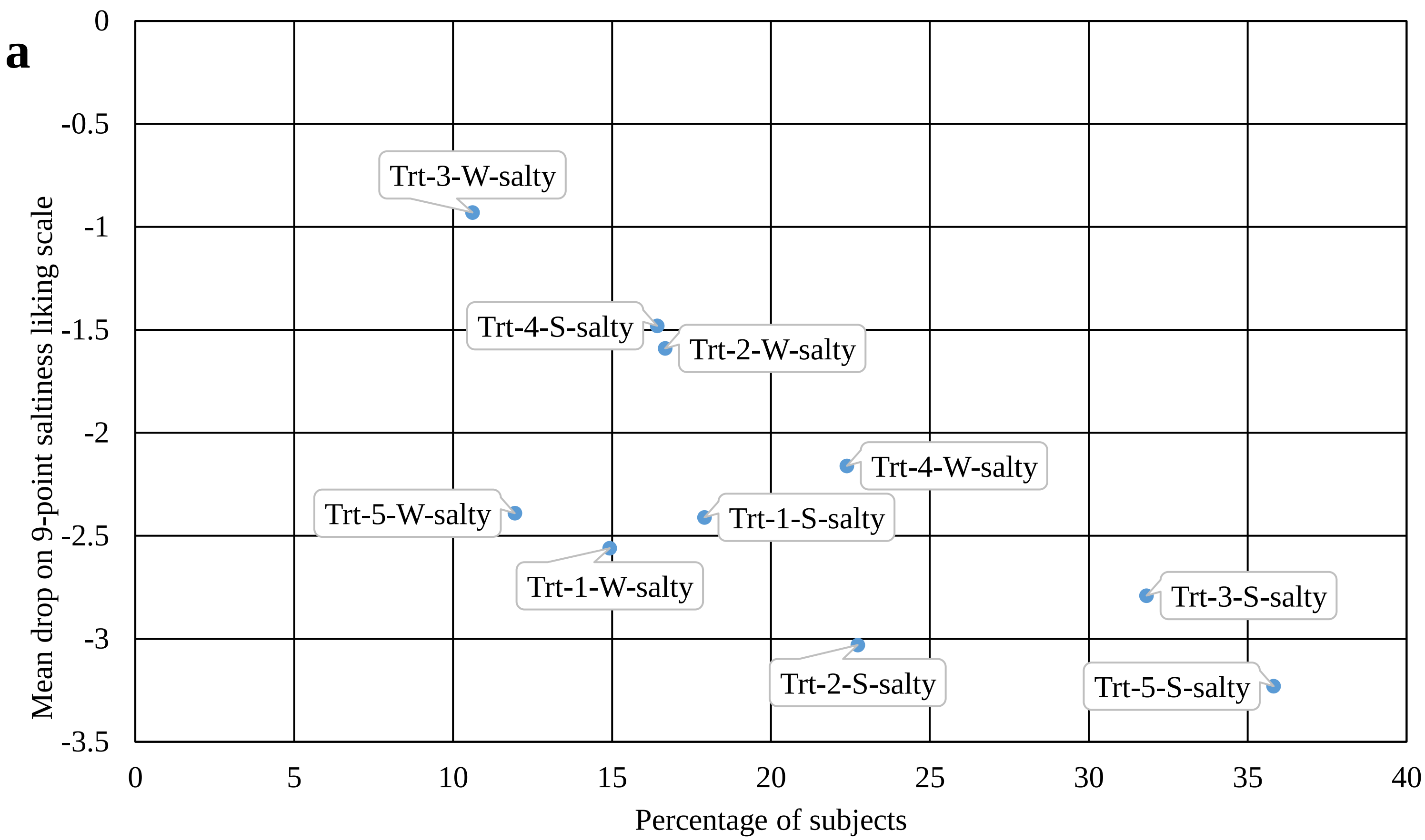
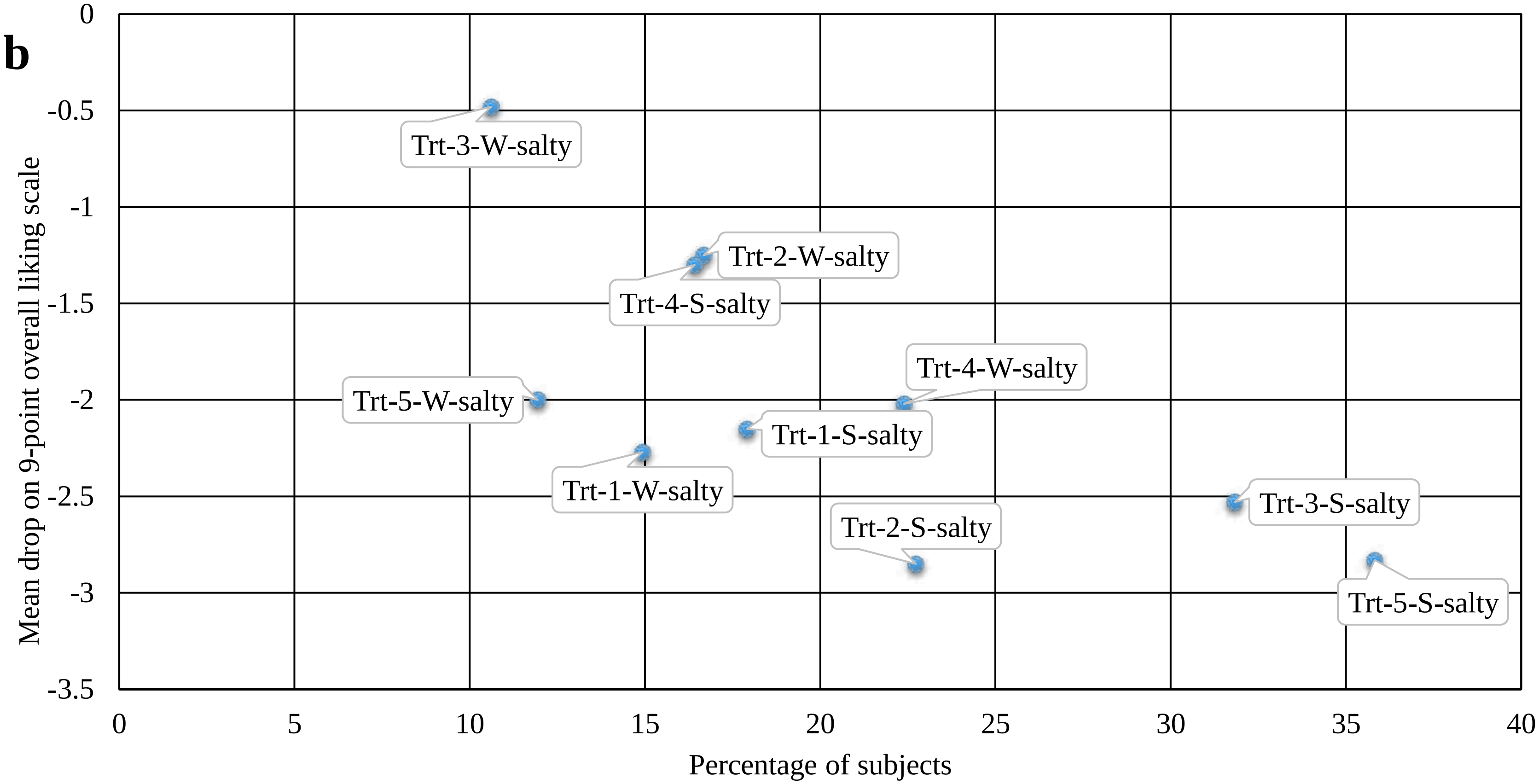


Figure 5.2 (a) Saltiness Penalty plot. S= Strong Saltiness; W= Weak Saltiness (affecting Saltiness liking). (b) Saltiness Penalty plot. S= Strong Saltiness; W= Weak Saltiness (affecting Overall liking)

(figure cont'd.)

b


Mean drop on 9-point overall liking scale
Percentage of subjects
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0
5
10
15
20
25
30
35
40
Trt-3-W-salty
Trt-2-W-salty
Trt-4-S-salty
Trt-4-W-salty
Trt-5-W-salty
Trt-1-S-salty
Trt-1-W-salty
Trt-3-S-salty
Trt-2-S-salty
Trt-5-S-salty

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CHAPTER 6. IMPROVING CONSUMER ACCEPTANCE, EMOTION, AND PURCHASE INTENT OF LOW-SODIUM SPREADS BY FLAVOR MODIFICATION AND ITS INCORPORATION INTO TURKEY SALAD SANDWICHES

6.1 Objectives

From the previous research, the spread with 1% KCl treatment was selected based on the sodium content and the overall acceptability compared to the other treatments. In this study, the objectives were to identify flavors that help reduce bitterness perception of low-sodium mayonnaise-type spreads, to evaluate consumer acceptance, emotional profile and purchase intent of flavored mayonnaise-type spreads before and after consumers have been given health benefit information regarding sodium content, and to assess how flavored mayonnaise-type spreads incorporated into a final product (turkey salad sandwich) improves their consumer acceptance, emotion, and purchase decision.

6.2 Materials and methods

6.2.1 Materials and mixture of salts

Twelve flavored mayonnaise-type spreads were prepared according the formulations in Table 6.1. Soybean oil (Great Value™, Wal-Mart Stores, Bentonville, AR, USA) and water were used as a base of the oil-in-water emulsions. Distilled white vinegar (Great Value™, Wal-Mart Stores, Bentonville, AR, USA) was used as an acidifier. Powdered whey protein concentrate (Grande Bravo® 500, Grande Custome Ingredients Group, Lomira, WI, USA) was used as an egg-replacer and for viscosity development. A commercial hydrocolloid mix (Tic Saladizer® 243 M Powder [modified corn starch, modified tapioca starch, guar gum, xanthan gum, and gum acacia]; Tic Gums Inc, Belcamp, MD, USA) was used for thickening and stabilization of the emulsion. KCl-99% (FCC grade, Extracts & Ingredients, LTD., Union, NJ, USA) was added to provide salty taste to the spreads. Four different commercial flavorings and three KCl concentrations, based on preliminary studies, were selected for this research. The four flavors used were: bacon (smoky type flavor powder, natural, Bell Flavors & Fragrances, Northbrook, IL USA), garlic & herb (Michaelok® natural, David Michael & Co., Philadelphia, PA, USA), chipotle (natural Chipotle Flavor "powder type", David Michael & Co., Philadelphia, PA, USA), and cheddar cheese (natural cheddar cheese WONF, David Michael & Co., Philadelphia, PA, USA).

Table 6.1 Flavored mayonnaise-type spreads formulations*

Treatments/flavor	**Oil**	**Vinegar**	**WPC**	**Gum**	**Water**	**Flavor**	**KCl**
Low-sodium cheddar cheese	65%	8.90%	5.4%	0.75%	16.45%	3%	0.5%
Low-sodium cheddar cheese	65%	8.90%	5.4%	0.75%	15.95%	3%	1.0%
Low-sodium cheddar cheese	65%	8.90%	5.4%	0.75%	15.45%	3%	1.5%
Low-sodium herb and garlic	65%	8.90%	5.4%	0.75%	17.45%	2%	0.5%
Low-sodium herb and garlic	65%	8.90%	5.4%	0.75%	16.95%	2%	1.0%
Low-sodium herb and garlic	65%	8.90%	5.4%	0.75%	16.45%	2%	1.5%
Low-sodium chipotle	65%	8.90%	5.4%	0.75%	17.45%	2%	0.5%
Low-sodium chipotle	65%	8.90%	5.4%	0.75%	16.95%	2%	1.0%
Low-sodium chipotle	65%	8.90%	5.4%	0.75%	16.45%	2%	1.5%
Low-sodium bacon	65%	8.90%	5.4%	0.75%	17.45%	2%	0.5%
Low-sodium bacon	65%	8.90%	5.4%	0.75%	16.95%	2%	1.0%
Low-sodium bacon	65%	8.90%	5.4%	0.75%	16.45%	2%	1.5%

*Percent of final product by weight. WPC = Whey Protein Concentrate

6.2.2 Flavored spread preparation

Ingredients were weighed with an Ohaus Precision Standard balance (model TS4KS; Ohaus Corporation, Florham Park, NJ USA). The vinegar and water were mixed using a Globe model SP20 commercial food mixer (Globe Food Equipment Co.; Dayton, OH USA) for 2 min. The dry ingredients (including the flavor for each treatment) were added and blended for 5 min to obtain a homogenous mixture. Oil was gradually added over 10 min to form an emulsion, and the spread was mixed for an additional 5 min on a high speed. The spread samples were portioned (approximately 15g servings) into two ounce clear plastic cups with lids and labeled with blinding codes. All samples were prepared two days in advance and refrigerated at 38°F prior to testing. All samples were given a "low-sodium" claim based on the 21CFR101.61 criteria (food contains <140mg of sodium per a reference amount customarily consumed).

6.2.3 Turkey sandwich preparation

Sliced white bread (Great Value™, Wal-Mart Stores) and turkey breasts (Butterball®, Wal-Mart Stores, Garner, NC, USA) were purchased to prepare the turkey-salad sandwiches. Batches of turkey breasts (8.7 pounds, on average) were boiled in 2 L of water for 40 min using a kettle pot (Tramontina®, Professional Stainless Steel, 80126/527, USA). Boiled turkey breasts were ground using a food processor (Black & Decker®, Quick 'N Easy Plus® FP1450, USA) for 15 seconds. The ground turkey was mixed with the flavored spreads (prepared as described in section 6.2.2) in a 2:1 proportion (by weight) to obtain the turkey salad. Crusts of the bread were removed, and sandwiches were prepared by spreading 30g of turkey salad between two slices of bread. Each whole sandwich was cut into four equally sized pieces. Each piece was packed in a Ziploc® sandwich bag, and stored under refrigerated conditions to be served the next day for the consumer study.

6.2.4 Experimental design and sensory evaluation of the flavored spreads

The spreads alone were evaluated following a Balanced Incomplete Block Design to avoid sensory fatigue due to a high number of samples. Each consumer evaluated 3 samples (out of 12 formulations). Samples were randomly coded for a total of 102 replications (observations) per treatment. A total of 408 people were recruited for this study.

Consumer testing was conducted in the Sensory Analysis Laboratory, the Animal and Food Sciences Laboratory building at Louisiana State University (Baton Rouge, LA, USA). All evaluations were performed in partitioned booths with cool natural lighting. The questionnaire was electronically presented to consumers, and data were collected using Compusense® *five* (Compusense Inc., Guelph, Canada) software. The research protocol for consumer testing was approved (IRB # HE15-9) by the Louisiana State University Agricultural Center Institutional Review Board.

Emotions related to the consumption of spreads were screened using a check-all-that-apply (CATA) online survey. Emotion terms from the EsSense Profile® (King & Meilseman, 2010) were used for the online survey which was administered using a web link created using the QuickSurveys™ program (Toluna QuickSurveys™; Toluna SAS, Levallois-Perret, France). Emotion terms selected by at least 20% of respondents were chosen for the consumer study. A total of twelve emotions (*bored, disgusted, eager, energetic, guilty, happy, interested, nostalgic, pleased, safe (pertaining to health), satisfied, worried*) were associated with consumption of flavored-spreads and were selected to be evaluated on a 5-point scale in the subsequent consumer study.

After agreeing to terms outlined in a consent form, consumers responded to demographic questions. The 12 treatments shown in Table 6.1 (three per participant, based on the BIB design) were first rated on a 9-point hedonic scale (1-Dislike extremely, 5-Neither like nor dislike, 9-Like extremely) for liking of color, saltiness, bitterness, flavor and overall liking (OL). A 3-point just about right (JAR) scale was used to rate intensities of saltiness and bitterness. Emotions were evaluated on a 5-point scale (1-Not-at-all, 5-Extremely) (King & Meiselman, 2010). Purchase intent (PI) was asked on a "yes/no" scale. A health message (HM) informing consumers of risks associated with excess sodium intake and benefits of dietary potassium was presented after sample evaluation. Then, OL, emotion intensities, and PI were evaluated again.

6.2.5 Experimental design and sensory evaluation for the turkey salad sandwiches

The 1% KCl spread formulations from each flavor (Table 6.1) were chosen (based on liking results) to prepare the turkey salad sandwiches. A total of four sandwich samples were served to 120 consumers (four different flavors, all at 1% KCl). Consumer testing was conducted in the Sensory Analysis Laboratory, the Animal and Food Sciences Laboratory building at Louisiana State University (Baton Rouge, LA, USA). All evaluations were performed in partitioned booths with cool natural lighting. The questionnaire was electronically presented to consumers, and data were collected using Compusense® *five* (Compusense Inc., Guelph, Canada) software.

After agreeing to terms outlined in a consent form, consumers responded to demographic questions. The four different sandwiches were first rated on a 9-point hedonic scale (1-Dislike extremely, 5-Neither like nor dislike, 9-Like extremely) for liking of flavor, saltiness, overall taste, and overall liking (OL). PI was asked on a "yes/no" scale. A health message (HM) informing consumers of risks associated with excess sodium intake and its association with heart disease was presented after sample evaluation. Then, OL and PI were evaluated again. PI of the flavored spreads used to prepare the turkey salad was also asked after the HM.

6.2.6 Statistical analyses

All data were analyzed using SAS software 9.4 (2015, SAS Institute Inc., Cary, NC USA). Analysis of variance (ANOVA) and the post-hoc Fisher LSD test were performed at α=0.05 significance level to compare mean differences between treatments for hedonic scores, and emotions. The McNemar test was performed to analyze significance changes in PI 'before' and 'after' receiving the HM. Logistic regression analysis (LRA) was used to determine whether overall liking and emotions significantly affected PI, both before and after the HM was presented to consumers. Penalty (mean drop) analysis was conducted to determine if the non-JAR responses for saltiness and bitterness intensities were associated with a concerning drop in bitterness liking, saltiness liking, and overall liking scores.

6.3 Results and discussion

6.3.1 Consumer acceptance and purchase intent of low-sodium flavored spreads

Mean liking scores and positive PI (% "yes" responses) of the twelve low-sodium flavored spreads are presented in Table 6.2. Depending on the flavor used, color of the spreads changed. Cheddar cheese and garlic & herb treatments were whitish in color while chipotle and bacon flavors had yellow/orange hues. Color liking scores of bacon and chipotle treatments (mean scores: 5.80-6.41) were higher than those of cheddar cheese and garlic & herb flavors (mean scores: 5.50-5.78). Bacon flavor with 1% KCl had the highest liking mean score (6.41) for color. Color is an important attribute in determining acceptance of food, and consumers often relate colorful foods with more flavor (Zampini *et al.*, 2007; Spence, 2015). This may explain the higher liking scores for the yellow/orange-colored treatments compared to the white ones. Mean saltiness liking scores ranged from 5.11-6.17 (on the 9-point hedonic scale) for all the treatments. Treatment 11 (bacon flavor with 1% KCl) exhibited the highest saltiness liking (mean score of 6.17) among treatments. Bacon flavored treatments, at the three different KCl levels (0.5, 1, and 1.5 %), received significantly higher saltiness liking scores (mean scores of 5.83-6.17) than all garlic and herb (0.5, 1, and 1.5 % KCl) spreads and cheddar cheese and chipotle treatments containing 1% KCl. Chan & Kane-Martinelli (1997) investigated the effect of color on food perception and found that changes in color had an effect on acceptance and perception of several food attributes. The color (yellow/orange) of bacon and chipotle spreads may have been a factor contributing to the higher saltiness liking of those treatments compared to cheddar cheese and garlic & herb samples (whitish color). The more savory taste of the bacon flavor treatments seems also to lead to higher saltiness liking (Table 6.2). Lower mean scores were observed for bitterness liking compared to other sensory attributes. Bitterness is usually not a desirable attribute expected in food (Duesing *et al*., 2014). KCl imparts bitter taste when added to food products (Torrico & Prinyawiwatkul, 2017). Bitterness of spreads was evaluated to compare any changes in bitter taste liking scores between the different KCl concentrations in the samples. Garlic & herb flavored treatments had the lowest mean scores for bitter taste liking (4.60-4.74 on the 9-point hedonic scale). Consumers rated bitterness intensity as "too strong" for the three garlic & herb treatments (refer to JAR- penalty results in Figure 6.1 (a) and (b)). Based on these results, the innate strong flavor of the garlic & herb flavoring combined with KCl seemed to enhance bitterness perception. Similar to the other sensory attributes evaluated, treatment 11 (bacon, 1% KCl) had the highest bitterness liking score, which was statistically different from all other treatments. Similarly, for flavor liking, treatment 11 had a significantly higher mean score (6.43) than the rest of the treatments. The three bacon flavored treatments (0.5, 1, and 1.5% KCl) were scored higher (5.81-6.43) for the flavor attribute compared to other flavor treatments (4.66-5.58). Across all sensory dimensions measured, bacon flavored samples had significantly higher liking scores compared to other treatments.

Table 6.2 Consumer acceptability scores[β] and purchase intent[λ] of low-sodium flavored spreads

Treatment/flavor		KCl %	Color	Saltiness	Bitterness	Flavor	OL Before	OL After	PI Before	PI After
1	Cheddar Cheese	0.5	5.60[c]	5.67[bc]	5.22[bc]	5.50[bcd]	5.52[bc]	5.46[bc]	47.06	50.00
2	Cheddar Cheese	1.0	5.77[bc]	5.32[cd]	5.06[bcd]	5.18[cde]	5.23[cde]	5.05[cd]	**31.37**	**38.24**
3	Cheddar Cheese	1.5	5.50[c]	5.42[bcd]	5.07[bcd]	5.09[cde]	5.18[cde]	5.09[cd]	36.27	40.20
4	Chipotle	0.5	5.88[bc]	5.55[bcd]	5.08[bcd]	5.57[bc]	5.64[bc]	5.58[bc]	**37.25**	**46.08**
5	Chipotle	1.0	5.91[bc]	5.30[cd]	4.89[bcd]	5.49[bcd]	5.46[bcd]	5.43[bc]	43.14	47.06
6	Chipotle	1.5	6.18[ab]	5.41[bcd]	5.05[bcd]	5.58[bc]	5.60[bc]	5.61[bc]	44.12	47.06
7	Garlic and Herb	0.5	5.54[c]	5.26[cd]	4.60[d]	4.66[e]	4.77[e]	4.64[d]	31.37	33.33
8	Garlic and Herb	1.0	5.52[c]	5.23[cd]	4.74[cd]	5.06[cde]	5.14[cde]	5.06[cd]	38.24	37.25
9	Garlic and Herb	1.5	5.78[bc]	5.11[d]	4.67[d]	4.94[de]	4.93[de]	4.80[d]	33.33	32.35
10	Bacon	0.5	5.84[bc]	5.83[ab]	5.36[b]	5.81[b]	5.87[b]	5.72[ab]	44.04	46.79
11	Bacon	1.0	6.41[a]	6.17[a]	5.98[a]	6.43[a]	6.44[a]	6.27[a]	54.13	55.96
12	Bacon	1.5	5.80[bc]	5.87[ab]	5.17[bc]	5.82[b]	5.84[b]	5.75[ab]	46.79	48.62
	Standard error		0.17	0.17	0.17	0.22	0.21	0.21		

[β] Means from 102 consumer responses based on a 9-point hedonic scale. Mean values in the same column followed by different letters are significantly different (P<0.05).

[λ] Statistically significant p-values in bold print (P<0.05) based on the McNemar Exact probability (evaluating changes in purchase intent before and after health benefit statement).

OL was evaluated before and after the HM was presented to consumers. Mean OL scores before HM ranged from 4.77 to 6.44, and from 4.64 to 6.27 after HM. None of the OL scores increased after the low-sodium HM was delivered. As expected, based on the other sensory attributes, the bacon-flavored spread containing 1% KCl had significantly higher OL mean scores both before and after HM, compared to the other flavored treatments. Consumers' willingness to purchase low-sodium spreads (PI) is also presented in Table 6.2. Liking scores of sensory attributes subsequently had an impact on PI (Durham *et al.*, 2015). The higher the liking scores for sensory attributes of the sample, the higher the expected PI. Positive PI before HM was below 50% (31.4-47.06%) for all treatments except the bacon-flavored 1% KCl treatment (54.13%). After the HM was presented to consumers, with the exception of garlic & herb (1 and 1.5% KCl) spreads, positive PI increased. Several authors have reported a positive effect of appropriate health benefit information on consumers' purchase decision (Bower *et al*., 2003; Poonnakasem *et al.*, 2016). The McNemar test was conducted to identify if the changes in PI after HM was significant. Based on the results, PI of cheddar cheese (1% KCl) samples significantly ($p<0.05$) increased from 31.37% to 38.24%. The low-sodium health benefit claim also had a significant impact on PI for treatment 4 (chipotle, 0.5% KCl).

6.3.2 Consumer acceptance and purchase intent of turkey sandwiches made with low-sodium flavored spreads.

To evaluate how the flavored spreads perform in a real food product, a consumer test was conducted with turkey salad sandwiches made with the 1% KCl flavored-spreads. Results for consumer acceptance and PI of the turkey salad sandwiches are presented in Table 6.3, when testing the spreads alone, the 1.0% bacon formulation was scored significantly higher than all others in liking of saltiness, bitterness, flavor, and OL (mean scores: 6.17-6.44; Table 6.2) with reported positive PI of 54.13% (Table 6.2). For the less acceptable flavors, intent to purchase was

< 50% (Table 6.2). When used as commonly consumed- in a turkey salad sandwich- PI of the garlic & herb-flavored spread increased from 38.24% to 52.83%. Mean OL of the turkey salads ranged from 5.59-6.01. No significant differences were found for any of the sensory attributes evaluated (saltiness, overall taste, OL before, and OL after) except flavor. Consumers indicated a positive PI (>50%) for chipotle, garlic & herb, and bacon turkey sandwiches. Based on the McNemar test (exact probability <0.05), PI of the turkey salad containing bacon-flavored spread significantly increased (from 61.32 to 66.98%) after a "low-sodium" claim. The turkey salad sandwiches prepared with flavored spreads yielded higher overall liking scores (5.72-6.16) than the spreads alone. PI of the spreads evaluated after consumers tasted them in the sandwiches increased for cheddar cheese and garlic & herb formulations compared to PI when the spreads were tasted alone (Table 6.2 vs Table 6.3). More uniform results from a final product may relate to less intense perceptions of the individual flavorings used. Incorporation of the spreads into foods such as turkey salad would be more indicative of their actual usage. Overall, low-sodium flavored spreads can be formulated with KCl, without addition of sodium, to impart saltiness and be perceived favorably (> 5 on 9-point hedonic scale).

6.3.3 Consumers' emotion responses after consumption of flavored spreads

Pre-screened emotions related to flavored spreads were rated in this study using a 5-point scale. Emotion responses were assessed both before and after a HM was displayed to consumers (Table 6.4). Emotions *energetic*, *nostalgic*, and *worried* did not show significant differences across treatments, neither before nor after low-sodium HM. In general, positive emotion magnitudes were higher than negative ones.

Table 6.3 Consumer acceptability scores[β] and purchase intent[λ] of turkey sandwiches made with low-sodium flavored spreads

Flavors (1%KCl)	**Flavor**	**Saltiness**	**Overall Taste**	**Overall liking before**	**Overall liking after**	**PIB (%)**	**PIA (%)**	**PI Spread[£]**
Cheddar Cheese	5.58 ± 1.78 [b]	5.50 ± 1.83 [a]	5.67 ± 1.89 [a]	5.59 ± 1.88 [a]	5.72 ± 1.85 [a]	47.17	52.83	43.40
Chipotle	5.96 ± 1.62 [ab]	5.58 ± 1.63 [a]	5.92 ± 1.58 [a]	5.93 ± 1.54 [a]	6.11 ± 1.70 [a]	51.89	55.66	40.57
Garlic and Herb	6.11 ± 2.08 [a]	5.69 ± 1.81 [a]	5.98 ± 2.17 [a]	5.99 ± 2.18 [a]	6.12 ± 2.20 [a]	53.77	56.60	52.83
Bacon	5.94 ± 1.58 [ab]	5.67 ± 1.55 [a]	5.98 ± 1.57 [a]	6.01 ± 1.55 [a]	6.16 ± 1.67 [a]	**61.32**	**66.98**	49.06

[β] Mean and Standard Deviation from 106 consumer responses based on a 9-point hedonic scale. Mean values in the same column followed by different letters are significantly different (P<0.05).
[λ] Statistically significant p-values in bold print (P<0.05) based on the McNemar Exact probability (evaluating changes in purchase intent before and after health benefit statement). [£]Purchase Intent of the flavored spread.

Results from a study conducted by Desmet & Schifferstein (2008) concurred with these findings, reporting that food consumption is mostly related to positive emotional responses. The proportion of KCl in samples with the same flavors did not seem to have an impact on consumers' emotion. Changes in emotion magnitudes were mainly found across flavors. That is, bacon flavored spreads consistently had higher scores for positive emotion terms (*happy, interested, pleased, safe,* and *satisfied*) compared to other flavors. Consumer responses indicated that they felt more *disgusted* when tasting garlic & herb samples both before (mean score range: 1.95-2.02) and after (mean score range: 1.81-1.91) HM, compared to other samples. Also, lower emotion magnitudes were observed for all garlic & herb treatments for the positive emotions *happy, safe,* and *satisfied* compared to bacon flavored samples. After the HM was presented to consumers, no significant differences were found among treatments in consumer emotional responses of *bored, nostalgic* and *safe.* With some exceptions, positive emotional scores tended to increase while negative ones tended to decrease after consumers were given the HM.

6.3.4 Factors affecting purchase intent predicted by logistic regression analysis (LRA)

Purchase decisions are made based on a combination of factors such as liking, emotions, and known information about a product (Johansen *et al*., 2010). Logistic Regression Analysis can be used to determine factors or attributes that significantly predict PI of a product. Liking and emotional magnitude responses were analyzed to identify the most impactful aspects of consumers' PI of flavored spreads. Table 6.5 contains results from the LRA performed to predict PI before and after HM was given to consumers.

Table 6.4 Consumer emotion magnitudes (on a 5-point Scale) before and after[β] Low-sodium Claim

Sample		Bored	Disgusted	Eager	Energetic	Guilty	Happy	Interested	Nostalgic	Pleased	Safe	Satisfied	Worried
1	before	1.79^{ABC}	1.68^{BCDE}	1.68^{BC}	1.6^{NS}	1.41^{B}	1.97^{ABC}	2.14^{BCD}	1.53^{NS}	2.25^{BCD}	2.54^{ABC}	2.45^{BC}	1.44^{NS}
	after	1.63^{NS}	1.56^{bcd}	1.64^{cd}	1.61^{NS}	1.29^{NS}	2.05^{abc}	2.10^{bcde}	1.56^{NS}	2.12^{bcd}	2.64^{NS}	2.50^{abcd}	1.37^{NS}
2	before	1.74^{ABC}	1.79^{ABCD}	1.60^{C}	1.57	1.66^{AB}	1.77^{C}	1.93^{D}	1.35	2.07^{CD}	2.41^{BC}	2.19^{CD}	1.62
	after	1.74	1.73^{abcd}	1.62^{cd}	1.59	1.46	1.81^{c}	1.93^{cde}	1.37	2.06^{cd}	2.63	2.24^{cde}	1.44
3	before	1.97^{A}	1.90^{ABC}	1.60^{C}	1.53	1.80^{A}	1.74^{C}	1.89^{D}	1.42	2.02^{D}	2.25^{C}	2.08^{D}	1.59
	after	1.83	1.78^{abc}	1.56^{d}	1.49	1.54	1.81^{c}	1.86^{e}	1.42	2.01^{cd}	2.49	2.14^{e}	1.46
4	before	1.76^{ABC}	1.51^{E}	1.81^{ABC}	1.75	1.65^{AB}	2.06^{AB}	2.13^{BCD}	1.58	2.34^{BC}	2.44^{BC}	2.46^{ABC}	1.36
	after	1.75	1.50^{d}	1.81^{abcd}	1.77	1.39	2.05^{abc}	2.20^{ba}	1.54	2.39^{ab}	2.51	2.52^{abcd}	1.24
5	before	1.46^{D}	1.55^{DE}	1.78^{ABC}	1.73	1.63^{AB}	1.99^{ABC}	2.24^{BC}	1.54	2.23^{BCD}	2.32^{BC}	2.43^{BC}	1.42
	after	1.53	1.53^{cd}	1.81^{abcd}	1.73	1.49	2.01^{abc}	2.23^{abc}	1.52	2.26^{bc}	2.64	2.46^{abcde}	1.31
6	before	1.67^{BCD}	1.70^{BCDE}	1.92^{A}	1.77	1.78^{A}	2.00^{ABC}	2.28^{AB}	1.6	2.36^{BC}	2.28^{BC}	2.44^{BC}	1.66
	after	1.59	1.69^{abcd}	1.87^{abc}	1.76	1.49	2.04^{abc}	2.31^{ab}	1.50	2.28^{bc}	2.65	2.54^{abc}	1.53
7	before	1.69^{BCD}	2.02^{A}	1.59^{C}	1.55	1.86^{A}	1.82^{BC}	1.98^{CD}	1.62	1.95^{D}	2.38^{BC}	2.09^{D}	1.51
	after	1.70	1.82^{ab}	1.68^{bcd}	1.65	1.55	1.84^{c}	2.01^{bcde}	1.61	2.03^{cd}	2.56	2.15^{e}	1.40
8	before	1.85^{AB}	1.94^{AB}	1.62^{C}	1.53	1.64^{AB}	1.87^{BC}	2.12^{BCD}	1.51	2.12^{BCD}	2.46^{BC}	2.29^{BCD}	1.57
	after	1.85	1.91^{a}	1.66^{bcd}	1.58	1.48	1.93^{bc}	2.15^{bcde}	1.50	2.16^{bcd}	2.61	2.26^{bcde}	1.44
9	before	1.70^{BCD}	1.95^{AB}	1.62^{C}	1.59	1.73^{A}	1.83^{BC}	1.93^{D}	1.53	2.05^{CD}	2.37^{BC}	2.19^{CD}	1.50
	after	1.76	1.81^{ab}	1.55^{d}	1.68	1.49	1.78^{c}	1.90^{de}	1.47	1.92^{d}	2.63	2.20^{de}	1.46
10	before	1.74^{ABC}	1.75^{ABCDE}	1.88^{AB}	1.74	1.80^{A}	2.19^{A}	2.32^{AB}	1.60	2.41^{AB}	2.57^{AB}	2.55^{AB}	1.66
	after	1.60	1.73^{abcd}	1.92^{ab}	1.81	1.54	2.19^{ab}	2.31^{ab}	1.58	2.42^{ab}	2.61	2.52^{abcd}	1.57
11	before	1.70^{BCD}	1.61^{DE}	1.75^{ABC}	1.63	1.85^{A}	2.23^{A}	2.55^{A}	1.81	2.68^{A}	2.82^{A}	2.76^{A}	1.51
	after	1.56	1.49^{d}	1.84^{abc}	1.71	1.46	2.24^{a}	2.48^{a}	1.60	2.65^{a}	2.95	2.74^{a}	1.38
12	before	1.58^{CD}	1.63^{CDE}	1.91^{AB}	1.73	1.80^{A}	2.21^{A}	2.33^{AB}	1.53	2.39^{AB}	2.49^{BC}	2.47^{ABC}	1.67
	after	1.63	1.61^{bcd}	1.95^{a}	1.86	1.60	2.23^{a}	2.31^{ab}	1.56	2.38^{ab}	2.66	2.57^{ab}	1.52
SE	before	0.09	0.10	0.09	0.09	0.09	0.10	0.10	0.09	0.11	0.11	0.11	0.09
	after	0.09	0.11	0.09	0.09	0.08	0.10	0.11	0.08	0.11	0.12	0.12	0.08

[λ] Mean and Standard Error from 102 consumer responses based on a 5-point scale per emotion term. [A-E] Mean values of emotions in the same column followed by different letters are significantly different ($P<0.05$)

[a-e] Mean values of emotions in the same column followed by different letters are significantly different ($P<0.05$). [NS] No significant differences were observed among the treatments ($P>0.05$).

[β] Before and after the sodium claim was given to consumers

Overall liking was a significant predictor ($P<0.0001$) of PI before and after HM was presented to consumers. For every one unit increase on the 9-point hedonic scale for OL, the odds of buying the product were 1.905 and 1.618 times greater (before and after HM, respectively). Emotion terms *bored*, *disgusted*, and *guilty* significantly predicted PI before HM. That is, by increasing one unit on the 5-point scale for the negative emotion terms *bored, disgusted,* and *guilty*, the odds of reported positive PI would be 0.599, 0.694, and 0.671 times lower, respectively, than negative PI. *Bored* and *disgusted* (odds ratio: 0.626 and 0.566, respectively) remained significant after the HM was given to consumers while *guilty* became insignificant. *Nostalgic*, *pleased* and *satisfied* were also significant in the LRA model for PI before, with odds ratio values of 1.302, 1.406, and 2.103, respectively, and became insignificant after HM. *Satisfied* was also a significant predictor of PI before and after HM was given to consumers. This means that for a one-point increase on the 5-point emotion scale, the probability (odds) of positive PI would be 2.103 (before HM) and 2.731 (after HM) times higher than negative PI. *Safe* became a significant emotion predicting PI after HM was given, meaning that for a one unit change in s*afe* magnitude, the odds of willingness to buy the product will be 1.20 times higher than not buying it. Health message regarding low-sodium benefits impacted how *safe* (pertaining to health) consumer felt about the product.

6.3.5 Effect of saltiness and bitterness intensity on consumers' liking

Figure 6.1 displays the effect of non-JAR saltiness on (a) saltiness liking and (b) OL scores. Treatment 4 (chipotle flavor containing 0.5% KCl), treatment 11 (bacon flavor containing 1.0% KCl), and treatment 7 (garlic & herb flavor containing 0.5% KCl) were perceived "too weak" in saltiness intensity by more than 30% of consumers. Low saltiness intensity produced mean drops >1.5, indicating decrease in saltiness liking scores for spreads when salty taste was not right for consumers. When the rest of the treatments were considered to be either "too weak" or "too strong" in saltiness intensity, there were no concerning mean drops in saltiness liking (Figure 6.1 (a)). Figure 6.1 (b), plots the effect of saltiness intensity on OL. More than 30% of subjects perceived treatments 7, 10, 4, and 11 as weak in saltiness. Nevertheless, none of the mean drops resulted in >1 unit decrease on the 9-point hedonic scale for OL.

Figure 6.2 shows the effect of non-JAR bitterness on (a) bitterness liking, and (b) OL scores. The three chipotle-flavored treatments (treatment 4, 5, and 6) were rated by >20% of consumers as "too bitter," which was associated with mean drops of 1.90, 1.60, and 1.51, respectively. None of the other treatments showed high impact on bitterness liking, meaning that a low percentage of consumers found the bitter taste to deviate from their expected ideal intensity. Based on the penalty analysis conducted, non-JAR bitterness intensities did not substantially affect OL scores of the spreads (Figure 6.2 (b)).

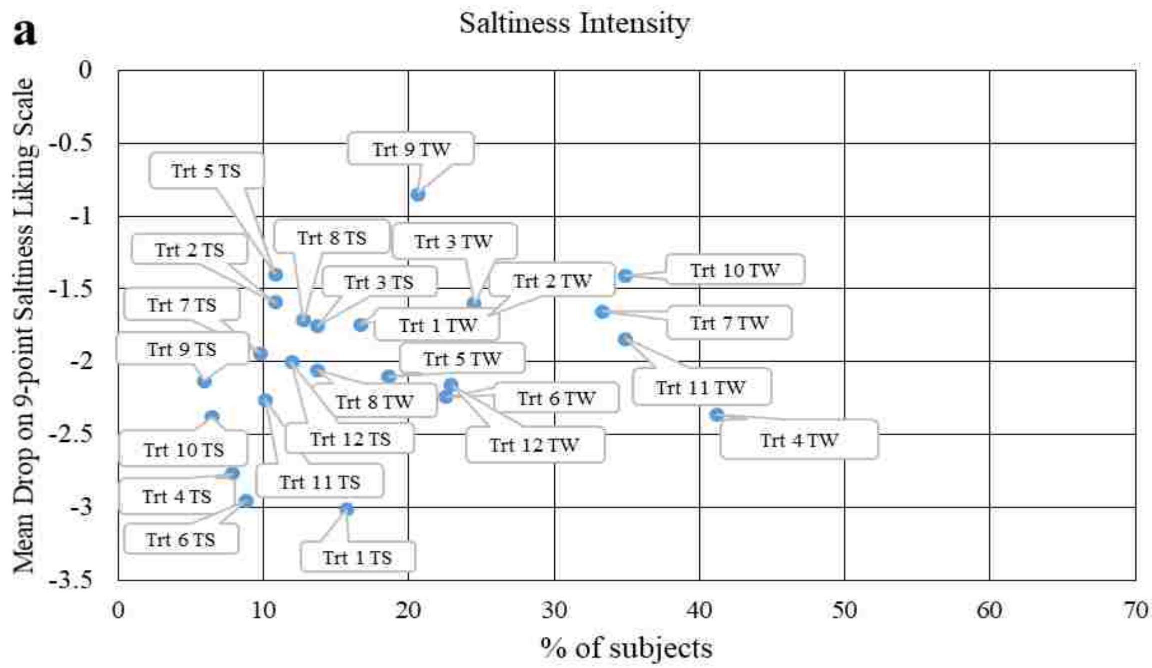
Table 6.5 Odds ratio estimates of consumers' purchase intent of flavored spreads

Parameters	**Pr > ChiSq***	**Odds ratio $^{\beta}$**	**Pr > ChiSq***	**Odds ratio $^{\mu}$**
Overall liking	**<0.0001**	**1.905**	**<0.0001**	**1.618**
Bored	**<0.0001**	**0.599**	**0.0004**	**0.626**
Disgusted	**0.0232**	**0.694**	**0.0003**	**0.566**
Eager	0.2222	1.207	0.4611	1.124
Energetic	0.3753	1.151	0.0827	1.332
Guilty	**0.0057**	**0.671**	0.9683	1.006
Happy	0.3123	1.181	0.1738	1.244
Interested	0.5914	0.924	0.9070	1.017
Nostalgic	**0.0461**	**1.302**	0.4723	1.105
Pleased	**0.0290**	**1.406**	0.8239	1.034
Safe	0.5496	0.943	**0.0344**	**0.837**
Satisfied	**<0.0001**	**2.103**	**<0.0001**	**2.731**
Worried	0.7534	0.953	0.7100	1.060

*statistically significant p-values in bold print ($p<0.05$)

$^{\beta}$ Purchase intent asked before consumers had been given low-sodium health benefits.

$^{\mu}$ Purchase intent asked after consumers had been given low-sodium health benefits.



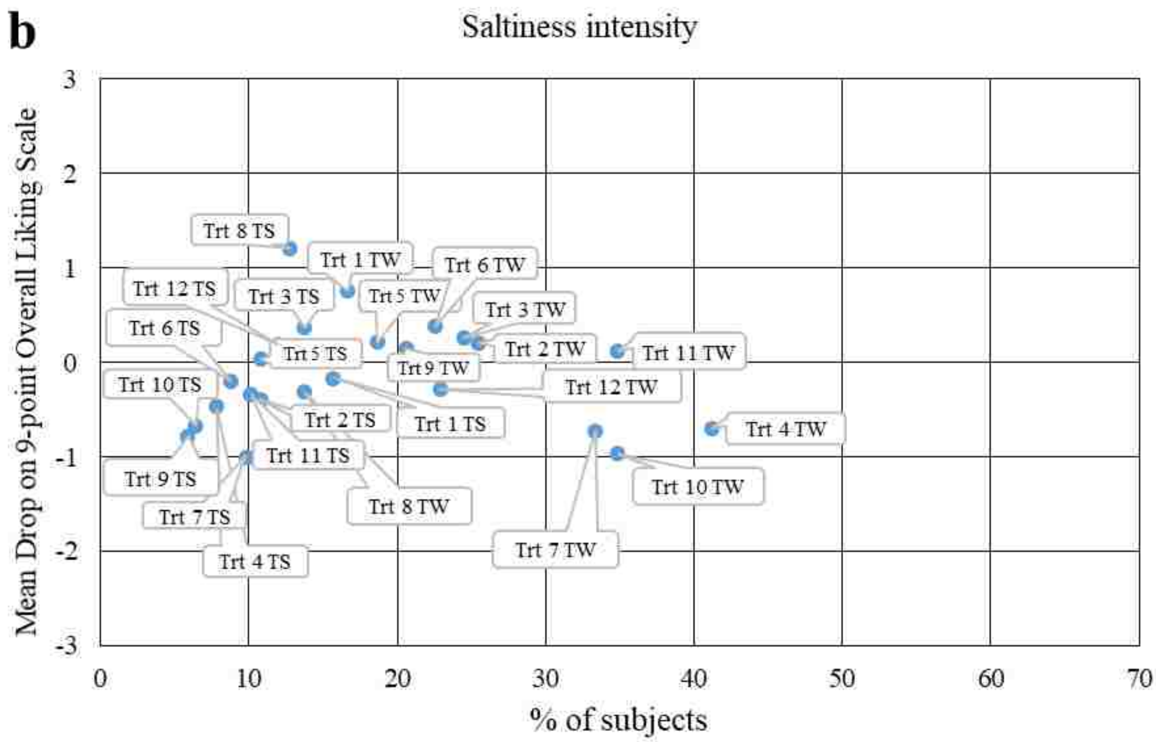


Figure 6.1 (a) Saltiness Penalty plot. TS= Strong Saltiness; TW= Weak Saltiness (affecting Saltiness liking). (b) Saltiness Penalty plot. TS= Strong Saltiness; TW= Weak Saltiness (affecting overall liking)

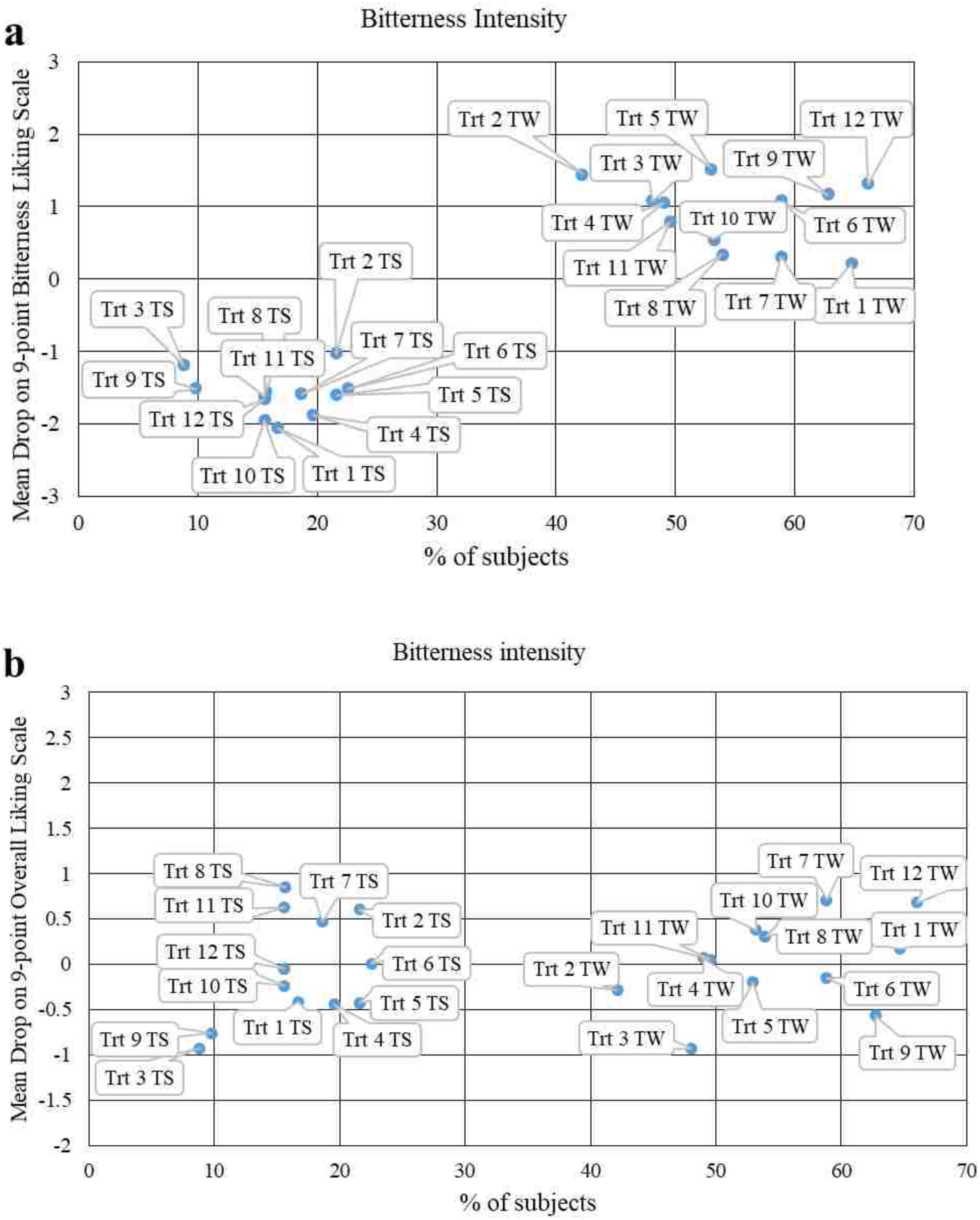


Figure 6.2 (a) Bitterness Penalty plot. TS= Strong Bitterness; TW= Weak Bitterness (affecting bitterness liking). (b) Bitterness Penalty plot. S= Strong Bitterness; W= Weak Bitterness (affecting overall liking)

6.4 Conclusions

The HM did not have a significant effect on OL scores. The percentage of KCl added to the samples did not significantly affect the sensory attributes evaluated within the same flavor, except for bacon flavor, for which the 1% KCl treatment outperformed the 0.5% and 1.5% KCl formulations. Overall, the 1% KCl bacon spread sample had higher scores compared to the rest of the treatments in all attributes evaluated. For ten of the twelve treatments, PI increased after the low-sodium HM was given to consumers. Overall liking and emotion terms *bored*, *disgusted*, and *satisfied* were significant predictors of PI of the flavored spreads before and after HM. The turkey salads prepared with flavored spreads yielded higher overall liking scores (5.72-6.16) than the spreads alone. More uniform results from a final product may relate to less intense perceptions by the individual of the flavorings used. This study demonstrated that, depending on the flavoring used, flavor modification and the use of the spreads in real food products can increase liking scores and PI of low-sodium spreads.

6.5 References

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CHAPTER 7. SUMMARY AND CONCLUSIONS

7.1 Summary and conclusions

Reduction of salt intake is a global effort. Due to health problems related to high sodium consumption, reducing or regulating the dietary intake of sodium, will potentially save lives and decrease cost of healthcare. Approximately 71% of Americans' daily sodium consumption comes from processed food. Sodium reduction in the food supply chain is recommended. Reducing particle size of salt crystals, using salt replacers, incorporating flavor-enhancer substances, among others, are techniques frequently applied to help reduce sodium in processed foods without significantly impacting products' sensory characteristics. This research aimed to develop acceptable low-sodium products by using KCl as a salt replacer in solid-matrix foods. Also, an oil-in-water emulsion system was used to develop low-sodium flavored spreads. The impact of health benefit information on consumers' willingness to purchase low-sodium products was also assessed.

To address the objectives of this dissertation, three main studies were conducted. Study I investigated the optimization of low-sodium (NaCl/KCl/Glycine) roasted peanuts based on sensory liking and emotion, and their purchase intent as affected by health benefit statement. The sodium content in low-sodium roasted peanuts could be decreased approximately 30% without decreasing sensory liking scores or PI. Overall liking, emotion *pleased*, and *satisfied* were significant predictors of PI based on LRA. The optimal range of NaCl/KCl/Glycine at 59-100/0-40/1-12.5 yielded acceptable low-sodium peanuts. The optimal range represents treatments containing about 37% less sodium below the "low-sodium" criteria. This study showed feasibility of producing acceptable low-sodium roasted peanuts via optimization based on sensory liking and emotional responses.

Study II examined the rejection Threshold (RjT) of added KCl, emotion, liking and PI of low-sodium roasted peanuts. Knowing that KCl has the disadvantage of imparting bitter and metallic aftertaste when added at high concentrations to food products, this study aimed to evaluate the changes in overall liking, emotion magnitudes and PI of low-sodium peanuts as the added KCl concentration increased. Potassium chloride addition up to 50% concentration to low-sodium roasted peanuts did not significantly decreased OL scores. However, when KCl amounts increased to 70-90%, OL scores decreased. Positive PI (>60%) was reported by consumers for treatments with up to 30% added KCl. Purchase intent decreased to 50-55% when added KCl increased to 50-90%. No significant differences were observed for positive emotion *energetic, happy,* and *pleased* among all treatments. Adding more than 70% KCl decreased emotion "*satisfied"* by 0.3 unit. No RjT of added KCl (up to 90% of NaCl used at 2.778g) was reached under the conditions of this study. Study III studied the development of acceptable low-sodium and sodium-free spreads by flavor modification and their incorporation into turkey salad sandwiches. Based on results from the first phase of this study, a 0.5%, 1%, and 1.5% KCl sodium-free spread formulation were selected to improve their acceptability by flavor modification. The flavored-spreads were also evaluated when used in a final food product (turkey salad sandwiches). Overall, acceptability of the spreads increased by flavor modification. Bacon flavor treatments had significantly higher liking scores compared to the other flavors evaluated. In this study, bitter taste was not associated with the "concerning mean drops" on OL scores. Health information increased PI of 10 of the 12 treatments, but did not affect OL scores. The turkey salad sandwiches prepared with flavored spreads yielded higher overall liking scores (5.72-6.16) than the spreads alone. Pairing sodium substitution with a known health claim (low-sodium) may further increase willingness to consume these low-sodium products.

APPENDIX A: SENSORY CHARACTERISTICS OF LOW-SODIUM PEANUTS CONTAINING SODIUM CHLORIDE, POTASSIUM CHLORIDE, AND GLYCINE

A.1 Consent form

Panelist Name: ____

Research Consent Form

I agree to participate in the research entitled "Sensory characteristics of low-sodium roasted peanuts containing sodium chloride (NaCl), potassium chloride (KCl) and glycine (Gly)" which is being conducted by Witoon Prinyawiwatkul of the School of Nutrition and Food Science 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. Two hundred consumers will participate in this research. For this particular research, about 5-10 minute 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 participation to the investigator any food allergies I may have.

2. The reason for the research is to evaluate how consumer liking of low-sodium roasted peanuts varies with different concentrations of NaCl, KCl, and Gly. The benefit that I may expect from it is a satisfaction that I have contributed to solution and evaluation of problems related to such examination.

3. The procedures are as follows: three 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 may be an allergic reaction **to peanuts, canola oil, sodium chloride (NaCl), potassium chloride (KCl), glycine (Gly), and unsalted crackers. However, because it is known to me beforehand that all those 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 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 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.

A.2 Questionnaire

A. Demographic information

Demographic information

Gender: [ ] Female [ ] Male

Age (years): [ ] 18-25 [ ] 26-35 [ ] 36-45 [ ] 46-55 [ ] 56-65 [ ] >65

Race: [ ] Caucasian [ ] Black American [ ] Hispanic [ ] Asian [ ] Other

Education level: [ ] High school or below [ ] College or above

Do you know what sodium chloride (NaCl) is?

[ ] Yes [ ] Not sure [ ] No

Do you know what potassium chloride (KCl) is?

[ ] Yes [ ] Not sure [ ] No

Do you consider yourself a regular user of salt for cooking?

[ ] Yes [ ] Not sure [ ] No

High sodium intake is associated with heart diseases. Would you consider lowing sodium in your diet?

[ ] Yes [ ] Not sure [ ] No

B. Samples testing

Please taste the following peanut samples in the order presented. Between the samples, drink water and eat unsalted crackers to clean your palate.

Sample 000

- How would you **rate** the following attributes of this product?

	Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
Texture	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9
Saltiness	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9
Overall taste	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9
Overall liking	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9

Please, **rate** the intensity of the following attributes of this product (Mark only one box).

Saltiness	[ ] None	[ ] Weak	[ ] Moderate	[ ] Strong	[ ] Very strong
Bitterness	[ ] None	[ ] Weak	[ ] Moderate	[ ] Strong	[ ] Very strong

Are you satisfied with the intensity of the following attributes?

Saltiness	[ ] No	[ ] Yes
Bitterness	[ ] No	[ ] Yes

How do you **emotionally feel** when consuming this product?

	Not at all	Slightly	Moderately	Very much	Extremely
Energetic	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Guilty (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Happy	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Pleased	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Satisfied	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Unsafe (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Worried (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5

How likely will you **purchase** this product?

[ ] Yes [ ] Not sure [ ] No

High sodium intake is associated with heart diseases. This sample is **low** in **sodium.**

Knowing the fact that this is a low-sodium product, please answer again the following questions:

How do you **emotionally feel** when consuming this product?

	Not at all	Slightly	Moderately	Very much	Extremely
Energetic	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Guilty (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Happy	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Pleased	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5

Satisfied	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Unsafe (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Worried (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5

How likely will you **purchase** this product?

[ ] Yes [ ] Not sure [ ] No

A.3 SAS codes

FREQUENCIES

```
DM "LOG;CLEAR";
ODS HTML CLOSE;
ODS HTML;
data Peanuts;
input Panelist Gender Age Race Education KnowNaCl KnowKCl ConsumeNaCl
Lowering_Na;
datalines;
;
proc freq data=Peanuts;
Title1 'Gender frequencie count %';
table Gender;
run;

proc freq data=Peanuts;
Title2 'Age frequencie count %';
table Age;
run;

proc freq data=Peanuts;
Title3 'Race frequencie count %';
table Race;
run;

proc freq data=Peanuts;
Title4 'Education frequencie count %';
table Education;
run;

proc freq data=Peanuts;
Title5 'KnowNaCl frequencie count %';
table KnowNaCl;
run;

proc freq data=Peanuts;
Title5 'KnowKCl frequencie count %';
table KnowKCl;
run;
```

```
proc freq data=Peanuts;
Title5 'ConsumeNaCl frequencie count %';
table ConsumeNaCl;
run;

proc freq data=Peanuts;
Title5 'Lowering_Na frequencie count %';
table Lowering_Na;
run;
```

MANOVA and DDA

```
dm 'log;clear;output;clear';
data peanutsmanova;
input Panelist Sample Texture Saltiness O_taste O_liking EnergeticB GuiltyB
HappyB PleasedB SatisfiedB UnsafeB WorriedB EnergeticA GuiltyA HappyA
PleasedA SatisfiedA UnsafeA WorriedA;
datalines;
;
proc candisc out=outcan mah;
class Sample;
var Texture Saltiness O_taste O_liking;
run;

proc candisc out=outcan mah;
class Sample;
var EnergeticB GuiltyB HappyB PleasedB SatisfiedB UnsafeB WorriedB;
run;
proc candisc out=outcan mah;
class Sample;
var EnergeticA GuiltyA HappyA PleasedA SatisfiedA UnsafeA WorriedA;
run;

proc candisc out=outcan mah;
class Sample;
var Texture Saltiness O_taste O_liking EnergeticB GuiltyB HappyB PleasedB
SatisfiedB UnsafeB WorriedB;
run;

proc candisc out=outcan mah;
class Sample;
var EnergeticB GuiltyB HappyB PleasedB SatisfiedB UnsafeB WorriedB EnergeticA
GuiltyA HappyA PleasedA SatisfiedA UnsafeA WorriedA;
run;
```

LRA PIb and PIa

```
DM "LOG;CLEAR";
ODS HTML CLOSE;
ODS HTML;
data Peanuts;
input Panelist Sample Gender Education KnowNaCl KnowKCl ConsumeNaCl
Lowering_Na Texture Saltiness O_taste O_liking EnergeticB GuiltyB HappyB
PleasedB SatisfiedB UnsafeB WorriedB PIb;
datalines;
;
Proc logistic data = Peanuts;
```

```
model PIb = Gender Education KnowNaCl KnowKCl ConsumeNaCl Lowering_Na Texture
Saltiness O_taste O_liking EnergeticB GuiltyB HappyB PleasedB SatisfiedB
UnsafeB WorriedB;
run;


DM "LOG;CLEAR";
ODS HTML CLOSE;
ODS HTML;
data Peanuts;
input Panelist Sample Gender Education KnowNaCl KnowKCl ConsumeNaCl
Lowering_Na EnergeticA GuiltyA HappyA PleasedA SatisfiedA UnsafeA WorriedA
PIa;
datalines;
;
Proc logistic data = Peanuts;
model PIa =  Gender Education KnowNaCl KnowKCl ConsumeNaCl Lowering_Na
EnergeticA GuiltyA HappyA PleasedA SatisfiedA UnsafeA WorriedA;
run;
```

MEANS, SD, ANOVA – LIKING AND EMOTIONS

```
dm 'log;clear;output;clear';
data ROASTEDPEANUTS;
input PANELIST TRT TEXTURE SALTINESS OVERALLTASTE OVERALLLIKING SALTINESSI
BITTERNESSI SALTINESSS BITTERNESSS ENERGETIC GUILTY HAPPY PLEASED SATISFIED
UNSAFE WORRIED ENERGETIC1 GUILTY1 HAPPY1 PLEASED1 SATISFIED1 UNSAFE1
WORRIED1;
DATALINES;
;
proc sort; by TRT;
run;

proc means mean std n maxdec=2; by TRT;
Var TEXTURE SALTINESS OVERALLTASTE OVERALLLIKING SALTINESSI BITTERNESSI;
run;

proc means mean std n maxdec=2; by TRT;
Var ENERGETIC GUILTY HAPPY PLEASED SATISFIED UNSAFE WORRIED;
run;

proc means mean std n maxdec=2; by TRT;
Var ENERGETIC1 GUILTY1 HAPPY1 PLEASED1 SATISFIED1 UNSAFE1 WORRIED1;
run;

proc glimmix;
title1 'ANOVA TEXTURE';
class PANELIST TRT;
model TEXTURE = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SALTINESS';
class PANELIST TRT;
```

```
model SALTINESS = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;


proc glimmix;
title1 'ANOVA OVERALLTASTE';
class PANELIST TRT;
model OVERALLTASTE = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA OVERALLLIKING';
class PANELIST TRT;
model OVERALLLIKING = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SALTINESSI';
class PANELIST TRT;
model SALTINESSI = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA BITTERNESSI';
class PANELIST TRT;
model BITTERNESSI = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc freq data=ROASTEDPEANUTS;
table SALTINESSS;
RUN;

proc freq data=ROASTEDPEANUTS;
table BITTERNESSS;
RUN;

proc glimmix;
title1 'ANOVA ENERGETIC';
class PANELIST TRT;
model ENERGETIC = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA GUILTY';
class PANELIST TRT;
```

```
model GUILTY = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA HAPPY';
class PANELIST TRT;
model HAPPY = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA PLEASED';
class PANELIST TRT;
model PLEASED = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SATISFIED';
class PANELIST TRT;
model SATISFIED = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA UNSAFE';
class PANELIST TRT;
model UNSAFE = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA WORRIED';
class PANELIST TRT;
model WORRIED = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA ENERGETIC1';
class PANELIST TRT;
model ENERGETIC1 = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA GUILTY1';
class PANELIST TRT;
model GUILTY1 = TRT;
```

```
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA HAPPY1';
class PANELIST TRT;
model HAPPY1 = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA PLEASED1';
class PANELIST TRT;
model PLEASED1 = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SATISFIED1';
class PANELIST TRT;
model SATISFIED1 = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA UNSAFE1';
class PANELIST TRT;
model UNSAFE1 = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA WORRIED1';
class PANELIST TRT;
model WORRIED1 = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;
```

Paired t-test emotions

```
dm 'log;clear;output;clear';
data EMOTIONS_B_A;
input Panelists Sample Energetic Guitly Happy Pleased Satisfied Unsafe
Worried EnergeticA GuitlyA HappyA PleasedA SatisfiedA UnsafeA WorriedA;
datalines;
;
proc sort; by Sample;
proc ttest; by Sample;
paired Energetic*EnergeticA;
run;

proc sort; by Sample;
```

```
proc ttest; by Sample;
paired Happy*HappyA;
run;

proc sort; by Sample;
proc ttest; by Sample;
paired Pleased*PleasedA;
run;

proc sort; by Sample;
proc ttest;by Sample;
paired Satisfied*SatisfiedA;
run;

proc sort; by Sample;
proc ttest;by Sample;
paired Unsafe*UnsafeA;
run;

proc sort; by Sample;
proc ttest;by Sample;
paired Worried*WorriedA;
run;
```

APPENDIX B: RJT OF ADDED KCL IN ROASTED PEANUTS

B.1 Consent form

Panelist Name: ____

Research Consent Form

I agree to participate in the research entitled 'Rejection Threshold (RjT) level of KCl in roasted peanuts affecting emotion, liking scores and purchase intent decision" which is being conducted by Witoon Prinyawiwatkul of the School of Nutrition and Food Science 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. Sixty consumers will participate in this research. For this particular research, about 5-10 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 participation to the investigator any food allergies I may have.

2. The reason for the research is to determine the RjT level of added KCl in roasted peanuts using 2-Alternative Forced Choices preference test. Also to evaluate how emotion and overall liking socres are affected by reaching KCl RjT in roasted peanuts . The benefit that I may expect from it is a satisfaction that I have contributed to solution and evaluation of problems related to such examination.

3. The procedures are as follows: four 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 may be an allergic reaction **to peanuts, canola oil, sodium chloride (NaCl), potassium chloride (KCl), and unsalted crackers. However, because it is known to me beforehand that all those 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 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 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.

B.2 Questionnaire

Session --

Name: ______________________________________

1. Questionnaire

Instruction:

Please taste the samples in the order presented and answer the following questions.

Rate the **saltiness of sample 000.**

Saltiness [ ] Not salty enough [ ] Just About Right [ ] Too salty

Rate the **saltiness of sample 000.**

Bitterness [ ] Not bitter [ ] Moderately bitter [ ] Too bitter

- How do you **emotionally feel** when consuming sample **000**?

	Not at all	Slightly	Moderately	Very much	Extremely
Energetic	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Guilty (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Happy	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Pleased	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Satisfied	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Unsafe (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5
Worried (health related)	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5

- How would you **rate** the overall liking of sample **000**?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9

- How likely will you **purchase** sample **000**?
  [ ] Yes [ ] No

Now please, *taste the samples* 000 and 111 from **left** to **right,** and based on **overall taste**, check which sample you prefer more**.** Between samples, you will take unsalted crackers and water to clean your palate.

Sample **000**	Sample **111**	**Equally preferred**
[ ]	[ ]	[ ]

B.3 SAS codes

MEANS, SD, ANOVA – LIKING AND EMOTIONS

```
dm 'log;clear;output;clear';
data RJT;
input PANELIST TRT OVERALLLIKING ENERGETIC GUILTY HAPPY PLEASED SATISFIED
UNSAFE WORRIED;
DATALINES;
;
proc sort; by TRT;
run;

proc means mean std n maxdec=2; by TRT;
Var OVERALLLIKING ENERGETIC GUILTY HAPPY PLEASED SATISFIED UNSAFE WORRIED;
run;


proc glimmix;
title1 'ANOVA OVERALLLIKING';
class PANELIST TRT;
model OVERALLLIKING = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;

proc glimmix;
title1 'ANOVA ENERGETIC';
class PANELIST TRT;
model ENERGETIC = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
```

```
run;

proc glimmix;
title1 'ANOVA GUILTY';
class PANELIST TRT;
model GUILTY = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA HAPPY';
class PANELIST TRT;
model HAPPY = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA PLEASED';
class PANELIST TRT;
model PLEASED = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SATISFIED';
class PANELIST TRT;
model SATISFIED = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA UNSAFE';
class PANELIST TRT;
model UNSAFE = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA WORRIED';
class PANELIST TRT;
model WORRIED = TRT;
random PANELIST;
lsmeans TRT/ diff CL lines;
run;
```

APPENDIX C: EMOTION AND PURCHASE INTENT OF MAYONNAISE-TYPE SPREADS AS AFFECTED BY NUTRIENT CLAIMS FOR SODIUM CONTENT (LOW-SODIUM, REDUCED-SODIUM, AND SODIUM-FREE)

C.1 Consent form

Panelist Name: ____

Research Consent Form

I, __________________________, agree to participate in the research entitled "Effects of Salty and Bitter Tastes on Liking, Expectation, Emotion and Purchase Intent of Low-Sodium Spreads" which is being conducted by Witoon Prinyawiwatkul 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 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 participation returned to me, removed from the experimental records, or destroyed. One hundred 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 saltiness and bitterness intensities of mayonnaise-like spreads. The benefit that I may expect is satisfaction that I have contributed to a solution and evaluation of problems relating to such examinations.
3. The procedures are as follows: three 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 may be an allergic reaction to canola oil, milk products, vinegar, sodium chloride (salt), potassium chloride (salt substitute) and/or food gums**. 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 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 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.

C.2 Questionnaire

Question # 1.

Please type your name in the box below if you agree to the terms of this consent form.

Question # 2.

Please select your gender.

Male
Female

Question # 3 - Sample ______

Sample %01

Please spread sample **%01** onto a piece of bread, taste, and answer the following questions:

Saltiness JAR

Too weak	Just about right	Too strong
1	2	3

Saltiness liking

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
1	2	3	4	5	6	7	8	9

Question # 4 - Sample ______

Sample %01

Please spread sample **%01** onto a piece of bread, taste, and answer the following questions:

Bitterness JAR

None (ideal)	Weak	Strong

Bitterness liking

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

Question # 5 - Sample ______

Sample %01

Please rate your overall liking of this spread.

Liking before

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

Question # 6 - Sample ______

Sample %01

How does the consumption of this product make you feel? Please click each box below and choose the intensity that best describes your emotion.

Bored

Not at all	Slightly	Moderately	Very much	Extremely

Calm

Not at all	Slightly	Moderately	Very much	Extremely

Disgusted

Not at all	Slightly	Moderately	Very much	Extremely

Eager

Not at all	Slightly	Moderately	Very much	Extremely

Energetic

Not at all	Slightly	Moderately	Very much	Extremely

Guilty

Not at all	Slightly	Moderately	Very much	Extremely

Question # 10 - Sample ______

Happy

Not at all	Slightly	Moderately	Very much	Extremely

Interested

Not at all	Slightly	Moderately	Very much	Extremely

Nostalgic

Not at all	Slightly	Moderately	Very much	Extremely

Pleased

Not at all	Slightly	Moderately	Very much	Extremely

Safe (pertaining to health)

Not at all	Slightly	Moderately	Very much	Extremely

Question # 11 - Sample ______

Satisfied

Not at all	slighlty	Moderately	Very much	Extremely

Worried (pertaining to health)

Not at all	slighlty	Moderately	Very much	Extremely

Question # 7 - Sample ______

Sample %01

Would you purchase this product?

Yes No

Excess sodium consumption contributes to high blood pressure, a leading cause of heart diseast, kidney disease, and stroke. **This sample contains 66% less sodium than the standard recipe.**

Question # 9 - Sample ______

<u>Sample %01</u>

Please rate your overall liking of this spread.

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

Question # 10 - Sample ______

<u>Sample %01</u>

How does the consumption of this product make you feel? Please click each box below and choose the intensity that best describes your emotion.

Bored

Not at all	Slightly	Moderately	Very much	Extremely
☐	☐	☐	☐	☐

Calm

Not at all	Slightly	Moderately	Very much	Extremely
☐	☐	☐	☐	☐

Disgusted

Not at all	Slightly	Moderately	Very much	Extremely
☐	☐	☐	☐	☐

Eager

Not at all	Slightly	Moderately	Very much	Extremely
☐	☐	☐	☐	☐

Energetic

Not at all	Slightly	Moderately	Very much	Extremely
☐	☐	☐	☐	☐

Guilty

Not at all	Slightly	Moderately	Very much	Extremely

Question # 10 - Sample ______

Happy

Not at all	Slightly	Moderately	Very much	Extremely

Interested

Not at all	Slightly	Moderately	Very much	Extremely

Nostalgic

Not at all	Slightly	Moderately	Very much	Extremely

Pleased

Not at all	Slightly	Moderately	Very much	Extremely

Safe (pertaining to health)

Not at all	Slightly	Moderately	Very much	Extremely

Question # 11 - Sample ______

Satisfied

Not at all	slighlty	Moderately	Very much	Extremely

Worried (pertaining to health)

Not at all	slighlty	Moderately	Very much	Extremely

Question # 11 - Sample ______

Sample %01

Would you purchase this product?

Yes No

C.3 SAS codes

McNemar

```
DM "LOG;CLEAR";
ODS HTML CLOSE;
ODS HTML;
data spreads;
input Panelist sample PIb PIa;
datalines;
;
proc sort;
by sample;
proc freq;
by sample;
tables      PIb   PIa;
tables  PIb*PIa;

proc sort; by sample;
/*the McNemar test below to get the chi-sq and prob values*/;
proc freq; by sample;
EXACT AGREE;
TABLES PIb*PIa;
run;
```

ANOVA HEDONIC

```
dm 'log;clear;output;clear';
data ANOVAHEDONIC;
input panelist sample SaltinessL BitternessL OLikingB OLikingA;
datalines;
;
proc sort; by sample;
run;

proc means mean std n maxdec=2; by sample;
Var SaltinessL BitternessL OLikingB OLikingA;
run;

proc glimmix;
title1 'ANOVA SaltinessL';
class panelist sample;
model SaltinessL = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA BitternessL';
class panelist sample;
model BitternessL = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA OLikingB';
```

```
class panelist sample;
model OLikingB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA OLikingA';
class panelist sample;
model OLikingA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;
```

ANOVA EMOTIONS BEFORE

```
dm 'log;clear;output;clear';
data ANOVAHEDONIC;
input panelist sample BoredB CalmB DisgustedB EagerB EnergeticB GuiltyB
HappyB InterestedB NostalgicB PleasedB SafeB SatisfiedB WorriedB;
datalines;
;
proc sort; by sample;
run;

proc means mean std n maxdec=2; by sample;
Var BoredB CalmB DisgustedB EagerB EnergeticB GuiltyB HappyB InterestedB
NostalgicB PleasedB SafeB SatisfiedB WorriedB;
run;

proc glimmix;
title1 'ANOVA BoredB';
class panelist sample;
model BoredB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA CalmB';
class panelist sample;
model CalmB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA DisgustedB';
class panelist sample;
model DisgustedB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA EagerB';
```

```
class panelist sample;
model EagerB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA EnergeticB';
class panelist sample;
model EnergeticB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;
proc glimmix;
title1 'ANOVA GuiltyB';
class panelist sample;
model GuiltyB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA HappyB';
class panelist sample;
model HappyB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA InterestedB';
class panelist sample;
model InterestedB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA NostalgicB';
class panelist sample;
model NostalgicB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA PleasedB';
class panelist sample;
model PleasedB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SafeB';
class panelist sample;
model SafeB = sample;
```

```
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SatisfiedB';
class panelist sample;
model SatisfiedB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA WorriedB';
class panelist sample;
model WorriedB = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;
```

ANOVA EMOTIONS AFTER

```
dm 'log;clear;output;clear';
data ANOVAHEDONIC;
input panelist sample BoredA CalmA DisgustedA EagerA EnergeticA GuiltyA
HappyA InterestedA NostalgicA PleasedA SafeA SatisfiedA WorriedA;
datalines;
;
proc sort; by sample;
run;

proc means mean std n maxdec=2; by sample;
Var BoredA CalmA DisgustedA EagerA EnergeticA GuiltyA HappyA InterestedA
NostalgicA PleasedA SafeA SatisfiedA WorriedA;
run;

proc glimmix;
title1 'ANOVA BoredA';
class panelist sample;
model BoredA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA CalmA';
class panelist sample;
model CalmA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA DisgustedA';
class panelist sample;
model DisgustedA = sample;
random panelist;
```

```
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA EagerA';
class panelist sample;
model EagerA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA EnergeticA';
class panelist sample;
model EnergeticA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;
proc glimmix;
title1 'ANOVA GuiltyA';
class panelist sample;
model GuiltyA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA HappyA';
class panelist sample;
model HappyA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA InterestedA';
class panelist sample;
model InterestedA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA NostalgicA';
class panelist sample;
model NostalgicA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA PleasedA';
class panelist sample;
model PleasedA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;
```

```
proc glimmix;
title1 'ANOVA SafeA';
class panelist sample;
model SafeA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA SatisfiedA';
class panelist sample;
model SatisfiedA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA WorriedA';
class panelist sample;
model WorriedA = sample;
random panelist;
lsmeans sample/ diff CL lines;
run;
```

LRA

```
DM "LOG;CLEAR";
ODS HTML CLOSE;
ODS HTML;
data LRAPIa;
input Panelist Sample Gender OLikingA BoredA CalmA DisgustedA EagerA
EnergeticA GuiltyA HappyA InterestedA NostalgicA PleasedA SafeA SatisfiedA
WorriedA PIa;
datalines;
;
Proc logistic data = LRAPIa;
model PIa = Gender OLikingA BoredA CalmA DisgustedA EagerA EnergeticA GuiltyA
HappyA InterestedA NostalgicA PleasedA SafeA SatisfiedA WorriedA;
run;

DM "LOG;CLEAR";
ODS HTML CLOSE;
ODS HTML;
data LRAPIb;
input Panelist Sample Gender SaltinessL BitternessL OLikingB BoredB CalmB
DisgustedB EagerB EnergeticB GuiltyB HappyB InterestedB NostalgicB PleasedB
SafeB SatisfiedB WorriedB PIb;
datalines;

Proc logistic data = LRAPIb;
model PIb = Gender SaltinessL BitternessL OLikingB BoredB CalmB DisgustedB
EagerB EnergeticB GuiltyB HappyB InterestedB NostalgicB PleasedB SafeB
SatisfiedB WorriedB;
run;
```

APPENDIX D: IMPROVING CONSUMER ACCEPTANCE, EMOTION, AND PURCHASE INTENT OF LOW-SODIUM SPREADS BY FLAVOR MODIFICATION AND ITS INCORPORATION INTO TURKEY SALAD SANDWICHES

D.1 Consent form

Panelist Name: ____

Research Consent Form

I agree to participate in the research entitled 'Improving Consumer Acceptance, and Purchase Intent of Low Sodium Mayonnaise-type Products by Flavor Modification" which is being conducted by Witoon Prinyawiwatkul of the School of Nutrition and Food Science 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. Four hundred-eight consumers will participate in this research. For this particular research, about 5-10 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 participation to the investigator any food allergies I may have.

2. The reason for the research is to develop and optimize acceptable low-sodium mayonnaise-type products using salt substitutes (KCl). Also to identify flavors that may reduce bitterness perception in these flavored mayonnaise-type product. The benefit that I may expect from it is a satisfaction that I have contributed to solution and evaluation of problems related to such examination.

3. The procedures are as follows: three 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 may be an allergic reaction **to soybean oil, sodium chloride (NaCl), potassium chloride (KCl), whey protein concentrate, cheddar cheese flavor, chipotle flavor, bacon flavor garlic and herb flavor, parsley, paprika, food grade gums, vinegar, carrots, and unsalted crackers. However, because it is known to me beforehand that all those 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 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 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.

D.2 Questionnaire

Question # 1.

Please write your name down if you agree with the terms of this consent form:

Question # 2.
Gender
Female
Male

Question # 3.

Do you consume mayonnaise or similar products?
Yes No

Question # 4.
How often?

Daily
Weekly
Monthly
Less than once per month

Question # 5.

Have you purchased low-sodium products?
Yes No

Question # 6.
Would you consider purchasing low-sodium products?
Yes No

Please dip a carrot into sample %01 and try the product.

Between samples, eat an unsalted cracker and drink water to cleanse your palate.

Question # 7 - Sample ______

How would you rate the **following attributes** of sample **%01**

Color

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

Saltiness

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

Bitterness

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

Flavor

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

Overall Liking

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

Question # 8 - Sample ______

Please **rate** the intensity of the following attributes of **sample %01**

Saltiness

Not salty enough	Just about right	Too salty
☐	☐	☐

Bitterness

Ideal (none)	Weak	Strong
☐	☐	☐

Question # 9 - Sample ______

Sample %01

How does this product make you feel? Please evaluate the following emotions:

Bored

Not at all Slightly Moderately Very much Extremely

Disgusted

Not at all | Slightly | Moderately | Very much | Extremely

Eager

Not at all | Slightly | Moderately | Very much | Extremely

Energetic

Not at all | Slightly | Moderately | Very much | Extremely

Guilty

Not at all | Slightly | Moderately | Very much | Extremely

Question # 10 - Sample ______

Happy

Not at all | Slightly | Moderately | Very much | Extremely

Interested

Not at all | Slightly | Moderately | Very much | Extremely

Nostalgic

Not at all | Slightly | Moderately | Very much | Extremely

Pleased

Not at all | Slightly | Moderately | Very much | Extremely

Safe (pertaining to health)

Not at all	Slightly	Moderately	Very much	Extremely

Question # 11 - Sample ______

Satisfied

Not at all	slighlty	Moderately	Very much	Extremely

Worried (pertaining to health)

Not at all	slighlty	Moderately	Very much	Extremely

Question # 12 - Sample ______

Sample %01

Would you **purchase** this product?

Yes No

This is a **low-sodium** product**.**

Please answer the following questions again:

Question # 13 - Sample ______

How much do you like sample **%01**

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

How does this product make you feel? Please evaluate the following emotions:

Bored

Not at all	Slightly	Moderately	Very much	Extremely

Disgusted

Not at all	Slightly	Moderately	Very much	Extremely

Eager

Not at all	Slightly	Moderately	Very much	Extremely

Energetic

Not at all	Slightly	Moderately	Very much	Extremely

Guilty

Not at all	Slightly	Moderately	Very much	Extremely

Question # 10 - Sample ______

Happy

Not at all	Slightly	Moderately	Very much	Extremely

Interested

Not at all	Slightly	Moderately	Very much	Extremely

Nostalgic

Not at all	Slightly	Moderately	Very much	Extremely

Pleased

Not at all	Slightly	Moderately	Very much	Extremely

Safe (pertaining to health)

Not at all	Slightly	Moderately	Very much	Extremely

Question # 11 - Sample ______

Satisfied

Not at all	slighlty	Moderately	Very much	Extremely

Worried (pertaining to health)

Not at all	slighlty	Moderately	Very much	Extremely

Question # 17 - Sample ______

Sample %01

Would you **purchase** this product?

Yes No

D.3 SAS codes

ANOVA-LIKING EMOTIONS, Logistic Regression Analysis and McNemar

```
dm 'log;clear;output;clear';
data MAYOSPREADALLFLAVORS;
input PANELIST Sample Color Saltiness Bitterness Flavor OLB BoredB DisgustedB
EagerB EnergeticB GuiltyB HappyB InterestedB NostalgicB PleasedB SafeB
SatisfiedB WorriedB PIB OLA BoredA DisgustedA EagerA EnergeticA GuiltyA
HappyA InterestedA NostalgicA PleasedA SafeA SatisfiedA WorriedA PIA;
datalines;


proc means mean std n maxdec=2; by Sample;
Var Color Saltiness Bitterness Flavor OLB BoredB DisgustedB EagerB EnergeticB
GuiltyB HappyB InterestedB NostalgicB PleasedB SafeB SatisfiedB WorriedB OLA
BoredA DisgustedA EagerA EnergeticA GuiltyA HappyA InterestedA NostalgicA
PleasedA SafeA SatisfiedA WorriedA;
run;

Proc logistic data = MAYOSPREADALLFLAVORS ;
model PIA =BoredA DisgustedA EagerA EnergeticA GuiltyA HappyA InterestedA
NostalgicA PleasedA SafeA SatisfiedA WorriedA;
run;

Proc logistic data = MAYOSPREADALLFLAVORS;
model PIB =BoredB DisgustedB EagerB EnergeticB GuiltyB HappyB InterestedB
NostalgicB PleasedB SafeB SatisfiedB WorriedB;
run;

Proc logistic data = MAYOSPREADALLFLAVORS ;
model PIA =OLA BoredA DisgustedA EagerA EnergeticA GuiltyA HappyA InterestedA
NostalgicA PleasedA SafeA SatisfiedA WorriedA;
run;

Proc logistic data = MAYOSPREADALLFLAVORS;
model PIB = Color Saltiness Bitterness Flavor OLB BoredB DisgustedB EagerB
EnergeticB GuiltyB HappyB InterestedB NostalgicB PleasedB SafeB SatisfiedB
WorriedB;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model Color = Sample;
random PANELIST;
```

```
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model Saltiness = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model Bitterness = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model Flavor = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model OLB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model BoredB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model DisgustedB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model EagerB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
```

```
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model EnergeticB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model GuiltyB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model HappyB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model InterestedB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model NostalgicB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model PleasedB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model SafeB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;
```

```
proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model SatisfiedB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model WorriedB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model OLA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model BoredA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model DisgustedA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model EagerA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model EnergeticA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
```

```
title1 'ANOVA MAYO';
class PANELIST Sample;
model GuiltyA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model HappyA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model InterestedA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model NostalgicA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model PleasedA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model SafeA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model SatisfiedA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
```

```
class PANELIST Sample;
model WorriedA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc freq;
by Sample;
tables      PIB   PIA;
tables   PIB*PIA;

proc sort; by Sample;
/*the McNemar test below to get the chi-sq and prob values*/;
proc freq; by Sample;
EXACT AGREE;
TABLES PIB*PIA;
run;
```

D.4 Consent form SANDWICH STUDY

Panelist Name: ____

I agree to participate in the research entitled 'Evaluation of consumer acceptance and purchase intent of turkey sandwich with low-sodium flavored mayonnaise-type spread" which is being conducted by Witoon Prinyawiwatkul of the School of Nutrition and Food Science 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. One hundred and ten consumers will participate in this research. For this particular research, about 5-10 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 participation to the investigator any food allergies I may have.

2. The reason for the research is to evaluate consumer acceptance and purchase decision of turkey sandwich when prepared with low-sodium flavored mayonnaise-type spreads. The benefit that I may expect from it is a satisfaction that I have contributed to solution and evaluation of problems related to such examination.

3. The procedures are as follows: Four 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 may be an allergic reaction **to canola oil, potassium chloride (KCl), whey protein concentrate, cheddar cheese flavor, chipotle flavor, garlic and herb flavor, bacon flavor, parsley, food grade gums, vinegar, white bread, turkey, and unsalted crackers. However, because it is known to me beforehand that all those 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 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 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.

D.5 Questionnaire SANDWICH STUDY

2. Questionnaire

C. Demographic information

Gender: [ ] Female [ ] Male

Age (years): [ ] 18-25 [ ] 26-35 [ ] 36-45 [ ] 46-55 [ ] 56-65 [ ] >65

Race: [ ] Caucasian [ ] Black American [ ] Hispanic [ ] Asian [ ] Other

D. Samples testing

Please taste the sandwiches in the order presented and answer the following questions (one at a time). Between the samples, drink water and eat unsalted crackers to clean your palate.

Sample 000

How would you **rate** the following attributes of the **turkey salad sandwich 000**?

	Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
Flavor	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9
Saltiness	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9
Overall taste	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9
Overall liking	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9

Would you **purchase** this product?

[ ] Yes [ ] No

High sodium intake is associated with heart diseases. The flavored-spread used in this sandwich is **low** in **sodium. Knowing this fact, please answer again the following questions:**

	Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
Overall liking	[ ] 1	[ ] 2	[ ] 3	[ ] 4	[ ] 5	[ ] 6	[ ] 7	[ ] 8	[ ] 9

Would you **purchase** this product?

[ ] Yes [ ] No

Would you **purchase** the flavored mayonnaise-type spread used in this turkey sandwich for your own cooking?

[ ] Yes [ ] No

D.6 SAS codes

```
dm 'log;clear;output;clear';
data SandwichALLFLAVORS;
input PANELIST Sample Flavor Saltiness Overalltaste OLB PIB OLA PIA PIA2;
datalines;
;
proc means mean std n maxdec=2; by Sample;
Var Flavor Saltiness Overalltaste OLB OLA;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model Flavor = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model Saltiness = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model Overalltaste= Sample;
```

```
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model OLB = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc glimmix;
title1 'ANOVA MAYO';
class PANELIST Sample;
model OLA = Sample;
random PANELIST;
lsmeans Sample/ diff CL lines;
run;

proc freq;
by Sample;
tables      PIB   PIA PIA2;
tables  PIB*PIA;

proc sort; by Sample;
/*the McNemar test below to get the chi-sq and prob values*/;
proc freq; by Sample;
EXACT AGREE;
TABLES PIB*PIA;
run;
```

APPENDIX E: IRB APPROVAL

LSU AgCenter Institutional Review Board (IRB)
Dr. Michael J. Keenan, Chair
School of Human Ecology
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/hs/training.htm)

1) Principal Investigator: Witoon Prinyawiwatkul **Rank:** Professor **Student?** No
School of Nutrition and Food Sciences **Ph:** 8-5188
E-mail: wprinyawiwatkul@agcenter.lsu.edu **and** wprinya@lsu.edu

2) Co-Investigator(s): please include department, rank, phone and e-mail for each NONE

- If student as principal or co-investigator(s), please identify and name supervising professor in this space

3) Project Title: **Consumer Acceptance and Perception of New and Healthier Food Products**
4) Grant Proposal?(yes or no) NO **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. **NONE**

6) PI signature ______ ****Date** 3-12-2015 (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 __ Not Exempted ✓ **IRB#** HE15-9
Reviewer Michael Keenan **Signature** Michael Keenan **Date** 3-16-2015

VITA

Kairy D Pujols Martinez was born in San José de Ocoa, a small town of the Dominican Republic, in May 1991. She got her Bachelor of Science in Food Technology from the Pan American School of Agriculture, Zamorano in December 2012. After receiving her bachelor's degree, she did an internship at Louisiana State University (LSU) for six months in 2013. Later in the same year, she started to work on her doctorate in the School of Nutrition and Food Sciences at LSU. She expects to complete her doctorate studies in May 2018.