IMPACT OF POTASSIUM CHLORIDE ON SALTINESS, BITTERNESS, AND OTHER SENSORY CHARACTERISTICS IN MODEL SOUP SYSTEMS

by

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Abstract

The challenge with reduced sodium foods is finding a suitable sodium replacement that delivers a salty flavor without extraneous off flavors. Potassium chloride (KCl), a commonly used salt replacer, when used in conjunction with sodium chloride, can be perceived as salty; however to some people, KCl tastes bitter or metallic.

The hypothesis for this research was the belief that a majority of people do not describe the flavors associated with KCl as bitter, metallic, or other possible negative terms. The objectives were 1) To determine the impact of KCl addition on the saltiness, bitterness, and other sensory characteristics in model soup systems using a trained descriptive analysis panel and 2) To determine what words are most frequently chosen by consumers to describe flavors associated with KCl.

There were two studies conducted; 1) The first study examined the basic taste intensities in samples with varying levels (19%-41%) of total sodium ions and samples with a set total sodium ion level (19%) and varying levels of KCl (0%-0.75%) in model soup systems in order to understand the potential interaction of KCl on the perceived saltiness of NaCl. The degree to which KCl can be used in reducing total sodium ion levels without adversely affecting the basic taste sensory properties was also examined.

Panelists evaluated the samples using the Sensory Spectrum® method. Salt, sour, bitter, umami, and metallic attributes were rated for chicken broth. Salt, sweet, sour, and bitter attributes were rated for tomato soup.

2) The second study examined the consumer language used to describe the flavors associated with KCl when used in a reduced sodium model soup system. Focus group participants generated the initial list of flavor descriptors for high (0.75%) KCl levels in chicken broth. A larger consumer study was conducted with subjects pre-screened for sensitivity to KCl Consumers were given reduced sodium chicken broth or tomato soup without KCl and another sample with 0.45% KCl, labelled Flavor A. Subjects then chose all of the descriptors from a pre-selected list that describe Flavor A, the flavors associated with KCl.

Comparisons in language descriptor selection were made among ethnic groups (African American, Hispanic, Caucasian, and Asian), gender, and age groups. As an example, among ethnic groups, for chicken broth, Hispanics chose the salty descriptor less frequently than the other ethnic groups, whereas Asians chose the salty descriptor more frequently than the other ethnic groups.

The trained descriptive analysis panel did not find an increase in bitterness perception as KCl levels increased. Consumers frequently selected characterizing flavor terms to describe flavors associated with KCl and rarely selected bitterness, metallic or other potentially negative terms to describe KCl flavor. The significance of these findings is that there may be a higher potential for sodium reduction in the food industry using KCl as a sodium ion replacer.

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I would like to dedicate this thesis to my best friend and husband, Shannon, and to my daughter Abigail Grace. Shannon, it is my privilege to be your wife. Abigail, I love being your mommy. Thanks for making my life so full and fun to live.

CHAPTER 1 - Review of Literature

The Link between Health and Sodium

The public is more concerned with sodium intake as stronger links between health problems and sodium emerge (Lynch 1987). Sodium may contribute to high blood pressure, as result of increases of fluid levels contained in the blood vessel. The heart, in turn, has to work harder to pump the larger volume of blood to all the tissues in the body (http://health.rutgers.edu/factsheets/sodium.htm, 09/16/2005). Sodium also impacts the arterioles. Arterioles constrict under the influence of sodium, increasing resistance to blood movement, lowering the volume of blood that can return to the heart. This higher resistance increases blood pressure (http://health.rutgers.edu/factsheets/sodium.htm, 09/16/2005). Jacobson (2005) estimated that 65 million American adults are hypertensive and another 45 million people are considered pre-hypertensive. People have different levels of susceptibility to the effects of sodium, and as one ages the sensitivity to sodium increases (http://www.health.gov/dietaryguidelines/dga2005/document/html/chapter8.htm, 04/27/2008). Currently there is not an accurate test that can assess who may be sensitive to the effects of sodium, so the entire population of the United States is advised to limit sodium intake (http://health.rutgers.edu/factsheets/sodium.htm, 09/16/2005).

The Necessity of Sodium and Current American Sodium Consumption

Sodium is a necessary mineral for nerves and muscles to function correctly. Sodium helps with the absorption of other nutrients for the body to maintain an important water and mineral balance (http://health.rutgers.edu/factsheets/sodium.htm, 09/16/2005). The body naturally recycles sodium, so the body only needs to replace daily losses. The body loses sodium through perspiration, secretions, and normal excretory functions (Jacobson, 2005). When the human body experiences a sodium chloride (NaCl) deficiency, the body will naturally seek more foods with salt (Olson & Terrell, 1981). One guideline for the minimum sodium amount required to maintain health is 500 milligrams (mg)/day for adults (Wardlaw & Insel, 1996). The guideline of 500 mg/day of sodium for adults is much higher than the body needs to maintain balanced systems. The body actually only needs about 100 mg/day to maintain balanced systems (Wardlaw & Insel, 1996). Most adults would need to consume one to three grams of sodium or one to one and one-half teaspoons of table salt per day to replace daily losses (Jacobson, 2005). Most Americans consume far more sodium than their bodies need (Olson & Terrell, 1981). The average daily intake of sodium in the United States is between 3,375 mg (National Health and Nutrition Examination Survey 1999-2000) and 4,000 mg (Jacobson, 2005) depending on the data source.

There are several reasons that American adults consume more sodium than is necessary for bodily functions. One reason is that many consumers do not understand the difference between sodium and salt and they have difficulty understanding how many milligrams of sodium per serving is a little or a lot (Lynch, 1987). A second reason is that the salty flavor is a desirable flavor characteristic in many foods. Most consumers are unwilling to accept a decrease in taste for health (Best, 1989). Many people consider unsalted foods unacceptable due to their bland and sometimes unpleasant flavors (Lynch, 1987). A third reason is the increase in portion size. As calorie intakes increase, so do sodium intakes. Generally, sodium intake is higher for men than women and higher for older age groups than young children. The higher sodium intake for men and older age groups is primarily due to the higher caloric intake for men versus women and adults versus children (National Health and Nutrition Examination Survey, 1999-2000). A final reason may be as people age and their ability to perceive flavor aromatics diminishes, they compensate with salt for flavor impact. Pangborn and Braddock (1989) found in their salt ad libitum study that, older adults (ages 36-66 years old) added significantly more salt to their test samples than the younger subjects (ages 17-32 years old).

People can adjust their preferences to salt, either lower or higher with repeated exposure. Olson and Terrell (1981) report that people that are used to eating heavily salted foods can lower what they find salty by repeated exposure to low salt foods. The researchers also state that this adaptation is reversible.

Sources of Sodium in the American Diet

Sodium chloride (NaCl), or table salt, is the primary way that sodium is introduced into the American diet (Jacobson, 2005). According to Olson and Terrell (1981), “Sodium is the principal element that makes sodium chloride taste like salt.”

Sodium is found naturally in low amounts in meats, nuts, grains, fruits, vegetables, and dairy products (http://health.rutgers.edu/factsheets/sodium.htm, 09/16/2005). Most of the sodium Americans eat comes in from processed foods. About 75% of sodium comes from processed foods and foods eaten outside the home (http://www.health.gov/dietaryguidelines/dga2005/document/html/chapter8.htm, 04/27/2008). Americans consume three to five times more sodium than they need through the consumption of processed foods. Manufacturers add salt to processed foods in order to preserve them and enhance flavors (http://health.rutgers.edu/factsheets/sodium.htm, 09/16/2005 and Jacobson, 2005). Sodium chloride plays an important role in preserving meats; in fact NaCl is the only compound that separates fresh and processed meats (Olson and Terrell, 1981). Sodium is present in chemical additives, such as sodium nitrate, sodium benzoate saccharin, and monosodium glutamate (Kurtz and Fuller, 1997).

Human Taste Mechanism for Saltiness and Age Related Changes

The five basic tastes, salt, sweet, sour, bitter, and umami are detected by taste buds on the tongue, soft palate, and to a lesser degree in the throat. The rates at which these basic tastes are detected vary. When comparing the detection rates of saltiness and bitterness, saltiness is detected relatively quickly, whereas bitterness is detected more slowly (Amerine *et al.*, 1965; Bravieri, 1983). Detection rates may vary based on the differences in taste mechanisms. Olson and Terrell (1981) indicate that the taste bud receptors for salt adapt slightly for salt concentration, but that most adaptation for salt concentration occurs in the central nervous system. Cations are believed to produce the salty taste, however the mechanism for salt taste perception is still being researched (Amerine *et al.*, 1965; Lynch, 1987). There are several theories about the taste perception mechanism. One of the theories that Lynch writes about is that salt perception is due to “stimulus-induced change in permeability of the membrane to certain ions (potassium (K), sodium (Na), chloride (Cl)), which interrupts the resting potential of the cell." Another theory Lynch writes about is that the "receptor potential is caused by a change in activity of an ion-transporting enzyme system present in the membrane (Na/K pump)" (Lynch, 1987). Currently, there are two major hypothesis about the human salt perception. One hypothesis focuses on Transient Receptor Potential Channel (TRP), consisting of a super family of cation channels and the other hypothesis focuses on Epithelial sodium channel (ENaC), which controls the transport of ions (DeSimone and Lyall, 2006; Venkatachalam and Montell, 2007). The perception of a salty flavor associated with potassium chloride (KCl) would indicate that humans have at least one, if not more, salt taste receptors that are cation selective in addition to Na^+ specific taste receptors (DeSimone and Lyall, 2006). The cellular mechanism which stimulates taste receptors by non-sodium salts is not known (St. John and Smith, 2000). Salt perception mechanisms is an area that under intense study and is highly controversial for the time being until more conclusive findings can be discovered.

Humans appear to be born neutral to salty flavor and with age and the full development of the salt taste mechanism develop a liking for salt. Studies involving newborns, show that through consumption and facial coding that newborns are neutral to salty taste. By four months old, children have developed a positive response to salt (Warwick, 1990). As humans age they learn that salty taste fits with certain food or beverages and not with others. For example, by preschool, children seem to understand the appropriateness of salt content, preferring salt in soup, but not in drinking water (Warwick, 1990). According to studies by Schiffman (2000), the ability to taste and smell remains fully intact until around age sixty and then functioning begins to decline and becomes more pronounced at age seventy (Schiffman, 2000). Medications, environmental factors, and surgery can impact the ability to taste. In contrast, Drewnowski *et al.* (1996) found in their study of varying sodium levels in chicken broth no evidence that ability to taste salt decreased with age. There were no significant effects of age when comparing 20-30 year olds with 60-75 year olds for intensity ratings of saltiness, sweetness, bitterness, sourness, chicken flavor, or blandness in chicken broth. The researchers suggested that differences seen in their study results versus other studies' results may be due to differences in lifestyle and health of the older subjects in the study; older subjects in their study were healthy nonsmokers of healthy weight.

When considering saltiness preference, there are differing results when looking at differences according to age. Drewnowski, *et al* (1996)., report that on average the 60-75 year olds preferred lower salt concentrations in chicken broth than the 20-30 year olds. In contrast, Chuahan (1989) found in her study of soup no significant differences for salt preferences among the age groups tested. Differences might be due to differences due to geographic location, as Drewnowski, *et al* conducted their study in Ann Arbor, Michigan and Chuahan's study was conducted in Edmondton, Canada.

Genetic Differences to Taste Perception

Genetic differences exist for the taste perception of basic tastes and the different compounds that elicit those basic taste perceptions. Most of the research that has been published has focused on bitter sensitivity to phenyl-thio-carbamide (PTC) or 6-n-proplthiouracil (PROP) (Levine & Anderson, 1932; Parr, 1934; Boyd & Boyd, 1937; Bartoshuk, 1979; Pasquet, *et al.*, 2002). Levine and Anderson (1932) studied the taste perception differences among full-blood Native Americans, Caucasians, and mixed Native American and Caucasians. The researchers found that Caucasians were more bitter blind, at 42%, than full-blood Native Americans at 6% to PTC. As the incidence of mixed race increased, so did the level of non-taster (Levine & Anderson, 1932). Parr (1934) expanded on Levine and Anderson's research by studying more diverse ethnic groups, such as Chinese and African Americans, and found that there were different levels of sensitivity based on race. The Chinese were found to have the highest level of bitter tasters at 94.01% to PTC, African Americans were at 76.5% tasters, and American Whites were found to have around 70% tasters (Parr, 1934). Boyd & Boyd (1937) concluded in their study that there were differences in culture for the perception of bitter caused by PTC and that the closer to China or more Eastern geographic location, the higher the percentage of tasters in those cultures. In contrast, a study of Australians and Japanese found no significant differences in taste sensitivities to sweet, salty, bitter, sour, and umami solutions due to culture (O'Donnell, 1997). O'Donnell (1997) indicates that while there was no significant difference in preference for sweet, salty, or bitter solutions, the Japanese were more tolerant of high levels of MSG (high umami taste) and high sour solutions than were the Australians.

Gender has been studied, in order to understand if there are different bitter sensitivities between men and women. The literature is mixed on whether there are difference due to gender, these may be due to differences in the compounds studies (PTC or PROP) or methodologies. Boyd & Boyd (1937) found that women were more likely to be bitter tasters than men when evaluating PTC. Pasquet *et al.* (2002) found in their study of Tunisians that there was not a difference in taste sensitivity due to gender.

Cultural Differences and Taste Preference

In addition to genetic differences due to race, taste sensitivities may be linked to the familiarity of foods in a culture. Soup is a common food in every culture around the world. Soup is a relatively inexpensive food that can be prepared easily in one cooking pot on any type of heating device, whether stove or open fire. Hispanic and Asian cuisines are especially laden with soup recipes. The ingredients that are used to create soup, or one pot meals, is what differs among ethnic groups. Hispanic soup recipes use chicken broth and tomatoes as soup bases, whereas Asian soup recipes focus on the use of chicken broth and fish sauce, with less familiarity with tomato based sauces. Cultural differences in exposure to different foods has been found to impact food preferences (O'Donnell, 1997). Asian cuisine tends to use a larger variety of spices and ingredients that mix multiple basic tastes together to create unique taste combinations of salty, sweet, and pungent (O'Donnell, 1997). Asian cuisine is characterized by the extensive use of fermented, dried, or brewed ingredients that contribute to intense, complex flavors (Hu, 2000). Traditional Hispanic food staples are rice, soup, beans, and tortillas. These foods are introduced into Hispanic children's diet at a very young age. Menella, Ziegler, Briefel, and Novak (2006) studied Hispanic feeding habits of infants. They found that children aged six to eleven months old were introduced to cultural foods such as soups and beans, and that the exposure to those foods remains strong into the toddler years. Due to the ready tomato supply in North America, tomatoes are a prevalent ingredient within the Hispanic diet; used as the base for many sauces and soups. Tomatoes were consumed by twelve to twenty-four month old Hispanic children at nearly double the frequency of non-Hispanic children (Menella *et al.*, 2006).

African American cuisine consists of a lot of protein and fewer vegetables. Meatloaf, fried chicken, cornbread, catfish, and crab cakes are all considered "comfort foods" as part of African American soul food (O'Donnell, 1997). Caucasian cuisine is as varied as the country of origins from which Caucasians hale. In comparison to the other ethnic cuisines described, common Caucasian foods are often considered bland. The language to describe foods is different based on culture. O'Donnell (1997) explains that different cultures have words for tastes and aromatics that may not be universal. An example would be the term umami. There is no English word equivalent to describe the umami taste experience. Japanese have used the term umami to describe the savory flavor associated with MSG for many years (O'Donnell, 1997). Differences in taste preferences are not strictly limited to cross ethnic differences. Within an "ethnic race" there are differences in types of foods consumed based on country of origin (Hu, 2000). For example, within the pan-ethnic classification of Asian, Japanese and Chinese cuisine utilize different ingredients to create distinct flavor combinations. Japanese cuisine is often characterized by simplicity and clean flavors. Chinese cuisine utilizes sauces with many different spices to create unique taste experiences (Hu, 2000). Similar cultural differences based on country of origin are seen within the pan-ethnic classification of Hispanic.

Salt Substitutes and the Challenge

Low sodium foods are generally less acceptable for two reasons, lack of the desirable salty flavor and off flavors are more prominent (Keast, Breslin, & Beauchamp, 2001). There are five main paths for reducing sodium in foods; 1) abstinence, 2) substitution of KCl for NaCl, and 3) use of bulking agent, such as starch, in conjunction with NaCl, 4) utilizing a different form of NaCl, such as flake, and 5) partial NaCl substitution by utilizing blends of NaCl and KCl (Kurtz & Fuller, 1997). The researchers found that the primary path of sodium reduction is through straight substitution of some portion of the NaCl with KCl.

One of the greatest challenges facing researchers and developers of a "true" salt substitute is the lack of understanding of the mechanism of salt perception (Lynch, 1987). In order to be successful, salt substitutes will have to mimic the multiple sensory functions of sodium in foods (Keast *et al.*, 2001). Sodium salts are able to selectively suppress certain flavors while producing a salty taste (Keast *et al.*, 2001). NaCl in addition to selectively suppressing bitterness is able to release other suppressed flavors (Keast *et al.*, 1997). NaCl impacts other sensory properties besides perceived salty flavor, such as enhancing other flavors, suppressing or masking undesirable flavors, and impacting texture of foods, such as tenderness in bread (Wade, 2006).

Neutral salts, such as potassium chloride (KCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$) should have the greatest likelihood of success replacing sodium chloride (Olson & Terrell, 1981). The literature does not fully explain why neutral salts might have the highest likelihood of success, but the success may be due to the similar structure of neutral salts, of which NaCl. Neutral salts consist of a cation and anion that has been neutralized (Amerine, *et al.*, 1965). Neutral salts, at high concentrations impart a bitter taste, which limit their potential. NaCl is the exception to this rule(Olson & Terrell, 1981). Wade found that bitter and metallic off-flavors were present in the typical 30-50% sodium reduction level when a portion of KCl is substituted for NaCl (Wade, 2006). Most salt substitutes are a mixture of KCl and one of the following; citric or other acids, monopotassium glutamate, choline, ammonium chloride, and spices (Lynch, 1987).

KCl has similar physical properties to sodium chloride. That being colorless and a transparent cubic crystal. In addition, KCl has a similar refractive indice, specific gravity, and critical humidity to NaCl (Lynch 1987). Currently, KCl is the closest salt substitute, but many people detect a bitter taste (Jacobson, 2005). Based on the literature, it is unclear what causes KCl to be bitter. Bitterness limits KCl's potential as a salt substitute (Bravieri, 1983; Lynch, 1987; Kurtz & Fuller, 1997). Bitter mechanisms are not well understood and a great amount of research is being conducted to understand the pathways and stimulators. In addition to bitterness, KCl is limited by chemical and metallic taste and aftertaste (Kilcast & Angus, 2007). Arganosa and Marriot (1990) described KCl as astringent when used in restructured ham, limiting the level at which the salt can be used to aid sodium reduction.

Table 1.1-Terms used to describe flavors associated with KCl cited in literature

Salty	Wyatt, 1981 Lynch, 1987 Breslin & Beauchamp, 1995
Bitter	Amerine *et al.*, 1965 Olson and Terrell, 1981 Fitzgerald & Buckley, 1985 Lynch, 1987 Anjan Reddy & Marth, 1993 Breslin & Beauchamp, 1995 Keast *et al.*, 2001
Metallic	Lynch, 1987 Katsiari *et al.*, 1998
Astringent	Lynch, 1987 Arganosa & Marriott, 1990
Burn	Katsiari *et al.*,1998
Bland	Olson & Terrell, 1981
Off Flavor	Hand *et al.*,1982
Sweet	Amerine *et al.*,1965
Sour	Amerine *et al.*,1965

Bravieri (1983) has found that a blend of KCl and NaCl is actually superior to a straight NaCl reduction or complete substitution for maintaining a salty taste. Similarly, Adams *et al.*(1994) found that when KCl was used alone in mashed potatoes, panelists perceived KCl as less salty than a sample with no salt added at that same sodium concentration, however when KCl is blended with NaCl there were similar saltiness perceptions at the same sodium concentration. Breslin and Beauchamp (1995) found in their research that when KCl was added to NaCl in mixture solutions there was a significant synergistic effect on salt taste intensity resulting in higher salt taste intensities when compared to solutions of NaCl alone. In contrast, Pangborn and Braddock (1989) found in their ad libitum salt study that respondents added lesser amounts of sodium when they used a NaCl and KCl mixture. The reduction in sodium was found to be due to the undesirable bitterness that KCl imparts rather than a higher perceived saltiness (Pangborn & Braddock, 1989). When using KCl, sodium reduction may come about due to consumers' aversion to the bitterness of KCl and reduced consumption of the food with KCl present. Pangborn and Braddock conclude that sodium intake decreases when KCl is substituted for NaCl due to reduced consumption of an undesirable product (Pangborn & Braddock, 1989). Lynch hypothesizes that salty flavors may be able to be optimized with certain levels of KCl without increasing bitterness or metallic flavor to unacceptable levels (Lynch, 1987).

The impact of repeated exposure to KCl is unclear. Familiarity with KCl may increase perceived sensitivity to off flavors or people may adapt to the flavors leading to acceptance. According to Olson and Terrell, increasing exposure to the bitter taste of KCl or the "bland" taste of a NaCl reduced product may increase acceptance over time (Olson & Terrell, 1981). They found in their study of fermented meat, that a panel that met over the course of multiple weeks gave less severe ratings as time progressed, which led them to hypothesize that familiarity may lead to acceptability (Olson & Terrell, 1981). In contrast, Wade (2006) indicated that sensitivity increases with the amount of KCl consumed. The higher the amount of KCl consumed, the more noticeable the off flavors become. The researcher further reputed that if consumers could become adjusted to the flavors associated with KCl, there could be a substantial health benefit to reducing sodium using KCl, in that KCl provides an opportunity to increase potassium consumption.

As stated earlier, the blending of KCl and NaCl shows some promise for reducing sodium in foods. The main reason that a blend of KCl and NaCl may be the most successful way of using KCl as a partial sodium replacer is due to the natural bitterness blocking properties of NaCl (Olson & Terrell, 1981; Breslin & Beauchamp, 1995). NaCl is very effective at blocking bitterness due to KCl (Keast *et al.*, 2001). Na^+ ion of NaCl is the active component in bitterness suppression (Breslin & Beauchamp, 1995). Keast *et al.*(2001), hypothesize that salts selectively suppress bitterness, which has the added side benefit of enhancing favorable flavors. The mechanism of how the sodium cation masks bitter perception is unknown. Among the current theories are sodium's influence over certain G-protein coupled receptors, this influence either creates an ionic shield or slightly disturbs the protein folding. Sodium may impact ion channel/pumps, stabilizing cell membranes; this could potentially limit access to bitter receptors by bitter compounds and or interfere with the cellular message system (Keast *et al.*, 2001). Sodium salts ability to suppress bitterness will vary widely across bitter substances (Keast, *et al.*, 2001). For KCl, NaCl can only mask bitterness up to a certain levels of KCl, and the amounts are product dependent. Olson and Terrell (1981) found that NaCl could mask bitterness in solutions of up to 1.5% KCl, however at the 1.5% or higher level of KCl there was an unacceptable level of bitterness. Breslin and Beauchamp (1995) found in their study of NaCl-KCl water solutions that all concentrations of NaCl suppressed bitterness for all concentrations of KCl. They tested four combinations of KCl and NaCl with both compounds ranging from 0.0M to 0.2M.

Acidifiers and sweeteners used in addition to NaCl are able to mask or block some of the bitterness of KCl (Wade, 2006). The researcher states that mixing KCl with yeast extracts can mask metallic flavors In addition to masking metallic flavors, yeast extracts enhance flavors, giving the perception of a fuller flavored product.

Many researchers have explored the used of KCl as a salt substitute in many different types of foods. Sodium reduction via KCl substitution has been studied in ham (Lin, *et al.*, 1991; Hand, *et al.*, 1982), meat products (Olson & Terrell, 1981), sausage (Totosaus, *et al.*, 2004), brined cod (Rodriguez, *et al.*, 2005), broths (Pangborn & Braddock, 1989), cheeses (Fitzgerald & Buckley, 1985; Anjan Reddy & Marth, 1993; Katsiari, *et al.*, 1998), green beans and corn (Wyatt, 1981), oatmeal (Lynch, 1987), mashed potatoes (Adams *et al.*, 1994), and vegetable juice (Adams *et al.*,1994).

The type of food will impact the saltiness perception, what level of saltiness is considered acceptable, and what level of KCl substitution is acceptable (Adams, *et al.*,1995). Adams, *et al.* (1995) found that sodium reductions of 50% are possible in a savory entrée, but saltiness perception and acceptability are product specific. In their study of reduced sodium savory entrées, while respondents were able to detect lower salt intensities in most (six of eight) of the entrées, four of the eight entrées were found to not be significantly different for acceptance from their full sodium version. They also found that perception of saltiness was not solely dependent on NaCl concentration, but was due to the interaction of NaCl and other ingredients, such as spice and fat in the complexity of food (Adams *et al.*,1995). The level of complexity of flavor and texture in the food dish has an impact on the degree of sodium reduction that is acceptable to consumers, with more complex foods showing a greater tolerance for sodium reduction (Wade, 2006; Kilcast & Angus, 2007). Similarly, Adams, Maller, and Cardello (1995), found that the simpler the food item, i.e. mashed potatoes, the higher the perceived saltiness, which in turn makes sodium reduction more challenging. The starting level of salt content greatly impacts whether a meaningful reduction in sodium will result in acceptable product (Wade, 2006). In addition, how evenly the KCl can be distributed in a product impacts the perceived saltiness and off flavors (Wade 2006).

Hand, *et al.* (1982) found that due to the off flavors from KCl, neither a blend of 50% KCl and 50% NaCl or a complete substitution of NaCl with KCl is possible in bone-in hams (Hand *et al.*, 1982). Similarly, for restructured hams, Lin *et al.*, (1991) found that only lower levels of KCl were acceptable and that salt perception decreased as KCl increased from 0% to 60%, whereas bitterness increased. Olson and Terrell (1981) found in their study of meat products, that different levels of KCl were acceptable in processed meats. For example, a 1.25% KCl level was unacceptable in bologna, but that same level was found acceptable in polish sausage (Olson & Terrell, 1981). The two meats were served at different temperatures which Olson and Terrell (1981) present as a possible explanation for the different results. The bologna was served cold, whereas the polish sausage was served warm, which may have impacted how the KCl flavor was perceived (Olson & Terrell, 1981). Totosaus, Alfaro-Rodriguez, & Pérez-Chabela (2004) found in their study of sausage, that 0.50% (w/w) KCl level could successfully be used in conjunction with a reduced sodium formula producing a product with no bitter taste due to KCl, they hypothesized that this was due to the low level of KCl that was used.

In a brined cod study, Rodriguez, *et al.*, (2005) found that brines with high concentrations of $CaCl_2$, $MgCl_2$, or KCl, in combination with NaCl at pH of 6.5 and 8.5 will produce a good quality cod. The use of KCl is limited slightly by its impact to microbial growth, it allowed for a slight increase in microbial growth in the brined cod (Rodriguez, *et al.*,2005).

Chicken broth studied by Pangborn and Braddock was less tolerant to any addition of KCl. Respondents indicated that chicken broth with KCl or mixture of KCl and NaCl were unacceptable due to the bitterness KCl imparts (Pangborn & Braddock, 1989).

Mixed results have been found for sodium reduction via KCl in cheeses. Fitzgerald and Buckley (1985) found that a 1:1 combination of KCl and NaCl produced cheeses that had similar flavor and texture profiles to control cheeses with NaCl, however when they studied cheddar cheese made with 3.18% KCl, the cheese was found to be unacceptable due to the high bitterness flavor. Katsiari *et al.*, (1998) found for kefalograviera cheese that a reduction of 25% to 50% sodium with a replacement of either 3:1 NaCl to KCl or 1:1 NaCl to KCl did not produce cheeses that were significantly different from control cheese, they hypothesize that this was due to the level of NaCl present in the cheese, which seemed to mask any off flavors from KCl (Katsiari *et al.*, 1998). In contrast, Anjan Reddy and Marth (1993) found that unsalted cheeses and cheese made with NaCl/KCl mixtures were rated to have strong bitter flavors. One hypothesis that they propose is that different starter bacteria may have imparted a higher levels of bitterness and that KCl was not as competent at masking that level of bitterness as NaCl (Anjan Reddy & Marth, 1993).

Salt perception was enhanced for green beans and corn when KCl was used in combination with NaCl (Wyatt, 1981). Similarly, salt perception increased in oatmeal when the concentration of KCl increased (Lynch, 1987).

For mashed potatoes, a mixture of NaCl and KCl is key to success in reducing sodium content. Adams, *et al.*, (1994) found in their mashed potato study, that a sample with no salt added and a sample with KCl only, with the same sodium concentrations, were rated less acceptable than samples with NaCl only or 1:1 NaCl and KCl mixture. The researchers found that 0.09% and 0.14% sodium concentrations were similar in perceived saltiness when they contained either NaCl only or NaCl and KCl mixture in mashed potatoes. Similar results from Adams e*t al.,* (1994) for vegetable juice were found. Consumer acceptance of a reduced sodium vegetable juice was not impacted when equal concentrations of KCl and NaCl replaced higher levels of NaCl. They found no significant differences in salt perceptions and acceptability ratings between vegetable juice samples with the same sodium concentration (0.14%) when evaluating NaCl or NaCl and KCl mixture to higher concentration levels of sodium (0.25-0.6%)(Adams, *et al.*,1994).

In the literature concerning KCl, very few studies outlined how they evaluated the off- flavors. The researchers did not state whether off-flavors were identified and evaluated with trained descriptive panelists, quality experts, or consumers. The literature is unclear on whether respondents show any differential sensitivity to off-flavors associated with KCl. All of these issues may contribute to the discrepancies among the results in literature.

Descriptive Analysis Method and Language Development

Descriptive analysis is a sensory method that utilizes the perceptions of a group of highly trained panelists to identify and quantify descriptions of products (Stone & Sidel, 1993). Descriptive analysis is the most sophisticated sensory analytical tool available (Lawless & Heymann, 1999). Lawless and Heymann (1999) state, "descriptive analysis requires precise and specific concepts articulated in carefully chosen scientific language". Unfortunately, the descriptive analysis tool is often misunderstood and applied incorrectly to evaluate products. For example, Rodriguez, *et al.*(2005) , used a descriptive panel to rate the quality of salted, desalted and cooked cod. The five-point scale that they used incorporated liking and whether the product was typical with the following scale points; 1= very unpleasant, 2= unpleasant, 3= neutral, 4= less typical, and 5= typical.

Descriptive analysis requires relatively few (10 to 20 is adequate), well-trained panelists (Stone & Sidel, 1993). Subjects must demonstrate that they can perceive differences better than chance. A training period is necessary for the descriptive panel to create or learn a scientific language in which to describe the product to be evaluated (Lawless & Heymann, 1999). The expected outcome of the training is for all judges to be able to consistently use the same concepts individually and collectively as a panel and to precisely communicate with each other. Reference samples should be used in training and will ground the panelists in the attribute boundaries exhibited by the references (Lawless & Heymann, 1999). Training is important because people are influenced by the context in which the stimulus is presented and tend to look at products holistically, making the breakdown of sensations to the most basic level difficult (Civille and Lawless, 1986).

Lawless and Heymann (1999) stated that the choice of appropriate descriptors should be based on the following; 1) descriptors can be used precisely and reliably by panelist, 2) terms should discriminate among the samples, 3) terms should be non-redundant, and 4) terms should be singular in nature, not integrated. Civille and Lawless (1986) indicated that the following criteria should be used for determining descriptive analysis word sets; 1) terms are orthogonal (uncorrelated to each other), 2) based on an underlying structure if known, 3) based on broad reference set, and 4) primary. Overall the intent of the descriptive terminology used is to allow for distinguishable attributes to be identified and described (Civille & Lawless, 1986). Kohno *et al.*(2005), in their study of dried bonito stock and chicken bouillon comparing Japanese and Chinese panelists outlined their process for terminology development. They suggested the following process; 1) review previous research, 2) eliminate redundant terms, 3) show questionnaire to group of experts to get feedback on list and have them rate how much the terms resemble each other, 4) The data from the questionnaire rating resemblance should be run through a multidimensional scaling program to understand which terms are similar and could be eliminated, 5) The last step in the process is consolidating the terms.

Giving people a list of descriptors with definitions helps them to more accurately identify aromas and flavor aromatics, as language can influence perceptions. Providing an explicit or internalized list of attributes that would likely be present in a product is an important part of terminology development (Civille & Lawless, 1986).

There are different styles and approaches to descriptive analysis. The method of focus for this study is the Sensory Spectrum® method. Meilagaard *et al.* (2007) stated that the Sensory Spectrum® method requires extensive panelist training. The training utilizes references for specified attributes and specified intensities. Sensory Spectrum® method uses a standardized lexicon with scales that are standardized with multiple reference point anchors. Sensory Spectrum® scales are usually 15pt, absolute intensity scales that are created to have equi-intensities across scales. Panelists are trained to used the scales identically. Spectrum® method has been used to evaluate a variety of food products, such as ice cream (Friedeck, *et al.*,2003), cheese (Van Hekkan, *et al.*, 2006), and white corn tortilla chips (Meullenet, *et al.*, 2003).

Focus Groups

Focus groups are a qualitative tool that can be used to explore consumers' language and beliefs about ideas or products. Focus groups can be effectively used to probe consumer attitudes and acceptability of novel items (Wan *et al.*, 2007). Researchers often use focus groups to understand consumer language in order to create consumer-focused questionnaires for subsequent quantitative studies (McNeill, *et al.*, 2000; Cardinal, *et al.*, 2003; Wan *et al.*, 2007; and Di Monacco, *et al.*, 2007). McNeill et. al. showed in their study of peanut butter that the product focused attributes that the focus groups generated were different from the descriptive analysis lexicon for peanut butter, resulting in development of a quantitative ballot focused on consumer based terminology (McNeill, *et al.*,2000). The researcher had respondents categorize the generated descriptive terms as either positive or negative.

Focus groups consist of generally 8-10 respondents, who have been recruited based on specific usage or demographics, that may be important to the discussion (Cardinal, *et al.*,2003). Pre-selected topic or topics are explored by a small group of participants led by a moderator (Krueger and Casey, 2000). A trained moderator facilitates the discussion and uses a standardized guide to ensure consistent discussion among sessions (Chambers *et al.*, 2004; Lawrence, *et al.*, 2007; Lee and Lee, 2007; and Di Monacco *et al.*,2007). The discussion should move from generalized questions, allowing participants to become more comfortable, to specific questions, probing when necessary to provide clarity and depth to the discussion (Chambers, *et al.*, 2004 and Di Monacco, *et al.*, 2007). Products or printed materials are often shown to respondents to provide stimulus. Di Monacco, *et al.*(2007), showed three different soups, Cardinal *et al.*(2003), showed consumers 4 different mayonnaise brands, and Chambers *et al.* (2004), showed printed nutrition material in different formats to generate feedback.

Data analysis is difficult due to the qualitative nature of the data (Wan, *et al.*, 2007). Trends or themes can often be identified from lists of grouped consumer comments that lead to insights and or hypothesis for subsequent quantitative testing (Chambers, *et al.*, 2004 and Lee & Lee, 2007).

Overall, focus groups have been found to be insightful in understanding differences in consumers and generating consumer friendly descriptive terms that can be used for quantitative ballots. Chambers *et al.,* (2004) found focus groups to be a useful tool to understand the different needs of two different age groups and concluded that generic nutrition education displays will not work to communicate effectively the message to all ages who need to hear the message, this insight may have not have been garnered in a traditional quantitative testing.

Objectives of the Study

The majority of previous studies have focused on the affective testing of different levels of KCl as well as blends of KCl with other salt substitutes. One study looked at chicken broth (Pangborn and Braddock, 1989) and the addition of KCl in an ad libitum manner. No studies were found that focused on screening methods for sensitivity to off-flavors from KCl addition in model soup systems. In addition, no studies found looked descriptively at basic taste intensity ratings for varying levels of total sodium ions with no addition of KCl and a constant level of total sodium ions with increasing levels of KCl in model soup systems. A better understanding of the interaction of KCl additions to salt perception would allow researchers to know what level of substitution is possible for soup systems. The hypothesis for this research was the belief that a majority of people do not describe the flavors associated with KCl as bitter, metallic, or other possible negative terms. Therefore, the objectives of this study were:

1) Compare the basic taste (salt, sweet, sour, bitter, and for chicken broth umami) modality intensities when evaluating varying levels of sodium in model soup systems and model soup systems with a sodium baseline of 460 mg sodium and increasing levels of KCl (0%-0.75%) in order to understand the interaction of KCl on the perceived saltiness of NaCl and better understand the degree to which KCl can be used in reducing sodium without adversely affecting the basic taste sensory properties.

2) To understand the impact of a fixed sodium level (460 mg sodium/230 g serving for chicken broth and 460 mg sodium/244 g serving for tomato soup) in model soup systems on perceived bitterness intensity for increasing levels of KCl (0.15% to 0.75%.) The 460 mg level represents approximately 50% sodium ion reduction, which is often the objective of industry sodium reduction initiatives.

3) To understand if different groups of consumers, such as ethnic, age, or gender related groups, choose different words to describe the flavor associated with KCl.

4) To determine which word descriptors are most frequently chosen by consumers who are sensitive to the flavor associated with KCl.

5) To place the above objectives and information into a study to validate the hypothesis that consumers do not perceive the flavors associated with KCl as bitter, metallic, or other possible negative terms.

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CHAPTER 2 - Detailed Materials and Methods

Description of Soups

Two model soup systems without particulates were evaluated in this study. Chicken broth was selected because of chicken broth's fairly simple flavor system, with saltiness as a primary flavor attribute. Chicken broth has been previously studied in association with KCl . Pangborn and Braddock (1989) used chicken broth in their ad libitum KCl study. Chicken bouillon, a product similar to chicken broth was explored by Kohno, et. al in their study of flavor preference between Japanese and Chinese (Kohno et. al., 2005). Tomato soup was chosen for testing because tomato soup has a slightly more complex flavor profile than chicken broth, which may impact the perception of KCl. When reviewing literature, none of the KCl studies examined used tomato soup as a test medium. The most similar product that has been tested in conjunction with KCl is vegetable juice by Adams, *et al. (*1994).

The 960 mg sodium level in chicken broth or tomato soup is a typical level of sodium found in commercially available soups in the market place, and served as the control. Many of the reduced sodium soups available in the market place have a 460 mg sodium level. The intermediate levels were chosen to allow for a systematic stepwise reduction in sodium, to allow enough data points to understand the resulting curves. The sodium levels in the chicken broth and tomato soup were primarily altered with the reduction of NaCl. Morton® TFC Purexor HG Blending salt from Morton® International (Chicago, IL) was used in this study. Morton® International manufactured the KCl with filler.

The varying levels of sodium ions and potassium chloride levels that were studied for each soup system and are listed as follows;

Table 2.1- Chicken broth samples with varying levels of total sodium ions and KCl

Sodium level/230 g serving	% KCl
960 mg	0.0
860 mg	0.0
760 mg	0.0
660 mg	0.0
560 mg	0.0
460 mg	0.0
360 mg	0.0
460 mg	0.75
460 mg	0.60
460 mg	0.45
460 mg	0.30
460 mg	0.15
460 mg	0.0
360 mg	0.15
360 mg	0.0

The 960 mg + 0.0% KCl sample served as the control for this study.

Table 2.2-Tomato soup samples with varying levels of total sodium ions and KCl

Sodium level/244 g serving	% KCl
960 mg	0.0
860 mg	0.0
760 mg	0.0
660 mg	0.0
560 mg	0.0
460 mg	0.0
360 mg	0.0
460 mg	0.75
460 mg	0.60
460 mg	0.45
460 mg	0.30
460 mg	0.15
460 mg	0.0
360 mg	0.15
360 mg	0.0

The 960 mg + 0.0% KCl sample served as the control for this study. The total sodium ion level was based on theoretical values for the calculated formulas. No formal salt analysis was conducted to verify the theoretical values due to resource constraints.

The soups were produced at the General Mills Pilot Plant in Golden Valley, Minnesota and the formulas are proprietary to General Mills, but represent typical formulations available on the retail market. Monosodium glutamate, hydrolyzed vegetable protein, and NaCl contribute to the sodium ion level in chicken broth. Chicken broth was made on September 26, 2005 and October 31, 2005. Tomato soup was made on October 3, 2005 and November 11, 2005. The same lots of ingredients were used to produce the chicken broth and tomato soup on the two different production days.

Storage of Canned Soup

The soups were produced using good manufacturing practices and were stored in 19- ounce metal sanitary cans with 307 easy open lids manufactured by Silgan Container Manufacturer Corporation (Woodland Hills, California). The cans were retorted during manufacturing and then the soup was stored in 4ºC (40ºF) refrigerated storage (Bally Walk-in cooler(Morehead City, North Carolina) 384 ft^2, single system with Copeland compressor (Rushville, Indiana) and a water cooled condenser, refrigerant type R22, 2 Larkin evaporators (Stone Mountain Georgia), Ranco brand electronic cold control (Delphos, Ohio), Frank bi-parting doors (Newport, North Carolina), and Honeywell chart recorders(Morristown, New Jersey). Soup was aged a minimum of one week in 4ºC (40ºF) refrigerated storage prior to descriptive analysis, to ensure full flavor equilibration. Upon review of the literature, there is no reference for how long soup is typically aged prior to descriptive or consumer testing.

As an added consumer safety precaution, the General Mills thermal processing specialist required refrigerated storage of the samples prior to the descriptive analysis and consumer evaluations.

Cans were transported to the consumer central location test sites in Coleman® (Wichita, KS) 50-quart wheeled coolers and were kept in the coolers on site until they were prepared. The metal soup cans were tightly packed into insulated coolers, which helped to maintain a cooled temperature (approximately 4°C-6°C); no additional cooling devices were used to keep the cans cooled below room temperature.

Soup Preparation

Refrigerated sealed soup cans were placed directly into a full size 6-inch stainless steel super pan 3 by Vollrath (Sheboygan, WI) (manufacturer number: 90062, purchased at www.hockenbergs.com with Hockenbergs number: VOL90062) and covered with water. The water level was to the top of the cans. The stainless steel pan with water and sealed cans was heated on a stovetop at medium to high setting until the water in the stainless steel pan boiled, approximately 30 min.. The stove burners were adjusted down until the water was at a low simmer. Sealed cans sat in simmering water for 45 min., heating the soup to 71ºC (160ºF). A sample can was opened and used for temperature readings. Barylko-Pikielna & Kostyra (2007) heated soup samples to 70ºC in a study to understand the sensory interaction of umami substances in model food systems. The stove makes and models varied by testing location, with all of the consumer locations using commercial gas stoves. The stove used to heat the descriptive analysis samples was a Whirlpool (Benton Harbor, MI) Super Capacity 465, with four burners and ceramic glass top. Upon review in the literature, there were no articles that outlined a heating process for canned soup. General Mills R&D has developed the technique of heating in the sealed can based on the theory that heating the soup in the sealed can allows for even heating for all products and eliminates any evaporation, which could affect flavor and product quality.

Once cans were heated, and opened the contents were put into 500-ml Pyrex® (Lowell, MA) glass beakers for the descriptive panels and in one-quarter size 6-inch stainless steel super pan 3 metal tub inserts by Vollrath (Sheboygan, WI) (manufacturer number: 90462, purchased at www.hockenbergs.com with Hockenbergs number: VOL90462) for the consumer testing. The beakers were generally left uncovered and monitored for temperature every 5 min.. The soup temperature was maintained at 63ºC (145ºF) to 66ºC (150ºF) by monitoring with a Sper Scientific (Scottsdale, AZ) (Scottsdale, AZ) Infrared Thermometer (model 800049, range -20 ºC ~450 ºC, Spectral response 6~14µm). If the product temperature started to go below the 63ºC minimum, then the beakers were covered with Reynolds® (Pittsburgh, PA) wrap aluminum foil and the stove temperature was adjusted as needed. Resurreccion (1998) suggests serving temperatures for soup of 60-71°. For the consumer test, the stainless steel tub inserts were left uncovered and the temperature was maintained at 63ºC (145ºF) to 66ºC (150ºF) by monitoring with VWR® Pocket Test Thermometer (West Chester, PA; 0º to 220°F; accuracy ±1% full scale; www.vwrsp.com VWR® catalog number 61157-582). The maximum amount of time that the soup was held was 1 hr..

Descriptive Analysis

Chicken broth was evaluated on October 3, 4, and 5, 2005 with three replications completed. Chicken broth sodium samples replication one and two were conducted on October 3rd. Chicken broth sodium samples replication three was conducted on October

4th. Chicken broth KCl samples replication one was conducted on October 4th. Replication two and three were conducted on October 5th. Tomato soup was evaluated on October 10, 11, and 17, 2005 with three replications completed. Replications one and two for the tomato soup sodium samples were evaluated on the October 10th. Replication three of the sodium samples was rated on the October 11th. Replication one of the tomato soup KCl samples was evaluated on October 11th and replications two and three were evaluated on October 17th. The samples were spread out over the three days because of the large number of samples and the potential for panelist fatigue.

Descriptive Panelists

Nine professional panelists from General Mills (eight females and one male) evaluated the chicken broth samples with varying levels of sodium and seven panelists (six females and one male) evaluated the chicken broth samples with varying levels of KCl. The highly trained panelists have had 100 hours of generalized training and average of 8 years of experience evaluating soup, such as chicken noodle, tomato basil, and minestrone using the Sensory Spectrum® Method. For tomato soup, the same nine professional panelists (eight females and one male) evaluated the tomato soup samples with varying levels of sodium and the tomato soup KCl samples. Testing occurred in the General Mills descriptive analysis room with white lighting.

Descriptive Orientation Sessions

An 1 hr. orientation session was conducted prior to evaluations. Panelists were shown a range of samples with varying levels of sodium ions and KCl. The same levels of sodium and KCl were shown for chicken broth and tomato soup. The following samples were presented in a sequential order and discussed.

Table 2.3-Chicken broth and tomato soup samples with varying levels of total sodium ions and KCl

Sample	
Chicken broth (230 g serving)	Tomato soup (244 g serving)
960 mg sodium	960 mg sodium
460 mg sodium	460 mg sodium
460 mg sodium + 0.15% KCl	460 mg sodium + 0.15% KCl
460 mg sodium + 0.45% KCl	460 mg sodium + 0.45% KCl
460 mg sodium + 0.60% KCl	460 mg sodium + 0.60% KCl
460 mg sodium + 0.75% KCl	460 mg sodium + 0.75% KCl

In addition to the chicken broth and tomato soup samples, the basic taste references listed in Table 2.4 and 2.5 were presented during orientation.

Descriptive Evaluation

Panelists evaluated the samples using the Sensory Spectrum® method (Sensory Spectrum, New Providence, New Jersey). The Spectrum® method has been used as an evaluation tool for many different types of foods, such as ice cream, cheese, and white corn tortilla chips (Friedeck, *et al.*, 2003; Van Hekkan, *et al.*, 2006; and Meullenet, *et al.*, 2003). Van Hekkan, *et al.* (2006), used the universal Sensory Spectrum® scale to evaluate both flavor and texture of four different brands of cheese from Chihuahua, Mexico. Friedeck *et al.*, (2003) used the Spectrum® method to evaluate color, flavor, and texture of ice cream Similarly, Meullenet, *et al.*, (2003) evaluated appearance, flavor, and texture attributes for white corn tortilla chips using the Spectrum® method. In this study, salt, sour, bitter, umami, and metallic attributes were rated for chicken broth. Salt, sweet, sour, and bitter attributes were rated for tomato soup.

Chicken broth and tomato soup were evaluated at temperatures between 60ºC (140ºF) to 66ºC (150ºF). Yamaguchi and Takahashi (1984) in their research of monosodium glutamate and NaCl on the palatability of a clear soup served panelists soup at approximately 60ºC. In addition, Resurreccion suggests serving temperatures for soup of 60-71° (Resurreccion, 1998). Panelists were served 1 oz. servings of each sample in a 2-oz. plastic cup (2oz Sweetheart® plastic portion cups).

The samples were served in randomized and balanced order, using a Williams design. There was a 2-min. rest period between samples. During the rest period, filtered water and Nabisco Premium® Unsalted Top saltine crackers were used to cleanse the palate between samples. Panelists were given basic taste references based on levels found in Meillaard *et. al.* (2007) at the beginning of each session (Sensory Evaluation Techniques, 4th Edition) The evaluation session was two hours in length.

The references were tasted before every replication.

Table 2.4- Saltiness, sourness and bitterness taste references for chicken broth evaluations

Attribute	Definition	Reference Intensity	Preparation Method	% Solution
Saltiness	A fundamental taste of which the taste of sodium chloride in water is typical	7.5	2.25g NaCl in 500 ml filtered water	0.45
Saltiness		10.0	2.75g NaCl in 500 ml filtered water	0.55
Saltiness		12.5	3.10 g NaCl in 500 ml filtered water	0.63
Sourness	A fundamental taste of which the taste of citric acid in water is typical	2.0	0.25g citric acid in 500 ml filtered water	0.05
Sourness		5.0	0.40 g citric acid in 500 ml filtered water	0.08
Bitterness	A fundamental taste of which the taste of caffeine in water is typical	2.0	0.25g caffeine in 500 ml filtered water	0.05
Bitterness		5.0	0.40 g caffeine in 500 ml filtered water	0.08

Table 2.5-Saltiness, sweetness, sourness and bitterness taste references for tomato soup evaluations

Attribute	Definition	Reference Intensity	Preparation Method	% Solution
Saltiness	A fundamental taste of which the taste of sodium chloride in water is typical	7.5	2.25g NaCl in 500 ml filtered water	0.45
Saltiness		10.0	2.75g NaCl in 500 ml filtered water	0.55
Saltiness		12.5	3.10 g NaCl in 500 ml filtered water	0.63
Sweetness	A fundamental taste of which the taste of sucrose in water is typical	2.0	10.0 g sucrose in 500 ml filtered water	2.0
Sweetness		5.0	25.0 g sucrose in 500 ml filtered water	5.0
Sourness	A fundamental taste of which the taste of citric acid in water is typical	2.0	0.25g citric acid in 500 ml filtered water	0.05
Sourness		5.0	0.40 g citric acid in 500 ml filtered water	0.08
Bitterness	A fundamental taste of which the taste of caffeine in water is typical	2.0	0.25g caffeine in 500 ml filtered water	0.05
Bitterness		5.0	0.40 g caffeine in 500 ml filtered water	0.08

(Appendix A)

Ballots were generated using Compusense 5 (Compusense, Guelph, Canada). Compusense is a software program that allows for electronic ballot generation and data collection (Temple et. al,. 2002). The program is capable of conducting statistical analysis. Panelists recorded their ratings electronically in Compusense 5. (Appendices B and C) The electronic ballot in this study showed all of the attributes on one computer screen. The panelist were instructed via computerized instructions to taste the basic taste references prior to starting the product evaluations and take two bites of cracker and a few sips of filtered water to cleanse their palates. A 2-min. delay was enforced via the programming in the Compusense ballot. The scale that was used is 15-point with 0.1-point increments (0=none to 15=extreme).

Experimental Design and Statistical Analysis

A Williams design was used for serving the panelists. The samples were balanced for absolute order and relative position. Sessions were two hours in length. Descriptive analysis data were analyzed using analysis of variance (ANOVA). The effects for ANOVA for each attribute were session, panelist, sample, and panelist*session. Tukey's Studentized Range (HSD) was used to compare samples and determine which samples were significantly different from one another.

Consumer Testing

Qualitative Consumer Groups

Subjects

Subjects were initially recruited for a vegetable beef soup test and the focus groups were supplemental to the vegetable beef soup test. Subjects had to indicate that they had consumed canned vegetable beef soup at least once in the last six months. Subjects had to be between 18 years and 65 years old. Twenty-four subjects total, twelve males and twelve females, were asked if they would be willing to taste chicken broth and have a 15-min. discussion. Focus group respondents were paid $10 for their time. The testing took place at Holy Name Catholic in Wayzata, Minnesota. The testing facility was a large room that is used for large church social events. The focus groups met in the corner of the room and participants sat around a round table.

Consumer focus groups were conducted prior to consumer testing in order to explore the words that consumers use to describe flavors associated with high levels of KCl in chicken broth. McNeill et. al. showed in their study of peanut butter that the product focused attributes that the focus groups generated were different from the descriptive analysis lexicon for peanut butter, resulting in development of a quantitative ballot focused on consumer based terminology (McNeill, et. al, 2000). Three groups of eight consumers participated in the fifteen-minute focus groups on October 25, 2005.

Samples

Consumers were given two chicken broth samples to taste. The descriptions are found in Table 2.6.

Table 2.6-Samples-for chicken broth evaluation in qualitative consumer test

Sample Label	Sodium level/230 g serving	% KCl
"Chicken Broth"	460 mg	0.0
"Chicken Broth + Flavor A"	460 mg	0.75

The 460 mg sample was chosen to show consumers a low sodium sample with no added KCl. The 460 mg + 0.75% KCl sample was selected because the 0.75% level is the highest level used in the quantitative consumer study and the level that is most likely to be able to be detected by most subjects, as was determined by preliminary sample screening.

The chicken broth was evaluated at temperatures between 60ºC (140ºF) to 66ºC (150ºF) (Yamaguchi & Takahashi, 1984; Resurreccion, 1998). Consumers received 2-oz. servings of the chicken broth samples in a three and one-half-ounce plastic cup (3.5oz Solo® plastic cold drink cups, No. P35). The chicken broth was approximately four weeks of age prior to consumer consumption, due to the consumer testing schedule timing. Product samples are commonly to shown to stimulate discussion. Di Monacco, *et al.*,(2007) showed three different soups, Cardinal *et al.*, (2003) showed consumers 4 different mayonnaise brands, and Chambers *et al.*, (2004) showed printed nutrition material in different formats to generate feedback.

Procedure

Three groups of eight consumers participated in the fifteen-minute focus groups on October 25, 2005. Twelve males and twelve females ranging in age from 25 years to 55 years old participated. A General Mills employee with experience leading focus groups acted as the moderator and followed a moderator's guide to lead the discussion (Appendix R)

Consumers were instructed to drink filtered water and eat Nabisco Premium® Unsalted Top Crackers saltine crackers before and between samples. Once consumers tried both samples, a discussion occurred with consumers describing the flavor differences between the samples. The words generated from this session, in conjunction with the words from the General Mills employee panel were used on the quantitative consumer paired comparison ballot as a list of descriptors consumers could choose from to describe “Flavor A”. The General Mills Employee panel is made up of employees that work at the Golden Valley, Minnesota technical center. The panelist range in age from 22 to 65 years old and there is a good mix of ethnicity and gender. The panel is used for internal discrimination testing. Sixty General Mills employees familiar with discrimination methods and regularly used as internal discrimination panelists tasted an orientation sample, in two series of tests, one for chicken broth and one for tomato soup. The orientation sample was labeled “Flavor A”, it was either chicken broth with 460 mg + 0.45% KCl or tomato soup with 460 mg + 0.45% KCl depending on the test. The employee panelists were then asked to generate words to describe “Flavor A” via an open- end question on the test ballot.

Date Interpretation

Qualitatively, the descriptor words were reviewed that the focus groups and the General Mills employee panel generated, looking for trends in the words used. Trends or themes can often be identified from lists of grouped consumer comments that lead to insights and or hypothesis for subsequent quantitative testing (Chambers, *et al.*, 2007 and Lee & Lee, 2007).

Generally if a word was chosen by at least three people then the term was included on the ballot. All possible “negative” terms were included, such as metallic, which was changed to metal can flavor to be more consumer friendly. Bitter, harsh, chemical, and processed were all included in order to allow for anyone sensitive to potential off-flavors associated with KCl to express more accurately their perception.

Quantitative Consumer Paired Comparison Testing

Subjects

Subjects were recruited to ensure a representative sample of minority groups with a mix of male and female as well as a range of ages 18-65 years old. The consumer ethnicity breakdowns are in Table 2.7.

Table 2.7 - Consumer Ethnicity Demographics from the Quantitative Paired Comparison Testing

Soup Type	Total number of consumers (n)	Caucasians (n)	Asian Americans (n)	Hispanics (n)	African Americans (n)	Other (n)
Chicken Broth	447	225	73	75	70	4
Tomato	437	203	76	75	70	13

Subjects had to have eaten canned soup, any flavor, at least once in the last 6 months and willing to taste the flavor of soup tested. Recruiting was primarily conducted through Consumer Surveys in Golden Valley, Minnesota. They used large group recruiting, such as church and civic non-profit organizations, to complete the recruitment for Caucasians, African Americans, and Hispanics. To supplement the African American and Hispanic recruiting numbers, Market Vision/Gateway Research Inc. in Orlando, Florida conducted additional testing at Universal Studios on December 27th. The Asian American recruitment and testing was conducted by Wharf Research of San Francisco, California and occurred in Oakland, California.

Chicken broth was tested on November 14, 15, 2005 and December 7, 11, and 27, 2005. Tomato soup was tested on November 29, 2005 and December 1, 7, 11, and 27, 2005. Chicken broth testing was conducted in Watertown, Minnesota at Watertown Mayer High School; Loretto, Minnesota at Salem Lutheran Church; Minneapolis, Minnesota at United Faith Pentecostal Church and Sagrado Corazon de Jesus; Oakland, California; and Orlando, Florida. Tomato soup testing was conducted in Osseo, Minnesota at Osseo United Methodist Church; St. Paul, Minnesota at St. Bernard's Catholic School; Minneapolis, Minnesota United Faith Pentecostal Church and Sagrado Corazon de Jesus; Oakland, California; and Orlando, Florida.

The Loretto, Minnesota, Minneapolis; Osseo, Minnesota; and St. Paul, Minnesota testing sites were all large social rooms within churches. The Watertown, Minnesota testing occurred in the high school cafeteria. The rooms were set up with 6'x 8' banquet tables with two respondents sitting side-by-side at the tables. The Orlando, Florida and Oakland, California testing facilities utilize consumer-testing booths. Sessions were 1 hr. in duration. Subjects were either compensated and/or their organization was given a donation for their participation.

Samples

Chicken broth and tomato soup was aged a minimum of 2 wks. with a maximum of 8 wks. in 4ºC (40ºF) refrigerated storage prior to consumer testing. The age range of the tested product was due to the availability of consumer testing sites. A subset of samples was tested with consumers and is listed below:

Chicken Broth

Table 2.8- Samples-for chicken broth evaluation in quantitative consumer test

Sample label	Sodium level/230 g serving	% KCl
"Chicken Broth"*	460 mg	0.0
"Chicken Broth + Flavor A"**	460 mg	0.45

*For the Spanish Ballot, "Chicken Broth" was labeled "Caldo de Pollo"

**For the Spanish Ballot, "Chicken Broth + Flavor A" was labeled "Caldo de Pollo + Sabor A"

The 0.45% KCl level was selected as an intermediate level, strong enough for consumers who might be sensitive to flavors associated with KCl, without being so strong that it would overpower the ability to taste subsequent samples.

Tomato

Table 2.9- Samples-for tomato soup evaluation in quantitative consumer test

Sample label	Sodium level/244 g serving	% KCl
"Tomato Soup"*	460 mg	0.0
"Tomato Soup + Flavor A"**	460 mg	0.45

*For the Spanish Ballot, "Tomato Soup" was labeled "Sopa de Tomate"

**For the Spanish Ballot, "Chicken Broth + Flavor A" was labeled "Sopa de Tomate+ Sabor A"

Chicken broth and tomato soup were evaluated at temperatures between 60ºC (140ºF) to 66ºC (150ºF) (Yamaguchi & Takahashi, 1984; Resurreccion, 1998). Consumers received two- ounce servings of each sample in a three and one-half ounce plastic cup (3.5oz Solo® plastic cold drink cups, No. P35). Filtered water and Nabisco Premium® Unsalted Top saltine crackers were provided to rinse the palate between samples.

Ballots were written in English for the Caucasians, Asian Americans, and African Americans. (Appendices L and N). A translated Spanish ballot was used with Hispanic consumers. (Appendices M and O) A native speaker who is familiar with Mexican dialects in the Spanish language and has previous experience in translating documents did the translation. As an additional check for accuracy, a native Spanish speaker familiar with Mexican dialects associated with Consumer Surveys, the consumer testing fielding agency, translated the Spanish ballot back into English. Four fielding staff, fluent in Spanish, were also available at the Hispanic testing site to answer any questions and work directly with subjects who were limited in their literacy skills. Consumers read and signed a consent, confidentiality, and allergy form. (Appendices P and Q).

Procedure

Consumers received either a chicken broth or tomato soup pair (Table 2.8, 2.9). They tasted the sample labeled "Chicken Broth" or "Tomato Soup" first and the sample labeled “Chicken Broth + Flavor A” or “Tomato Soup + Flavor A” second. Consumers drank water and ate a bite of cracker between each sample. After tasting both samples, consumers marked all the words on a “check all that apply” ballot that described “Flavor A”.

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Data Analysis

Frequency counts were calculated for each of the terms that consumers could select to describe “Flavor A.” A chi-square analysis was completed to determine if there were significant differences within ethnic groups, age groups, and gender for how terms were used. Descriptive terms were analyzed using SAS® and two-sided Chi-Square analysis. It is possible to understand which terms the groups chose at significantly different amounts, but due to the non-continuous nature of the data, separation techniques can not be used to determine within a descriptive term which groups are different from one another. General trends can be shown, but significance cannot be determined. A p-value less than or equal to 0.05 was considered statistically significant for this research.

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CHAPTER 3 - A comparison of tastes and selected trigeminal characteristics for varying levels of total sodium and potassium chloride in two model soup systems

Abstract

Sodium reduction and replacement in processed foods is a looming health trend. With aging boomers looking to manage their health through diet and exercise, the need for reduced and low sodium foods will continue to grow. The challenge with reduced sodium foods is finding a suitable sodium replacement that delivers a salty flavor without extraneous flavors, some which may be considered negative. Potassium chloride (KCl) is a common salt replacer used in the food industry. KCl , when used in conjunction with sodium chloride (NaCl), can be perceived as salty; however to some people, KCl can have bitter or metallic flavors.

This study examined the basic taste intensities in samples with varying levels of total sodium and samples with a set total sodium level and varying levels of KCl in model soup systems in order to understand the potential interaction of KCl on the perceived saltiness of NaCl and a better understanding of the degree to which KCl can be used in reducing total sodium levels without adversely affecting the basic taste sensory properties .

Panelists evaluated the samples using the Sensory Spectrum® method. Salt, sour, bitter, umami, and metallic attributes were rated for chicken broth. Salt, sweet, sour, and bitter attributes were rated for tomato soup.

Comparisons in basic taste intensities were made among samples with varying levels of total sodium ions and samples with a set total sodium ion level and varying levels of KCl for chicken broth and tomato soup. A few differences were found between the two analysis. As an example, in chicken broth, in order to achieve a 48% sodium reduction a 0.6% or 0.75% level of KCl is needed to maintain a similar salt intensity perception when compared to a full sodium sample. In contrast, a 48% sodium reduction

is possible in tomato soup by a straight reduction or a reduction with the addition of 0.45%, 0.60%, or 0.75% KCl.

Keywords: basic taste modalities, potassium chloride, KCl, descriptive analysis, sensory

Introduction

One of the greatest challenges facing researchers and developers of a “true” salt substitute is the lack of understanding of the mechanism of salt perception (Lynch, 1987). In order to be successful, salt substitutes will have to mimic the multiple sensory functions of sodium in foods (Keast, Breslin, & Beauchamp, 2001). Sodium salts are able to selectively suppress certain flavors while producing a salty taste (Keast *et al.*, 2001). NaCl in addition to selectively suppressing bitterness is able to release other suppressed flavors (Keast, Breslin, & Beauchamp, 1997). NaCl impacts other sensory properties besides perceived salty flavor, such as enhancing other flavors, suppressing or masking undesirable flavors, and impacting texture of foods, such as tenderness in bread (Wade, 2006).

Neutral salts, such as potassium chloride (KCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$) should have the greatest likelihood of success replacing sodium chloride (Olson & Terrell, 1981). The literature does not explain why neutral salts might have the highest likelihood of success, but the reason may be due to the similar structure of neutral salts, of which NaCl is one. The cellular mechanism stimulating taste for receptors by non-sodium salts is not known (St. John. & Smith, 2000). Neutral salts consist of a cation and anion that has been neutralized (Amerine, *et. al*, 1965). Neutral salts, at high concentrations impart a bitter taste, which limit their potential. NaCl is the exception (Olson & Terrell, 1981). Wade found that bitter and metallic off-flavors were present in the typical 30-50% sodium reduction level when a portion of KCl is substituted for NaCl (Wade, 2006). Most salt substitutes are a mixture of KCl and one of the following; citric or other acids, monopotassium glutamate, choline, ammonium chloride, and spices (Lynch, 1987).

Currently, KCl is the closest salt substitute, but many people detect a bitter taste associated with KCl (Jacobson, 2005). Bitterness limits KCl's potential as a salt substitute (Bravieri, 1983; Lynch,1987; Kurtz & Fuller, 1997). Bitter mechanisms are not well understood and a great amount of research is being conducted to understand the pathways and stimulators. Based on the literature, the source of KCl's bitterness is unclear. In addition to bitterness, KCl is limited by chemical and metallic taste and aftertaste (Kilcast & Angus, 2007). Despite the unacceptable bitterness when used alone, KCl when blended with NaCl shows promise as a partial sodium replacer (Bravieri, 1983; Adams, *et al.*, 1994; Breslin & Beauchamp, 1995). In contrast, Pangborn and Braddock(1989) found in their ad libitum salt study that respondents added lesser amounts of sodium when they used a NaCl and KCl mixture. The reduction in sodium was found to be due to the undesirable bitterness that KCl imparts rather than a higher perceived saltiness. There are mixed study findings on whether repeated exposure sensitizes or desensitize people to the bitter associated with KCl. Wade (2006) indicates that sensitivity increases with the amount of KCl consumed. According to Olson and Terrell, increasing exposure to the bitter taste of KCl or the "bland" taste of a NaCl reduced product may increase acceptance over time (Olson & Terrell, 1981).

The main reason that a blend of KCl and NaCl may be the most successful way of using KCl as a partial sodium replacer is due to NaCl natural bitterness blocking properties (Olson & Terrell, 1981; Breslin & Beauchamp, 1995). NaCl can only mask bitterness up to a certain amount of KCl, and the amounts are product dependent. Olson and Terrell (1981) found that up to 1.5% KCl, NaCl could mask bitterness, however at the 1.5% or higher level of KCl there was an unacceptable level of bitterness. Breslin and Beauchamp (1995) found in their study of NaCl-KCl water solutions that all concentrations of NaCl suppressed bitterness for all concentrations of KCl, with both compounds ranging from 0.0M to 0.2M.

Many researchers have explored the use of KCl as a salt substitute in many different types of foods. Sodium reduction via KCl substitution has been studied in ham (Lin, Mittal, & Barbut, 1991; Hand, Terrell, & Smith, 1982), meat products (Olson & Terrell, 1981), sausage (Totosaus, Alfaro-Rodriguez, & Pérez-Chabela, 2004), brined cod (Rodriguez, Ho, López-Caballero, Bandarra, & Nunes 2005), broths (Pangborn &

Braddock, 1989), cheeses (Fitzgerald & Buckley, 1985; Anjan Reddy & Marth, 1993; Katsiari, Voutsinas, Alichanidis, & Roussis, 1998), green beans and corn (Wyatt, 1981), oatmeal (Lynch, 1987), mashed potatoes (Adams, *et al.*,1994), and vegetable juice (Adams *et al.*,1994). The level of acceptable KCl substitution is highly dependent on the food system.

In the literature concerning KCl, very few studies outlined how they evaluated the off-flavors or bitterness intensities. The studies do not state whether off-flavors were identified and evaluated with trained descriptive panelists, quality experts, or consumers. There are different styles and approaches to descriptive analysis. The method of focus for this study is the Sensory Spectrum® method. Meilagaard *et al.* (2007) stated that the Sensory Spectrum® method requires extensive panelist training. The training utilizes references for specified attributes and specified intensities. Sensory Spectrum® method uses a standardized lexicon with scales that are standardized with multiple reference point anchors. Sensory Spectrum® scales are usually 15pt, absolute intensity scales that are created to have equi-intensities across scales. Panelists are trained to used the scales identically.

The objectives of this study are to:

1) Compare the basic taste (salt, sweet, sour, bitter, and for chicken broth umami) modality intensities when evaluating varying levels of sodium ions in model soup systems and model soup systems with a sodium baseline of 460 mg sodium and increasing levels of KCl in order to understand the interaction of KCl on the perceived saltiness of NaCl and better understand the degree to which KCl can be used in reducing sodium without adversely affecting the basic taste sensory properties.

2) Understand the impact of a fixed sodium level (460 mg NaCl/1 cup serving) in model soup systems on perceived bitterness intensity for increasing levels of KCl (0.15% to 0.75%)

Materials and Methods

Samples

Two model soup systems without particulate were evaluated in this study. Chicken broth was selected because chicken broth is a fairly simple flavor system, with saltiness as a primary flavor attribute. Chicken broth has been previously studied in association with KCl . Pangborn and Braddock (1989) used chicken broth in their ad libitum KCl study. Chicken bouillon, a product similar to chicken broth was explored by Kohno, *et al.*,(2005) in their study of flavor preference between Japanese and Chinese. Tomato soup was chosen for testing because tomato soup has a slightly more complex flavor profile than chicken broth, that may impact the perception of KCl. When reviewing literature, none of the KCl studies examined used tomato soup as a test medium. The most similar product that has been tested in conjunction with KCl is vegetable juice by Adams *et al.*, (1994).

The 960 mg sodium level in chicken broth or tomato soup is a typical level of sodium found in commercially available soups in the market place. Many of the reduced sodium soups available in the market place have a 460 mg sodium level. The intermediate levels were chosen to allow for a systematic stepwise reduction in sodium, to allow enough data points to understand the resulting curves. The sodium levels in the chicken broth and tomato soup were primarily altered with the reduction of NaCl. Morton® TFC Purexor HG Blending salt from Morton® International (Chicago, IL) was used in this study. Morton® International manufactured the KCl with filler. The varying levels of sodium ions and potassium chloride levels that were studied for each soup system and are listed as follows;

Table 3.1-Chicken broth samples for descriptive analysis profiling of select sensory attributes with varying levels of total sodium ions and KCl

Sodium level/230 g serving	% KCl
960 mg	0.0
860 mg	0.0
760 mg	0.0
660 mg	0.0
560 mg	0.0
460 mg	0.0
360 mg	0.0
460 mg	0.75
460 mg	0.60
460 mg	0.45
460 mg	0.30
460 mg	0.15
460 mg	0.0
360 mg	0.15
360 mg	0.0

Table 3.2-Tomato soup samples for descriptive analysis profiling of select sensory attributes with varying levels of total sodium ions and KCl

Sodium level/244 g serving	% KCl
960 mg	0.0
860 mg	0.0
760 mg	0.0
660 mg	0.0
560 mg	0.0
460 mg	0.0
360 mg	0.0
460 mg	0.75
460 mg	0.60
460 mg	0.45
460 mg	0.30
460 mg	0.15
460 mg	0.0
360 mg	0.15
360 mg	0.0

The soups were produced at the General Mills Pilot Plant in Golden Valley, Minnesota and the formulas are proprietary to General Mills, but represent typical formulations available on the retail market. The soups were produced using good manufacturing practices and were stored in 19-ounce metal sanitary cans with 307 easy open lids manufactured by Silgan Container Manufacturer Corporation(Woodland Hills, California). The cans were retorted during manufacturing and then the soup was stored in 4ºC (40ºF) refrigerated storage (Bally Walk-in cooler(Morehead City, North Carolina) 384 ft^2, single system with Copeland compressor (Rushville, Indiana) and a water cooled condenser, refrigerant type R22, 2 Larkin evaporators (Stone Mountain Georgia), Ranco brand electronic cold control (Delphos, Ohio), Frank bi-parting doors (Newport, North Carolina), and Honeywell chart recorders(Morristown, New Jersey). Cans were stored in refrigerated storage as an additional safety measure. Soup was aged a minimum of one week in 4ºC (40ºF) refrigerated storage prior to descriptive analysis, to ensure full flavor equilibration. Upon review of the literature, there is no reference for how long soup is typically aged prior to descriptive or consumer testing.

Soup Preparation

Refrigerated sealed soup cans were placed directly into a full size 6-inch stainless steel super pan 3 by Vollrath (Sheboygan, WI) (manufacturer number: 90062, purchased at www.hockenbergs.com with Hockenbergs number: VOL90062) and covered with water. The water level was to the top of the cans. The stainless steel pan with water and sealed cans was heated on a stovetop at medium-high heat until the water in the stainless steel pan boiled, approximately 30 min.. The stove burners were adjusted down until the water was at a low simmer. Sealed cans sat in simmering water for 45 min., heating the soup to 71ºC (160ºF). A sample can was opened and used for temperature readings.Barylko-Pikielna and Kostyra (2007) heated soup samples to 70ºC in a study to understand the sensory interaction of umami substances in model food systems. The stove used to heat the descriptive analysis samples was a Whirlpool (Benton Harbor, MI) Super Capacity 465, with four burners and ceramic glass top. Upon review in the literature, there were no articles found that outlined a heating process for canned soup. General Mills R&D has developed the technique of heating in the sealed can based on the theory that heating the soup in the sealed can allows for even heating for all products and eliminates any evaporation, which could affect flavor and product quality. Once cans were heated, they were opened and the contents were put into 500-mlPyrex® (Lowell, MA) glass beakers. The beakers were generally left uncovered and monitored for temperature every 5 min. The soup temperature was maintained at 63ºC (145ºF) to 66ºC (150ºF) by monitoring with a Sper Scientific (Scottsdale, AZ) (Scottsdale, AZ) Infrared Thermometer (model 800049, range -20 ºC ~450 ºC, Spectral response 6~14µm). If the product temperature started to go below the 63ºC minimum, then the beakers were covered with Reynolds® (Pittsburgh, PA) wrap aluminum foil and the stove temperature was adjusted as needed. Resurreccion (1998) suggests serving temperatures for soup of 60-71°. The maximum amount of time that the soup was held was 1 hr..

Subjects

Nine professional panelists from General Mills (eight females and one male) evaluated the chicken broth samples with varying levels of sodium ions and seven panelists (six females and one male) evaluated the chicken broth KCl samples. The highly trained panelists have had 100 hours of generalized training and average of 8 years of experience evaluating soup, such as chicken noodle, tomato basil, and minestrone using the Sensory Spectrum® Method. For tomato soup, the same nine professional panelists (eight females and one male) evaluated the tomato soup samples with varying levels of sodium ions and the tomato soup KCl samples. Testing occurred in the General Mills descriptive analysis room with white lighting.

Descriptive Orientation Sessions

A 1 hr. orientation session was conducted prior to evaluations. Panelists were shown a range of samples with varying levels of sodium ions and KCl. The same levels of sodium and KCl were shown for chicken broth and tomato soup. The following samples were presented in a sequential order and discussed.

Table 3.3-Chicken broth and tomato soup samples used in descriptive analysis orientation training session with varying levels of KCl and sodium

Sample	
Chicken broth (230 g serving)	Tomato soup (244 g serving)
960 mg sodium	960 mg sodium
460 mg sodium	460 mg sodium
460 mg sodium + 0.15% KCl	460 mg sodium + 0.15% KCl
460 mg sodium + 0.45% KCl	460 mg sodium + 0.45% KCl
460 mg sodium + 0.60% KCl	460 mg sodium + 0.60% KCl
460 mg sodium + 0.75% KCl	460 mg sodium + 0.75% KCl

In addition to the chicken broth and tomato soup samples, the basic taste references listed in Table 3.4 and 3.5 were presented during orientation.

Table 3.4-Saltiness, sourness and bitterness taste references for chicken broth evaluations used by descriptive analysis panelists

Attribute	Definition	Reference Intensity	Preparation Method	% Solution
Saltiness	A fundamental taste of which the taste of sodium chloride in water is typical	7.5	2.25g NaCl in 500 ml filtered water	0.45
Saltiness		10.0	2.75g NaCl in 500 ml filtered water	0.55
Saltiness		12.5	3.10 g NaCl in 500 ml filtered water	0.63
Sourness	A fundamental taste of which the taste of citric acid in water is typical	2.0	0.25g citric acid in 500 ml filtered water	0.05
Sourness		5.0	0.40 g citric acid in 500 ml filtered water	0.08
Bitterness	A fundamental taste of which the taste of caffeine in water is typical	2.0	0.25g caffeine in 500 ml filtered water	0.05
Bitterness		5.0	0.40 g caffeine in 500 ml filtered water	0.08

Table 3.5 Saltiness, sweetness, sourness and bitterness taste references for tomato soup evaluations used by descriptive analysis panelists

Attribute	Definition	Reference Intensity	Preparation Method	% Solution
Saltiness	A fundamental taste of which the taste of sodium chloride in water is typical	7.5	2.25g NaCl in 500 ml filtered water	0.45
Saltiness		10.0	2.75g NaCl in 500 ml filtered water	0.55
Saltiness		12.5	3.10 g NaCl in 500 ml filtered water	0.63
Sweetness	A fundamental taste of which the taste of sucrose in water is typical	2.0	10.0 g sucrose in 500 ml filtered water	2.0
Sweetness		5.0	25.0 g sucrose in 500 ml filtered water	5.0
Sourness	A fundamental taste of which the taste of citric acid in water is typical	2.0	0.25g citric acid in 500 ml filtered water	0.05
Sourness		5.0	0.40 g citric acid in 500 ml filtered water	0.08
Bitterness	A fundamental taste of which the taste of caffeine in water is typical	2.0	0.25g caffeine in 500 ml filtered water	0.05
Bitterness		5.0	0.40 g caffeine in 500 ml filtered water	0.08

Procedure

Panelists evaluated the samples using the Sensory Spectrum® method (Sensory Spectrum, New Providence, New Jersey). The Spectrum® method has been used as an evaluation tool for many different types of foods, such as ice cream, cheese, and white corn tortilla chips (Friedeck, *et al.*,2003; Van Hekkan, *et al.*, 2006; and Meullenet, *et al.*, 2003). Van Hekkan, *et al.*, (2006) used the universal Sensory Spectrum® scale to evaluate both flavor and texture of four different brands of cheese from Chihuahua, Mexico. Friedeck *et al.*, (2003) used the Spectrum® method to evaluate color, flavor, and texture of ice cream. Similarly, Meullenet, *et al.*, (2003) evaluated appearance, flavor, and texture attributes for white corn tortilla chips using the Spectrum® method.

In this study, salt, sour, bitter, umami, and metallic attributes were rated for chicken broth. Salt, sweet, sour, and bitter attributes were rated for tomato soup. Chicken broth and tomato soup were evaluated at temperatures between 60ºC (140ºF) to 66ºC (150ºF) Yamaguchi and Takahashi (1984) in their research of MSG and NaCl on the palatability of a clear soup served panelists soup at approximately 60ºC . In addition, Resurreccion (1998) suggests serving temperatures for soup of 60-71°. Panelists were served 1 oz. servings of each sample in a 2-oz. plastic cup (2oz Sweetheart® plastic portion cups). The samples were served in randomized and balanced order, using a Williams design. There was a 2-min. rest period between samples. During the rest period, filtered water and Nabisco Premium® Unsalted Top saltine crackers were used to cleanse the palate between samples. Panelists were given basic taste references based on levels found in Meillaard *et. al.* (2007) at the beginning of each session (Sensory Evaluation Techniques, 4th Edition). The evaluation session was two hours in length.

Ballots were generated using Compusense 5 (Compusense, Guelph, Canada). Compusense is a software program that allows for electronic ballot generation and data collection (Temple et. al,. 2002). The program is capable of conducting statistical analysis. Panelists recorded their ratings electronically in Compusense 5. The electronic ballot in this study showed all of the attributes on one computer screen. The panelist were instructed via computerized instructions to taste the basic taste references prior to starting the product evaluations and take two bites of cracker and a few sips of filtered water to cleanse their palates. A 2-min. delay was enforced via the programming in the Compusense ballot. A 15-point scale with 0.1-point increments (0=none to 15=extreme) was used.

Experimental Design and Statistical Analysis

A Williams design was used for serving the panelists. The samples were balanced for absolute order and relative position. Sessions were two hours in length. Panelists evaluated the fifteen chicken broth and tomato soup samples in triplicate over three days. Replications one and two for the sodium samples were evaluated on the first day, replication three of the sodium samples was rated on the second day, replication one of the KCl samples was evaluated on the second day, and replications two and three were evaluated on the third day. The samples were spread out over the three days because of the large number of samples and the potential for panelist fatigue.

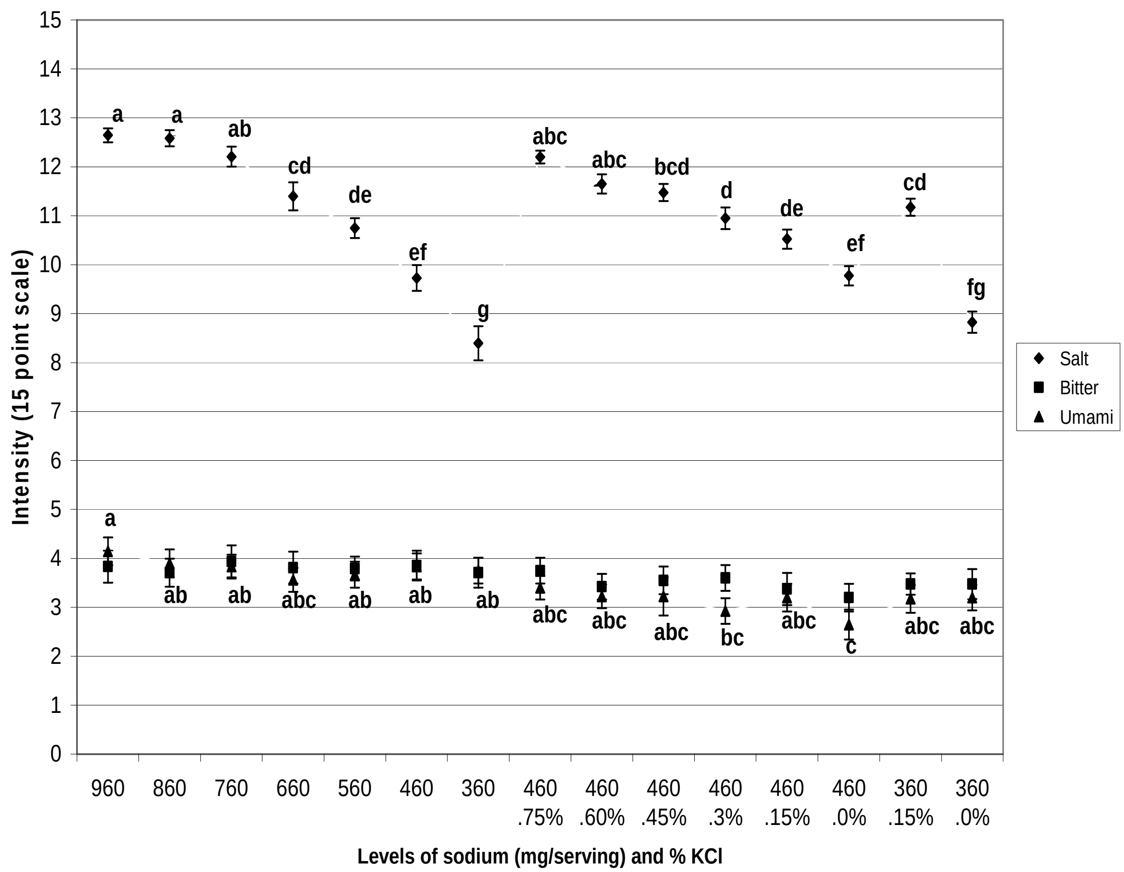
Descriptive analysis data were analyzed using analysis of variance (ANOVA). The effects for ANOVA for each attribute were session, panelist, sample, and panelist*session. Tukey's Studentized Range (HSD) was used to compare samples and determine which samples were significantly different from one another.

Results

Chicken broth results

The 960 mg sample showed the highest salt intensity rating, however no significant differences were found compared to the following samples: 860 mg, 760 mg, 460 mg + 0.75% KCl, and 460 mg + 0.60% KCl (Figure 3.2). Salt intensity was significantly lower at 660 mg and lower sodium levels; as well as at 460 mg + 0.45% KCl and lower KCl levels (Figure 3.1). Decreasing sodium generally resulted in decreasing saltiness and the addition of KCl increased saltiness at moderate sodium levels (i.e. 460 mg and 360 mg). The 360 mg + 0.15% KCl sample was perceived to have a significantly higher salt intensity than the 460 mg + 0% KCl. At the 360 mg total sodium ion level, the addition of a low level of KCl, 0.15%, contributed more to salt perception than a 100 mg increase in total sodium ion level.

Figure 3.1- Select attribute intensities for varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth



Umami is the only other taste modality, in which samples were significantly different from one another, however in not any systematic way. The 960 mg sample was rated significantly more intense in umami taste than either 460 mg +0.0% KCl and 460 mg +.0.3% KCl (Figure 3.1). The 460 mg +0% KCl was significantly different from 360 mg, 460 mg, 560 mg, 760 mg, 860 mg as well. The difference between the two samples both at 460 mg (460 mg and 460 mg + 0% KCl) is unexpected; 360 mg + 0% KCl was lower than 360 mg, but not at a significant level. This difference may be due to context effect, since the samples were evaluated within their respective sample sets, sodium samples or KCl samples. Panelists' inconsistency may have played a role, as there was no intensity reference for umami.

No significant differences were found for sour (intensity range 3.5-3.8), bitter (intensity range 3.2-3.9) taste, or feeling factor metallic (intensity range 2.1-2.9).

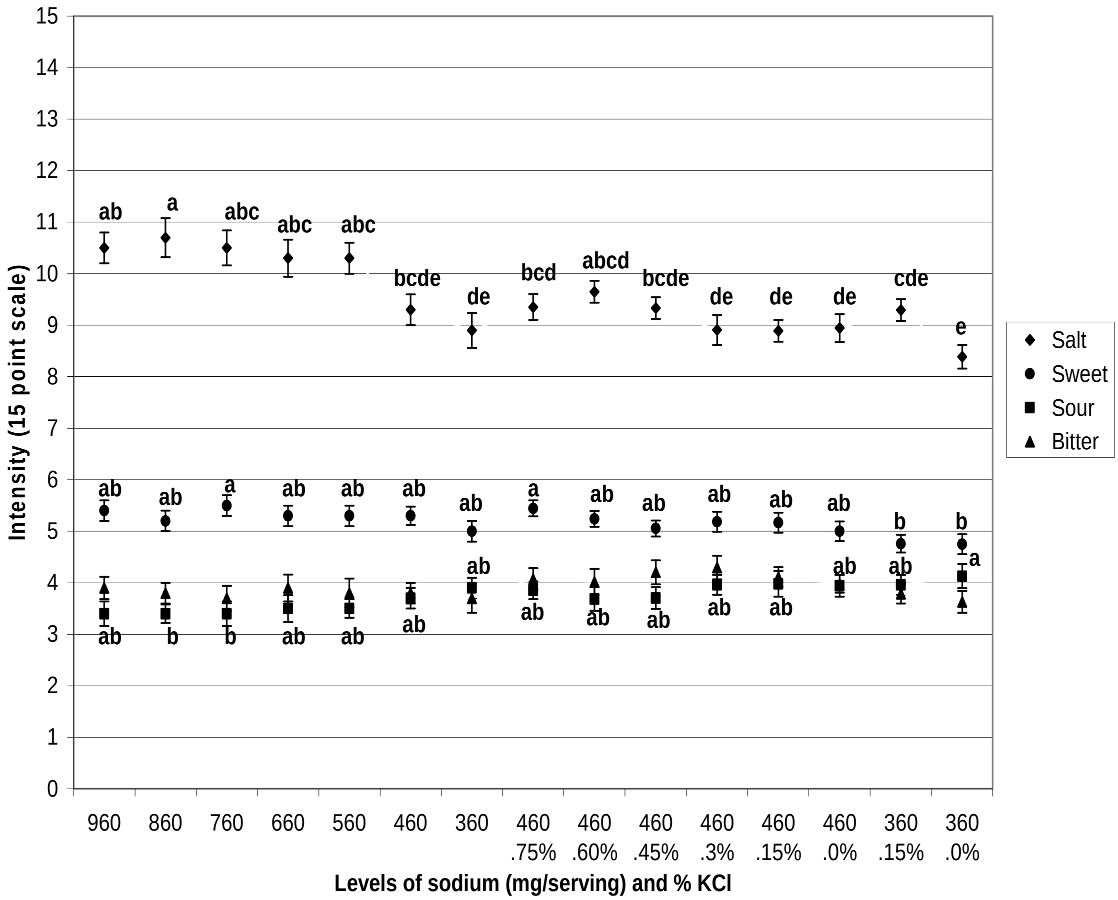
The bars above and below the attribute intensity scores represent the standard error of the sample means. The standard error is dependent on the standard deviation for each sample and the number of evaluations. As the number of evaluations increase, the standard error decreases because the possibility of chance error decreases, allowing for more certainty in the mean attribute estimates. Samples sharing the same letter are not statistically different from one another at the 95% confidence level. This is consistent for chicken broth and tomato soup samples.

The 360 mg and 460 mg levels were evaluated within the sodium sample group and the KCl sample group. They were included within each group for two reasons, 1) to act as control samples, since the sodium samples were evaluated on different days than the KCl samples, and 2) to understand the 360 mg and 460 mg total sodium ion levels within the context of lower sodium levels for the sodium group and a base line lower total sodium ion level with 0% KCl for the KCl samples. This was consistent for chicken broth and tomato soup.

Tomato soup results

The sodium level had to drop to 360 mg sodium in order to be significantly different from 960 mg (Figure 3.2). The level had to drop to 0.3% or lower in order to be statistically different from 960 mg (Figure 3.2). Significant differences were found among the samples when comparing to the 860 mg, which had the highest salt intensity rating. The 460 mg + 0.60% KCl was the only KCl sample that was not rated significantly different in salt intensity from the 860mg sample, all other KCl samples were rated lower in salt intensity than the 860 mg sample (Figure 3.2). Additionally, the 460 mg and 360 mg were rated lower in salt intensity than the 860 mg sample (Figure 3.2). The decrease in sodium had less of an impact on saltiness and the impact of KCL on saltiness was low at moderate sodium levels (i.e. 460 mg and 360 mg).

Figure 3.2-Select attribute intensities for varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup



There were a few differences rated among the samples for sweetness (intensity range 4.7-5.5) and sourness (intensity range 3.4-4.1), however in not any systematic way. The 360 mg + 0.0% KCl and 360 mg + 0.15% KCl sample were rated less sweet than the 760 mg sample and 460 mg + 0.75% KCl/244 g sample (Figure 3.2). Additionally, the 360 mg +0.0% KCl was rated more sour than the 760 mg sample or the 860 mg sample (Figure 3.2).

Similar to the chicken broth Figure 3.1, the error bars in Figure 3.2 are the standard error of means and samples sharing a letter are not significantly different from one another at the 95% confidence level.

Discussion

In this study, for chicken broth, a 48% sodium reduction was possible without the loss of salt intensity or a significant increase in bitterness or metallic feeling factor. A total sodium ion level reduction to 460 mg total sodium ion level with the addition of either 0.60% KCl or 0.75% KCl from 960 mg total sodium ion level, resulted in approximately a 48% sodium reduction. A similar 48% sodium reduction was possible in tomato soup through either a straight sodium reduction to 460 mg sodium or with the addition of 0.45% KCl, 0.60% KCl, or 0.75% KCl. For chicken broth, decreasing sodium generally resulted in decreasing saltiness and the addition of KCl increased saltiness at moderate sodium levels (i.e. 460 mg and 360 mg). For tomato soup, the decrease in sodium had less of an impact on saltiness and the impact of KCl on saltiness was low at moderate sodium levels (i.e. 460 mg and 360 mg).

The standard error bars of the sample means for the tomato soup samples were larger than the standard error bars of the sample means for the chicken broth samples, which would indicate a higher level of uncertainty around the mean attribute intensity estimates, or less precision in the mean attribute intensity estimates. The differences in the size of the standard error bars of the sample means is likely due to the increased difficulty in rating the more complex flavor of tomato soup, resulting in larger panelist variability for each of the attributes.

The sour and bitter tastes were relatively high for all the samples, compared to previous studies on similar flavors of soup; these higher levels may have masked any additional bitterness or sourness resulting from the addition of KCl. The sour taste for chicken broth when compared to tomato soup did not behave as expected. The expectation would be that the tomato soup samples would have been rated higher in sour taste compared to chicken broth, because of the lower pH of the tomato soup samples, however the sour intensity ranges overlapped one another. For chicken broth, the ranges for sour intensity were 3.5-3.8 and bitter intensity were 3.2-3.9. For tomato soup, the ranges for sour intensity were 3.4-4.1 and bitter intensity were 3.4-4.3. In addition to the potential masking due to higher sourness and bitterness, the 460 mg level of sodium may have been high enough to suppress any additional bitterness caused by KCl. The 0.6% and 0.75% KCl level in chicken broth and 0.45% KCl, 0.60% KCl, or 0.75% KCl level in tomato soup found to give a similar salt intensity likely contributed an additional salty taste, which allowed for similar perception levels when compared to the full sodium sample.

The lack of increased perceived bitterness from KCl may be due to a lack of sensitivity by some or all panelists to bitterness caused by KCl. There are approximately 25 different bitter receptors in the human body (Maehashi, *et al.*, 2008; Pronin, *et al.*, 2007; Sainz, *et al.*, 2007; and Wade, M., 2004). Humans differ in their sensitivity to different bitter compounds. These differences in sensitivity are often due to genetic differences and whether certain receptors have all the genetic components to work properly (Pronin, *et al.*, 2007). Panelists were originally screened for their sensitivity to bitterness caused by caffeine, not KCl.

Another potential explanation for the results is that only basic tastes were evaluated in this study for tomato soup and basic tastes with the addition of metallic feeling factor were evaluated for chicken broth. There is a possibility that differences in the samples might be found in other flavor attributes or feeling factors that were not evaluated.

The differences found between chicken broth and tomato soup, where tomato soup had more flexibility in level of KCl needed to achieve a similar salt perception to a full sodium soup is likely due to differences in the complexity of the flavor system. Tomato soup is a more complex flavor system, allowing for fuller flavor even in the presence of reduced sodium.

The level of potential reduction identified in this study is similar to: Bravieri(1983); Adams, *et al.*, (1994); and Breslin and Beauchamp (1995) who all found that a partial sodium reduction and sodium replacement was possible when KCl was blended with NaCl. The maximum amount of KCl used in this study, 0.75%, was well below the level of 1.5% that Olson and Terrell (1981), found to be acceptable. They found that levels higher than 1.5% KCl would contribute an unacceptable level of bitterness. In contrast, the lack of increased bitter and metallic notes at a 48% sodium reduction is not consistent with the findings from Wade (2006), who found that a typical sodium reduction is 30-50% when NaCl and KCl are blended, however with the amount of KCl needed to achieve that level of reduction, bitterness and metallic notes are more present. Pangborn and Braddock (1989) found in their ad libitum salt study that a sodium reduction when using a NaCl and KCl blend was due to undesirable levels of bitterness.

At the KCl levels tested, bitterness intensity did not increase with increasing levels of KCl. The bitterness levels in the KCl samples were similar to the levels in the samples with varying levels of sodium ions. There is a possibility that the levels of KCl in this study were low enough for any bitterness imparted by the KCl to be suppressed by the 460 mg sodium level. As previously mentioned, Olson and Terrell (1981) found that NaCl could adequately mask bitterness in samples with up to 1.5% KCl. Breslin and Beauchamp (1995) found in their study of NaCl-KCl water solutions that all concentrations of NaCl suppressed bitterness for all concentrations of KCl, with both compounds ranging from 0.0M to 0.2M.

Conclusions and Recommendations

This study showed that there is the potential to reduce sodium in model chicken broth and tomato soup systems by about 48% without a significant increase in bitterness. Additional testing is needed to confirm these results. While this study shows that maximum basic taste modalities and metallic feeling factors are not impacted significantly by the addition of KCl, the impact on the temporal profiles may be different among the samples. The time intensity method should be incorporated into future work in order to better understand the temporal profile of at least the salt and bitterness taste modalities. A full descriptive analysis profile would be beneficial in order to understand if the addition of KCl had an impact on any of the other flavor attributes that were not incorporated into this study as well understanding the impact of reducing sodium on those same attributes.

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CHAPTER 4 - Consumer Language Selection for Flavors Associated with Potassium Chloride in Model Soup Systems

Abstract

Sodium reduction and replacement in processed foods is a looming health trend. With aging boomers looking to manage their health through diet and exercise, the need for reduced and low sodium foods will continue to grow. The challenge with reduced sodium foods is finding a suitable sodium replacement that delivers a salty flavor without extraneous flavors, some which may be considered negative by consumers. Potassium chloride (KCl) is a common salt replacer used in the food industry. KCl , when used in conjunction with sodium chloride, can be perceived as salty; however to some people, KCl may have bitter or metallic flavors.

This study examined the language that consumers use to describe the flavors associated with KCl when used in a reduced sodium model soup system. Focus groups were used to generate the initial list of flavor descriptors for high (0.75%) KCl levels in chicken broth. Chicken, rich, more flavor, and Oriental Ramen Noodle flavor are a subset of terms generated by the focus group to describe flavors associated with KCl. A larger consumer study then was conducted with subjects pre-screened for sensitivity to KCl They were given reduced sodium chicken broth or tomato soup without KCl and another reduced sodium chicken broth or tomato soup sample with 0.45% KCl added, labelled Flavor A. Subjects then chose all of the descriptors from a pre-selected list that describe Flavor A, the flavors associated with KCl. Comparisons in language descriptor selection were made between ethnic groups (African American, Hispanic, Caucasian, and Asian), gender, and age groups. Consumers most frequently selected terms that described the characterizing flavor of the soups to describe KCl flavor. Terms such as bitter, harsh, metallic, and chemical were infrequently selected by consumers to describe the flavors associated with KCl.

Keywords: consumer language, potassium chloride, KCl, sensory

Introduction

Humans appear to be born neutral to salty flavor and with age and the full development of the salt taste mechanism develop a liking for salt. Studies involving newborns, show through consumption and facial coding that newborns are neutral to salty taste. By four months old, children have developed a positive response to salt (Warwick,1990). As humans age they learn that salty taste fits with certain food or beverages and not with others. For example, by preschool, children seem to understand the appropriateness of salt content, preferring salt in soup, but not in drinking water (Warwick, 1990). According to studies by Schiffman (2000), the ability to taste and smell remains fully intact until around age sixty and then functioning begins to decline and becomes more pronounced at age seventy. Medications, environmental factors, and surgery can impact the ability to taste (Schiffman, 2000). In contrast, Drewnowski, *et. al.* (1996) found in their study of varying sodium levels in chicken broth no evidence that the ability to taste salt decreased with age. There were no significant effect of age when comparing 20-30 year olds with 60-75 year olds for intensity ratings of saltiness, sweetness, bitterness, sourness, chicken flavor, or blandness in chicken broth. The researchers suggested that differences seen in their study results versus other studies' results may be due to differences in lifestyle and health of the older subjects in the study; older subjects in their study were healthy nonsmokers of healthy weight (Drewnowski *et al.*, 1996). When considering saltiness preference, there are differing results when looking at differences according to age. Drewnowski *et al.* (1996) report that on average the 60-75 year olds preferred lower salt concentrations in chicken broth than the 20-30 year olds. In contrast, Chuahan (1989) reported that there were no significant differences in salt preferences among the age groups tested.

One of the greatest challenges facing researchers and developers of a "true" salt substitute is the lack of understanding of the mechanism of salt perception (Lynch, 1987). In order to be successful, salt substitutes will have to mimic the multiple sensory functions of sodium in foods (Keast, Breslin, and Beauchamp, 2001). Sodium salts are able to selectively suppress certain flavors while producing a salty taste (Keast *et al.*, 2001). NaCl in addition to selectively suppressing bitterness is able to release other suppressed flavors (Keast, *et. al.*, 1997). NaCl impacts other sensory properties besides perceived salty flavor, such as enhancing other flavors, suppressing or masking undesirable flavors, and impacting texture of foods, such as tenderness in bread (Wade, 2006).

Neutral salts, such as potassium chloride (KCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$) should have the greatest likelihood of success replacing sodium chloride (Olson & Terrell, 1981). The literature does not explain why neutral salts might have the highest likelihood of success, but the reason may be due to the similar structure of neutral salts, of which NaCl is one. The cellular mechanism stimulating taste for receptors by non-sodium salts is not known (St. John. & Smith, 2000). Neutral salts consist of a cation and anion that has been neutralized (Amerine, *et. al*, 1965). Neutral salts, at high concentrations impart a bitter taste, which limit their potential. NaCl is the exception to the rule (Olson & Terrell, 1981). Wade (2006) found that bitter and metallic off-flavors were present in the typical 30-50% sodium reduction level when a portion of KCl is substituted for NaCl. Most salt substitutes are a mixture of KCl and one of the following; citric or other acids, monopotassium glutamate, choline, ammonium chloride, and spices (Lynch, 1987).

Currently, KCl is the closest salt substitute, but many people detect a bitter taste associated with KCl (Jacobson, 2005). Bitterness limits KCl's potential as a salt substitute (Bravieri, 1983; Lynch,1987; Kurtz & Fuller, 1997). Bitter mechanisms are not well understood and a great amount of research is being conducted to understand the pathways and stimulators. Based on the literature, the source of KCl's bitterness is unclear. In addition to bitterness, KCl is limited by chemical and metallic taste and aftertaste (Kilcast & Angus, 2007). Despite the unacceptable bitterness when used alone, KCl when blended with NaCl shows promise as a partial sodium replacer (Bravieri, 1983; Adams, *et. al.*, 1994; Breslin & Beauchamp, 1995). The main reason that a blend of KCl and NaCl may be the most successful way of using KCl as a partial sodium replacer is due to NaCl natural bitterness blocking properties (Olson & Terrell, 1981; Breslin & Beauchamp, 1995). The Na+ ion of NaCl is the active component in bitterness suppression (Breslin & Beauchamp, 1995). Keast *et al.* (2001) hypothesize that salts selectively suppress bitterness, which has the added side benefit of enhancing favorable flavors. Sodium salts ability to suppress bitterness will vary widely across bitter substances (Keast *et al.* 2001). NaCl can only mask bitterness up to a certain amount of KCl, and the amounts are product dependent. Olson and Terrell (1981) found that NaCl could mask bitterness in solutions of up to 1.5% KCl, however at the 1.5% or higher level of KCl there was an unacceptable level of bitterness. Breslin and Beauchamp (1995) found in their study of NaCl-KCl water solutions that all concentrations of NaCl suppressed bitterness for all concentrations of KCl. They tested four combinations of KCl and NaCl with both compounds ranging from 0.0M to 0.2M. In contrast, Pangborn and Braddock (1989) found in their ad libitum salt study that respondents added lesser amounts of sodium when they used a NaCl and KCl mixture. The reduction in sodium was found to be due to the undesirable bitterness that KCl imparts rather than a higher perceived saltiness.

There are mixed study findings on whether repeated exposure sensitizes or desensitizes people to the bitter associated with KCl. It is unclear whether familiarity with KCl increases perceived sensitivity to off flavors or if people adapt to the flavors leading to acceptance. According to Olson and Terrell (1981), increasing exposure to the bitter taste of KCl or the "bland" taste of a NaCl reduced product may increase acceptance over time. They found in their study of fermented meat, that a panel that met over the course of multiple weeks gave less severe ratings as time progressed, which led them to hypothesize that familiarity may lead to acceptability (Olson & Terrell, 1981). In contrast, Wade (2006) indicates that sensitivity increases with the amount of KCl consumed. The higher the amount of KCl consumed, the more noticeable the off flavors become.

In addition to genetic differences due to race, taste sensitivities may be linked to the familiarity of foods in a culture. Soup is a common food in every culture around the world. Soup is a relatively inexpensive food that can be prepared easily in one cooking pot on any type of heating device, whether stove or open fire. Hispanic and Asian cuisines are especially laden with soup recipes. The ingredients that are used to create soup, or one pot meals, is what differs among ethnic groups. Hispanic soup recipes use chicken broth and tomatoes as soup bases, whereas, Asian soup recipes focus on the use of chicken broth and fish sauce, with less familiarity with tomato based sauces. Cultural differences in exposure to different foods has been found to impact food preferences (O'Donnell, 1997). Asian cuisine tends to use a larger variety of spices and ingredients that mix multiple basic tastes together to create unique taste combinations of salty, sweet, and pungent (O'Donnell, 1997). Asian cuisine is characterized by the extensive use of fermented, dried, or brewed ingredients that contribute to intense, complex flavors (Hu, 2000). Traditional Hispanic food staples are rice, soup, beans, and tortillas. These foods are introduced into Hispanic children's diet at a very young age. Menella, Ziegler, Briefel, and Novak (2006) studied Hispanic feeding habits of infants. They found that children aged six to eleven months old were introduced to cultural foods such as soups and beans, and that the exposure to those foods remains strong into the toddler years. Due to the ready tomato supply in North America, tomatoes are a prevalent ingredient within the Hispanic diet; used as the base for many sauces and soups. Tomatoes were consumed by twelve to twenty-four month old Hispanic children at nearly double the frequency of non-Hispanic children (Menella *et al.*, 2006).

African American cuisine consists of a lot of protein and fewer vegetables. Meatloaf, fried chicken, cornbread, catfish, and crab cakes are all considered "comfort foods" as part of African American soul food (O'Donnell, 1997). Caucasian cuisine is as varied as the country of origins from which Caucasians hale. In comparison to the other ethnic cuisines described, common Caucasian foods are often considered bland. The language to describe foods is different based on culture. O'Donnell (1997) explains that different cultures have words for tastes and aromatics that may not be universal. An example would be the term umami. There is no English word equivalent to describe the umami taste experience. Japanese have used the term umami to describe the savory flavor associated with MSG for many years (O'Donnell, 1997). Differences in taste preferences are not strictly limited to cross ethnic differences. Within an "ethnic race" there are differences in types of foods consumed based on country of origin (Hu, 2000). For example, within the pan-ethnic classification of Asian, Japanese and Chinese cuisine different ingredients are utilized to create distinct flavor combinations. Japanese cuisine is often characterized by simplicity and clean flavors. Chinese cuisine utilizes sauces with many different spices to create unique taste experiences (Hu, 2000). Similar cultural differences based on country of origin are seen within the pan-ethnic classification of Hispanic.

Many researchers have explored the use of KCl as a salt substitute in many different types of foods. Sodium reduction via KCl substitution has been studied in ham (Lin, Mittal, & Barbut, 1991; Hand, Terrell, & Smith, 1982), meat products (Olson & Terrell, 1981), sausage (Totosaus, Alfaro-Rodriguez, &Pérez-Chabela, 2004), brined cod (Rodriguez, Ho, López-Caballero, Bandarra, & Nunes 2005), broths (Pangborn & Braddock, 1989), cheeses (Fitzgerald & Buckley, 1985; Anjan Reddy & Marth, 1993; Katsiari, Voutsinas, Alichanidis, & Roussis, 1998), green beans and corn (Wyatt, 1981), oatmeal (Lynch, 1987), mashed potatoes (Adams, Maller, & Cardello, 1994), and vegetable juice (Adams *et al.*, 1994). The level of acceptable KCl substitution is highly dependent on the food system.

In the literature concerning KCl, very few studies outlined how they evaluated the off flavors or bitterness intensities. The studies do not state whether off flavors were identified and evaluated with trained descriptive panelists, quality experts, or consumers.

Focus groups are a qualitative tool that can be used to explore consumers' language and beliefs about ideas or products. Focus groups can be effectively used to probe consumer attitudes and acceptability of novel items (Wan *et al.* 2007). Researchers often use focus groups to understand consumer language in order to create consumer-focused questionnaires for subsequent quantitative studies (McNeill, *et al.*, 2000; Cardinal, *et al.*, 2003; Wan *et al.*, 2007; Di Monacco, *et al.*, 2007). McNeill *et al.* (2000). showed in their study of peanut butter that the product focused attributes that the focus groups generated were different from the descriptive analysis lexicon for peanut butter, resulting in development of a quantitative ballot focused on consumer based terminology . They also had respondents categorize the generated descriptive terms as either positive or negative (McNeill *et al.*, 2000).

Focus groups generally consist of 8-10 respondents, who have been recruited based on specific usage or demographics, which might be important to the discussion (Cardinal *et al.*, 2003). Pre-selected topic or topics are explored by a small group of participants led by a moderator (Krueger & Casey, 2000). A trained moderator facilitates the discussion and uses a standardized guide to ensure consistent discussion among sessions (Chambers *et al.*, 2004; Lawrence *et al.*,2007; Lee & Lee, 2007; and Di Monacco *et al.*, 2007). The discussion should move from generalized questions, allowing participants to become more comfortable, to specific questions, probing when necessary to provide clarity and depth to the discussion (Chambers *et al.*, 2004 and Di Monacco *et al.*, 2007). Products or printed materials are often shown to respondents to provide stimulus. Di Monacco, *et al.*(2007) showed three different soups, Cardinal *et al.* (2003) showed consumers 4 different mayonnaise brands, and Chambers *et al.* (2004) showed printed nutrition material in different formats to generate feedback.

Data analysis is difficult due to the qualitative nature of the data (Wan *et al.*, 2007). Trends or themes can often be identified from lists of grouped consumer comments that lead to insights and or hypotheses for subsequent quantitative testing (Chambers *et al.,* 2007; Lee & Lee, 2007).

Overall, focus groups have been found to be insightful in understanding differences in consumers and generating consumer friendly descriptive terms that can be used for quantitative ballots. Chambers *et al.*(2004) found focus groups to be a useful tool to understand the different needs of two different age groups and concluded that generic nutrition education displays will not work to communicate effectively the message to all ages who need to hear the message, this insight may have not have been garnered in a traditional quantitative testing.

This study focused on the consumers perception of KCl in chicken broth and tomato soup and explored the impact of gender, ethnicity, and age on the ability to identify and describe off flavor associated with KCl in the model soup systems.

Materials and Methods

Samples

Two model soup systems without particulates were evaluated in this study. Chicken broth is a fairly simple flavor system, with saltiness as a primary flavor attribute. Chicken broth has been previously studied in association with KCl. Pangborn and Braddock (1989) used chicken broth in their ad libitum KCl study. Chicken bouillon, a product similar to chicken broth was explored by Kohno *et al* (2005) in their study of flavor preference between Japanese and Chinese. Tomato soup was chosen for testing because tomato soup has a slightly more complex flavor profile than chicken broth, which may impact the perception of KCl. When reviewing literature, none of the KCl studies examined used tomato soup as a test medium. The most similar product that has been tested in conjunction with KCl is vegetable juice by Adams *et al.* (1994).

Consumers were shown two samples of either chicken broth or tomato soup. The samples descriptions are found below in Table 4.1 and 4.2.

Table 4.1-Chicken Broth Samples with fixed total sodium ion level and varying levels of KCl

Sodium level/230 g serving	% KCl
460 mg	0.0
460 mg	0.45

Table 4.2-Tomato Soup Samples with fixed total sodium ion level and varying levels of KCl

Sodium level/244 g serving	% KCl
460 mg	0.0
460 mg	0.45

The 460 mg sodium level was selected because many of the reduced sodium soups available in the market place are currently at or near that sodium level. The 0.45% KCl level was selected as an intermediate KCl level, strong enough for consumers who might be sensitive to flavors associated with KCl, without being so strong that the KCl flavor would overpower the ability to taste subsequent samples. Morton® TFC Purexor HG Blending salt from Morton® International (Chicago, IL) was used in this study. Morton® International manufactured the KCl with filler.

The soups were produced at the General Mills Pilot Plant in Golden Valley, Minnesota and the formulas are proprietary to General Mills, but represent typical formulations available on the retail market. The same lots of ingredients were used to produce the chicken broth and tomato soup on the two different production days.

Storage of Canned Soup

The soups were produced using good manufacturing practices and were stored in 19- ounce metal sanitary cans with 307 easy open lids manufactured by Silgan Container Manufacturer Corporation(Woodland Hills, California). The cans were retorted during manufacturing and the soup was stored in 4ºC (40ºF) refrigerated storage (Bally Walk-in cooler(Morehead City, North Carolina) 384 ft^2, single system with Copeland compressor (Rushville, Indiana) and a water cooled condenser, refrigerant type R22, 2 Larkin evaporators (Stone Mountain Georgia), Ranco brand electronic cold control (Delphos, Ohio), Frank bi-parting doors (Newport, North Carolina), and Honeywell chart recorders(Morristown, New Jersey). Cans were stored in refrigerated storage as an additional safety measure. Cans were transported to the consumer central location test sites in Coleman® (Wichita, KS) 50-quart wheeled coolers and were kept in the coolers on site until they were prepared. The metal soup cans were tightly packed into insulated coolers; no additional cooling devices were used to keep the cans cooled below room temperature.

Soup Preparation

The stainless steel pan with water and sealed cans was heated on a stovetop until the water in the stainless steel pan boiled. The stove burners were adjusted down until the water was at a low simmer. Sealed cans sat in simmering water for 45 min, heating the soup to 71ºC (160ºF). Barylko-Pikielna and Kostyra (2007) heated soup samples to 70ºC in a study to understand the sensory interaction of umami substances in model food systems. The stove makes and models varied by testing location, with all of the consumer locations using commercial gas stoves. Upon review in the literature, there were no articles that outlined a heating process for canned soup. General Mills R&D has developed the technique of heating in the sealed can based on the theory that heating the soup in the sealed can allows for even heating for all products and eliminates any evaporation, which could affect flavor and product quality. Once cans were heated, they were opened and the contents were put into one-quarter size 6-inch stainless steel super pan 3 metal tub inserts by Vollrath (Sheboygan, WI) (manufacturer number: 90462, purchased at www.hockenbergs.com with Hockenbergs number: VOL90462). The pans were left uncovered and monitored for temperature every 5 min. The soup temperature was maintained at 63ºC (145ºF) to 66ºC (150ºF) by monitoring with VWR® Pocket Test Thermometer (West Chester, PA; 0º to 220°F; accuracy ±1% full scale; www.vwrsp.com VWR® catalog number 61157-582). If the product temperature started to go below the 63ºC minimum, the stove temperature was adjusted as needed. Resurreccion (1998) suggests serving temperatures for soup of 60-71°. The maximum amount of time that the soup was held was 1 hr..

Qualitative Consumer Groups

Subjects

Subjects were initially recruited for a vegetable beef soup test and the focus groups were supplemental to the vegetable beef soup test. Subjects had to indicate that they had consumed canned vegetable beef soup at least once in the last six months. Subjects had to be between 18 years and 65 years old. Twenty-four subjects total, twelve males and twelve females, were asked if they would be willing to taste chicken broth and have a 15-min. discussion. Focus group respondents were paid $10 for their time. The testing took place at Holy Name Catholic in Wayzata, Minnesota. The testing facility was a large room that is used for large church social events. The focus groups met in the corner of the room and participants sat around a round table.

Consumer focus groups were conducted prior to consumer testing in order to explore the words that consumers use to describe flavors associated with high levels of KCl in chicken broth. McNeill et. al. showed in their study of peanut butter that the product focused attributes that the focus groups generated were different from the descriptive analysis lexicon for peanut butter, resulting in development of a quantitative ballot focused on consumer based terminology (McNeill *et al*, 2000). Three groups of eight consumers participated in the fifteen-minute focus groups.

Samples

Consumers were given two chicken broth samples to taste. The sample descriptions are found in Table 4.3.

Table 4.3- Samples-for chicken broth evaluation in qualitative consumer test

Sample Label	Sodium level/230 g serving	% KCl
"Chicken Broth"	460 mg	0.0
"Chicken Broth + Flavor A"	460 mg	0.75

The 460 mg sample was chosen to show consumers a low sodium sample with no added KCl. The 460 mg + 0.75% KCl sample was selected because the 0.75% level was the highest level used in the quantitative consumer study and the level that was most likely to be able to be detected by most subjects, as was determined by preliminary sample screening.

The chicken broth was evaluated at temperatures between 60ºC (140ºF) to 66ºC (150ºF) (Yamaguchi and Takahashi, 1984; Resurreccion, 1998). Consumers received 2-oz. servings of the chicken broth samples in a three and one-half-ounce plastic cup (3.5oz Solo® plastic cold drink cups, No. P35). The chicken broth was approximately four weeks of age prior to consumer consumption, due to the consumer testing schedule timing. Product samples are commonly shown to stimulate discussion. Di Monacco *et al.* (2007) showed three different soups, Cardinal *et al.* (2003) showed consumers 4 different mayonnaise brands, and Chambers *et al*. (2004) showed printed nutrition material in different formats to generate feedback.

Procedure

Three groups of eight consumers participated in the 15-min. focus groups. Twelve males and twelve females ranging in age from 25 years to 55 years old participated. A General Mills employee with experience leading focus groups acted as the moderator and followed a moderator's guide to lead the discussion.

Consumers were instructed to drink filtered water and eat Nabisco Premium® Unsalted Top Crackers saltine crackers before and between samples. Once consumers tried both samples, a discussion time occurred with consumers describing the flavor differences between the samples. The words generated from this session, in conjunction with the words from the General Mills employee panel were used on the quantitative consumer paired comparison ballot as a list of descriptors consumers could choose from to describe “Flavor A”. The General Mills Employee panel is made up of employees that work at the Golden Valley, Minnesota technical center. The panelist range in age from 22 to 65 years old and there is a good mix of ethnicity and gender. The panel is used for internal discrimination testing. Sixty General Mills employees familiar with discrimination methods and regularly used as internal discrimination panelists tasted an orientation sample, in two series of tests, one for chicken broth and one for tomato soup. The orientation sample was labeled “Flavor A”, the sample was either chicken broth with 460 mg sodium+ 0.45% KCl or tomato soup with 460 mg sodium + 0.45% KCl depending on the test. The employee panelists were asked to generate words to describe “Flavor A” via an open- end question on the test ballot.

Date Interpretation

Qualitatively, the descriptor words were reviewed that the focus groups and the General Mills employee panel generated, looking for trends in the words used. Trends or themes can often be identified from lists of grouped consumer comments that lead to insights and or hypothesis for subsequent quantitative testing (Chambers, et. al., 2007 and Lee & Lee, 2007). Generally if a word was chosen by at least three people the term was included on the ballot. All possible “negative” terms were included, such as metallic, which was changed to metal can flavor to be more consumer friendly. Bitter, harsh, chemical, and processed were all included in order to allow for anyone sensitive to potential off-flavors associated with KCl to express more accurately their perception.

Quantitative Consumer Paired Comparison Testing

Samples

Chicken broth and tomato soup was aged a minimum of 2 wks. with a maximum of 8 wks. in 4ºC (40ºF) refrigerated storage prior to consumer testing. The age range of the tested product was due to the availability of consumer testing sites.

Chicken Broth

Table 4.4- Samples-for chicken broth evaluation in quantitative consumer test

Sample Label	Sodium level/230 g serving	% KCl
"Chicken Broth"*	460 mg	0.0
"Chicken Broth + Flavor A"**	460 mg	0.45

*For the Spanish Ballot, "Chicken Broth" was labeled "Caldo de Pollo"

**For the Spanish Ballot, "Chicken Broth + Flavor A" was labeled "Caldo de Pollo + Sabor A"

Tomato

Table 4.5- Samples-for tomato soup evaluation in quantitative consumer test

Sample Label	Sodium level/244 g serving	% KCl
"Tomato Soup"*	460 mg	0.0
"Tomato Soup + Flavor A"**	460 mg	0.45

*For the Spanish Ballot, "Tomato Soup" was labeled "Sopa de Tomate"

**For the Spanish Ballot, "Chicken Broth + Flavor A" was labeled "Sopa de Tomate+ Sabor A"

Subjects

Subjects were recruited to ensure a representative sample of minority groups with a mix of male and female as well as a range of ages 18-65 years old. The consumer ethnicity breakdowns are in Table 4.6.

Table 4.6- Consumer Ethnicity Demographics from the Quantitative Paired Comparison Testing

Soup Type	Total number of consumers (n)	Caucasians (n)	Asian Americans (n)	Hispanics (n)	African Americans (n)	Other (n)
Chicken Broth	447	225	73	75	70	4
Tomato	437	203	76	75	70	13

Subjects had to have eaten canned soup, any flavor, at least once in the last 6 months and willing to taste the flavor of soup tested. Recruiting was primarily conducted through Consumer Surveys in Golden Valley, Minnesota. They used large group recruiting, such as church and civic non-profit organizations, to complete the recruitment for Caucasians, African Americans, and Hispanics. To supplement the African American and Hispanic recruiting numbers, Market Vision/Gateway Research Inc. in Orlando, Florida conducted additional testing at Universal Studios. The Asian American recruitment and testing was conducted by Wharf Research of San Francisco, California and occurred in Oakland, California.

Chicken broth testing was conducted in Watertown, Minnesota at Watertown Mayer High School; Loretto, Minnesota at Salem Lutheran Church; Minneapolis, Minnesota at United Faith Pentecostal Church and Sagrado Corazon de Jesus; Oakland, California; and Orlando, Florida. Tomato soup testing was conducted in Osseo, Minnesota at Osseo United Methodist Church; St. Paul, Minnesota at St. Bernard's Catholic School; Minneapolis, Minnesota United Faith Pentecostal Church and Sagrado Corazon de Jesus; Oakland, California; and Orlando, Florida.

The Loretto, Minnesota, Minneapolis; Osseo, Minnesota; and St. Paul, Minnesota testing sites were all large social rooms within churches. The Watertown, Minnesota testing occurred in the high school cafeteria. The rooms were set up with 6'x 8' banquet tables with two respondents sitting side-by-side at the tables. The Orlando, Florida and Oakland, California testing facilities utilize consumer-testing booths. Sessions were 1 hr.

in duration.   Subjects were either compensated and/or their organization was given a donation for their participation.

Procedure

Chicken broth and tomato soup were evaluated at temperatures between 60ºC (140ºF) to 66ºC (150ºF). Consumers received 2-oz. servings of each sample in a three and one-half- ounce plastic cup (3.5oz Solo® plastic cold drink cups, No. P35). Filtered water and Nabisco Premium® Unsalted Top saltine crackers were provided to rinse the palate between samples.

Ballots were written in English for the Caucasians, Asian Americans, and African Americans. A translated Spanish ballot was used with Hispanic consumers. A native speaker who is familiar with Mexican dialects in the Spanish language and has previous experience in translating documents did the translation. As an additional check for accuracy, a native Spanish speaker familiar with Mexican dialects associated with Consumer Surveys, the consumer testing fielding agency, translated the Spanish ballot back into English. Four fielding staff, fluent in Spanish, were also available at the Hispanic testing site to answer any questions and work directly with subjects who were limited in their literacy skills. Consumers read and signed a consent, confidentiality, and allergy form.

Consumers received chicken broth or tomato soup. They tasted the sample labeled "Chicken Broth" or "Tomato Soup" first and the sample labeled "Chicken Broth + Flavor A" or "Tomato Soup + Flavor A" second. Consumers drank water and ate a bite of cracker between each sample. After tasting both samples, consumers marked all the words on a "check all that apply" ballot that described "Flavor A".

Data Analysis and Test Design

Consumers always tasted the sample marked "Chicken Broth" or "Tomato Soup" first and then tasted the corresponding sample of either "Chicken Broth + Flavor A" or "Tomato Soup + Flavor A." This test design was used so that consumers would have the initial reference point of chicken broth or tomato soup without the addition of KCl prior to tasting the sample with KCl, which was described to consumers as "Flavor A."

Frequency counts were calculated for each of the terms that consumers could select to describe "Flavor A." A chi-square analysis was completed to determine if there were significant differences within ethnic groups, age groups, and gender for how terms were used. Descriptive terms were analyzed using SAS® and two-sided Chi-Square analysis. Statistical significance can be determined in order to understand which terms the groups chose at significantly different amounts, but due to the non-continuous nature of the data, separation techniques can not be used to determine within a descriptive term which groups are different from one another. General trends can be shown, but significance cannot be determined. A p-value less than or equal to 0.05 was considered statistically significant for this research.

Results

Qualitative Consumer Results (Focus Groups)

Twenty-four consumers discussed their impressions of the flavors associated with KCl, after tasting a chicken broth with no KCl and one with 0.75% KCl. The words that consumers most frequently used to describe the flavors associated with KCl were: more overall flavor, more chicken flavor, rich, butter, salty, and Oriental Ramen noodle flavor. Only a very small minority, three of twenty-four consumers, found any off flavors. They described the flavors as chemical, processed, unpleasant, and metal can flavor. The terms that these consumers described were used to create the full list that the larger scale consumer test used to understand the flavors consumers associate with KCl (Table 4.7).

Table 4.7-Consumer terms used to describe flavors associated with the addition of 0.75% KCl in chicken broth

Salty	More Overall Flavor	Rich	Sour
Chicken	Hearty	More Seasoning	Umami
Turkey	Vegetable Flavors-celery, onion, carrot	Spicy	Harsh
Beef	Mushroom	Peppery	Chemical
Savory	Garlic	Bitter	Processed
Buttery	Yeasty	Bite to it	Cardboard Aftertaste
Sweet	Oriental Ramen Noodle Flavor	Metal Can Flavor	Unpleasant Aftertaste

Quantitative Consumer Results

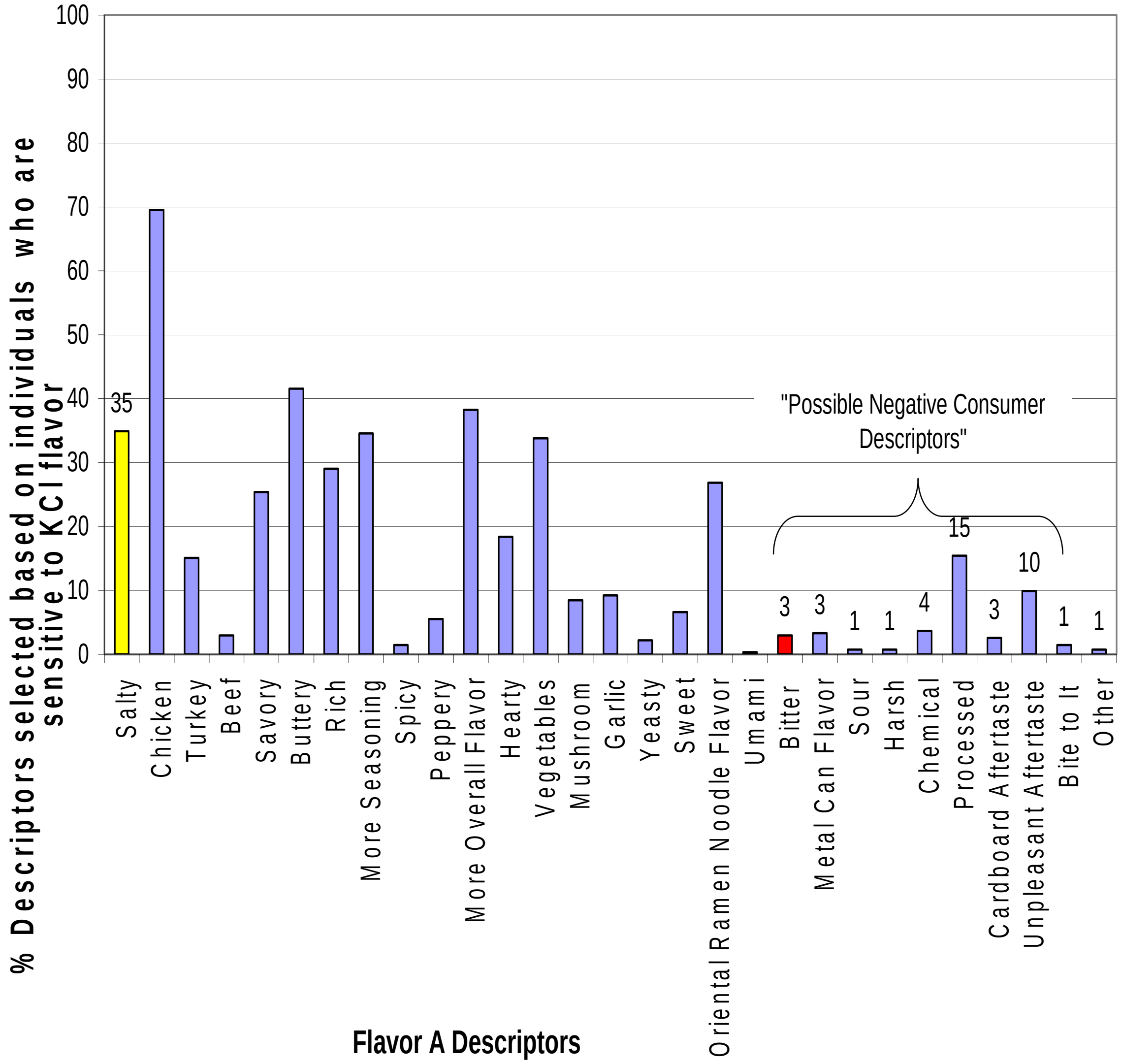
<u>Chicken Broth</u>

Total Consumer Results

Overall a very low percentage of consumers, 3%, selected the term bitter to describe the flavor associated with KCl (Figure 4.1). Most of the terms that might be classified as "negative consumer descriptors" such as bitter, metal can flavor, harsh, chemical, cardboard aftertaste, and "bite to it" were selected as words that describe the flavors associated with KCl by less than 5% of respondents. Processed and unpleasant aftertaste were selected by 15% and 10% of respondents, respectively.

Chicken flavor was the term most frequently selected, by about 70% of respondents, whereas salty, was selected by half that level of respondents at 35%. Consumers chose descriptors like butter, more seasoning, more overall flavor, and vegetables as frequently as salty to describe the flavors associated with KCl.

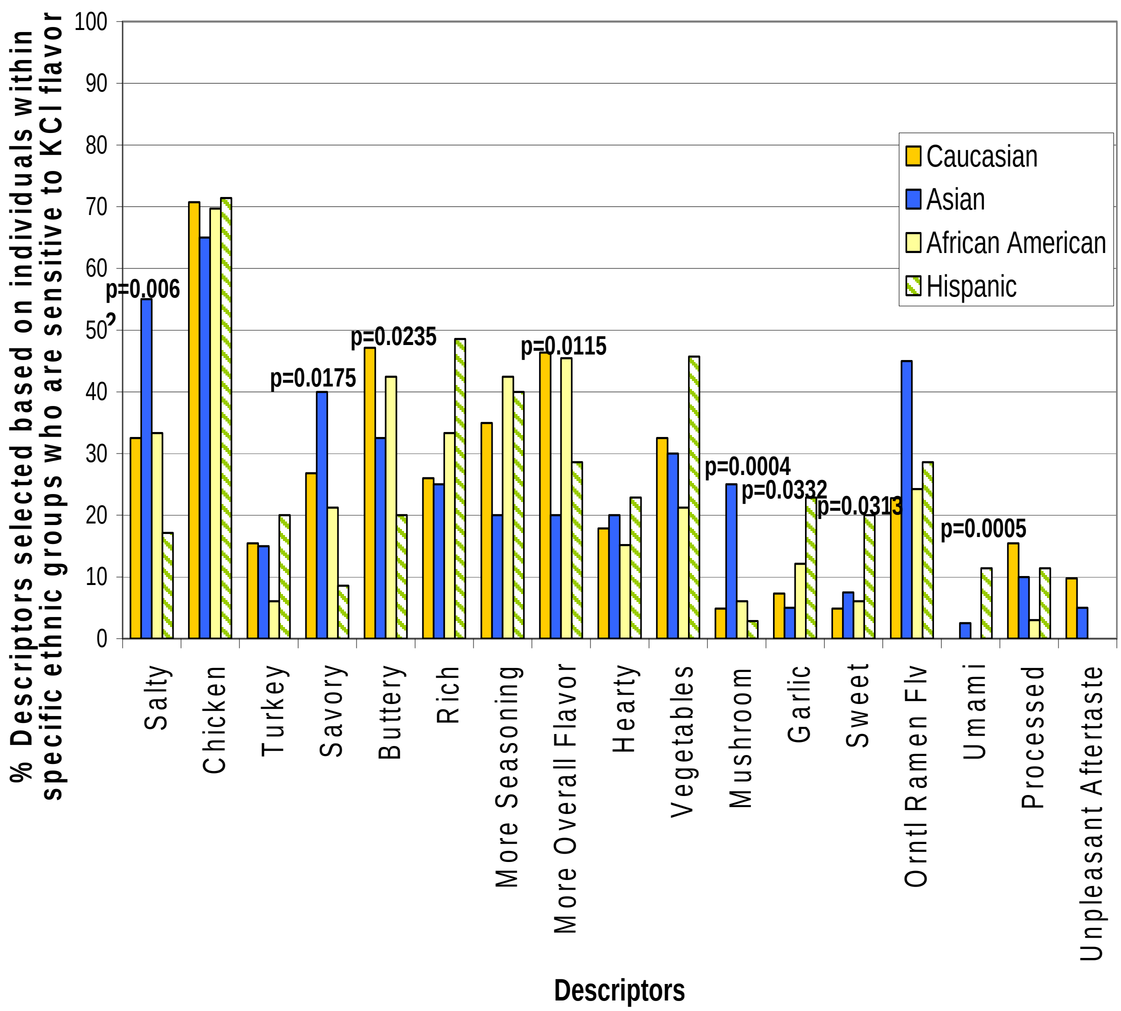
Figure 4.1- Frequency of consumer selected descriptors for flavor A for consumers who are sensitive to KCl flavor in chicken broth



Ethnic Group Results

Differences were found among the ethnic groups for the frequency of descriptors selected for the following terms at the 95% confidence level; salty, savory, buttery, more overall flavor, mushroom, sweet, and umami (Figure 4.2).

Figure 4.2- Frequency of consumer selected descriptors (subset of descriptors) for flavor A for consumers, based on ethnicity, who are sensitive to KCl flavor in chicken broth



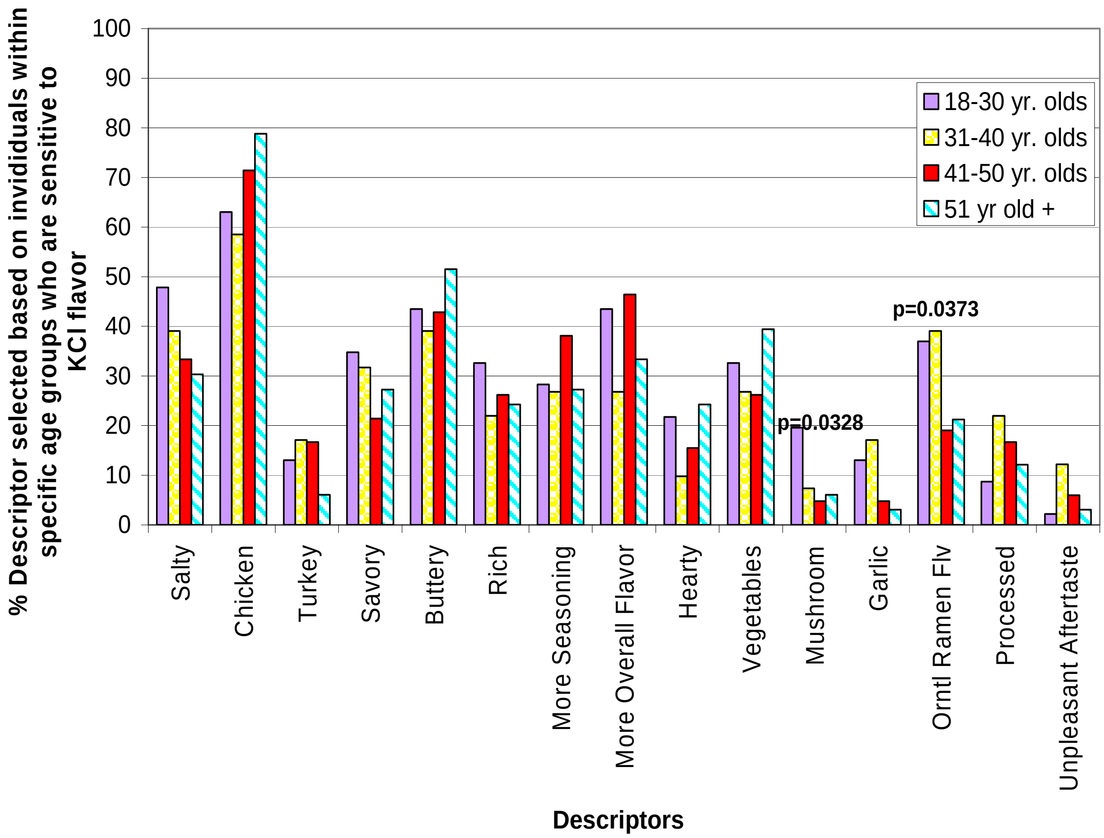
Asians selected the term "salty" to describe the flavor associated with KCl three times more often than Hispanics and nearly twice as often as Caucasians and African Americans. The percent of respondents in each ethnic group that selected "salty" were 55% Asian, 33% Caucasian, 33% African American, and 17% Hispanic. Similarly, Asians selected savory, mushroom, and Oriental Ramen noodle flavor much more frequently than the other ethnic group. Mushroom and ramen noodles are used extensively in Asian cuisine and more than likely they selected these terms based on a stronger familiarity with those flavors. Asian cuisine is typically described as savory, so Asians may be more accustomed to using that word to describe non-sweet foods.

Caucasians and African Americans selected buttery twice as frequently as Hispanics. Hispanics selected rich nearly twice as frequently as Caucasians or African Americans. The terms buttery and rich were likely describing a similar taste sensations among Caucasians, African Americans, and Hispanics, however the terminology used to describe the taste sensation was slightly different. If the frequency counts for buttery and rich were combined, the frequency would be 71%. Buttery and rich were used to describe the flavor associated with KCl in chicken broth as frequently as the main characterizing flavor, chicken. Umami was chosen by 11% of Hispanics and 2.5% of Asians, whereas, Caucasians and African Americans were at 0% for this term. Most consumers likely do not understand the flavors associated with umami, resulting in the non-rating for Caucasians and African Americans. The higher usage of the umami term by Hispanics was unexpected and may have been selected out of confusion for what the term means.

Age Group Results

Only three descriptors were found to be different among the age groups tested. Mushroom flavor was selected by 18-30 year olds nearly three times as frequently as the other age groups (Figure 4.3).

Figure 4.3- Frequency of consumer selected descriptors (subset of descriptors) for flavor A for consumers, based on age, who are sensitive to KCl flavor in chicken broth



Oriental Ramen noodle flavor was selected by 18-30 and 31-40 year olds nearly twice as frequently as 41-50 year olds or 51 year olds and older. Consumers under the age of forty are likely more familiar with Ramen noodles, a typical food staple in college.

Gender Results

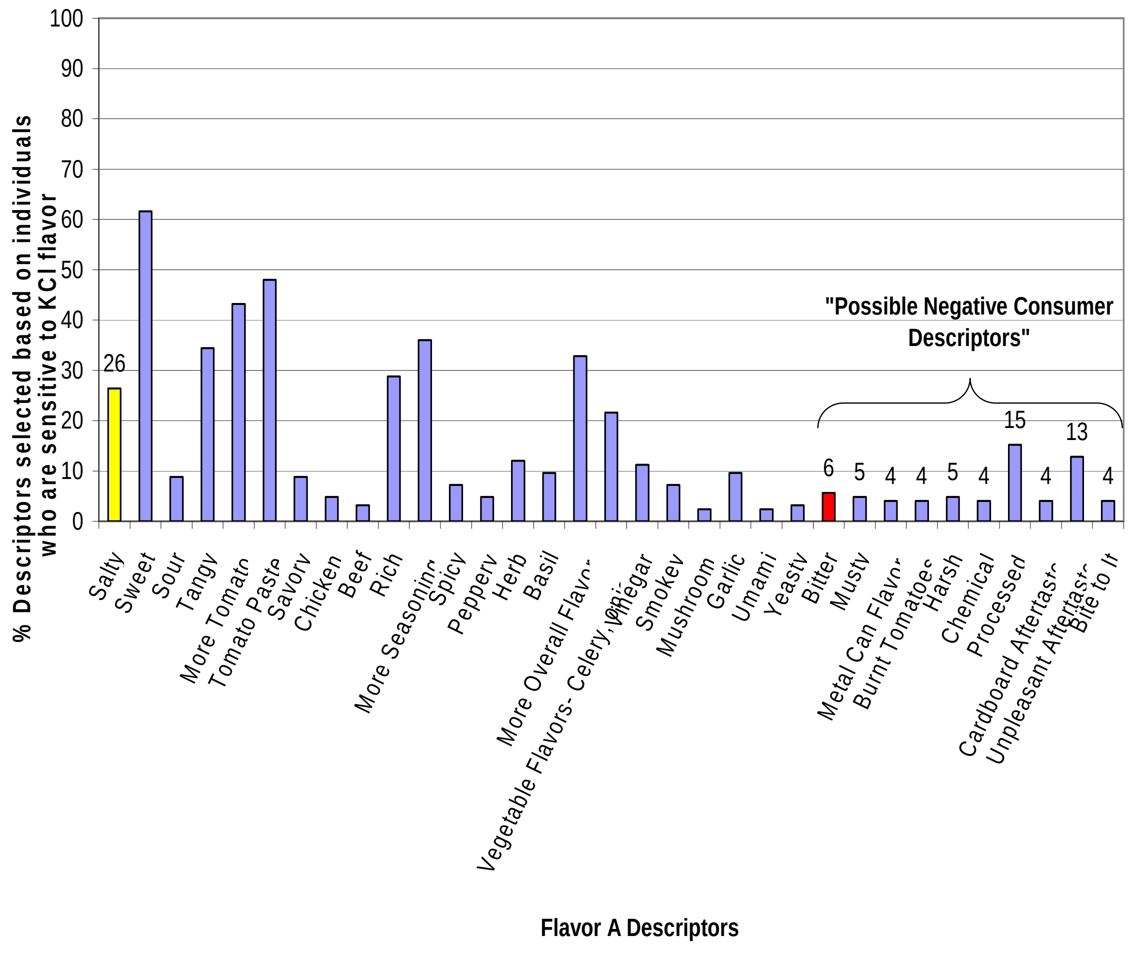
No significant differences or trends were found when the data was analyzed by gender. Men and women were consistently using the terms.

Tomato Soup

Total Consumer Results

Similar to the responses for chicken broth, the percentage of consumers selecting "negative consumer descriptors" was relatively low for tomato soup with the following words chosen 5% or less; musty, metal can flavor, burnt tomatoes, umami, harsh, chemical, cardboard aftertaste, and "bite to it" (Figure 4.4).

Figure 4.4-Frequency of consumer selected descriptors for flavor A for consumers who correctly identified both levels of KCl in tomato soup



Bitterness was selected by 6% of the total respondents to describe the flavors associated with KCl. Processed and unpleasant aftertaste were selected by 15% and 13% of respondents respectively.

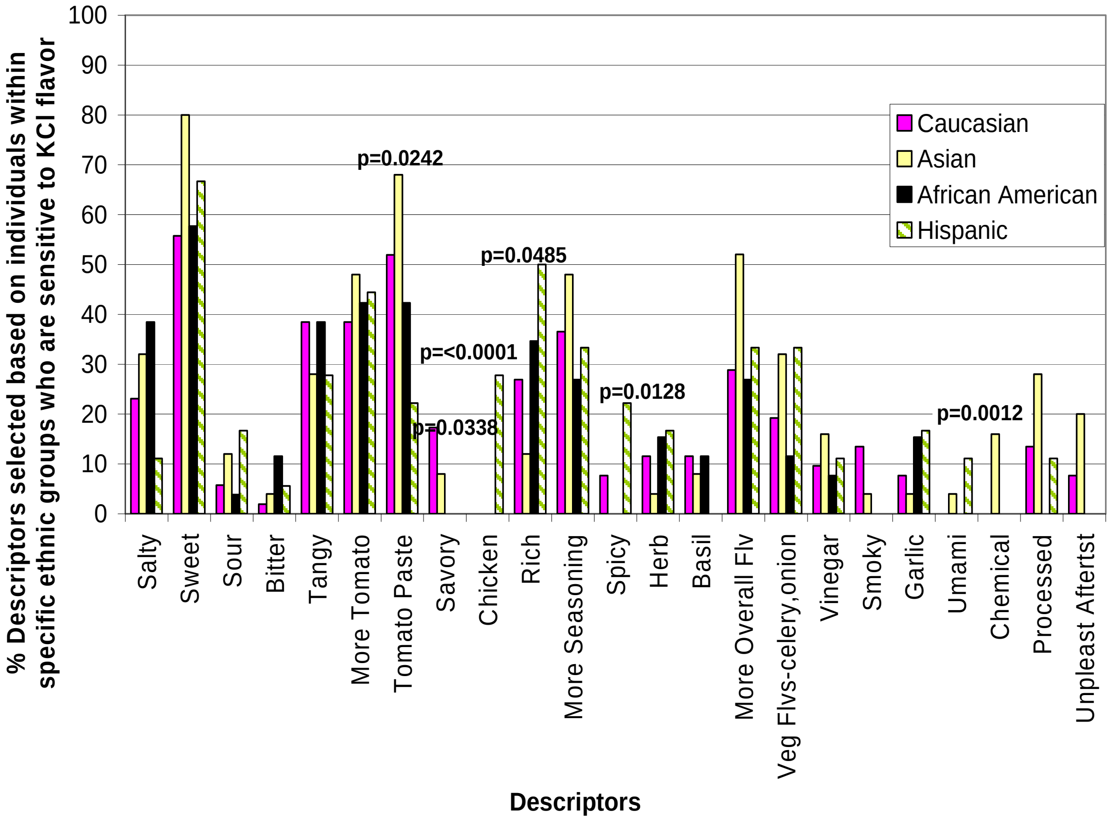
Sweet was the term most frequently selected by consumers at about 60%. Tomato paste and more tomato also had a high frequency, selected by more than 40% of respondents. Once again, salty was selected by less than a third of respondents at 26%.

Ethnic Group Results

There were several differences among ethnic groups for descriptors chosen to describe the flavors associated with KCl in tomato soup. Overall African Americans selected fewer terms than the other ethnic groups, which may be due to lower familiarity with flavors associated with tomatoes.

Asians selected tomato paste three times more frequently than Hispanics, whereas Caucasians and African Americans selected tomato paste at least twice as frequently as Hispanics (Figure 4.5). Food pastes are a common way to deliver concentrated flavor within Asian culture, so Asians might have chosen tomato paste as way to describe a more intense tomato flavor.

Figure 4.5- Frequency of consumer selected descriptors (subset of descriptors) for flavor A for consumers, based on ethnicity, who are sensitive to KCl flavor in tomato soup

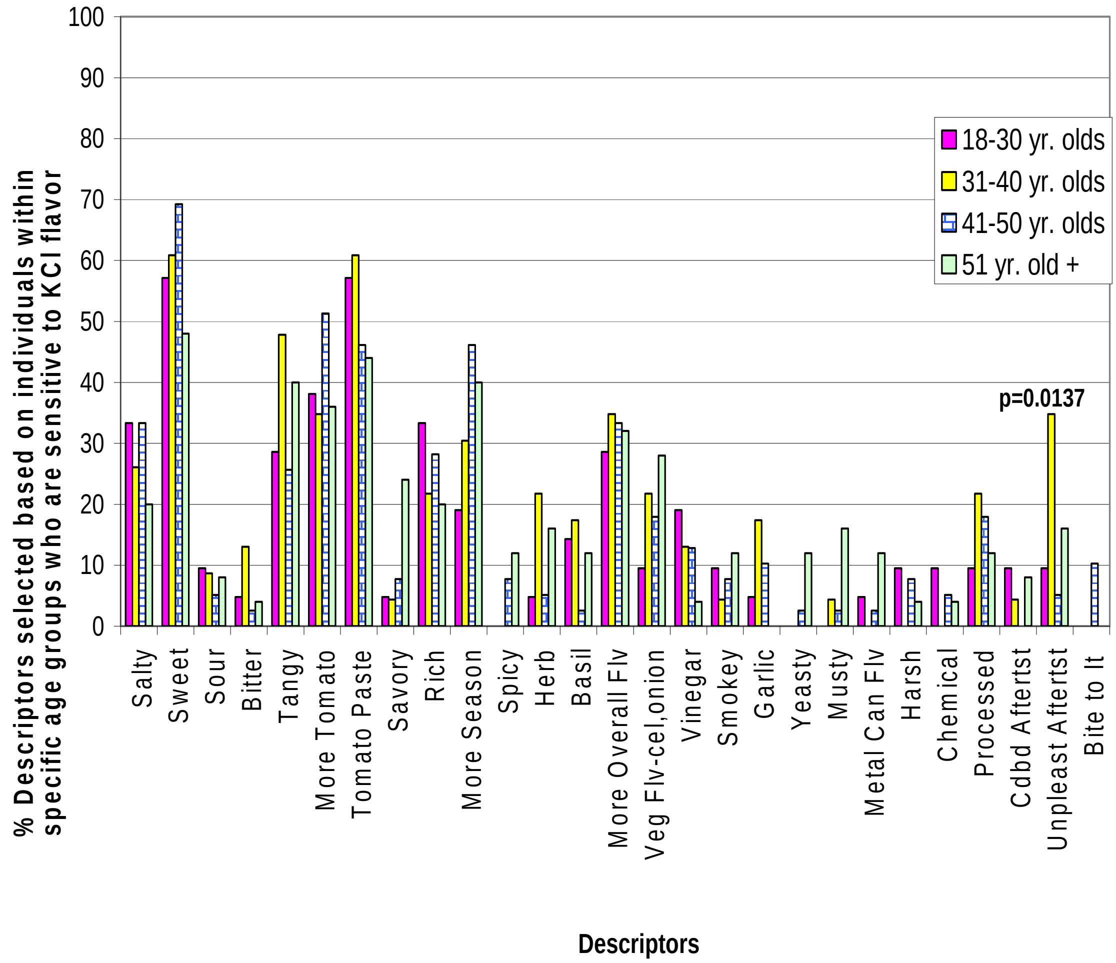


Caucasians and Asians selected the term savory, however African Americans and Hispanics did not use that word to describe the KCl flavor. Nearly 30% of Hispanics selected chicken as a descriptor, none of the other ethnic groups selected this term. Hispanics frequently selected rich as a descriptor, choosing rich one and one-half times more frequently than Caucasians and Africans Americans and four times more frequently than Asians. Some Caucasians and Hispanics found the KCl to be spicy with 8% and 22% of those ethnic groups selecting that term respectively. Caucasians and Asians selected smoky to describe flavor associated with KCl, whereas no African Americans or Hispanics selected this term. Similarly to chicken broth, a small group of Hispanics and Asians selected umami, whereas Caucasians and Africans did not use that term. Sixteen percent of Asians selected chemical to describe KCl flavor, none of the other ethnic groups selected this term.

Age Group Results

Only one significant difference was found for how the age groups selected terms. Unpleasant aftertaste was significantly different with 31-40 year olds selecting this term two to three times more frequently than the other groups. Directionally, at the 90% confidence level, the following terms are used differently by the various age groups; bite to it, musty, yeasty, and savory (Figure 4.6).

Figure 4.6 - Frequency of consumer selected descriptors (subset of descriptors) for flavor A for consumers, based on age, who are sensitive to KCl flavor in tomato soup



Gender Results

No significant differences or trends were found when the data was analyzed by gender. Men and women were consistently using the terms.

Discussion

Many of the terms that consumers used to describe the flavor associated with KCl in this study were related to the characterizing flavor of the product evaluated. For example, in chicken broth, the descriptor chicken was chosen the most frequently by respondents (70% of respondents). Similarly for tomato soup; sweet, tomato paste, and more tomato were chosen frequently by consumers to describe the flavor associated with KCl. Consumers may have had difficulty focusing on more subtle flavors or in identifying flavors other than the characterizing ones.

Bitterness, metallic (metal can flavor), chemical, and harsh were all chosen by less than 10% of respondents in both chicken broth and tomato soup. These findings are somewhat contrary to the many studies found in the literature. Bitterness is often cited in the literature as a negative flavor attribute contributed by the addition of KCl as a sodium replacer (Amerine *et al.*, 1965; Bravieri, 1983; Lynch, 1987; Kurtz & Fuller, 1997; Wade, 2006). Kilcast and Angus (2007) comment that KCl contributes a chemical and metallic aftertaste, which limits the usefulness of KCl. Previous studies did not clearly state what type of respondents, trained panelists or naïve consumers, were used in these studies evaluating KCl flavor; naïve consumers may be less likely to be able to identify bitter. Less than 10% of consumers in this study used either chemical or metallic to describe the flavors associated with KCl. The lack of strong consumer response for bitterness when tested with 0.45% KCl does agree with the findings from Olson and Terrell (1981), who found that NaCl could mask bitterness when used in conjunction with KCl levels up to 1.5%. These results could be explained in two different ways. There is the possibility that the level of KCl in these model soup systems was not high enough to be perceived by consumers as bitter at the NaCl level in the study, or the majority of consumers in this study were not sensitive to bitterness from KCl, which seems less likely.

The term salty was chosen by 35% of respondents for chicken broth and 26% of respondents for tomato soup when describing the flavor associated with KCl. A majority of consumers in this study did not perceive or describe KCl flavor as salty. The lack of additional salt perception with the addition of KCl may be problematic considering the reason for the addition of KCl in a reduced sodium product is to mimic salt taste

When the data was analyzed for different sub-groups, significant differences were found for ethnicity and age, but not gender. Difference in the sub-group data may be due to differences in typical diet of the different ethnic groups and ages. Soup is a common food in every culture around the world. Soup is a relatively inexpensive food that can be prepared easily in one cooking pot on any type of heating device, whether stove or open fire. Hispanic and Asian cuisines are especially laden with soup recipes. Hispanic soup recipes are strong in chicken broth as well as tomato based soups. Due to the ready tomato supply in North America, tomatoes are a prevalent ingredient within the Hispanic diet; used as the base for many sauces and soups. In contrast, Asian cuisine soup bases focus on the use of chicken broth and fish sauce, and there is less familiarity with tomato based sauces. Within the ethnic groups, Caucasians and African Americans appear most similar in how they describe the flavors associated with KCl in chicken broth and tomato soup, which is likely due to the similarity of lifestyle and food exposure within Minnesota. Hispanics and Asians appear to differ considerably from each other and Caucasians and African Americans. The Hispanics within Minnesota were not highly acculturated to the United States, which may have contributed to the differences in their word selection based on their lack of familiarity with processed soup compared to scratch cooking. Asian Americans in this study lived in California and there may have been varying levels of acculturation or differences due to location and availability to a wider variety of food (Midwest versus West coast). When looking at terms to describe chicken broth, Asians selected savory, mushroom, and Oriental Ramen Noodle flavor terms more frequently that the other ethnic groups. Mushrooms and ramen noodles are common ingredients in Asian cuisine. Savory is a term that typifies Asian cuisine, so the higher use of these terms by consumers would be expected. Similarly, for tomato soup, tomato paste was selected by Asians more than Hispanics. Food pastes are a common way to deliver concentrated flavor within Asian culture, so it stands to reason that Asians might have chosen tomato paste as way to describe a more intense tomato flavor. The breadth of words used by African Americans for tomato soup was more limited than the other ethnic groups, which may be due to less familiarity with vegetable products and their associated flavors.

For bitterness, metal can flavor, and harsh there were no significant differences among the ethnic groups for either chicken broth or tomato soup. Asians chose the term chemical at a significantly higher level than the other ethnic groups for tomato soup, but not chicken broth, this may be due to a lack of experience with canned tomato products. Hispanics found the KCl to be spicy with 22% selecting that term, much higher than the other ethnic groups. The spicy sensation might be due to the combination of natural umami within tomatoes and a metallic feeling sensation may have been perceived in a similar way to a heat sensation, which is typical of Hispanic foods. While differences were found among the ethnic groups for both chicken broth and tomato soup, the reasons for the differences are unclear. The differences may be due to genetic taste perception differences, cultural differences, or familiarity with the flavors tested and descriptive terms used in this study. Within the literature, there were no studies that looked at whether there are differences in the way different ethnic groups describe the flavor associated with KCl.

Few significant differences were found when the data was analyzed for age. For chicken broth, consumers of different ages rated mushroom and Oriental Ramen Noodle flavor differently. Consumers under the age of forty may be more familiar with Ramen noodles, a typical food staple in college. For tomato soup, only one descriptive term was found to be significant among the different age groups, unpleasant aftertaste. Within the literature, there is some disagreement on how large a role aging plays on the ability to taste. Most of the studies were looking at subjects older than were used for this study. The maximum age in this study was 60 years old. Schiffman (2000) and Drewnowski *et al.* (1996) both studied subjects up into their sixties and seventies, finding different conclusions on the effect of aging and taste. Schiffman (2000) found that age did have a impact after age sixty declining to a significant impact after age seventy, which can be caused by normal aging, medications, environmental factors, and surgery. Drewnowski *et al.* (1996) found no loss of ability for subjects aged 60-75 year old compared to 20-30 year olds. They suggest that differences seen in their study results versus other studies' results may be due to differences in lifestyle and health of the older subjects in the study; older subjects in their study were healthy nonsmokers of healthy weight (Drewnowski, *et .al.*, 1996).

Conclusions and Recommendations

This study found that a large majority of naïve, non-sensory trained, consumers did not use bitter, metal can flavor, harsh, or chemical to describe the flavors associated with KCl. They also did not use salty to describe the KCl flavor. The terms that were most frequently used were the characterizing flavor terms, such as chicken for chicken broth or sweet and tomato paste for tomato soup.

More differences in the descriptive term selection were found for ethnic groups than age. No significant differences in descriptive term selection were found for gender. Additional studies will need to be completed to understand if the difference in ethnicity are due to cultural differences or genetics.

Additional research is needed to understand consumers response to KCl after consuming larger quantities of KCl in this and other model food systems. Research is needed to understand the impact on sensitivity of repeated exposure of KCl in model food systems.

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Appendix A - Basic taste references

Table A.1-Salt basic taste references

Intensity based on the Sensory Spectrum Scale	Amount of NaCl (grams)	Amount of filtered water (milliliter)	% solution
7.5	2.25	500	0.45
10.0	2.75	500	0.55
12.5	3.10	500	0.63

Table A.2-Sweet basic taste references

Intensity based on the Sensory Spectrum Scale	Amount of sucrose (grams)	Amount of filtered water (milliliter)	% solution
2.0	10.0	500	2.0
5.0	25.0	500	5.0

Table A.3-Sour basic taste references

Intensity based on the Sensory Spectrum Scale	Amount of citric acid (grams)	Amount of filtered water (milliliter)	% solution
2.0	0.25	500	0.05
5.0	0.40	500	0.08

Table A.4-Bitter basic taste references

Intensity based on the Sensory Spectrum Scale	Amount of caffeine (grams)	Amount of filtered water (milliliter)	% solution
2.0	0.25	500	0.05
5.0	0.40	500	0.08

Appendix B - Chicken broth descriptive analysis ballot

WELCOME to
Descriptive Analysis
using COMPUSENSE *five*

Please remember that all products tasted are proprietary to General Mills and should not be discussed with anyone outside of General Mills.

To begin: Click on the CONTINUE button below.

Panelist Code: ________________________

Panelist Name: ____

Review Instructions

You will be tasting BROTH for this project.

You will be able to taste BASIC TASTE solutions before evaluating.
Calibrate yourself using the BASIC TASTES.

You must swallow all of the EVALUATION SAMPLES (NOT THE BASIC TASTES!)

It is important to follow the technique carefully.

Question # 1 - Sample ______

Please taste all of your BASIC TASTE SOLUTIONS. Rinse with water between each one.

When you have calibrated yourself to all the solutions, please pass them all back into the lab.

Click CONTINUE when you have returned all your solution cups.

(There is nothing to type in the line below - just ignore it!)

Thanks!

Question # 2 - Sample ______

Please cleanse your palate by taking 2 bites of cracker (chew and swallow)
and then rinsing with plenty of water.
(There is nothing to type in the line below - just ignore it!)
Click CONTINUE when you have finished.

Question # 3 : Time Delay /Signal. ________

This is a 2-minute time delay.

Please wait until the counter goes to ZERO and then click

NEXT QUESTION.

Question # 4 - Sample ______

Please sip and swallow ALL the broth in your sample before rating the BASIC TASTES.

SALT __________

SWEET __________

SOUR __________

BITTER __________

Umami __________

METALLIC __________

Question # 5 - Sample ______

Please cleanse your palate by taking 2 bites of cracker (chew and swallow)
and then rinsing with plenty of water.

(There is nothing to type in the line below - just ignore it!)

Go to NEXT SAMPLE when you are ready.

Appendix C - Tomato soup descriptive analysis ballot

WELCOME to
Descriptive Analysis
using COMPUSENSE *five*

Please remember that all products tasted are proprietary to General Mills and should not be discussed with anyone outside of General Mills.

To begin: Click on the CONTINUE button below.

Panelist Code: ________________________

Panelist Name: ____

Review Instructions

You will be tasting SOUP for this project.

You will be able to taste BASIC TASTE solutions before evaluating.
Calibrate yourself using the BASIC TASTES.

You must swallow all of the EVALUATION SAMPLES (NOT THE BASIC TASTES!)

It is important to follow the technique carefully.

Question # 1 - Sample ______

Please taste all of your BASIC TASTE SOLUTIONS. Rinse with water between each one.

When you have calibrated yourself to all the solutions, please pass them all back into the lab.

Click CONTINUE when you have returned all your solution cups.

(There is nothing to type in the line below - just ignore it!)

Thanks!

Question # 2 - Sample ______

Please cleanse your palate by taking 2 bites of cracker (chew and swallow)
and then rinsing with plenty of water.
(There is nothing to type in the line below - just ignore it!)
Click CONTINUE when you have finished.

____

Question # 3 : Time Delay /Signal.

This is a 2-minute time delay.

Please wait until the counter goes to ZERO and then click

NEXT QUESTION.

Question # 4 - Sample ______

Please sip and swallow ALL the broth in your sample before rating the BASIC TASTES.

SALT __________

SWEET __________

SOUR __________

BITTER __________

Question # 5 - Sample ______

Please cleanse your palate by taking 2 bites of cracker (chew and swallow)
and then rinsing with plenty of water.

(There is nothing to type in the line below - just ignore it!)

Go to NEXT SAMPLE when you are ready.

Appendix D - Mean intensity scores for salt, sour, bitter, umami, and metallic flavors for varying levels of sodium ions (mg/230 g serving) and % KCl in chicken broth

Table D.1-Mean intensity scores salt, sour, bitter, umami, and metallic flavors for independent analysis of varying levels of sodium ions (mg/serving) and %KCl in chicken broth (360 mg sodium +0.0% KCl, 360 mg sodium +0.15% KCl, and 460 mg sodium +0.0% KCl)

	Sample		
	360 mg sodium + 0.0% KCl**	360 mg sodium + 0.15% KCl**	460 mg sodium + 0.0% KCl**
Flavor Intensity	Mean	Mean	Mean
Salt	8.8 e	11.2 bc	9.8 d
Sour	3.7 a	3.5 a	3.5 a
Bitter	3.5 a	3.5 a	3.2 a
Umami	3.2 a	3.2 a	2.7 a
Metallic	2.2 a	2.3 a	2.1 a

* mg NaCl/230 g serving

**mg sodium /230 g serving + % KCl

Mean scores sharing the same letter are not significantly different at the 95% confidence level.

Table D.2- Mean intensity scores salt, sour, bitter, umami, and metallic flavors for independent analysis of varying levels of sodium ions (mg/serving) and %KCl in chicken broth (460 mg sodium +0.15%, 460 mg sodium +0.30%, 460 mg sodium +0.45%, 460 mg sodium +0.60% KCl, and 460 mg sodium +0.75% KCl)

Sample					
	460 mg sodium + 0.15% KCl*	460 mg sodium + 0.30% KCl*	460 mg sodium + 0.45% KCl*	460 mg sodium + 0.60% KCl*	460 mg sodium + 0.75% KCl*
Flavor Intensity	Mean	Mean	Mean	Mean	Mean
Salt	10.5 c	11.0 bc	11.5 b	11.7 ab	12.2 a
Sour	3.7 a	3.6 a	3.6 a	3.7 a	3.7 a
Bitter	3.4 a	3.6 a	3.6 a	3.4 a	3.8 a
Umami	3.2 a	2.9 a	3.2 a	3.2 a	3.4 a
Metallic	2.2 a	2.1 a	2.3 a	2.5 a	2.5 a

*mg sodium /230 g serving + % KCl

Mean scores sharing the same letter are not significantly different at the 95% confidence level.

Table D.3- Mean intensity scores salt, sour, bitter, umami, and metallic flavors for independent analysis of varying levels of sodium ions (mg/serving) in chicken broth (360 mg sodium, 460 mg sodium, 560 mg sodium, 660 mg sodium, 760 mg sodium, 860 mg sodium, and 960 mg sodium)

Sample							
	360 mg sodium*	460 mg sodium*	560 mg sodium*	660 mg sodium*	760 mg sodium*	860 mg sodium*	960 mg sodium*
Flavor Intensity	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Salt	8.4 e	9.7 d	10.8 cd	11.4 bc	12.2 ab	12.6 a	12.6 a
Sour	3.8 a	3.8 a	3.8 a	3.8 a	3.8 a	3.7 a	3.8 a
Bitter	3.7 a	3.9 a	3.8 a	3.8 a	3.9 a	3.7 a	3.8 a
Umami	3.8 a	3.8 a	3.7 a	3.6 a	3.8 a	3.9 a	4.1 a
Metallic	2.4 a	2.6 a	2.5 a	2.9 a	2.5 a	2.4 a	2.4 a

*mg sodium /230 g serving

Mean scores sharing the same letter are not significantly different at the 95% confidence level.

Appendix E - Mean intensity scores for salt, sweet, sour, and bitter flavors for varying levels of sodium ions (mg/244 g serving) and % KCl in tomato soup

Table E.1- Mean intensity scores salt, sweet, sour, and bitter flavors for independent analysis of varying levels of sodium ions (mg/serving) and %KCl in tomato soup (360 mg sodium +0.0% KCl, 360 mg sodium +0.15% KCl, and 460 mg sodium +0.0% KCl)

Sample			
	360 mg sodium + 0.0% KCl**	360 mg sodium + 0.15% KCl**	460 mg sodium + 0.0% KCl**
Flavor Intensity	Mean	Mean	Mean
Salt	8.4 b	9.3 a	8.9 ab
Sweet	4.7 b	4.8 b	5.0 ab
Sour	4.1 a	4.0 a	3.9 a
Bitter	3.6 b	3.8 ab	4.0 ab

* mg sodium /244 g serving

**mg sodium /244 g serving + % KCl

Mean scores sharing the same letter are not significantly different at the 95% confidence level.

Table E.2- Mean intensity scores salt, sweet, sour, and bitter flavors for independent analysis of varying levels of sodium ions (mg/serving) and %KCl in tomato soup (460 mg sodium +0.15%, 460 mg sodium +0.30%, 460 mg sodium +0.45%, 460 mg sodium +0.60% KCl, and 460 mg sodium +0.75% KCl)

Sample					
	460 mg sodium + 0.15% KCl*	460 mg sodium + 0.30% KCl*	460 mg sodium + 0.45% KCl*	460 mg sodium + 0.60% KCl*	460 mg sodium + 0.75% KCl*
Flavor Intensity	Mean	Mean	Mean	Mean	Mean
Salt	8.9 ab	8.9 ab	9.3 a	9.6 a	9.4 a
Sweet	5.2 ab	5.2 ab	5.1 ab	5.2 ab	5.4 a
Sour	4.0 a	4.0 a	3.7 a	3.7 a	3.9 a
Bitter	4.1 ab	4.3 a	4.2 a	4.0 ab	4.1 ab

*mg sodium /244 g serving + % KCl

Mean scores sharing the same letter are not significantly different at the 95% confidence level.

Table E.3- Mean intensity scores salt, sweet, sour, and bitter flavors for independent analysis of varying levels of sodium ions (mg/serving) in tomato soup (360 mg sodium, 460 mg sodium, 560 mg sodium, 660 mg sodium, 760 mg sodium, 860 mg sodium, and 960 mg sodium)

Sample							
	360 mg sodium*	460 mg sodium*	560 mg sodium*	660 mg sodium*	760 mg sodium*	860 mg sodium*	960 mg sodium*
Flavor Intensity	Mean	Mean	Mean	Mean	Mean	Mean	Mean
Salt	8.9 b	9.3 b	10.3 a	10.3 a	10.5 a	10.7 a	10.5 a
Sweet	5.0 a	5.3 a	5.3 a	5.3 a	5.5 a	5.2 a	5.4 a
Sour	3.9 a	3.7 a	3.5 a	3.5 a	3.4 a	3.4 a	3.4 a
Bitter	3.7 a	3.8 a	3.8 a	3.9 a	3.4 a	3.8 a	3.9 a

*mg sodium/244 g serving

Mean scores sharing the same letter are not significantly different at the 95% confidence level.

Appendix F - Intensity ratings for independent analysis of varying levels of sodium ions (mg/serving) and %KCl in chicken broth

Error bars in all of the following graphs are the standard deviations.

Figure F.1- Salt intensity ratings for independent analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

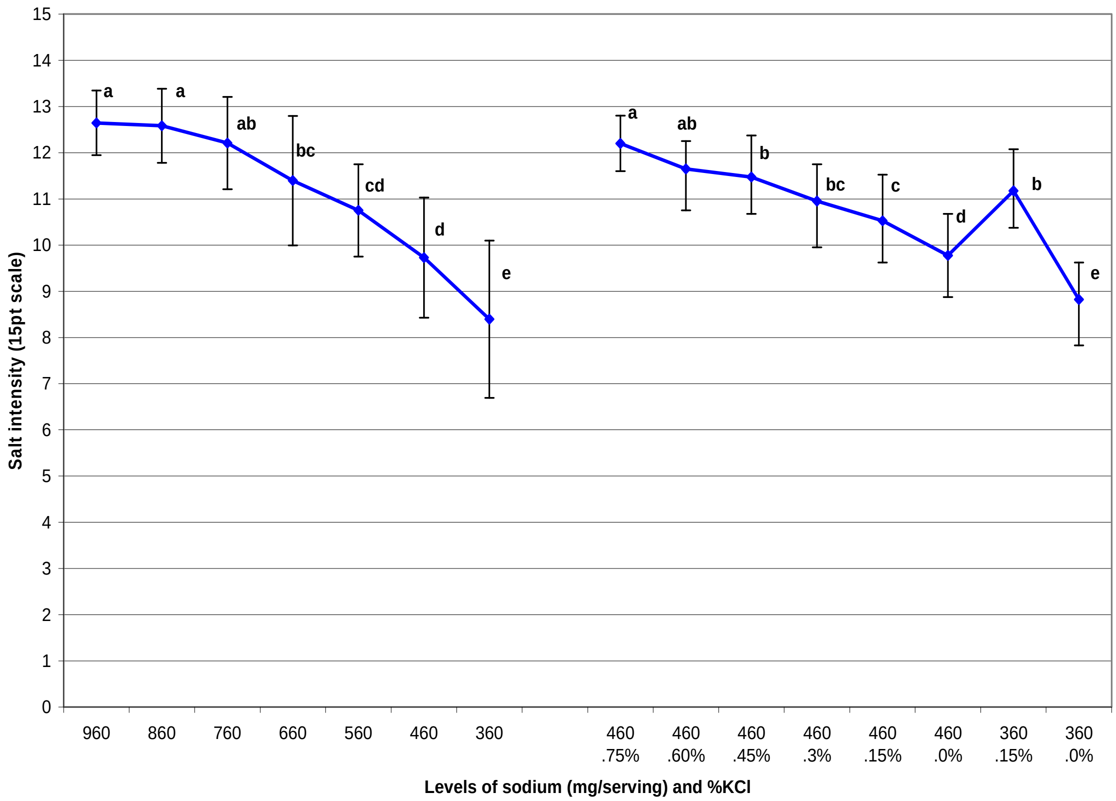


Figure F.2- Sour intensity ratings for independent analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

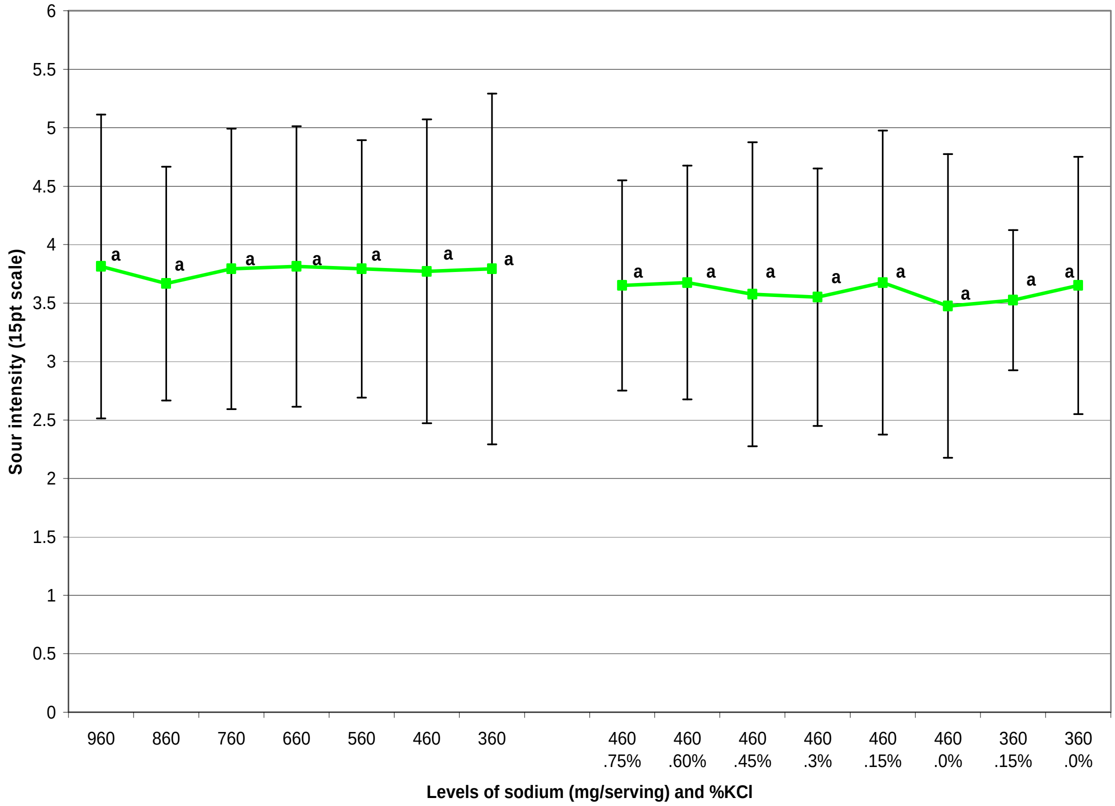


Figure F.3- Bitter intensity ratings for independent analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

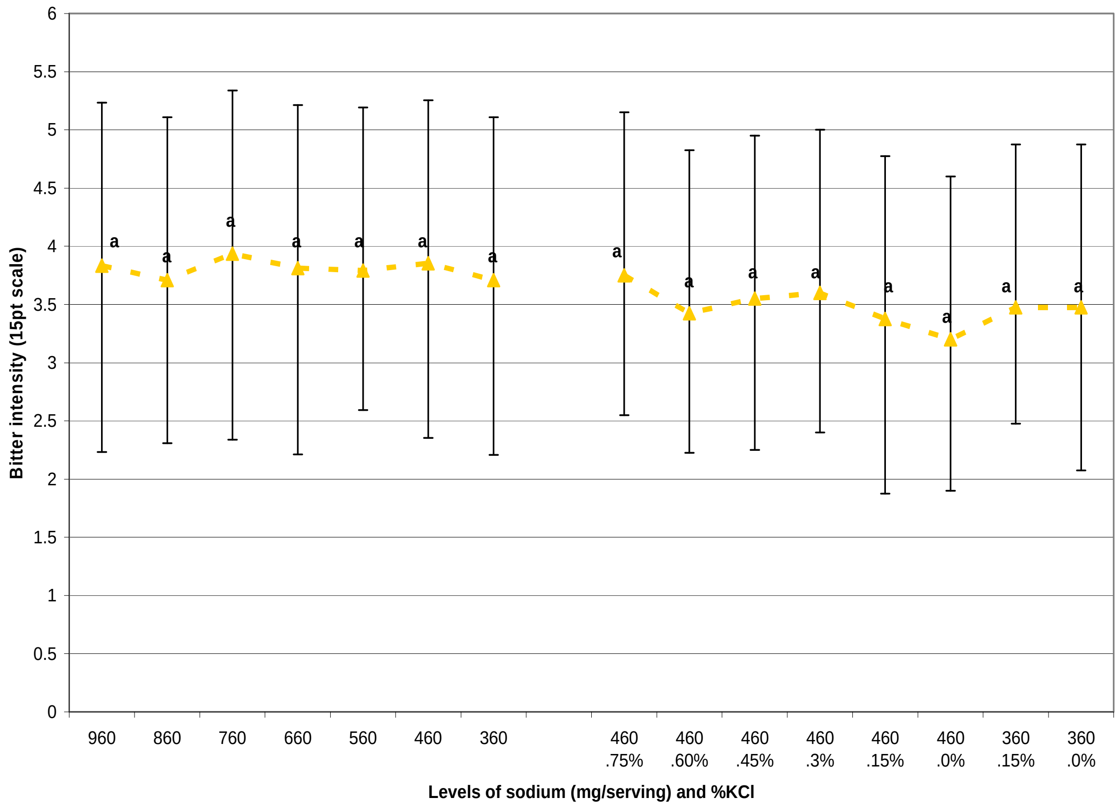


Figure F.4- Umami intensity ratings for independent analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

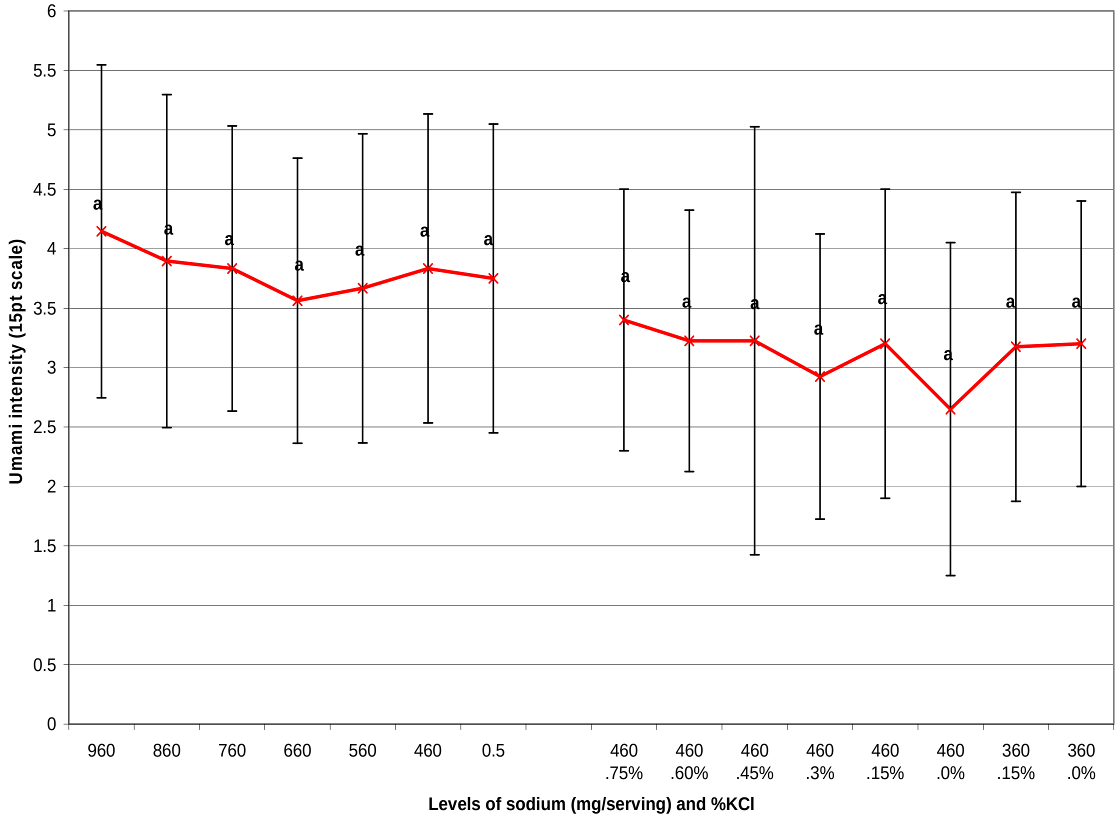
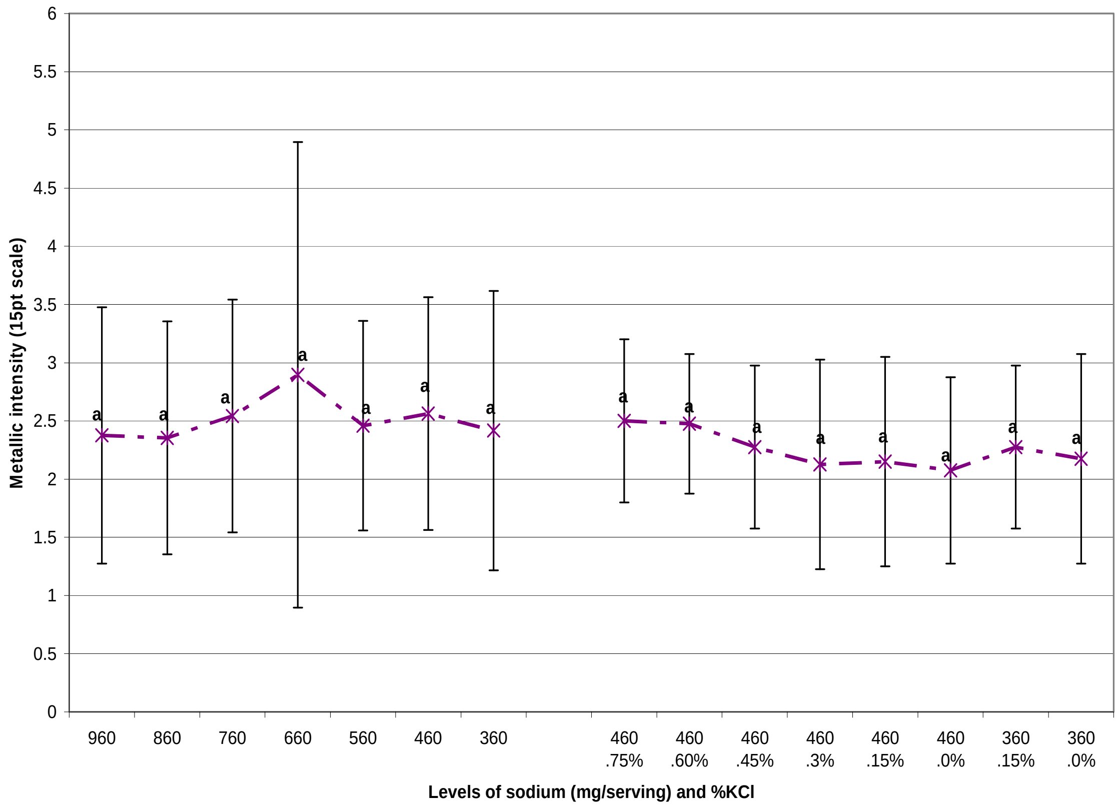


Figure F.5-Metallic intensity ratings for independent analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth



Appendix G - Intensity ratings for combined analysis of varying levels of sodium ions (mg/serving) and %KCl in chicken broth

Figure G.1-Salt intensity ratings for combined analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

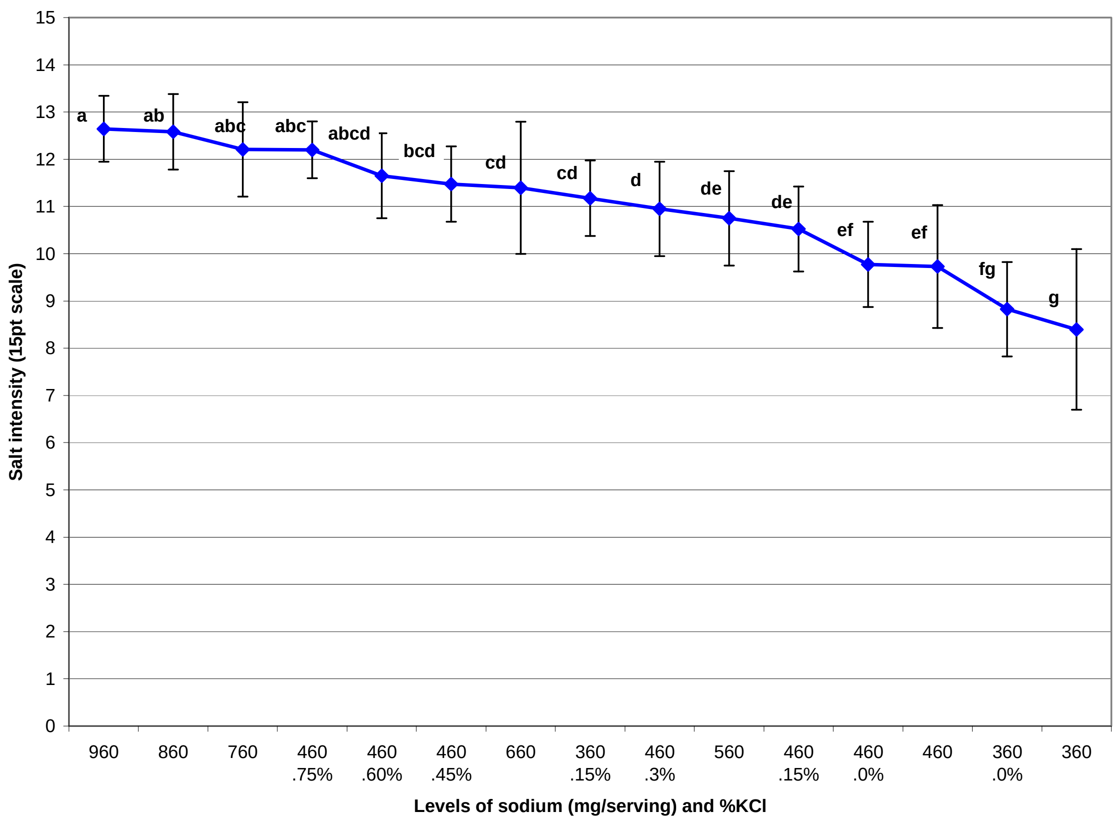


Figure G.2-Sour intensity ratings for combined analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

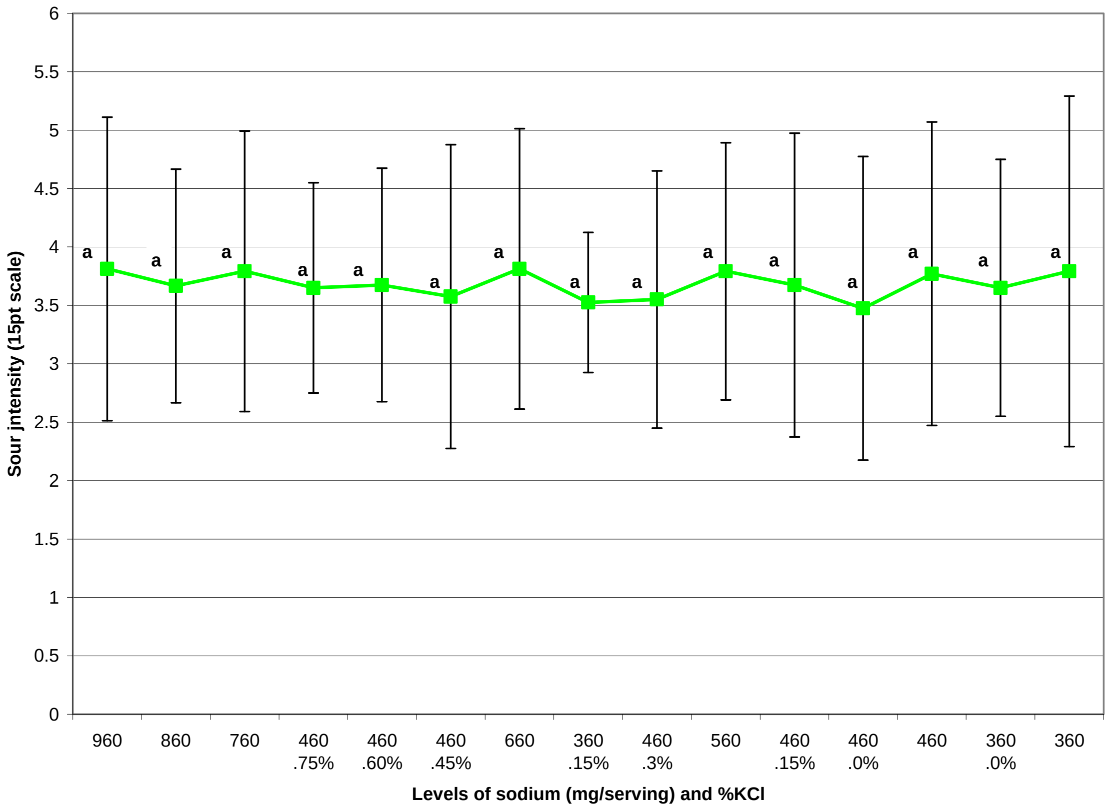


Figure G.3-Bitter intensity ratings for combined analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

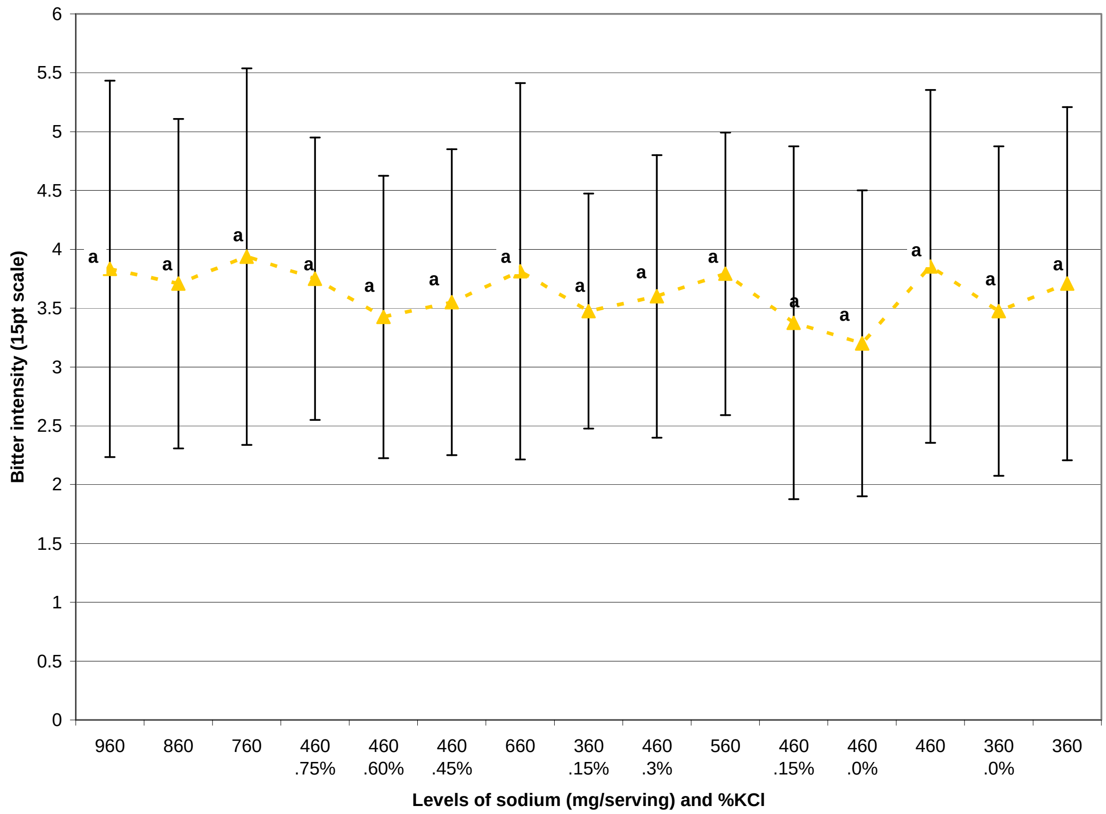


Figure G.4-Umami intensity ratings for combined analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth

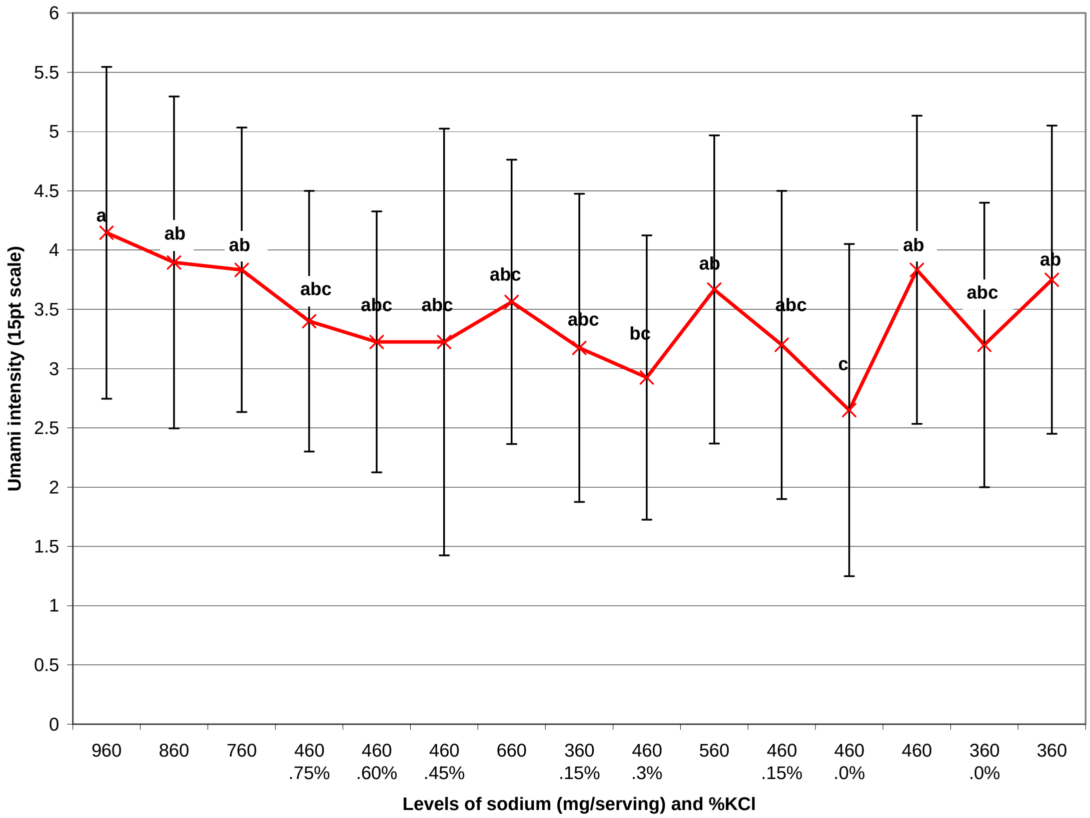
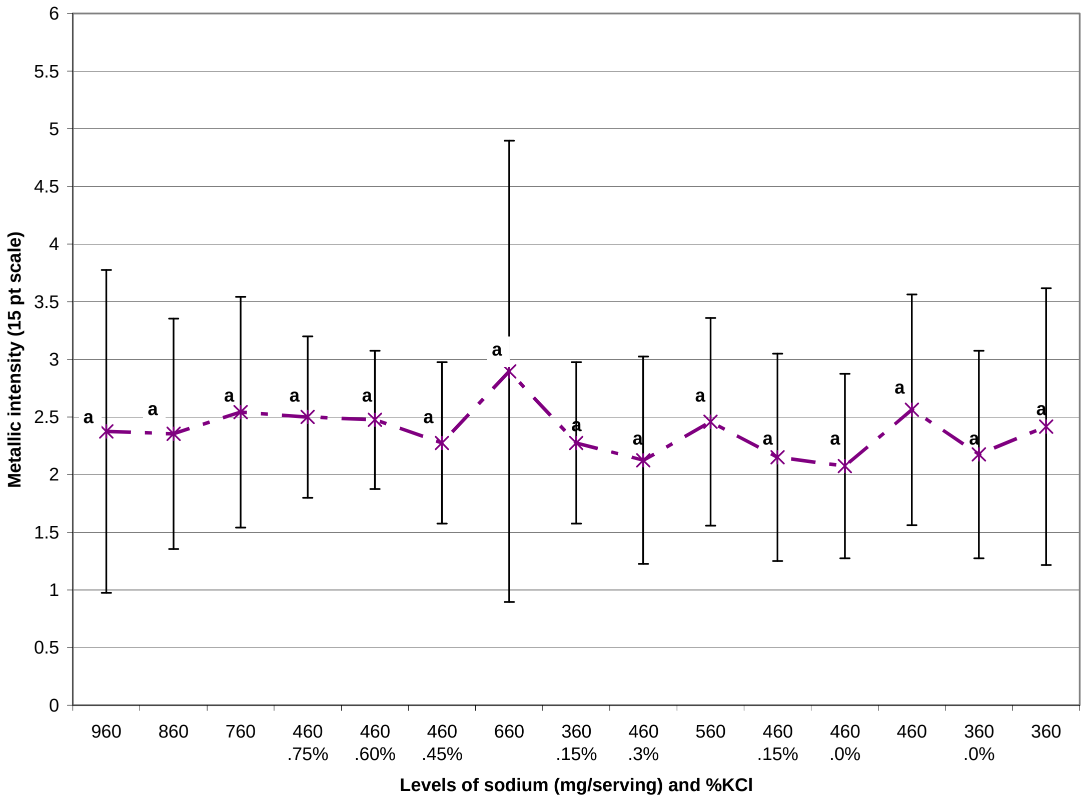


Figure G.5-Metallic intensity ratings for combined analysis of varying levels of sodium ions (mg/230 g serving) and %KCl in chicken broth



Appendix H - Intensity ratings for independent analysis of varying levels of sodium ions (mg/serving) and %KCl in tomato soup

Figure H.1-Salt intensity ratings for independent analysis of varying levels of sodium mg/244 g serving) and %KCl in tomato soup

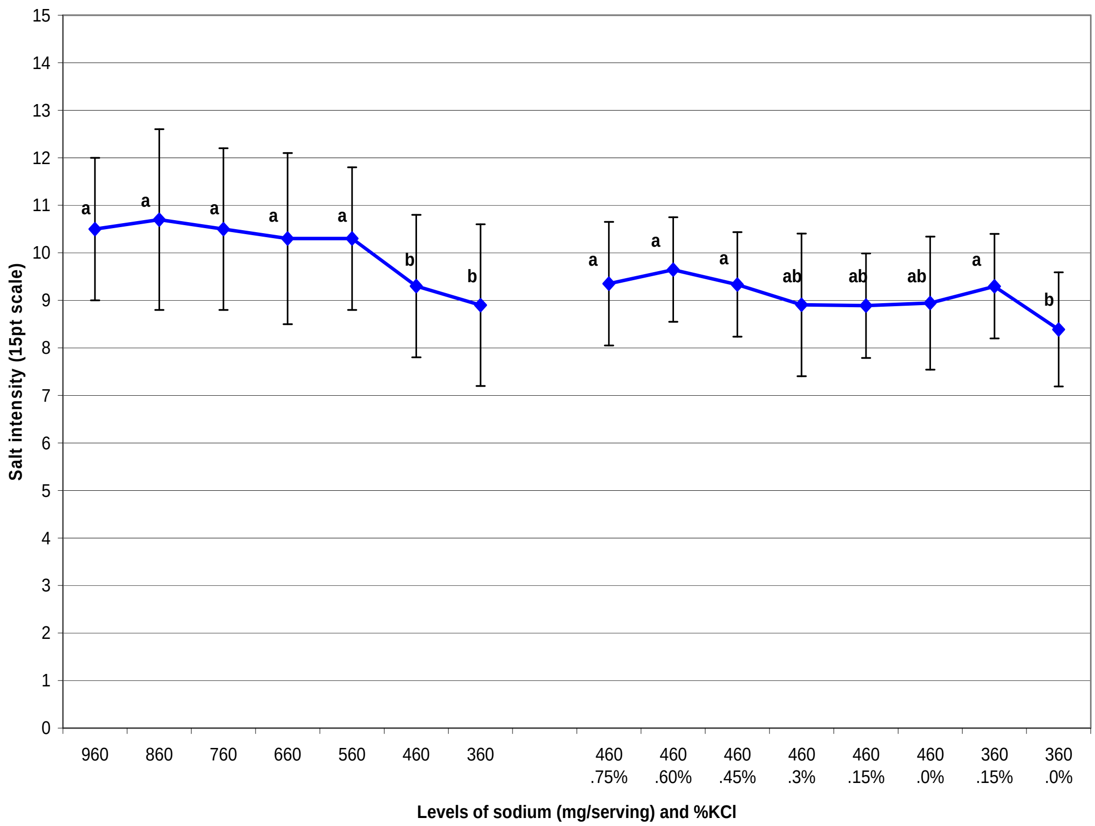


Figure H.2-Sweet intensity ratings for independent analysis of varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup

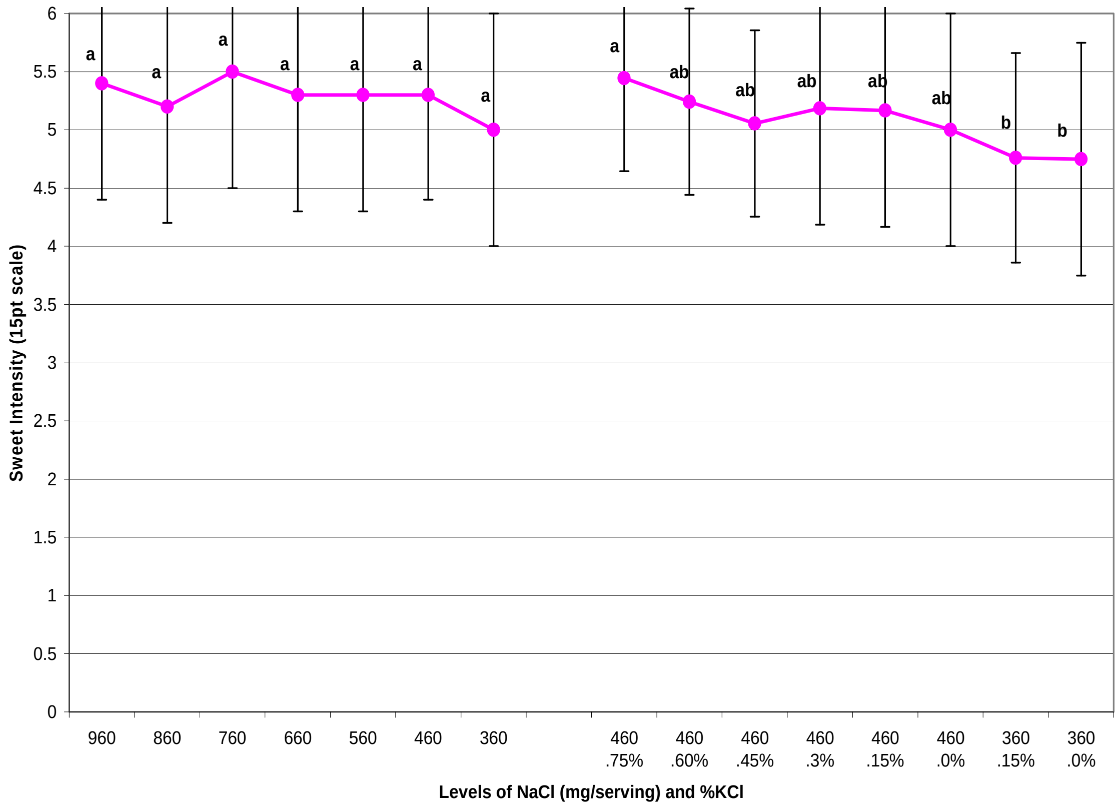


Figure H.3-Sour intensity ratings for independent analysis of varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup

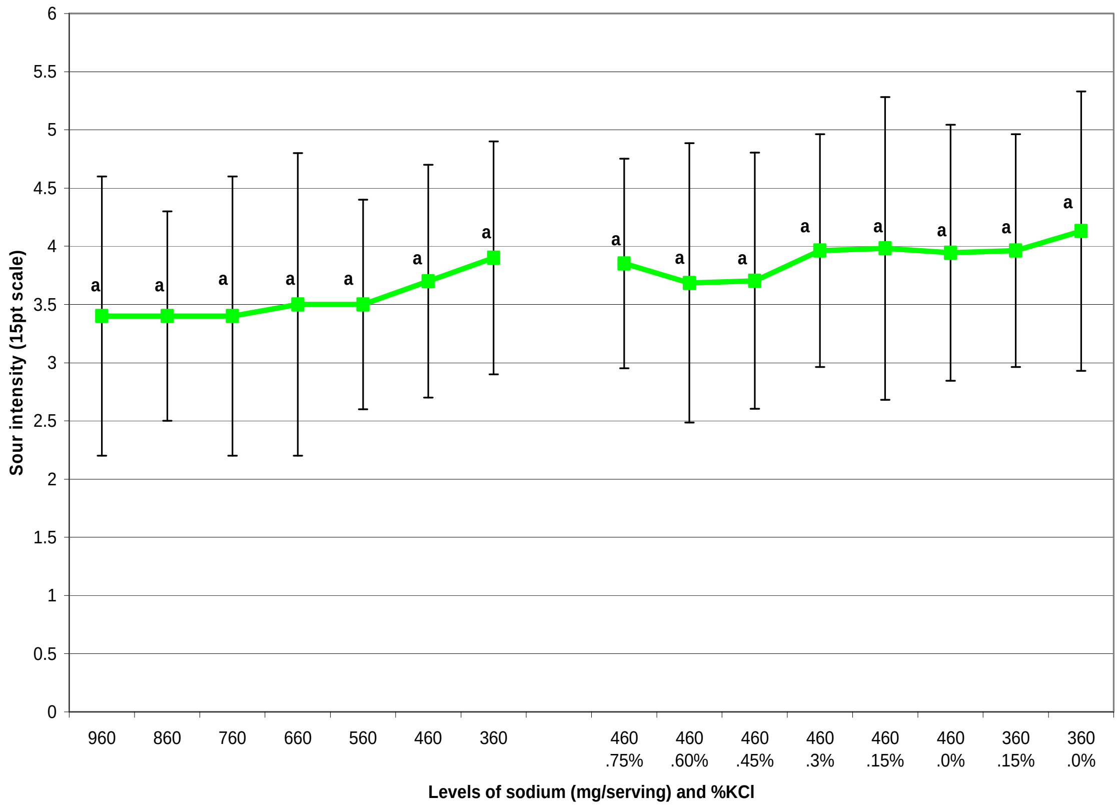
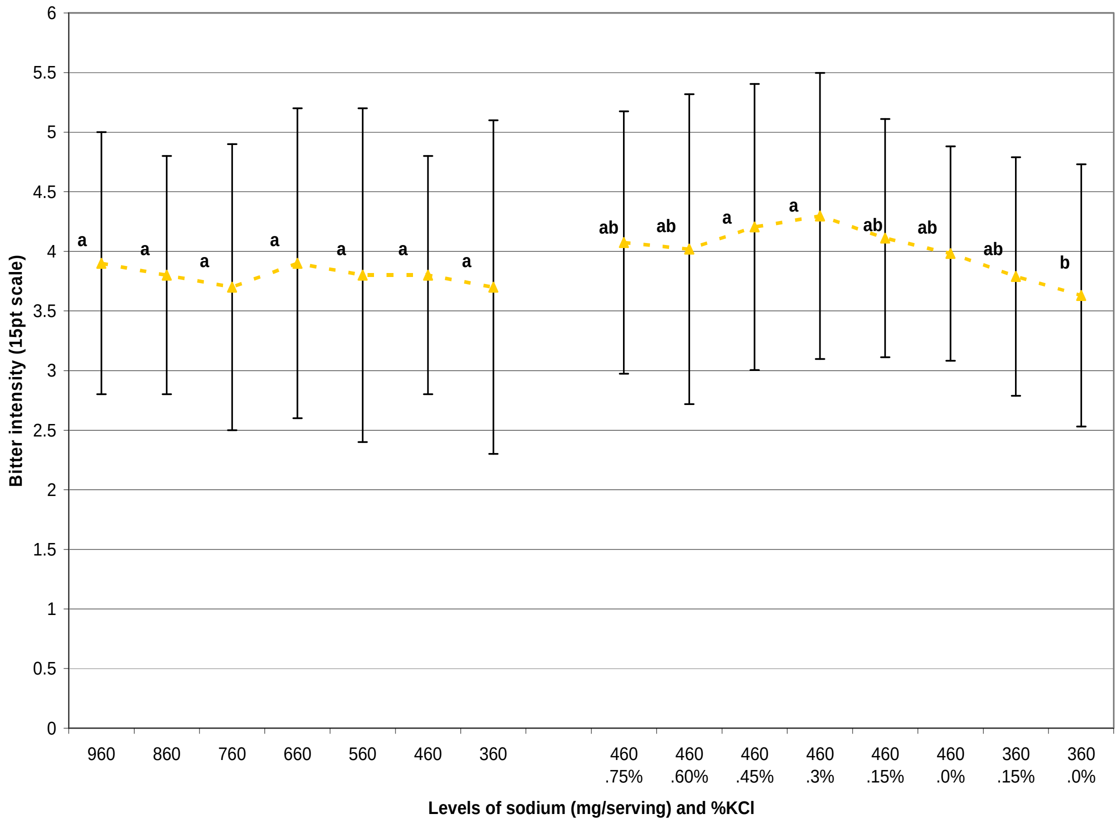


Figure H.4-Bitter intensity ratings for independent analysis of varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup



Appendix I - Intensity ratings for combined analysis of varying levels of sodium ions (mg/serving) and %KCl in tomato soup

Figure I.1-Salt intensity ratings for combined analysis of varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup

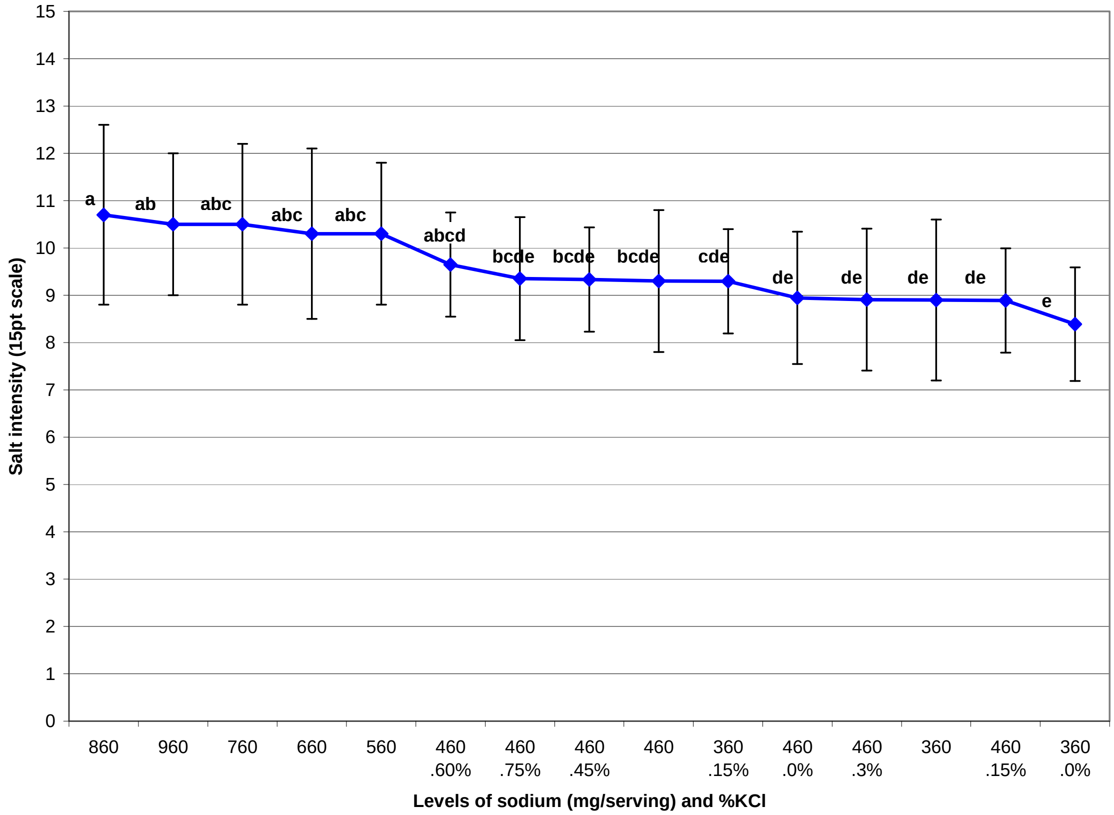


Figure I.2-Sweet intensity ratings for combined analysis of varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup

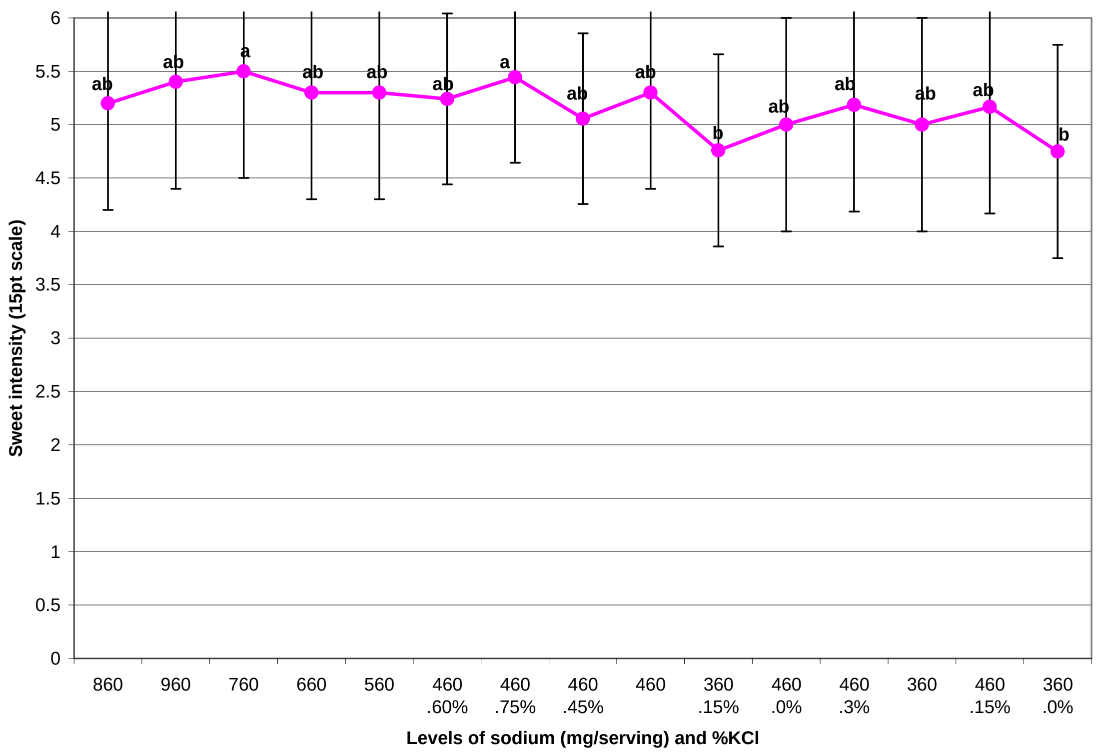


Figure I.3-Sour intensity ratings for combined analysis of varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup

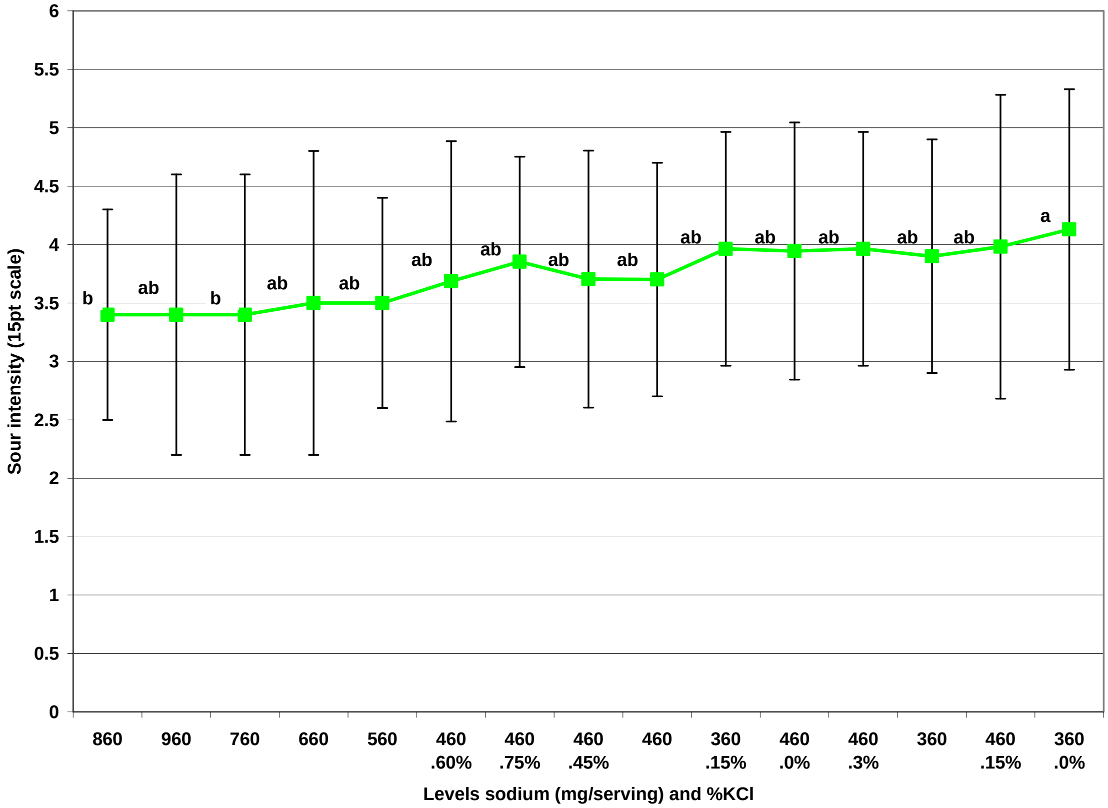
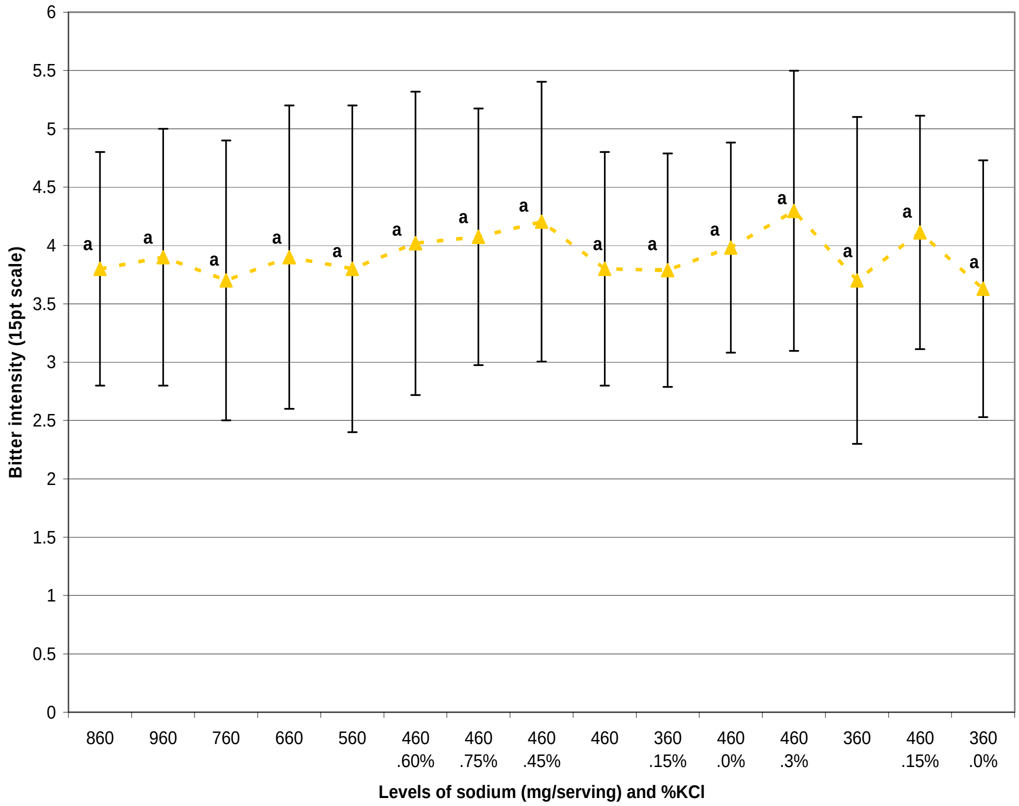


Figure I.4-Bitter intensity ratings for combined analysis of varying levels of sodium ions (mg/244 g serving) and %KCl in tomato soup



Appendix J - Additional consumer evaluation graphs based on demographic information for chicken broth

Figure J.1- Frequency of consumer selected descriptors (full list of descriptors) for flavor A for consumers, based on ethnicity, who are sensitive to KCl flavor in chicken broth

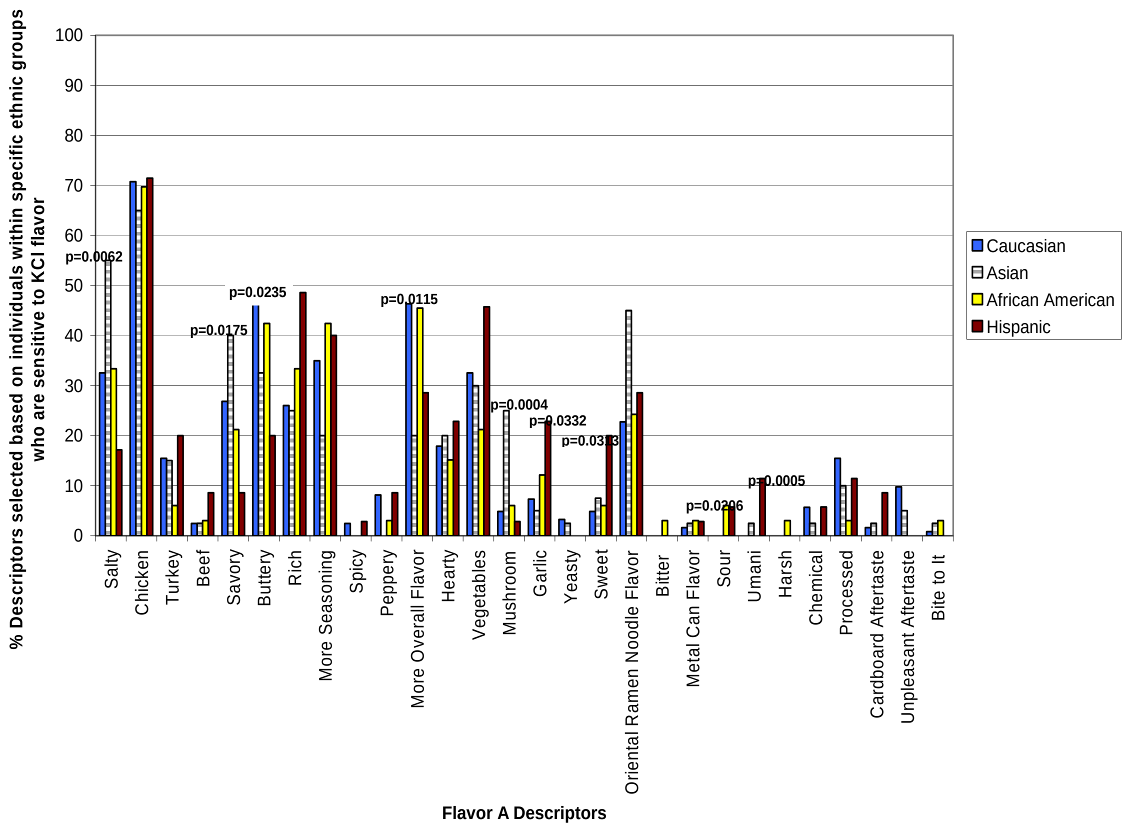


Figure J.2- Frequency of consumer selected descriptors (full list of descriptors) for flavor A for consumers, based on age, who are sensitive to KCl flavor in chicken broth

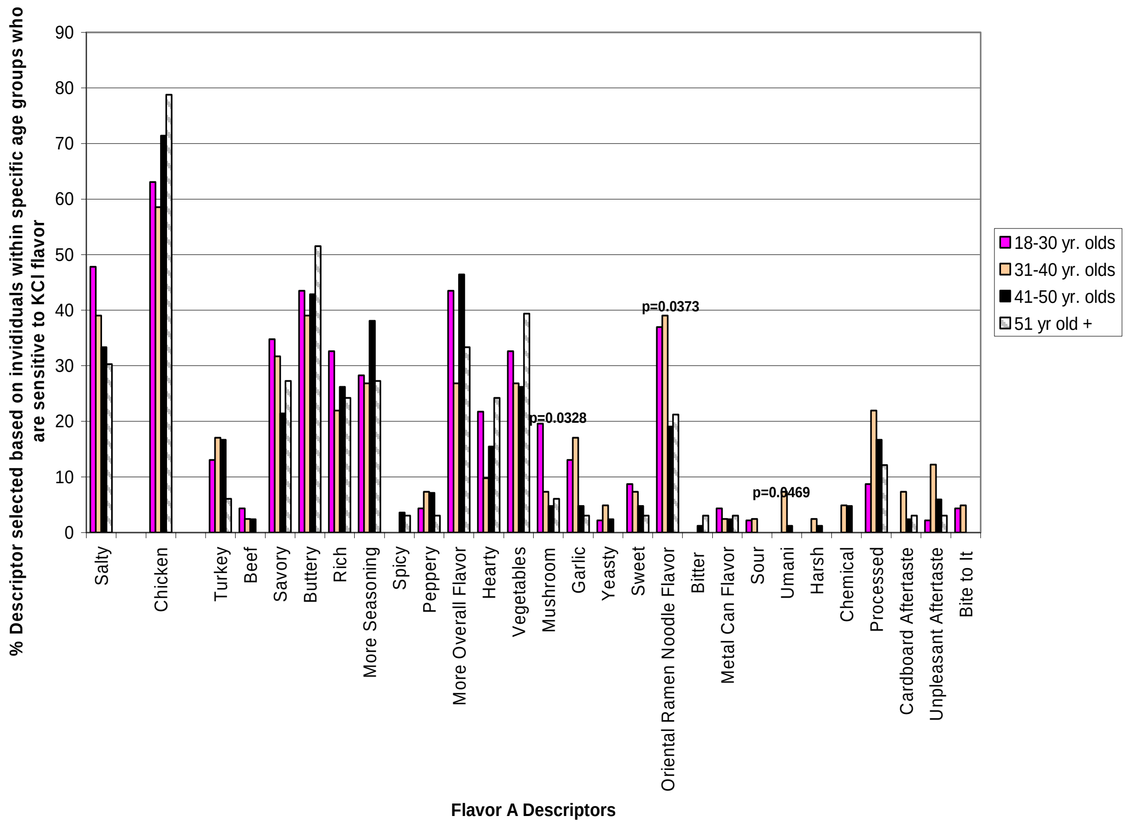
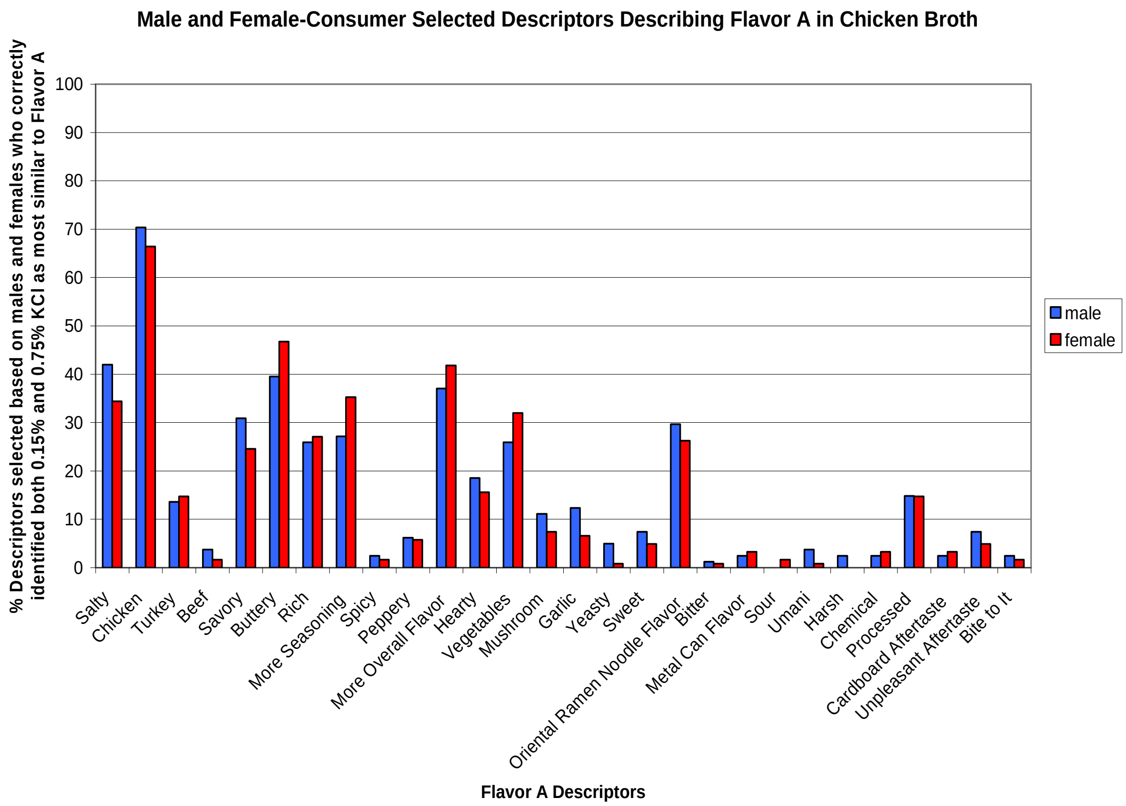


Figure J.3- Frequency of consumer selected descriptors (full set of descriptors) for flavor A for consumers, based on gender, who are sensitive to KCl flavor in chicken broth



Appendix K - Additional consumer evaluation graphs based on demographic information for tomato soup

Figure K.1- Frequency of consumer selected descriptors (full list of descriptors) for flavor A for consumers, based on ethnicity, who are sensitive to KCl flavor in tomato soup

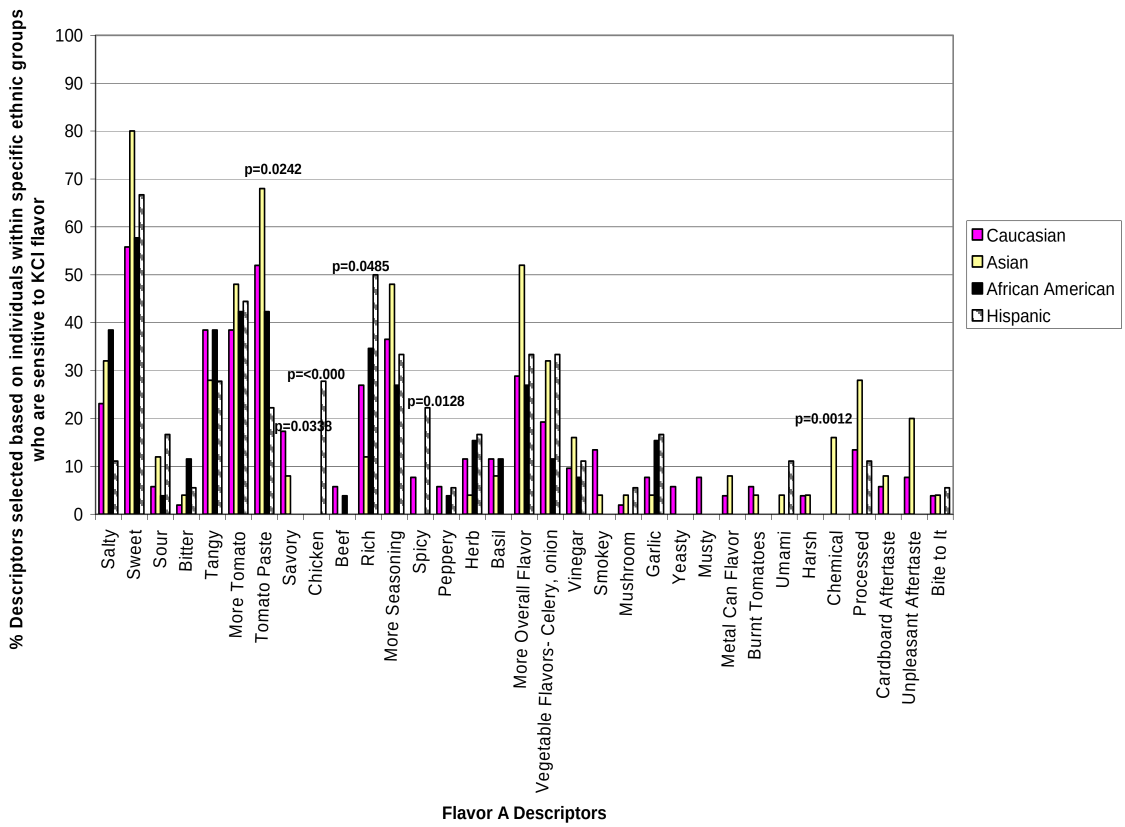


Figure K.2- Frequency of consumer selected descriptors (full list of descriptors) for flavor A for consumers, based on age, who are sensitive to KCl flavor in tomato soup

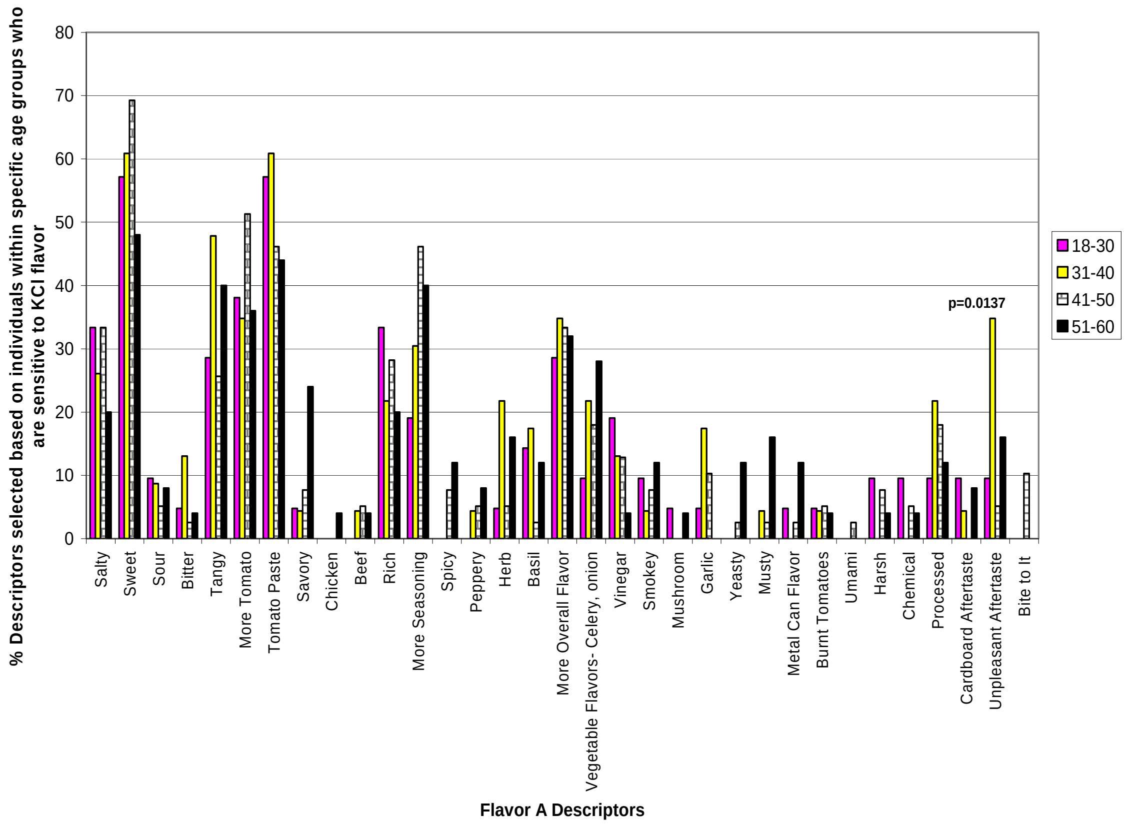
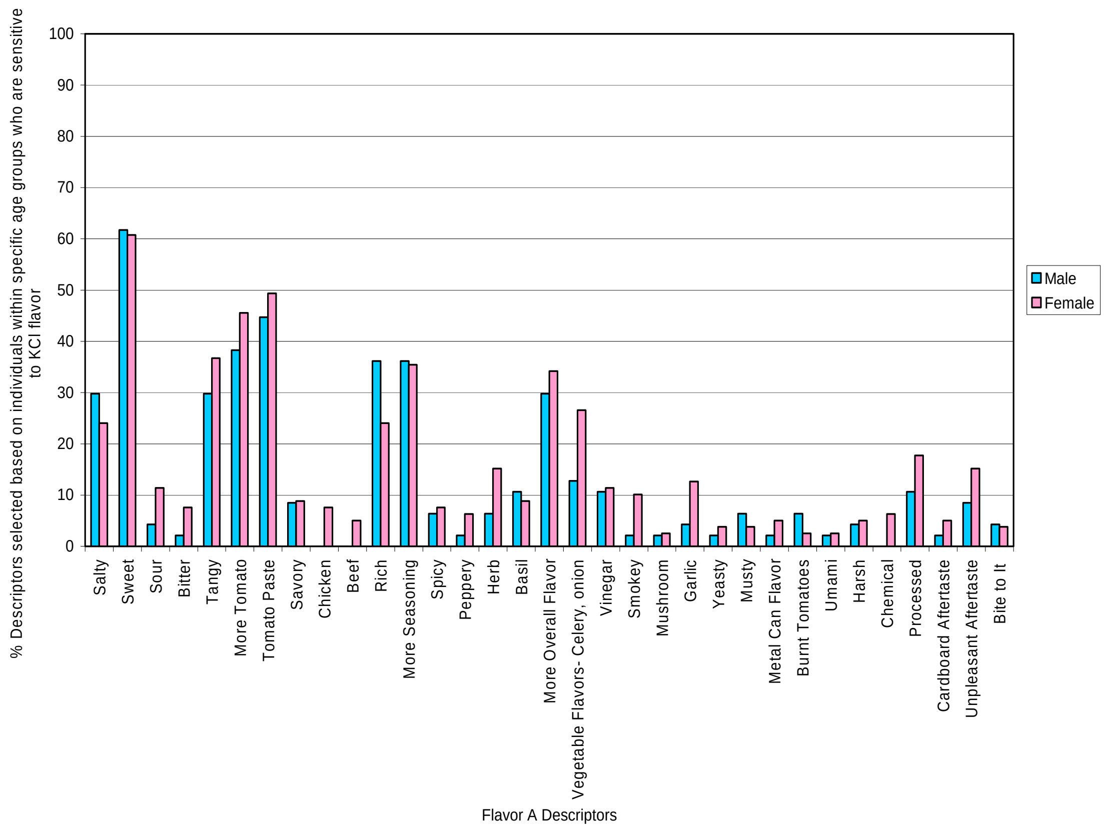


Figure K.3- Frequency of consumer selected descriptors (full list of descriptors) for flavor A for consumers, based on gender, who are sensitive to KCl flavor in tomato soup



Appendix L - Chicken broth paired comparison ballot-consumer version in English

PARTICIPANT NO.

City and State

Chicken Broth

Please taste the sample labeled "Chicken Broth".
Next taste the sample labeled "Chicken Broth + Flavor A".

CHECK all of the words that describe the flavors that you taste associated with "**FLAVOR A**"

- ☐ Salty
- ☐ Chicken
- ☐ Turkey
- ☐ Beef
- ☐ Savory
- ☐ Buttery
- ☐ Rich
- ☐ More Seasoning
- ☐ Spicy
- ☐ Peppery
- ☐ More Overall Flavor
- ☐ Hearty
- ☐ Vegetable Flavors- celery, onion, carrot
- ☐ Mushroom
- ☐ Garlic
- ☐ Yeasty
- ☐ Sweet
- ☐ Oriental Ramen Noodle Flavor
- ☐ Bitter
- ☐ Metal Can Flavor
- ☐ Sour
- ☐ Umami
- ☐ Harsh
- ☐ Chemical
- ☐ Processed
- ☐ Cardboard Aftertaste
- ☐ Unpleasant Aftertaste
- ☐ Bite to It

☐ Other, please explain____

In which of the following age groups do you belong?

- ☐ 20 or below
- ☐ 21-30
- ☐ 31-40
- ☐ 41-50
- ☐ 51-60
- ☐ 61 or above

Are you?

- ☐ Male
- ☐ Female

Which one of the following best describes you? Please select one.

- ☐ White/Caucasian
- ☐ Black/African American
- ☐ Asian
- ☐ Pacific Islander
- ☐ Native American
- ☐ Other
- ☐ Prefer not to answer

Appendix M - Chicken broth paired comparison ballot-consumer version in Spanish

Numero del participante

Ciudad y

Estado___________________________________

Caldo de Pollo

Favor de saborear la muestra designada "Caldo de Pollo".
Siguiente saboree la muestra designada "Caldo de Pollo + Sabor A"

Indique todas las palabras que usted saborea associadas con "Sabor A"

- ☐ Salado
- ☐ Pollo
- ☐ Guajalote (Pavo)
- ☐ Res
- ☐ Carnoso
- ☐ Mantequilla
- ☐ Rico
- ☐ Más Sazonado
- ☐ Picante
- ☐ Pimienta
- ☐ Más Sabroso
- ☐ Robusto
- ☐ Sabores Vegetales – cebolla, zanahoria, apio
- ☐ Champiñon
- ☐ Ajo
- ☐ Levadura
- ☐ Dulce
- ☐ Tallarín Ramen Sabor Oriental
- ☐ Amargo
- ☐ Lata de Metal
- ☐ Agrio
- ☐ Umami
- ☐ Áspero
- ☐ Quimíco
- ☐ Procesado
- ☐ Resabio de Cartón
- ☐ Resabio desagradable
- ☐ Mordura
- ☐ Otro Sabor, favor de explicar_____

Appendix N - Tomato soup paired comparison ballot-consumer version in English

PARTICIPANT NO.

City and State

Tomato Soup

Please taste the sample labeled Tomato Soup.
Next taste the sample labeled "Tomato Soup + Flavor A".

CHECK all of the words that describe the flavors associated with

"**FLAVOR A**"

- ☐ Salty
- ☐ Sweet
- ☐ Sour
- ☐ Bitter
- ☐ Tangy
- ☐ More Tomato
- ☐ Tomato Paste
- ☐ Savory
- ☐ Chicken
- ☐ Beef
- ☐ Rich
- ☐ More Seasoning
- ☐ Spicy
- ☐ Peppery
- ☐ Herb
- ☐ Basil
- ☐ More Overall Flavor
- ☐ Vegetable Flavors- celery, onion
- ☐ Vinegar
- ☐ Smokey
- ☐ Mushroom
- ☐ Garlic
- ☐ Yeasty
- ☐ Musty
- ☐ Metal Can Flavor
- ☐ Burnt Tomatoes
- ☐ Umami
- ☐ Harsh
- ☐ Chemical
- ☐ Processed
- ☐ Cardboard Aftertaste
- ☐ Unpleasant Aftertaste

- ☐ Bite to It
- ☐ Other, please explain____

In which of the following age groups do you belong?

- ☐ 20 or below
- ☐ 21-30
- ☐ 31-40
- ☐ 41-50
- ☐ 51-60
- ☐ 61 or above

Are you?

- ☐ Male
- ☐ Female

Which one of the following best describes you? Please select one.

- ☐ White/Caucasian
- ☐ Black/African American
- ☐ Asian
- ☐ Pacific Islander
- ☐ Native American
- ☐ Other
- ☐ Prefer not to answer

Appendix O - Tomato soup paired comparison ballot-consumer version in Spanish

Numero del participante

Ciudad y

Estado____________________________________

Sopa De Tomate

Favor de saborear la muestra designada "Sopa De Tomate".
Siguiente saboree la muestra designada "Sopa De Tomate + Sabor A"

Indique todas las palabras que usted saborea associadas con "Sabor A"

- ☐ Salado
- ☐ Dulce
- ☐ Agrio
- ☐ Amargo
- ☐ Resabio agridulce
- ☐ Más Tomate
- ☐ Pasta de Tomate
- ☐ Pollo
- ☐ Res
- ☐ Rico
- ☐ Más Sazonado
- ☐ Picante
- ☐ Pimienta
- ☐ Hierbas
- ☐ Albahaca
- ☐ Más Sabroso
- ☐ Sabores Vegetales – cebolla, zanahoria, apio
- ☐ Vinagre
- ☐ Ahumado
- ☐ Champiñon
- ☐ Ajo
- ☐ Levadura
- ☐ Mohoso
- ☐ Lata de Metal
- ☐ Tomate quemado
- ☐ Umami
- ☐ Áspero
- ☐ Quimíco
- ☐ Procesado
- ☐ Resabio de Cartón
- ☐ Resabio desagradable
- ☐ Mordura
- ☐ Otro Sabor, favor de explicar____

Appendix P - Chicken broth confidentiality and allergy screening form

Dear Respondent:

Thank you for deciding to participate in our consumer research project. This project is designed to obtain consumer input about new food products currently being developed by a major company. Because the products are not yet publicly available, we ask that you keep the products and related information you see today confidential. Therefore, we request your agreement that you will not disclose this information to your friends, relatives, neighbors or any other individuals. Your agreement to keep these products and related information confidential extends beyond your participation in this study indefinitely or until the products tested today have been made publicly available. No product or portion thereof may be removed from the study area.

Please sign this statement acknowledging your participation and your agreement to keep the products and related information disclosed to you as part of this project confidential. Your cooperation and support are appreciated. Your signature below also acknowledges that you have read and answered the allergy statement. You should be aware that participation in this project is at the sole discretion of the sponsor. Participation in this project is voluntary and is conducted *at your own risk*.

Thank you!

Please print your name:

____

Signature: (in Ink)

____

Date:

<u>DD/MM/YY- Chicken Broth</u>

Figure 4.31

FOR YOUR SAFETY AND COMFORT, WE WANT TO MAKE SURE YOU DO NOT TEST ANY FOOD TO WHICH YOU MIGHT BE ALLERGIC.

Please check the appropriate box below.

- ☐ **I do <u>NOT</u> have any known allergies to <u>*any* food or food ingredient</u>.**
- ☐ **I <u>HAVE</u> a <u>food allergy</u> (for example: peanuts, tree nuts such as almonds, walnuts, pecans, etc., milk and dairy products , eggs, soy, fish, shellfish, grains, sulfating agents) or <u>other dietary restrictions</u>.**

Appendix Q - Tomato soup confidentiality and allergy screening form

Dear Respondent:

Thank you for deciding to participate in our consumer research project. This project is designed to obtain consumer input about new food products currently being developed by a major company. Because the products are not yet publicly available, we ask that you keep the products and related information you see today confidential. Therefore, we request your agreement that you will not disclose this information to your friends, relatives, neighbors or any other individuals. Your agreement to keep these products and related information confidential extends beyond your participation in this study indefinitely or until the products tested today have been made publicly available. No product or portion thereof may be removed from the study area.

Please sign this statement acknowledging your participation and your agreement to keep the products and related information disclosed to you as part of this project confidential. Your cooperation and support are appreciated. Your signature below also acknowledges that you have read and answered the allergy statement. You should be aware that participation in this project is at the sole discretion of the sponsor. Participation in this project is voluntary and is conducted *at your own risk*.

Thank you!

Please print your name:

____

Signature: (in Ink)

____

Date:

<u>DD/MM/YY- Tomato Soup</u>

FOR YOUR SAFETY AND COMFORT, WE WANT TO MAKE SURE YOU DO NOT TEST ANY FOOD TO WHICH YOU MIGHT BE ALLERGIC.
Please check the appropriate box below.

- ❑ **I do <u>NOT</u> have any known allergies to <u>*any* food or food ingredient</u>.**
- ❑ **I <u>HAVE</u> a <u>food allergy</u> (for example: peanuts, tree nuts such as almonds, walnuts, pecans, etc., milk and dairy products , eggs, soy, fish, shellfish, grains, sulfating agents) or <u>other dietary restrictions</u>.**

Appendix R - Focus Group Moderator Guide

Chicken Broth Consumer Descriptors for KCl Moderator Guide

10-25-05

Wayzata, MN

Hi, my name is Susan Hooge with Consumer Surveys. Thank you for taking a few minutes tonight to talk with me about chicken broth. Let’s go around the table and have everyone introduce themselves and tell me what your favorite movie is and why.

Great, thanks for sharing. Next, I want to share some ground rules for tonight’s discussion;

1) Be honest in your responses, there are not right or wrong answers.
2) Only one person speaks at a time.
3) Everyone needs to share their opinions.

Tonight we are going to have you try two samples of chicken broth. One is labeled “chicken broth” and the other one is labeled “chicken broth + Flavor A”. Please take a sip of water before you try the first sample. Everyone is going to try the sample labeled “chicken broth” first.

Go ahead and try the first sample, labeled "chicken broth" and write down on your paper the words that you would use to describe the flavor you taste in the first sample.

Now that you have tried the sample labeled "chicken broth", please take a few sips of water and eat a couple bites of cracker to cleanse you palate. Once you have had some water and few bites of cracker, you can go ahead and taste the sample labeled "chicken broth + flavor A". Write down on your paper the words that you would use to describe the flavor you taste in the second sample, labeled "chicken broth + flavor A."

Great, now that everyone has had a chance to try both samples, I would like for us to discuss the words that you used to describe the flavors in the samples. Let's start with the first sample, labeled "chicken broth".

What words did you write down ___________(insert participants name)? What other words did other people write down? Any other thoughts on the flavor before we move on to the next sample? (Probe on the words that they use and ask for clarification if any of the terms are unclear.)

Now let's talk about the sample, labeled "chicken broth + flavor A". What flavors did you taste in this sample? How was this similar or different from the other sample? How would you describe "flavor A"? Any other thoughts about what you tasted in this sample?

Great, thank you so much for your time this evening. Your input has been invaluable and I really appreciate your willingness to help with this project.

Appendix S - SAS code for descriptive analysis-chicken broth sodium data

```
options nocenter formchar='|----|+|---+=|-/\<>*';
```

```
title "Chicken Broth NaCl Sodium Curve";
title2 '360 mg NaCl to 960 mg NaCl in 100 mg Increments';

DATA One;
  INPUT PANELIST SESSION SAMPNO A1 A2 A3 A4 A5 ;

  LABEL
    A1='FLAVOR - Salt'
    A2='FLAVOR - Sour'
    A3='FLAVOR - Bitter'
    A4='FLAVOR - Umami'
    A5='FLAVOR- Metallic'
    ;

If SAMPNO =  "1" Then SAMPLE = "360 mg NaCl";
If SAMPNO =  "2" Then SAMPLE = "560 mg NaCl";
If SAMPNO =  "3" Then SAMPLE = "660 mg NaCl";
If SAMPNO =  "4" Then SAMPLE = "760 mg NaCl";
If SAMPNO =  "5" Then SAMPLE = "860 mg NaCl";
If SAMPNO =  "6" Then SAMPLE = "960 mg NaCl";
If SAMPNO =  "7" Then SAMPLE = "460 mg NaCl";


CARDS;
1 1 1 9.5 4.5 5.0 5.0 3.0
1 2   1 9.0 5.5 5.5 6.0 4.0
1 3   1 9.0 5.0 6.0 5.0 3.5
2 1   1 8.5 3.0 2.0 3.5 2.0
2 2   1 7.5 3.0 3.0 2.0 1.5
2 3   1 7.5 3.0 2.5 3.0 1.5
3 1   1 11.0 4.0 3.5 4.0 2.5
3 2   1 8.0 3.0 2.0 2.0 2.0
3 3   1 10.0 2.0 3.0 3.0 2.0
4 1   1 9.0 4.0 4.0 6.5 2.0
4 2   1 5.0 2.0 2.0 1.0 0.0
4 3   1 9.0 4.0 5.0 5.0 3.0
5 1 1 . . . . .
```

```
5 2   1 8.0 4.0 3.0 2.0 4.0
5 3   1 10.0 5.0 6.0 5.0 5.0
6 1 1 . . . . .
6 2   1 5.0 1.0 3.0 4.0 2.5
6 3   1 5.0 2.0 1.0 4.0 2.0
7 1   1 7.5 4.0 4.0 3.5 3.5
7 2   1 8.5 3.0 4.0 3.0 3.0
7 3   1 8.0 4.0 4.0 4.0 3.0
8 1   1 9.0 6.0 6.0 5.0 2.0
8 2   1 11.0 4.5 3.0 3.5 2.0
8 3   1 9.5 4.5 6.0 4.0 3.0
9 1 1 . . . . .
9 2   1 7.0 8.0 2.5 3.0 1.0
9 3   1 10.0 2.0 3.0 3.0 0.0
1 1   2 9.0 5.0 5.0 5.0 3.0
1 2   2 9.5 5.0 5.0 5.0 3.0
1 3   2 10.0 5.0 5.0 4.5 3.0
2 1   2 10.0 3.0 3.0 3.5 2.0
2 2   2 10.0 4.0 3.5 3.0 2.5
2 3   2 11.5 3.5 3.0 3.0 2.0
3 1   2 11.0 4.5 4.0 3.0 2.0
3 2   2 12.5 5.0 4.0 3.0 2.0
3 3   2 11.0 3.0 3.0 3.5 1.5
4 1   2 12.0 4.0 5.0 7.0 2.0
4 2   2 11.0 3.0 2.5 4.0 2.0
4 3   2 10.0 3.0 3.0 4.0 2.0
5 1 2 . . . . .
5 2   2 11.5 4.0 3.5 3.0 4.0
5 3   2 10.0 5.0 4.0 5.0 5.0
6 1 2 . . . . .
6 2   2 11.5 1.5 2.0 4.0 2.0
6 3   2 9.5 2.0 1.0 3.5 2.0
7 1   2 10.0 3.5 4.0 4.0 3.0
7 2   2 10.0 3.0 4.0 3.0 3.0
7 3   2 11.0 3.5 4.0 3.0 3.0
8 1   2 10.0 4.0 5.0 3.5 2.0
8 2   2 12.0 6.0 5.0 5.0 2.0
8 3   2 12.0 4.5 6.5 3.0 3.0
```

```
9 1 2 . . . . .
9 2   2 11.0 3.0 3.0 0.5 2.0
9 3   2 12.0 3.0 3.0 2.0 1.0
1 1   3 9.0 5.0 6.0 5.0 3.0
1 2   3 9.5 5.0 6.0 6.0 3.0
1 3   3 9.5 5.0 5.0 3.5 3.0
2 1   3 10.5 3.5 3.5 3.0 2.0
2 2   3 10.5 3.5 3.0 2.0 2.0
2 3   3 12.0 3.5 3.0 2.5 2.0
3 1   3 12.5 4.0 3.5 2.5 1.5
3 2   3 13.0 4.0 3.0 4.0 2.0
3 3   3 12.5 3.0 2.5 3.5 2.0
4 1   3 11.0 5.0 4.0 6.0 3.0
4 2   3 10.0 4.0 4.0 2.5 3.0
4 3   3 12.0 2.0 2.0 5.0 4.0
5 1 3 . . . . .
5 2   3 11.5 4.0 3.0 3.5 4.0
5 3   3 11.0 4.0 5.0 4.0 4.0
6 1 3 . . . . .
6 2   3 12.0 2.0 1.0 5.0 1.0
6 3   3 13.0 1.0 1.5 4.0 1.0
7 1   3 11.5 4.0 4.0 4.5 3.5
7 2   3 8.0 3.5 3.5 3.0 3.0
7 3   3 12.5 3.5 3.0 3.5 3.5
8 1   3 12.0 6.0 6.0 3.0 2.0
8 2   3 13.0 5.0 6.0 3.0 3.0
8 3   3 12.0 5.0 7.0 3.0 2.0
9 1 3 . . . . .
9 2   3 12.5 3.0 3.0 1.5 1.0
9 3   3 12.5 3.0 3.0 2.0 11.0
1 1   4 10.0 6.0 6.0 6.0 3.0
1 2   4 11.0 5.0 5.0 5.0 3.0
1 3   4 12.0 6.0 6.0 6.0 3.0
2 1   4 11.5 3.5 3.5 3.0 2.0
2 2   4 13.0 4.0 4.0 3.5 2.0
2 3   4 12.5 4.0 4.0 3.5 2.0
3 1   4 12.5 4.5 4.0 4.0 2.0
3 2   4 13.0 3.0 3.0 2.0 1.5
```

```
3 3   4 12.5 3.0 2.5 3.0 2.5
4 1   4 10.0 4.0 6.0 6.5 2.0
4 2   4 12.5 3.5 3.0 3.0 3.0
4 3   4 12.5 3.0 2.0 4.0 2.0
5 1 4 . . . . .
5 2   4 12.0 4.0 5.0 4.0 5.0
5 3   4 13.0 4.0 5.0 4.0 4.0
6 1 4 . . . . .
6 2   4 10.5 1.0 0.0 3.0 1.0
6 3   4 13.0 1.0 1.0 4.5 3.0
7 1   4 13.0 3.5 3.0 3.5 3.5
7 2   4 12.5 4.0 3.5 3.5 3.0
7 3   4 13.0 4.0 3.0 3.0 3.0
8 1   4 12.0 5.0 5.5 4.0 3.0
8 2   4 14.0 4.5 5.5 4.0 2.5
8 3   4 12.0 4.5 6.0 4.0 3.0
9 1 4 . . . . .
9 2   4 12.5 3.0 3.0 1.0 2.0
9 3   4 12.5 3.0 5.0 4.0 0.0
1 1   5 11.0 5.0 6.0 7.0 3.0
1 2   5 11.5 6.0 6.0 6.0 3.0
1 3   5 12.0 6.0 6.5 7.0 3.5
2 1   5 12.5 4.0 3.5 4.0 2.0
2 2   5 13.5 3.5 3.0 2.5 2.0
2 3   5 14.0 4.0 4.0 4.0 2.5
3 1   5 12.5 4.0 3.5 3.0 2.0
3 2   5 12.5 3.5 3.0 2.0 2.5
3 3   5 13.0 3.0 3.0 4.0 2.0
4 1   5 13.0 4.0 4.0 6.0 2.5
4 2   5 12.0 3.0 3.0 3.0 2.0
4 3   5 12.0 4.0 2.0 4.0 2.0
5 1 5 . . . . .
5 2   5 11.5 3.0 3.0 3.0 4.0
5 3   5 13.0 3.0 3.5 4.0 4.0
6 1 5 . . . . .
6 2   5 11.0 1.5 0.5 3.0 0.0
6 3   5 13.0 2.0 2.5 5.0 2.0
7 1   5 13.0 4.0 4.5 4.0 3.5
```

```
7 2   5 13.0 4.0 4.0 3.0 3.0
7 3   5 13.5 4.0 3.5 4.0 3.0
8 1   5 13.0 3.5 6.0 4.0 1.5
8 2   5 13.0 3.0 3.0 4.0 2.5
8 3   5 13.0 4.0 4.0 2.0 2.0
9 1 5 . . . . .
9 2   5 12.5 3.0 3.0 2.0 1.0
9 3   5 13.0 3.0 4.0 3.0 1.0
1 1   6 11.5 6.0 6.0 6.0 3.0
1 2   6 12.5 6.5 6.5 6.5 3.5
1 3   6 12.5 6.0 7.0 7.0 4.0
2 1   6 13.0 4.0 4.0 4.0 2.5
2 2   6 13.0 4.0 4.0 5.0 2.0
2 3   6 13.0 4.0 4.0 3.0 2.0
3 1   6 13.0 3.5 3.0 4.0 2.5
3 2   6 13.0 4.0 3.0 2.0 2.0
3 3   6 12.5 3.0 2.0 3.0 2.0
4 1   6 11.0 4.0 3.0 4.0 3.0
4 2   6 11.0 2.0 2.0 2.0 1.0
4 3   6 13.0 3.0 4.0 6.0 4.0
5 1 6 . . . . .
5 2   6 12.5 3.5 3.0 2.5 4.0
5 3   6 12.0 3.0 3.0 3.0 3.0
6 1 6 . . . . .
6 2   6 12.5 1.5 1.0 4.0 1.0
6 3   6 13.0 1.0 1.5 3.5 1.0
7 1   6 13.5 4.0 4.0 4.0 3.5
7 2   6 13.0 4.0 3.5 4.0 3.0
7 3   6 13.0 4.0 3.0 4.0 3.5
8 1   6 13.0 5.0 4.0 4.0 1.0
8 2   6 14.0 4.0 6.0 5.0 3.0
8 3   6 13.0 4.5 6.5 4.0 1.5
9 1 6 . . . . .
9 2   6 13.0 3.0 3.0 3.0 1.0
9 3   6 12.0 4.0 5.0 6.0 0.0
1 1   7 10.0 5.0 6.0 6.0 3.0
1 2   7 10.5 5.0 6.0 5.0 4.0
1 3   7 10.0 6.0 5.0 5.0 3.0
```

```
2 1   7 10.0 4.0 3.0 4.0 2.0
2 2   7 7.5 3.0 3.0 3.5 1.5
2 3   7 10.0 3.5 4.0 3.0 2.0
3 1   7 11.0 5.0 5.5 4.5 2.5
3 2   7 11.0 5.0 3.0 2.0 3.0
3 3   7 11.0 3.0 3.0 3.5 2.0
4 1   7 11.0 4.0 4.0 6.0 2.0
4 2   7 7.0 2.0 3.5 1.5 3.5
4 3   7 9.0 3.0 4.0 4.0 3.0
5 1 7 . . . . .
5 2   7 9.5 3.0 2.5 1.5 3.5
5 3   7 11.0 4.0 3.0 3.0 3.0
6 1 7 . . . . .
6 2   7 7.5 2.5 0.5 4.0 2.0
6 3   7 8.0 1.0 1.0 4.0 2.0
7 1   7 9.5 3.5 3.5 4.0 3.5
7 2   7 8.0 3.0 4.0 4.0 3.5
7 3   7 9.5 4.0 4.0 3.5 3.0
8 1   7 10.0 6.0 6.0 5.0 3.0
8 2   7 11.0 6.0 6.0 5.0 4.0
8 3   7 11.0 4.0 6.0 3.0 1.5
9 1 7 . . . . .
9 2   7 11.5 2.0 3.0 2.0 1.0
9 3   7 9.0 3.0 3.0 5.0 0.0
;

/*proc contents data=Necc; run;
proc means data=necc; run;
proc print data=necc; run;*/

/*proc freq;
table A1; run;*/

/*Always Plot your Data*/

/*proc plot vpercent=33;
plot (A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
      A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26)*panelist;
```

```
run;*/

/*Session=Reps*/

/*Run this GLM first; if Panelist*sample is significant for a
given
  attribute then use the GLM with Panelist*sample error term*/

proc glm data=one;
classes session panelist sample;
model A1 A2 A3 A4 A5 =session panelist sample panelist*sample;
test h=sample e=panelist*sample;
means session sample /tukey line E=panelist*sample
;
run;

/*If Panel*sample is not significant use standard GLM*/

/*proc glm data=one;
classes session panelist sample;
model A1 A7 A11 A12 A13 A15 A16 A19 A20 A21 A22 A23 A24 A25 A26
      =session panelist sample;
means sample /tukey line;
run;*/

proc tabulate data=one;
classes sample;
var A1 A2 A3 A4 A5 ;
table (A1 A2 A3 A4 A5 ), sample*mean*f=10.1/rts=35;
run;
quit;
```

Appendix T - SAS code for descriptive analysis-chicken broth KCl data

```
options nocenter formchar='|----|+|---+=|-/\<>*';

title "Chicken Broth KCl Sodium Curve";
title2 '360 mg NaCl+0.15%, 360 mg NaCl to 460 mg NaCl and 460 mg
NaCl 0.15%, 0.30%, 0.45%, 0.60%, and 0.75% KCl';

DATA One;
  INPUT PANELIST SESSION SAMPNO A1 A2 A3 A4 A5 ;

  LABEL
    A1='FLAVOR - Salt'
    A2='FLAVOR - Sour'
    A3='FLAVOR - Bitter'
    A4='FLAVOR - Umami'
    A5='FLAVOR- Metallic'
    ;

If SAMPNO =  "1" Then SAMPLE = "360 mg NaCl +0.15%";
If SAMPNO =  "2" Then SAMPLE = "360 mg NaCl +0.0% KCl";
If SAMPNO =  "3" Then SAMPLE = "460 mg NaCl +0.0% KCl";
If SAMPNO =  "4" Then SAMPLE = "460 mg NaCl + 0.15%";
If SAMPNO =  "5" Then SAMPLE = "460 mg NaCl + 0.30%";
If SAMPNO =  "6" Then SAMPLE = "460 mg NaCl + 0.45%";
If SAMPNO =  "7" Then SAMPLE = "460 mg NaCl + 0.60%";
If SAMPNO =  "8" Then SAMPLE = "460 mg NaCl + 0.75%";


CARDS;
1 1 1 11.0 3.5 3.5 2.0 2.0
1 2   1 12.0 4.0 4.0 4.0 3.0
1 3   1 10.5 4.5 5.0 4.0 3.0
2 1   1 10.0 2.5 2.5 2.5 2.0
2 2   1 10.5 3.5 3.0 3.0 2.0
2 3   1 11.5 4.0 3.0 3.0 2.0
3 1   1 12.5 3.0 3.5 2.0 2.0
3 2   1 12.5 3.0 2.0 2.0 1.0
3 3   1 11.0 3.0 3.0 2.0 1.0
4 1   1 11.0 3.0 2.0 2.0 1.0
```

```
4 2   1 11.0 4.0 3.5 4.0 3.5
4 3   1 9.5 4.0 3.0 6.0 2.0
5 1   1 10.5 3.0 4.0 2.5 2.5
5 2   1 11.0 3.5 4.5 4.5 3.0
5 3   1 11.5 3.0 3.5 2.5 2.5
6 1   1 10.5 4.0 3.5 4.0 3.0
6 2   1 12.0 4.0 3.0 3.5 2.0
6 3   1 12.0 4.0 6.0 5.0 3.0
7 1   1 11.0 3.0 3.0 1.0 2.0
7 2   1 12.0 4.0 4.0 4.0 3.0
7 3   1 .   . .   . .
1 1   2 9.0 6.0 6.0 5.0 4.0
1 2   2 8.0 5.0 5.0 4.0 3.0
1 3   2 9.0 5.0 5.0 4.0 3.0
2 1   2 7.5 2.0 2.0 3.0 2.0
2 2   2 7.5 2.0 2.5 3.0 2.0
2 3   2 8.0 2.5 3.0 3.0 1.5
3 1   2 8.0 3.0 2.0 2.0 2.0
3 2   2 9.0 3.0 2.0 2.0 1.0
3 3   2 10.0 4.0 3.0 2.0 2.0
4 1   2 9.0 3.0 2.0 2.0 0.0
4 2   2 8.0 4.0 3.0 4.0 2.0
4 3   2 7.5 4.0 3.0 5.0 3.0
5 1   2 9.5 3.0 4.0 3.5 3.0
5 2   2 8.0 4.0 4.0 3.0 3.0
5 3   2 9.5 2.5 3.0 1.5 3.0
6 1   2 9.0 3.0 3.5 2.0 2.0
6 2   2 10.5 4.0 2.5 1.5 2.0
6 3   2 9.5 5.0 7.0 4.5 2.0
7 1   2 10.0 4.0 3.0 4.0 2.0
7 2   2 10.0 4.0 4.0 5.0 1.0
7 3   2 .   . .   . .
1 1   3 9.5 6.0 6.0 6.0 3.0
1 2   3 10.0 6.5 5.5 5.0 3.0
1 3   3 9.0 6.0 5.0 5.0 3.0
2 1   3 9.0 2.0 1.5 2.0 1.5
2 2   3 9.0 3.5 2.5 2.0 2.0
2 3   3 9.0 2.5 2.5 3.0 1.5
```

```
3 1   3 7.5 2.0 1.0 1.5 1.0
3 2   3 11.0 2.0 2.5 2.0 1.0
3 3   3 11.0 3.5 4.0 2.0 1.0
4 1   3 9.5 3.0 2.0 1.0 1.0
4 2   3 11.0 3.0 4.0 3.0 2.0
4 3   3 10.0 4.0 3.5 4.0 3.0
5 1   3 9.5 3.0 2.5 2.0 2.5
5 2   3 10.0 3.0 3.5 2.5 3.0
5 3   3 9.0 3.5 3.0 3.0 2.5
6 1   3 10.0 3.0 2.5 1.5 3.0
6 2   3 10.5 3.0 2.5 1.0 2.0
6 3   3 10.0 4.0 4.5 3.5 1.5
7 1   3 11.0 3.0 2.5 1.0 2.0
7 2   3 10.0 3.0 3.0 2.0 2.0
7 3   3 .   . .   . .
1 1   4 10.5 6.5 6.5 5.0 3.0
1 2   4 11.0 6.0 6.0 5.0 3.0
1 3   4 10.0 6.0 5.0 5.0 3.0
2 1   4 10.0 3.0 2.0 2.0 2.0
2 2   4 9.5 2.5 2.0 2.0 2.0
2 3   4 10.0 2.5 2.0 4.0 2.0
3 1   4 11.0 3.0 2.0 2.5 1.0
3 2   4 11.0 2.0 2.0 2.0 1.0
3 3   4 12.5 4.0 3.0 3.0 2.0
4 1   4 10.0 2.5 2.0 3.0 2.5
4 2   4 12.0 4.0 4.0 3.5 3.0
4 3   4 11.0 4.0 5.0 5.0 4.0
5 1   4 10.5 3.5 3.0 3.5 2.0
5 2   4 9.5 3.0 2.5 2.0 2.0
5 3   4 10.5 3.5 3.5 4.0 3.0
6 1   4 9.5 3.5 2.0 2.0 2.5
6 2   4 11.0 2.5 2.5 1.5 1.0
6 3   4 11.0 4.5 5.5 4.0 1.0
7 1   4 9.0 3.0 3.0 1.0 1.0
7 2   4 11.0 4.0 4.0 4.0 2.0
7 3   4 .   . .   . .
1 1   5 11.0 5.5 6.0 5.0 3.0
1 2   5 12.0 5.0 5.0 5.0 3.0
```

```
1 3   5 11.5 6.0 6.0 5.0 2.0
2 1   5 10.0 3.0 2.0 2.0 1.0
2 2   5 11.0 3.0 2.5 2.0 2.5
2 3   5 11.0 3.5 3.0 2.0 1.5
3 1   5 11.0 2.0 2.0 1.0 1.0
3 2   5 12.5 3.0 3.0 2.0 1.0
3 3   5 12.5 4.5 4.0 3.0 2.0
4 1   5 10.0 3.0 3.0 3.0 3.0
4 2   5 11.0 4.0 3.0 4.0 3.0
4 3   5 12.5 4.0 5.0 4.0 4.0
5 1   5 10.0 3.0 3.0 2.0 2.5
5 2   5 10.0 3.0 3.0 2.0 2.5
5 3   5 11.0 2.5 4.0 2.5 2.5
6 1   5 9.0 2.5 3.0 3.5 2.5
6 2   5 10.0 4.0 2.5 1.0 2.0
6 3   5 12.0 4.0 5.0 3.5 1.5
7 1   5 11.0 2.5 3.0 3.0 1.0
7 2   5 10.0 3.0 4.0 3.0 1.0
7 3   5 .    . .    . .
1 1   6 11.0 6.0 6.0 6.0 3.0
1 2   6 12.0 6.0 6.0 6.0 3.0
1 3   6 11.5 7.0 6.0 6.0 3.0
2 1   6 11.0 3.0 2.5 2.5 2.0
2 2   6 10.5 3.0 2.5 2.0 2.5
2 3   6 11.5 2.5 3.5 2.0 2.0
3 1   6 11.0 2.0 2.0 0.0 1.0
3 2   6 12.5 3.0 3.0 3.0 2.0
3 3   6 12.5 4.0 4.5 3.0 2.0
4 1   6 12.0 3.0 4.0 3.0 2.0
4 2   6 10.0 3.0 3.0 3.0 3.0
4 3   6 12.5 4.0 4.0 5.0 3.5
5 1   6 11.0 3.5 3.0 3.0 2.5
5 2   6 11.0 3.0 3.0 2.0 3.0
5 3   6 12.0 3.0 2.0 2.0 2.5
6 1   6 10.5 3.0 2.0 1.0 2.0
6 2   6 13.0 3.0 4.0 4.0 2.0
6 3   6 11.0 3.0 3.0 2.0 1.5
7 1   6 11.0 2.5 3.0 3.0 1.0
```

```
7 2   6 12.0 4.0 4.0 6.0 2.0
7 .   6 .    . .    . .
1 1   7 10.5 4.0 5.0 5.0 3.0
1 2   7 11.0 5.0 5.0 4.0 3.0
1 3   7 12.0 6.0 6.0 6.0 3.0
2 1   7 11.5 3.0 2.0 3.0 2.5
2 2   7 11.5 3.0 2.0 2.0 2.5
2 3   7 11.0 3.0 2.0 1.5 1.5
3 1   7 12.5 2.0 2.5 2.0 2.0
3 2   7 12.5 3.0 3.0 3.0 2.0
3 3   7 12.5 3.5 4.0 3.0 2.0
4 1   7 11.5 4.0 2.5 3.5 2.5
4 2   7 12.0 4.0 3.0 2.5 2.0
4 3   7 10.0 6.0 5.0 4.0 4.0
5 1   7 12.0 4.0 2.0 2.5 3.0
5 2   7 11.5 3.5 3.0 3.5 3.0
5 3   7 12.0 3.0 3.0 3.0 3.0
6 1   7 10.0 2.5 3.0 2.5 3.0
6 2   7 13.0 3.0 3.5 2.5 1.5
6 3   7 13.0 4.0 5.0 4.0 2.0
7 1   7 11.5 3.0 3.0 4.0 2.0
7 2   7 11.5 4.0 4.0 3.0 2.0
7 3   7 .    . .    . .
1 1   8 12.0 4.0 5.0 4.0 3.0
1 2   8 12.5 5.0 5.0 4.0 3.5
1 3   8 12.5 5.0 6.0 6.0 3.0
2 1   8 11.0 3.0 3.5 2.0 2.0
2 2   8 12.0 3.0 3.0 4.0 3.0
2 3   8 12.0 3.5 3.0 2.5 2.0
3 1   8 12.5 3.0 2.0 2.0 1.0
3 2   8 13.0 3.5 3.0 3.5 2.0
3 3   8 12.5 4.0 3.5 3.0 2.0
4 1   8 12.0 3.0 2.5 3.0 1.0
4 2   8 12.0 5.0 3.5 4.0 3.0
4 3   8 13.0 4.0 5.0 3.0 2.5
5 1   8 11.0 3.5 4.0 4.0 3.0
5 2   8 12.5 3.5 2.5 2.5 3.0
5 3   8 12.5 2.0 2.5 1.5 2.5
```

```
6 1   8 11.0 3.5 3.0 3.0 2.5
6 2   8 13.0 2.5 5.0 4.0 3.0
6 3   8 13.0 5.0 6.0 4.0 3.0
7 1   8 12.0 3.0 3.0 3.0 2.0
7 2   8 12.0 4.0 4.0 5.0 3.0
7 3   8 .    . .    . .
;

/*proc contents data=Necc; run;
proc means data=necc; run;
proc print data=necc; run;*/

/*proc freq;
table A1; run;*/

/*Always Plot your Data*/

/*proc plot vpercent=33;
plot (A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
      A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26)*panelist;
run;*/

/*Session=Reps*/

/*Run this GLM first; if Panelist*sample is significant for a
given
  attribute then use the GLM with Panelist*sample error term*/

proc glm data=one;
classes session panelist sample;
model A1 A2 A3 A4 A5 =session panelist sample panelist*sample;
test h=sample e=panelist*sample;
means session sample /tukey line E=panelist*sample
;
run;

/*If Panel*sample is not significant use standard GLM*/
```

```
/*proc glm data=one;
classes session panelist sample;
model A1 A7 A11 A12 A13 A15 A16 A19 A20 A21 A22 A23 A24 A25 A26
      =session panelist sample;
means sample /tukey line;
run;*/

proc tabulate data=one;
classes sample;
var A1 A2 A3 A4 A5 ;
table (A1 A2 A3 A4 A5 ), sample*mean*f=10.1/rts=35;
run;
quit;
```

Appendix U - SAS code for descriptive analysis-chicken broth sodium and KCl data

```
options nocenter formchar='|----|+|---+=|-/\<>*';

title "Chicken Broth NaCl and KCl Sodium Curve";
title2 '360 mg to 960 mg in 100 mg increments, 360 mg NaCl+0.15%,
360 mg NaCl to 460 mg NaCl and 460 mg NaCl 0.15%, 0.30%, 0.45%, 0.60%,
and 0.75% KCl';

DATA One;
  INPUT PANELIST SESSION SAMPNO A1 A2 A3 A4 A5 ;

  LABEL
    A1='FLAVOR - Salt'
    A2='FLAVOR - Sour'
    A3='FLAVOR - Bitter'
    A4='FLAVOR - Umami'
    A5='FLAVOR- Metallic'
    ;
If SAMPNO =  "1" Then SAMPLE = "360 mg NaCl";
```

```
If SAMPNO =  "2" Then SAMPLE = "560 mg NaCl";
If SAMPNO =  "3" Then SAMPLE = "660 mg NaCl";
If SAMPNO =  "4" Then SAMPLE = "760 mg NaCl";
If SAMPNO =  "5" Then SAMPLE = "860 mg NaCl";
If SAMPNO =  "6" Then SAMPLE = "960 mg NaCl";
If SAMPNO =  "7" Then SAMPLE = "460 mg NaCl";
If SAMPNO =  "8" Then SAMPLE = "360 mg+0.15%";
If SAMPNO =  "9" Then SAMPLE = "360 mg+0.0%";
If SAMPNO =  "10" Then SAMPLE = "460 mg+0.0%";
If SAMPNO =  "11" Then SAMPLE = "460 mg+0.15%";
If SAMPNO =  "12" Then SAMPLE = "460 mg+0.30%";
If SAMPNO =  "13" Then SAMPLE = "460 mg+0.45%";
If SAMPNO =  "14" Then SAMPLE = "460 mg+0.60%";
If SAMPNO =  "15" Then SAMPLE = "460 mg+0.75%";


CARDS;
1 1 1 9.5 4.5 5.0 5.0 3.0
1 2   1 9.0 5.5 5.5 6.0 4.0
1 3   1 9.0 5.0 6.0 5.0 3.5
2 1   1 8.5 3.0 2.0 3.5 2.0
2 2   1 7.5 3.0 3.0 2.0 1.5
2 3   1 7.5 3.0 2.5 3.0 1.5
3 1   1 11.0 4.0 3.5 4.0 2.5
3 2   1 8.0 3.0 2.0 2.0 2.0
3 3   1 10.0 2.0 3.0 3.0 2.0
4 1   1 9.0 4.0 4.0 6.5 2.0
4 2   1 5.0 2.0 2.0 1.0 0.0
4 3   1 9.0 4.0 5.0 5.0 3.0
5 1 1 . . . . .
5 2   1 8.0 4.0 3.0 2.0 4.0
5 3   1 10.0 5.0 6.0 5.0 5.0
6 1 1 . . . . .
6 2   1 5.0 1.0 3.0 4.0 2.5
6 3   1 5.0 2.0 1.0 4.0 2.0
7 1   1 7.5 4.0 4.0 3.5 3.5
7 2   1 8.5 3.0 4.0 3.0 3.0
7 3   1 8.0 4.0 4.0 4.0 3.0
```

```
8 1   1 9.0 6.0 6.0 5.0 2.0
8 2   1 11.0 4.5 3.0 3.5 2.0
8 3   1 9.5 4.5 6.0 4.0 3.0
9 1 1 . . . . .
9 2   1 7.0 8.0 2.5 3.0 1.0
9 3   1 10.0 2.0 3.0 3.0 0.0
1 1   2 9.0 5.0 5.0 5.0 3.0
1 2   2 9.5 5.0 5.0 5.0 3.0
1 3   2 10.0 5.0 5.0 4.5 3.0
2 1   2 10.0 3.0 3.0 3.5 2.0
2 2   2 10.0 4.0 3.5 3.0 2.5
2 3   2 11.5 3.5 3.0 3.0 2.0
3 1   2 11.0 4.5 4.0 3.0 2.0
3 2   2 12.5 5.0 4.0 3.0 2.0
3 3   2 11.0 3.0 3.0 3.5 1.5
4 1   2 12.0 4.0 5.0 7.0 2.0
4 2   2 11.0 3.0 2.5 4.0 2.0
4 3   2 10.0 3.0 3.0 4.0 2.0
5 1 2 . . . . .
5 2   2 11.5 4.0 3.5 3.0 4.0
5 3   2 10.0 5.0 4.0 5.0 5.0
6 1 2 . . . . .
6 2   2 11.5 1.5 2.0 4.0 2.0
6 3   2 9.5 2.0 1.0 3.5 2.0
7 1   2 10.0 3.5 4.0 4.0 3.0
7 2   2 10.0 3.0 4.0 3.0 3.0
7 3   2 11.0 3.5 4.0 3.0 3.0
8 1   2 10.0 4.0 5.0 3.5 2.0
8 2   2 12.0 6.0 5.0 5.0 2.0
8 3   2 12.0 4.5 6.5 3.0 3.0
9 1 2 . . . . .
9 2   2 11.0 3.0 3.0 0.5 2.0
9 3   2 12.0 3.0 3.0 2.0 1.0
1 1   3 9.0 5.0 6.0 5.0 3.0
1 2   3 9.5 5.0 6.0 6.0 3.0
1 3   3 9.5 5.0 5.0 3.5 3.0
2 1   3 10.5 3.5 3.5 3.0 2.0
2 2   3 10.5 3.5 3.0 2.0 2.0
```

```
2 3   3 12.0 3.5 3.0 2.5 2.0
3 1   3 12.5 4.0 3.5 2.5 1.5
3 2   3 13.0 4.0 3.0 4.0 2.0
3 3   3 12.5 3.0 2.5 3.5 2.0
4 1   3 11.0 5.0 4.0 6.0 3.0
4 2   3 10.0 4.0 4.0 2.5 3.0
4 3   3 12.0 2.0 2.0 5.0 4.0
5 1 3 . . . . .
5 2   3 11.5 4.0 3.0 3.5 4.0
5 3   3 11.0 4.0 5.0 4.0 4.0
6 1 3 . . . . .
6 2   3 12.0 2.0 1.0 5.0 1.0
6 3   3 13.0 1.0 1.5 4.0 1.0
7 1   3 11.5 4.0 4.0 4.5 3.5
7 2   3 8.0 3.5 3.5 3.0 3.0
7 3   3 12.5 3.5 3.0 3.5 3.5
8 1   3 12.0 6.0 6.0 3.0 2.0
8 2   3 13.0 5.0 6.0 3.0 3.0
8 3   3 12.0 5.0 7.0 3.0 2.0
9 1 3 . . . . .
9 2   3 12.5 3.0 3.0 1.5 1.0
9 3   3 12.5 3.0 3.0 2.0 11.0
1 1   4 10.0 6.0 6.0 6.0 3.0
1 2   4 11.0 5.0 5.0 5.0 3.0
1 3   4 12.0 6.0 6.0 6.0 3.0
2 1   4 11.5 3.5 3.5 3.0 2.0
2 2   4 13.0 4.0 4.0 3.5 2.0
2 3   4 12.5 4.0 4.0 3.5 2.0
3 1   4 12.5 4.5 4.0 4.0 2.0
3 2   4 13.0 3.0 3.0 2.0 1.5
3 3   4 12.5 3.0 2.5 3.0 2.5
4 1   4 10.0 4.0 6.0 6.5 2.0
4 2   4 12.5 3.5 3.0 3.0 3.0
4 3   4 12.5 3.0 2.0 4.0 2.0
5 1 4 . . . . .
5 2   4 12.0 4.0 5.0 4.0 5.0
5 3   4 13.0 4.0 5.0 4.0 4.0
6 1 4 . . . . .
```

```
6 2   4 10.5 1.0 0.0 3.0 1.0
6 3   4 13.0 1.0 1.0 4.5 3.0
7 1   4 13.0 3.5 3.0 3.5 3.5
7 2   4 12.5 4.0 3.5 3.5 3.0
7 3   4 13.0 4.0 3.0 3.0 3.0
8 1   4 12.0 5.0 5.5 4.0 3.0
8 2   4 14.0 4.5 5.5 4.0 2.5
8 3   4 12.0 4.5 6.0 4.0 3.0
9 1 4 . . . . .
9 2   4 12.5 3.0 3.0 1.0 2.0
9 3   4 12.5 3.0 5.0 4.0 0.0
1 1   5 11.0 5.0 6.0 7.0 3.0
1 2   5 11.5 6.0 6.0 6.0 3.0
1 3   5 12.0 6.0 6.5 7.0 3.5
2 1   5 12.5 4.0 3.5 4.0 2.0
2 2   5 13.5 3.5 3.0 2.5 2.0
2 3   5 14.0 4.0 4.0 4.0 2.5
3 1   5 12.5 4.0 3.5 3.0 2.0
3 2   5 12.5 3.5 3.0 2.0 2.5
3 3   5 13.0 3.0 3.0 4.0 2.0
4 1   5 13.0 4.0 4.0 6.0 2.5
4 2   5 12.0 3.0 3.0 3.0 2.0
4 3   5 12.0 4.0 2.0 4.0 2.0
5 1 5 . . . . .
5 2   5 11.5 3.0 3.0 3.0 4.0
5 3   5 13.0 3.0 3.5 4.0 4.0
6 1 5 . . . . .
6 2   5 11.0 1.5 0.5 3.0 0.0
6 3   5 13.0 2.0 2.5 5.0 2.0
7 1   5 13.0 4.0 4.5 4.0 3.5
7 2   5 13.0 4.0 4.0 3.0 3.0
7 3   5 13.5 4.0 3.5 4.0 3.0
8 1   5 13.0 3.5 6.0 4.0 1.5
8 2   5 13.0 3.0 3.0 4.0 2.5
8 3   5 13.0 4.0 4.0 2.0 2.0
9 1 5 . . . . .
9 2   5 12.5 3.0 3.0 2.0 1.0
9 3   5 13.0 3.0 4.0 3.0 1.0
```

```
1 1   6 11.5 6.0 6.0 6.0 3.0
1 2   6 12.5 6.5 6.5 6.5 3.5
1 3   6 12.5 6.0 7.0 7.0 4.0
2 1   6 13.0 4.0 4.0 4.0 2.5
2 2   6 13.0 4.0 4.0 5.0 2.0
2 3   6 13.0 4.0 4.0 3.0 2.0
3 1   6 13.0 3.5 3.0 4.0 2.5
3 2   6 13.0 4.0 3.0 2.0 2.0
3 3   6 12.5 3.0 2.0 3.0 2.0
4 1   6 11.0 4.0 3.0 4.0 3.0
4 2   6 11.0 2.0 2.0 2.0 1.0
4 3   6 13.0 3.0 4.0 6.0 4.0
5 1 6 . . . . .
5 2   6 12.5 3.5 3.0 2.5 4.0
5 3   6 12.0 3.0 3.0 3.0 3.0
6 1 6 . . . . .
6 2   6 12.5 1.5 1.0 4.0 1.0
6 3   6 13.0 1.0 1.5 3.5 1.0
7 1   6 13.5 4.0 4.0 4.0 3.5
7 2   6 13.0 4.0 3.5 4.0 3.0
7 3   6 13.0 4.0 3.0 4.0 3.5
8 1   6 13.0 5.0 4.0 4.0 1.0
8 2   6 14.0 4.0 6.0 5.0 3.0
8 3   6 13.0 4.5 6.5 4.0 1.5
9 1 6 . . . . .
9 2   6 13.0 3.0 3.0 3.0 1.0
9 3   6 12.0 4.0 5.0 6.0 0.0
1 1   7 10.0 5.0 6.0 6.0 3.0
1 2   7 10.5 5.0 6.0 5.0 4.0
1 3   7 10.0 6.0 5.0 5.0 3.0
2 1   7 10.0 4.0 3.0 4.0 2.0
2 2   7 7.5 3.0 3.0 3.5 1.5
2 3   7 10.0 3.5 4.0 3.0 2.0
3 1   7 11.0 5.0 5.5 4.5 2.5
3 2   7 11.0 5.0 3.0 2.0 3.0
3 3   7 11.0 3.0 3.0 3.5 2.0
4 1   7 11.0 4.0 4.0 6.0 2.0
4 2   7 7.0 2.0 3.5 1.5 3.5
```

```
4 3   7 9.0 3.0 4.0 4.0 3.0
5 1 7 . . . . .
5 2   7 9.5 3.0 2.5 1.5 3.5
5 3   7 11.0 4.0 3.0 3.0 3.0
6 1 7 . . . . .
6 2   7 7.5 2.5 0.5 4.0 2.0
6 3   7 8.0 1.0 1.0 4.0 2.0
7 1   7 9.5 3.5 3.5 4.0 3.5
7 2   7 8.0 3.0 4.0 4.0 3.5
7 3   7 9.5 4.0 4.0 3.5 3.0
8 1   7 10.0 6.0 6.0 5.0 3.0
8 2   7 11.0 6.0 6.0 5.0 4.0
8 3   7 11.0 4.0 6.0 3.0 1.5
9 1 7 . . . . .
9 2   7 11.5 2.0 3.0 2.0 1.0
9 3   7 9.0 3.0 3.0 5.0 0.0
1 1 8 11.0 3.5 3.5 2.0 2.0
1 2   8 12.0 4.0 4.0 4.0 3.0
1 3   8 10.5 4.5 5.0 4.0 3.0
2 1   8 10.0 2.5 2.5 2.5 2.0
2 2   8 10.5 3.5 3.0 3.0 2.0
2 3   8 11.5 4.0 3.0 3.0 2.0
3 1   8 12.5 3.0 3.5 2.0 2.0
3 2   8 12.5 3.0 2.0 2.0 1.0
3 3   8 11.0 3.0 3.0 2.0 1.0
4 1   8 11.0 3.0 2.0 2.0 1.0
4 2   8 11.0 4.0 3.5 4.0 3.5
4 3   8 9.5 4.0 3.0 6.0 2.0
5 1   8 10.5 3.0 4.0 2.5 2.5
5 2   8 11.0 3.5 4.5 4.5 3.0
5 3   8 11.5 3.0 3.5 2.5 2.5
6 1   8 10.5 4.0 3.5 4.0 3.0
6 2   8 12.0 4.0 3.0 3.5 2.0
6 3   8 12.0 4.0 6.0 5.0 3.0
7 1   8 11.0 3.0 3.0 1.0 2.0
7 2   8 12.0 4.0 4.0 4.0 3.0
7 3   8 .   . .   . .
1 1   9 9.0 6.0 6.0 5.0 4.0
```

```
1 2   9 8.0 5.0 5.0 4.0 3.0
1 3   9 9.0 5.0 5.0 4.0 3.0
2 1   9 7.5 2.0 2.0 3.0 2.0
2 2   9 7.5 2.0 2.5 3.0 2.0
2 3   9 8.0 2.5 3.0 3.0 1.5
3 1   9 8.0 3.0 2.0 2.0 2.0
3 2   9 9.0 3.0 2.0 2.0 1.0
3 3   9 10.0 4.0 3.0 2.0 2.0
4 1   9 9.0 3.0 2.0 2.0 0.0
4 2   9 8.0 4.0 3.0 4.0 2.0
4 3   9 7.5 4.0 3.0 5.0 3.0
5 1   9 9.5 3.0 4.0 3.5 3.0
5 2   9 8.0 4.0 4.0 3.0 3.0
5 3   9 9.5 2.5 3.0 1.5 3.0
6 1   9 9.0 3.0 3.5 2.0 2.0
6 2   9 10.5 4.0 2.5 1.5 2.0
6 3   9 9.5 5.0 7.0 4.5 2.0
7 1   9 10.0 4.0 3.0 4.0 2.0
7 2   9 10.0 4.0 4.0 5.0 1.0
7 3   9 .   . .   . .
1 1   10 9.5 6.0 6.0 6.0 3.0
1 2   10 10.0 6.5 5.5 5.0 3.0
1 3   10 9.0 6.0 5.0 5.0 3.0
2 1   10 9.0 2.0 1.5 2.0 1.5
2 2   10 9.0 3.5 2.5 2.0 2.0
2 3   10 9.0 2.5 2.5 3.0 1.5
3 1   10 7.5 2.0 1.0 1.5 1.0
3 2   10 11.0 2.0 2.5 2.0 1.0
3 3   10 11.0 3.5 4.0 2.0 1.0
4 1   10 9.5 3.0 2.0 1.0 1.0
4 2   10 11.0 3.0 4.0 3.0 2.0
4 3   10 10.0 4.0 3.5 4.0 3.0
5 1   10 9.5 3.0 2.5 2.0 2.5
5 2   10 10.0 3.0 3.5 2.5 3.0
5 3   10 9.0 3.5 3.0 3.0 2.5
6 1   10 10.0 3.0 2.5 1.5 3.0
6 2   10 10.5 3.0 2.5 1.0 2.0
6 3   10 10.0 4.0 4.5 3.5 1.5
```

```
7 1   10 11.0 3.0 2.5 1.0 2.0
7 2   10 10.0 3.0 3.0 2.0 2.0
7 3   10 .  . .   . .
1 1   11 10.5 6.5 6.5 5.0 3.0
1 2   11 11.0 6.0 6.0 5.0 3.0
1 3   11 10.0 6.0 5.0 5.0 3.0
2 1   11 10.0 3.0 2.0 2.0 2.0
2 2   11 9.5 2.5 2.0 2.0 2.0
2 3   11 10.0 2.5 2.0 4.0 2.0
3 1   11 11.0 3.0 2.0 2.5 1.0
3 2   11 11.0 2.0 2.0 2.0 1.0
3 3   11 12.5 4.0 3.0 3.0 2.0
4 1   11 10.0 2.5 2.0 3.0 2.5
4 2   11 12.0 4.0 4.0 3.5 3.0
4 3   11 11.0 4.0 5.0 5.0 4.0
5 1   11 10.5 3.5 3.0 3.5 2.0
5 2   11 9.5 3.0 2.5 2.0 2.0
5 3   11 10.5 3.5 3.5 4.0 3.0
6 1   11 9.5 3.5 2.0 2.0 2.5
6 2   11 11.0 2.5 2.5 1.5 1.0
6 3   11 11.0 4.5 5.5 4.0 1.0
7 1   11 9.0 3.0 3.0 1.0 1.0
7 2   11 11.0 4.0 4.0 4.0 2.0
7 3   11 .  . .   . .
1 1   12 11.0 5.5 6.0 5.0 3.0
1 2   12 12.0 5.0 5.0 5.0 3.0
1 3   12 11.5 6.0 6.0 5.0 2.0
2 1   12 10.0 3.0 2.0 2.0 1.0
2 2   12 11.0 3.0 2.5 2.0 2.5
2 3   12 11.0 3.5 3.0 2.0 1.5
3 1   12 11.0 2.0 2.0 1.0 1.0
3 2   12 12.5 3.0 3.0 2.0 1.0
3 3   12 12.5 4.5 4.0 3.0 2.0
4 1   12 10.0 3.0 3.0 3.0 3.0
4 2   12 11.0 4.0 3.0 4.0 3.0
4 3   12 12.5 4.0 5.0 4.0 4.0
5 1   12 10.0 3.0 3.0 2.0 2.5
5 2   12 10.0 3.0 3.0 2.0 2.5
```

```
5 3   12 11.0 2.5 4.0 2.5 2.5
6 1   12 9.0 2.5 3.0 3.5 2.5
6 2   12 10.0 4.0 2.5 1.0 2.0
6 3   12 12.0 4.0 5.0 3.5 1.5
7 1   12 11.0 2.5 3.0 3.0 1.0
7 2   12 10.0 3.0 4.0 3.0 1.0
7 3   12 .   . .   . .
1 1   13 11.0 6.0 6.0 6.0 3.0
1 2   13 12.0 6.0 6.0 6.0 3.0
1 3   13 11.5 7.0 6.0 6.0 3.0
2 1   13 11.0 3.0 2.5 2.5 2.0
2 2   13 10.5 3.0 2.5 2.0 2.5
2 3   13 11.5 2.5 3.5 2.0 2.0
3 1   13 11.0 2.0 2.0 0.0 1.0
3 2   13 12.5 3.0 3.0 3.0 2.0
3 3   13 12.5 4.0 4.5 3.0 2.0
4 1   13 12.0 3.0 4.0 3.0 2.0
4 2   13 10.0 3.0 3.0 3.0 3.0
4 3   13 12.5 4.0 4.0 5.0 3.5
5 1   13 11.0 3.5 3.0 3.0 2.5
5 2   13 11.0 3.0 3.0 2.0 3.0
5 3   13 12.0 3.0 2.0 2.0 2.5
6 1   13 10.5 3.0 2.0 1.0 2.0
6 2   13 13.0 3.0 4.0 4.0 2.0
6 3   13 11.0 3.0 3.0 2.0 1.5
7 1   13 11.0 2.5 3.0 3.0 1.0
7 2   13 12.0 4.0 4.0 6.0 2.0
7 .   13 .   . .   . .
1 1   14 10.5 4.0 5.0 5.0 3.0
1 2   14 11.0 5.0 5.0 4.0 3.0
1 3   14 12.0 6.0 6.0 6.0 3.0
2 1   14 11.5 3.0 2.0 3.0 2.5
2 2   14 11.5 3.0 2.0 2.0 2.5
2 3   14 11.0 3.0 2.0 1.5 1.5
3 1   14 12.5 2.0 2.5 2.0 2.0
3 2   14 12.5 3.0 3.0 3.0 2.0
3 3   14 12.5 3.5 4.0 3.0 2.0
4 1   14 11.5 4.0 2.5 3.5 2.5
```

```
4 2   14 12.0 4.0 3.0 2.5 2.0
4 3   14 10.0 6.0 5.0 4.0 4.0
5 1   14 12.0 4.0 2.0 2.5 3.0
5 2   14 11.5 3.5 3.0 3.5 3.0
5 3   14 12.0 3.0 3.0 3.0 3.0
6 1   14 10.0 2.5 3.0 2.5 3.0
6 2   14 13.0 3.0 3.5 2.5 1.5
6 3   14 13.0 4.0 5.0 4.0 2.0
7 1   14 11.5 3.0 3.0 4.0 2.0
7 2   14 11.5 4.0 4.0 3.0 2.0
7 3   14 .  . .   . .
1 1   15 12.0 4.0 5.0 4.0 3.0
1 2   15 12.5 5.0 5.0 4.0 3.5
1 3   15 12.5 5.0 6.0 6.0 3.0
2 1   15 11.0 3.0 3.5 2.0 2.0
2 2   15 12.0 3.0 3.0 4.0 3.0
2 3   15 12.0 3.5 3.0 2.5 2.0
3 1   15 12.5 3.0 2.0 2.0 1.0
3 2   15 13.0 3.5 3.0 3.5 2.0
3 3   15 12.5 4.0 3.5 3.0 2.0
4 1   15 12.0 3.0 2.5 3.0 1.0
4 2   15 12.0 5.0 3.5 4.0 3.0
4 3   15 13.0 4.0 5.0 3.0 2.5
5 1   15 11.0 3.5 4.0 4.0 3.0
5 2   15 12.5 3.5 2.5 2.5 3.0
5 3   15 12.5 2.0 2.5 1.5 2.5
6 1   15 11.0 3.5 3.0 3.0 2.5
6 2   15 13.0 2.5 5.0 4.0 3.0
6 3   15 13.0 5.0 6.0 4.0 3.0
7 1   15 12.0 3.0 3.0 3.0 2.0
7 2   15 12.0 4.0 4.0 5.0 3.0
7 3   15 . . . . .
;

/*proc contents data=Necc; run;
proc means data=necc; run;
proc print data=necc; run;*/
```

```
/*proc freq;
table A1; run;*/

/*Always Plot your Data*/

/*proc plot vpercent=33;
plot (A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
      A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26)*panelist;
run;*/

/*Session=Reps*/

/*Run this GLM first; if Panelist*sample is significant for a
given
  attribute then use the GLM with Panelist*sample error term*/

proc glm data=one;
classes session panelist sample;
model A1 A2 A3 A4 A5 =session panelist sample panelist*sample;
test h=sample e=panelist*sample;
means session sample /tukey line E=panelist*sample
;
run;

/*If Panel*sample is not significant use standard GLM*/

/*proc glm data=one;
classes session panelist sample;
model A1 A7 A11 A12 A13 A15 A16 A19 A20 A21 A22 A23 A24 A25 A26
      =session panelist sample;
means sample /tukey line;
run;*/

proc tabulate data=one;
classes sample;
var A1 A2 A3 A4 A5 ;
table (A1 A2 A3 A4 A5 ), sample*mean*f=10.1/rts=35;
run;
```

```
quit;
```

Appendix V - SAS code for descriptive analysis-tomato soup sodium data

```
options nocenter formchar='|----|+|---+=|-/\<>*';

title "Tomato Soup NaCl Sodium Curve";
title2 '360 mg NaCl to 960 mg NaCl in 100 mg increments ';

DATA One;
  INPUT PANELIST SESSION SAMPNO A1 A2 A3 A4 ;

  LABEL
    A1='FLAVOR - Salt'
    A2='FLAVOR - Sweet'
    A3='FLAVOR - Sour'
    A4='FLAVOR - Bitter'
    ;

If SAMPNO =  "1" Then SAMPLE = "360 mg NaCl";
If SAMPNO =  "2" Then SAMPLE = "560 mg";
If SAMPNO =  "3" Then SAMPLE = "660 mg";
If SAMPNO =  "4" Then SAMPLE = "760 mg";
If SAMPNO =  "5" Then SAMPLE = "860 mg";
If SAMPNO =  "6" Then SAMPLE = "960 mg";
If SAMPNO =  "7" Then SAMPLE = "460 mg";


CARDS;
   1       1       1       10      6.5      5       5
   1       2       1       .       .        .       .
   1       3       1       .       .        .       .
   2       1       1       8       4        3       3.5
   2       2       1       8.5     4.5      4       4
```

2	3	1	9.5	4	3	3
3	1	1	9	4	4	3
3	2	1	10	5	3	4
3	3	1	9	5	3.5	2.5
4	1	1	7.5	6.5	5	3
4	2	1	5	5	1	3
4	3	1	7.5	4.5	2.5	3.5
5	1	1	10	4	4	3
5	2	1	10	7	3	6
5	3	1	12	7	4	6
6	1	1	7.5	4.5	5	2.5
6	2	1	8	5	5	1
6	3	1	9.5	5	5	1.5
7	1	1	9	5	4	4.5
7	2	1	8.5	6	4.5	3.5
7	3	1	10.5	5.5	5	3
8	1	1	10.5	5.5	3.5	6
8	2	1	11	4	3	6
8	3	1	11	4	3.5	3.5
9	1	1	8	5	5	5
9	2	1	6	3.5	5	4
9	3	1	7	4	5	3
1	1	2	10.5	6	4.5	4
1	2	2	.	.	.	.
1	3	2	.	.	.	.
2	1	2	9.5	4	4	3
2	2	2	10	5	3	3.5
2	3	2	10.5	4.5	4	3
3	1	2	10	5	4	3
3	2	2	11	5	3	4
3	3	2	11	4	3.5	2.5
4	1	2	9	6	4	3.5
4	2	2	8	5.5	1	3
4	3	2	8	5	1.5	3
5	1	2	11	6	4	4
5	2	2	12	7.5	3	5
5	3	2	13	7	3	8
6	1	2	11	5	4.5	2

6	2	2	10	4	4	1.5
6	3	2	9.5	4.5	5	2
7	1	2	9.5	6	4	4.5
7	2	2	10.5	5.5	4	4
7	3	2	10.5	5.5	4.5	3.5
8	1	2	11.5	5	3.5	5
8	2	2	13	5.5	3	6
8	3	2	12.5	5	3	4
9	1	2	9	6	4.5	5
9	2	2	9.5	5	2	5
9	3	2	7.5	5	3	3.5
1	1	3	11	6	5	4
1	2	3	.	.	.	.
1	3	3	.	.	.	.
2	1	3	9	4	3	4
2	2	3	11	6	3.5	4
2	3	3	11.5	4.5	3.5	3
3	1	3	11	4	3	3
3	2	3	11	5	3	4
3	3	3	12.5	4	4	3
4	1	3	7	6	4	3
4	2	3	9	5.5	1.5	3
4	3	3	7	6	2	3
5	1	3	10	7	3	4.5
5	2	3	13	8	3	7
5	3	3	13	7	3.5	5
6	1	3	10	2.5	4	2
6	2	3	10.5	5	5	1.5
6	3	3	10.5	4.5	5	1.5
7	1	3	9.5	6	4.5	5
7	2	3	8	6.5	5	5
7	3	3	11	6	4.5	4.5
8	1	3	12	5	3	5
8	2	3	12	6	3	4.5
8	3	3	12	4	3	3.5
9	1	3	10	6	2	6
9	2	3	7.5	5	2.5	5
9	3	3	7.5	3.5	5	3

1	1	4	10.5	6	4.5	5
1	2	4	.	.	.	.
1	3	4	.	.	.	.
2	1	4	9.5	4	4	3.5
2	2	4	11.5	4.5	3.5	3.5
2	3	4	10	4.5	3	3.5
3	1	4	13	5	3	3.5
3	2	4	11	4	3	4
3	3	4	12	5	3.5	2.5
4	1	4	9	5	5	3
4	2	4	8.5	6	1.5	3
4	3	4	7.5	4.5	2	2
5	1	4	11.5	6.5	4	4
5	2	4	12.5	8	3	6
5	3	4	13	8	3.5	6
6	1	4	10	5	4.5	3
6	2	4	10.5	4	4.5	1.5
6	3	4	12	5	5	1.5
7	1	4	10.5	6.5	4.5	4.5
7	2	4	10.5	5.5	4	3.5
7	3	4	10	6.5	4	4
8	1	4	10	5.5	2.5	4
8	2	4	11.5	5.5	3	5
8	3	4	13	6	3.5	3
9	1	4	9	7	2	5
9	2	4	8	6	2	4
9	3	4	7.5	4	2	3
1	1	5	11	6	5	4
1	2	5	.	.	.	.
1	2	5	.	.	.	.
2	1	5	9	4.5	3.5	4
2	2	5	11	4.5	3	3.5
2	3	5	11.5	4	3	3
3	1	5	12.5	5	3	4
3	2	5	11	5	3	4
3	3	5	12	4	3	3.5
4	1	5	8	5.5	5	2.5
4	2	5	7.5	4.5	3	2

4	3	5	7	5	1	3
5	1	5	12	7.5	3	4
5	2	5	13	7	3	5
5	3	5	14	6.5	3.5	6
6	1	5	11.5	4.5	3.5	3
6	2	5	11	5	5	3
6	3	5	11.5	4.5	4.5	2
7	1	5	10	6	4	4.5
7	2	5	9.5	5	4	3.5
7	3	5	10.5	5.5	4.5	4
8	1	5	11	5.5	3	5
8	2	5	12.5	5	3	4
8	3	5	13	4.5	3.5	3.5
9	1	5	10	5	2	5
9	2	5	7	6	4	5
9	3	5	10	5	2	4
1	1	6	12	7	5	5
1	2	6	.	.	.	.
1	3	6	.	.	.	.
2	1	6	9	4.5	3.5	3.5
2	2	6	10	5	3	4
2	3	6	11	4.5	3.5	4
3	1	6	11	4	3	3
3	2	6	10	4	2	4
3	3	6	11	4	3	3
4	1	6	9	6.5	4	3
4	2	6	8.5	5	1	3.5
4	3	6	8	5.5	2	3.5
5	1	6	12	7	3.5	4
5	2	6	12	7	4	4
5	3	6	13	8	4	6
6	1	6	12	4	5	3.5
6	2	6	10.5	4	4	2
6	3	6	11	5	5.5	1.5
7	1	6	10	6.5	4	4
7	2	6	10.5	6	3.5	4
7	3	6	10	6	4	4
8	1	6	11	5.5	3	6

```
8	2	6	12	5	3.5	5
8	3	6	12.5	6	3	5
9	1	6	10	5	4	4
9	2	6	10	5	2	5
9	3	6	7	4	3	3.5
1	1	7	11	7.5	4	5
1	2	7	.	.	.	.
1	3	7	.	.	.	.
2	1	7	9	5	3.5	4
2	2	7	9	4	3.5	3
2	3	7	9.5	5.5	3.5	3.5
3	1	7	9	5	4	3
3	2	7	10	4	3	3
3	3	7	10	4.5	3	3
4	1	7	9	7	5	4
4	2	7	7	5.5	2	3
4	3	7	8.5	6	1.5	2.5
5	1	7	10	6	3.5	5
5	2	7	12	6	4	4
5	3	7	12.5	6	4	6
6	1	7	7.5	4.5	4	2.5
6	2	7	9	5.5	4.5	2
6	3	7	10.5	5	4.5	2.5
7	1	7	9	6	4.5	4
7	2	7	8.5	6	3.5	4
7	3	7	10	6	4	4.5
8	1	7	9.5	6	3.5	5
8	2	7	11	4.5	3	4.5
8	3	7	10.5	4	3.5	4
9	1	7	7.5	6	5	5
9	2	7	7	4	5	4
9	3	7	7	4	2	3
;
/*proc contents data=Necc; run;
proc means data=necc; run;
proc print data=necc; run;*/

/*proc freq;
```

```
table A1; run;*/

/*Always Plot your Data*/

/*proc plot vpercent=33;
plot (A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
      A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26)*panelist;
run;*/

/*Session=Reps*/

/*Run this GLM first; if Panelist*sample is significant for a
given
  attribute then use the GLM with Panelist*sample error term*/

proc glm data=one;
classes session panelist sample;
model A1 A2 A3 A4 =session panelist sample panelist*sample;
test h=sample e=panelist*sample;
means session sample /tukey line E=panelist*sample
;
run;

/*If Panel*sample is not significant use standard GLM*/

/*proc glm data=one;
classes session panelist sample;
model A1 A7 A11 A12 A13 A15 A16 A19 A20 A21 A22 A23 A24 A25 A26
      =session panelist sample;
means sample /tukey line;
run;*/

proc tabulate data=one;
classes sample;
var A1 A2 A3 A4 ;
table (A1 A2 A3 A4 ), sample*mean*f=10.1/rts=35;
run;
quit;
```

Appendix W - SAS code for descriptive analysis-tomato soup KCl data

```
options nocenter formchar='|----|+|---+=|-/\<>*';

title "Tomato Soup KCl Sodium Curve";
title2 '360 mg NaCl, 360 mg +0.15% KCl, 460 mg, 460 mg + 0.15%,
0.30%, 0.45%, 0.60%, 0.75% KCl';

DATA One;
  INPUT PANELIST SESSION SAMPNO A1 A2 A3 A4 ;

  LABEL
    A1='FLAVOR - Salt'
      A2='FLAVOR - Sweet'
      A3='FLAVOR - Sour'
    A4='FLAVOR - Bitter'
    ;

If SAMPNO =  "1" Then SAMPLE = "360 mg + 0.0% KCl";
If SAMPNO =  "2" Then SAMPLE = "360 mg + 0.15% KCl";
If SAMPNO =  "3" Then SAMPLE = "460 mg + 0.0% KCl";
If SAMPNO =  "4" Then SAMPLE = "460 mg + 0.15% KCl";
If SAMPNO =  "5" Then SAMPLE = "460 mg + 0.30% KCl";
If SAMPNO =  "6" Then SAMPLE = "460 mg + 0.45% KCl";
If SAMPNO =  "7" Then SAMPLE = "460 mg + 0.60% KCl";
If SAMPNO =  "8" Then SAMPLE = "460 mg + 0.75% KCl";
CARDS;
   1       1       1      9.5     5.5     4.5     3.0
   1       2       1      10.0    6.0     5.0     3.0
   1       3       1      10.0    6.0     4.0     4.0
   2       1       1      7.5     4.0     4.0     3.5
   2       2       1      9.0     4.0     3.0     3.5
```

2	3	1	8.5	4.5	4.0	3.5
3	1	1	7.0	5.0	3.0	4.0
3	2	1	10.0	5.0	3.0	4.0
3	3	1	10.0	4.0	2.5	4.0
4	1	1	9.0	6.0	3.0	2.0
4	2	1	10.0	6.0	4.5	4.0
4	3	1	8.0	4.5	3.5	4.0
5	1	1	9.0	6.0	4.5	3.0
5	2	1	10.0	6.0	4.0	4.0
5	3	1	10.0	5.0	4.0	3.0
6	1	1	10.5	2.5	4.5	2.5
6	2	1	9.5	3.5	4.5	2.0
6	3	1	11.0	4.5	5.5	2.5
7	1	1	7.5	5.0	4.0	5.5
7	2	1	9.5	6.0	4.0	5.0
7	3	1	8.0	5.0	5.0	4.5
8	1	1	9.0	3.5	3.0	6.0
8	2	1	11.0	4.0	3.0	.
8	3	1	10.5	5.0	2.0	5.0
9	1	1	9.0	3.0	6.0	4.0
9	2	1	8.0	4.0	5.0	4.0
9	3	1	10.0	5.0	4.0	5.0
1	1	2	8.0	6.0	4.0	4.0
1	2	2	9.0	5.0	5.0	4.0
1	3	2	9.0	6.0	4.5	4.5
2	1	2	7.0	3.5	4.0	3.5
2	2	2	7.5	4.0	4.0	3.5
2	3	2	8.0	4.0	4.0	3.5
3	1	2	6.5	4.0	3.5	3.0
3	2	2	10.0	4.0	3.0	3.0
3	3	2	8.0	3.0	2.0	3.0
4	1	2	7.5	5.5	4.0	3.0
4	2	2	8.0	5.5	6.0	3.0
4	3	2	7.0	6.0	3.0	2.0
5	1	2	9.0	4.5	4.0	3.0
5	2	2	11.0	6.0	4.0	4.0
5	3	2	10.0	7.0	3.0	4.5
6	1	2	8.5	5.0	5.0	1.5

6	2	2	6.5	1.5	5.5	1.5
6	3	2	7.0	4.5	5.0	2.0
7	1	2	8.0	6.0	5.0	5.0
7	2	2	8.0	6.0	4.5	4.5
7	3	2	7.5	5.0	5.0	3.0
8	1	2	9.5	3.7	3.0	5.5
8	2	2	10.0	3.5	4.0	6.0
8	3	2	9.0	6.0	2.5	4.5
9	1	2	8.0	4.0	5.0	4.0
9	2	2	10.0	4.0	4.0	4.0
9	3	2	9.0	5.0	5.0	5.0
1	1	3	10.0	6.0	4.5	5.0
1	2	3	10.5	5.0	4.0	4.0
1	3	3	9.0	6.0	4.0	4.5
2	1	3	7.5	5.0	3.5	4.0
2	2	3	8.5	4.0	3.5	3.5
2	3	3	8.0	4.0	4.5	4.0
3	1	3	7.5	3.0	2.0	3.0
3	2	3	7.5	4.5	3.0	4.0
3	3	3	10.0	4.0	2.0	3.0
4	1	3	10.0	5.0	4.5	3.5
4	2	3	8.5	6.0	4.0	4.0
4	3	3	9.0	4.0	3.0	3.0
5	1	3	10.0	6.0	4.5	3.5
5	2	3	10.0	6.5	3.5	4.5
5	3	3	11.5	7.5	3.0	5.0
6	1	3	7.0	3.0	5.0	2.5
6	2	3	10.0	5.0	5.0	2.5
6	3	3	7.0	4.5	5.5	2.0
7	1	3	7.5	5.5	5.0	5.0
7	2	3	9.0	6.0	4.5	4.0
7	3	3	7.5	6.0	5.0	4.0
8	1	3	9.0	3.0	3.0	4.0
8	2	3	9.0	4.5	4.0	6.0
8	3	3	11.0	6.0	2.0	5.0
9	1	3	11.0	5.0	5.0	5.0
9	2	3	10.0	5.0	5.0	4.0
9	3	3	6.0	5.0	4.0	5.0

1	1	4	9.0	7.0	5.0	5.0
1	2	4	9.0	7.5	5.0	5.0
1	3	4	10.0	6.5	4.0	4.5
2	1	4	7.0	4.0	4.0	3.5
2	2	4	8.0	4.0	4.0	4.0
2	3	4	8.5	4.0	4.5	4.0
3	1	4	9.0	4.0	3.0	4.0
3	2	4	10.0	5.0	3.0	3.5
3	3	4	9.0	3.0	2.0	3.0
4	1	4	8.0	6.0	3.5	4.5
4	2	4	8.0	6.0	3.0	3.0
4	3	4	8.0	6.5	3.0	4.5
5	1	4	11.0	7.0	3.5	4.5
5	2	4	9.0	4.0	4.5	3.5
5	3	4	10.0	7.0	3.5	5.0
6	1	4	10.5	6.0	6.5	2.0
6	2	4	9.5	3.0	4.5	3.0
6	3	4	7.0	5.0	5.0	2.0
7	1	4	7.0	5.0	4.5	4.0
7	2	4	9.0	6.0	4.5	4.0
7	3	4	8.5	6.0	5.0	3.5
8	1	4	9.0	4.0	2.5	6.0
8	2	4	9.5	5.0	3.0	5.0
8	3	4	10.0	4.0	2.5	5.0
9	1	4	8.0	5.0	4.0	5.0
9	2	4	10.5	5.0	5.0	5.0
9	3	4	8.0	4.0	5.0	5.0
1	1	5	8.5	6.5	5.0	5.0
1	2	5	8.0	6.0	5.0	5.0
1	3	5	8.0	7.0	5.0	5.0
2	1	5	8.0	4.0	4.0	4.5
2	2	5	9.0	4.0	3.5	3.5
2	3	5	8.5	4.5	4.0	3.5
3	1	5	7.5	4.0	3.0	4.0
3	2	5	10.0	5.0	3.0	4.0
3	3	5	11.0	5.0	2.0	3.0
4	1	5	7.5	6.0	5.0	4.0
4	2	5	6.5	6.0	4.0	3.5

4	3	5	7.5	6.0	3.0	4.0
5	1	5	10.0	7.0	3.5	6.0
5	2	5	10.0	5.0	4.0	4.0
5	3	5	11.0	6.5	3.5	4.0
6	1	5	5.5	5.0	5.5	3.0
6	2	5	12.0	4.5	4.5	2.0
6	3	5	7.5	3.0	5.0	1.5
7	1	5	7.5	6.0	5.0	4.5
7	2	5	10.0	6.0	4.5	4.5
7	3	5	8.5	5.0	5.0	4.0
8	1	5	10.0	4.0	2.5	5.0
8	2	5	10.5	4.0	3.0	5.5
8	3	5	9.0	5.0	3.0	6.0
9	1	5	10.0	5.0	5.0	6.0
9	2	5	10.0	5.0	3.5	5.0
9	3	5	9.0	5.0	3.0	6.0
1	1	6	10.0	6.0	4.0	4.0
1	2	6	10.5	6.5	5.0	5.0
1	3	6	10.5	7.5	5.0	4.5
2	1	6	8.0	4.0	4.5	4.0
2	2	6	9.5	4.5	3.5	3.5
2	3	6	7.5	4.0	3.5	4.0
3	1	6	8.0	4.0	3.0	2.5
3	2	6	10.0	4.0	3.0	4.0
3	3	6	10.0	5.0	2.0	3.0
4	1	6	10.0	5.5	3.5	4.0
4	2	6	9.0	5.5	3.5	3.0
4	3	6	7.0	6.0	3.5	4.0
5	1	6	9.0	6.0	3.0	6.0
5	2	6	11.0	4.0	4.5	3.0
5	3	6	10.0	7.5	3.0	6.0
6	1	6	9.5	3.0	5.0	2.0
6	2	6	11.0	4.0	4.5	3.0
6	3	6	9.0	4.5	4.5	2.5
7	1	6	7.0	5.0	4.0	4.5
7	2	6	9.0	5.0	3.5	3.0
7	3	6	8.5	6.0	4.5	5.0
8	1	6	10.5	4.0	2.5	5.0

8	2	6	10.0	4.5	3.5	6.0
8	3	6	9.5	4.5	2.5	6.0
9	1	6	9.0	5.0	4.0	6.0
9	2	6	9.0	5.0	4.0	5.0
9	3	6	10.0	6.0	3.0	5.0
1	1	7	10.0	6.5	4.5	4.0
1	2	7	10.0	7.0	4.0	5.0
1	3	7	11.0	7.0	4.5	4.5
2	1	7	8.0	4.0	3.5	4.5
2	2	7	9.0	4.0	3.5	3.5
2	3	7	7.5	3.5	3.0	3.0
3	1	7	9.0	3.0	3.0	5.0
3	2	7	10.0	5.0	3.0	4.0
3	3	7	11.0	4.0	2.0	4.0
4	1	7	9.5	6.5	4.0	4.0
4	2	7	9.5	4.0	5.0	2.0
4	3	7	9.0	6.0	4.0	2.5
5	1	7	11.0	6.0	4.0	3.5
5	2	7	11.0	6.0	4.0	5.0
5	3	7	11.0	7.0	3.0	5.0
6	1	7	10.0	5.0	4.5	1.5
6	2	7	10.5	3.5	4.5	2.0
6	3	7	10.0	5.5	4.5	2.0
7	1	7	8.0	5.0	4.0	5.0
7	2	7	9.5	5.0	4.0	3.0
7	3	7	9.0	6.0	4.0	4.0
8	1	7	10.5	6.0	2.5	6.0
8	2	7	10.0	4.0	3.0	5.5
8	3	7	10.0	6.0	2.0	5.0
9	1	7	9.0	5.0	4.0	4.0
9	2	7	10.0	5.0	4.5	5.0
9	3	7	7.5	6.0	3.0	6.0
1	1	8	9.0	6.5	4.0	3.0
1	2	8	9.0	6.5	5.0	4.0
1	3	8	9.0	7.0	4.0	4.0
2	1	8	7.5	5.0	4.0	5.0
2	2	8	8.5	3.5	3.5	4.0
2	3	8	8.5	4.5	3.5	3.0

```
   3        1        8       7.5      4.5      3.0      4.0
   3        2        8       11.0     5.0      3.0      4.0
   3        3        8       11.0     5.0      2.0      4.0
   4        1        8       8.5      6.0      3.5      3.0
   4        2        8       9.0      6.5      4.0      4.0
   4        3        8       8.0      6.5      3.5      4.0
   5        1        8       11.0     7.0      4.0      4.0
   5        2        8       11.0     6.0      4.5      5.0
   5        3        8       11.0     6.0      3.5      4.0
   6        1        8       9.5      5.0      5.0      1.0
   6        2        8       10.5     4.5      3.5      3.0
   6        3        8       10.0     4.5      5.0      2.0
   7        1        8       8.0      6.0      3.5      5.0
   7        2        8       10.0     6.0      3.5      4.0
   7        3        8       8.0      6.0      5.0      5.0
   8        1        8       9.0      5.0      5.0      5.0
   8        2        8       11.0     4.0      3.0      5.0
   8        3        8       9.0      6.0      2.5      5.0
   9        1        8       10.0     5.0      5.0      5.0
   9        2        8       11.0     4.5      4.0      5.0
   9        3        8       7.0      5.0      4.0      6.0
;
/*proc contents data=Necc; run;
proc means data=necc; run;
proc print data=necc; run;*/

/*proc freq;
table A1; run;*/

/*Always Plot your Data*/

/*proc plot vpercent=33;
plot (A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
      A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26)*panelist;
run;*/

/*Session=Reps*/
```

```
/*Run this GLM first; if Panelist*sample is significant for a
given
  attribute then use the GLM with Panelist*sample error term*/

proc glm data=one;
classes session panelist sample;
model A1 A2 A3 A4 =session panelist sample panelist*sample;
test h=sample e=panelist*sample;
means session sample /tukey line E=panelist*sample
;
run;

/*If Panel*sample is not significant use standard GLM*/

/*proc glm data=one;
classes session panelist sample;
model A1 A7 A11 A12 A13 A15 A16 A19 A20 A21 A22 A23 A24 A25 A26
      =session panelist sample;
means sample /tukey line;
run;*/

proc tabulate data=one;
classes sample;
var A1 A2 A3 A4 ;
table (A1 A2 A3 A4 ), sample*mean*f=10.1/rts=35;
run;
quit;
```

Appendix X - SAS code for descriptive analysis-chicken broth sodium and KCl data

```
options nocenter formchar='|----|+|---+=|-/\<>*';

title "Tomato soup NaCl and KCl Sodium Curve";
```

```
title2 '360 mg to 960 mg in 100 mg increments, 360 mg NaCl+0.15%, 360 mg NaCl to
460 mg NaCl and 460 mg NaCl 0.15%, 0.30%, 0.45%, 0.60%, and 0.75% KCl';

DATA One;
  INPUT PANELIST SESSION SAMPNO A1 A2 A3 A4 ;

  LABEL
    A1='FLAVOR - Salt'
    A2= 'Flavor-Sweet'
    A3='FLAVOR - Sour'
    A4='FLAVOR - Bitter'

    ;
If SAMPNO =  "1" Then SAMPLE = "360 mg NaCl";
If SAMPNO =  "2" Then SAMPLE = "560 mg NaCl";
If SAMPNO =  "3" Then SAMPLE = "660 mg NaCl";
If SAMPNO =  "4" Then SAMPLE = "760 mg NaCl";
If SAMPNO =  "5" Then SAMPLE = "860 mg NaCl";
If SAMPNO =  "6" Then SAMPLE = "960 mg NaCl";
If SAMPNO =  "7" Then SAMPLE = "460 mg NaCl";
If SAMPNO =  "8" Then SAMPLE = "360 mg+0.15%";
If SAMPNO =  "9" Then SAMPLE = "360 mg+0.0%";
If SAMPNO =  "10" Then SAMPLE = "460 mg+0.0%";
If SAMPNO =  "11" Then SAMPLE = "460 mg+0.15%";
If SAMPNO =  "12" Then SAMPLE = "460 mg+0.30%";
If SAMPNO =  "13" Then SAMPLE = "460 mg+0.45%";
If SAMPNO =  "14" Then SAMPLE = "460 mg+0.60%";
If SAMPNO =  "15" Then SAMPLE = "460 mg+0.75%";


CARDS;
   1       1       1       10      6.5      5       5
   1       2       1       .       .        .       .
   1       3       1       .       .        .       .
   2       1       1       8       4        3       3.5
   2       2       1       8.5     4.5      4       4
   2       3       1       9.5     4        3       3
   3       1       1       9       4        4       3
```

3	2	1	10	5	3	4
3	3	1	9	5	3.5	2.5
4	1	1	7.5	6.5	5	3
4	2	1	5	5	1	3
4	3	1	7.5	4.5	2.5	3.5
5	1	1	10	4	4	3
5	2	1	10	7	3	6
5	3	1	12	7	4	6
6	1	1	7.5	4.5	5	2.5
6	2	1	8	5	5	1
6	3	1	9.5	5	5	1.5
7	1	1	9	5	4	4.5
7	2	1	8.5	6	4.5	3.5
7	3	1	10.5	5.5	5	3
8	1	1	10.5	5.5	3.5	6
8	2	1	11	4	3	6
8	3	1	11	4	3.5	3.5
9	1	1	8	5	5	5
9	2	1	6	3.5	5	4
9	3	1	7	4	5	3
1	1	2	10.5	6	4.5	4
1	2	2	.	.	.	.
1	3	2	.	.	.	.
2	1	2	9.5	4	4	3
2	2	2	10	5	3	3.5
2	3	2	10.5	4.5	4	3
3	1	2	10	5	4	3
3	2	2	11	5	3	4
3	3	2	11	4	3.5	2.5
4	1	2	9	6	4	3.5
4	2	2	8	5.5	1	3
4	3	2	8	5	1.5	3
5	1	2	11	6	4	4
5	2	2	12	7.5	3	5
5	3	2	13	7	3	8
6	1	2	11	5	4.5	2
6	2	2	10	4	4	1.5
6	3	2	9.5	4.5	5	2

7	1	2	9.5	6	4	4.5
7	2	2	10.5	5.5	4	4
7	3	2	10.5	5.5	4.5	3.5
8	1	2	11.5	5	3.5	5
8	2	2	13	5.5	3	6
8	3	2	12.5	5	3	4
9	1	2	9	6	4.5	5
9	2	2	9.5	5	2	5
9	3	2	7.5	5	3	3.5
1	1	3	11	6	5	4
1	2	3	.	.	.	.
1	3	3	.	.	.	.
2	1	3	9	4	3	4
2	2	3	11	6	3.5	4
2	3	3	11.5	4.5	3.5	3
3	1	3	11	4	3	3
3	2	3	11	5	3	4
3	3	3	12.5	4	4	3
4	1	3	7	6	4	3
4	2	3	9	5.5	1.5	3
4	3	3	7	6	2	3
5	1	3	10	7	3	4.5
5	2	3	13	8	3	7
5	3	3	13	7	3.5	5
6	1	3	10	2.5	4	2
6	2	3	10.5	5	5	1.5
6	3	3	10.5	4.5	5	1.5
7	1	3	9.5	6	4.5	5
7	2	3	8	6.5	5	5
7	3	3	11	6	4.5	4.5
8	1	3	12	5	3	5
8	2	3	12	6	3	4.5
8	3	3	12	4	3	3.5
9	1	3	10	6	2	6
9	2	3	7.5	5	2.5	5
9	3	3	7.5	3.5	5	3
1	1	4	10.5	6	4.5	5
1	2	4	.	.	.	.

1	3	4	.	.	.	.
2	1	4	9.5	4	4	3.5
2	2	4	11.5	4.5	3.5	3.5
2	3	4	10	4.5	3	3.5
3	1	4	13	5	3	3.5
3	2	4	11	4	3	4
3	3	4	12	5	3.5	2.5
4	1	4	9	5	5	3
4	2	4	8.5	6	1.5	3
4	3	4	7.5	4.5	2	2
5	1	4	11.5	6.5	4	4
5	2	4	12.5	8	3	6
5	3	4	13	8	3.5	6
6	1	4	10	5	4.5	3
6	2	4	10.5	4	4.5	1.5
6	3	4	12	5	5	1.5
7	1	4	10.5	6.5	4.5	4.5
7	2	4	10.5	5.5	4	3.5
7	3	4	10	6.5	4	4
8	1	4	10	5.5	2.5	4
8	2	4	11.5	5.5	3	5
8	3	4	13	6	3.5	3
9	1	4	9	7	2	5
9	2	4	8	6	2	4
9	3	4	7.5	4	2	3
1	1	5	11	6	5	4
1	2	5	.	.	.	.
1	2	5	.	.	.	.
2	1	5	9	4.5	3.5	4
2	2	5	11	4.5	3	3.5
2	3	5	11.5	4	3	3
3	1	5	12.5	5	3	4
3	2	5	11	5	3	4
3	3	5	12	4	3	3.5
4	1	5	8	5.5	5	2.5
4	2	5	7.5	4.5	3	2
4	3	5	7	5	1	3
5	1	5	12	7.5	3	4

5	2	5	13	7	3	5
5	3	5	14	6.5	3.5	6
6	1	5	11.5	4.5	3.5	3
6	2	5	11	5	5	3
6	3	5	11.5	4.5	4.5	2
7	1	5	10	6	4	4.5
7	2	5	9.5	5	4	3.5
7	3	5	10.5	5.5	4.5	4
8	1	5	11	5.5	3	5
8	2	5	12.5	5	3	4
8	3	5	13	4.5	3.5	3.5
9	1	5	10	5	2	5
9	2	5	7	6	4	5
9	3	5	10	5	2	4
1	1	6	12	7	5	5
1	2	6	.	.	.	.
1	3	6	.	.	.	.
2	1	6	9	4.5	3.5	3.5
2	2	6	10	5	3	4
2	3	6	11	4.5	3.5	4
3	1	6	11	4	3	3
3	2	6	10	4	2	4
3	3	6	11	4	3	3
4	1	6	9	6.5	4	3
4	2	6	8.5	5	1	3.5
4	3	6	8	5.5	2	3.5
5	1	6	12	7	3.5	4
5	2	6	12	7	4	4
5	3	6	13	8	4	6
6	1	6	12	4	5	3.5
6	2	6	10.5	4	4	2
6	3	6	11	5	5.5	1.5
7	1	6	10	6.5	4	4
7	2	6	10.5	6	3.5	4
7	3	6	10	6	4	4
8	1	6	11	5.5	3	6
8	2	6	12	5	3.5	5
8	3	6	12.5	6	3	5

9	1	6	10	5	4	4
9	2	6	10	5	2	5
9	3	6	7	4	3	3.5
1	1	7	11	7.5	4	5
1	2	7	.	.	.	.
1	3	7	.	.	.	.
2	1	7	9	5	3.5	4
2	2	7	9	4	3.5	3
2	3	7	9.5	5.5	3.5	3.5
3	1	7	9	5	4	3
3	2	7	10	4	3	3
3	3	7	10	4.5	3	3
4	1	7	9	7	5	4
4	2	7	7	5.5	2	3
4	3	7	8.5	6	1.5	2.5
5	1	7	10	6	3.5	5
5	2	7	12	6	4	4
5	3	7	12.5	6	4	6
6	1	7	7.5	4.5	4	2.5
6	2	7	9	5.5	4.5	2
6	3	7	10.5	5	4.5	2.5
7	1	7	9	6	4.5	4
7	2	7	8.5	6	3.5	4
7	3	7	10	6	4	4.5
8	1	7	9.5	6	3.5	5
8	2	7	11	4.5	3	4.5
8	3	7	10.5	4	3.5	4
9	1	7	7.5	6	5	5
9	2	7	7	4	5	4
9	3	7	7	4	2	3
1	1	8	9.5	5.5	4.5	3.0
1	2	8	10.0	6.0	5.0	3.0
1	3	8	10.0	6.0	4.0	4.0
2	1	8	7.5	4.0	4.0	3.5
2	2	8	9.0	4.0	3.0	3.5
2	3	8	8.5	4.5	4.0	3.5
3	1	8	7.0	5.0	3.0	4.0
3	2	8	10.0	5.0	3.0	4.0

3	3	8	10.0	4.0	2.5	4.0
4	1	8	9.0	6.0	3.0	2.0
4	2	8	10.0	6.0	4.5	4.0
4	3	8	8.0	4.5	3.5	4.0
5	1	8	9.0	6.0	4.5	3.0
5	2	8	10.0	6.0	4.0	4.0
5	3	8	10.0	5.0	4.0	3.0
6	1	8	10.5	2.5	4.5	2.5
6	2	8	9.5	3.5	4.5	2.0
6	3	8	11.0	4.5	5.5	2.5
7	1	8	7.5	5.0	4.0	5.5
7	2	8	9.5	6.0	4.0	5.0
7	3	8	8.0	5.0	5.0	4.5
8	1	8	9.0	3.5	3.0	6.0
8	2	8	11.0	4.0	3.0	.
8	3	8	10.5	5.0	2.0	5.0
9	1	8	9.0	3.0	6.0	4.0
9	2	8	8.0	4.0	5.0	4.0
9	3	8	10.0	5.0	4.0	5.0
1	1	9	8.0	6.0	4.0	4.0
1	2	9	9.0	5.0	5.0	4.0
1	3	9	9.0	6.0	4.5	4.5
2	1	9	7.0	3.5	4.0	3.5
2	2	9	7.5	4.0	4.0	3.5
2	3	9	8.0	4.0	4.0	3.5
3	1	9	6.5	4.0	3.5	3.0
3	2	9	10.0	4.0	3.0	3.0
3	3	9	8.0	3.0	2.0	3.0
4	1	9	7.5	5.5	4.0	3.0
4	2	9	8.0	5.5	6.0	3.0
4	3	9	7.0	6.0	3.0	2.0
5	1	9	9.0	4.5	4.0	3.0
5	2	9	11.0	6.0	4.0	4.0
5	3	9	10.0	7.0	3.0	4.5
6	1	9	8.5	5.0	5.0	1.5
6	2	9	6.5	1.5	5.5	1.5
6	3	9	7.0	4.5	5.0	2.0
7	1	9	8.0	6.0	5.0	5.0

7	2	9	8.0	6.0	4.5	4.5
7	3	9	7.5	5.0	5.0	3.0
8	1	9	9.5	3.7	3.0	5.5
8	2	9	10.0	3.5	4.0	6.0
8	3	9	9.0	6.0	2.5	4.5
9	1	9	8.0	4.0	5.0	4.0
9	2	9	10.0	4.0	4.0	4.0
9	3	9	9.0	5.0	5.0	5.0
1	1	10	10.0	6.0	4.5	5.0
1	2	10	10.5	5.0	4.0	4.0
1	3	10	9.0	6.0	4.0	4.5
2	1	10	7.5	5.0	3.5	4.0
2	2	10	8.5	4.0	3.5	3.5
2	3	10	8.0	4.0	4.5	4.0
3	1	10	7.5	3.0	2.0	3.0
3	2	10	7.5	4.5	3.0	4.0
3	3	10	10.0	4.0	2.0	3.0
4	1	10	10.0	5.0	4.5	3.5
4	2	10	8.5	6.0	4.0	4.0
4	3	10	9.0	4.0	3.0	3.0
5	1	10	10.0	6.0	4.5	3.5
5	2	10	10.0	6.5	3.5	4.5
5	3	10	11.5	7.5	3.0	5.0
6	1	10	7.0	3.0	5.0	2.5
6	2	10	10.0	5.0	5.0	2.5
6	3	10	7.0	4.5	5.5	2.0
7	1	10	7.5	5.5	5.0	5.0
7	2	10	9.0	6.0	4.5	4.0
7	3	10	7.5	6.0	5.0	4.0
8	1	10	9.0	3.0	3.0	4.0
8	2	10	9.0	4.5	4.0	6.0
8	3	10	11.0	6.0	2.0	5.0
9	1	10	11.0	5.0	5.0	5.0
9	2	10	10.0	5.0	5.0	4.0
9	3	10	6.0	5.0	4.0	5.0
1	1	11	9.0	7.0	5.0	5.0
1	2	11	9.0	7.5	5.0	5.0
1	3	11	10.0	6.5	4.0	4.5

2	1	11	7.0	4.0	4.0	3.5
2	2	11	8.0	4.0	4.0	4.0
2	3	11	8.5	4.0	4.5	4.0
3	1	11	9.0	4.0	3.0	4.0
3	2	11	10.0	5.0	3.0	3.5
3	3	11	9.0	3.0	2.0	3.0
4	1	11	8.0	6.0	3.5	4.5
4	2	11	8.0	6.0	3.0	3.0
4	3	11	8.0	6.5	3.0	4.5
5	1	11	11.0	7.0	3.5	4.5
5	2	11	9.0	4.0	4.5	3.5
5	3	11	10.0	7.0	3.5	5.0
6	1	11	10.5	6.0	6.5	2.0
6	2	11	9.5	3.0	4.5	3.0
6	3	11	7.0	5.0	5.0	2.0
7	1	11	7.0	5.0	4.5	4.0
7	2	11	9.0	6.0	4.5	4.0
7	3	11	8.5	6.0	5.0	3.5
8	1	11	9.0	4.0	2.5	6.0
8	2	11	9.5	5.0	3.0	5.0
8	3	11	10.0	4.0	2.5	5.0
9	1	11	8.0	5.0	4.0	5.0
9	2	11	10.5	5.0	5.0	5.0
9	3	11	8.0	4.0	5.0	5.0
1	1	12	8.5	6.5	5.0	5.0
1	2	12	8.0	6.0	5.0	5.0
1	3	12	8.0	7.0	5.0	5.0
2	1	12	8.0	4.0	4.0	4.5
2	2	12	9.0	4.0	3.5	3.5
2	3	12	8.5	4.5	4.0	3.5
3	1	12	7.5	4.0	3.0	4.0
3	2	12	10.0	5.0	3.0	4.0
3	3	12	11.0	5.0	2.0	3.0
4	1	12	7.5	6.0	5.0	4.0
4	2	12	6.5	6.0	4.0	3.5
4	3	12	7.5	6.0	3.0	4.0
5	1	12	10.0	7.0	3.5	6.0
5	2	12	10.0	5.0	4.0	4.0

5	3	12	11.0	6.5	3.5	4.0
6	1	12	5.5	5.0	5.5	3.0
6	2	12	12.0	4.5	4.5	2.0
6	3	12	7.5	3.0	5.0	1.5
7	1	12	7.5	6.0	5.0	4.5
7	2	12	10.0	6.0	4.5	4.5
7	3	12	8.5	5.0	5.0	4.0
8	1	12	10.0	4.0	2.5	5.0
8	2	12	10.5	4.0	3.0	5.5
8	3	12	9.0	5.0	3.0	6.0
9	1	12	10.0	5.0	5.0	6.0
9	2	12	10.0	5.0	3.5	5.0
9	3	12	9.0	5.0	3.0	6.0
1	1	13	10.0	6.0	4.0	4.0
1	2	13	10.5	6.5	5.0	5.0
1	3	13	10.5	7.5	5.0	4.5
2	1	13	8.0	4.0	4.5	4.0
2	2	13	9.5	4.5	3.5	3.5
2	3	13	7.5	4.0	3.5	4.0
3	1	13	8.0	4.0	3.0	2.5
3	2	13	10.0	4.0	3.0	4.0
3	3	13	10.0	5.0	2.0	3.0
4	1	13	10.0	5.5	3.5	4.0
4	2	13	9.0	5.5	3.5	3.0
4	3	13	7.0	6.0	3.5	4.0
5	1	13	9.0	6.0	3.0	6.0
5	2	13	11.0	4.0	4.5	3.0
5	3	13	10.0	7.5	3.0	6.0
6	1	13	9.5	3.0	5.0	2.0
6	2	13	11.0	4.0	4.5	3.0
6	3	13	9.0	4.5	4.5	2.5
7	1	13	7.0	5.0	4.0	4.5
7	2	13	9.0	5.0	3.5	3.0
7	3	13	8.5	6.0	4.5	5.0
8	1	13	10.5	4.0	2.5	5.0
8	2	13	10.0	4.5	3.5	6.0
8	3	13	9.5	4.5	2.5	6.0
9	1	13	9.0	5.0	4.0	6.0

9	2	13	9.0	5.0	4.0	5.0
9	3	13	10.0	6.0	3.0	5.0
1	1	14	10.0	6.5	4.5	4.0
1	2	14	10.0	7.0	4.0	5.0
1	3	14	11.0	7.0	4.5	4.5
2	1	14	8.0	4.0	3.5	4.5
2	2	14	9.0	4.0	3.5	3.5
2	3	14	7.5	3.5	3.0	3.0
3	1	14	9.0	3.0	3.0	5.0
3	2	14	10.0	5.0	3.0	4.0
3	3	14	11.0	4.0	2.0	4.0
4	1	14	9.5	6.5	4.0	4.0
4	2	14	9.5	4.0	5.0	2.0
4	3	14	9.0	6.0	4.0	2.5
5	1	14	11.0	6.0	4.0	3.5
5	2	14	11.0	6.0	4.0	5.0
5	3	14	11.0	7.0	3.0	5.0
6	1	14	10.0	5.0	4.5	1.5
6	2	14	10.5	3.5	4.5	2.0
6	3	14	10.0	5.5	4.5	2.0
7	1	14	8.0	5.0	4.0	5.0
7	2	14	9.5	5.0	4.0	3.0
7	3	14	9.0	6.0	4.0	4.0
8	1	14	10.5	6.0	2.5	6.0
8	2	14	10.0	4.0	3.0	5.5
8	3	14	10.0	6.0	2.0	5.0
9	1	14	9.0	5.0	4.0	4.0
9	2	14	10.0	5.0	4.5	5.0
9	3	14	7.5	6.0	3.0	6.0
1	1	15	9.0	6.5	4.0	3.0
1	2	15	9.0	6.5	5.0	4.0
1	3	15	9.0	7.0	4.0	4.0
2	1	15	7.5	5.0	4.0	5.0
2	2	15	8.5	3.5	3.5	4.0
2	3	15	8.5	4.5	3.5	3.0
3	1	15	7.5	4.5	3.0	4.0
3	2	15	11.0	5.0	3.0	4.0
3	3	15	11.0	5.0	2.0	4.0

```
   4       1       15      8.5     6.0     3.5     3.0
   4       2       15      9.0     6.5     4.0     4.0
   4       3       15      8.0     6.5     3.5     4.0
   5       1       15      11.0    7.0     4.0     4.0
   5       2       15      11.0    6.0     4.5     5.0
   5       3       15      11.0    6.0     3.5     4.0
   6       1       15      9.5     5.0     5.0     1.0
   6       2       15      10.5    4.5     3.5     3.0
   6       3       15      10.0    4.5     5.0     2.0
   7       1       15     8.0     6.0     3.5     5.0
   7       2       15      10.0    6.0     3.5     4.0
   7       3       15      8.0     6.0     5.0     5.0
   8       1       15      9.0     5.0     5.0     5.0
   8       2       15      11.0    4.0     3.0     5.0
   8       3       15      9.0     6.0     2.5     5.0
   9       1       15      10.0    5.0     5.0     5.0
   9       2       15      11.0    4.5     4.0     5.0
   9       3       15     7.0     5.0     4.0     6.0
;

/*proc contents data=Necc; run;
proc means data=necc; run;
proc print data=necc; run;*/

/*proc freq;
table A1; run;*/

/*Always Plot your Data*/

/*proc plot vpercent=33;
plot (A1 A2 A3 A4 A5 A6 A7 A8 A9 A10 A11 A12 A13 A14 A15
      A16 A17 A18 A19 A20 A21 A22 A23 A24 A25 A26)*panelist;
run;*/

/*Session=Reps*/

/*Run this GLM first; if Panelist*sample is significant for a given
  attribute then use the GLM with Panelist*sample error term*/
```

```
proc glm data=one;
classes session panelist sample;
model A1 A2 A3 A4 =session panelist sample panelist*sample;
test h=sample e=panelist*sample;
means session sample /tukey line E=panelist*sample
;
run;

/*If Panel*sample is not significant use standard GLM*/

/*proc glm data=one;
classes session panelist sample;
model A1 A7 A11 A12 A13 A15 A16 A19 A20 A21 A22 A23 A24 A25 A26
      =session panelist sample;
means sample /tukey line;
run;*/

proc tabulate data=one;
classes sample;
var A1 A2 A3 A4 ;
table (A1 A2 A3 A4 ), sample*mean*f=10.1/rts=35;
run;
quit;
```