THE EFFECTS OF SPICE BLENDS IN AN APPLE-BASED EXTRUDED CEREAL-LIKE PRODUCT: MAXIMIZING FLAVOR AND HEALTH

by

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B.S., University of Missouri, 2007

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Food Science
College of Human Ecology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2009

Approved by:

Major Professor
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Abstract

The potential health benefits of spices, used as flavor enhancers since ancient times, are being explored more and more by researchers in animal and in vitro models. The application of mood and emotion constructs to understand the consumer psyche is a relatively new area of study in food science. The main objective of our study was to determine if spices (a blend of cinnamon, ginger, nutmeg, and cloves) that have high antioxidant properties evoke/change emotions in consumers. The carrier food, an extruded apple-based cereal-like product, was selected because cereals are convenient and consumed by many. Three cereal-like products containing 0, 4, or a 5% spice blend were extruded at Kansas State University. Four consumer tests, one day of hedonic and just-about-right evaluations (n= 100), followed by three days of emotion testing were carried out. For the emotion tests, 25 consumers saw the control sample three times, 25 consumers saw the 4% blend sample three times, 25 consumers saw the 5% blend sample three times, and 25 consumers saw all three samples once. In a clinical trial (n=10), total antioxidant capacity and blood glucose levels were determined from two samples (control and the 4% blend). The data were subjected to analysis of variance and principal components analysis to determine significant effects and trends in the data, respectively. 'Calm' was the only emotion that was significantly different in all three samples, which decreased over time (pre-consumption to 1-hour post consumption). The emotion 'Satisfied' increased significantly in the 5% blend showing that there might have been an effect because of the higher spice content. The PCAs showed that for the 4% and 5% blends, the movement of the consumers was towards emotions such as active, energetic, and enthusiastic. There were no trends for the control. For the clinical trial, the 4% blend was significantly higher ($P < 0.05$) in total antioxidant capacity than the baseline, although the differences in absolute terms are debatable. Blood glucose levels were not significantly different. Future research needs to be done to better understand how individual emotions affect overall liking and product acceptance.

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Acknowledgements

The completion of a thesis requires the assistance, guidance, and support of a plethora of people. I wish to express my complete gratitude to all of those individuals who extended their expertise and encouragement throughout my "journey." First and foremost, I owe myriad thanks to my major professor, mentor, and friend, Dr. K. Your vast wisdom in sensory and food science, unparalleled generosity, and your ability to see things clearly make you the professor and colleague everyone enjoys having around. Without your statistical brilliance and hours of editing, advice, and counsel, my journey would have been a rough one. Thanks for helping me keep my project within reach, for encouraging me to get involved in other projects, for always providing a good word in my behalf, and for introducing me to my new best friend, B.M. You made my K-State experience a great one and I was grateful having a fellow Tiger in the halls of Justin. The basement and Indian cooking lessons were an amazing bonus. Remember, always add sugar! I look forward to future collaboration, Dave, and baseball games.

I also would like to thank my other committee members, Dr. Edgar Chambers and Dr. Mark Haub. Dr. Chambers, thank you for making complex things seem so simple. I am of the belief that everyone is right on target when the say your expertise and sensory knowledge is unrivaled in the field. Dr Haub, thanks for patience and for giving me the opportunity to obtain some clinical nutrition experience. I also would like to thank Kelcie, Jen, Brian, and James for your early morning assistance!

A special thanks goes out to my motivator, thesis-writing partner, and best friend, Valerie. Thanks for listening to my frustrations, indulging in my excitements, and for your constant support and love. Thanks for sharing late-night cheap pizza, for JU 147 laughter, for fair-trade coffee goodness, and for good mix stations. Now that we've made it, let's "ride the blue all the way to the end of the world."

I appreciate the help from Dr. Alavi, Elisa Karkle, Eric Maichel and the rest of the extrusion team. Thanks for explaining the basics, for your time and flexibility, and for graciously letting me use your equipment and materials.

I would like to recognize and thank Brian Strouts and AIB International for amiably helping me sugar coat the products. Thanks to Tree Top Inc. for generously providing the apple fiber at no cost.

Next, I would like to express my utmost appreciation to Marianne Gillette, Silvia King, and Milda Embuscado at McCormick and Company. Your expertise and collaborative ideas helped me align my passions of sensory and nutrition into a unique and successful thesis project. Silvia, I cannot thank you enough for what your mentorship and for getting me intrigued to study emotions. Thanks for hastily responding to my never-ending emails. Thanks also to Guy Johnson at the McCormick Science Institute for generously supplying the spice samples.

Sherry, you were a life saver. Thanks for always listening and for your endless support and encouragement. I would have had a nervous breakdown had you not helped immensely with the endless consumer tests! I am grateful for the fun and laughter that you always provided to me and the SAC crew. You make working a good time.

Lastly, I would like to thank all of my friends and family who have supported me the past couple of years. Jared and Stacy, thanks for listening to me vent and for being my Manhattan family. I love you guys so much! I appreciate the friendships I have gained at SAC. You all will always hold a close place in my heart and I look forward to seeing you all around. It is a small world in sensory, and I will miss all of you telling me I need a haircut!

CHAPTER 1 - Review of Literature

An Overview of Herbs and Spices

The differentiation of spices and herbs is often unknown by those outside of the culinary world. An herb is defined as the leaf of a plant such as basil, bay leaf, mint, oregano, and thyme. Herbs are often consumed fresh or used in cooking. A spice is defined as all other parts of a plant, besides the leaves, though bulbs are often classified as herbs. Spices are often consumed once they have been dried. Types of spices include: barks, roots, rhizomes, seeds, dried fruits/berries, flower stigmas, and buds. Examples of spices include: cinnamon, cloves, nutmeg, ginger, saffron, mustard seed, black pepper, and turmeric (Lampe 2003).

History of Herbs and Spices

Herbs and spices have been used since ancient times. The Sumerians embraced thyme as a health ingredient as early as 5000 BCE, while in Ethiopia there was an extensive spice trade, dating somewhere between 4500-1900 BCE. The Egyptians had a passion for spices and herbs as they used them for flavoring foods, embalmment of the dead, and as medicines. Ancient Egyptians worshipped garlic and, thinking it would provide good flavor for meals in the afterlife, it was placed in many tombs of Egyptian kings. The Egyptians also fed garlic to their slaves to promote health and strength.

In ancient Greece and Rome, herbs tended to be more prevalent than spices, as Hippocrates outlined 300 herbal remedies during his life (460-377 BCE). Garlic was used to treat cancer, mint helped with digestive health, licorice had extensive uses including anti-inflammatory properties and for treatment of ulcers and asthma, and rosemary was used to improve memory. These cultural remedies have been passed down through the ages, evidenced by the fact that Greek students still burn rosemary incense before tests, hoping it will enable them to remember their studies. Around the first century, a Greek botanist and physician named Pedanius Dioscorides expanded Hippocrates' previous work and published the first plant monograph outlining how to pick, store, and use a variety of plants for health purposes. The Roman emperor Charlamagne was quoted as saying, "an herb is a friend of physicians and the praise of cooks," signifying their duality as both flavor enhancers and what we term "functional foods" today (Hemphill and Cobiac 2006).

Chinese legend credits two Chinese emperors, Sheng Nong and Huang Di, for the discovery of herbs and documenting their medicinal properties. Culturally, the Chinese have

fused the concepts of food, nutrition, and health, as evidenced by their diet and cuisine. Common dishes typically include an assortment of spices and herbs to boost health. Ginseng is thought to improve stamina and cognition, galangal aids in digestion, nutmeg is thought to decrease diarrhea and its symptoms, and cinnamon is thought to be a cure for the flu and common cold in Chinese culture.

Spices and herbs are a big part of Indian culture as well. Traditional medicine, known as Ayurveda, was passed on orally from around 5000 BCE until it was written in Sanskrit in 1500 BCE. The Ayurveda emphasizes the promotion of well being, health, and disease prevention through food sources. Indians are known for their health claims for turmeric and cinnamon. Indians use a plethora of spices and herbs for flavoring, so they consume a significant amount daily through their diet. Indian culture identifies ginger as the universal medicine, a natural cure for the upset stomach (Hemphill and Cobiac 2006).

Current Research for Cinnamon, Ginger, Nutmeg, and Cloves

Cinnamon

Cinnamon is the second most used spice, with black pepper being the first. It has been used for thousands of years as a suspected medicinal and health agent, as well as a flavor enhancer. It comes from the inner bark of evergreen trees, the major constituent being cinnamaldehyde (Singletary 2008). There has been a plethora of cell culture studies and research and findings in animals, but more scientific evidence is needed to certify the health benefits of cinnamon for humans.

Antidiabetic Agent

One of the heavily researched study areas for cinnamon is its purported claim of lowering blood glucose and insulin in the blood. Studies show that cinnamon has decreased blood glucose and insulin levels in diabetic rats and rats fed high sugar diets (Kannapan and Jayaram 2006; Talpur *et al.* 2005). Human studies are slightly more inconclusive as inconsistencies are evident in the research done. Khan *et al.* (2003) and Mang *et al.* (2006) reported that cinnamon decreased fasting blood glucose levels in clinical studies conducted using type 2 diabetes patients. In other clinical studies concentrating on the possible diabetic benefits of cinnamon, fasting blood glucose was not affected by the consumption of certain doses of cinnamon in type

2 diabetes patients (Vanschoonbeek *et al.* 2006; Suppapitiporn *et al.* 2006; Blevins *et al.* 2007). The specific compound responsible for the possible reduction of blood glucose and insulin levels is unknown, though cinnamaldehyde is a suspected factor (Babu *et al.* 2007; Imparl-Radosevich 1998).

Antioxidant Effects

Cinnamon is one of the best antioxidant food sources (see Table 1-1). Cinnamon contains approximately 18 mmol/100g of antioxidants. A cross-sectional pharmacological study was conducted using water, tea, and cinnamon tea. The cinnamon tea was shown to increase total antioxidant levels and decrease lipid peroxidation (Ranjbar *et al.* 2006). Polyphenols isolated from cinnamon have been shown to reduce oxidative stress. Antioxidants from cinnamon have demonstrated a possible contribution to cinnamon's antidiabetic effects as antioxidants have been shown to slow diabetic complications and symptoms (Anderson *et al.* 2004; Paolisso *et al.* 1993). The phenolic compounds/phytochemicals are antioxidants that scavenge free radicals and are present in cinnamon. Several cell culture experiments have demonstrated that cinnamon does have bioactive antioxidant activities and the ability to scavenge free radicals (Shan 2005; Singh 2007). Research is scarce as to the bioavailability of antioxidants from spices in human clinical trials (Dugoua 2007).

Antimicrobial Properties

Cinnamon inhibited the growth of bacteria in cell culture studies. It has demonstrated antibacterial, antifungal, and antiviral activity in vitro. Cinnamaldehyde has been shown to inhibit the growth of pathogenic bacteria, such as *Clostridium perfringens*, *Listeria monocytogenes*, and *Escherichia coli* (Lee and Ahn 1998; Ooi *et al.* 2006).

Cholesterol-lowering Properties

Khan *et al.* (2003) reported a slight decrease in LDL cholesterol in a clinical trial with type 2 diabetes patients. However, most of the present literature found this research to be inconclusive (Mang *et al.* 2006; Vanshcoonbeek *et al.* 2006; Blevins 2007).

Ginger

Ginger, often confused as a root, is actually a rhizome of *Zingiber officinale roscoe*. It has a diverse range of usages in flavoring foods, from pickled in sushi, to fresh in stir fry and

ginger ale, to its dried use in cookies. Many medicinal/health benefits are also associated with the spice including: reducing fever, curing colds, minimizing gastrointestinal problems, reducing diabetes, and motion sickness, increasing cardiovascular health, and reducing the chances of cancer, though more conclusive research is needed (Kundu *et al.* 2009). It has approximately 21.5 mmol/100 g of antioxidants (see Table 1-1).

Antioxidant Effects

In cell culture studies, ginger has proven to scavenge free radicals, as well as inhibit peroxidation due to its antioxidant activities. Gingerol is the compound associated with this claim (Bone 1997; Shan *et al.* 2005).

Cholesterol-lowering Properties

In animal studies, ginger has shown the ability to improve blood lipid profiles by reducing LDL cholesterol and increasing HDL cholesterol (Gujral *et al.* 1978; Bhandari *et al.* 1998). Human research studies are lacking, as well as a firm understanding of the mechanisms behind the claim.

Anticancer Properties

Finally, ginger has shown the potential effect to be chemopreventive. Gingerol, a phenolic compound, has antimutagenic and anticarcinogenic properties, stemming from its antioxidative and anti-inflammatory properties (Surh 1998).

Nutmeg

Nutmeg, also known as *Myristica fragrans*, comes from the seed of evergreen tree native to Indonesia. Interestingly, the spice mace comes from the covering of the same seed. (Shulgin *et al.* 1967). In the United States, it is traditionally used as a sweet spice, such as in cookies or eggnog, but in world cuisine it is commonly consumed as a savory spice. Though traditionally known to be a pain reliever, in excess it has toxic effects. Nutmeg toxicity leads to psychotropic effects, including hallucinations and other unpleasant effects, though large doses are required to reach levels of toxicity (Sangalli and Chiang 2000).

Antioxidant Effects

Nutmeg possesses powerful antioxidants, containing approximately 2000 ORAC/tsp. In vitro, the phytochemicals (antioxidants) have shown bioactivity as the scatter free radicals at a moderate rate (Shan *et al.* 2005). More research is needed from human clinical studies.

Antidiabetic Agent

Broadhurst *et al.* (2000) determined that nutmeg has antidiabetic properties in an animal study, as it enhances insulin activity. Research is lacking in this claim, necessitating future research to gain a better understanding on the claim.

Cloves

Cloves (Eugenia caryophylllus) are the dried flower buds of a plant from the Myrtle family. They are strongly aromatic and contain the pungent chemical compound, eugenol, known for numbing and its characteristic aroma (Singh *et al.* 2009). Therefore, when adding to food, it should be used sparingly. Clove is a powerful antioxidant, also known for its antibacterial (Cai and Wu 1996), anesthetic (Ghelardini *et al.* 2001), and aphrodisiac activities (Taajuddin *et al.* 2003).

Antioxidant Effects

Cloves contain the most antioxidants of any food source, containing approximately 125.5 mmol/100 g (see Table 1-1). (Shobana and Naidu 2000). In vitro, cloves demonstrated the strongest radical scavenging activity. Cloves also contained the highest level of phenolics when analytically measuring and comparing 26 spices using the Folin-Ciocalteu colorimetric method (Shan *et al.* 2005; Oya *et al.* 1997). In rats, the spice has also been shown to scavenge free radicals during aflatoxicosis (Abdel-Wahhab *et al.* 2005). More research needs to be conducted using human subjects to determine the bioavailability of the antioxidants found in cloves.

Antidiabetic Agent

Broadhurst *et al.* (2000) determined that cloves have antidiabetic properties in an animal study, as the spice enhances insulin activity. Like ginger, further research needs to be carried out to strengthen this possible claim.

Table 1-1 Antioxidant Values of the Top Food Sources (Halvorsen *et al.* 2006)

The 50 foods with the highest antioxidant content

Product	Antioxidant content[1]
	mmol/100 g
Cloves, ground	125.549
Oregano leaf, dried	40.299
Ginger, ground	21.571
Cinnamon, ground	17.647
Turmeric powder	15.679
Walnuts	13.126
Basil leaf, dried	12.307
Mustard seed, yellow, ground	10.527
Curry powder	9.980
Pecans	9.668
Chocolate, baking, unsweetened	8.876
Paprika	8.601
Chili powder	8.372
Parsley, dried	7.430
Molasses, dark	4.900
Pepper, black	4.444
Artichokes, prepared	4.237
Chocolate, dark	4.188
Blackberries	3.990
Whole-grain cereal	3.412
Cranberries	3.289
Pudding mix, chocolate, cook-and-serve	3.026
Bran cereal	2.925
Power bar, chocolate flavor[2]	2.757
Chocolates, sugar-free	2.567
Raspberries	2.334
Strawberries	2.159
Blueberries	2.154
Cabbage, red, cooked	2.153
Wine, red	2.135
Barley malt syrup, organic	2.121
Prunes	2.018
Cherries, sour	1.814
Peppers, red, cooked	1.640
Chocolate cookies with vanilla creme filling	1.604
Cocoa Krispies cereal[3]	1.558
Chocolate chip cookies	1.524
Mustard, yellow, prepared	1.501
Milk-chocolate candy	1.483
Pistachios	1.426
Plums	1.330
Kiwi fruit	1.325
Corn flakes	1.255
Coffee	1.249
Spinach, frozen	1.226
Flaxseed, ground or milled	1.125
Rice and corn cereals	1.121
Toasty peanut crackers	1.101
Cupcakes, chocolate	1.059
Grape juice	1.011

[1] All values are means.
[2] POWERBAR Co, Berkeley, CA.
[3] Kellogg Co, Battle Creek, MI.

Clinical Focus: Diabetes and Antioxidants

Diabetes

Type 1 diabetes is an autoimmune disease, eliciting hyperglycemia caused by a deficiency of insulin in the body. The immune system attacks the beta cells in the pancreas that produce insulin. Insulin is a hormone that facilitates the uptake of glucose from the blood. Without insulin present, glucose remains in the blood, leading to many harmful effects, causing the body burn fat as an energy source. Type 1 diabetes is fatal without insulin injections (Alemzadeh and Wyatt 2007).

Type 2 diabetes is a disease associated with high blood glucose, due to insulin resistance. Insulin is often produced at a normal rate, but the cells cannot effectively uptake glucose from the blood. Type 2 diabetes is a chronic disease with no known cure; however the symptoms can be lessened with a modified diet and increased physical activity (Zimmet *et al.* 2001). Type 2 diabetes has become an epidemic, according to CDC (2009), as rates have doubled from 1990 to 2005. Children are being diagnosed with the disease at an alarming rate. The CDC estimates 23.6 million people have diabetes in the United States, 90% of which have type 2. Type 2 diabetes is diagnosed using a blood glucose analyzer. When the fasting plasma glucose is greater than 7.0 mmol/L (126 mg/dL) type 2 diabetes is confirmed (World Health Organization 2006). Glucose intake should be minimized in those with type 2 diabetes. Research has shown that spices, especially cinnamon, may have blood glucose levels lowering effects (Khan *et al.* 2003; Mang *et al.* 2006).

Antioxidants and Free Radicals

Antioxidants and Free Radicals Overview

Antioxidants are molecules that slow or prevent the oxidation of other molecules which contain substrates that are susceptible to oxidation. Oxidative stress occurs at the cellular level when the number of oxidants exceeds the number of antioxidants. This stress leads to the formation of free radicals. Free radicals are highly unstable molecules that readily react with other molecules and are often present as hydroxyl radical (·OH) and the superoxide anion (O_2^-). (Valko *et al.* 2007). The oxidation of proteins, lipids, and DNA is particularly harmful in the body. DNA oxidation leads to cancers and the oxidation of proteins leads to protein denaturation

and enzyme inhibition (Nakabeppu *et al.* 2006; Stadtman 1992). The oxidation of lipids is referred to as lipid peroxidation. Free radicals take an electron from lipids, thus damaging the lipid cellular structure, possibly leading to mutagenic or carcinogenic effects (Marnett 1999). Antioxidants are present in the form of enzymatic and non-enzymatic compounds. They protect the cell membranes against the formation of free radicals, which have been shown to increase the chances of certain cancers and cardiovascular diseases by damaging or destroying cells (Wasowicz and Gromadzinska 2005). Antioxidants are reducing agents that are easily oxidized. Antioxidants scavenge free radicals that otherwise would oxidize cells, which would lead to cellular damage or destruction (Wolf 2005). The shelf life of products containing unsaturated fats increases with the presence of antioxidants as they inhibit oxidation that would lead to oxidative rancidity and spoilage by oxidants otherwise (German 1999).

Antioxidants are naturally present in plant sources and therefore, are best obtained from plant-derived foods. Fruits, vegetables, legumes, spices and herbs, teas, coffees, beers, and wines are the richest sources of antioxidants. The antioxidant capacities of animal-derived food sources are dependent on the diet of the animal. If the animal consumes a diet rich in vitamins A or E and/or selenium, some antioxidants will be present in the food, though they are still not a significant source of antioxidants in the diet (Sikora *et al.* 2008).

Antioxidants in the diets are present as: vitamins A, C (ascorbic acid), and E (tocopherols), provitamin A (beta-carotene), selenium, and phenolic compounds (Sikora *et al.* 2008). Selenium and zinc are referred to as antioxidant nutrients because they are not active as antioxidants without the presence of certain enzymes. Carotenoids, including lycopene and lutein, have recently been identified as strong antioxidants. Lycopene has been identified as reducing the chances of obtaining cancer (Wasowicz and Gromadzinska 2005) and lutein protects the retina from free radical damage and is beneficial in the prevention of atherosclerosis (Boban 2002). Phenolic compounds, present as phenolic acids or flavonoids, have recently gained research momentum as effective and powerful antioxidants (Nijveldt 2001; Manach *et al.* 2004). Polyphenols are considered to be the most effective antioxidants, as they work synergistically with other antioxidants to increase their antioxidant activities. Flavonoids are the most commonly present polyphenols but are also present as resveratrols (Sikora *et al.* 2008).

There are a few antioxidants that are synthesized naturally by the body. For example, Ubiquinol (coenzyme Q) and glutathione (made from amino acids) are both produced in the

body. These antioxidants are not produced in abundance, so consumption of antioxidants may be necessary for health (Turunen *et al.* 2004; Witschi *et al.* 1992). However, recent data suggests vitamins E and C may not be effective in reducing the chances of chronic illness (Millen *et al.* 2004).

Antioxidant Assays

Antioxidant assays are divided into two types: hydrogen atom transfer (HAT) reactions and electron transfer (ET) assays. HAT reaction assays include the oxygen radical absorbance capacity (ORAC), the total radical trapping antioxidant parameter (TRAP), and crocin bleaching assays. For these reactions, antioxidants compete with substrates for peroxyl radicals. ET assays include Folin-Ciocalteu reagent (FCR), Trolox equivalence antioxidant assay (TEAC), the ferric reducing/antioxidant power (FRAP) assay, and the DPPH method. ET assays measure the ability of antioxidants to reduce oxidants, which leads to a color change (Huang 2005).

The ABTS (trolox assay) and DPPH methods are the most commonly used antioxidant assays. They both have great reproducibility but generate significant differences in their data output (Wojdylo *et al.* 2007). The ferric reducing/antioxidant power (FRAP) assay is also commonly used. The assay works by using the ferric reducing ability of plasma. The total antioxidants are measurable because antioxidants will reduce the ferric ion (Fe^{3+}) to a ferrous ion (Fe^{2+}). Because of the reduction, the absorption at 593 nm is increased (Benzie and Strain 1996).

Antioxidant capacities are commonly labeled in ORAC units or Trolox equivalents. A list of ORAC values for most foods has been published (Halvorsen *et al.* 2006; Wu *et al.* 2004).

Food Research

Antioxidants are a fairly new scientific area of research in food. Most existing data has been collected within the last two decades, primarily concentrating on the antioxidants in fruits and vegetables. Berries have been particularly highlighted (Sikora 2008). Other areas of emphasis include tea and coffee, with concentrations on epigallocatechin gallate and chlorogenic acid, respectively (Stavric 1995). Research started with micronutrients, such as vitamins A and C, and has recently transitioned into the phytonutrients, such as polyphenols (Sikora 2008). Epidemiological studies have shown inverse relationships between diets rich in fruits and vegetables and to chronic diseases (Ness and Powles 1997, Joshipura *et al.* 1999). Antioxidants

are not heavily concentrated in grains, though the small amount of polyphenols in them can add up because grains are such a large part of peoples' diets (Sikora 2008).

In the past 25 years, the consumption of culinary spices and herbs has increased (Tapsell 2006). Spices and herbs have significant levels of antioxidants, rivaling fruits and vegetables as the best sources on a weight for weight basis. Cloves, ginger, cinnamon, and turmeric have the highest weight for weight antioxidant capacity of any foods (see Table 1-1).

Spice Application

Recently, spices and herbs have been one of the foci of antioxidant research due to the significant amounts of antioxidants. Italian researchers identified many spices as having high amounts of antioxidants and phenolic concentrations. They also found that certain spices, such as marjoram, increased the bioavailability of other antioxidants and nutrients when added to foods (Ninfali *et al.* 2005). Much of the present research is concentrated on total phenolics and antioxidant capacity assays of spices, not on human studies and effectiveness. Most of the antioxidant health studies have been used on animal models (Wojdylo 2007). Capecka *et al.* (2005) identified drying herbs as reducers of antioxidant capacities. More research needs to be conducted to understand the possible synergies that exist between spices and other foods, as well as to understand the bioavailability of these antioxidants. We know spices and herbs have a plethora of antioxidants but the research is limited as to the effectiveness of absorption of them in the human body. The emotional impact of spices also is another area of interest.

Effect of Food on Mood and Emotion

Overview

Affect takes into account two distinctive terms: emotions and mood. Emotions are defined as brief, intense behaviors focused on a referent. An example of an emotion would be the elation one would feel after he or she makes the game-winning touchdown. Moods are behaviors that build up over a longer period of time, last longer, and are not focused on a referent (Frijda 1993). An example of a mood would be one saying that he or she woke up on the "wrong side of the bed" and are therefore in a bad mood, for no apparent reason. It is necessary to identify that emotions can transition to moods and vice versa.

The assessment of emotions and moods has been used for quite some time in the psychiatric setting. In a review of literature, Laros and Steenkdamp (2005) identified 316 emotions, of which 173 were negative. The use of emotions in the food realm is relatively new consumer research that is emerging to identify how food affects emotions. To date, there has been a very limited focus on food product development and its impact on the emotions of consumer liking and acceptability (King and Meiselman 2009). Stepcoe *et al.* (1995) identified in a Food Choice Questionnaire that food affects the way we feel and that mood was a key determinate of food choice. One's emotional state can be altered by a food solely by its appearance; the mere image of the food or memories evoked by it can affect one's mood or emotions. For example, one might experience an increase in disgust by looking at a food that is unappealing (Rozin and Fallon 1987).

King and Meiselman (2009) identified the lack of a consistent and standard method for measuring emotion in the food world. Again, emotions and moods were often measured in the psychiatric setting so the terminologies and methods of measurement are predominantly taken from the clinical setting. The Profile of Mood States (POMS) and Multiple Affect Adjective Check List (MAACL) are two of the staple questionnaires in regards to emotion and mood. Both questionnaires were designed for a clinical setting. Observation of facial expressions, "facial scaling," has also been used to measure emotions. King and Meiselman (2009) established a mood and emotion questionnaire which targets information for use in the commercial food context. For this questionnaire, central location tests (CLTs) and internet surveys were used to identify appropriate terms to accurately measure emotions within the context. This consumer feedback, along with existing questionnaires, including the POMS and MACCL, were used to create a list of pertinent emotions. Thirty-nine emotional terms were selected based on the results of the screening. The list in not intended to be all-inclusive, as terms are often product-specific. Emotions were measured using a 5-point intensity scale, anchored from 1 = not at all to 5 = extremely (see Appendix B). The ballot was named the EsSense Profile™ and was designed to differentiate among completely different food products, as well as among like foods with slight changes in formula. To test the effects of the test, King designed CLTs to see if moods could be based on differentiating food categories including: pizza, chocolate, ice cream, and mashed potatoes and gravy. To test products within the same product category, but with slight

variations, King used salty crackers. In both tests, products were able to be separated and differentiated based on the consumer moods alone.

Relation Between Hedonics and Mood

In reaction to eating foods, consumers are much more likely to associate positive words or emotions, rather than negative ones. This phenomenon is referred to as "hedonic asymmetry." It is attributed to the fact that foods are created to be liked by consumers (Desmet and Schifferstein 2008). If negative words were more prevalent, product developers would know they were moving in the wrong direction. As for product development, data are still lacking concerning the link between acceptance and emotional intensities. Some CLTs have shown a positive correlation between overall liking and positive emotional intensities, while other tests have shown little to no correlation. This finding might provide a reason why a product can be heavily liked in consumer tests and yet fail in the marketplace, as emotions may be factoring into the buying decision (King and Meiselman 2009).

King and Meiselman (2009) also noted the necessity to include a large number of emotions in the ballot. In the tests, 36 out of the 39 emotions showed significant differences, either due to the products or the testing environment. If the researcher reduced the number of terms to tests, potentially critical and useful data that might help to characterize the product accurately might be overlooked. Hence, a longer list of emotions is essential, especially when characterizing new products.

Another important finding is that product users tend to have more positively anchored emotions than non-users, who have stronger negative emotion profiles. Generally speaking, this coincides with hedonic data, with users rating 6 or higher and non-users rating less than 5 on a 9-point hedonic scale.

According to Gibson (2006), one's mood or emotion can be affected by food choice and vice versa. Consumers often eat foods, consciously or subconsciously, that coincides with their current mood status or the mood outcome desired. An example would consumers eating pleasurable foods that activate neural substrates which underlie affective behaviors. The foods often lead to a reduction of stress and a rise in mood status, often due to the suppression of negative emotions or moods. Personality and other cognitive factors also affect the level to which moods are changed when eating hedonically acceptable food (Matthews 1998). The

neural substrates that increase pleasure include dopamine, opioid, and benzodiazepine neurotransmitter systems. Dopamine is thought to be released in response to wanting food, whereas the opioid and benzodiazepine systems are released in response to the hedonic impact and acceptance of foods (Berridge and Robinson 1998).

Again, it has been identified that foods affect emotion and mood. Benton and Donohoe (1999) identified that carbohydrate-rich, intensely sweet foods, and some micronutrients, such as thiamine, increase positive moods and emotions. The positive affect of high carbohydrate foods has been linked to the release of endorphins, which are neurotransmitters in the brain that relieve pain and produce a feeling of wellness. (Benton and Donohoe 1999).

When consumers are burdened by negative emotions outside of eating, the emotions affect eating habits. The consumption of food is increased by restrained eaters, bulimic or those who tend to binge eat, while emotional eaters consume foods high in carbohydrates (sweet) and fat (Macht 2008).

Macht and Simons (2000) did a review of existing surveys and reported that consumers' appetites are affected by emotional stress (see Table 1-2). When all the survey were averaged, emotionally stressed consumers were 30% more appetitive and 48% less appetitive.

Table 1-2 Changes in Appetite in Response to Emotional Stress (Macht 2008)

Change of eating	*N*	Reference
11% more appetite, 70% less appetite	364	Krumbacher and Meyer (1963)
16% more appetite, 38% less appetite	1950	Pudel and Richter (1980)
25% more appetite, 32% less appetite	1024	Pudel (1984)
44% eat more, 48% eat less	80	Willenbring et al. (1986)
4% eat more, 55% eat less	475	Popper et al. (1989)
49% eat more, 51 do not eat more	500	Spillman (1990)
55% eat more, 45% do not eat more	101	Weinstein et al. (1997)
38% eat more, 42% eat less	212	Oliver and Wardle (1999)

Several emotions, including anger, sadness, and joy, are thought to be prolonged in duration and have been identified for their affects on eating responses throughout the ingestion

cycle. Such affects include eating motivation (Macht and Simons 2000), affective responses to foods (Willner and Healy 1994), affect on food choice (Gibson 2006), chewing (Macht 1998), eating speed (Krebs *et al.* 1996), and metabolism and digestion (Blair *et al.* 1991). Table 1-3 summarizes how emotions affect our eating responses. It is important to note that some studies came to opposite conclusions as to the effect the emotion had on the eating measurement (i.e. fear increases/decreases/has no effect on food intake).

Table 1-3 Emotional Effects on Eating (Macht 2008)

Effects of emotions on eating: experimental studies in normal subjects

Effect	Eating measure	Emotion	Reference
Increase	Food intake	Negative mood	Lowe and Maycock (1988)
		Negative mood	Willner et al. (1998)
		Fear	Pine (1985)
		Fear	Pines and Gal (1977)
		Fear	Bellisle et al. (1990)
		Arousal	Glass (1967)
		Arousal	Cantor et al. (1982)
		Arousal	Grunberg and Straub (1992)
		Boredom	Abramson and Stinson (1977)
		Anger	Macht (1996)
	Hedonic responses	Arousal/stress	Ferber and Cabanac (1987)
		Joy	Macht et al. (2002)
	Motivation to eat	Joy	Macht et al. (2002)
		Anger	Macht (1996)
	Chocolate craving	Negative mood	Willner et al. (1998)
Decrease	Food intake	Negative mood	Baucom and Aiken (1981)
		Fear	Schachter et al. (1968)
		Fear	Herman and Polivy (1975)
		Fear	Heatherton et al. (1991)
		Fear	Herman et al. (1987)
		Fear	Bellisle et al. (1990)
		Arousal	Grunberg and Straub (1992)
	Hedonic responses	Depressive mood	Willner and Healy (1994)
		Sadness	Macht et al. (2002)
	Motivation to eat	Sadness	Macht et al. (2002)
		Arousal	Macht (1998)
	Chewing	Arousal	Macht (1998)
Effect	Eating measure	Emotion	Reference
No effect	Food intake	Negative mood	Frost et al. (1982)
		Negative mood	Tuschen et al. (1993)
		Negative mood	Telch and Agras (1996)
		Negative mood	Ruderman (1985)
		Fear	Reznick and Balch (1977)
		Fear	Heatherton et al. (1991)
		Fear	Schotte et al. (1990)
		Fear	Cools et al. (1992)

Hedonics, food, and mood and emotions are often interrelated due to food's effect on the body. When people are hungry, they are often irritable and aroused. The consumption of foods therefore will increase satiation, which in turn induces calming and positive thoughts. Thus, eating is generally a positive experience in healthy consumers. The alteration of the moods can consciously or subconsciously affect the liking of a particular food (Macht *et al.* 2004).

Rationale

Spice consumption is on the rise as consumers are looking for new and trendy flavors. According to the USDA (2007), per capita spice consumption increased from 1.2 to 3.3 pounds per year from 1966 to 2006. Better knowledge about the functionality and benefits of these culinary flavor agents could further increase the demand for spices and herbs. If the antioxidants are found to be highly bioactive and/or the antidiabetic claims are further solidified, then the consumption of spices and herbs could have significant effects on the one's health.

The ready-to-eat cereal category is a 6 billion dollar industry and cereal snacks/bars are also a growing sector at just over 450 million dollars of sales in 2004 generated (Whitaker 2004). An extrusion base was used because cereal represents a growing market, is convenient, and is eaten by a majority of consumers. The hedonic data will help determine the optimal amount of spices to maximize liking. Consumers want enough spices to effectively flavor their foods but not too much to the point they overwhelm the senses. Finally, the research should provide a better understanding of the emotional impact of consuming the spices used. This will show whether the spices could improve wellness by improving overall mood and emotional status.

Objectives

We found limited to no research on the effect of spices on mood and emotion or human clinical studies outlining the benefits of foods with functional spice blends. The major objective of this study was to determine the effects of a spice blend (cinnamon, ginger, nutmeg, and cloves) on the emotions of consumers. The difference between consumers who evaluated products one time and consumers who evaluated the products three times during the emotion study was also determined. Further, the health implications (blood glucose effect and bioactivity of antioxidants) of the spices were studied in a small group of human subjects. The carrier food was an extruded apple-based cereal-like product containing 0, 4, and 5 g/100 g levels of the spice blend.

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CHAPTER 2 - Detailed Materials and Methods

This research was divided into four segments. The first part included the development of an extruded cereal-like product. The second section consisted of four consumer tests, focusing on hedonics and emotions. A small clinical trial was completed in the third section. Analysis of the data was the fourth and final step in the research. Approval from Kansas State University's committee for research involving human subjects (IRB) was obtained for both the consumer tests and clinical trial before conducting the study.

Section 1 - Preparation of the Extruded Cereal-Like Samples

The foods evaluated in the study were an extruded cereal-like mix with the base of corn flour (Bunge Milling Inc. St. Louis, MO), apple fiber (Tree Top Inc., Selah, WA), and salt that was extruded in a Micro-18 twin-screw extruder (American Leistritz, Somerville, NJ). All the foods were evaluated at Kansas State University with controlled processing parameters (see Figure 2-1). Three blends were formulated, including a control and two test samples with spices, including cinnamon, ginger, nutmeg, and cloves (McCormick and Company experimental samples, Hunt Valley, MD). The spices were added at varying percentages (see Table 2-1). Ten kilograms of each sample were extruded and each sample was weighed out in three batches due to scale weighing constrictions. The dry ingredients were blended in a model A-200 mixer (The Hobart Mfg. Co., Troy, OH) at medium speed for 5 min and water was sprayed in continuously until the specified moisture content of 20% was reached. The final "wet" mix was blended for an additional five minutes to ensure a homogenous mixture. The wet mix was sealed in 1-gallon Ziploc bags and then placed in a refrigerator (1 C) for 48 hours in order for the moisture content to standardize and for the sample to equilibrate. After 48 hrs, each sample was extruded.

Oxygen Radical Absorbance Capacity (ORAC) analysis was conducted on many foods by the USDA (2007). The spices and ORAC values for those used in the developed extruded cereal-like product are as follows: cinnamon (267,536 µmol TE/100 g), ginger (28,811 µmol TE/100 g), nutmeg (39,800 µmol TE/100 g), and cloves (314,446 µmol TE/100 g). The spice blend was formulated on the basis of providing a substantial amount of antioxidants, as well as attempting to maximize overall liking. The level of each spice was multiplied by the ORAC concentration for the respective spices to calculate a total ORAC value for the extruded cereal-like product. Using the set ORAC values as references and taking into account the specific spice percentages, the ORAC value of the product was 2,204 µmol TE/serving. Two servings (60 g)

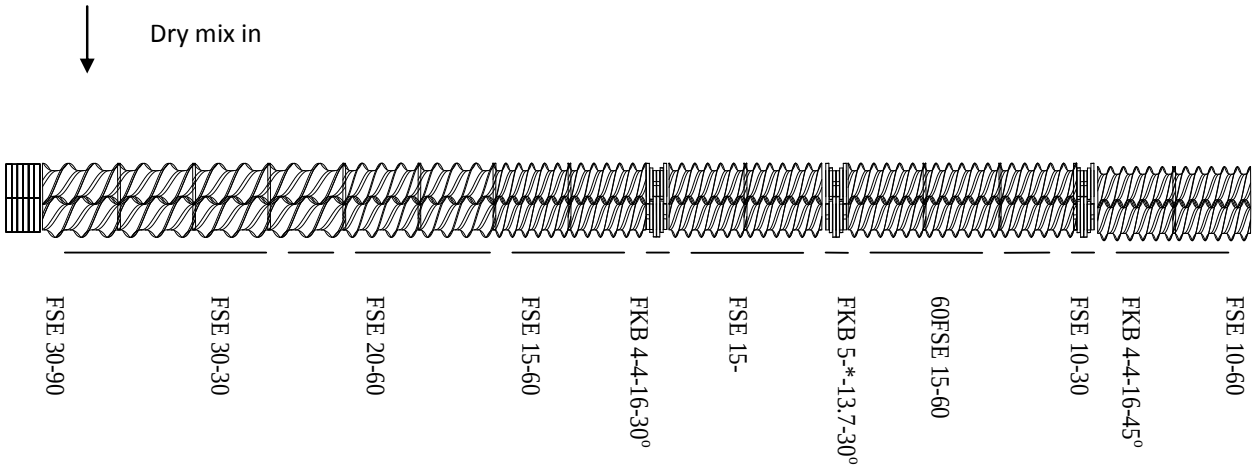
of product were consumed for the clinical study, so approximately 4,408 µmol TE were consumed. A single serving provides a substantial amount of total ORAC recommended by health experts (Prior *et al.* 2007).

Prior to extrusion, the moisture content of the cereal-like products was standardized at 20%. In order to do this, the moisture content of the volatile matter was calculated and water was added to each blend respectively (see Table 2-1) to give it a pre-extrusion moisture content of 20%. The percent moisture was calculated in triplicate and averaged. The percent moisture of volatile matter is calculated as follows:

$$\%\,\text{Moisture of Volatile Matter} = \frac{(\text{Moist Weight} - \text{Dry Weight})100}{\text{Dry Weight}}$$

Initially, an aluminum moisture dish (55 mm diameter) was tared on a scale and 2 g of the sample were placed in the dish. The 2 g samples were baked in an oven (Thelco lab oven) at 135 C for 2 hrs and weighed for dry weight after cooling for 5 min.

Figure 2-1 Extrusion Parameters



The forward screw element (FSE) was double-flighted. FKB represents the forward kneading block and RKB represents the reverse kneading block. For screw elements, the first number indicates the length of flight and the second number indicates the total element length. For kneading blocks, the numbers indicate the number of blocks, length of blocks, total element

length and angle of blocks, respectively. All lengths are in millimeters (* 1 block 3.2 mm + 3 blocks 2.5 mm + 1 block 3 mm).

The Micro-18 twin-screw extruder had a feed rate of approximately 2.5 kg/h and a screw speed of 350 rpm. The temperature profile was: 50, 65, 80, 90, 110, and 120 C respectively. The extruder used a 3.1 mm circular die and no cutting tool was present to evenly break up the extruded product.

Table 2-1 Ingredient Percentages

Ingredients	**Blend (test) 1**	**Blend (test) 2**	**Blend (control) 3**
Cinnamon (%)	57.00	57.00	N/A
Ginger (%)	22.00	22.00	N/A
Nutmeg (%)	15.00	15.00	N/A
Cloves (%)	6.00	6.00	N/A
Salt (%)	1.00	1.00	1.00
Corn Flour (%) wet mix	66.20	66.98	70.05
Apple Fiber (%) wet mix	18.67	18.89	19.75
Total Spice (%) wet mix	4.24	3.44	N/A
Added Moisture (%)	11.15	10.90	10.25

The cereal-like products were stick-shaped, brown to dark brown in color, extruded onto cookie sheets, and broken by hand into approximately 5 cm pieces in length and 6 mm in diameter. Each sample was tested in duplicate for percent moisture of volatile matter. After extrusion, the samples were dried in a commercial convection oven (Bodgett, Topeka, KS) at 121 C for 30 min to achieve final moisture content under 4% to minimize possible microbial contamination. The samples were placed in 1-gallon Ziploc bags (S.C. Johnson & Son, Inc., Racine WI) and were double bagged to minimize oxidation.

A simple syrup was prepared using equal parts sugar (C&H cane sugar) and water. The syrup was made on a stove top. A four gallon pot of water was brought to a boil. The sugar was then added and the heat was reduced to a simmer (180 C). The mixture was stirred for three minutes and removed from the heat after the sugar had fully dissolved into the solution. A total of 25 kg of syrup (12.5 kg sugar and 12.5 kg water) was prepared and placed in the refrigerator (1 C) overnight to equilibrate. The syrup was placed in the tank of a sprayer (Advanced Bakery Engineering, Inc.) at AIB International (Manhattan, Kansas). The product was coated with the syrup by the sprayer. The weight addition was 28%, meaning that approximately 14% sucrose was added to the final product. The product was set on a tray, immediately placed in an industrial convection oven (Revent Inc. Somerset, NJ), and baked at 110 C for 20 min. Finally, the moisture contents of the samples were taken with a moisture balance heat lamp (CSC Scientific Company, Inc. Denver, CO). Moisture content of the samples was analyzed in triplicate and the numbers were averaged to get the final product moisture contents. The moisture contents of each blend were: Blend 1 = 3.1%, Blend 2 = 2.9%, and Blend 3 = 2.7%.

The cereal-like products were relatively constant in texture, varied in spice flavor, and were presented to the consumers as an extruded cereal-like product.

Section 2 - Consumer Studies

Consumer Demographics and Hedonic Testing

One hundred consumers (61 females and 39 males) were recruited from Manhattan, Kansas to participate in four consumer tests at Kansas State University in Justin Hall. The participants were recruited on the basis that they could attend all four sessions, had no known allergies, regularly consumed cinnamon, cloves, and nutmeg, and were within the age criteria. Age ranges were 18-24 (19%), 25-40 (42%), 41-55 (28%), and 56-69 (11%). A total of four consumer tests were conducted during a two week period. Informed consent, age, gender, and ethnicity demographics were obtained. The following is the consumer racial background: 89 Caucasians, 5 Latin Americans, 4 African Americans, 1 American Indian, and 1 "Other." Approximately 10 g of each product was served using a sequential monadic test design. The products were labeled with a randomly generated 3-digit code and served in sandwich-sized Ziploc bags (S.C. Johnson & Son, Inc., Racine, WI). The consumers completed a 2-page

questionnaire with overall liking and JAR questions (see Appendix A) per product. The serving order was randomized and balanced.

Consumer Emotion Testing

The final three sessions were emotion-focused, with each consumer testing one sample per session. The emotion ballot listed 39 emotions (see Appendix B) and was completed using a 5-point scale, from feeling the particular emotion "not at all" (1) to "extremely" (5). Overall liking, frequency of consumption, and serving size liking questions were also asked. Consumers were asked to fast for at least two hours prior to the consumer test. Twenty-five of the consumers evaluated the control all three sessions, 25 evaluated the 4% blend all three sessions, 25 evaluated the 5% blend all three sessions, and 25 evaluated all three products. Each consumer filled out three mood questionnaires: one prior to consumption, one immediately after consumption of a serving (30 g) of product, and a final one an hour after consumption. Each session lasted approximately 25 min. The consumers completed the last emotion ballot an hour later away from the CLT and were asked not to eat during this one hour period of time. The ballot was to be returned within a week of the consumer test. After attending the fourth session, the consumers received monetary compensation for their time.

Section 3 - Clinical Study

Ten consumers were recruited from Kansas State University for clinical research in Manhattan, Kansas at Justin Hall in the human nutrition metabolism lab. Participants were recruited on the basis of having no known food allergies, no aversion cinnamon, and willingness to have blood drawn. Participation was voluntary and each participant had to fast at least 10 hrs prior to the test. Prior to testing, participants signed an informed consent, approved of by the Institutional Review Board (IRB) at Kansas State University, which outlined the potential risks, the methods, and the purpose of the research.

For the study, the participants consumed two servings of product (60 g) and gave four blood samples over a 2-hour period. The blood samples were used to measure glycemic index and total antioxidants. Finger prick blood samples were taken via high flow safety lancets (1.8 mm depth, Fisher Scientific, Houston, TX) at 30 and 60 min post-consumption. The blood (approximately 0.1 mL) was collected in heparinized micro-hematocrit capillary tubes (Fisher Scientific, Pittsburg, PA) and transferred to 1.7 mL micro centrifuge tubes (VWR international).

The tubes were labeled to identify each participant to minimize confusion and for storage purposes. Glycemic index measurements were analyzed with a glucose analyzer (YSI 2300 STAT PLUS, Rankin Biomedical Corp, Clarkston, MI) immediately to prevent blood coagulation. Venous samples were taken prior to consumption (0 minutes/baseline) and at 120 min post-consumption. A trained phlebotomist took approximately 2.5 mL of blood intravenously using a 5 mL disposable syringe (Nipro Medical Corp., Miami, FL) and an eclipse needle (0.6 mm x 25 mm, BD, Franklin Lakes, NJ). The blood was transferred immediately into 6 mL vacutainers (BD K2 EDTA 10.8 mg, Franklin Lakes, NJ) to prevent blood coagulation. Glycemic index measurements were analyzed with the glucose analyzer to obtain glycemic index values for 0 and 120 min. All measurements were recorded and the exact time of blood extraction was noted as well to ensure the samples were taken on time. When taking blood, sterile alcohol prep pads (Fisher Scientific, Houston, TX) were always used to maintain sterility. Non-sterile cotton gauze sponges were used to promote clotting. Immediately following the glycemic index test, the vacutainers were centrifuged (CRU-5000 centrifuge, Damon, IEC Division, Nutley, NJ) at 4 C for 10 min to separate the plasma from the blood. The plasma was then transferred via a transfer pipet to a 1.7 mL micro centrifuge tubes and placed in a freezer at -20 C.

The antioxidant analyses were conducted on the venous plasma samples only and were all analyzed at the same time after the completion of the final week. For the analysis, 3.0 µl of thawed plasma was assayed using Total Antioxidant Capacity (TAC) Assay Kits (Catalog #K274-100, BioVision Research Products, Mountain View, CA). The plasma was combined with 3.0 µl of protein mask. Of the lyophilized Trolox standard, 0, 4, 8, 12, 16, and 20 µl were placed in the individual wells of the kit. Deionized, distilled water was added to the wells to bring the volume up to 100 µl. Next, a stock of working solution was prepared by diluting 1 part Cu^{++} reagent with 49 parts of Assay diluent. 100 µl of the working solution was then added to each well (standard and samples). All samples were done in duplicate to minimize the chances of plating error. The TAC plate was covered and left at room temperature for 1.5 hrs. After the incubation time, the absorbencies were read at 570 nm using the software program KC junior and the µQuant plate reader (Bio-Tek Instruments, Inc, Winooski, VT). The sample curve was plotted using the absorbance at 570 nm. The sample antioxidant capacity was calculated using the following formula:

$$\text{Total Antioxidant Capacity} = \frac{[(\text{Sample Absorbance - Blank Absorbance}) \times (\mu\text{L of Sample})}{\text{Slope of the Standard Curve}}$$

The participants' repetitions were averaged, along with the plate duplicates in order to get one number for total antioxidants for each of the two samples.

The participants came in a total of four times over a four week period. The control and 4% blend were tested in duplicate and the participants received compensation for their time. The 5% blend was not tested in the clinical study.

Section 4 - Statistical Analysis

Acceptability data was analyzed by analysis of variance (ANOVA) using PROC GLM in SAS® version 9.2 (SAS Institute Inc., Cary, NC). Post-hoc mean separation was carried out by using Fisher's Least Significant Difference (LSD). All significant differences were determined at the 95% confidence level ($\alpha = 0.05$). SPSS®, version 17 (SPSS Inc., Chicago, IL) was used to run JAR (just-about-right) frequencies.

Exploratory factor analysis (PROC FACTOR in SAS®) was carried out to validate the reliability of each emotion term. Cronbach's α coefficient was also calculated for each term. Mean scores and difference (emotions immediately after consumption and 1 h post consumption) from the baseline (emotions before consuming a product) for each product were calculated using Microsoft Excel® 2007 and presented as radar plots. Principal Components Analysis (PCA) was also conducted on the emotion data (Unscrambler®, 2008, version 9.8; Camo A/S, Oslo, Norway) to evaluate relationships among the 39 emotions, the samples, and the testing day and time. PCA was used to reduce the dimensionality of the emotions to better show the relationship between the emotions and the samples.

The TAC measurements were subjected to a one-way ANOVA, and means were separated using Fisher's LSD. Analysis of incremental area under the curve was conducted using GraphPad Prism version 5.1 (GraphPad Software, La Jolla, CA) to analyze the blood glucose data.

CHAPTER 3 - Maximizing Flavor and Health in an Extruded Cereal-Like Product: An Emotion Study

Abstract

The potential health benefits of spices, used as flavor enhancers since ancient times, are being explored. The application of mood and emotion constructs to understand the consumer psyche is a relatively new area of study in food science. The main objective of our study was to determine if spices (a blend of cinnamon, ginger, nutmeg, and cloves) high in antioxidants evoke/change emotions in consumers. Three extruded cereal-like products containing 0, 4, or a 5% spice blend were extruded at Kansas State University. Four consumer tests, one day of hedonic and just-about-right evaluations (n= 100), followed by three days of emotion testing were carried out. For the emotion tests, 25 consumers saw the control sample three times, 25 consumers saw the 4% blend sample three times, 25 consumers saw the 5% blend sample three times, and 25 consumers saw all three samples once. In a clinical trial (n=10), total antioxidant capacity and blood glucose levels were determined from two samples (control and the 4% blend). The data were subjected to analysis of variance and principal components analysis to determine significant effects and trends in the data, respectively. The emotion 'Satisfied' increased significantly in the 5% blend showing that there might have been an effect because of the higher spice content. The PCAs showed that for the 4% and 5% blends, the movement of the consumers was towards emotions such as active, energetic, and enthusiastic. There were no trends for the control. For the clinical trial, the 4% blend was significantly higher ($P < 0.05$) in total antioxidant capacity than the baseline, although the differences in absolute terms are debatable. Blood glucose levels were not significantly different. Future research needs to be done to better understand how individual emotions affect overall liking and product acceptance.

Introduction

Spices and Emotion

The emotional impact of antioxidants is also another area of interest. The use of emotions to evaluate food is a relatively new type of consumer research that identifies how food affects emotions. To date, there has been a very limited focus on food product development and its impact on the emotions of consumer liking and acceptability (King and Meiselman 2009). Stepcoe *et al.* (1995) identified in a Food Choice Questionnaire that food affects the way we feel and that mood was a key determinant of food choice. King and Meiselman (2009) established a mood and emotion questionnaire which targets information for use in the commercial food context. The EsSense Profile™ was designed to differentiate among completely different food products, as well as among similar foods with slight differences.

As for product development, the data is still lacking concerning the link between acceptance and emotional intensities. Some central location tests (CLTs) have shown a positive correlation between overall liking and positive emotional intensities, while other tests have shown little to no correlation. This finding might provide a reason why a product can be well liked in consumer tests and yet fail in the marketplace, as emotions may be playing a role in the buying decision (King and Meiselman 2009). According to Gibson (2006), one's mood or emotion can be affected by food choice and vice versa. Consumers often eat foods, consciously or subconsciously, that coincides with their current mood statuses or the mood outcome desired. Hedonics, food, mood, and emotions are often interrelated due to food's effect on the body. When people are hungry, they are often irritable and aroused. The consumption of foods will therefore increase satiation, which in turn induces calming and positive thoughts. Thus, eating is generally a positive experience in healthy consumers. The alteration of the moods can consciously or subconsciously affect the liking of a particular food (Macht *et al.* 2004). Rétiveau *et al.* (2004) found significant relationships between odor perception of fragrances and moods of women. This is important because of the fact that most foods evoke both positive and negative emotions in people through their aroma.

Spices and Antioxidant Activity

Antioxidants are molecules that slow or prevent the oxidation of other molecules which contain substrates that are susceptible to oxidation (Valko *et al.* 2007). The oxidation of

proteins, lipids, and DNA is particularly harmful for the body. DNA oxidation could lead to various cancers and the oxidation of proteins could lead to protein denaturation and enzyme inhibition (Nakabeppu *et al.* 2006; Stadtman 1992). Antioxidants scavenge free radicals that would otherwise oxidize other cells which would lead to cellular damage or destruction (Wolf 2005).

Antioxidants are naturally present in plant sources and are, therefore, best obtained from plant-derived foods. Antioxidants in diets are present as: vitamins A, C (ascorbic acid), and E (tocopherols), provitamin A (beta-carotene), selenium, and phenolic compounds (Sikora *et al.* 2008). Polyphenols are considered to be the most effective antioxidants as they work synergistically with other antioxidants to increase the total antioxidant activity (Sikora *et al.* 2008).

Antioxidant assays are divided into two types: hydrogen atom transfer (HAT) reactions and electron transfer (ET) assays. HAT reaction assays include the oxygen radical absorbance capacity (ORAC), the total radical trapping antioxidant parameter (TRAP), and crocin bleaching assays. For these reactions, antioxidants compete with substrates for peroxyl radicals. ET assays include Folin-Ciocalteu reagent (FCR), Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid) equivalence antioxidant assay (TEAC), the ferric reducing/antioxidant power (FRAP) assay, and the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. ET assays measure the ability of antioxidants to reduce oxidants, which leads to a color change (Huang 2005).

Cinnamon is one of the most used spices and there has been a plethora of cell culture studies and research conducted on animals, but more scientific evidence is needed to demonstrate the health benefits of cinnamon in humans. Studies have shown that cinnamon decreases blood glucose and insulin levels in diabetic rats and rats fed high sugar diets (Kannapan and Jayaram 2006; Talpur *et al.* 2005). Antioxidants from cinnamon have been shown to slow down diabetic complications and symptoms (Anderson *et al.* 2004; Paolisso *et al.* 1993). Several cell culture experiments have demonstrated that cinnamon has bioactive antioxidant activities and the ability to scavenge free radicals (Shan 2005; Singh 2007). Research is scarce as to the bioavailability of antioxidants from spices in human clinical trials (Dugoua 2007).

Type 2 diabetes is a disease associated with high blood glucose, due to insulin resistance. Type 2 diabetes is a chronic disease with no known cure; however the symptoms can be lessened with a modified diet and increased physical activity (Zimmet *et al.* 2001). According to CDC

(2009), type 2 diabetes has become an epidemic, as rates have doubled from 1990 to 2005. The CDC estimates 23.6 million people have diabetes in the United States, 90% of which have type 2. Research has shown that spices, especially cinnamon, may have blood glucose levels lowering effects (Khan *et al.* 2003; Mang *et al.* 2006).

Ginger, nutmeg, and cloves are also powerful antioxidants. In a cell culture study, ginger was proven to scavenge free radicals, as well as inhibit peroxidation because of its antioxidant activities (Bone 1997; Shan *et al.* 2005). Nutmeg contains powerful antioxidants equivalent to approximately 2000 ORAC/tsp (oxygen radical absorbance capacity per teaspoon). In vitro, the phytochemicals in nutmeg have demonstrated strong bioactivity; the antioxidants scatter free radicals at a moderate rate (Shan *et al.* 2005). Cloves have the highest amount of antioxidants (125.5 mmol/100 g) when plant sources are considered. In vitro, cloves have demonstrated the strongest radical scavenging activity (Shobana and Naidu 2000).

We found limited to no research on the effect of spices on mood and emotion or human clinical studies outlining the benefits of foods with functional spice blends. The major objective of this study was to determine the effects of a spice blend (cinnamon, ginger, nutmeg, and cloves) on the emotions of consumers. The difference between consumers who evaluated products one time and consumers who evaluated the products repeatedly during the emotion study also was determined. Further, the health implications (blood glucose effect and bioactivity of antioxidants) of the spices were studied clinically. The carrier food was an extruded apple-based cereal-like product containing 0, 4, or 5 g/100 g levels of the spice blend.

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Experimental

Preparation of the Extruded Cereal-Like Samples Containing the Spice Blend

A spice blend was created using cinnamon (57%), ginger (22%), nutmeg (15%), and cloves (6%) obtained from McCormick and Company (experimental samples; Hunt Valley, MD). An apple-based extruded cereal-like product containing 0 (control), 4, or 5 g/100 g of the spice blend (final composition) was used as a carrier food for this study. The snack products were made with corn flour (Bunge Milling Inc. St. Louis, MO), apple pomace (Tree Top Inc., Selah, WA), and table salt (1%). The products were extruded in a Micro-18 twin-screw extruder (American Leistritz, Somerville, NJ) under controlled processing conditions. The extruder had a feed rate of approximately 2.5 kg/h and a screw speed of 350 rpm. The temperature profile from the inlet to the outlet was: 50, 65, 80, 90, 110, and 120 C, respectively.

The composition of the cereal-like products (dry-weight basis) is given in Table 3-1. The "control" throughout the paper is the non-spiced sample and the two test samples are referred to as the "4% blend" and "5% blend," identifying their respective spice blend proportions. A sugar coating, using simple syrup (28%), was sprayed on the outside of the product. The products were stored in food-grade plastic bins with lids (36 L; Sterilite Corporation, Townsend, MA) at room temperature (22 ± 1 C) until packaged in individual sandwich-sized Zip-Loc® bags (S.C. Johnson & Son, Inc., Racine, WI) for the various evaluations. The samples were presented to the consumers as an "extruded cereal-like product."

The spices and ORAC values for those used in the developed extruded cereal-like product are as follows: cinnamon (267,536 µmol TE/100 g), ginger (28,811 µmol TE/100 g), nutmeg (39,800 µmol TE/100 g), and cloves (314,446 µmol TE/100 g) (USDA 2007). Using the set ORAC values as references and taking into account the specific spice percentages, the ORAC value of the product was 2,204 µmol TE/serving.

Table 3-1 Composition of the Extruded Cereal-Like Products (g/100 g of product)

Ingredients	Control	4% Blend	5% Blend
Cinnamon	*N/A*	*2.28*	*2.85*
Ginger	*N/A*	*0.88*	*1.10*
Nutmeg	*N/A*	*0.60*	*0.75*
Cloves	*N/A*	*0.24*	*0.30*
Total Spice Blend	N/A	4.00	5.00
Salt	1.00	0.96	0.95
Corn Flour	77.00	73.92	73.15
Apple Fiber	22.00	21.12	20.90

Consumer Studies – Hedonic Testing

Consumers

One hundred consumers (61 females and 39 males) were recruited from Manhattan, Kansas and surrounding areas to participate in four consumer tests. The participants were recruited on the basis that they could attend all four sessions, had no known food allergies, regularly consumed cinnamon, cloves, and nutmeg, and were within the age criteria. Age ranges were 18-24 (19%), 25-40 (42%), 41-55 (28%), and 56-69 (11%). A total of four consumer tests were conducted during a two week period. Informed consent, age, gender, and ethnicity demographics were obtained from each consumer.

Prior to all testing (hedonic, emotion, and clinical), participants signed an informed consent, approved of by the Institutional Review Board (IRB) of Kansas State University, which outlined the potential risks, the methods, and the purpose of the research.

Samples and Testing

Approximately 10 g of each of the three products was served using a sequential monadic test design. The products were labeled with a randomly generated 3-digit code and served in sandwich-sized Ziploc bags (S.C. Johnson & Son, Inc., Racine, WI). The consumers completed

a 2-page questionnaire with overall liking and JAR questions (see Appendix A) on each product. The serving order was randomized and balanced.

Consumer Studies – Emotion Testing

Samples and Testing

The final three sessions were used for evaluating the effects of the spices on emotions, with each consumer testing one sample per session. The same 100 consumers were used from the hedonic test. The emotion ballot listed 39 emotions (see Appendix B) and was completed using a 5-point scale (the EsSense Profile™), from feeling each particular emotion "Not at All" (1) to "Extremely" (5). Consumers were asked to fast for at least two hours prior to the emotion evaluation. Twenty-five consumers evaluated the control in all the three sessions, 25 evaluated the 4% blend in all the three sessions, 25 evaluated the 5% blend in all the three sessions, and 25 evaluated all three products. Each consumer filled out three mood questionnaires: one prior to consumption, one immediately after consumption of one serving (30 g) of product, and a final one an hour after consumption. Overall liking was asked on the second ballot immediately after consumption of the product. Each session lasted approximately 25 min. The consumers completed the last emotion ballot an hour later, away from the test location, and were asked not to eat during this one hour period of time. The ballots were to be returned within a week of the consumer test.

Clinical Study

Ten subjects were recruited for the clinical portion of the research, which was conducted in the human nutrition metabolism lab. Participants were recruited on the basis of having no known food allergies, no aversion to cinnamon, and willingness to have blood drawn. For the study, the participants consumed two servings of the product (60 g) and gave four blood samples over a 2-hour period. Participation was voluntary and each participant had to fast at least 10 hours prior to the test. The participants came in a total of four times over a four week period. The control and 4% blend were tested in duplicate. The 5% blend was not assessed in the clinical study.

Total Antioxidant Capacity

Venous samples were taken prior to consumption (0 min/baseline) and at 120 min post-consumption. A trained phlebotomist took approximately 2.5 mL of blood intravenously using a 5 mL disposable syringe (Nipro Medical Corp., Miami, FL) and an eclipse needle (0.6 mm × 25 mm, BD, Franklin Lakes, NJ). The blood was transferred immediately to 6 mL vacutainers (BD K2 EDTA 10.8 mg, Franklin Lakes, NJ) to prevent blood coagulation. The vacutainers were centrifuged (CRU-5000 centrifuge, Damon, IEC division, Nutley, NJ) at 4 C for 10 min to separate the plasma from the blood. The plasma was then transferred via transfer pipet to a 1.7 mL micro centrifuge tubes and placed in a freezer at -20 C.

Total antioxidant capacity (TAC) kits (Catalog #K274-100, BioVision Research Products, Mountain View, CA) were used to determine the bioavailability of the antioxidants from the extruded products. For the analysis, 3.0 µl of thawed plasma was assayed using TAC assay kits. The total antioxidant capacity was calculated using the following formula:

$$\text{Total Antioxidant Capacity} = \frac{[(\text{Sample Absorbance - Blank Absorbance}) \times (\mu\text{L of Sample})}{\text{Slope of the Standard Curve}}$$

The participants' repetitions were averaged, along with the plate duplicates in order to get one number for total antioxidants for each of the two samples.

Glycemic Index

For glycemic index measurements, finger prick blood samples were taken via high flow safety lancets (1.8 mm depth, Fisher Scientific, Houston, TX) at 30 and 60 min post-consumption. The glycemic index measurements were analyzed with a glucose analyzer (YSI 2300 STAT PLUS, Rankin Biomedical Corp, Clarkston, MI) immediately after blood collection to prevent blood coagulation.

Data Analysis

Acceptability data was analyzed by analysis of variance (ANOVA) using PROC GLM in SAS® version 9.2 (SAS Institute Inc., Cary, N.C., USA). Post-hoc mean separation was carried out by using Fisher's Least Significant Difference (LSD). All significant differences were

determined at the 95% confidence level ($\alpha = 0.05$). SPSS®, version 17 (SPSS Inc., Chicago, I.L., USA) was used to run JAR (just-about-right) frequencies.

Exploratory factor analysis (PROC FACTOR in SAS®) was carried out to validate the reliability of each emotion. Cronbach's α coefficient was also calculated for each term. Mean scores and difference (emotions immediately after consumption and 1 h after consumption) from the baseline (emotions before consuming a product) for each product were calculated using Microsoft Excel 2007 and presented as radar plots. Principal Components Analysis (PCA) was also conducted on the emotion data (Unscrambler®, 2008, version 9.8; Camo A/S, Oslo, Norway) to evaluate relationships among the 39 emotions, the samples, and the testing day and time. PCA was used to reduce the dimensionality of the emotions to better show the relationship between the emotions and the samples.

The TAC measurements were subjected to a one-way ANOVA and means were separated using Fisher's LSD. Analysis of incremental area under the curve was conducted using GraphPad Prism version 5.1 (GraphPad Software, La Jolla, CA) to analyze the blood glucose data.

Results and Discussion

Consumer Studies – Hedonic Testing

Overall Liking Data

Overall liking, appearance liking, flavor liking, and texture liking were assessed by all 100 consumers and showed significant differences ($P < 0.05$) based on the blend of the cereal-like products. Consumers equally liked both the 5% and the 4% blend sample over the control (see Table 3-2). Table 3-2 shows that the hedonic differences between samples are very minimal. The appearance of all three products was disliked slightly and this might have influenced the other attributes as well. The 4% blend cereal-like products was not liked for its texture as compared to the 5% spice bend product.

Table 3-2 Hedonic Mean Scores

Sample	Overall Liking	Appearance Liking	Flavor Liking	Texture Liking
5% Blend	5.4a	4.0a	5.3a	5.6a
4% Blend	5.4a	3.9a	5.3a	5.2b
Control	5.2a	4.0a	5.2a	5.6a

For product development, a developer wants to see overall liking scores of 6 (like slightly) or higher on a 9-point hedonic scale (Sriwattana *et al.* 2008). In Figure 3-1, the overall liking scores have been grouped for each of the three samples. This data is a good supplement to the mean averages, because it shows if there are any outliers that are skewing the results. A 9-point hedonic scale, anchored from "Dislike Extremely" to "Like Extremely," was used to collect the data. Over half of the consumers, 56% and 55%, respectively, rated the overall liking at least a "6" for the 5% blend and 4% blend, whereas only 48% of consumers rated the control that high. This suggests that the spice blend increased overall liking for the average consumer, increasing overall acceptability. This is in agreement with Table 3-1 as the 4% and 5% blends have higher mean flavor liking scores, which seem to correlate with overall liking.

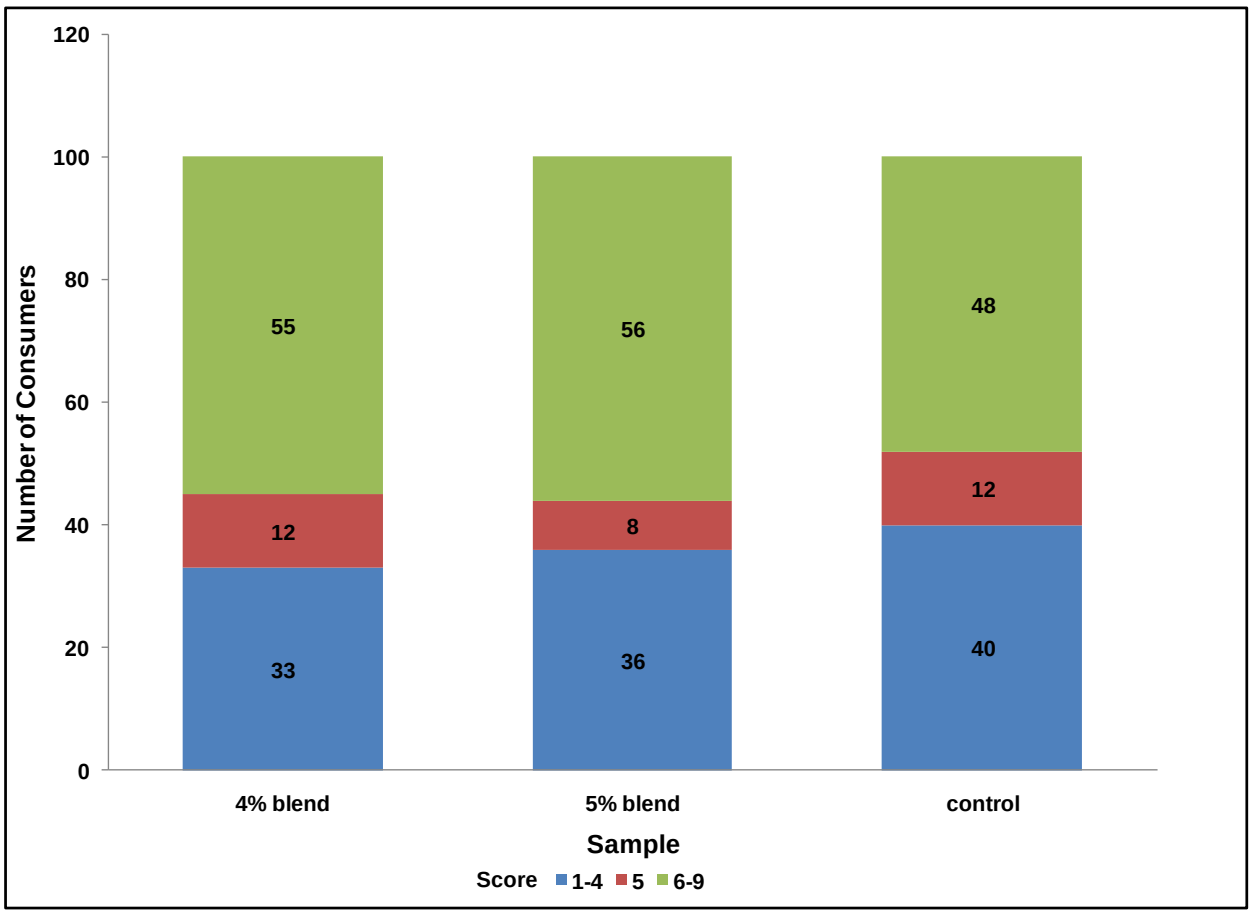


Figure 3-1 Overall Liking Score Groupings

Just-About-Right (JAR) Data

All three samples contained the same base, so the only formula difference came from the addition of the spices. The JAR frequencies for color, saltiness, soft/hard, airy/dense, and toothpacking were very similar.

A majority of the consumers (65/100) said that the control was "Slightly Too Weak" to "Much Too Weak" for overall flavor. This is not surprising because the control was made without the addition of the spices. For the 4% blend and 5% blend, the results were reversed as 29 consumers and 41 consumers thought the overall flavor of the blends were "Slightly Too Strong" to "Much Too Strong," respectively. This result shows that most consumers are sensitive to flavor change as they are able to differentiate the spiced samples from the control and that some consumers are moderately to extremely discriminatory as they can identify a 1% difference in spice concentration. To confirm the difference threshold, a difference test such as a

triangle test or the duo-trio test should be performed. This data would be a good supplement to the hedonic data (Nasser-El-Dine and Olabi 2009). The overall spice flavor JAR data were similar to the overall flavor data. The cinnamon JAR frequency table identified that 12 more consumers thought the 5% blend was "Slightly Too Strong" to "Much Too Strong" when compared to the 4% blend. A product developer must be aware of flavor JAR scores in the "too high" or "too strong" range, because existing research shows that such scores result in significant decreases in overall liking (Drake *et al.* 2009). Not surprisingly, 66 consumers noted the cinnamon flavor was too weak in the control because of the absence of the spices.

The analysis of the sweetness JAR was another comparison of interest. More consumers said the sweetness was "Just About Right" for the 4% blend (51) than for the control (41) or 5% blend (39). The increase in the sweetness perception from the control to the 4% blend sample might be because the increase in the spice content, especially cinnamon, might have enhanced the perception of sweetness, although all the three samples had the same sucrose content. The 4% blend might have been the spice concentration upper limit for sweetness enhancement as more consumers noted the sweetness for the 5% blend was "Slightly Too Weak" as compared with the 4% blend. At the 5% spice concentration, the spices may have begun to overwhelm the consumer, thus detracting from the perception of sweetness.

JAR scale analysis can be an important tool for better understanding consumer acceptability. Gacula *et al.* (2008) noted this finding and suggested the use of %JAR and relating JAR with hedonic data. Future research should attempt to better understand the interaction of cinnamon, overall spice, and sweetness on specific hedonic attributes.

Overall Liking – Hedonic vs. Emotion Data

All 100 consumers evaluated the three samples for overall liking on the hedonic ballot. In the subsequent consumer testing sessions, the consumers also evaluated overall liking on the emotion ballots, post consumption. Twenty-five consumers evaluated overall liking for the control three times; twenty-five consumers evaluated overall liking for the 4% blend three times; twenty-five consumers evaluated overall liking for the 5% blend three times; and twenty-five consumers evaluated overall liking for the control, the 4% blend, and the 5% blend once. The results are shown below in Tables 3-3 and 3-4.

Table 3-3 Comparison of Overall Liking Scores Between Same Groups of Consumers (n = 25) Who Saw the Various Cereal-Like Product During Hedonic and Emotion Testing on Different Days

Sample	Overall Liking (Average Scores)	
	Hedonic Test	Emotion Test
Control	5.12	5.44
4% Blend	5.72	6.04
5% Blend	5.24	5.24

Table 3-4 Comparison of Overall Liking Scores Among the Same Group of Consumers (n=25) Who Saw the Same Cereal-Like Product Four Times: Hedonic (one time) and Emotion (three times) Testing on Different Days

Ballot	Overall Liking (Average Scores)		
	Control	4% Blend	5% Blend
Hedonic	5.12	5.24	6.04
Emotion Day 1	5.32	5.12	5.52
Emotion Day 2	5.26	5.04	5.60
Emotion Day 3	5.38	5.18	5.69

Table 3-3 shows that the average overall liking scores on the emotion ballot either stayed constant or increased from the hedonic ballot average scores. The only difference between the two tests was the amount of sample consumed. The hypothesis was that the overall liking scores for the emotion ballot would decrease because of the larger serving size and the mandatory consumption requirement. Consumers had to eat 30 g (1 serving) of the sample in order to see the spice-emotion interactions. For the hedonic test, consumers were given approximately 10 g of the sample but only had to eat enough to get a good representation of the sample. The hypothesis was incorrect and it appears either the product became more acceptable after eating a larger amount or that overall liking was increased because of better product familiarity.

Table 3-4 shows that the overall liking scores for the control samples increased slightly from the hedonic test day to the emotion testing days. For the 4% blend, the scores remained relatively constant throughout all four days, while the 5% blend decreased around 0.4 points on

the hedonic scale. The decrease in overall liking for the 5% blend might be related to the higher spice content of the product.

It is also important to point out the possibility of interaction of different types of questions on the same ballot on overall liking scores. Average overall liking score on the emotion ballot for all three days appear to be within a similar range (Table 3-4); however, overall liking score from the hedonic test were not within this range. Overall liking has been shown to decrease when consumers are also asked questions other than acceptability questions in the same ballot. Popper *et al.* (2004) noted that that overall liking scores decreased when followed by JAR questions as compared to when only liking questions were asked. Although Popper *et al.* (2004) did not study the effect of including emotion questions in the same questionnaire with overall liking; however there is a possibility that the emotion questions might have had some effect on the liking scores in our study and this should be explored further.

Consumer Studies – Emotion Testing

Reliability of the Ballot Constructs

Exploratory factor analysis was conducted in SAS® on the emotion constructs to ensure their reliability. The variance explained by the top two dimensions (listed as a cumulative %) is outlined in Table 3-5. An acceptable amount of variation is explained by the top two factors for each blend. Cronbach's α values were obtained and the smallest value is listed in Table 3-5 for each blend. A Cronbach α value of at least 0.50 is sometimes acceptable in literature, but to ensure consistency and reliability of the constructs and scale, a higher value is desired. A Cronbach α coefficient lower than 0.70 is a possible cause for concern and would signify that the particular construct associated with that value might not be reliable (Nunnaly 1978). The 39 Cronbach's α values obtained for each individual sample were acceptable, confirming the consistency of the scale; similarly, the α values for all three blends combined also demonstrated reliability and validity for the 39 emotions. The α coefficients listed in Table 3-5 shows that the emotion constructs were all highly reliable and valid as all the values for the 39 emotion constructs were well over 0.70.

Table 3-5 Exploratory Factor Analysis Results

Blend	% Variation in the 1st 2 dimensions	Cronbach's α Coefficient
Control	0.684	> 0.937
4% blend	0.684	> 0.919
5% blend	0.608	> 0.878
All 3 blends	0.664	> 0.929

Emotion Differences by Blend and Intensity

In Table 3-6, emotions that were significantly different within samples are highlighted. An up arrow indicates a significant increase in emotion intensity from the preceding time, while a down arrow indicates a significant decrease in emotion intensity from the preceding time. Horizontal arrows signify little or no change. Post-hoc mean separation by using Fisher's LSD identified eight significant constructs for both 4% and 5% spice blend products, while seven constructs were significant for the control. Interestingly, 'Calm' was the only emotion that was significantly different in all three samples. Calmness significantly decreased over time from immediate post-consumption to 1-hour post consumption across all three blends. This finding is contrary to the research conducted by Macht *et al.* (2004), who found that consumption of food reduces irritability and increases calmness because of the increase of satiation. The emotion 'Satisfied' also stands out; it only significantly differed in the 5% blend. Satisfaction increased both from pre to post and post to post1 and it might have increased due to spice interaction, although the 4% blend did not show a similar trend.

Table 3-6 Significant Differences in Emotions Within Each Samples Over Time

	Control			4% Blend			5% Blend		
Emotions	**Pre**	**Post**	**Post1**	**Pre**	**Post**	**Post1**	**Pre**	**Post**	**Post1**
Active	→	→	→	→	→	→	→	→	→
Adventurous	→	→	→	→	→	→	→	→	→
Affectionate	→	→	→	→	→	→	→	→	→
Aggressive	→	→	→	→	→	→	→	↓	↑
Bored	→	→	→	→	→	→	→	→	→
Calm	→	→	↓	→	→	↓	→	↑	↓
Daring	→	→	→	→	→	→	→	→	→
Disgusted	→	→	→	→	→	→	→	→	→
Eager	→	→	→	→	→	→	→	→	→
Energetic	→	→	→	→	→	→	→	→	→
Enthusiastic	→	→	↑	→	→	→	→	→	→
Free	→	→	→	→	→	→	→	→	→
Friendly	→	→	→	→	→	→	→	→	→
Glad	→	→	→	→	→	→	→	→	→
Good	→	→	→	→	→	→	→	→	→
Good-natured	→	↓	→	→	→	→	→	→	→
Guilty	→	→	→	→	→	→	→	→	→
Happy	→	→	→	→	→	→	→	→	→
Interested	→	→	→	→	→	→	→	→	→
Joyful	→	→	→	→	↓	↑	→	→	→
Loving	→	→	→	→	→	→	→	→	→
Merry	→	→	→	→	→	→	→	↓	↑
Mild	→	→	→	→	→	↓	→	→	→
Nostalgic	→	→	↓	→	→	→	→	→	→
Peaceful	→	→	→	→	↑	↓	→	→	↑
Pleased	→	→	→	→	→	→	→	→	→
Pleasant	→	→	→	→	→	↓	→	↑	↑
Polite	→	→	→	→	→	→	→	→	→
Quiet	→	→	→	→	→	↓	→	→	→
Satisfied	→	→	→	→	→	→	→	↑	↑
Secure	→	→	→	→	→	→	→	→	→
Steady	→	→	→	→	→	→	→	→	→
Tame	→	→	→	→	→	→	→	↓	↓
Tender	→	→	→	→	→	→	→	→	→
Understanding	→	→	→	→	↓	↓	→	→	→
Warm	→	→	↓	→	→	→	→	→	→
Whole	→	→	↓	→	→	→	→	→	→
Wild	→	→	→	→	→	→	→	→	↓
Worried	→	↓	→	→	↓	↓	→	→	→

Figure 3-2 highlights the differences between samples for emotions over time (post-Δ scores vs. post1-Δ scores). The post-Δ scores were calculated by subtracting individual immediate-post emotion scores from pre-consumption emotion scores. The post-Δ scores for

each blend were the average of the 25 consumers who ate the product three times, along with the 25 consumers who ate the product once. The post1-Δ scores were derived the same way. The 1-hour post-consumption emotion scores were subtracted from the pre-consumption emotion scores to obtain the value. The delta scores were calculated in order to offset the day-to-day variation in consumers' emotions and standardize the initial emotion intensities of all of the consumers.

For the control (Figure 3-2a), the post1-Δ scores were slightly higher than post-Δ scores, in general. In most cases, the pre-consumption, emotion scores were more intense than the post and post1 emotion scores as many of the peaks and valleys were either near or below 0.00. The post1-Δ scores had large positive peaks for the terms, 'Wild,' 'Daring', and 'Adventurous,' while the post-Δ score had a large positive peak for the emotion 'Free.' From a physiological standpoint, it appears the spices in our samples may have a suppressing effect on these certain emotions. This might relate to the study conducted by Rétiveau *et al.* (2004) where they found that certain emotions were lessened in subjects wearing pleasant fragrances up to 3 hrs or as long as the perfumes were still discernable.

Figures 3-2b and 3-2c underscore the post-Δ scores vs. post1-Δ scores for the 4% blend and 5% blend, respectively. The trend observed for both spiced blends appears opposite of the consumer sample trend. For the 4% and 5% blends, the post-Δ scores are slightly higher than post1-Δ scores, in general. This is opposite to the trend for the consumer sample as the post1-Δ scores were slightly higher than post-Δ scores for that sample. Also noteworthy is the observation that the range of the delta scores is narrower for the 4% and 5% blends, in general, when compared to the control. For the 4% blend, the emotion terms that stand out are: 'Calm,' 'Bored,' 'Peaceful,' Polite,' and 'Quiet.' The significance of these emotion intensity differences in this particular context deserves future research in order to gain a better understanding of their particular meaning. The terms may have a significant impact on product acceptance or prove a way to more fully understand a particular product, however, research is lacking. For the 5% blend, 'Satisfied,' 'Pleasant,' 'Peaceful,' and 'Affectionate' stood out as both the post-Δ scores and post1-Δ scores had large, positive peaks. Particularly of interest in the product development setting is the term "Satisfied" which will be discussed later in the section.

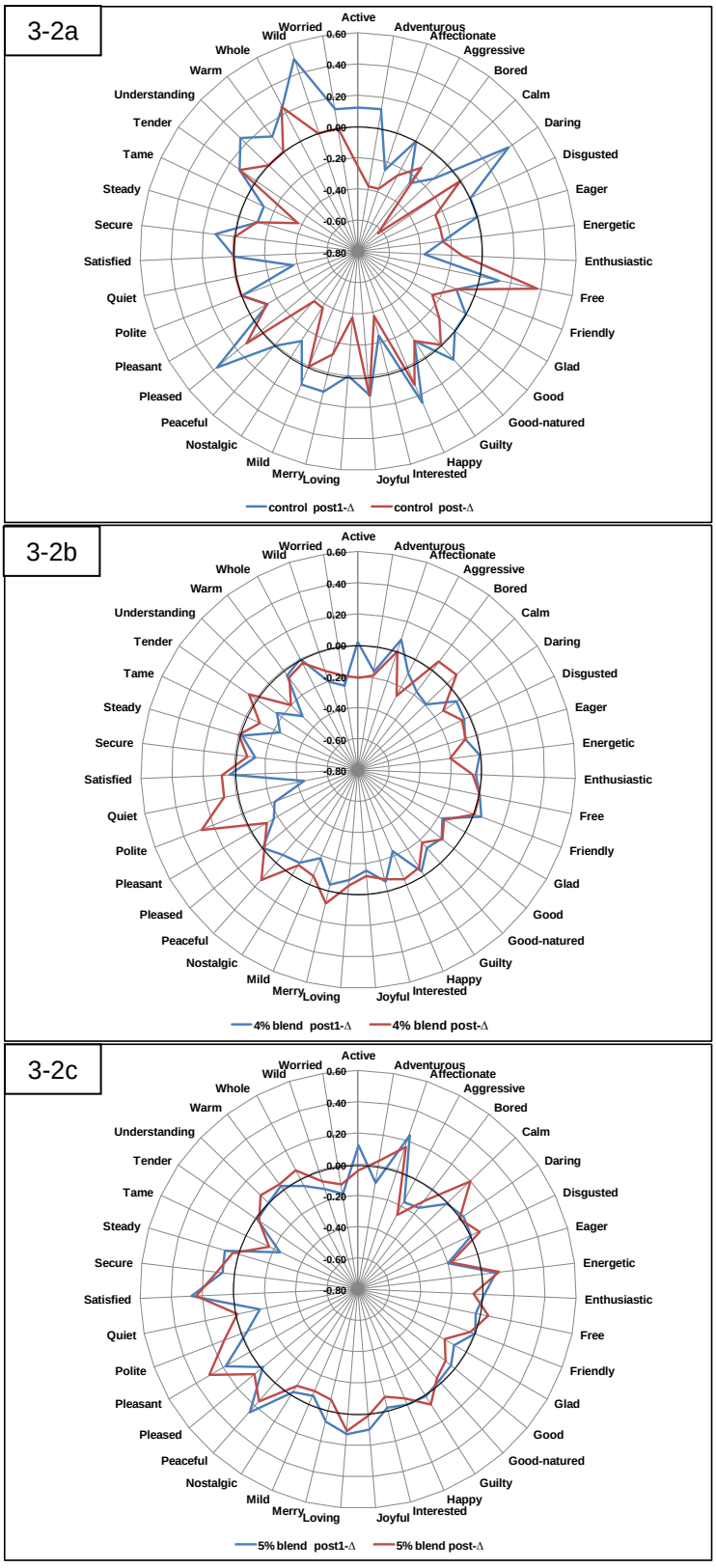


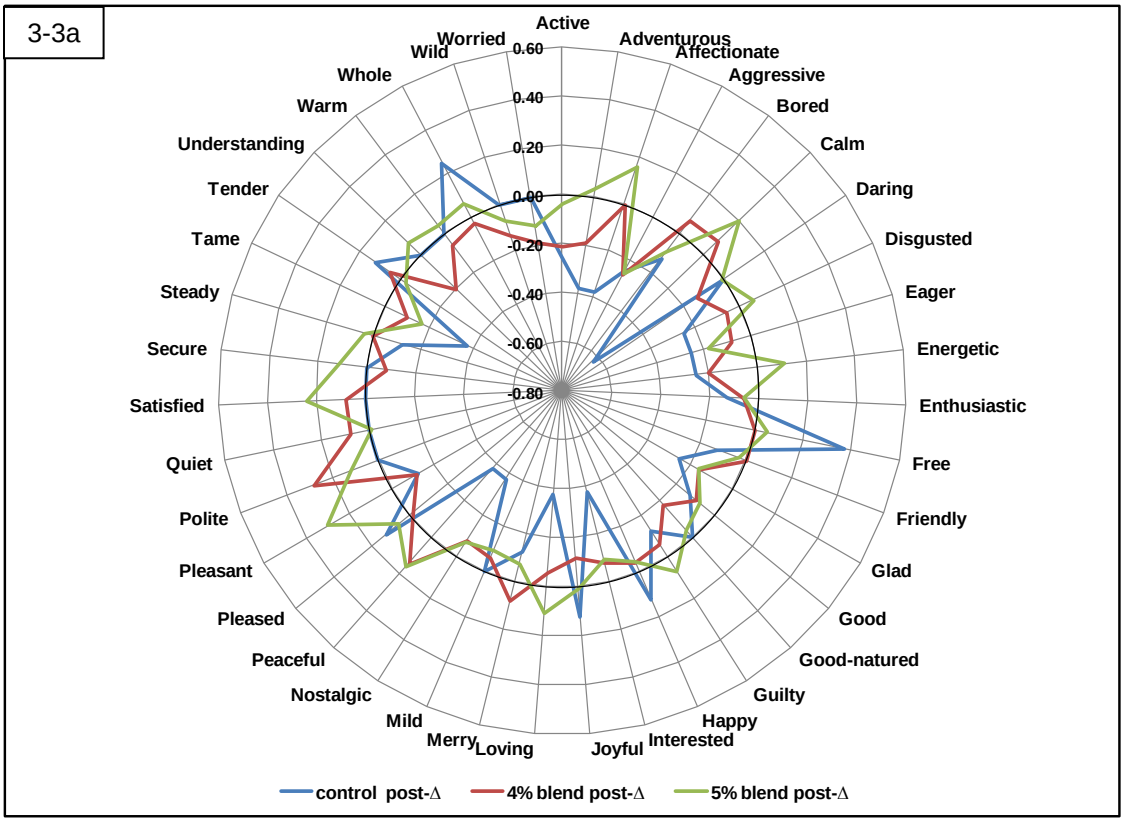
Figure 3-2 Emotion Intensity Changes Over Time for Each Individual Product: a) Control, b) 4% Blend, and c) 5% Blend

Figure 3-3 is similar to Figure 3-2, except it differentiates the samples from one another at the post-Δ and post1-Δ time points. With a few exceptions, the 5% blend post-Δ scores seem slightly higher than the 4% blend and control post-Δ scores (Figure 3-3a). Another notable trend is that the 4% and 5% blends seem relatively stable, both the Δ scores usually ranging from 0.2 to -0.2, whereas the control had more variance, as seen by the plethora of peaks and valleys and wider range. Figure 3-3b shows the variation in the intensities of emotion for the post1-Δ scores for the three different samples. Again, the 4% and 5% blends averages were more stable than the control. But, unlike the trend seen for the post-Δ scores, the control post1-Δ scores appear slightly higher than the spiced blends, on average. The scores for control showed larger positive peaks that are much higher than the other two blends for the emotions 'Understanding,' 'Wild,' 'Worried,' 'Daring,' 'Happy,' and 'Pleased.' The particular significance or underlying meaning of these terms needs to be further looked into, bridging the gap between product development and psychology. If these emotions positively affect product acceptance, the developed samples would require reformulation to increase these emotions. Lastly, the 5% blend is higher in 'Satisfied' intensity compared to the 4% blend and the control sample. This suggests the possibility that the extra 1% spice concentration in the 5% blend sample has a positive effect on the "satisfaction" of consumers.

Benton and Donohoe (1999) identified that sweet, carbohydrate-rich foods and some micronutrients increase positive moods and emotions. Endorphins, which are neurotransmitters in the brain that relieve pain and produce a feeling of wellness and satisfaction, are thought to be responsible for this positive affect. Perhaps, the sweetness of the extruded products was not sufficiently high enough to evoke such an endorphin response. The control sample had little to no change in 'Satisfaction' intensity, as evidenced in Figures 3-3a, b. However, perhaps the phytochemicals or other constituents in the spice blends caused the increase in 'Satisfaction' shown in the spice blend samples.

It would be interesting to further increase the spice concentration in the blend to gain a better understanding of the interaction between the spices and consumer satisfaction. For this, varying concentrations of the spices could be tested to determine the optimal spice concentration or threshold to maximize consumer satisfaction. The compositions of the spice blends could also be altered in an attempt to maximize consumer satisfaction.

With further research and a better understanding of how emotions relate to product success, product developers would have another tool to measure potential consumer acceptance. This research could prove beneficial because, if certain emotions were confirmed as predictors of potential market success, then product developers could reduce their risks of introducing a product that is prone to fail, as well as reduce the lengthy testing time that extended use tests require.



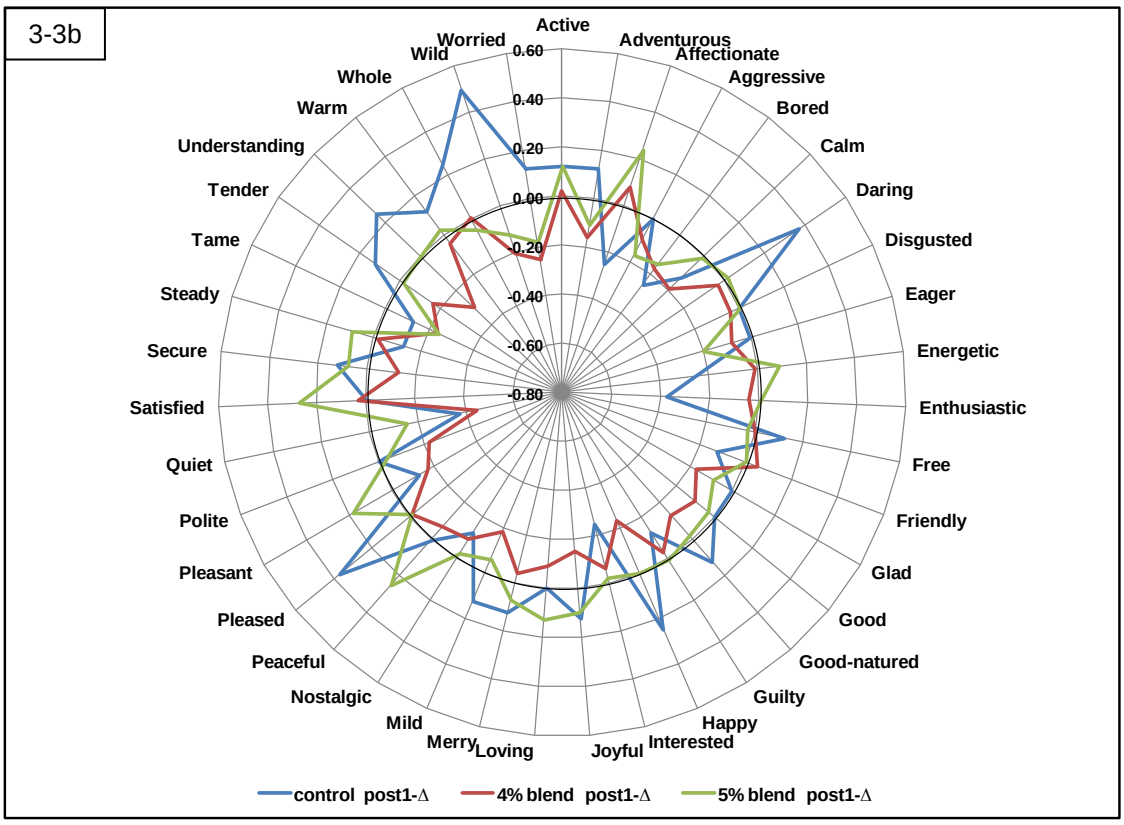


Figure 3-3 Emotion Intensity Changes Over Time for All the Products: a) Post-Δ Scores and b) Post1-Δ Scores

Principal Components Analysis (PCA) - Trends by Blend and Day

The PCA for the control sample is represented in Figure 3-4. The time differences among days do not seem to have much of an effect as the movement is slight from pre to post and from post to post1. The "Day 1, 2, and 3" groups of consumers were the same 25 people who saw the control products three times in three different days. "Day" represents the group of different consumers who saw the product only once. Only the Day 1 group results have substantial movement. All four of the consumer groups are in different quadrants and appear to be moving away from the emotions. The results appear to be inconclusive and null of any trends. It also shows that emotions with control product could not be replicated within a group.

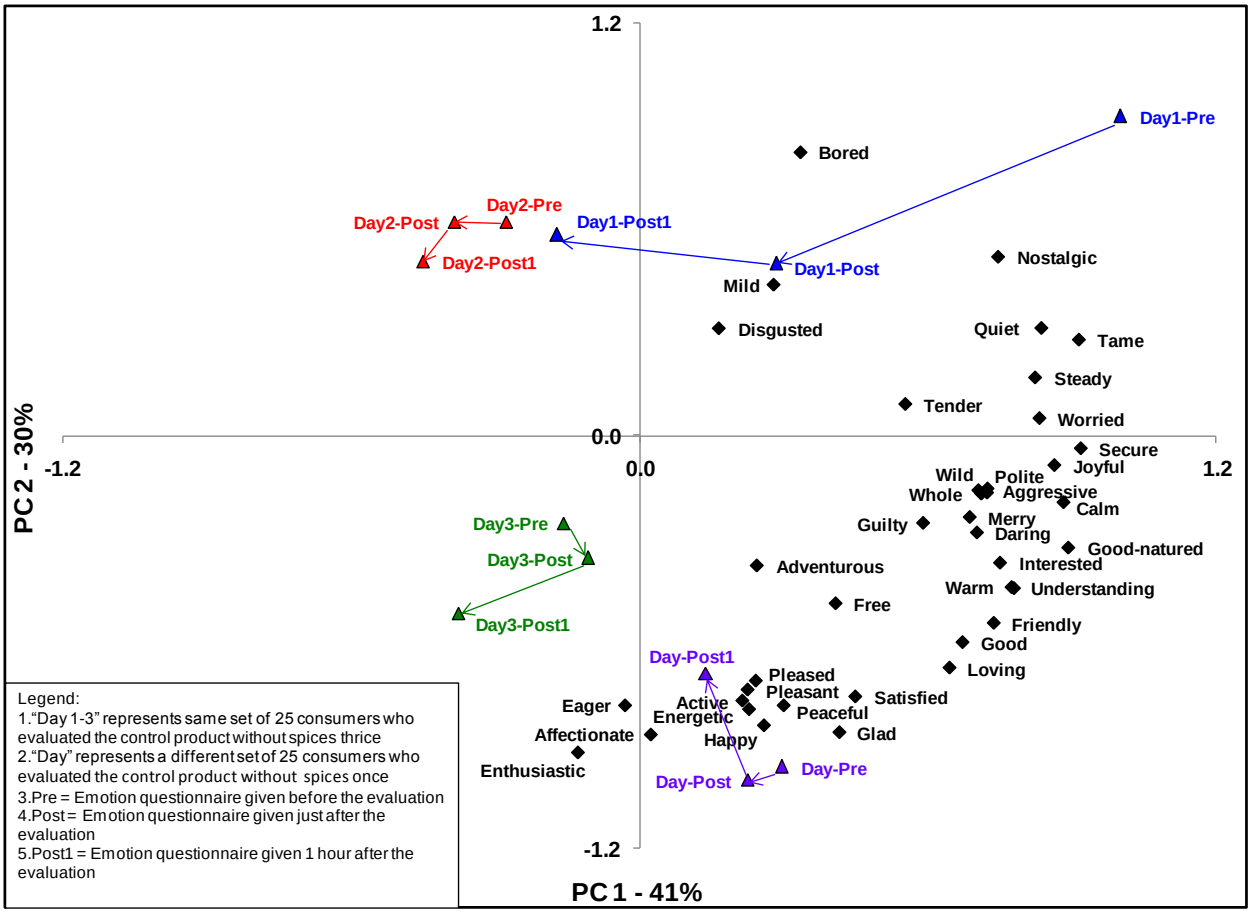


Figure 3-4 Comparison of Emotions Between Consumers (n=25) Who Evaluated the Control Product (without spices) Once with the Consumers (n=25) Who Evaluated the Same Product Three Times.

The trends in the PCAs for the 4% consumer groups (Figure 3-5) and 5% consumer groups (Figure 3-6) are of more interest and they are somewhat similar. In Figure 3-5, the downward left trend is constant for all four groups. The consumers in Figure 3-6 have the same leftward movement among all four consumer groups. This figure is particularly interesting as it represents the only PCA where the arrows are moving toward the emotions. The group of consumers who saw the 5% blend three times are moving toward the emotion 'Satisfied' over the three days of emotion tests.

When analyzing Figures 3-4, 3-5, and 3-6, two interesting observations can be made. Firstly, there appears to be more movement in "Day1" for all three PCAs. Perhaps, the consumers had familiarized themselves with the ballots and testing procedure over the multiple-day tests, which may have reduced the intensity of movement from pre to post and from post to

post1. The next observation is that the different time points of "Day" consumers for all PCAs are all closely positioned without much movement. Time does not appear to have much of an effect for the 25 consumers who evaluated all three of the samples.

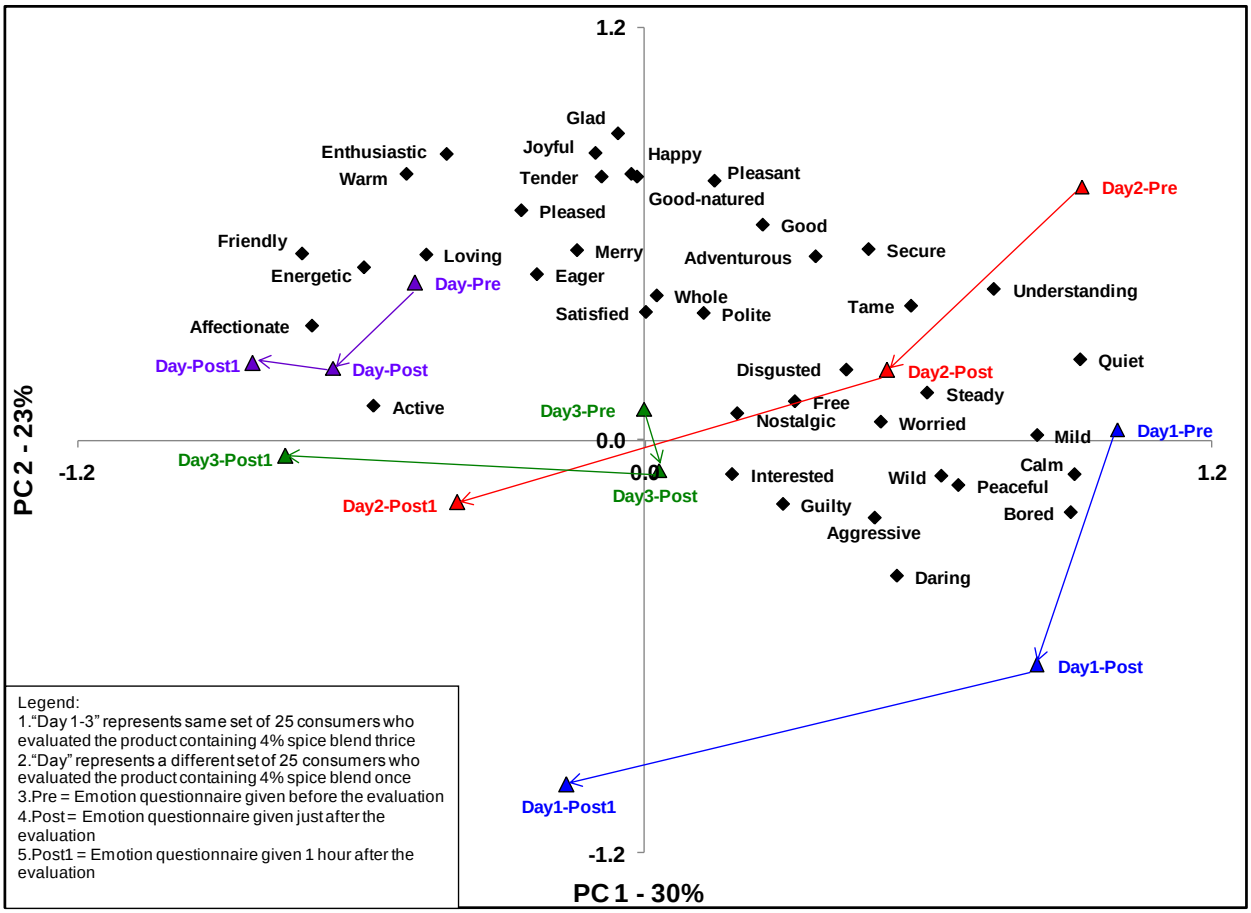


Figure 3-5 Comparison of Emotions Between Consumers (n=25) Who Evaluated the Product Containing 5% Spice Blend Once With the Consumers (n=25) Who Evaluated the Same Product Three Times.

Interestingly, 'Wild' and 'Calm' were closely associated on all three PCAs. Common negative terms ('Disgusted,' 'Guilty,' 'Bored,' and 'Worried') were looked at to identify possible mapping trends. 'Disgusted,' 'Guilty,' and 'Worried' were close to each other in all three PCAs but 'Bored' did not always seem to associate as it was inconsistent in position on the PCAs.

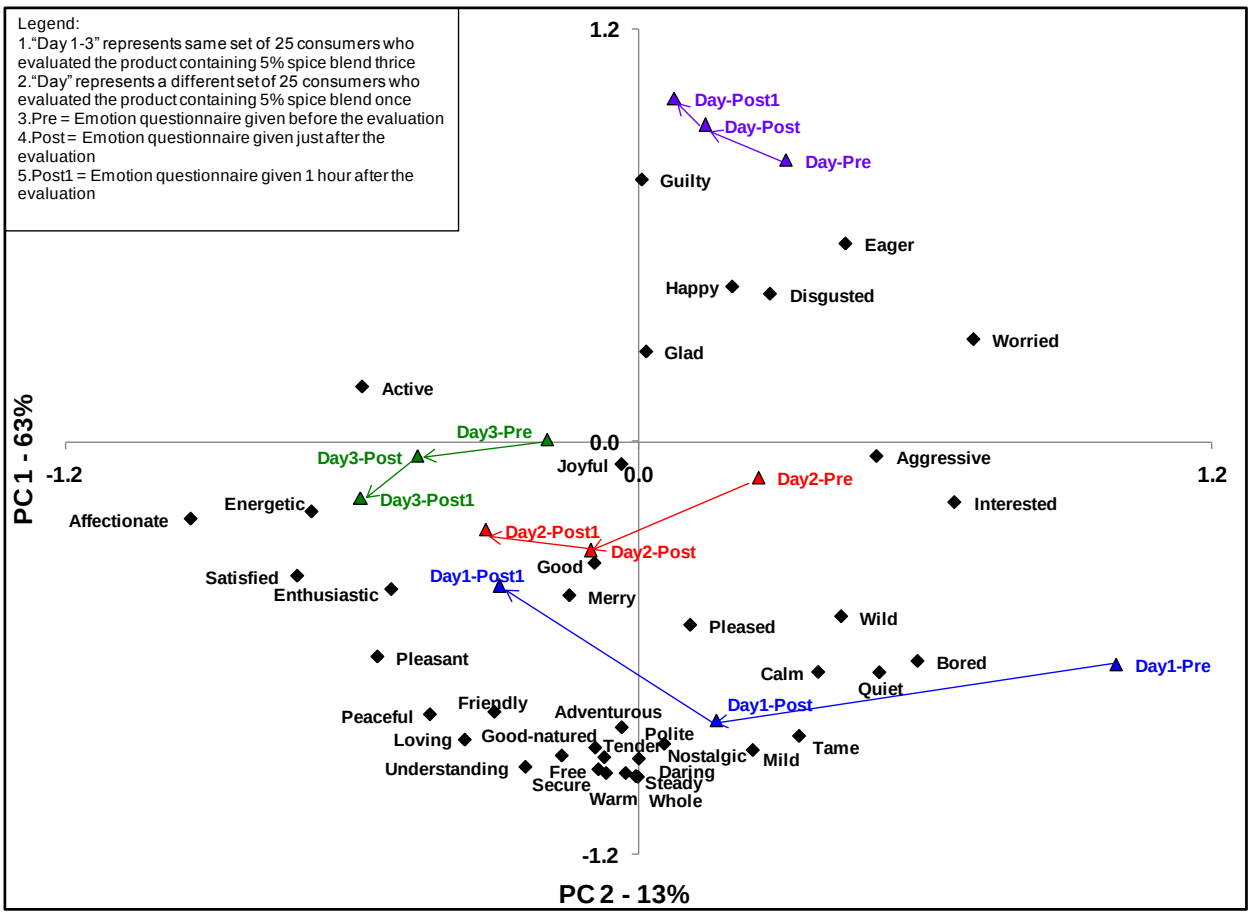


Figure 3-6 Comparison of Emotions Between Consumers (n=25) Who Evaluated the Product Containing 4% Spice Blend Once With the Consumers (n=25) Who Evaluated the Same Product Three Times.

The results from the emotion study confirm the ability of the EsSense Profile™ to discriminate products with slight variations, yet are still within the same product category, using emotions (King and Meiselman 2009). All three products are distinguishable from each other, based on differences in emotional intensities. Also, overall liking did not seem to have any identifiable correlations with emotion intensities. This finding is consistent with the research conducted by King and Meiselman (2009), which showed that overall liking does not always reflect positive or negative changes in emotion intensities. There were possible individual "positive" emotions that enhanced overall liking, but with such a large list of emotions, it is difficult to understand the underlying relationships.

Clinical Study

Antioxidant Levels

The 4% spice blend sample was selected for the clinical study to be assessed against the control because, after initial hedonic analysis, it was liked slightly more than the 5% spice blend sample. However, after a complete hedonic analysis of the two blends, there was no statistical difference between the two cereal-like products. There is currently no established recommended daily allowances (RDA) for antioxidants, however, the range of 3,000 to 5,000 oxygen radical absorbance capacity (ORAC) units has been recommended by health experts (Prior *et al.* 2007). The hypothesis was that the consumption of the 4% blend (4,400 µmol TE/2 servings) would lead to a significantly higher antioxidant capacity due to its higher ORAC value. Baseline measurements were taken to have a standard against which to compare. The total antioxidant capacity (TAC) results, measured as µmol TE/100 g (TE stands for Trolox Equivalent), are shown in Table 3-7. The 4% blend was significantly higher in TAC than the control, although it may be debatable as to whether this statistical significance has any clinical significance. Prior *et al.* (2007) came to the same conclusion in similar research, identifying that the amount of increase of plasma antioxidant capacity required to decrease the risk of potential chronic diseases is unknown.

Table 3-7 The Total Antioxidant Capacity Results (n = 10)

Measurement time points	TAC (µmol TE/100g)
Baseline – antioxidant activity at 0 h	107.1b
Control – antioxidant activity after 2 h	110.3a
4% Spice Sample – antioxidant activity after 2 h	114.6a

A consumer must be careful because total antioxidant levels do not fully explain how bioavailable they are. A clinical study was conducted on children, assessing antioxidant capacities in several fruits. The kiwifruit had significantly more antioxidants present in the blood plasma than grapes or strawberries, even though the ORAC values were relatively similar (Prior *et al.* 2007). Researchers are currently trying to understand what factors are contributing to the better absorption of antioxidants. The type of antioxidant has an effect, but the complexity

of antioxidant systems needs further study to fully understand the intricate mechanisms. All antioxidants do not behave in the same manner. Some antioxidants take longer than others to get in the bloodstream. According to Prior *et al.* (2007), antioxidants can take up to 5 hrs to fully be absorbed. Thus, in future research, it is recommended that blood plasma be drawn at 2 hrs, 3.5 hrs, and 5 hrs to get an accurate assessment of the bioavailability of all the antioxidants.

This study did not take into account the effects that extrusion processing parameters have on total antioxidant capacity. Ozer *et al.* (2006) identified that high screw speeds (~340 rpm) and low feed rates (~22.0 kg $h^{-}1$) decreased the total antioxidant capacity in the extruded flour-based products. For the current research, a higher screw speed (~350 rpm) and a moderate feed rate (~2.5 kg/h) were used, which may have led to the reduction of total antioxidant capacity.

Glycemic Index

Cinnamon made up 57% of the spice blend, comprising just over 2% of the total blend. The hypothesis was that the 4% spice blend would reduce the level of glucose in the blood more quickly than the control because of the antidiabetic properties of the spice blend. The results are shown in Table 3-8. The 4% spice sample and the control showed no significant differences in the one-way ANOVA as seen by the separation of means by Fisher's LSD. The finding that cinnamon and the other spices have no effect on lowering blood glucose is reflective of other diabetic studies (Suppapitiporn *et al.* 2006; Vanschoonbeek *et al.* 2006).

Cinnamon has shown antidiabetic properties in human studies (Kannapan and Jayaram 2006; Talpur *et al.* 2005), though the data remains inconsistent as other studies have shown no impact (Suppapitiporn *et al.* 2006). Nutmeg and cloves have also shown the ability to enhance insulin activity in animals, but the current research is much more prevalent on cinnamon's ability to reduce blood glucose levels (Broadhurst *et al.* 2000).

Table 3-8 The Incremental Area Under the Curve Results (n = 10)

Blend	AUC (Area Under the Curve)
Control	117.4a
4% Spice Sample	115.6a

Conclusions

The additions of the spice blends to the control base did not significantly affect overall liking, flavor liking, or appearance liking, although texture liking was liked significantly less for the 4% blend than for the 5% blend or control. However, the percentage of consumers scoring overall liking a 6 or higher for the spiced samples is higher than for the control. Average appearance liking for all samples was low, possibly influencing the scores of the other attributes. Just-about-right scores appeared to favor the 4% blend sample over the 5% blend and control samples.

The spice blends had an effect on the intensity of emotions. The duration of a particular emotion's intensity was also affected by spice/lack of spice. Spices seem to increase certain emotional intensities immediately after consumption, but these intensities generally diminished after one hour post-consumption. The emotion "Satisfied" was enhanced by the 5% spice blend, though the relation to hedonic attributes was not clear. Inconsistencies in the data suggest future research needs to be done to better understand how individual emotions affect overall liking and product acceptance.

The addition of the spice blend showed a minimal increase in total antioxidant capacity, whereas blood glucose values were not significantly affected by the addition of the spices to the 4% blend. In the future, the clinical sample size should be increased and the effects of extrusion parameters on antioxidant capacity and blood glucose levels should be researched.

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CHAPTER 4 - Conclusions and Future Research

The additions of the spice blends to the control base did not significantly affect overall liking, flavor liking, or appearance liking, although texture liking was liked significantly less for the 4% blend than for the 5% blend or control. Average appearance liking for all samples was low, possibly influencing the results of the other attributes. Just about right scores appeared to favor the 4% blend sample over the 5% blend and control samples.

The spice blends had an effect on the intensity of emotions, as well as the duration of emotions experienced. Spices seem to increase certain emotional intensities immediately after consumption, but these intensities generally diminish after one hour post-consumption. Exploratory factor analysis proved the validity and reliability of the EsSense Profile™ scale constructs. The emotion "Satisfied" is enhanced by the spice blend, though the relation to hedonic attributes is unknown. Inconsistencies in the data suggest future research needs to be done to better understand how individual emotions affect overall liking and product acceptance.

Lastly, the clinical study showed evidence that the antioxidants in spices are bioactive as the addition of spices of the 4% blend sample increased the Total Antioxidant Capacity significantly more than the control sample. The spice blend did not have a significant effect on blood glucose values. In the future, a larger scale clinical study needs to be conducted, taking blood plasma samples over an extended period of time, to better understand the bioavailability of antioxidants in spices.

New research should focus on a single spice because there do not appear to be any antidiabetic synergies existing within the blend. A better representation of the curve would have increased the accuracy of the curve so more time points are recommended for similar studies in the future. The 4% and 5% blends were still in the acceptable range hedonically so the concentration of spice could be increased 6% or 7%) to obtain results with the possibility of significance. The caveat would be not to increase the percent too much as to make it unpalatable. Consumers are driven first by products that are hedonically acceptable. The challenge of product development is to provide consumers with a product they prefer, but that also offers nutritional and functional benefits (Griep *et al.* 2003).

The screw speeds and feed rates could be altered in future research studies to further understand their affect on the total antioxidants capacities of extruded "spiced" products. Other extrusion processing parameters, including barrel temperatures, die sizes, and cutting

mechanisms, should also be looked into as we do not know the effect a change in these parameters would have on total antioxidant capacity.

Appendices

Appendix A - Hedonic Questionnaire

Figure A-1 Hedonic Questionnaire

Consumer # _____ Sample # Date _____

Instruction A. **You are evaluating extruded snack samples.**

Instruction B. **Please rinse your mouth with water and take a bite of the cracker between samples or as needed.**

Instruction C. **Please eat at least half of the sample before answering any of the questions.**

Instruction D. **Mark an "X" in the box next to the phrase that best describes your opinion about the sample you just tasted from Dislike extremely to Like extremely**

	Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
1. How much do you like this sample **OVERALL**?	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. How much do you like the **APPEARANCE**?	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. How much do you like the **FLAVOR**?	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. How much do you like the **TEXTURE**?	☐	☐	☐	☐	☐	☐	☐	☐	☐

Consumer # _____ Sample #

Instruction E. **Mark an "X" in the box next to the phrase that best describes your opinion about the sample you just tasted.**

		Much Too Dark	Moderately Too Dark	Slightly Too Dark	Just About Right	Slightly Too Light	Moderately Too Light	Much Too Light
APPEARANCE	6. Color of Snack?	☐	☐	☐	☐	☐	☐	☐
		Much Too Weak	Moderately Too Weak	Slightly Too Weak	Just About Right	Slightly Too Strong	Moderately Too Strong	Much Too Strong
FLAVOR	7. Overall flavor?	☐	☐	☐	☐	☐	☐	☐
FLAVOR	8. Sweetness?	☐	☐	☐	☐	☐	☐	☐
FLAVOR	9. Overall Spice Flavor?	☐	☐	☐	☐	☐	☐	☐
FLAVOR	10.Saltiness?	☐	☐	☐	☐	☐	☐	☐
FLAVOR	11. Cinnamon Flavor?	☐	☐	☐	☐	☐	☐	☐
		Much Too Soft	Moderately Too Soft	Slightly Too Soft	Just About Right	Slightly Too Hard	Moderately Too Hard	Much Too Hard
TEXTURE	12. Soft/Hard?	☐	☐	☐	☐	☐	☐	☐
		Much Too Airy	Moderately Too Airy	Slightly Too Airy	Just About Right	Slightly Too Dense	Moderately Too Dense	Much Too Dense
TEXTURE	13. Airy/Dense?	☐	☐	☐	☐	☐	☐	☐
		Much Too Little	Moderately Too Little	Slightly Too Little	Just About Right	Slightly Too Much	Moderately Too Much	Much Too Much
TEXTURE	14. Toothpacking (that is the amount of sample left on teeth after swallowing)?	☐	☐	☐	☐	☐	☐	☐

Appendix B - EsSense Profile™

Table B-1 EsSense Profile (King and Meiselman 2009)

Feeling	Not at all	Slightly	Moderately	Very	Extremely
Active	1	2	3	4	5
Adventurous	1	2	3	4	5
Affectionate	1	2	3	4	5
Aggressive	1	2	3	4	5
Bored	1	2	3	4	5
Calm	1	2	3	4	5
Daring	1	2	3	4	5
Disgusted	1	2	3	4	5
Eager	1	2	3	4	5
Energetic	1	2	3	4	5
Enthusiastic	1	2	3	4	5
Free	1	2	3	4	5
Friendly	1	2	3	4	5
Glad	1	2	3	4	5
Good	1	2	3	4	5
Good-natured	1	2	3	4	5
Guilty	1	2	3	4	5
Happy	1	2	3	4	5
Interested	1	2	3	4	5
Joyful	1	2	3	4	5
Loving	1	2	3	4	5
Merry	1	2	3	4	5
Mild	1	2	3	4	5
Nostalgic	1	2	3	4	5
Peaceful	1	2	3	4	5
Pleased	1	2	3	4	5
Pleasant	1	2	3	4	5
Polite	1	2	3	4	5

Quiet	1	2	3	4	5
Satisfied	1	2	3	4	5
Secure	1	2	3	4	5
Steady	1	2	3	4	5
Tame	1	2	3	4	5
Tender	1	2	3	4	5
Understanding	1	2	3	4	5
Warm	1	2	3	4	5
Whole	1	2	3	4	5
Wild	1	2	3	4	5
Worried	1	2	3	4	5

Are there any other emotions that you are feeling right now?

Appendix C - Consumer Hedonic Data

Table C-1 Liking ANOVA Data

Dependent Variable: Overall Liking

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	101	583.1300000	5.7735644	3.29	<.0001
Error	198	347.7866667	1.7564983		
Corrected Total	299	930.9166667			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Consumer	99	579.5833333	5.8543771	3.33	<.0001
Sample	2	3.5466667	1.7733333	1.01	0.3662

Dependent Variable: Appearance Liking

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	101	522.4300000	5.1725743	5.32	<.0001
Error	198	192.4066667	0.9717508		
Corrected Total	299	714.8366667			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Consumer	99	521.5033333	5.2677104	5.42	<.0001
Sample	2	0.9266667	0.4633333	0.48	0.6215

Dependent Variable: Flavor Liking

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	101	514.6966667	5.0960066	2.18	<.0001
Error	198	463.5000000	2.3409091		
Corrected Total	299	978.1966667			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Consumer	99	513.5300000	5.1871717	2.22	<.0001
Sample	2	1.1666667	0.5833333	0.25	0.7797

Dependent Variable: Texture Liking

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	101	442.4600000	4.3807921	2.62	<.0001
Error	198	330.4866667	1.6691246		
Corrected Total	299	772.9466667			

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Consumer	99	431.6133333	4.3597306	2.61	<.0001
Sample	2	10.8466667	5.4233333	3.25	0.0409

Table C-2 LSD for Hedonic Attributes

*4bln = 4% blend, 5bln = 5% blend, cont = control

LSD for Overall Liking

Alpha	0.05
Error Degrees of Freedom	198
Error Mean Square	1.756498
Critical Value of t	1.97202
Least Significant Difference	0.3696

Means with the same letter are not significantly different.			
t Grouping	**Mean**	**N**	**Sample**
A	5.4300	100	5bln
A			
A	5.3500	100	4bln
A			
A	5.1700	100	cont

LSD for Appearance Liking

Alpha	0.05
Error Degrees of Freedom	198
Error Mean Square	0.971751
Critical Value of t	1.97202
Least Significant Difference	0.2749

Means with the same letter are not significantly different.			
t Grouping	Mean	N	Sample
A	4.0300	100	5bln
A			
A	4.0000	100	cont
A			
A	3.9000	100	4bln

LSD for Flavor Liking

Alpha	0.05
Error Degrees of Freedom	198
Error Mean Square	2.340909
Critical Value of t	1.97202
Least Significant Difference	0.4267

Means with the same letter are not significantly different.			
t Grouping	Mean	N	Sample
A	5.3300	100	4bln
A			
A	5.2800	100	5bln
A			
A	5.1800	100	cont

LSD for Texture Liking

Alpha	0.05
Error Degrees of Freedom	198
Error Mean Square	1.669125
Critical Value of t	1.97202
Least Significant Difference	0.3603

Means with the same letter are not significantly different.			
t Grouping	Mean	N	Sample
A	5.6500	100	5bln
A			
A	5.5900	100	cont
B	5.2200	100	4bln

Appendix D - Consumer JAR Data

Table D-1 JAR Frequencies

Color JAR Frequencies

Color JAR - 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	6	6.0	6.0	6.0
	3	24	24.0	24.0	30.0
	4	61	61.0	61.0	91.0
	5	9	9.0	9.0	100.0
	Total	100	100.0	100.0	

Color JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	11	11.0	11.0	11.0
	3	28	28.0	28.0	39.0
	4	54	54.0	54.0	93.0
	5	7	7.0	7.0	100.0
	Total	100	100.0	100.0	

Color JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	3	3.0	3.0	3.0
	3	15	15.0	15.0	18.0
	4	59	59.0	59.0	77.0
	5	20	20.0	20.0	97.0
	6	1	1.0	1.0	98.0
	7	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Overall Flavor JAR Frequencies

Overall Flavor JAR - 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	2.0	2.0	2.0
	2	2	2.0	2.0	4.0
	3	27	27.0	27.0	31.0
	4	40	40.0	40.0	71.0
	5	23	23.0	23.0	94.0
	6	5	5.0	5.0	99.0
	7	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

Overall Flavor JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	2.0	2.0	2.0
	2	6	6.0	6.0	8.0
	3	20	20.0	20.0	28.0
	4	31	31.0	31.0	59.0
	5	29	29.0	29.0	88.0
	6	10	10.0	10.0	98.0
	7	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Overall Flavor JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	11	11.0	11.0	11.0
	2	13	13.0	13.0	24.0
	3	41	41.0	41.0	65.0
	4	30	30.0	30.0	95.0
	5	3	3.0	3.0	98.0
	6	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Overall Spice Flavor JAR Frequencies

Overall Spice Flavor JAR – 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	3.0	3.0	3.0
	2	3	3.0	3.0	6.0
	3	20	20.0	20.0	26.0
	4	40	40.0	40.0	66.0
	5	26	26.0	26.0	92.0
	6	6	6.0	6.0	98.0
	7	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Overall Spice Flavor JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	2	2.0	2.0	2.0
	2	3	3.0	3.0	5.0
	3	12	12.0	12.0	17.0
	4	37	37.0	37.0	54.0
	5	34	34.0	34.0	88.0
	6	7	7.0	7.0	95.0
	7	5	5.0	5.0	100.0
	Total	100	100.0	100.0	

Overall Spice Flavor JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	10	10.0	10.0	10.0
	2	16	16.0	16.0	26.0
	3	34	34.0	34.0	60.0
	4	33	33.0	33.0	93.0
	5	7	7.0	7.0	100.0
	Total	100	100.0	100.0	

Sweetness JAR Frequencies

Sweetness JAR – 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	4	4.0	4.0	4.0
	2	9	9.0	9.0	13.0
	3	30	30.0	30.0	43.0
	4	51	51.0	51.0	94.0
	5	5	5.0	5.0	99.0
	6	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

Sweetness JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	5	5.0	5.0	5.0
	2	11	11.0	11.0	16.0
	3	40	40.0	40.0	56.0
	4	39	39.0	39.0	95.0
	5	4	4.0	4.0	99.0
	6	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

Sweetness JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	5	5.0	5.0	5.0
	2	15	15.0	15.0	20.0
	3	35	35.0	35.0	55.0
	4	41	41.0	41.0	96.0
	5	4	4.0	4.0	100.0
	Total	100	100.0	100.0	

Saltiness JAR Frequencies

Saltiness JAR – 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	6	6.0	6.0	6.0
	2	8	8.0	8.0	14.0
	3	23	23.0	23.0	37.0
	4	55	55.0	55.0	92.0
	5	8	8.0	8.0	100.0
	Total	100	100.0	100.0	

Saltiness JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	6	6.0	6.0	6.0
	2	10	10.0	10.0	16.0
	3	22	22.0	22.0	38.0
	4	57	57.0	57.0	95.0
	5	5	5.0	5.0	100.0
	Total	100	100.0	100.0	

Saltiness JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	9	9.0	9.0	9.0
	2	11	11.0	11.0	20.0
	3	26	26.0	26.0	46.0
	4	53	53.0	53.0	99.0
	5	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

Cinnamon JAR Frequencies

Cinnamon JAR – 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	3.0	3.0	3.0
	2	5	5.0	5.0	8.0
	3	28	28.0	28.0	36.0
	4	38	38.0	38.0	74.0
	5	19	19.0	19.0	93.0
	6	5	5.0	5.0	98.0
	7	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Cinnamon JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	3	3.0	3.0	3.0
	2	3	3.0	3.0	6.0
	3	19	19.0	19.0	25.0
	4	37	37.0	37.0	62.0
	5	24	24.0	24.0	86.0
	6	7	7.0	7.0	93.0
	7	7	7.0	7.0	100.0
	Total	100	100.0	100.0	

Cinnamon JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	17	17.0	17.0	17.0
	2	23	23.0	23.0	40.0
	3	26	26.0	26.0	66.0
	4	31	31.0	31.0	97.0
	5	3	3.0	3.0	100.0
	Total	100	100.0	100.0	

Soft/Hard JAR Frequencies

Soft/Hard JAR – 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	1.0	1.0	1.0
	3	7	7.0	7.0	8.0
	4	52	52.0	52.0	60.0
	5	32	32.0	32.0	92.0
	6	8	8.0	8.0	100.0
	Total	100	100.0	100.0	

Soft/Hard JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	2	2.0	2.0	2.0
	4	69	69.0	69.0	71.0
	5	23	23.0	23.0	94.0
	6	6	6.0	6.0	100.0
	Total	100	100.0	100.0	

Soft/Hard JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	1.0	1.0	1.0
	4	73	73.0	73.0	74.0
	5	22	22.0	22.0	96.0
	6	3	3.0	3.0	99.0
	7	1	1.0	1.0	100.0
	Total	100	100.0	100.0	

Airy/Dense JAR Frequencies

Airy/Dense JAR – 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	1	1.0	1.0	1.0
	2	3	3.0	3.0	4.0
	3	4	4.0	4.0	8.0
	4	46	46.0	46.0	54.0
	5	38	38.0	38.0	92.0
	6	8	8.0	8.0	100.0
	Total	100	100.0	100.0	

Airy/Dense JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	5	5.0	5.0	5.0
	4	62	62.0	62.0	67.0
	5	29	29.0	29.0	96.0
	6	4	4.0	4.0	100.0
	Total	100	100.0	100.0	

Airy/Dense JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	1.0	1.0	1.0
	3	4	4.0	4.0	5.0
	4	67	67.0	67.0	72.0
	5	26	26.0	26.0	98.0
	6	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Toothpacking JAR Frequencies

Toothpacking JAR – 4% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	43	43.0	43.0	43.0
	5	42	42.0	42.0	85.0
	6	13	13.0	13.0	98.0
	7	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Toothpacking JAR – 5% blend

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	1	1.0	1.0	1.0
	4	40	40.0	40.0	41.0
	5	51	51.0	51.0	92.0
	6	6	6.0	6.0	98.0
	7	2	2.0	2.0	100.0
	Total	100	100.0	100.0	

Toothpacking JAR - control

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	42	42.0	42.0	42.0
	5	43	43.0	43.0	85.0
	6	13	13.0	13.0	98.0
	7	2	2.0	2.0	100.0
	Total	100	100.0	100.0	