CULINOLOGY APPLICATIONS TO A CONVENIENT

AND ECONOMIC FROZEN DINNER SET

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A Thesis presented to the Faculty of the Graduate School

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of the Requirements for the Degree

Master of Science

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by

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The undersigned, appointed by the Dean of the Graduate School, have examined the

thesis entitled

CULINOLOGY APPLICATIONS TO A CONVENIENT AND ECONOMIC

FROZEN DINNER SET

Presented by Gregory J. Cosgrove

A candidate for the degree of Master of Food Science

And hereby certify, that in their opinion, it is worthy of acceptance.

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Thank you to the Kappa Sigma Fraternity for all your brotherly care. A.E.K.Δ.B.

Thanks to my parents who never stopped believing in me. This was all for you.

Love you both.

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CULINOLOGY APPLICATIONS TO A CONVENIENT AND ECONOMIC FROZEN DINNER SET

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ABSTRACT

With the rising demand for convenient foods, there usually comes a decrease in quality. Combining the work of food science with culinary arts may result in a food product that is both convenient and economic without having to sacrifice any sensory characteristics. In this study, a culinary arts inspired meal was modified using various food science methods, such as gelling properties, use of the lactoperoxidase system, sensory analysis, and food engineering. The result is a frozen three-course meal that can be cooked at home but can rival the quality of an up-scale restaurant.

CHAPTER 1

INTRODUCTION

Today, many American families go out to eat at fast food restaurants rather than cooking and eating at home, a habit that has been indicated to contribute to the rising obesity rate of the American population. All-You-Can-Eat buffets contribute to the issue by promoting customers to gorge as much food as possible to get their value's worth resulting in bad portion control. Value is a major driving force for most Americans as well as convenience. Journalist Catherine Mitros (2009) describes how Americans are currently not only looking for value, but also for convenience at their local grocery stores. However, there is still a larger rise in fast food orders. McDonalds' monthly stock has more than doubled in the time frame of January 2000 (29.51) to December 2009 (62.17) (Yahoo! Finance, accessed March 2011). This combination of cheap and fast convenience food is causing families to spend more time in drive-throughs and less time at the dinner table.

It has been shown that the saying "a family that eats together, stays together," upholds its reputation. Journalist Nancy Gibbs (2006) described that family members that eat at the dinner table are less likely to be depressed, try illegal substances, or develop eating disorders. In addition, eating dinner together is supposed to also promote trust between kids and parents. This structured time is essential to family life. However, with parents and children always on the move, they may find it hard to find the time to actually make a home cooked meal, or perhaps they don't even know how to cook at all.

Another possible concern is that children are constantly being exposed to the same foods over and over again. Chicken fingers, hamburgers, fries, macaroni and cheese, and peanut butter and jelly are just a few examples of these commonly used children foods. Children need to be able to expand their palate to new varieties of food. It may be frustrating to a mother who can only cook chicken to feed her picky eaters. Even getting kids to eat vegetables has been a common issue throughout the ages. Kids, being force-fed the same old canned green beans and peas, have convinced themselves that all greens are distasteful. However, using various cooking techniques, these once undesirable greens can become good eats.

To further the issue, to some, the terms *crème brulee, sauté, mirepoix, & mis en place* are all foreign French cooking terms that many cooks don't understand or have not even heard of, but these terms can make cooking easier and food taste better if one is to expand their culinary expertise. These techniques, commonly found in an up-scale restaurant, don't have to reside just there, but could be brought to the home. A product that helps with portion control, has great value and convenience, as well as brings the feeling of a nice restaurant to a home would be a great incentive to bring the family back to the dinner table and promote good family structure.

The objective is to create a dinner product that could be found in an upscale restaurant and reformulated to a convenient frozen family dinner at an affordable price. This can be achieved using culinology methods. Culinology is a term that describes the combination of the disciplines of food science and culinary arts (Rittman, 2007). The dinner set developed for this project consists of three courses to promote a good eating

pace and to reenact the experience of a restaurant. Each dish: appetizer, entrée, and dessert, has undergone various tests. The dishes are simple enough to accommodate a picky eater, but introduce characteristics that makes it "gourmet." The goal is to feed a family of four a meal that will rival the quality of a meal prepared by a trained chef, combined with the convenience and price of fast food, all in one frozen package to be found at the local grocery store.

The project consisted of three main focus points. The entrée uses the lactoperoxidase system to inhibit microbial growth, the dessert uses hydrocolloids to produce texture, spherification, and anti-thawing capabilities, and sensory testing to conclude if all the dishes are likable as individual dishes and as a whole meal. The completed product is supposed to provide an affordable gourmet dinner for a family of four at home. This should, in the long run, teach proper portion control and eating pace, expand the palate, promote good family values, as well as increase self-confidence in cooking skills.

CHAPTER 2

LITERATURE REVIEW

2.1 Culinology

2.1.1 Introduction

Culinology is the interdisciplinary field of food science and culinary arts. Understanding and application of this discipline allows one to be well versed in the world of product development. The organization was founded in 1996 by a group of professionals that wished to merge their disciplines of culinary arts and food science (culinology.com accessed March 2011). Other names that are often used interchangeably with Culinology are "molecular gastronomy," "kitchen science" and "kitchen chemistry." The merger of both disciplines allow for a more unique touch to product development. In the past, food companies had two teams that probably argued back and forth. For example, the food scientists may have wanted to add preservatives or colors to ensure stability, but the chefs would disagree due to the fact that it would depreciate the flavor and/or texture that they worked hard to achieve. However, the understanding and opinions are shifting. Now, chefs have realized that the addition of certain food compounds can actually enhance their dish. For example, adding soy lecithin and nitrogen to a blueberry puree will make a very smooth and light foam for a dessert. These chemicals, which were not readily used by culinary specialists in the past, are becoming common ingredients in some of their dishes. In addition, food scientists that couldn't understand what a chef meant when they said they were making a *confit*, are

learning the language of culinary arts and are gaining a new appreciation for textures and complex flavors as well as bringing the communication barrier down to create sensational dishes.

2.1.2. Cooking Methods

The most common form of cooking done in households these days is probably the use of the microwave. Frozen foods are cooked in just a manner of seconds. The microwave, although providing us with the convenience of quickly heating our food, also provides us with quality defects of soggy foods. Microwaves simply heat your food by emitting electromagnetic waves that excite the water molecules in the food, causing them to vibrate at a very high rate producing friction at the molecular level, thus producing heat. Easy-cook dinners have underestimated the prime kitchen tool: the oven. Although food is not cooked as quickly, the oven supplies food with a superior taste and texture. This is primarily because oven heat promotes the Maillard reaction. This reaction is commonly known as "browning." In addition, when we cook food, we denature proteins. As this phenomenon occurs, we release certain chemicals that were trapped by these proteins, namely, aromatics. Proteins act like a spider web, holding fats, moisture, and aromatics in place. When heated, the proteins will unwind, loosening up allowing these other chemicals to move freely. As aromatics are very volatile, they will be released into the air. This will also enhance the flavor of food as smell constitutes a more important portion of flavor than taste does. Browning also causes the proteins that were once

simple, to form a new network of complex flavors further enhancing the quality of the food. This process just does not happen as well in a simple microwave.

Another method that will be further explored in this project is the *sous vide* method. The words mean "under vacuum" in French. In this method, the cook will take the desired food, and place it in a bag that is then vacuum sealed. It will then actually slow-cook the food in a pot of water or steamed environment. The food is being heated from all sides and retains its natural juices. Since the food is cooked at a low temperature, the dish is never overcooked and always tender. For example, Chef Thomas Keller will actually take a bag and insert a beef tenderloin and a small amount of sauce, vacuum seal it, and then cook it in water at 155°F for an hour. This practice ensures the food will never exceed 155°F, which would overcook the meat, and allows the sauce to be cooked and absorbed into the dish. The process takes much longer, but the texture of the food will be superior as any collagen in the meat will be reduced to gelatin, thus thickening and adding flavor to the sauce upon resting. This particular method will be the basis of cooking methods for this project. If browning is not of major importance, such as in pasta, it can be cooked in boiling water. If browning is important, such as with meat, it can be cooked in a sauce while in the oven.

2.1.3 Plating

One of the most important aspects of fine dining, besides taste and texture, is the appearance of the food. If something does not look appetizing, the diner may not enjoy the meal. Chefs want to make sure that the foods are neat and clean. The main

ingredients should be easy to see and there is usually some form of a garnish on the plate

to complement the main dish. A garnish can be as simple as a piece of kale, which is

probably the most common at an average bar and grill restaurant or even just a side dish

such as a salad or vegetable. Nicer restaurants can use other various techniques such as

swirls of sauce on the plate, adding a small pile of a form of relish, or simply putting a

dusting of seasoning such as oregano or powdered sugar on top of the food or dish. More

creative chefs have thought even more outside the box by using magnets to create a

floating illusion and dry ice for a simple fog. Liquid nitrogen has also entered some more

innovative kitchens.

2.1.4 Product Development

Product development is usually the cornerstone of any food provider. Without

new products, companies may have difficulty expanding. Even a popular company

known around the world, such as Coca-Cola, still tries to get new products out on the

shelves to appeal to various customers. Companies are trying to provide the customers

with products based on the latest trends. Since there is a rising demand in foods that are

quick and easy to prepare, companies are working hard to produce foods that are cooked

in a matter of minutes or even seconds. This project answers this rising demand as well

as other trends such as convenience, healthfulness, variety, portion control, freshness and

naturalness, value, and flavor (Glicksman 1985). There are also other factors that affect

the decisions of the household grocery shopper. Glicksman (1985) gives examples of

how market trends can help predict what we buy. For instance, with many families with

dual-working parents, there is a growing desire to purchase "more expensive and value-added foods." Glicksman continues to point out that as technology advances, so does the education and awareness of food ingredients. Currently, some companies are actually dropping their processed ingredients and moving to something more natural due to customers' demand such as substituting high fructose corn syrup for normal sugar. These trends are usually the driving force behind what new products will be on the shelves.

The procedure of developing a new product can be very complex because there are several steps and hurdles that the product must overcome. Companies will usually listen to the demands of the customers or look at market trends and anticipate what may be a good product for the future. In most cases, a large amount of ideas are presented, but perhaps only one or two may show promise. Developers will make small prototypes and then decide which one to continue with. Although a product may not make the initial cut does not mean that it may not meet the market demands later. After the concept has been laid out, the recipe has to undergo rigorous testing. Flavor, texture, safety, and appearance are some of the most important things that a food scientist must work on while making a food prototype. Later, mass production feasibility becomes the next step. The stress of the new product needing to be convenient can make it difficult to achieve these goals. As stated before, the food must be pleasing not only to the palate, but also to the eyes, nose, mouth, and even the ears. A freshly baked cookie may taste and smell good, but if it has an odd color, or an undesirable lack or over-presence of crunch, the customer may not purchase the product. Therefore, testing must be done to appeal to the

desired audience, be it a wide audience, or a specific focus group, such as children or health enthusiasts.

The next step after a food has passed its primary sensory testing is that the food must be considered safe according to FDA and/or USDA regulations. These regulations include the labeling information for the product. All food products must have a list of ingredients, nutritional information, and weight somewhere on the package for ready-to-eat foods. Microbiological testing must also be done at the large scale level to ensure that no pathogens are present during the manufacturing process. After the food is proven to be safe, it can undergo packaging.

Some companies are even converting to smarter packaging to provide information about the food using barcodes or what is called "active packaging" (Yam and others 2005). Such packaging could be found on future food products, and will help regulate the presence of certain food characteristics, such as retention of specific gasses or moisture, allowing osmosis for specific gasses, or even releasing gasses over time. The packaging can also be thermally stable to perhaps resist freezer burn, or even be stable enough to be placed in a cooking vessel while containing the food. This latter version is gaining great reputation due to the high demand for quick microwavable meals that take only minutes to heat. There are also bags of frozen vegetables that can be placed in the microwave, where the bag will actually help steam cook the vegetables by regulating air flow.

If the product successfully meets the demands of the market, the product is usually introduced as a promotion or test run in an area that would most likely approve of

the product, similar to a large scale interest group. If the product survives under the best possible marketing conditions, the producers may either go to a larger scale or perhaps even further enhance their product by using customer feedback. If the product fails to meet customer demand, the project may be scrapped or redone.

Most new products are line extensions. A similar product with a slight change, such as oatmeal cookies with raisins becomes oatmeal cookies with chocolate chips. It rarely happens that a product is completely replaced, but in April 1985 Coke-Cola replaced their main product entirely. The product "New Coke" or "Coke II," as it was renamed in 1992, proved to do so well in focus groups that they ended production of the old formula and produced only the newer version. However, sales plummeted so much that Coke reintroduced the original formula as Coke Classic in order to regain sales after only four months of New Coke production (Mikkelson 2007).

2.1.5 Cooking Chemistry

Chemistry is everywhere and certainly also in the kitchen. A cook may even be considered a simple kitchen chemist. There are many techniques that cooks use to make cooking better or easier that are based on chemistry. Chemistry is why meat browns on the grill, why we separate egg yolks and whites in a meringue, why adding vinegar may change the color of our food, why we ripen peaches in a brown bag, and why we add oil to boiling pasta to make it not stick or add salt to make the water hotter.   Even further, if to examine the ingredients on a food package sometime, manufacturers may add some common ingredients such as locust bean gum, aspartame, isolated soy protein,

hydrolyzed oil, or other science based ingredients found in the statement to provide

various effects. These particular ingredients add either body, protein, sweetness, or

stability to foods at the molecular level. Utilizing this technology while following the

steps of product development, creative foods can be formulated. These practices include,

but are not limited to, browning, cooking, moisture retention, texture, flavor, aroma,

gelation, spherification, and freeze/thaw stability.

2.2 Hydrocolloids

2.2.1 Introduction: Gels in the Food Industry

Gels and emulsions are very common in today's food industry. An emulsion is a

network of proteins that have formed a web that protects and holds either air, fats, or

water. Ice cream, hot dogs, and salad dressings are all emulsions. A gel differs from an

emulsion in that it has a water binding ingredient. For example, gelatin forms a semi-

solid gel when it has been heated with water and allowed to cool. Gelatin is also called a

hydrocolloid, a common ingredient to a food scientist or chef when trying to thicken a

food with a small amount of ingredient. Hydrocolloids are hydrophilic white powders

that are commonly derived from plants, bacteria, or in the case of gelatin, from animals.

Hydrocolloids have various functionalities such as gelling, thickening, creating

emulsions, or increasing or even decreasing the viscosity of food depending on its

environment. For example, when squeezing a ketchup bottle, the condiment comes out

easy, but when it has settled and no pressure is acting upon it, it will thicken up again. A

cornstarch solution, on the other hand will thicken up when pressure is applied, and form

a liquid when not under pressure. These ingredients are not very popular in the common household yet as the common cook may not be welcome to the thought of using or having the understanding of this level of science, but they are becoming more common in the culinary industries. Hydrocolloids can possibly even replicate the texture of fat at just a minor fraction of the calories, if any, as well as using a smaller amount of ingredient leading to a healthier product. They can also act as fat analogs used in vegan dishes as they are from non-animal sources. They may not be well known to most chefs, but these hydrocolloids are not new at all as they have been gaining a good reputation since the mid-1900 for enhancing ready-made products.

Hydrocolloids became a popular ingredient in fabricated foods around the time of World War II. "The movement of large numbers of women out of the kitchen and into the workforce created a demand for time-saving convenience foods" (Glicksman 1985). The war caused a decline in protein rich foods as well as required foods that were stable while the soldiers were moving. Hydrocolloids were added to foods to ensure there was greater convenience and longer shelf life of foods. "In the early 1970s, the Arab oil boycott and takeover of the world oil markets by OPEC led to a massive economic upheaval. As the prices of feedstock, fertilizer, pesticides, and other oil dependent commodities rose, the price of meat" went out of control forcing efforts to find an alternative protein source (Glicksman 1985). The answer lied in soybeans and to some extent, previously undesired animal parts. Meat analogs were a booming fad for about a decade until the world oil markets calmed back down and oil became more affordable

again. Glicksman (1985) continues by showing that hydrocolloids come from various

sources which can be seen in Table 1.

Table 1: Edible hydrocolloids

Exudates	Extracts	Flours	Biosynthetic (fermentation)	Semi-synthetic (modified natural)	Synthetic
Plant: Arabic Chatti Karaya Tragacanth	Seaweed: Agar Alginates Carrageenans Furcellaran Plant: Pectin Arabinoga-lactan Animal: Gelatin Cereal: Corn hull Oat Vegetable: Okra	Seed: Locust bean Guar Tara Tamarind Quince Psyllium seed Flax seed Cereal starches: Corn Wheat Rye Waxy maize Tuber: Potato starch Konjac mannan Root: Tapioca starch	Dextrans Xanthan Curdlan Polytran Gellan Pullulan	Cellulose derivatives: Carboxymethylcellulose Methylcellulose Hydroxypropylmethyl-cellulose Hydroxypropylcellulose Hydroxyethylcellulose Starch derivatives: Hydroxypropyl starches Propylene glycol alginate Low methoxyl pectin Hydroxypropyl guar	Polyvinylpyrrolidone (PVP) Polyethylene oxide polymers (Polyox) Acrylic acid polymer (Carbopol) Methyl vinyl ether/ maleic anhydride (Gantrez An) Polyvinyl alcohol (PVA) Polyethylene glycol polymers (Carbowax)

Hydrocolloids, with the exception of the protein gelatin, are hydrophilic

carbohydrate polymers that are usually multi-functional. They are also so powerful that

most applications call for about, if not less than, one percent of the bulk weight

(Glicksman 1985). This low concentration can be further reduced by combining specific

hydrocolloids that work synergistically to obtain a certain characteristic. This synergy

can enhance the desired characteristic to a greater extent than a single hydrocolloid alone.

For example, Soukoulis and others (2008) showed the effects of various hydrocolloids at

two different concentrations with and without the addition of k-carrageenan to ice cream.

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The different concentrations, and mixtures had various effects on the overrun, storage quality, and melting time of the ice cream.

Although there can be synergy between hydrocolloids, there can also be antagonistic occurrences between them and with other chemicals as well (Zasypkin and others 1997). In the experiments of Soukoulis and others (2008), the addition of k-carrageenan enhanced several characteristics but in the case of melting time, the addition actually caused the ice cream to melt sooner. Table 2 shows the hydrocolloids that were used as well as their concentrations. The melting time of these combinations can be seen in Table 3.

Table 2: Composition of vanilla ice cream samples used in study.

Sample	Hydrocolloid percentage (%)		Hydrocolloid type
	Primary	κ-carrageenan	
C1	0.1	—	CMC
C2	0.2	—	Cekol 4000P
G1	0.1	—	Guar gum
G2	0.2	—	Grinsted
A1	0.1	—	Sodium alginate
A2	0.2	—	Protanal HF120L
X1	0.1	—	Xanthan gum
X2	0.2	—	Luxara 7571-200
CK1	0.09	0.01	CMC/κ-carrageenan
CK2	0.18	0.02	Cekol 4000P/Seakem IC 518
GK1	0.09	0.01	Guar gum/κ-carrageenan
GK2	0.18	0.02	Grindsted/Seakem IC 518
AK1	0.09	0.01	Sodium alginate/κ-carrageenan
AK2	0.18	0.02	Protanal HF120L/Seakem IC 518
XK1	0.09	0.01	Xanthan gum/κ-carrageenan
XK2	0.18	0.02	Luxara 7571-200/Seakem IC 518

Table 3: Melting time of ice cream enhanced with hydrocolloid types with and without the presence of kappa carrageenan.

Sample	Melting rate $(\text{g g}^{-1}\text{ min})$	First dripping time (s)
C1	1.32^{cd}	1525^{cd}
C2	1.36^{d}	1340^{bcd}
G1	1.42^{de}	1500^{cd}
G2	1.22^{c}	1225^{bc}
A1	1.42^{de}	1160^{b}
A2	0.39^{a}	1222^{bc}
X1	1.53^{e}	1472^{cd}
X2	1.08^{bc}	1585^{e}
CK1	1.66^{g}	1070^{ab}
CK2	1.31^{cd}	1250^{bc}
GK1	1.48^{de}	970^{a}
GK2	0.95^{b}	1140^{b}
AK1	1.50^{e}	1410^{cd}
AK2	1.67^{g}	1534^{cd}
XK1	1.23^{c}	945^{a}
XK2	1.30^{cd}	1531^{cd}

$^{a-e,g}$Different letters between the rows indicates significant difference ($p < 0.05$) among the ice cream samples according to Duncan's mean values comparison test.

Sodium, sugar, and calcium may also have an effect on gelling properties of hydrocolloids. The molecules will bond to the hydrocolloid preventing the formation of any other covalent bonds that are needed to form the gel. Therefore, careful attention must be paid to which hydrocolloid and environment is needed to ensure the right level of gelling is achieved.

2.2.2. Carboxymethylcellulose

Carboxymethylcellulose (CMC) is a white powder hydrocolloid derived from tree cellulose. It is special as it does not need to be heated in order to hydrate. It does,

however, need to be added slowly and agitated as it forms gels very quickly. It is non-digestible, non-toxic, and non-allergenic. It is manufactured using a two-step process. The first step is an alkali-catalyzed reaction by using sodium hydroxide, which opens up the bound cellulose chains. With the cellulose chains opened, water can now enter. For the second part of the process, sodium monochloroacetic acid is added and the polar carboxyl groups thus render the cellulose soluble and chemically reactive (Hoefler 2010), which is shown in the chemical reaction can be seen in Figure 1.

Figure 1: Manufacture of CMC

Manufacture of CMC

Step One:

R-OH + NaOH -----> R-ONa + H2O

Step Two:

R-ONa + Cl-CH2-COONa -----> R-O-CH2-COONa

(Hoefler 2010)
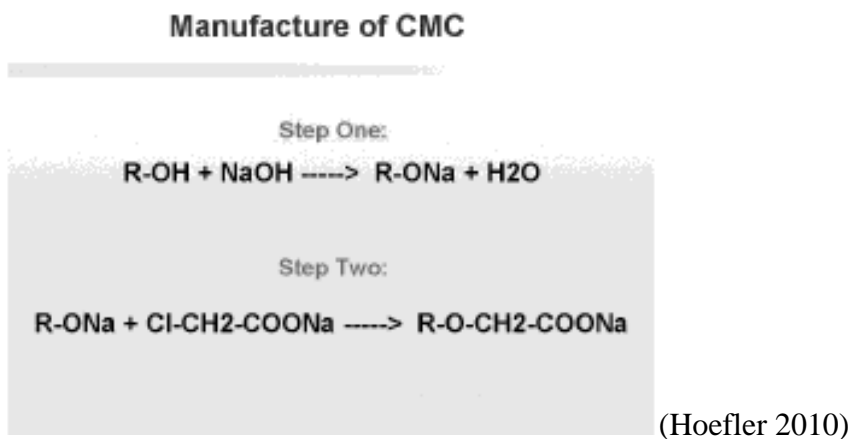
It is used in and outside of the food industry, such as in oil drilling, pharmacological applications, and in paints. Its nomenclature can be seen in Figure 2.

Figure 2: CMC Nomenclature

(Hoefler 2010)
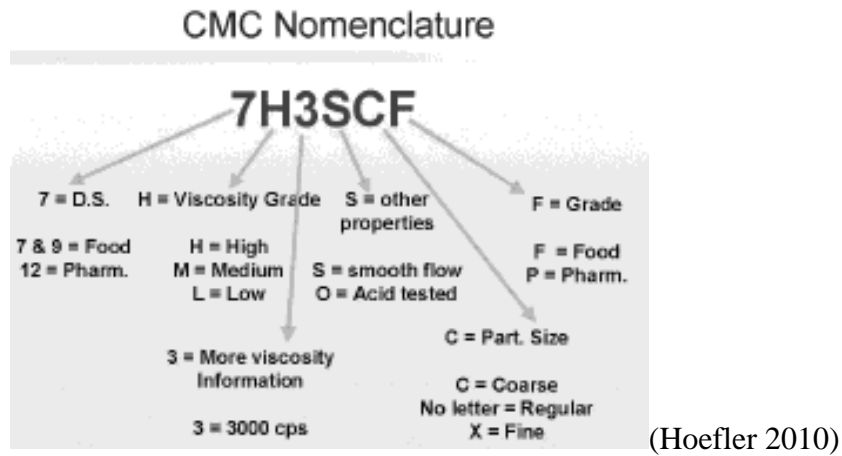
CMC has a strange characteristic as it can form a fluid gel at lower temperatures but at 130°C it will actually form a solid gel. This can be useful in many cooking techniques. For instance, when cooking cheese sticks, the cheese melts and sometimes leaks out of the breading, but by adding CMC, the gel would form causing less leakage. Upon cooling, the gel relaxes and becomes fluid again to avoid any textural issues. CMC can even be put in vegetarian burgers, which lack structure when heated. It is also used as a water barrier in some ice cream cones. Specifically, Rico-Pena and Torres (1990) developed a method using an edible CMC based film to create a moisture barrier extending the shelf life of a sundae ice cream cone. Using a 3:1 ratio of CMC and palmitic acid, the team created the film to be about 60 μm thick, which was placed between the cone and the ice cream with a layer of chocolate on the bottom. This thin film increased the shelf life of the treat past 3 months before the cone began obtaining a soggy texture.

2.2.3 Gellan Gum

Gellan gum is the controlled fermentation of a byproduct polysaccharide that is produced by the bacteria Sphyngomonas [formerly *Pseudomonas elodea*.] (Sworn 1995)] Oxygen, temperature, and acidity are factors that are controlled during the fermentation. This hydrocolloid is a repeating chain of [→3)-β-D-glucopyranose-(1→4)-β-D-glucopyranosyluronic acid- (1→4)-β-D-glucopyranose-(1→4)-α-L rhamnopyranose-(1→] (Quinn and others 1993) leaving one carboxyl side group and an O-acetyl substituent for each repeating molecule (Moritaka and others 1995). Gellan gum is commonly used as a thickener, emulsifier, texturizer, stabilizer, film former, and has the properties of an excellent flavor releaser (Chalupa and others 1994; Sworn and others 1995). It also improves freeze/thaw stability, reduces syneresis, and modifies mouthfeel (Sanderson and others 1987). One particular application of gellan gum is in ice cream, as well as other dairy products. Since it can be used at concentrations as low as 0.02%, and is rarely used over 0.25%, it does not contribute any flavor (Laaman 1991). It is also used in the beverage industry in conjunction with CMC. Chocolate milks and fruit juices require some form of stabilization most of the time. Gellan cannot give enough of a structure to prevent settling, but with the addition of CMC at a ratio of 3:1, it can be suitable for these soft drinks. Gellan gum uses various divalent cation metals such as sodium, calcium, and magnesium, to form firm temperature independent gels (Chalupa and others 1994; Moritaka 2002). Gellan gum can form gels so well that some researchers consider other hydrocolloids such as guar, xanthan, locust bean, and CMC to be diluents as they hold little to no effect over gellan gum features; and in acidic dairy

products, they are actually used to hold the gellan gum in check against reactivity with

milk proteins (Sanderson and others 1984; 1987). Gellan gum comes in two forms, high

and low acyl, where low acyl is the most commonly used for its ability to form fluid to

firm brittle gels, and high acyl is used to form thicker jelly like gels. Although gelatin

and starches are predominantly used in the food industry, gellan gum can replicate their

properties just as well in most cases and can also complement many starches. As stated

before, hydrocolloids can be used to decrease viscosity when sheared and regain it upon

resting (Sanderson 1987). The secret to gellan gum's strong bonding abilities is its

ability to form a double helix creating a three dimensional network using physical forces,

hydrogen bonding and Van der Waal forces (Moritaka 2002). "As well as contributing to

the coordination between cation and the carboxylate groups to stabilize the double helix,

it has been suggested that polyion-cation-water-cation-polyion bridges may bind the

double helices together to form junction zones" (Quinn and others 1993).

Although gellan gum does have great stability in many foods, it does have an

antagonist, which is a sugar level above 30% (Bell and others 1994). The metals that act

as synergists can also inhibit any gelling when in higher concentrations. According to

Moritaka and others (1995), the carboxyl side groups of glucuronosyl residues actually

inhibit any bonding unless the mono and divalent metals are present.

2.2.4. Alginic Acid

Alginic acid, or alginate, as it is more commonly called, is derived from seaweed

or algae. In this project, sodium alginate $(NaC_6H_7O_6)_n$ is the specific salt from alginic

acid that was used. Like the other hydrocolloids mentioned before, it is a white powder

that can form a quick gel by absorbing water molecules. Alginates are able to hold up to

300 times their weight with water, allowing them to be exceptional thickeners at low

concentrations (Rowe 2009). It has been commonly used in the dental industry to make

teeth molds. Sodium alginate reacts very strongly to calcium ions, similar to gellan gum,

causing immediate electrostatic cross-linking. This application can cause a food with this

gum to undergo spherification which is beginning to become a trend in the culinary

industry.

2.3 Microbiology

2.3.1 Introduction

Microbiological control is a major concern in the food industry. According to the World

Health Organization website (accessed 18 February 2011), 76 million illnesses, 325,000

hospitalizations, and 5,000 deaths occur in the United States due to foodborne illnesses.

Of those, 14 million illnesses, 60,000 hospitalizations, and 1,800 deaths were from

pathogens. *Salmonella, Listeria,* and *Toxoplasma* are the three most common deadly

pathogens, which are responsible for over 75% of the deaths. With these statistics, food

companies must make sure that there is no sign of any food contamination. According to

an article in USA Today (Weise 2010), food-borne illnesses cost the United States over

$152 billion a year. Companies spend a lot of money to guarantee this assurance by

utilizing various programs that inhibit, control, or destroy any microbial activity in their

food products.

2.3.2 *Escherichia coli*

Escherichia coli or *E. coli*, is one of the most common species of bacteria. It was discovered by German bacteriologist Theodor Escherich in 1885 (Feng and others 2002). It can reproduce at a rapid rate and is found in the intestines of all animals. It is a gram negative prokaryotic rod shaped bacteria. Although most strains of *E. coli* are harmless, the strain O157:H7 can cause dramatic negative effects on the human body.   The FDA has a zero tolerance for its presence in food. Any product that is *E. coli* O157:H7 positive has to be destroyed as the strain produces heat stable enterotoxins, meaning that if the toxin is present, it won't be destroyed along with the bacteria. It has been most commonly found on unwashed vegetation or in uncooked meat. The deadly strain can cause cramping, nausea, vomiting and bloody diarrhea via renal failure in just a small matter of time. In 2000, O157:H7 caused over 62,000 illnesses with over $700 million in medical bills. The bacteria thrive in slightly acidic solutions and can grow in aerobic or anaerobic environments. The bacteria is most commonly found in large scale cattle farms that are corn fed as the animals are continuously walking around in constant bacterial infested grounds. *E. coli* also has a strong resistance building system. As we utilize various antibiotics, the bacteria begin building a resistance to the harsh environments (acidity, water availability, and chemical).

2.3.3 *Salmonella* **enterica**

Salmonella is another harmful bacteria that constitutes about one-third of the world's food poisoning deaths with about 30,000 confirmed cases reported by the CDC in

2005. In 2000, these illnesses had a net cost of $2.4 billion in medical bills according the

USDA (Min and others 2006). Salmonella is a rod shaped gram negative facultative

anaerobic bacteria that thrives in the intestinal tract of animals. It has been most

commonly associated with chickens and eggs. When a human is infected by *Salmonella*,

the illness is defined as *Salmonellosis*. The symptoms are usually runny diarrhea,

cramping, fever and vomiting 12 to 72 hours after ingesting the infected food. Symptoms

can last up to 7 days according the CDC.

2.3.4 Lactoperoxidase

Lactoperoxidase (LP) is an enzyme commonly found in bovine milk. It is

commonly used to reduce the amount of bacteria in raw milk. The enzyme, in

combination with other chemicals, creates a simple system that naturally inhibits bacterial

growth such as *E. coli, Salmonella, P. fluorescens,* and *L. monocytogene* without having

any major sensory defects (Tan and Ockerman 2006).   The system consists of the

enzyme lactoperoxidase and the addition of thiocyanate (-SCN) and hydrogen peroxide.

The enzyme will cleave the oxygen off the hydrogen peroxide and then oxidize the

thiocyanate ion, thus forming hypothiocyanate, a compound that has been shown to

reduce microbial activity. This system, known as the lactoperoxidase system (LPOS),

can kill cell counts of 2 to 5 CFU/ml in TSB at concentrations as low as 1 ppm (Wolfson

and others 1993; Min and others 2006). Reducing the microbial count is beneficial not

only because is decreases pathogens, but it also increases the shelf life of foods, such as

poultry, by 3 to 7 days (Mountney 1976). It can be even more efficient with higher levels

of hydrogen peroxide as it has been shown that short lived oxidation chemicals O2SCN-

and O3SCN- are very efficient at destroying *E. coli* (Pruitt and Tenovuo 1982; Reiter and

Harnulv 1984; Min and others 2006).

According to Wolfson and others (1994), the lactoperoxidase system results in a

13% reduction in *Salmonella* growth at 25°C or room temperature at 30 minutes.

Although a small reduction, it will inhibit or lower any microbial activity in the food

product at temperatures which microbes tend to thrive. This specific temperature range

of 40°C to 140°C is commonly called "the danger zone" by many food producers.

Heating foods to high temperatures such as 160°F will kill most microbes and spores,

which is critical because Bunning and others (1990) showed that *Salmonella* can actually

form heat shock proteins when it is exposed to harsh environments such as heat, ethanol,

and hydrogen peroxide which could render the LPOS useless, however extreme heat can

overcome these defensive measures.

2.3.5 Hypothiocyanite

Hypothiocyanate, as mentioned before, is the "secret weapon" of the LPOS. As

stated, the reaction of hydrogen peroxide and thiocyante is catalyzed by the

lactoperoxidase to produce the hypothiocyanate ion and water. It is the conjugate base of

hypothiocyanous acid and is formed when oxygen bonds to the thiocyanate group

(Furtmuller and others 2006). The compound reduces the microbial count due to the fact

that it will oxidize protein sulfhydryls which will kill microbes over time. This oxidation

of the sulfhydryl groups in bacteria will actually block the transportation of glucose, as

well as cause loss of other essential nutrients such as potassium, and amino acids, thus technically starving the microbe (Pruitt and Tenovuo 1985). It is effective against many gram positive and negative bacteria as well as viruses. Hypothiocyanate can be found naturally in the human body in the saliva, mucus, tears, and in the respiratory tract. It has been suggested to be used as a preservative and in the pharmaceutical industry because it has been shown to be toxic to bacteria, but harmless to human body cells (Carlsson and others 1984) and is considered to be generally recognized as safe (GRAS) (Min and others 2006). Hypothiocyanate has also been shown to help clean the air passageway of patients with cystic fibrosis (Gattas and others 2009).

2.4 Functional Ingredients

2.4.1. Introduction

Functional ingredients are those that are added to serve a specific purpose. Most functional ingredients are added for more than one reason. One example of a functional food ingredient would be the addition of herbs in a food. Various herbs contain antioxidants that are considered healthy and also contribute to the flavor or texture of the food product. Garlic, a very powerful flavor, contains the chemical allicin which can also be used to reduce microbial activity. Some functional foods are ingested because of the beneficial properties it has on the human body. For example, yogurts may contain probiotics that assist in various systems such as digestion. These valuable additional properties can be great incentives to purchase a given product.

2.4.2 Antioxidants

Antioxidants are chemicals commonly found in colorful fruits such as blueberries, strawberries and oranges. Some vitamins, like vitamins A, C and E are common examples of antioxidants. These compounds are used to inhibit oxidation in some reactions, thus extending shelf life of some foods. They are also commonly found in dietary supplements as they can prevent cancer, coronary heart disease and even altitude sickness (Baillie and others 2009). Antioxidants are the compounds that prevent the occurrence of cellular damage done by oxidation. Oxidation can be initiated in different manners: chemical, enzymatic, and photo-oxidative. Chemically initiated oxidation can be as simple as oxygen penetrating food packaging and exposing the food to unwanted oxygen. Enzymatically initiated oxidation is commonly seen in fruits such as bananas, apples, and peaches. This oxidation can turn the fruit soft and brown. In the case of the LPOS, the addition of hydrogen peroxide primes the process. Photo-oxidative initiation is caused by direct sunlight. This can occur with foods that contain chemicals that are susceptible to oxidation, such as short chain fatty acids in milk. If milk is left under fluorescent light long enough, the fatty acids release free radicals that can shorten the shelf life of the milk as well as alter the flavor to a "cardboard" like flavor (Rhee and Myers 2003). In addition to the primed oxidation processes, as the body digests foods, it forms byproducts called free radicals which have been known to begin chain reactions that break down various cells. As mentioned, antioxidants are powerful tools to prevent oxidation and also restore damaged cells.

Antioxidants can be found in various herbs and spices such as oregano and garlic. In this project, these ingredients are added to prolong shelf life, act as anti-microbial agents, promote good health, as well as contribute to the flavor of the foods. Oregano, for example, has high amounts of phenolic acids that have been shown to work well against the pathogen *Listeria monocytongenes* (Faleiro and others 2005).

2.4.3 Allicin

Garlic has the chemical allicin which has additional properties. Although garlic contains functional properties and can be good for the body, some people are wary of it because of its smell and the odor it leaves on the body. An article by the BBC authors Barringer and Hansanugrum (2010) claim that scientists have discovered that milk can help deodorize the smell that is left on the body. According to the study, higher fat milk will counteract the allyl methyl sulphide compounds that give this odor. Since the sulphides cannot be broken down in the gut, it is released in the breath and sweat. The study continued in stating that other foods, such as mushrooms, and herbs, such as basil, can also assist in diminishing the powerful smell of garlic. This information was used specifically in the development of this project to design the entrée sauce.

"Allicin is produced during the crushing of garlic cloves by the chemical interaction between the non-protein amino acid alliin and the enzyme alliinase," (Sela and others 2004). Allicin has been shown to have various anti-microbial control properties against gram positive and gram negative bacteria. It also has antifungal activity against *Candida albicans*, and effectiveness against parasites and some viruses

(Uchida and others 1975; Yamada and others 1977; Mirelman and others 1987; Ankri and others 1999; Harris and others 2001). Sela and others (2004) continue their argument that allicin also reduces serum cholesterol and LDL levels and also prevents oxidation which reduces the risk of atherosclerosis (Eilat S and others 1995; Abramovits and others 1999; Lau 2001).

2.5 Sensory

2.5.1 Introduction

Sensory science is the practice of applying the human senses of sight, smell, taste, touch, hearing, and/or rheology. Rheology is the understanding of the overall texture, including viscosity, crunchiness, mouthfeel, color, etc. In some cases, a mechanical device is used to give a specific numerical value to a characteristic such as hardness or viscosity. How a product is sensorially perceived is a very important aspect of a product. If consumers are not happy with the sensorial qualities of a food, it will not be marketable and the product will fail. The human tongue has about 2,000 to 8,000 papillae or "taste buds" that cover the surface of the tongue. These microscopic receptors detect the taste-active chemicals of the food (Bernays 2009). About 2% of people have additional papillae and are considered "super tasters." These individuals can taste flavors at a smaller amount as they are more sensitive to particular chemical compounds. They prefer more "mild" flavors than most people. Although taste and flavor may be considered the same, they are, in fact, different. Taste is defined as the sensation by the sensory organs sent to the brain. Flavor is overall perception of these tastes that create

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the complex response. In addition to the taste profiles depicted on the tongue, the sense of smell is an even greater contributor to the perception of a food's flavor. When a panelist has a nasal issue such as congestion, they are not able to properly smell their food, which contributes a high percentage overall tasting ability since olfactory receptors are more sensitive than the papillae on the tongue. This complication causes the food to be considered blander than it actually is. This issue can have a positive effect if a subject is being forced to ingest something that is considered distasteful such as a child taking cough medicine.

Sensory analysis can be supported by instrumental analysis. There are various instruments that can measure a given characteristic and give a numerical value, allowing for more precise quality control over the quality of the product. These instruments can measure color, hardness, viscosity, or food aromatic chemicals. A colorimeter sends a beam of light down onto the food product. The reflecting light is then automatically analyzed using the L*a*b* system to give a numerical value. Hardness or viscosity is measured by textural analyzers that apply a form of shear stress on the food. The amount of resistance is measured and translated. Flavor compound aromatics can be detected and displayed by using such instruments as a gas chromatography (GC).

2.5.2. Sensory Tests

Stone and Sidel (1985) distinguish between the types of sensory testing methods. There are discrimination, descriptive, and affective tests. Each one is used differently to gain information about a panelist's opinion using different methods. The panelist can be

asked to either differentiate between products, describe products, or display preference, all of which are subject to the data needed by the investigator.

2.5.2.1 Discrimination Testing

Discrimination tests are used to perceive differences between two products or preparation methods. There are various methods to gather this data. For an example scenario, a slab of bacon is considered too salty. Therefore, one sample of bacon is washed in water to remove some salt. A panelist is given one sample of the salty bacon, and one sample of the washed bacon. The goal of the investigator is to see if the panelists can tell a difference in the salt level. If the data is conclusive that the difference is detectable, the investigator can conclude that washing the bacon removes enough salt to affect the taste of the food.

One method to gather this information is the paired comparison test. In this test, the panelist is given one of each sample mentioned before (one salty bacon, one washed) and asked which one contains a specific characteristic such as salty, dry, or chewy. The characteristic is up to the investigator. Another method called the duo-trio test gives the panelist a control along with two testing samples. This time the panelist is asked which testing sample is the same (or different) to that of the control. The last example is the triangle test which is very similar to the duo-trio. In this test, no control is given, but the panelist is still given three samples, two the same, and one different. It is the job of the panelist to tell which one is not like the others.

2.5.2.2 Descriptive Testing

Descriptive testing is broken into two sub groups: qualitative and quantitative. Qualitative, in a general meaning, is a test given that asks the panelist to describe the product with words. In the wine industry, a sommelier may be called in as the expert to describe the wine.

In quantitative testing, a trained panel is used. During these tests, qualities of the product are given and the job of the panel is to give their opinion of this characteristic in a numerical form. For example, using the bacon scenario mentioned before, the panelist is asked to rank the level of salt detected in each sample by drawing a perpendicular line on a line scale displaying the level of salt. The panelist is told that the left side of the line represents "unsalty" and the right side of the line is "salty." If the data shows that the washed bacon sample is always on the left of the salted bacon, it is shown there is a clear difference. If the panelist is given a line of bacon samples each one washed at different times, they can be asked at what level they taste the salt. This method is called a threshold test.

2.5.2.3. Affective Testing

The goal of affective testing is to determine the liking of the product. Various methods are used to attain this data that have been mentioned before, but the correct version would be the hedonic test. The panelist is given their sample(s) and asked to rank their degree of liking on a set number scale such as 1-9.

2.5.3 Warmed Over Flavor

Warmed-over flavor (WOF) is a particular defect found in precooked meat products. It is described as a range of undesirable flavors that have been described as "rancid, sulphur/rubber, roasted, toasted, and bitter." This flavor defect is mainly caused by "the autoxidation of polyunsaturated fatty acids, mainly in the phospholipids, and iron, in different forms is a catalyst in the reactions" (Pearson and others 1977; Gray and Pearson 1987; Byrne and others 2001). As this defect increases, it begins to overpower the expected "meaty" flavor that is commonly affiliated with freshly prepared meat. Fish and poultry are the most susceptible to this reaction. Byrne and others conducted an experiment using gas chromatography to isolate the aromas that are emitted. Samples were cooked, chilled and then reheated at three different temperature ranges: 160, 180, and 190°F over a four day period. This data can be seen in Table 4.

Table 4: Volatile compounds identical to chicken patties from different cooking
temperatures and chill-storage.

Compound	LRI[a]	Approximate quantity (ng/40 g sample)[b]									Significance level[c]	
		T160			T180			T190			Temp	Days
		d0	d1	d4	d0	d1	d4	d0	d1	d4		
Alkanes												
Octane	800	640.00	1030.00	1240.00	520.00	530.00	790.00	380.00	600.00	500.00	*** (−)	* (+)
Nonane	900	9.50	13.00	14.00	8.10	9.80	11.00	6.50	7.50	11.00	*** (−)	*** (+)
Undecane	1100	2.30	1.90	2.30	1.70	3.00	2.20	1.50	1.20	1.80	* (−)	ns
Dodecane	1200	0.80	1.40	1.50	0.41	1.20	0.87	0.57	1.00	0.64	* (−)	ns
Tridecane	1299	0.70	2.10	2.20	0.28	1.60	2.70	0.38	1.50	2.70	ns	*** (+)
Alcohols												
1-Octen-3-ol	982	2.30	24.00	48.00	1.00	24.00	51.00	4.10	16.00	51.00	ns	*** (+)
Aldehydes												
3-Methylbutanal	619	12.00	25.00	20.00	18.00	13.00	21.00	26.00	33.00	11.00	ns	ns
2-Methylbutanal	635	20.00	14.00	13.00	29.00	22.00	19.00	30.00	31.00	28.00	ns	ns
Hexanal	804	120.00	1970.00	7860.00	69.00	2060.00	8190.00	280.00	2130.00	8030.00	ns	*** (+)
Heptanal	904	12.00	22.00	41.00	8.10	28.00	49.00	8.70	25.00	63.00	ns	ns
(E)-2-Heptenal	960	0.00	4.20	4.70	0.32	3.60	3.90	0.80	1.50	2.80	ns	*** (+)
Benzaldehyde	970	10.00	15.00	20.00	6.90	15.00	21.00	8.70	14.00	20.00	* (−)	*** (+)
(Z,Z)-2,4-Heptadienal	1001	0.19	1.60	2.20	0.00	1.40	2.10	0.19	1.00	1.60	ns	*** (+)
Octanal	1005	11.00	33.00	58.00	7.40	28.00	44.00	8.50	21.00	41.00	*** (−)	*** (+)
(E,E)-2,4-Heptadienal	1016	0.12	1.80	2.50	0.00	2.10	2.10	0.38	1.20	1.90	ns	ns
Nonanal	1107	39.00	65.00	65.00	17.00	32.00	43.00	23.00	35.00	36.00	*** (−)	* (+)
Decanal	1209	12.00	15.00	11.00	7.90	12.00	7.40	6.70	9.50	5.50	ns	ns
(E,E)-2,4-Nonadienal	1222	0.00	0.00	0.30	0.00	0.17	0.13	0.00	0.02	0.20	ns	ns
(E,E)-2,4-Decadienal	1324	0.10	0.00	0.75	0.00	0.59	0.95	0.00	0.35	0.99	** (+)	*** (+)
Ketones												
2-Heptanone	891	4.90	10.00	24.00	2.20	8.90	22.00	2.70	7.10	22.00	** (−)	*** (+)
2,3-Octanedione	984	0.49	21.00	43.00	0.32	30.00	54.00	6.00	27.00	42.00	ns	*** (+)
Sulphur-containing compounds												
Dimethyl disulfide	746	99.00	140.00	28.00	63.00	180.00	47.00	90.00	69.00	32.00	Ns	* (−)
3-Methylthiopropanal	911	0.00	0.00	0.23	0.00	0.35	0.77	0.00	0.10	0.83	*** (+)	* (+)
Dimethyl trisulfide	978	130.00	110.00	21.00	62.00	120.00	55.00	87.00	52.00	40.00	ns	* (−)
Dimethyl tetrasulfide	1234	8.50	10.00	3.00	2.70	12.00	9.60	2.60	6.00	8.50	ns	ns
Pyrazines												
2,5-Dimethylpyrazine	918	0.17	0.25	0.01	0.19	0.41	0.96	0.70	0.58	2.00	*** (+)	ns

[a] Linear retention index on a BPX5 column.
[b] Approximate quantity calculated from the peak area relative to the internal standard 1,2-dichlorobenzene (100 ng). The values given are the mean of three replicate measurements. The sample codes represent cooking temperature (T in °C) and cold storage (d in days).
[c] Significance level of regression coefficients from ANOVA-PLSR for temperature and storage days variables with in the parenthesis the sign of the coefficients; ns, not significant; *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$. The interactions temp×days were not significant ($P > 0.05$).

By looking at the data, it can be seen there are various increases in alkanes, aldehydes, and sulphur-containing compounds. It was proven that there was rapid lipid and protein oxidation development of the cooked food under refrigerated conditions which correlated with the amount of aromatic thiols and other sulfide compounds.

2.5.4 Freezing and Thawing of Foods

The freezing and thawing of foods has caused various problems in the food industry. This phenomenon occurs first in the freezing process. Within a food, there are free and bound water molecules. When freezing, these molecules will turn to ice. Water has an additional phenomenon that causes its density to be greatest at 4°C, with its density decreasing as the temperature drops below 4°C, which is the reason why ice will float on top of water. Below 4°C, the water molecules spread out, thus, explaining the decrease in density. When these molecules expand, they will form imperfect water crystals. In addition, these crystals can obtain sharp and jagged edges. These sharp edges are capable of causing microscopic cuts in the food tissues of meat products. Freezing also causes foods to pick up additional water from the atmosphere because of condensation. This amount of water can vary depending on the amount of water present in the food as well as the humidity of the environment. The greater the amount of water present at this time, the more water will be picked up. When a food is frozen, the food-bound water molecules will slowly acquire the atmospheric free water in their proximity. When the temperature reaches a specific point, in the transition of phases, such as water to ice, a phenomenon occurs. This event is called the heat of fusion where water molecules quickly migrate to a previously formed ice crystal seed. Wang and others (1997) provide a picture of the phenomenon. When the temperature reaches the freezing point, the molecules will begin to vibrate as they are transitioning to the other physical phase. This buildup of energy by vibrating is suddenly released and the molecules will migrate to pre-existing ice crystals with any "kinks," or sites where water can bind to. If

an ice crystal is small enough and does not have any "kink sites", the available water will most likely return to it is minimally sized ice crystal and not form any larger ones keeping the texture at an acceptable rate (Wang and others 1998). This rapid movement gives a very small, yet rapid, spike in temperature. A general graph can be seen in Figure 3.

Figure 3: Temperature fluctuation during heat of fusion
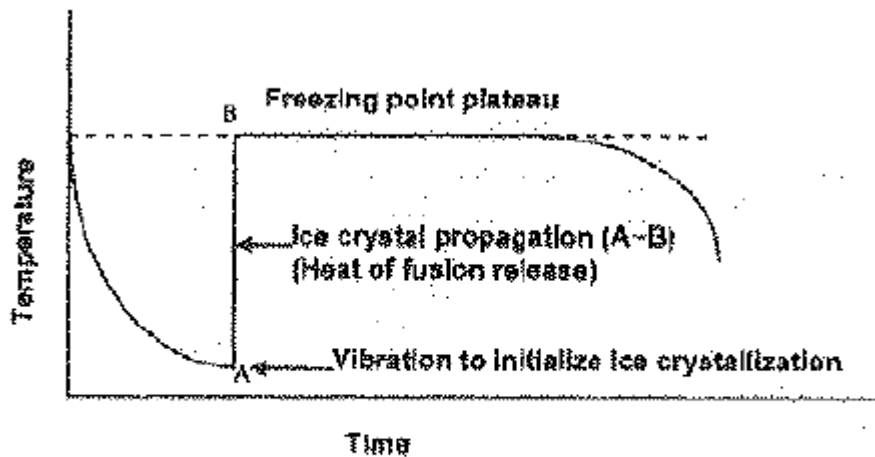
The addition of this free water makes the water crystal larger. The larger the crystal, the greater the damage to the food. The solution that food manufacturers use is to freeze the food as quickly as possible. The longer the molecules are in the liquid phase, the higher the chance they will move and form large aggregates. If all of the molecules are frozen simultaneously in rapid time, the lower the distance the water can move in its liquid phase resulting in smaller ice crystals.

Additional damage can occur when a food is thermally abused meaning that a food is frozen, thawed, and then refrozen in constant succession. The constant freezing causes the ice crystals to cut more into any protein networks and therefore weaken the water holding capacities for bound water. Furthermore, when thawed, this once bound water has been converted to free water which can leak out of the food system. This can be observed when thawing frozen meat. Upon thawing, a considerable amount of water can be found in the thawing vessel. When the product is then cooked, it may have a dry texture due to this loss of water, and at the same time a soggy texture because of all the network damage. If this freeze-thaw process is done over and over again, the product could be damaged to such a degree that it is rendered inedible.

In some food products, however, it is not a dry texture that is the result of freeze-thaw instability, but the texture of ice crystals themselves, especially in foods we consume frozen, such as ice cream. Ice cream is very susceptible to the heat of fusion phenomenon. Ice cream is considered to be a bi-phase serum as some water molecules are frozen, and some are not. Water will freeze at 0°C, however, ice cream has other components, such as fats, proteins and carbohydrates that freeze at different temperatures. This combination of ingredients lowers the freezing temperature of the food by a few degrees. The problem that arises from that phenomenon is that some ice cream confections can be just on the verge of melting in the freezer. The constant opening and closing of a freezer allows warm air to enter and will melt some of the ice crystals. When the freezer door is closed, these liquid water molecules undergo the heat of fusion and bind to other water molecule seeds. This again will cause the crystals to grow larger and

larger which humans can detect during tasting. Furthermore, the food loses its uniformity

as water is being concentrated in large areas and not equally dispersed, and these large

crystals also attract the water vapor from the environment. This addition of water will

dilute the ice cream in theory causing a less acceptable product. Since ice cream is so

vulnerable to this issue, many companies put stabilizers in the form of hydrocolloids in

their products to inhibit the occurrence of the heat of fusion. These stabilizers, as

mentioned before, help the ice cream retain uniformity and add texture

2.5.5 Ice Cream Characteristics

Ice cream is actually considered to be a very complex food product in terms of

sensory science. As stated, the most common defect of ice cream is due to frequent

thawing and refreezing. However, to better understand what happens when the heat of

fusion occurs in ice cream, it is important to understand exactly what ice cream is.

It has been claimed by BBC (The origin of ice-cream 2009), that the first form of

ice cream was recorded in China around 200 BC. The mixture was said to be made of

frozen milk and rice. Two and a half centuries later, Roman emperor Nero was said to

have had his servants climb the mountains to retrieve ice and flavor it with fruits, honey,

and nuts (Andrews 2000). Since then, ice cream has evolved greatly. Today, ice cream

is a complex foam emulsion containing cream, flavorings, sweeteners, and a minimal

amount of salt. To create ice cream, the ingredients are added and mixed and then put

into a churn, which will whip the cream, incorporating air while freezing it at the same

time. The amount of air that is introduced is called overrun. In most commercial

practices, the overrun is set at 100%. To calculate the amount of overrun, the equation as given by Marshall and others (2003) is used:

(Wt. of mix - Wt. of same vol. of ice cream)/Wt. of same vol. of ice cream x 100% = %Overrun

Overrun allows the ice cream to be fluffy and airy. It also helps give the ice cream structure and distribute flavor. "Premium" ice cream brands use a lower percentage of overrun resulting in a thicker, richer texture. After churning, the ice cream is extruded into containers and then deep frozen as quickly as possible in order to control the ice crystal growth.

There are various characteristics that are tested when looking at ice cream. Soukoulis and others (2008) supply an acceptable description of various sensory criteria. These particular attributes consist of sweet, flavor, hard, coarse, brittle, gummy, icy, watery, sandy, and creamy. This list is shown in Table 2. These properties can be affected by various events such as poor production, packaging, temperature abuse, or ingredients.

Sweetness is highly desired in ice cream by many people. However, with many customers demanding sugar free or lower calories, manufacturers have looked into artificial sweeteners. These sweeteners are usually non-caloric and can be exceptionally sweeter than normal sugar and therefore can be used in smaller amounts. On the downside, they do not contain the same taste as sugar. These artificial sweeteners usually

give a quick punch of sweetness and then quickly dissipate. The amount of sweeteners, sugar or artificial, can greatly affect the flavor, structure, and texture of the ice cream. Sugar, unlike artificial sweeteners makes the foam network stronger. It does however act similar to salt and lowers the freezing temperature. This has a two-fold effect as it causes the aqueous part of the ice cream to remain mobile which can cause ice crystal growth, but then also adds a softer texture and sweeter taste to the ice cream.

Flavor can be a driving force behind any food product. It can make or break a product. Careful attention must be paid to the amount and quality of the ingredients going into a product. Fresh cream is essential to an ice cream confection. If the cream is old, oxidized, or rancid, the finished product will have those flavors as well. Some consumers can also taste the difference between artificial and natural vanilla flavorings. Temperature also has a small effect on flavor perception. As the ice cream comes in contact with the tongue, there is a short numbing as the lower temperature of the ice cream slows down the tasting reactions. This causes a delayed flavor release. If the consumer has already swallowed the ice cream, they may not perceive the whole flavor. Soukoulis and others (2007) continue to argue that larger ice crystals also give a watery flavor as well as inhibit a "volatile flavor compound release," thus making it harder to differentiate the complex flavors upon tasting.

Hardness is a textural characteristic that is affected by the growth of ice crystals or even the introduction of a few hydrocolloids in rare cases. As the ice crystals grow they bring in more water, and since ice freezes at a higher temperature than the other compounds, the soft creamy confection will slowly turn into a block of ice. Again, this

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issue can be resolved by reducing the amount of ice fluctuation or the addition of

ingredients such as sugar, salt, or some better hydrocolloids. Hardness can be measured

instrumentally using a texture analyzer that will apply a probe using a downward force

and read the amount of force needed to penetrate the product. However, when measuring

hardness, it is essential to have a temperature standard as it can greatly affect the results.

Soukoulis and others (2008) used -28°C as a commercial standard for measuring

hardness of ice cream.

Coarseness and icy are very similar texture defects as they too are greatly affected

by the detection of ice crystals. If the ice crystals grow too large, they can pose a

problem as they take away from the smoothness of the ice cream. However, since the

crystals will melt, these defects are only temporary to the palate, but as mentioned before,

these crystals will numb the tongue delaying true flavor perception. Thus, the consumer

does not get to properly taste the flavor and texture the ice cream was intended to have

(Soukoulis 2008).

Gummy is a defect formed by inconsistent overrun. Some parts of the ice cream

that are not properly incorporated in the churning will not be frozen at the same rate.

This can cause a sticky, "gummy" texture. One particular ingredient that contributes to

this is the use of corn syrup. To resolve this issue, companies have to pay close attention

to the amount of syrup added (if any) as well as the time for incorporating overrun. If not

churned enough, the ice cream may be gummy, and if too much, the ice cream is then

considered to be "fluffy." When the overrun is too high, the ice cream may suffer from

poor structure, flavor perception, and becomes slightly chewy in texture. Ice cream is

supposed to be an emulsion, which contains small molecules that are evenly dispersed. If the air molecules in the mixture are too big, the ice cream may become more like a meringue. If over beaten, a meringue will begin to collapse on itself. The proteins have been shear-denatured to such a degree that they have problems reforming and all the liquid they were holding is released. If egg whites are beaten enough, they will form a foam floating on top of a pool of liquid. Ice cream foam, like egg white foam, consists of proteins. If overbeaten, there will be some similar problems. The milk proteins that did form a light fluffy foam will remain on top and any more dense liquids will slowly make their way down to the bottom of the container like the crumbs in a potato chip bag (Soukoulis 2008).

Sandy is a very rare defect that occurs in ice cream. It appears when the lactose forms crystals. These crystals can be present even if the ice cream is completely melted as the crystals are not affected by temperatures. This texture is best described as a very gritty texture, similar to course sand. Although very rare in occurrences, it is very easily detected and can destroy the enjoyment of the ice cream. (Soukoulis and others 2008)

The last characteristic to be described is creaminess.   Creaminess is the mouthfeel detection of the fats in the ice cream. It should be thick, smooth, and homogeneous. Creaminess is usually linear with viscosity. Creaminess can also be improved by using higher fat content cream or the addition of some hydrocolloids. Kilcast and Clegg (2002) claim that creaminess also improves flavor perception as fats tend to carry flavors very well. Higher creaminess levels in ice cream usually mean there are lower detection levels of any defects.

2.5.6 Hydrocolloids in Ice Cream

  The texture of ice cream has further been controlled by the use of hydrocolloids and quick freezing. Hydrocolloids, when in partnership with proteins, cause a strong network that can inhibit ice recrystallization. When the ice cream is initially frozen, there are no pre-existing ice crystals, and therefore all the crystals are evenly distributed and small in size, if the food is frozen quickly enough for uniformity. The hydrocolloids in the ice cream help inhibit many of the problems that result in the freeze-thaw ice crystals growth issue in various ways (Regand and Goff 2002). First, the hydrocolloids bind the water, converting the free water molecules to bound molecules. This helps inhibit the amount of water available to grow into larger ice crystals. Second, they delay the melting of the frozen water molecules resulting in less initial thawing during temperature abuse, such as the opening of the freezer door. Wang and others (1998) show a graph that illustrates the delay of the heat of fusion using guar gum at different concentrations. This graph can be seen in Figure 4.

Figure 4: Heat of fusion with 0.2% and 0.4% guar gum
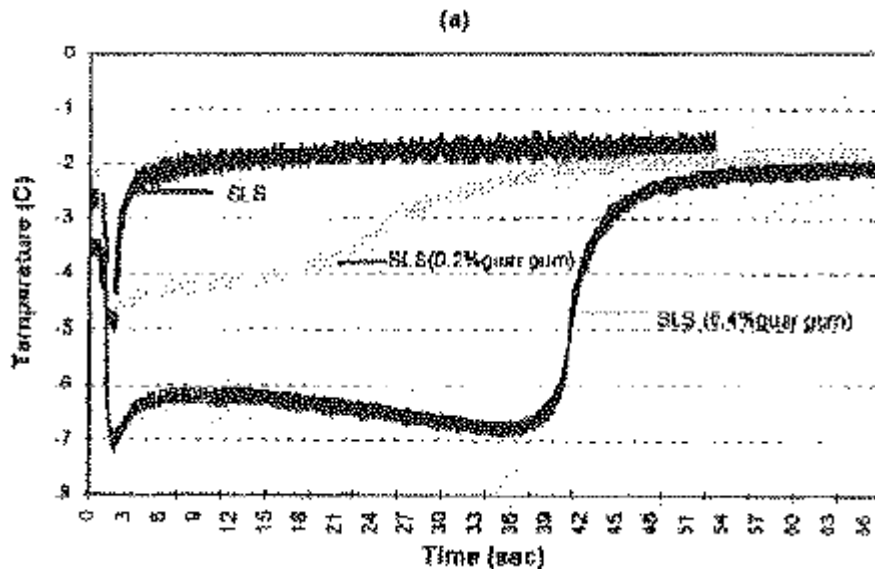
Some scientists were considering that the viscosity of the hydrocolloid was the true factor

behind the inhibition of water migration. Regand and Goff (2002) state that water

molecules will migrate up to 10 μm to form an ice crystal during freezing.

Soukoulis and others (2008) and Glicksman (1985) agree that the functionality of

hydrocolloids is not only for textural purposes, such as enhancing viscosity, mouthfeel,

and structural retention, but also as a cryoprotectant.   It was suggested by Wang and

others (1998) that ice crystals grow at a rate of 0.15 g/cm^3 when in a sucrose solution and

the addition of stabilizers retarded its growth versus an ice cream sample that had been

placed in storage for 3 weeks, where Wang continued to state "the distribution of ice

crystals in an unstabilized ice cream showed a higher percentage of large crystals

(>80μm),"   Blanshard and others (1991) and Buyong and Fennema (1988) also state that

at moderate concentration stabilizers will retarded ice crystal growth to a small but significant extent.

Ice crystal formation can greatly affect the way an ice cream is perceived. Since hydrocolloids help prevent the growth of ice crystals, it will have an obvious effect on the quality of ice cream over time. Soukolis and others (2008) show the sensory characteristics of ice cream that have been quiescently stored for up for 4, 8, and 16 weeks using different hydrocolloid combinations that can be seen in Table 5. The figures for weeks 4, 8, and 16 can be seen in Table 5a, b, & c, respectively.

Table 5: Effect of hydrocolloids and kappa-carrageenan present on sensory attributes (mean values of ice cream after a) 4 weeks, b) 8 weeks, and c) 16 weeks of quiescent frozen storage

Table 5A: Effect of hydrocolloids and kappa-carrageenan present on sensory attributes (mean values of ice cream after 4 weeks of quiescent frozen storage)

Sample	Color	Flavor	Palatable	Sweet	Hard	Coarse scoop	Brittle	Gummy	Icy	Coarse	Watery	Creamy	Sandy
C1	7.52^c	5.65^{bc}	9.14^d	8.35^b	5.02^e	1.20^a	2.51^b	3.83^d	7.89^e	2.51^b	5.02^{bc}	5.94^{bc}	1.17^a
C2	6.45^b	7.90^{ef}	6.86^b	9.54^{cd}	4.51^{de}	1.15^a	2.52^b	3.98^{de}	5.26^b	2.47^b	3.39^a	6.64^{de}	1.05^a
G1	7.52^c	5.65^{bc}	6.90^b	7.75^{ab}	4.53^{de}	1.97^b	2.59^b	2.55^b	6.30^c	3.51^{cd}	3.32^a	5.40^b	1.08^a
G2	6.45^b	6.21^c	9.14^d	7.75^{ab}	2.92^a	2.48^{bc}	2.03^{ab}	4.68^e	5.21^b	3.53^{cd}	4.50^b	7.02^e	1.00^a
A1	7.52^c	4.52^a	8.00^c	7.75^{ab}	4.17^{cd}	1.14^a	5.08^e	2.46^b	7.31^d	2.00^{ab}	6.76^d	6.78^{de}	1.00^a
A2	4.30^a	7.34^{de}	9.14^d	9.54^{cd}	4.52^{de}	1.05^a	6.55^f	1.70^a	7.39^d	2.02^{ab}	3.38^a	8.10^h	1.00^a
X1	6.45^b	6.77^d	9.14^d	8.94^{bc}	5.00^e	3.47^d	3.59^c	2.55^b	7.42^d	3.53^{cd}	5.63^c	7.86^{fg}	1.00^a
X2	6.45^b	6.77^d	8.00^c	8.94^{bc}	3.33^{ab}	2.98^{cd}	3.75^c	2.18^{ab}	6.32^c	3.03^{bc}	7.88^e	7.94^g	1.00^a
CK1	7.52^c	5.52^b	6.86^b	7.16^a	5.42^f	3.47^d	3.49^c	2.59^b	7.37^d	4.09^e	7.30^{de}	4.32^a	1.06^a
CK2	6.45^b	6.65^d	6.86^b	7.16^a	3.75^{bc}	2.98^{cd}	3.53^c	2.95^c	4.74^{ab}	4.01^e	6.71^d	6.48^{cd}	1.09^a
GK1	6.45^b	6.39^{cd}	5.71^a	7.75^{ab}	5.43^f	3.43^d	3.44^c	2.50^b	7.35^d	3.99^{de}	7.32^{de}	4.35^a	1.05^a
GK2	7.52^c	8.47^f	8.00^c	9.54^{cd}	3.77^{bc}	1.09^a	1.52^a	4.25^{de}	5.28^b	3.53^d	5.07^{bc}	7.56^f	1.10^a
AK1	7.52^c	6.21^c	8.00^c	9.54^{cd}	4.58^{de}	1.95^b	4.57^{de}	2.55^b	6.29^c	2.52^b	7.35^{de}	5.40^b	1.00^a
AK2	6.45^b	7.74^{ef}	9.14^d	9.54^{cd}	3.31^{ab}	1.04^a	4.01^{cd}	2.05^a	4.21^a	2.02^{ab}	3.22^a	8.64^i	1.00^a
XK1	6.45^b	6.77^d	8.57^{cd}	9.54^{cd}	4.14^{cd}	1.93^b	3.55^c	2.56^b	6.89^e	1.51^a	5.60^c	5.94^{bc}	1.00^a
XK2	6.45^b	7.65^{ef}	6.86^b	9.66^{cd}	3.34^{ab}	1.91^b	4.06^{cd}	2.15^{ab}	5.87^{bc}	3.03^{bc}	6.69^d	6.48^{cd}	1.00^a

[a-i]Different letters between the rows indicates significant difference ($p < 0.05$) among the ice cream samples according to Duncan's mean values comparison test.

Table 5B: Effect of hydrocolloids and kappa-carrageenan present on sensory attributes (mean values of ice cream after 8 weeks of quiescent frozen storage)

Sample	Color	Flavor	Palatable	Sweet	Hard	Coarse scoop	Brittle	Gummy	Icy	Coarse	Watery	Creamy	Sandy
C1	8.01^{bc}	5.08^{de}	8.00^{c}	8.94^{cd}	5.42^{d}	2.52^{bc}	3.05^{b}	3.40^{d}	8.42^{e}	2.68^{c}	7.32^{e}	5.40^{c}	1.19^{a}
C2	6.98^{ab}	4.42^{cd}	8.00^{c}	8.29^{c}	3.33^{bc}	2.07^{b}	3.55^{c}	4.68^{e}	6.32^{cd}	1.01^{a}	5.25^{b}	6.72^{e}	1.13^{a}
G1	7.52^{b}	2.82^{a}	6.86^{b}	5.96^{a}	5.50^{d}	3.97^{d}	4.57^{d}	2.13^{b}	8.42^{e}	4.13^{d}	8.45^{f}	4.32^{ab}	1.12^{a}
G2	6.99^{ab}	4.50^{cd}	6.86^{b}	7.16^{b}	2.92^{b}	2.98^{c}	3.05^{b}	2.55^{c}	3.68^{a}	5.04^{e}	5.88^{cd}	3.24^{a}	1.09^{a}
A1	7.50^{b}	3.95^{bc}	6.86^{b}	7.75^{bc}	4.17^{c}	1.99^{b}	4.05^{cd}	3.40^{d}	6.84^{d}	1.51^{ab}	5.88^{cd}	6.48^{e}	1.12^{a}
A2	7.43^{b}	4.52^{cd}	7.43^{bc}	7.16^{b}	5.32^{d}	1.89^{b}	4.23^{cd}	3.10^{cd}	6.84^{d}	2.52^{c}	3.07^{a}	6.91^{f}	1.05^{a}
X1	7.59^{b}	3.91^{bc}	6.29^{ab}	7.75^{bc}	6.67^{ef}	2.57^{bc}	4.57^{d}	2.55^{c}	7.47^{de}	4.04^{d}	5.88^{cd}	6.82^{f}	1.12^{a}
X2	8.60^{cd}	4.67^{cd}	7.43^{bc}	7.75^{bc}	4.10^{c}	1.99^{b}	4.06^{cd}	2.35^{bc}	4.74^{b}	2.02^{b}	4.76^{b}	6.48^{e}	1.07^{a}
CK1	6.45^{a}	5.65^{e}	8.57^{d}	9.14^{d}	7.08^{f}	2.48^{bc}	3.09^{b}	3.40^{d}	6.32^{cd}	2.57^{c}	7.32^{e}	5.94^{d}	1.08^{a}
CK2	8.06^{bc}	3.39^{ab}	6.86^{b}	7.16^{b}	3.26^{bc}	1.95^{b}	3.14^{b}	2.55^{c}	7.89^{e}	2.44^{c}	6.76^{e}	5.40^{c}	1.04^{a}
GK1	9.13^{d}	2.86^{a}	5.71^{a}	5.96^{a}	5.22^{d}	1.97^{b}	4.06^{cd}	3.40^{d}	6.32^{cd}	3.53^{d}	9.01^{f}	4.86^{bc}	1.10^{a}
GK2	7.63^{b}	4.46^{cd}	7.43^{bc}	7.16^{b}	5.47^{d}	1.89^{b}	2.03^{a}	3.40^{d}	5.42^{bc}	2.52^{c}	5.07^{b}	6.48^{e}	1.08^{a}
AK1	7.67^{b}	4.56^{cd}	6.86^{b}	8.39^{c}	4.11^{c}	1.49^{ab}	4.57^{d}	2.98^{c}	5.32^{b}	2.02^{b}	4.76^{b}	6.56^{e}	1.00^{a}
AK2	7.60^{b}	5.65^{e}	8.71^{d}	9.73^{f}	1.67^{a}	1.17^{a}	7.61^{f}	1.28^{a}	6.84^{d}	1.51^{ab}	2.50^{a}	8.64^{g}	1.00^{a}
XK1	6.48^{a}	6.21^{f}	8.68^{d}	8.35^{c}	6.25^{e}	2.48^{bc}	5.08^{e}	2.55^{c}	6.42^{cd}	2.02^{b}	6.08^{de}	6.92^{f}	1.00^{a}
XK2	6.41^{a}	7.34^{g}	8.00^{c}	8.30^{c}	3.75^{c}	1.85^{b}	3.05^{b}	2.55^{c}	6.12^{c}	2.02^{b}	4.50^{b}	7.24^{f}	1.00^{a}

$^{a-f}$Different letters between the rows indicates significant difference ($p < 0.05$) among the ice cream samples according to Duncan's mean values comparison test.

Table 5C: Effect of hydrocolloids and kappa-carrageenan present on sensory attributes (mean values of ice cream after 16 weeks of quiescent frozen storage)

Sample	Color	Flavor	Palatable	Sweet	Hard	Coarse scoop	Brittle	Gummy	Icy	Coarse	Watery	Creamy	Sandy
C1	6.02^{a}	3.95^{d}	7.43^{cd}	7.94^{bc}	5.17^{c}	4.99^{f}	3.55^{ab}	3.40^{d}	8.62^{f}	3.63^{e}	7.63^{g}	5.01^{ab}	1.82^{b}
C2	6.27^{a}	2.26^{b}	6.81^{c}	8.64^{c}	3.41^{a}	4.18^{e}	3.25^{a}	3.95^{e}	6.38^{c}	3.02^{d}	6.50^{e}	5.68^{c}	1.21^{a}
G1	6.11^{a}	2.82^{bc}	6.86^{c}	7.35^{b}	6.79^{e}	4.02^{e}	3.15^{a}	4.25^{e}	8.42^{f}	5.04	6.76^{f}	4.86^{a}	5.09^{d}
G2	6.05^{a}	2.26^{b}	6.79^{c}	6.16^{a}	4.17^{b}	2.98^{c}	3.05^{a}	5.10^{f}	5.26^{b}	4.54	6.66^{f}	5.40^{bc}	1.13^{a}
A1	6.18^{a}	2.26^{b}	5.71^{b}	7.35^{b}	5.83^{d}	3.95^{e}	6.09^{d}	2.13^{a}	7.37^{e}	3.06^{de}	5.88^{d}	5.24^{b}	1.23^{a}
A2	6.26^{a}	4.59^{e}	9.14^{e}	8.59^{c}	3.33^{a}	1.89^{b}	7.11^{e}	2.58^{b}	6.32^{c}	2.09^{b}	4.50^{b}	8.10^{h}	1.04^{a}
X1	6.25^{a}	1.69^{a}	4.57^{a}	6.16^{a}	7.50^{f}	2.87^{c}	4.06^{b}	2.51^{b}	7.37^{e}	3.53^{e}	6.76	5.29^{b}	1.70^{b}
X2	7.52^{b}	2.82^{bc}	7.33^{cd}	7.35^{b}	4.17^{b}	3.27^{cd}	4.01^{b}	2.44^{b}	5.31^{b}	3.64^{e}	4.76^{b}	6.51^{ef}	1.05^{a}
CK1	6.18^{a}	2.26^{b}	7.98^{d}	9.73^{e}	7.92^{f}	2.78^{c}	3.05^{a}	3.25	7.97^{ef}	2.52^{c}	6.94^{f}	7.56^{g}	1.24^{a}
CK2	6.50^{a}	4.52^{e}	5.71^{b}	8.54^{c}	5.00^{c}	3.17^{cd}	4.16^{b}	2.59^{b}	6.84^{d}	6.05	5.32^{c}	5.40^{bc}	1.19^{a}
GK1	6.73^{a}	4.68^{e}	8.11^{d}	9.14^{d}	5.83^{d}	3.37^{cd}	3.00^{a}	2.55^{b}	6.20^{c}	5.04	4.59^{b}	6.48^{e}	2.55^{c}
GK2	7.69^{b}	5.65^{f}	8.02^{d}	8.35^{c}	4.17^{b}	4.07^{e}	3.42^{ab}	3.33^{d}	7.27^{e}	4.54	4.55^{b}	5.44^{bc}	1.15^{a}
AK1	6.60^{a}	3.39^{c}	8.09^{d}	8.44^{c}	6.67^{e}	3.36^{cd}	5.08^{c}	2.48^{b}	6.19^{c}	2.02^{b}	3.38^{a}	6.08^{d}	1.03^{a}
AK2	6.59^{a}	3.49^{c}	4.57^{a}	7.35^{b}	3.21^{a}	1.09^{a}	8.12^{f}	2.50^{b}	4.21^{a}	1.09^{a}	3.17^{a}	8.64^{i}	1.11^{a}
XK1	6.42^{a}	3.95^{d}	8.15^{d}	8.34^{c}	5.83^{d}	2.93^{c}	4.06^{b}	2.57^{b}	7.42^{e}	3.41^{e}	4.40^{b}	6.01^{d}	1.05^{a}
XK2	6.49^{a}	4.03^{d}	8.19^{d}	8.47^{c}	3.19^{a}	1.97^{b}	2.95^{a}	2.98^{cd}	6.37^{c}	2.44^{c}	3.19^{a}	6.99^{f}	1.07^{a}

$^{a-i}$ Different letters between the rows indicates significant difference ($p < 0.05$) among the ice cream samples according to Duncan's mean values comparison test.

CHAPTER 3

MATERIALS AND METHODS

3.1 Food Items

3.1.1 Introduction to Recipes

The recipes were designed to fulfill various criteria to make the dish be easily

prepared in a residential kitchen, provide foods that most consumers might find appealing

while at the same time applying certain culinary aspects of appearance, complimenting

flavors, include innovative ideas, and apply various practices of food science such as

chemistry, microbiology, sensory analysis, and product development. In this project a

three course meal was created. A brown butter fettuccine with sage for the appetizer, a

garlic cream poached chicken with Duchess potatoes and sautéed asparagus for side

items, and dessert confection of an egg shaped vanilla ice cream with hard caramel shell

and honey-citrus gel center. One goal was to appeal to the stereotypical "picky eater"

with foods that are popular to the masses, such as chicken, and apply a culinary

application such as garlic cream. Buttered noodles are a very comforting food to some,

but when the butter has been browned, it provides a slightly different flavor profile which

can make a dish that is familiar, simple, and gourmet. The foods are easily prepared with

little clean up. All ingredients were purchased at a local grocery store unless noted. The

procedures and amounts that will be mentioned do not necessarily reflect the instructions

or amount that will be given at the retail level. This consumer information will be

discussed later. Also, it is important to note that the cook can easily concentrate on one

dish while the others are in a cooking stage making it easy to not have to multi-task.

Simple garnishing techniques are also suggested to ensure the food looks its best. For

instance, fried sage leaves can complement the appetizer, the entrée can be sprinkled with

some oregano, and the dessert is in the unique shape of an egg with a sweet gel hidden in

the center. Chocolate swirls on the plate could also add a nice touch to the dessert.

These garnishes are easy to apply and will be supplied in the dinner set.

3.1.2 Brown Butter Fettuccine with Sage

16 oz fettuccine

5 tbs butter

2 tbs sage

3 tbs beef broth

2 tbs chicken broth

5 tbs parmesan cheese

TT salt and pepper (testing used 1 tsp each)

Procedure:

1) Boil salted water. When at a rolling boil, add pasta. Cook until pasta just
   begins to bend for about 5 minutes. (NOTE: this is done so that when it is
   cooked at the consumer level it will cook to *al dente*).

2) Cook or "brown" the butter in a pan over medium-low heat with sage. When
   sage is brown, add broth.

3) Strain cooked noodles and add to butter mixture. Add cheese while mixing.

4) Season with salt and pepper.

   (Fletcher 2008)

5) Fill a teacup and twirl with fork; invert on to plate. Top with more cheese and

   fried sage.

3.1.3 Garlic Cream Poached Chicken

The chicken is packaged raw in order to prevent the warmed over flavor

mentioned before. The lactoperoxidase was added to reduce any microbial growth which

should reduce the possibility of food poisoning if undercooked.

1 can cream of chicken soup

1 cup heavy cream

1.5 tbs garlic (minced)

0.5 cup cheese (50/50 mozzarella - muenster)

0.25 tbs cayenne

0.5 cup chicken broth

0.5 cup sliced mushrooms

1 tsp lemon juice

5 lbs chicken breast (raw)

Oregano (garnish) (0.5 tsp)

Procedure:

1) Mix all ingredients and put into a casserole dish.

2) Cover and place in a 400°F oven for 45 minutes or 250°F for at least 2 hours.

(NOTE: Types of ovens have various ranges of cooking power. To ensure

the product is thoroughly cooked, the meat always needs to be checked by

inserting a thermometer in three different places to ensure the temperature

of the inside of the chicken was over 160°F).

3) Garnish chicken with oregano,

3.1.4. Bacon Wrapped Asparagus

1 tbs salted butter

2 stalks asparagus

Half strip of thin cut bacon

Procedure:

1) Wrap asparagus with bacon in a spiral motion. Hold in place with toothpick
   (if needed).

2) Heat pan until it is hot. Add butter to pan. When butter melts, add asparagus.
   Cook until asparagus is soft or bacon is to liking. (Suggested: 2 minutes).

3.1.5. Herbed Duchess Potatoes

Duchess Potatoes are mashed potatoes that have been squeezed though a pastry

piper in a decorative manner.

6 medium potatoes

2 tbs oregano

1 tbs thyme

1 tbs rosemary

1 tbs basil

2 tbs salt

3 eggs

3 tbs butter

0.5 cup heavy cream

Procedure:

1) Bring water to a rolling boil. Peel and cut potatoes into 1 inch cubes. Add potatoes and herbs to water. Cook approximately 20 minutes.

2) Drain potatoes and return to pot set over low heat. Add butter, salt and heavy cream. Whip using a stick blender or whisk.

3) Beat eggs in another bowl. Slowly add mashed potatoes to egg mixture in small batches (about a whiskfull or 1 cup), while mixing vigorously. After five installments, pour the egg/potato mixture into the large pot and mix to combine. Cook for about 5 minutes on low heat.

4) Transfer potatoes to a pipette bag with a large star tip (#64). Pipette about 25 grams of potato onto a greased cooking sheet in a helix motion.

5) Bake in the oven at 400°F for 20 minutes or until browned on the top.

6) Garnish with sea salt (optional, not used)

3.1.6. "Golden Egg" dessert confection

The dessert is a vanilla ice cream formed in the shape of an egg, coated with a caramel shell with a honey-citrus gel center. The center was designed so that when the consumer cuts into the egg, the gel center would leak out like a poached egg yolk. A hard caramel shell is applied to provide a golden color, simulate the egg shell, provide flavor, and allow the confection to be held upright by providing a flat bottom.

Ice cream:

> 2 cups milk (whole)
>
> 2 cups half and half
>
> 4 cups heavy whipping cream
>
> 1.75 cups sugar
>
> 1 tbs clean vanilla extract
>
> 0.5 tsp salt
>
> 15 g carboxymethlcellulose (TIC Pretested TECACEL HV Powder) (lot#15565)
>
> > (TIC Gums, Maryland)
>
> 1 g low acyl gellan gum (CPKelco, Georgia)

Yolk ingredients:

> 200 mL Bolthouse® Mango smoothie
>
> 100 mL grape concentrate
>
> 50 mL lemonade concentrate
>
> 100 mL honey
>
> 100 mL light corn syrup

80 g sugar

2.9 g high acyl gellan gum (Kelcogel LT100)(lot#OD767OA) (CPKelco,

Georgia)

2.9 g low acyl gellan gum (Kelcogel F)(lot#9J6836A) (CPKelco, Georgia)

5.8 g sodium alginate (lot#7242) (Gum Technology, Arizona)

Other prepared items:

5% calcium solution:

5g calcium chloride (Fisher, Pennsylvania)

100 mL distilled water

Clean water for rinse

Egg shape mold (Amazing Mold Putty; Alumnite Corp., Ohio)

Smucker's® Magic Shell: Caramel

Procedure:

1) Mix all the yolk ingredients together except for the calcium solution which
   will be set aside completely.

2) With a small disher or melon baller, scoop out a small portion of the yolk
   mixture (about 2 grams). Carefully submerge the mixture into the calcium
   solution, and pour the mixture out while remaining completely submerged. A
   gel ball should have formed. Let rest for exactly 30 seconds.

3) Remove ball with a strainer or slotted spoon and briefly dip in a bowl of clean
   water to remove any residual calcium. Set yolks aside.

4) Prepare the ice cream by first heating the dairy products to 90°C. Then add the CMC and gellan gum.

5) Combine the remaining ingredients and whisk in a stand mixer for 30 minutes.

6) Cover, label, and refrigerate mixture at least 12 hours for the hydrocolloids to hydrate.

7) Put mixture in preferred ice cream maker and follow the manufacturer's instructions.

8) When ice cream is at a yogurt like consistency, quickly spoon ice cream into egg mold about half way up. Place yolk center in the mold on top of the ice cream and then top off the mold with additional ice cream.

9) Place egg mold(s) in a deep freezer.

10) When solid, remove from mold and dip in caramel solution. Allow shell to harden. Return to freezer promptly.

3.2 Brown Butter Fettuccine with Sage

3.2.1 Cooking Time Determination

To determine the correct cooking time, a large batch was made using the procedure mentioned and then distributed into heat resistant plastic containers and frozen in a blast freezer for 12 hours then transferred to a non-commercial freezer for at least 24 hours. Each sample was weighed out to be 100 g of pasta. The samples were placed in a covered hot water bath at degree ranges of 60°C, 72°C, and 100°C. Sample centers were

checked every 15 to 30 minutes using sensory techniques and a thermometer. The target

temperature was 60°C.

3.3 Garlic Cream Poached Chicken

3.3.1 Lactoperoxidase System Testing

A baseline study was run to better understand the amount of bacteria in a freshly

made chicken sample. Using the data from Wolfson and others (1994), a control was

made that was plated at 0 hours and two LPS samples run at the 2 hour and 4 hour points.

The sauce was made by mixing one can of condensed cream of chicken, 1c. heavy cream,

4 tbs. garlic powder, 1 tsp lemon juice, 1.5 tbs. minced onion, 0.5 c. cheese (50/50

mozzarella - muenster), 0.25 tbs. cayenne, and 0.5 c. chicken broth. They were mixed

using standard laboratory practices. Three hundred grams of the sauce was then extracted

and placed in a 42 oz. Nasco® Whirl-pak stomacher bag (Fort Atkinson, WI). One

hundred grams of pureed raw chicken was then added. The sample was stomached using

a Seward® Stomacher model 400 (Seward, New York) at 300rpm for two minutes. One

hundred grams was then removed for the control sampling. To the remaining 300 grams,

1.75g of potassium thiocyanate (Fisher, Pennsylvania), 0.46mL 30% hydrogen peroxide

(Fisher, Pennsylvania), and a minute amount consisting of a few granules of

lactoperoxidase (Sigma, Missouri) was added. The ingredients were added and

stomached by hand each time a chemical was added. It was then stomached again at

300rpm for 2 minutes and split into two bags and left at room temperature (22°C). A

sample was taken from each bag at 0, 2, and 4 hours.

A pilot test was done first. For each sample, at hours 0, 2, and 4, 1 mL was extracted and placed in 9 mL of prepared peptone water (Difco, New Jersey). The dilutions were repeated from 10^-1 up to 10^-5 using aseptic techniques. Samples were put into duplicate pour plates using PCA agar (Difco, New Jersey). The plates were cooled at room temperature and then placed in a 37°C incubator for 24h. They were then extracted and left at room temp for 12h before counting.

Using the data from the previous pilot test, a larger scale test with some improvements was conducted. Using the same chicken recipe and LPS inoculation procedure, dilutions were made by putting 11 g of the entrée into 99 mL peptone water rather than 1 mL into 9 mL due to the difficulty of obtaining such a small sample of a sauce with large particulates. The control was also expanded by adding 2h and 4h observations. The plating dilutions were also changed to 10^-4 to 10^-8. Incubation time was raised to 48h at 37°C so that the colonies had more time to grow larger and thus easier to count.

3.3.2 Cooking Time Determination

The chicken was prepared using the same ingredients and procedures as mentioned previously and was split into two glass containers. One was placed in the oven at 250°F and another at 400°F with an electronic thermometer set to go off at 160°F. On the 250°F oven, the probe alarm went off at 1 hour, 47 minutes. To ensure food safety, 2 hours would be recommended. On the 400°F oven, the alarm went off at 41 minutes.

3.3.3. Sides

The use of Duchess potatoes was determined initially by averaging and testing various other recipes. Small test runs including thickness of the asparagus and thickness of the bacon were conducted for the asparagus side dish. Four samples were made: thick asparagus with thin bacon, thick asparagus with thick bacon, thin asparagus with thick bacon and thin asparagus with thin bacon. The side was prepared, blast frozen for 12 hours and then transferred to a retail freezer for 24 hours. Sensory techniques were used to determine quality. Target sensory was a slightly crispy bacon with soft but not soggy asparagus.

3.4 "Golden Egg"

3.4.1 Preparation of Ice Cream Base

The dessert was originally planned to be an ice cream egg, rolled in sugar, and then torched. The plan was to create a crème brule shell by torching the sugar, thus CMC was the first hydrocolloid added because it is commonly used in ice creams as well as having the property of forming a solid gel when heated to 130°C and then turning back to a liquid at lower temperatures. Since the ice cream was to be heated to extreme temperatures, something was needed to ensure the ice cream would not melt immediately. The hydrocolloid would form a gel when being heated retaining the ice cream, and when the sugar coating had been torched and the ice cream placed back into the freezer, the CMC would then serve as a normal stabilizer in a liquid phase. It was suggested that a concentration of 0.8% was to be used by TIC gums who supplied the CMC. In a later

experiment, 0.05% concentration of low acyl gellan gum was added to the ice cream using the concentration suggested by CPKelco who supplied the gellan.

Other tests were done by dipping the ice cream egg shaped confection into a 4% CMC edible film mixture. This film can help retain moisture (Rico-Pena and Torres 1990). If the film were to act as an additional barrier, it could inhibit any water transfer from the environment to the ice cream resulting in smaller ice crystals. To test this, 100 mL of water was brought to a boil and 4.5 g each of sucrose and CMC were slowly added while mixing for 30 minutes. During the mixing phase, 200 mL of additional water was added. Two samples were dipped into this mixture before and after they were torched, then dipped one more time.

3.4.2 Gel Center

The gel center went through numerous tests regarding its taste with ingredients, and combination of hydrocolloids. The target product was something that would not freeze solid at normal frozen temperatures while providing a soft gel coating on the outside of the ball while the inside was very soft and slightly runny and at the same time, resembling the color of a real egg yolk. Orange juice and mango juice were the two driving types of juice with orange color that were tested. The following were tested:

Recipe 1:

 500g peach puree

 200g sugar

1.5 tbs cornstarch

1 tbs orange juice

Procedure: all ingredients were combined in a blender

Recipe 2:

0.5 cup water

3 tbs sugar

2 tsp cornstarch

1g nutmeg

1 can peaches (drained and pureed)

0.25 tsp almond extract

Procedure:

1) Bring water, sugar, cornstarch, and nutmeg to boil.

2) Add peach puree. Cook 2 minutes.

3) Remove from heat, add extract. Freeze.

Recipe 3:

400g orange juice

200g sugar

15g cornstarch

1g gellan gum

Procedure:

    1) Mix juice, sugar and cornstarch in blender.

    2) 100 mL (110g) aliquot was taken and 1g of gellan was added.

    3) Blend aliquot for an additional 30 seconds.

These tests did not hold up to the expected results, so the following recipe was tried with various different combinations:

Recipe 4:

    125g X juice

    0.8g gellan gum

    0.2g sodium hexametaphosphate (SHMP) (4mular)

The beverages (X juice) used consisted of:

    A) orange G2 Gatorade®,

    B) mango nectar,

    C) guava nectar,

    D) Welches® orange pineapple drink,

    E) Nestle® Juicy Juice orange tangerine,

    F) Great Value® orange juice concentrate,

    G) Fuze® peach mango,

    H) orange Kool-Aid®,

    I) Bolthouse® Farms C-Boost smoothie,

J) SunnyD® orange drink,

K) V8® V-fusion peach mango.

Procedure:

1) Blend juice and slowly add gellan and SHMP for approximately 2 minutes.

2) Place in refrigerator for 30 minutes before testing.

Recipe 5:

100g lemon concentrate

100g Fuze® peach mango

Procedure: ingredients were mixed in a blender

Recipe 6:

10 mL Welches® orange pineapple

20 mL Great Value® grape juice concentrate

10 mL strawberry-banana nectar

3g sugar

Procedure: ingredients were mixed in a blender

Recipe 7:

100g Fuze® peach mango

10g sugar

2g lemon concentrate

Procedure: ingredients were mixed in a blender

Recipe 8:

       30 mL orange juice concentrate

       10 mL grape juice concentrate

       10 mL Fuze® peach mango

       5g sugar

Procedure: ingredients were mixed in a blender

Recipe 9:

       30 mL Bolthouse® smoothie

       10 mL grape concentrate

       5 mL lemon concentrate

       5 mL strawberry-banana juice

       10 mL light corn syrup

Procedure: ingredients were mixed in a blender

Recipe 10:

       20 mL Bolthouse® smoothie

       5g sugar

       5 mL lemon concentrate

       10 mL grape concentrate

5 mL light corn syrup

Recipe 11:

20 mL Bolthouse® smoothie

5g sugar

5 mL lemon concentrate

10 mL grape concentrate

10 mL honey

10 mL light corn syrup

Procedure: ingredients were mixed in a blender

Recipe 12:

20 mL tropical V8®

10 mL light corn syrup

10 mL grape concentrate

10 mL mango nectar

Procedure: ingredients were mixed in a blender

Recipe 13:

20 mL Bolthouse® smoothie

20 mL light corn syrup

10 mL honey

Procedure: ingredients were mixed in a blender

Recipe 14:

    10 mL honey

    10 mL V8® peach mango

Procedure: ingredients were mixed in a blender

Recipe 11 showed to be the best possible candidate. The following tests to determine the correct amount of hydrocolloids used this recipe:

Sodium alginate showed similar gelling properties to gellan gum and was considered to be an exceptional candidate to test. One hundred grams of the mango mixture was tested against 0.5, 0.6, and 0.7% concentration of sodium alginate. The mixture was placed in a blender and the alginate was slowly added to ensure proper hydration. If added too quickly, some powder would float on the top and not mix properly.

The mixture tests were not gelling properly enough, additional tests were done to conclude if combining gels would increase the gelling properties and prove the synergetic effects with multi-polymer networks. The test concentrations can be seen in Table 6 using sodium alginate, low acyl (LA) gellan and high acyl (HA) gellan gum (CPKelco) at various concentrations.

Table 6: Testing of hydrocolloids for gel center of "Golden Egg".

Test #	Alginate (g)	LA gellan (g)	HA gellan (g)
1	0.7	0.3	0
2	0.4	0.3	0.3
3	0.5	0.5	0.5
4	0.8	0.4	0.4

3.5.3 Ice Cream Shell

The initial idea for the ice cream shell was to roll the egg in sugar and then torch it. The goal was to create a golden brown coating on the outside of the egg that would represent the shell of the egg. It needed to be very brittle and easily broken with a hit by a spoon. Granulated sugar, brown sugar, confectioners sugar, and an equal mixture of granulated and brown sugar were tested to see which sugar would supply an even coating while still giving an acceptable crunch. The ice cream eggs were deep frozen and immediately taken to be rolled in one of these sugars. The ice cream was suspended with a fondue fork so there could be good coverage but a safe distance while torching.

Another idea was tested using the idea of freshly dipped soft serve ice cream. The coating had a similar thickness and function of the sugar coating. A commercially produced product was suggested and used. Smucker's® Magic Shell coating was the golden color which was desired as well as provided a sufficient shell. To apply the coating, the syrup was poured into a tall cocktail glass, and the egg was lowered and

completely submerged using the fondue fork. When extracted, the egg was manually

turned to ensure an even coating until hardened. Once solid, the sample was ready to

serve.

3.5 Sensory Evaluation

3.5.1 Introduction

The testing was done at the University of Missouri in room 126 of Eckles Hall

and conducted on December 7-9, 2010 between the hours of 10am and 4pm. Fifty

panelists were welcome to participate. All participants above the age of 18, and with no

food allergens, were allowed to participate. Flyers, which can be found in appendix 1,

were posted around the building in areas of high traffic such as large classrooms, the

café, entrances, and in hallways outside of bathrooms. A mass email, which can be found

in appendix 2, was sent out through the University of Missouri's College of Agriculture,

Food, and Natural Resources listserve.   The panelists were asked to sign a consent form,

which can be found in appendix 3. They were then seated and asked a few questions on a

computer using the Compusense® Five (Compusense Inc, Ontario) program. The

panelists were also given crackers and water to cleanse their palette between samples.

The dishes and questions were coded as follows:

111- Appetizer

222- Entrée with sides

333- Dessert

444- Dinner as whole

The products were made using the same recipes as mentioned before. The food appetizer and entrée were made three days ahead of each test day, frozen immediately using a residential freezer, and then thawed in the refrigerator the night before testing. On each day of the testing, small batches were made about every two hours to ensure preparedness and freshness. Some fluctuations appeared on day two as there was high traffic thus samples were made more often possibly resulting in a higher freshness quality, which will be discussed later.

3.5.2 Questions

The questions were evaluated using a hedonic scale of 1-9, ranking the panelists' degree of liking for the appetizer, the entrée with sides, the dessert, and then finally the meal as a whole. The answers were labeled numerically and titled as follows:

1- Dislike extremely

2- Dislike strongly

3- Dislike moderately

4- Dislike slightly

5- Neither like nor dislike

6- Like slightly

7- Like moderately

8- Like strongly

9- Like extremely

A mandatory screen showed up after every sample giving the panelist a 30 second break to masticate crackers and have some water to cleanse the palette. All questions were done solitary and recorded anonymously. The directives, introduction, debriefing, and questions that the panelists were asked can be seen in appendix 4.

3.5.3 Statistical Analysis

A statistical analysis was initially calculated using the Compusense® Five program, the same one used to present the questions to the panelists. However, the number of panelists was considered too small, and the forth question regarding the meal as a whole had skewed the overall sensory statistics due to its dependency on the other food item scores. Therefore, the results were re-run using SAS program (SAS, North Carolina) testing the first three questions, excluding the forth, and simulating a panel of an additional 100 individuals in order to render a smaller standard deviation with a rise in n.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Appetizer

The appetizer was frozen and cooked at temperatures of 60°, 72°, and 100°C in a hot water bath. The temperature of the center was taken every 15 minutes. The values are shown in Table 7. The target cooking temperature was 60°C.

Table 7: Internal temperature (°C) of appetizer at preselected intervals at three heating temperatures.

	60C	72C	100C
15min	3°	8°	67°
30min	10°	19°	76°
45min	19°	53°	
60min	29°	70°	
75min	45°		
90min	58°		

It can be seen from the results that the appetizer can be cooked at various temperatures and times. For the purpose of ease for the cook and speed, the consumer will heat water to a boil (100°C) and have the pasta cook for exactly 15 minutes. The result produced a firm, yet still soft pasta.

4.2 Entrée with Sides

4.2.1. Garlic Cream Poached Chicken

The chicken was subjected to a test to determine if the LPS would actually inhibit any bacterial growth. Tests 1 and 2 were pilot tests to determine the parameters of dilutions for the larger scale test. Tests 3, 4, and 5 were done in daily succession using fresh ingredients. The results can be seen in Table 8 below. Plates with too great a number to count were marked as "too numerous to count" (TNTC). The averages of the bacterial counts are seen in Table 9.

Table 8. Bacterial results of LPS on Garlic Cream Poached Chicken.

Test 1	10^-1		10^-2		10^-3		10^-4		10^-5	
Control	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	85	85	8	21
LPS 2hr	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	100	33	9	18
LPS 4hr	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	73	TNTC	196	187

Test 2

Control	10^-4		10^-5		10^-6		10^-7		10^-8		10^-9	
0 h	TNTC	TNTC	TNTC	TNTC	67	88						
2 h			TNTC	TNTC	242	198	85	86				
4 h					TNTC	TNTC	93	76	27	28	<25	<25

LPS	10^-4		10^-5		10^-6		10^-7		10^-8		10^-9	
0 h	TNTC	TNTC	TNTC	TNTC	52	47						
2 h	TNTC	TNTC	TNTC	TNTC	66	96						
4 h					78	88	17	14	<25	<25	<25	<25

Test 3

Control	10^-4		10^-5		10^-6		10^-7		10^-8	
0 h	78	93	58	47	26	20				
2 h			<25	<25	<25	<25	<25	<25		
4 h					28	31	<25	<25	<25	<25

LPS	10^-4		10^-5		10^-6		10^-7		10^-8	
0 h	<25	<25	<25	<25	0	0				
2 h	<25	<25	<25	<25	<25	<25				
4 h			<25	<25	<25	<25	<25	<25		

Test 4

Control	10^-4		10^-5		10^-6		10^-7		10^-8	
0 h	TNTC	TNTC	221	216	92	85				
2 h			TNTC	TNTC	111	107	26	36		
4 h					141	143	39	42	<25	<25

LPS	10^-4		10^-5		10^-6		10^-7		10^-8	
0 h	184	190	44	47	<25	<25				
2 h	70	56	<25	<25	<25	<25				
4 h			<25	<25	<25	<25	<25	<25		

Test 5

Control	10^-4		10^-5		10^-6		10^-7		10^-8	
0 h	TNTC	TNTC	215	208	51	44				
2 h			87	91	61	91	27	38		
4 h					79	87	30	39	<25	<25

LPS	10^-4		10^-5		10^-6		10^-7		10^-8	
0 h	80	95	<25	<25	<25	<25				
2 h	32	34	<25	<25	0	0				
4 h			<25	<25	<25	<25	<25	<25		

Table 9: Average CFU of Microbial Counts Using LPS in Garlic Chicken.

Test 1	
Control	8.5x10^5
LPS 2hr	6.6x10^5
LPS 4hr	1.9x10^5

Test 2		
	Control	LPS
0h	7.7x10^7	4.9x10^7
2h	4.3x10^8	8.1x10^7
4h	1.6x10^9	8.3x10^7

Test 3		
	Control	LPS
0h	5.2x10^6	-
2h	-	-
4h	3x10^7	-

Test 4		
	Control	LPS
0h	5.5x10^7	6.3x10^6
2h	2.1x10^8	6.3x10^5
4h	5.5x10^8	-

Test 5		
	Control	LPS
0h	3.5x10^7	8.7x10^5
2h	4.1x10^8	3.3x10^5
4h	4.3x10^8	-

These results of the initial pilot test show that the LPS actually inhibit and lower the

bacterial activity for up to four hours. At four hours, the plates should have been all

TNTC, but the LPS still inhibited most bacterial growth.

The second pilot test showed better results than the first. There was a slightly

higher amount of bacteria, which would be expected since some materials used from the

first test were used for the second, as well as due to the increase in time the plates spent

in room temperature after incubation. As can be seen, there is an increase in overall

bacteria, but a clearer difference in the amount of bacteria in the test methods. With the

pilot test results, the larger scale test with fresh ingredients was done in rapid succession

to ensure lower microbial variation from the materials.

The large scale tests (3-5) confirm the data from the previous tests. The addition

of LPS greatly diminished the amount of microbial activity to almost nil in most samples.

The averages shown in Table 9 show a decrease in samples. Each test run using the LPS

showed little to no microbial growth in comparison to the control. In the case of test 5,

the LPS actually lowered microbial counts by 40% in only two hours from the initial time

to the two hour mark. In the control there was a growth of 12% at the same time. This

proves that the LPS can, in fact, lower microbial activity even under thriving bacterial environments.

4.2.2. Bacon Wrapped Asparagus

Four samples with duplicates were made by alternating thin and thick food products. For the bacon, actual thick cut strips were used (~8mm thick) versus thin strips (~3mm), and for asparagus the range was about 3cm for thick and 1cm for thin. The samples were prepared, frozen, and then allowed to thaw for 30 minutes in a refrigerator. The target product was to have crispy bacon and soft, but not soggy asparagus. Table 10 shows the results.

Table 10: Texture test of Bacon Wrapped Asparagus.

		Asparagus	
		Thin	Thick
Bacon	Thin	Asparagus over cooked	Good
	Thick	Asparagus over cooked	Asparagus over cooked

In every case except for the thick asparagus and thin bacon, the asparagus was too brown and too soft. Which was not the desired texture, therefore the thick vegetables

with a thin slice of bacon proved to provide the crispy bacon as well as cooked asparagus spear.

4.3 "Golden Egg"

4.3.1. Ice Cream

The tests showed that, a 0.8% concentration of CMC gave a thicker, almost custard like texture when the ice cream came out of the machine. The 0.7% had a similar texture, but when tested under flame to brulee the sugar coating, they melted too quickly. A concentration of 0.9% showed a gummy texture which was not desirable. When the gellan gum was added, the ice cream became slightly thicker, but retained its creamy texture and may even have been enhanced. This is because gellan gum forms a gel when in contact with calcium ions. Thus ice cream formed an extra thick gel at extremely low concentrations.

4.3.2. Gel Center

As can be seen in the recipe section, various recipes were compared using different concentrations. The recipes were chosen because of their light orange color, similar to the color of an egg yolk. Therefore, mangos, oranges, and peaches were chosen. The goal was to attain a spherificated gel that was solid on the outside and viscous on the inside, but would not freeze solid when in a residential freezer. Tests began using gellan gum on its own so there could be a determination as to the thickness desired. It was found that adding sugar to the gel added viscosity and lowered the

freezing temperature because a 0.6% gellan concentration with 35% sugar had a slight

give to the ball versus a 0.6% gellan concentration without sugar. With this data, the

recipes were designed with acceptable concentrations of sugar. Table 11 shows the

recipes and general comments regarding each one.

It can be seen that recipes 1-4 already have the hydrocolloid present. After

numerous failures, in order to conserve materials, the recipes were then tested for their

inhibition to freezing. After the best candidate was chosen, additional tests were done to

find the proper amount of hydrocolloids needed.

Table 11: Textural Analysis of Gel Center for "Golden Egg".

Recipe	Status gelled	Status frozen	Taste
1	good	too solid	good
2	ok	too solid	bad
3	failed to gel	N/A	ok
4A	failed to gel	N/A	bland
4B	failed to gel	N/A	ok
4C	failed to gel	N/A	ok
4D	failed to gel	N/A	good
4E	failed to gel	N/A	ok
4F	failed to gel	N/A	bad
4G	failed to gel	N/A	bad
4H	failed to gel	N/A	bland

4I	failed to gel	N/A	Great
4J	failed to gel	N/A	good
4K	failed to gel	N/A	good
5	N/A	ok	bad
6	N/A	icy	good
7	N/A	solid	N/A
8	N/A	ok	bad
9	N/A	ok	ok
10	N/A	good	good
11	N/A	great	great
12	N/A	solid	N/A
13	N/A	good	bad
14	N/A	good	bad

It was seen that recipe 11 was the best candidate to proceed with. Table 12 shows the testing done to find the best combination of hydrocolloids.

Table 12: Testing for Spherification for Gel Center.

	Amount of Hydrocolloid			
Test #	Sodium Alginate	High Acyl Gellan	Low Acyl Gellan	Result
1	-	-	0.52%	none
2	-	-	1%	poor gel
3	0.60%	-	0.20%	poor gel
4	0.70%	-	0.3	none
5	0.40%	0.30%	0.30%	none
6	-	0.50%	0.50%	Thick, poor gel
7	0.80%	0.40%	0.40%	good

4.3.3. Shell Coating

The original goal was for the dessert to have a sugar coating. The CMC was added to ensure that the ice cream would not melt as soon as the heat was introduced and would actually thicken, in theory, the more heat was added. After the ice cream was extruded from the ice cream machine, it was placed in plastic egg molds and put into a deep freezer to ensure the best probability for survival against flame. Table 13 shows the results of a test with various size ice cream balls and sugar coating types.

Table 13: Results of Sugar Brulee of Golden Egg Ice Cream.

Test #	Size	Coating	Result
1	small	granulated sugar	success
2	large	granulated sugar	failure
3	small	brown sugar	success
4	large	brown sugar	failure
5	small	50/50	success
6	large	50/50	failure

The data shows that the smaller egg sizes (~40g) will succeed versus a larger

version (~100g) as the larger eggs started to have a small layer of ice cream that began to

melt away when heated. The small eggs had a perfect shell that supplied a slight crunch

and good golden color. The samples were quickly placed in the freezer after brulee. The

following morning, the successful tests were found to have good color, but the crunch

was no longer existent. It is assumed that the humidity of the freezer rehydrated the

sugar crystals as it formed a slight caramel candy like texture.

Due to these problems, it was decided to use a commercially available thin

chocolate coating using Schmuckers® brand Magic Shell Coating. An ice cream egg was

placed in a beaker full of the caramel coating and when extracted the commercial coating

served to provide a good golden color, the texture needed, and it also made the process

easier.

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4.4 Nutritional Labeling

The nutritional values of the dishes were estimated using the general ingredients supplied using the computer program Genesis R&D® (Garuda International. Exeter, CA). Cooked weight yield was taken into consideration.

4.4.1 Brown Butter Fettuccini with sage

The nutritional value of the Brown Butter Fettuccini with Sage is shown in Figure 5.

Figure 5: Nutritional value of Brown Butter Fettuccine with Sage

Nutrition Facts

Serving Size (100g)
Servings Per Container

Amount Per Serving

Calories 310   Calories from Fat 100

% Daily Value*

Total Fat 11g	**17%**
Saturated Fat 6g	**30%**
Cholesterol 25mg	**9%**
Sodium 330mg	**14%**
Total Carbohydrate 42g	**14%**
Dietary Fiber 2g	**10%**
Sugars 1g	
Protein 10g	

Vitamin A 8%	•	Vitamin C 0%
Calcium 6%	•	Iron 2%

4.4.2 Garlic Cream Poached Chicken

The nutritional value of the Garlic Cream Poached Chicken is shown in Figure 6.

Figure 6: Nutritional value of Garlic Cream Poached Chicken

Nutrition Facts

Serving Size (200g)
Servings Per Container

Amount Per Serving

Calories 460   Calories from Fat 210

% Daily Value*

Total Fat 23g	**35%**
Saturated Fat 9g	**45%**
Cholesterol 180mg	**59%**
Sodium 250mg	**10%**
Total Carbohydrate 4g	**1%**
Dietary Fiber less than 1g	**2%**
Sugars 0g	
Protein 57g	

Vitamin A 10%	•	Vitamin C 2%
Calcium 8%	•	Iron 10%

4.4.3 Bacon Wrapped Asparagus

The nutritional value of the Bacon Wrapped Asparagus is shown in Figure 7.

Figure 7: Nutritional value of Bacon Wrapped Asparagus

Nutrition Facts

Serving Size (40g)
Servings Per Container

Amount Per Serving

Calories 50   Calories from Fat 35

% Daily Value*

Total Fat 4g   **6%**

Saturated Fat 1.5g   **8%**

Cholesterol 5mg   **2%**

Sodium 80mg   **3%**

Total Carbohydrate 1g   **0%**

Dietary Fiber less than 1g   **3%**

Sugars 1g

Protein 3g

Vitamin A 4%   •   Vitamin C 6%

Calcium 0%   •   Iron 2%

4.4.4 Herbed Duchess Potatoes

The nutritional value of the Herbed Duchess Potatoes is shown in Figure 8.

Figure 8: Nutritional value of Herbed Duchess Potatoes

Nutrition Facts

Serving Size (100g)
Servings Per Container

Amount Per Serving

Calories 110   Calories from Fat 30

	% Daily Value*
Total Fat 3g	5%
Saturated Fat 2g	9%
Cholesterol 10mg	4%
Sodium 125mg	5%
Total Carbohydrate 18g	6%
Dietary Fiber 2g	7%
Sugars 1g	
Protein 2g	

Vitamin A 2%	•	Vitamin C 10%
Calcium 2%	•	Iron 2%

4.4.5 "Golden Egg"

The nutritional value of the "Golden Egg" is shown in Figure 9.

Figure 9: Nutritional value of "Golden Egg"

Nutrition Facts

Serving Size (62g)
Servings Per Container

Amount Per Serving

Calories 160   Calories from Fat 90

	% Daily Value*
Total Fat 10g	**15%**
Saturated Fat 6g	**30%**
Cholesterol 35mg	**11%**
Sodium 50mg	**2%**
Total Carbohydrate 16g	**5%**
Dietary Fiber 0g	**0%**
Sugars 14g	
Protein 1g	

Vitamin A 6%	•	Vitamin C 2%
Calcium 4%	•	Iron 0%

4.5 Sensory Analysis

   The raw data from the sensory test using the Compusense® program can be seen in appendix 4, and the raw data analyzed using the SAS program can be seen in appendix 5. The data below in Table 14 shows the SAS data since the Compusense® data was considered invalid due to the dependence factor mentioned earlier. Although the Compusense® data showed that the product concept as a whole received a score of 7.6 out of 9, the data for the question was omitted in the SAS data. With the change, the error mean square went from 1.275 to 1.696 using the t-test, proving that the data is more accurate. Individually, the appetizer received a mean of 6.7, the entrée with sides a 7.0, and the dessert with a 7.28. If this product were to undergo any menu adjustments, the appetizer might have to be either adjusted or changed since it scored the lowest. The dessert appears to be the most popular and therefore, should undergo little to no adjustments. Due to the limitations of not having the dessert samples in the desired egg form, the dessert score could increase if the panelist was given the dessert in its planned shape. The product would need to be made at the mass production level for the item to be made efficiently. There could also be another adjustment with the test by breaking up the entrée to ask the opinion of the chicken, asparagus, and potatoes as individuals rather than as a whole dish. It could be possible that some panelists enjoyed the chicken and potatoes, but were not fond of asparagus. The panelists might have given the dish a lower score because of this. If evaluated separately, a judgment could be made regarding if there should be a change or adjustment in a particular side item. Another future adjustment would be to increase the number of panelists to give a more accurate idea of

the overall opinion by diminishing the standard deviation. After the test result prove

satisfactory, a marketing test should be done to follow up. As previously mentioned,

although the intention of the forth question given to the panelists was to rate their degree

of liking of the dishes as a whole, it was decided that given the limitations of the test, that

similar questions should be asked in a completely separate marketing survey and not

affiliated with the sensory of the food products.

Table 14: Sensory analysis statistics using the SAS program.

	Appetizer	Entrée with Sides	Dessert
Dependant Variable			
Appetizer	-	0.2523	0.0283
Entrée with Sides	0.2523	-	0.2851
Dessert	0.0283	0.2851	-
Mean	6.7	7	7.28

Standard Error	0.184
Alpha	0.05
Error Mean Square	1.696
Crit. Value of t	1.984
Least Significant Difference	0.517

CHAPTER 5

SUMMARY AND CONCLUSIONS

The research conducted for this project showed that culinary arts can help us create new delicious foods, and that the addition of food science results in even more unique creations that can be mass produced. Some families may have problems finding time to cook dinner for their families and have to expedite their dinner to a restaurant. The convenient dinner developed in this project provides food quality similar to that of an upscale restaurant but at a fraction of the price, allows consumers to cook food in the comfort of their home, and can improve confidence in cooking.

Further testing will have to be done after adjusting the recipes of the dishes. For instance, the appetizer should be changed in a manner that would be more appealing to the public by either a change in the recipe, cooking instructions, or be changed to a completely different item. It would also be beneficial to have the dessert in the desired egg shape which could be done using a third party manufacturer. A marketing survey should follow when the product scores are more satisfactory.

APPENDICES

Appendix 1: Public flyer for taste sensory panel

Culinary Taste Test Panel Needed

What: pasta, chicken with sides, and ice cream confection
When: Dec 7-9 2010 from 10am to 4pm (tests done hourly)
Where: 126 Eckles Hall
Why: Free sampling of a 3-course meal
How: RSVP by emailing the names below. Hurry, only 50 slots!

Questions? RSVP at
Greg Cosgrove   314-265-9225   gjcz76@mail.missouri.edu
Ingolf Gruen   573-882-6746 grueni@missouri.edu

Appendix 2: Email to public to recruit for sensory panel

Dear Colleagues and Students:

We would like to invite you to participate in a sensory study. This study consists of sampling a 3-course gourmet meal and selecting your degree of liking. The testing will take place on December 7-9 from 10AM to 4PM at 126 Eckles Hall.

If you are interested in participating, please contact Greg Cosgrove at gjcz76@mail.missouri.edu.

Appendix 3: Consent form for sensory panel
INFORMED CONSENT

I, (Name_____), (Date_____) consent to participate in this research project and understand the following:

PROJECT BACKGROUND: This project involves gathering data on product development of a 3-course frozen convenience dinner. The data will be collected for analysis and may be published. You must be at least 18 years of age to participate.

PURPOSE: The purpose of this study is to determine the degree of liking of 3 different dishes to consider if the product is marketable.

VOLUNTARY: The survey is entirely voluntary. You may refuse to answer any question or choose to withdraw from participation at any time without any penalty or loss of benefits to which you are otherwise entitled.

WHAT DO YOU DO? All participants of the sensory panel will taste an appetizer, a main dish and a dessert and then answer 4 questions regarding their liking of the presented dishes. The entire test will take no more than approximately 30 minutes.

BENEFITS: Your participation in this research project will enrich the information base. U.S. consumers enjoy the safest and most varied food supply in the world, in large part because of the great achievements of the food science research. Due to the rise in demand for fast, convenient, and delicious food, the data would prove beneficial to future development of similar products.

RISKS: The expected risks are none other than those encountered in normal daily food consumption. All products have either been prepared under sanitary conditions or are commercially available products bought in a grocery store. If you know that you are allergic to dairy, soy, or wheat products, you may NOT participate in this study.

CONFIDENTIALITY: Your confidentiality will be maintained in that a participant's name will not appear on the ballot or in the published study itself. The data will only be reported in aggregate form. Score sheets will be stored for a period of three years in a locked file cabinet in the principal investigators office and then destroyed.

INJURY: It is not the policy of the University of Missouri to compensate human subjects in the event the research results in injury. The University of Missouri does have medical, professional and general liability self-insurance coverage for any injury caused by the negligence of its faculty and staff. Within the limitations of the laws of the State of Missouri, the University of Missouri will also provide facilities and medical attention to subjects who suffer injuries while participating in the research projects of the University of Missouri. In the event you have suffered injury as the result of participating in this research project, you are to immediately contact the Campus Institutional Review Board Compliance Officer at (573) 882-9585 and the Risk Management Officer at (573) 882-3735 to review the matter and provide you further information. This statement is not to be construed as an admission of liability.

Thank you for your assistance in developing new culinary products. Although great strides have been made in the instrumental analysis of foods, the development of new foods still requires the human sensory response and feedback. Your efforts are greatly appreciated. If you have any questions regarding the study, please contact Dr. Ingolf Gruen at (572) 882-6746. If you have questions regarding your rights as a participant in research, please feel free to contact the Campus Institutional Review Board at (573) 882-9585.

Please keep one copy of this consent form for your records if you wish.

Date:

Signature of Participant:_____

Signature of Dr. Ingolf Gruen:_____

Directive #1:

You will now be handed the appetizer of the meal. This dish is a **Brown Butter Fettuccini with Sage**. Please taste the sample and select your degree of liking. When you are done, click "next" on the screen.

Directive #2:

You will now be handed the entrée and sides. The main dish is a **Garlic Cream Poached Chicken.** The sides are **Bacon Wrapped Sauteed Asparagus,** and **Herbed Duchess Potatoes.** Please select your degree of liking regarding the dish **as a whole** (chicken and sides). When you are done, click "next" on the screen.

Directive #3:

You will now be handed the dessert of the meal. The dessert is a custard-like vanilla ice cream with a honey-citrus center. Please make sure you at least try the sweet center with the ice cream. Then, please select your degree of liking of the dessert. When you are done, click "next" on the screen.

Directive #4:

You are now done with the tasting portion of the test. If you would please select your degree of liking **for the meal as a whole** (appetizer, entrée & sides, and dessert). Some things to consider are:

> Did the dishes complement each other?
> The dishes apply to a large audience of adults?
> Would I find these dishes in a "fancy restaurant?"
> Was the meal "unique?"

When you are done, please select "next," read the debriefing, and then select "finish."

Welcome page:

Welcome to
Culinology Sensory Testing

To start the test, click on the continue button below:

"Continue"

Today you will be sampling a three course meal. You will be asked four questions.
Please pay attention to the paper placed above the sampling door in front of you for the
questions to be asked.
The order of dishes are as follows:
- Brown butter fettuccini with sage
- Garlic cream poached chicken with bacon wrapped asparagus and herbed duchess
  potatoes
- Vanilla ice cream with honey citrus center
- You will also be asked how the sample dinner was as a whole

You will be instructed to cleanse your palette between each sampling. This is done by
eating a cracker and rinsing your mouth with water provided.
Feel free to knock on the sample door if you have an immediate question.
To begin, flip the switch once and you will be presented with the appetizer. Click
"Continue" to begin the testing.

"Continue"

Question 1 of 2
Sample x of 4

Please read the directive on the paper above your sample door to the corresponding
sample, then display your degree of liking by clicking on the bow below.
Click "next question" when done.
Sample 111
1 – Dislike extremely
2 - Dislike very much
3 – Dislike moderately
4 – Dislike slightly
5 – Neither like nor dislike
6 – Like slightly
7 – Like moderately
8 – Like very much
9 – Like extremely

"Next question"

Question 2 of 2
The panelist will now have a mandatory 30 second break with the following message:
Please take this time to eat a cracker and rinse your mouth with water. Please ensure you do not have any aftertaste from the previous dish. Flip the switch once to be presented with the next sample.
The computer will automatically take them to the next question. These questions repeat three more times for a total of four occurrences.

Thank you/debrief:
You have just participated in a sensory evaluation. Please flip the switch one more time to have your place cleared. Thanks again and have a great day!

Project: 01 CULINOLOGY

Question Number:1
Question Type:Category / Hedonics
Question Title:Culinology
Attribute Number:1
Attribute Title:appetizer
Design:T=4, K=4, B=50

Products

Products	Code	Name
1 - 111	1	app
2 - 222	2	entree
3 - 333	3	dessert
4 - 444	4	overall

Scale Parameters

Value	Descriptor
1	dislike extremely
2	dislike very much
3	dislike moderately
4	dislike slightly
5	neither like nor dislike
6	like slightly
7	like moderately
8	like very much
9	like extremely

Note: Numbers shown in brackets are the 'values' associated with the category selected.

Results

Panelist	1-111	2-222	3-333	4-444
1	4	4	6	5
2	6	8	9	7
3	7	9	8	8
4	7	7	9	7
5	7	6	8	6
6	8	9	7	8
7	7	8	9	8
8	8	8	9	8
9	6	6	8	6
10	6	7	8	7
11	7	6	9	7
12	4	8	8	8
13	8	8	7	8
14	6	7	4	9
15	4	7	6	6
16	6	7	8	7
17	7	5	8	7
18	3	4	7	4
19	6	2	7	4
20	4	7	8	7
21	7	6	9	7
22	7	5	6	5
23	8	6	7	6
24	6	6	7	6
25	7	8	8	8
26	8	8	8	8
27	8	7	7	7
28	7	8	7	7
29	9	9	3	8
30	4	7	8	6
31	7	6	7	6
32	6	7	8	7
33	6	7	8	7
34	7	6	5	7
35	6	6	5	6
36	8	7	6	7
37	9	9	7	9
38	7	9	8	8
39	7	8	8	8
40	7	8	8	8
41	8	7	7	7
42	6	8	4	7
43	6	7	7	6
44	8	7	9	8
45	8	6	8	7

46	8	8	9	8
47	8	8	4	8
48	8	8	7	8
49	7	8	8	8
50	6	7	8	8

Crosstabulation

Sample	1 [1]	2 [2]	3 [3]	4 [4]	5 [5]	6 [6]	7 [7]	8 [8]	9 [9]	Total
1 - 111			1	5		13	16	13	2	50
2 - 222		1		2	2	10	15	15	5	50
3 - 333			1	3	2	4	13	19	8	50
4 - 444				2	2	9	17	18	2	50
TOTALS		1	2	12	6	36	61	65	17	200

Percentage Crosstabulation

Sample	1 [1]	2 [2]	3 [3]	4 [4]	5 [5]	6 [6]	7 [7]	8 [8]	9 [9]	Total
1 - 111			2.0	10.0		26.0	32.0	26.0	4.0	100
2 - 222		2.0		4.0	4.0	20.0	30.0	30.0	10.0	100
3 - 333			2.0	6.0	4.0	8.0	26.0	38.0	16.0	100
4 - 444				4.0	4.0	18.0	34.0	36.0	4.0	100

Counts, Medians, Means and SD's

Sample Number	Count	Total	Median	Mean	Standard Deviation
1 - 111	50	335.00	7.00	6.70	1.359
2 - 222	50	350.00	7.00	7.00	1.400
3 - 333	50	364.00	8.00	7.28	1.443
4 - 444	50	353.00	7.00	7.06	1.114

Appendix 6: SAS program data

Obs	trt	id	response
1	1	1	4
2	2	1	4
3	3	1	6
4	4	1	5
5	1	2	6
6	2	2	8
7	3	2	9
8	4	2	7
9	1	3	7
10	2	3	9
11	3	3	8
12	4	3	8
13	1	4	7
14	2	4	7
15	3	4	9
16	4	4	7
17	1	5	7
18	2	5	6
19	3	5	8
20	4	5	6
21	1	6	8
22	2	6	9
23	3	6	7
24	4	6	8
25	1	7	7
26	2	7	8
27	3	7	9
28	4	7	8
29	1	8	8
30	2	8	8
31	3	8	9
32	4	8	8
33	1	9	6
34	2	9	6
35	3	9	8
36	4	9	6
37	1	10	6
38	2	10	7
39	3	10	8
40	4	10	7
41	1	11	7
42	2	11	6
43	3	11	9
44	4	11	7
45	1	12	4
46	2	12	8
47	3	12	8
48	4	12	8
49	1	13	8
50	2	13	8
51	3	13	7
52	4	13	8
53	1	14	6
54	2	14	7
55	3	14	4
56	4	14	9
57	1	15	4
58	2	15	7
59	3	15	6
60	4	15	6
61	1	16	6
62	2	16	7
63	3	16	8
64	4	16	7
65	1	17	7
66	2	17	5

Obs	trt	id	response
67	3	17	8
68	4	17	7
69	1	18	3
70	2	18	4
71	3	18	7
72	4	18	4
73	1	19	6
74	2	19	2
75	3	19	7
76	4	19	4
77	1	20	4
78	2	20	7
79	3	20	8
80	4	20	7
81	1	21	7
82	2	21	6
83	3	21	9
84	4	21	7
85	1	22	7
86	2	22	5
87	3	22	6
88	4	22	5
89	1	23	8
90	2	23	6
91	3	23	7
92	4	23	6
93	1	24	6
94	2	24	6
95	3	24	7
96	4	24	6
97	1	25	7
98	2	25	8
99	3	25	8
100	4	25	8
101	1	26	8
102	2	26	8
103	3	26	8
104	4	26	8
105	1	27	8
106	2	27	7
107	3	27	7
108	4	27	7
109	1	28	7
110	2	28	8
111	3	28	7
112	4	28	7
113	1	29	9
114	2	29	9
115	3	29	3
116	4	29	8
117	1	30	4
118	2	30	7
119	3	30	8
120	4	30	6
121	1	31	7
122	2	31	6
123	3	31	7
124	4	31	6
125	1	32	6
126	2	32	7
127	3	32	8
128	4	32	7
129	1	33	6
130	2	33	7
131	3	33	8
132	4	33	7

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Obs	trt	id	response
133	1	34	7
134	2	34	6
135	3	34	5
136	4	34	7
137	1	35	6
138	2	35	6
139	3	35	5
140	4	35	6
141	1	36	8
142	2	36	7
143	3	36	6
144	4	36	7
145	1	37	9
146	2	37	9
147	3	37	7
148	4	37	9
149	1	38	7
150	2	38	9
151	3	38	8
152	4	38	8
153	1	39	7
154	2	39	8
155	3	39	8
156	4	39	8
157	1	40	7
158	2	40	8
159	3	40	8
160	4	40	8
161	1	41	8
162	2	41	7
163	3	41	7
164	4	41	7
165	1	42	6
166	2	42	8
167	3	42	4
168	4	42	7
169	1	43	6
170	2	43	7
171	3	43	7
172	4	43	6
173	1	44	8
174	2	44	7
175	3	44	9
176	4	44	8
177	1	45	8
178	2	45	6
179	3	45	8
180	4	45	7
181	1	46	8
182	2	46	8
183	3	46	9
184	4	46	8
185	1	47	8
186	2	47	8
187	3	47	4
188	4	47	8
189	1	48	8
190	2	48	8
191	3	48	7
192	4	48	8
193	1	49	7
194	2	49	8
195	3	49	8
196	4	49	8
197	1	50	6
198	2	50	7
199	3	50	8
200	4	50	8

The GLM Procedure

Class Level Information

Class	Levels	Values
id	50	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
trt	4	1 2 3 4

Number of Observations Read   200
Number of Observations Used   200

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The GLM Procedure

Dependent Variable: response

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	52	170.5600000	3.2800000	2.57	<.0001
Error	147	187.4200000	1.2749660		
Corrected Total	199	357.9800000			

R-Square	Coeff Var	Root MSE	response Mean
0.476451	16.10762	1.129144	7.010000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
id	49	161.9800000	3.3057143	2.59	<.0001
trt	3	8.5800000	2.8600000	2.24	0.0857

Source	DF	Type III SS	Mean Square	F Value	Pr > F
id	49	161.9800000	3.3057143	2.59	<.0001
trt	3	8.5800000	2.8600000	2.24	0.0857

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The SAS System   14:52 Thursday, April 21, 2011   7

The GLM Procedure

t Tests (LSD) for response

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

          Alpha   0.05
          Error Degrees of Freedom   147
          Error Mean Square   1.274966
          Critical Value of t   1.97623
          Least Significant Difference 0.4463

     Means with the same letter are not significantly different.

          t Grouping   Mean   N   trt

                  A   7.2800   50   3
                  A
          B   A   7.0600   50   4
          B   A
          B   A   7.0000   50   2
          B
          B   6.7000   50   1

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                         The GLM Procedure
                       Least Squares Means

                response   Standard   LSMEAN
     trt   LSMEAN   Error   Pr > |t| Number

      1   6.70000000   0.15968506   <.0001   1
      2   7.00000000   0.15968506   <.0001   2
      3   7.28000000   0.15968506   <.0001   3
      4   7.06000000   0.15968506   <.0001   4

               Least Squares Means for effect trt
               Pr > |t| for H0: LSMean(i)=LSMean(j)

                  Dependent Variable: response

       i/j   1   2   3   4

         1   0.1861   0.0112   0.1131
         2   0.1861   0.2170   0.7909
         3   0.0112   0.2170   0.3316
         4   0.1131   0.7909   0.3316

   NOTE: To ensure overall protection level, only probabilities associated with pre-planned
         comparisons should be used.

                              The GLM Procedure

                           Class Level Information

Class   Levels Values

id   50 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
                    31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50

trt   3 1 2 3

                    Number of Observations Read   150
                    Number of Observations Used   150

The GLM Procedure

Dependent Variable: response

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	51	130.7400000	2.5635294	1.51	0.0407
Error	98	166.2533333	1.6964626		
Corrected Total	149	296.9933333			

R-Square	Coeff Var	Root MSE	response Mean
0.440212	18.62464	1.302483	6.993333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
id	49	122.3266667	2.4964626	1.47	0.0534
trt	2	8.4133333	4.2066667	2.48	0.0890

Source	DF	Type III SS	Mean Square	F Value	Pr > F
id	49	122.3266667	2.4964626	1.47	0.0534
trt	2	8.4133333	4.2066667	2.48	0.0890

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rt

The GLM Procedure

t Tests (LSD) for response

NOTE: This test controls the Type I comparisonwise error rate, not the experimentwise error rate.

```
Alpha                          0.05
Error Degrees of Freedom         98
Error Mean Square          1.696463
Critical Value of t         1.98447
Least Significant Difference  0.5169
```

Means with the same letter are not significantly different.

```
t Grouping        Mean     N    trt

          A      7.2800    50    3
          A
    B     A      7.0000    50    2
    B
    B            6.7000    50    1
```

The GLM Procedure
Least Squares Means

trt	response LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
1	6.70000000	0.18419895	<.0001	1
2	7.00000000	0.18419895	<.0001	2
3	7.28000000	0.18419895	<.0001	3

Least Squares Means for effect trt
Pr > \|t\| for H0: LSMean(i)=LSMean(j)

Dependent Variable: response

i/j	1	2	3
1		0.2523	0.0283
2	0.2523		0.2851
3	0.0283	0.2851	

NOTE: To ensure overall protection level, only probabilities associated with pre-planned
      comparisons should be used.

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