

Consumer Acceptance of Cranberry Seed Oil in
Several Food Formulations

By

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ABSTRACT

Attention has been turning to cold-pressed edible seed oils due to their high levels of nutrients retained during the unique cold-press processing method. Cranberry seed oil has shown to be an optimal cold-pressed edible seed oil due to its ideally balanced 1:1 ratio of omega-6 to omega-3 fatty acids, high levels of polyunsaturated and monounsaturated fatty acids, low levels of saturated fatty acids, phospholipids, phytosterols, and a high concentration of antioxidants. It has also been shown that shelf life of cranberry seed oil is not only comparable, but also surpasses that of other popular cooking oils. Consumption of cranberry seed oil could therefore be very beneficial to human health. There has been scarce research on consumer acceptance of cranberry seed oil in food formulations. This study was conducted to determine consumer acceptance of cranberry seed oil in several food formulations. Sensory evaluation of three food products (chocolate cupcakes, pasta salad, and salad dressing) were based on a paired preference

two-sided directional difference test in which consumers compared two samples of each product, one sample prepared with canola oil and one sample prepared with cranberry seed oil. This study showed that consumers (n = 116) significantly ($p < 0.05$) preferred chocolate cupcakes made with canola oil, but there was no significant difference ($p < 0.05$) observed between the preference of the pasta salad (n = 122) and the salad dressing (n = 84). Therefore, cranberry seed oil could be substituted for canola oil for both pasta salad and salad dressing providing additional beneficial components from the cranberry seed oil for the consumer.

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Chapter I: Introduction

The North American cranberry, *Vaccinium macrocarpon*, Aiton, is one out of the three fruits native to North America along side Concord grapes and blueberries (Natural history of the American cranberry, *vaccinium macrocarpon* Ait, 2006). The cranberry served as a staple in the diets of Native Americans many years before the arrival of the Pilgrims. Today cranberries are still consumed and in many different forms with approximately 99% of Americans consuming cranberries at least once a year (Luke, 2006). Cranberries are commonly grown in the north central and northeastern areas of the United States along with southeastern areas of Canada (Figure 1.1).



Figure 1.1. Native Distribution of Cranberry in North America

Source: Natural history of the American cranberry, *vaccinium macrocarpon* Ait, 2006

Cranberries are continually increasing in popularity. The New England Agricultural Statistics show that in 2006, the United States cranberry production shot up by 10% (Keough, 2007). Tom Lochner, executive director of the Wisconsin State Cranberry Growers Association (WSCGA), associates the increasing demand for cranberries to several different efforts (Lochner & Naidl, 2007). Progress in international marketing has increased cranberry exports dramatically

at 27% of the crop. A higher demand can also be attributed to the nutritional benefits from cranberries and cranberry products. Many studies have shown that cranberries and cranberry products are linked to health benefits and disease fighting capabilities. Also, many new cranberry products are emerging on the market. The WSCGA (2007) claims that the number of cranberry products in today's market top 700 items. Some of the newer food items include cranberry crackers, ice cream topping and pancake mix while non-food items such as cranberry seed soap and body lotions are also available.

Cranberry juice continues to be a popular cranberry product. It is often in the spotlight as a nutritious beverage that can aid in preventing cancers, arteriosclerosis, peptic ulcers, dental caries and even premature aging (Emerging Research, n.d.). New research indicates that the most nutritious parts of the cranberry are actually the skin, pomace and seeds, which are mainly waste products or byproducts of cranberry juice processing (Luke, 2006). These "waste" products are host to a wide array of nutrients such as phytosterols, phospholipids, antioxidants, vitamin E, essential fatty acids (EFAs), fiber, minerals and proteins, in addition to the oil.

The oil from the cranberry seed contains an abundance of nutrients that are extremely beneficial to human health. These concentrated nutrients are not bio-available to the human body when the whole cranberry is consumed. The human digestive system is not able to break down the fibrous seed material causing the nutrients locked inside the seed to pass through the body unutilized. In 1992, Bernard Lager began developing a cold processing method of extraction to remove oil from the cranberry seeds without compromising the natural nutrients contained in the oil (Luke, 2006). This cold processing method allows for the bio-availability of these nutrients.

Cranberry seed oil contains an abundance of polyunsaturated fatty acids (PUFAs), monounsaturated fatty acids (MUFAs) and is very low in saturated fatty acids. A nutritional

highlight of cranberry seed oil is that it contains an ideally balanced ratio of 1:1 omega-6 and omega-3 EFAs. Currently the Western diet is extremely unbalanced with a ratio of 20-25:1 of omega-6 to omega-3 fats thus, highly deficient in omega-3 fatty acids (Simpoulous, 1999). Numerous studies have confirmed that omega-3 fatty acids are essential for proper development of the retina and brain in premature infants and are even associated with a decreased rate of cancer and cardiovascular disease. This unbalance in fatty acids in the Western diet increases risk of cardiovascular disease, diabetes, obesity and possibly cancer.

The Western diet also lacks antioxidants, powerful protectors of cells against free radical damage (Simpoulous, 1999). Cranberry seed oil contains all eight isomers of vitamin E along with carotenoids, making it a rich source of antioxidants that aids in cancer prevention and premature aging. According to a study at the University of Massachusetts at Amherst, it was discovered that cranberry seed oil is the richest known source of tocotrienols, four different isomers of vitamin E (Luke, 2006).

Phospholipids found in plants and fruits serve as a source of EFAs and aid in circulation and liver function (Luke, 2006). Phytosterols are plant compounds that have been shown to positively affect cholesterol levels in the blood stream. Since cranberry seed oil consists of both phospholipids and phytosterols, these would add to the nutritional benefits of the oil.

Statement of the Problem

Cranberry seed oil, with its abundance of nutrients could be beneficial to the human diet. Currently, cranberry seed oil is sold mainly in the form of supplements to aid in everyday nutrition. Analytical studies have been performed to determine fatty acid levels, nutrient levels, and oxidative stability of cranberry seed oil but, no research has been conducted to determine if consumers would accept the use of cranberry seed oil to prepare or be incorporated into food

products. If consumers accepted cranberry seed oil in food formulations, this oil could be substituted for other oils such as canola oil or vegetable oil, thus providing a more nutritious profile and therefore positively affecting human health.

Purpose of the Study

The purpose of this study was to determine if consumers accepted the use of cranberry seed oil in several food formulations. Chocolate cupcakes, pasta salad, and Italian salad dressing were all prepared using cranberry seed oil and then compared to the same food items prepared using canola oil. All food items were compared by sensory evaluation through consumers using a paired preference two-sided directional difference test.

Limitations of the Study

The limitations of this study were based on the sample used. The study was conducted on the University of Wisconsin-Stout campus and open to all persons 18 years of age or older. Although open to the public, the majority of the panelists consisted of UW-Stout students and faculty. This sample size does not generally represent the national population.

Another limitation is that only three food items were evaluated. There are numerous food products that contain oil or that are prepared in the home using oil. The results of this study are only representative to the specific food items used in the study and to the specific population that consumed these food items.

Chapter II: Literature Review

Introduction

This chapter will discuss an overview of fats and oils, cranberries, cranberry seed oil, nutrition associated with cranberry seed oil, and sensory evaluation.

Importance of Fats in Food Products, Processing & Sensory Functions

The term fat defines extracted lipids that are in a solid state at room temperature. The term oil refers to extracted lipids that are in a liquid state at room temperature. In food preparation, lipids are usually used in the form of solid fat or oil such as shortenings, frying fats and/or salad oils. The fat itself serves some major functions in the preparation of foods. Fats can be used to tenderize, contribute to dough and batter aeration, serve as a heating medium, act as a phase in an emulsion, contribute to the flavor of the food, and fats can enhance properties such as smoothness, body, and other textural properties (Campbell & Penfield, 1990). Fat also plays an extremely important role in the “fried foods” segment of the food industry. For example, potato chips, corn chips, doughnuts, potatoes, battered meats, poultry, and fish are all fried foods. The fat that these food items are fried in serves to transfer heat to the foods and also plays an extremely important role in flavor development of the food (Stauffer, 1996).

Fats can contribute to the flavor of foods either positively or negatively. As mentioned, deep frying allows for fat to absorb into the food item. The flavor results from the fat’s interaction with other components such as carbohydrates and proteins. When the fat is heated and/or exposed to oxygen, oxidation products occur that also contribute to the flavor complexity of fried foods (Stauffer, 1996). Without these oxidation products, the food would taste rather bland.

Most fats or oils contribute positively to the flavor of food. For example, olive oil is known for its distinct flavor and is often used in salad dressings. Olive oil, along with other oils that are exposed to heat or oxygen can oxidize and can develop reversion flavor, which is a mild off flavor that can develop in refined oils if exposed to oxygen (Stauffer, 1996). Cranberry seed oil does have a distinct flavor and if exposed to oxygen will undergo flavor reversion. Some characteristics of reversion flavor can be described as “beany,” “grassy,” and “metallic,” but differ between oil types.

Fats are found in many food sources. Some foods that are the major contributors of fat in our diets are muscle foods such as meat, poultry, and fish, oils, butter and margarines, shortenings, cheeses, salad dressings, whole milk, peanut butter, and confections (Wardlaw, 2000).

Importance of Fats in the Diet

Fats serve many nutritional and biological functions. Consuming fat is one way to obtain energy needed for our bodies to function. Fats are very energy dense providing our bodies with nine kilocalories per gram versus four kilocalories per gram for both carbohydrates and proteins. Fat is stored in adipose tissue and can act as an energy reserve when food intake is decreased.

Fat contributes positively to nutrition in other ways as well. Fat can be the carrier of fat soluble vitamins A, D, E, and K. Phospholipids are essential structural components of cell membranes and are formed by the metabolization of fatty acids (Stauffer, 1996). A proper balance of saturated and unsaturated fats is necessary to provide the ideal cell structure. Essential fatty acids (EFAs) are required by the human diet because humans are unable to synthesize them. Two important EFAs are linoleic and α -linolenic acids and without proper

consumption of these symptoms of hair loss, scaly skin, and loss of reproductive capability can appear (Wardlaw, 2000).

Fatty Acid Composition

Lipids are very diverse chemical compounds, however they share one major characteristic; they do not readily dissolve in water or other polar solvents (McWilliams, 2001). Lipids are compounds that are soluble in organic solvents. They are organic compounds composed of carbon, hydrogen, and oxygen.

The terms fats, lipids, and oils are often interchangeable. When discussing food labeling and the human diet the term fat is usually used. It can be expressed as dietary fat, percent fat, or calories from fat. These all refer to the lipid components of the foodstuff and usually in contrast to other sources of energy such as carbohydrates and proteins. The terms fats and oils often refer to bulk products of commerce, that are either crude or refined and have been extracted from animal or plant products (Nielsen, 1998).

When fats are listed on nutrition labels, the term fat is defined as the total lipid fatty acids (Nielsen, 1998). These fatty acids are expressed as triglycerides. Triglycerides are composed of a glycerol backbone which is esterified to three fatty acids. The fatty acids are chains of hydrocarbons usually containing between four and 24 carbons. These fatty acids chains can exist in many different forms (Table 2.1). Cranberry seed oil has been added into Table 2.1 as a source based on findings adapted from Adams, et al. (2003).

Table 2.1

Nomenclature and sources of fatty acids

Systematic Name	Common Name	Carbon Length	Source
Butanoic	Butyric	C4:0	Butter
Hexanoic	Caproic	C6:0	Butter
Octanoic	Caprylic	C8:0	Babassu, coconut, palm kernel, butter
Decanoic	Capric	C10:0	Babassu, coconut, palm kernel, butter
9-Decenoic	Caproleic	C10:1	Butter
Dodecanoic	Lauric	C12:0	Babassu, coconut, palm kernel, butter, lard
5-Dodecenoic	...	C12:1	Sperm Whale
9-Dodecenoic	Lauroleic	C12:1	Butter
Tetradecanoic	Myristic	C14:0	Babassu, coconut, cottonseed, palm, soybean, butter, lard, tallow
5-Tetradecenoic	Phyteric	C14:1	Sperm Whale
9-Tetradecenoic	Myristoleic	C14:1	Butter, lard, mutton tallow
Pentadecanoic	...	C15:0	Lard, mutton tallow
Hexadecanoic	Palmitic	C16:0	Babassu, coconut, cocoa butter, corn, cotton seed, olive, palm, peanut, safflower, sunflower, soybean, butter, lard tallow, cranberry seed
9-Hexadecenoic	Palmitoleic	C16:1	Coconut, cotton seed, olive, butter, lard, tallow
Heptadecanoic	Margaric	17:0	Lard, tallow, mutton tallow
Octadecanoic	Stearic	C18:0	Babassu, coconut, cocoa butter, corn, cottonseed, olive, palm, peanut, safflower, sunflower, soybean, butter, lard, cranberry seed
9-Octadecenoic	Oleic	C18:1	Same as for C18:0
9,12-Octadecadienoic	Linoleic	C18:2	Same as for C18:0
9,12,15-Octadecatrienoic	Linolenic	C18:3	Soybean, corn, rapeseed, canola, butter, lard, mutton tallow, cranberry seed
Eicosanoic	Arachidic	C20:0	Olive, palm, peanut, safflower, soybean, lard, tallow
9-Eicosenoic	Gadoleic	C20:1	Marine oils
5,8,11,14-Eicosatetraenoic	Arachidonic	C20:4	Marine oils
Eicosapentaenoic	...	C20:5	Herring, menhaden, salmon
Docosanoic	Behenic	C22:0	Peanut, rapeseed, canola
13-Docosenoic	Erucic	C22:1	Rapeseed
4,8,12,15,19-Docosapentenoic	Clupanodonic	C22:5	Marine oils
4,7,10,13,16,19-Docosahexenoic	Nisinic	C22:6	Rapeseed, menhaden, salmon

Source: Stauffer, 1996

Saturated Fatty Acids

Saturated fatty acids can be defined as fatty acid chains that are completely saturated with hydrogens. There are no double bonds found in saturated fatty acids. Fatty acids tend to be rigid and have higher melting points than fatty acids that contain double bonds, such as mono- and polyunsaturated fatty acids. Fats that are solid at room temperature contain large amounts of saturated fatty acids.

Saturated fats, or triglycerides that are primarily composed of saturated fatty acids, are considered “bad” fats. Consumption of saturated fats can have negative effects on health such as raising blood levels of total LDL (bad) cholesterol (Klimis-Zacas, 2003). Because of the negative effects on health caused by saturated fats, it is recommended that no more than 10% of total calories be from saturated fats. Cranberry seed oil is comprised of less than 10% saturated fatty acids (Adams et al., 2003). The saturated fatty acids present in cranberry seed oil are palmitic (16:0) and stearic (18:0).

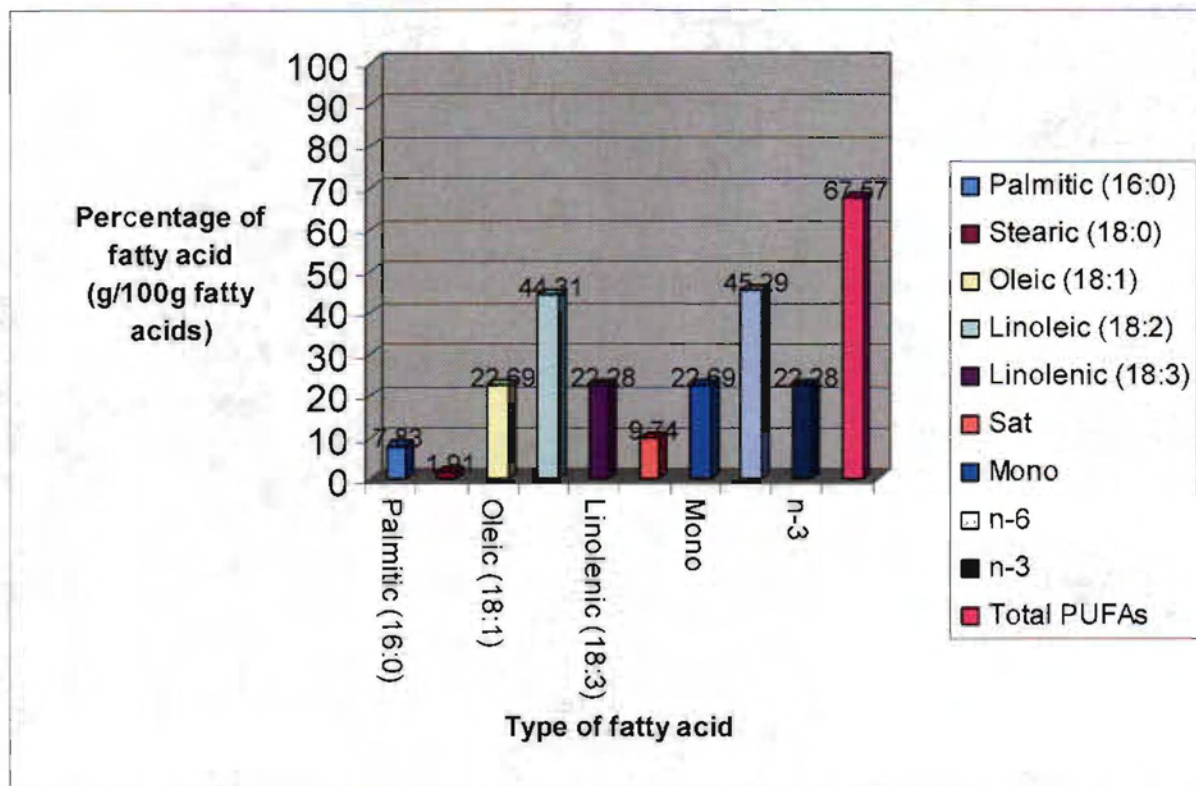
Monounsaturated Fatty Acids

Monounsaturated fatty acids are fatty acid chains that contain one carbon-carbon double bond. Normally this double bond occurs in the cis transformation, making it harder for these types of fatty acids to pack together. Monounsaturated fats are considered good or healthy fats because they contribute to lowering LDL cholesterol, but do not decrease levels of HDL (good) cholesterol (Klimis-Zacas, 2003). Both canola oil and olive oil contain a high percentage of monounsaturated fatty acids (Wardlaw, 2000). Cranberry seed oil is composed of approximately 23% monounsaturated fatty acids existing in the form of oleic acid (18:1), the same heart healthy fatty acids found in both canola oil and olive oil (Adams et al., 2003).

Polyunsaturated Fatty Acids

Polyunsaturated fatty acids are fatty acids that contain two or more carbon-carbon double bonds in their hydrocarbon chain. These types of fatty acids are much more fluid than saturated fatty acids. They are generally found in oils and have lower melting points than saturated fatty acids. The more unsaturated the fatty acid becomes, the lower the melting point. Corn, canola, soybean, and safflower oils are all very rich in polyunsaturated fatty acids (Wardlaw, 2000). A study by Adams et al., (2003), showed that cranberry seed oil contains a large percentage of polyunsaturated fatty acids at about 68%.

Figure 2.1 shows the fatty acid composition of cranberry seed oil (Adams et al., 2003). The oil is low in saturated fat at approximately 10%, consisting of both palmitic and stearic acids. The remaining 90% of the fat is comprised of both mono- and polyunsaturated fatty acids. Other common oils high in polyunsaturated fatty acids are safflower oil (77%), sunflower oil (69%), corn oil (61%) and soybean oil (61%) (Wardlaw, 2000). Although these oils are high in polyunsaturated fatty acids, they are unlike cranberry seed oil in the respect that they (except soybean oil) do not contain both linoleic (omega-6) and alpha-linoleic (omega-3) fatty acids. These oils contain only linoleic acid. Soybean oil contains both linoleic (54%) and alpha-linoleic acids (7%), but the ratio of soybean oil (7:1, omega-6 to omega-3) is not as balanced as cranberry seed oil which has a ratio closer to 1:1, omega-6 to omega-3 (Wardlaw, 2000 & Adams et al., 2003).



Sat: Saturated fatty acids

Mono: Monounsaturated fatty acids

n-6: Polyunsaturated n-6 fatty acids

n-3: Polyunsaturated n-3 fatty acids

PUFA: Polyunsaturated fatty acids

Figure 2.1. Fatty acid composition of cold-pressed cranberry seed oil

Source: Adams et al., 2003

The North American Cranberry, Vaccinium macrocarpon, Aiton

Cranberries, native to North America, were a staple in the diets of Native Americans many years before the arrival of the Pilgrims (Natural history of the American cranberry, *Vaccinium macrocarpon* Ait, 2006). This tart fruit was consumed fresh, ground, and also mashed and incorporated with cornmeal to make breads. The Native Americans had uses for the cranberry that went beyond consumption. They brewed cranberry poultices which were used to

draw poison from wounds. The juice from the cranberry was a deep rich red and acted as a dye. The Native Americans used the juice to dye their blankets and clothing.

The name “cranberry” was not derived until the Pilgrims’ arrival in North America (Natural history of the American cranberry, *vaccinium macrocarpon* Ait, 2006). The Native Americans had an array of names for this tiny fruit, but it was the Pilgrims that claimed the cranberry plant’s stem and blossoms resembled the neck, head, and beak of the crane. Due to the resemblance, the fruit was called “crane berry.” Eventually this name was condensed to “cranberry.”

Today cranberries are widely recognized for their outstanding nutritional qualities. Numerous studies have been performed linking the consumption of cranberries juice to many health benefits such as preventing cancers, arteriosclerosis, peptic ulcers, dental caries and premature aging (Emerging Research, n.d.). But perhaps the greatest benefits of cranberries are locked inside their tiny little seeds, the source for cranberry seed oil.

Cranberry Seed Oil

Cranberry seed oil, locked within the tiny seed of the fruit, holds a wealth of nutrition. Allen Luke (2006), of Fruit Essentials, Inc., refers to the seed as the “nutrient powerhouse” that houses all the genetic information that will create the next generation of cranberries. It is these nutrients that help the new cranberry plants flourish. These concentrated nutrients are also beneficial if consumed, but unfortunately since these nutrients are locked in the seed and protected by a thick hull that is indigestible by humans; these nutrients are not bio-available.

In 1992, Bernard Lager of Wisconsin, discovered cranberry seed oil in commercial quantities (Luke, 2006). In 2004, after many years of development, Lager created a sophisticated extraction technique that removed the oil from the seeds without compromising the integrity of

the oil's many nutrients. This extraction method uses no chemicals and is referred to as a cold pressing technique due to very low levels of heat created by friction of the action of the press. Once the oil is removed from the seed, it is then made bio-available to humans.

Further research went on to show that cranberry seed oil is a rich source of many nutrients such as essential fatty acids, phytosterols, phospholipids, and very powerful antioxidants. In a 2003 study by Adams et al., it was found that cranberry seed oil had the greatest level of α -linolenic acid when compared to caraway, hemp, and carrot seed oils. This study also indicated that ratio of n-6 and n-3 fatty acids were approximately 3:1 and that the addition of cranberry seed oil to the diet might help improve the current ratio imbalance. Even though cranberry seed oil is approximately comprised of 90% monounsaturated and polyunsaturated fatty acids, it is highly stable with an oxidative stability index (OSI) of approximately 50 hours. This indicates that there are large levels of powerful antioxidants drastically slowing the rate of oxidative rancidity of cranberry seed oil. Cranberry seed oil's OSI surpassed that of hemp seed oil, Wesson brand soybean oil, and was comparable to Crisco soybean oil, and Archer salad soybean oil. This is a great indication that cranberry seed oil could be utilized in food preparation. Table 2.2 describes characteristics of cranberry seed oil and Table 2.3 displays a typical analysis of the oil (Luke, 2006).

Table 2.2

Characteristics of cranberry seed oil

Characteristic	Description
Appearance	Greenish-gold oil
Odor	Characteristic of vegetable oil
pH as supplied	4.8
Specific gravity	0.923
Shelf Life	24 months from the date of manufacture

Source: Luke, 2006

Table 2.3

Typical chemical analysis of cranberry seed oil

Analysis	Result
Iodine value ¹	150.1
Peroxide value	12 meq/kg
Unsaponifiables	1.18%
Free fatty acids	0.55%
Saturated fat	6.68%
Monounsaturated fat	23.51%
Oleic acid (18:1)	23.12%
Polyunsaturated fat	69.5%
Linoleic acid (18:2)	35.13%
Linolenic acid (18:3)	34.26%
Phosphatidylinositol	9.9 mg/kg
Phosphatidylcholine	202.0 mg/kg
Stigmasterol	68 mg/kg
Campesterol	66 mg/kg
Beta-Sitosterol	1319 mg/kg
Alpha Tocopherol	341 mg/kg
Gamma Tocopherol	110 mg/kg
Gamma Tocotrienol	1700 mg/kg
Vitamin A	390 IU ² /kg

¹ Iodine value is a chemical constant for a fat or oil and measures unsaturation of fatty acids (O'Brien, 2004)

² IU stands for International Unit and is a measure of fat soluble vitamin activity (Stauffer, 1996)
Source: Luke, 2006

Even though very little research has been done on the shelf life and nutrition of cranberry seed oil, the results do show that there is potential for this product to be sold to the public. Cranberry seed oil can currently be produced on a commercial scale. It is important to remember, however, that it takes many cranberries to produce cranberry seed oil. One cranberry contains approximately 28 tiny seeds (Figure 2.1). It takes about 40,000 lbs of cranberries to produce only five gallons of cranberry seed oil (Figure 2.2). This could potentially make cranberry seed oil quite costly to consumers. Currently cranberry seed oil is sold mainly in the form of supplements, which are not regulated by the FDA. There have been no published studies on the acceptance of cranberry seed oil used in food products or how cranberry seed oil will affect the sensory qualities of food products.

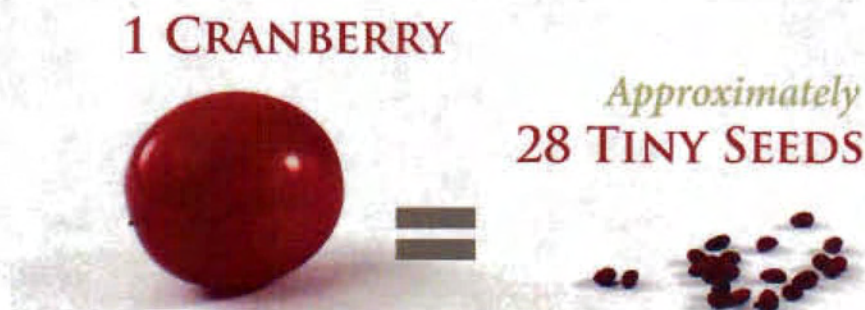


Figure 2.1. Amount of seeds contained in one cranberry

Source: Luke, 2006

1 TRUCKLOAD OF CRANBERRIES = 5 GALLONS OF SEED OIL
(Approximately 40,000 lbs.)

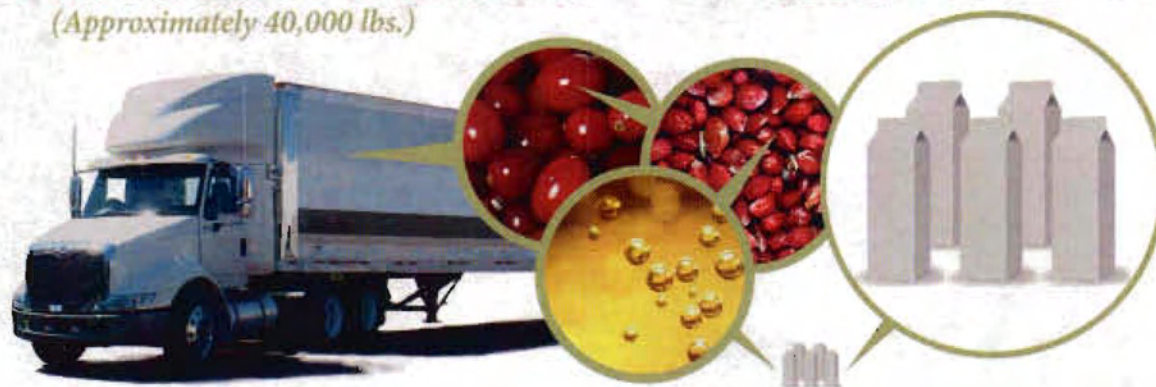


Figure 2.2. Amount of cranberries needed to produce five gallons of seed oil

Source: Luke, 2006

Processing Methods of Cranberry Seed Oil

There are very few crude fats and oils that are suitable for consumption until they have undergone processing. Processing is the technique that actually isolates the fat or oil from its natural matrix (Stauffer, 1996). Refining is the process that makes the fat or oil edible by removing impurities.

Processing and refining the oil makes it more suitable or useful in the food industry. For example, most oils that are processed in order to be used in the food industry have many of their natural qualities changed removing color, flavor, and volatiles (O'Brien, 2004). Processing can even change the texture, softening or hardening the fat, change crystal habit, and even rearrange the molecular structure of the oil.

Generally, there are two ways to remove oil from a vegetable or plant seed. The oil can either be physically pressed out using a hydraulic or screw press or the oil can be extracted using a chemical solvent (O'Brien, 2004). In most cases, these two methods are combined. The objective for removing the oil is always the same; to obtain the maximum amount of oil with decreasing the amount of impurities as much as possible. Mechanical extraction is less

complicated than solvent extraction, but also less efficient (Stauffer, 1996). Even though most seeds are dehulled before processing, mechanical extraction leaves press meal which can contain three to six percent oil. Meal left over from solvent extraction only contains 0.5 – 1.5% oil, meaning that more oil was removed during the processing.

Most natural oils are very diverse in color and flavor and often full of impurities such as phosphatides (gums), free fatty acids, color compounds (carotenoids and chlorophyll), tocopherols (vitamin E), waxes, moisture, meal fines, and dirt (Stauffer, 1996). Refining removes these impurities.

The refining process generally consists of degumming, neutralization, dewaxing, bleaching, filtration, and deodorization (Stauffer, 1996). Degumming consists of hydrating the gum present in the oil and then separating them through centrifugation.

Neutralization is the process of removing any free fatty acids from the oil. Aqueous sodium hydroxide is added to the oil, converting free fatty acids into soaps that are water soluble. These water soluble soaps can either be drained off or removed by centrifugation.

Waxes are also removed by centrifugation in the dewaxing process after the oil is cooled and mixed with water that contains a surfactant. Corn oils and sunflower oils contain both contain large amounts of waxes. If an oil is not dewaxed, it will become cloudy upon refrigeration.

Bleaching not only removes color from oils, but can also remove oxidation products as well. If the oil is bleached properly, it is nearly colorless and has a peroxide value of zero. Filtration is done after the bleaching process to remove any remaining bleaching earth. Residual clay can act as a prooxidant so it is extremely important that it is completely filtered from the oil. Undesirable flavors or odors can be removed through the deodorization process. This process

consists of bubbling steam through the hot oil under high vacuum. After this step the oil is referred to as RBD oil, meaning refined, bleached, and deodorized.

Cranberry seed oil is processed in a slightly different manner. Cranberry seed oil is only extracted by mechanical measures, so chemical solvents are never used as an extraction method. The seed is dehulled, exposing the “meat” inside. This also makes for a more efficient extraction technique because if the hulls were left on, valuable oil would absorb into them decreasing the amount extracted (Stauffer, 1996). Expeller presses are used to squeeze the oil from the cranberry seed meat. Normally when pressing oil from the seeds, friction can cause the oil to heat up. Bernard Lager’s method of cold-press processing keeps the temperatures generated by friction under 100°F (Luke, 2006). This ensures that the integrity of the original phytonutrient profile of the oil is well maintained. During this process, very little of the oil’s nutrients are lost. The oil is then filtered to remove any oil or debris present, but no chemical processes are used to do this. After the filtering process, the oil is immediately packed in nitrogen to reduce exposure to oxidation, thus allowing the oil to retain the majority of all of its natural nutrients, colors, odors, and flavors.

Nutrients of Cranberry Seed Oil

As mentioned, cranberry seed oil is rich in nutrients such as essential fatty acids, phytosterols, antioxidants (vitamin E), carotenoids, and phospholipids. Together, these nutrients make cranberry seed oil beneficial to the human diet, as many of them may aid in disease prevention and contribute to overall health and well-being.

Essential fatty acids (EFAs) are fatty acids that must be consumed in order to maintain proper health. They are called essential because the human body is unable to synthesize them on its own. Alpha-linolenic acid (ALA) is an essential fatty acid and the main omega-3 fatty acid

found in food. Linoleic acid (LA) is also an essential fatty acid and is the major omega-6 fatty acid found in food.

Pre-agricultural humans ate diets that were rich in fish, lean meat, nuts, berries, fruits, green leafy vegetables, and honey (Simopoulos, 2002). It was these foods that shaped the genetic nutritional requirements of the modern human. Cereal grains became a major staple in the human diet about 10,000 years ago with the Agricultural Revolution. Consumption of cereal grains has greatly affected the health of humans, introducing a diet high in carbohydrates and omega-6 fatty acids and low in omega-3 fatty acids and antioxidants. This type of diet can increase insulin resistance and hyperinsulinemia leading to the increased risk of coronary heart disease (CHD), diabetes, obesity, and hypertension.

This increase in consumption of omega-6 fatty acids has increased even more in the last 100 years with the growing technology in the vegetable oil industry (Simopoulos, 2002). Processing and refining techniques allowed for the increased production of oils for cooking. With the introduction of hydrogenation, the ALA that was in these oils was reduced leaving a high concentration of linoleic acid. This was not the only cause for increase in omega-6 consumption. Modern agriculture put emphasis on grain feeds, high in omega-6 fatty acid, for livestock. This increase in consumption of omega-6 fatty acids in domestic livestock increased the amount of these fatty acids present in their bodies. In turn, when humans consume these animals or by-products of these animals, they are consuming increased amounts of omega-6 fatty acids. Even fish, a well known source of omega-3 fatty acids, are becoming less likely to contain the levels of omega-3 fatty acids expected. Fish contain omega-3 fatty acids because of the plants they consume. Commercially raised fish are fed food low in omega-3 fatty acids and high in omega-6 fatty acids causing the balance to change (Simopoulos, 2002).

These changes in the human diet have caused the omega-6 to omega-3 ratio to change drastically. For the majority of human existence, the diet has consisted of a 1:1 ratio of these two fatty acids. Currently, in the Western diet, the ratio is closer to 20:1 (Simopoulos, 2002). Omega-3 and omega-6 fatty acids are functionally and metabolically distinct. The human body can not convert one to the other due to the lack of the necessary enzyme, omega-3 desaturase. Because omega-3 and omega-6 fatty acids have opposing physiological functions, a natural balanced intake of 1:1 is important. Omega-3 fatty acids are anti-inflammatory while omega-6 fatty acids increase inflammation. A diet too rich in omega-6 fatty acids with little omega-3 fatty acids can cause an increase in blood viscosity, vasospasm, and vasoconstriction. Omega-3 fatty acids work to thin the blood while omega-6 fatty acids can actually decrease bleeding time by increasing blood viscosity. Consuming too much of one or the other will lead to health problems and a proper balance is needed between the two. Incorporating more omega-3 fatty acids into today's diet rich in omega-6 fatty acids can lead to health benefits such as reduced risk for CHD (Ohr, 2003).

Cranberry seed oil, with a balanced ratio of 1-3:1 omega-6 fatty acids to omega-3 fatty acids could play a positive role in altering the current unbalanced ratio in the Western diet. Depending on the source (Adams, et al., 2003; Luke, 2006), cranberry seed oil is shown to contain approximately 22-35% omega-3 fatty acids. In addition, it is a great source of antioxidants.

Antioxidants are important chemical compounds that can slow oxidative rancidity in food items by donating a hydrogen to stop formation of free radicals in fatty acids or by scavenging oxygen or metal (McWilliams, 2001). In the human body, antioxidants can protect cells and DNA from damage or mutations by trapping harmful free radicals. Vitamin C, vitamin E,

carotenoids, and selenium are all natural antioxidants found in foods that can aid in preventing the formation of a potent carcinogen (Wardlaw, 2000).

In the food industry, there are several synthetic antioxidants that are food additives used to extend the shelf-life of food by retarding oxidative rancidity in fats and oils (McWilliams, 2001). Vegetable oils commonly have synthetic antioxidants added to them because of their high levels of mono and polyunsaturated fatty acids. Tertiary-butylhydroquinone (TBHQ) is a synthetic antioxidant commonly added to vegetable oil because of its ability to maintain its antioxidant capabilities in both baking and frying. Propyl gallate (PG) is also useful in vegetable oils. Adding these antioxidants to vegetable oils greatly improves their shelf life.

Cranberry seed oil contains natural antioxidants, mostly vitamin E. Cranberry seed oil actually contains all eight isomers of vitamin E, four tocopherols and four tocotrienol isomers. These isomers are naturally found in most seed oils and vegetable oils, but many are lost during processing and refining (O'Brien, 2004). Up to 60% of vitamin E can be lost in the deodorization process. The cold-pressed processing technique allows cranberry seed oil to retain its natural high levels of vitamin E. This powerful antioxidant allows for the extended shelf life of cranberry seed oil and also adds nutritional quality to the oil.

Sterols are found in animals, whereas phytosterols are plant compounds with a structure similar to cholesterol. Their role in plants is similar to that of cholesterol in animals or humans. They serve a structural purpose in cell membrane walls. Phytosterols have cholesterol reducing properties by lowering the amount of cholesterol absorbed in the gut (Ohr, 2003). In 2000, companies were allowed to use labeling health claims regarding plant sterols and their role in reducing CHD due to authorization by the FDA. In order for plant sterols to have a significant effect in lowering cholesterol, 1.3 grams must be consumed daily. Phytosterols are naturally

found in vegetable oils, but only in small quantities. Cranberry seed oil contains approximately 145.3 mg/100g. Corn oil and soybean oil contain larger amounts at 968 mg/100 g and 327 mg/100 g, respectively. Consuming cranberry seed oil alone would not be a sufficient way to meet the serving recommended to affectively lower cholesterol, but it could be combined with other phytosterol-containing foods to help reach that goal.

Carotenoids are plant pigments and are what give cranberry seed oil its rich color. Carotenoids are precursors to vitamin A and are often referred to as provitamin A because they can be converted into vitamin A if needed. Some major functions of vitamin A are to promote vision and growth, prevent drying of the skin and eyes, and to promote resistance to bacterial infection (Wardlaw, 2000). Deficiencies of vitamin A can lead to growth retardation, dryness of skin, night blindness, and xerophthalmia. Xerophthalmia is the drying of the eyes due to lack of mucus production. This is a cause of blindness from deficiency of vitamin A.

Phospholipids are a natural part of fat and are built similar to triglycerides but have a compound containing phosphorous that is connected to the glyceride (Wardlaw, 2000). Phospholipids act as surfactants that can stabilize emulsions. Lecithin is an example of a common phospholipid and is found in egg yolk and soybeans. Lecithin is found in cells throughout the body, but also helps aid in fat digestion in the intestinal tract. Different types of phospholipids exist in the body and are commonly found in the brain. They help form the membrane of cells. Normally vegetable oils contain 0.1 – 3% phospholipids and these are removed during the refining process (Stauffer, 1996). Since cranberry seed oil undergoes a unique processing method, the phospholipids are retained in the oil. The human body produces its own phospholipids, so it is not essential to get it from dietary intake.

Sensory Evaluation

Sensory evaluation is the science of evaluating, measuring, and interpreting the quality of food substances through the use of senses. The five human senses used to evaluate food are vision, touch, taste, smell and hearing (Meilgaard et al., 1999). Sensory evaluation is very valued in the food industry because it can guide companies in development of new products and help in improving current products.

The sensory test used in the current study is called a paired preference test and consists of two samples. The objective for this test was to test products prepared with canola oil directly against the same products prepared with cranberry seed oil. There was no single factor such as flavor, appearance, texture, smell, etc., that was being compared. It was based on an overall preference. This kind of preference test forces consumers to make a choice between the two food items, but does not indicate if either of the products were liked or disliked (Meilgaard et al., 1999). Since canola oil is a good representation of a common household oil that is deemed “healthy” due to its low levels of saturated fats and higher levels of mono and polyunsaturated fats, it was chosen to be directly compared to cranberry seed oil.

Chapter III: Methodology

Sample Selection and Description

Food samples for this study were chosen based on food items that have oil as an added component. The three items that were chosen were Pillsbury® Moist Supreme Devils Food Cake Mix, Betty Crocker® Suddenly Pasta Salad Classic flavor, and Good Seasons® Italian Dressing and Recipe Mix. All food items and other preparation materials used in this study were purchased from a local grocery store (Menomonie, WI). The black plastic two ounce sample cups were purchased locally (Legacy Chocolates, Menomonie, WI) and the cranberry seed oil was donated by Fruit Essentials, Inc (New Richmond, WI).

Sample Preparation

All samples were prepared in room 240 of the Home Economics building at UW-Stout the evening before the corresponding sensory evaluation. Enough samples were made to accommodate a sample size of 160 participants. Preparation methods were performed according to the instructions printed on the packaging of each food item.

Chocolate cupcakes. The chocolate cupcakes were prepared using Pillsbury® Moist Supreme Devil's Food Premium cake mix. The directions located on the back of the box (Figure 3.1) were followed and the list of ingredients and materials used are shown in Table 3.1.



Figure 3.1. Box directions

Table 3.1

Ingredients and preparation/baking items used to prepare chocolate cupcakes

Ingredients	Preparation /Baking Items
Pillsbury® Moist Supreme Devil's Food Premium Cake Mix	Large Stainless Steel Mixing Bowl
Large Eggs	Electric Mixer
Canola Oil or Cranberry Seed Oil	Rubber Spatula
Water	Measuring Cups
Pam® Non Stick Cooking Spray	Oneida® Mini Muffin Pans
	Tablespoon
	Oven
	Cooling Racks
	Rubbermaid® Plastic Storage Containers

Two variations of cupcakes were made, one using standard canola oil and one using cranberry seed oil. Each batch of cupcakes was prepared using the same methods and only differing in the type of oil added.

For batch one, four boxes of cake mix were transferred into a large stainless steel mixing bowl. Next, 12 eggs, two cups of canola oil, and five cups of water were blended into the mix using an electric mixer. The mix was blended until all visible lumps were gone and the batter was smooth (Figure 3.2).



Figure 3.2. Mixed cake batter

Seven mini muffin pans were sprayed with non stick cooking spray. One tablespoon of batter was dropped into each opening of the mini muffin pans using a tablespoon and a small rubber spatula. Each pan was placed into a separate oven which had been preheated to 350°F.



Figure 3.3. One tablespoon of batter spooned into each opening of muffin pan



Figure 3.4. Oven used to bake cupcakes

The cupcakes were baked for 15 minutes and then removed from the oven and placed on cooling racks (Figure 3.5). Once cool, the mini cupcakes were removed from the muffin pans and placed into Rubbermaid® plastic containers (Figure 3.6) and sealed with an airtight lid to be stored overnight at room temperature in room 240 of the UW-Stout Home Economics Building.



Figure 3.5. Cupcakes cooling on cooling racks



Figure 3.6. Cupcakes placed into Rubbermaid® plastic container

Batch two followed the exact same steps as the preparation for batch one, but used cranberry seed oil instead of canola oil. There were no noticeable changes in product performance or bake time due to the variation in oils.

Pasta salad. The pasta salad samples were prepared using Betty Crocker® Suddenly Pasta Salad Classic flavor. The directions located on the back of the box (Figure 3.7) were followed and the list of ingredients and materials used are shown in Table 3.2



Figure 3.7. Box directions

Table 3.2

Ingredients and preparation/cooking items used to prepare pasta salad

Ingredients	Preparation/Cooking Items
Betty Crocker® Suddenly Pasta Salad (Classic)	3-quart saucepan
cold water	Water
canola oil or cranberry seed oil	Colander
	Rubber spatula
	Large stainless steel bowl
	Wire Whisk
	Plastic wrap

Two boxes of pasta were boiled at one time in two separate 3-quart saucepans (Figure 3.8) Water was brought to a boil and then the pasta was added. The heat was reduced to produce a gentle boil. The pasta was boiled 14 minutes as instructed and was stirred occasionally to ensure the noodles would not stick to one another or the pan.



Figure 3.8. Pasta noodles boiling

While the pasta was boiling, the five packets of seasoning mix, 15 tablespoons of cold water, and 10 tablespoons of canola oil were stirred together in a stainless steel bowl using a wire whisk (Figure 3.9). The pasta was then added to the stainless steel bowl and thoroughly incorporated with the seasoning mix using a rubber spatula (Figure 3.10). The stainless steel bowl filled with pasta was then covered tightly in plastic wrap and stored overnight in the refrigerator. Batch two was made following the exact steps of batch one, but used cranberry seed oil instead of canola oil.



Figure 3.9. Mixing seasoning with water and oil



Figure 3.10. Mixing cooked pasta with seasoning mix

Salad dressing. The pasta salad dressing samples were prepared using Good Seasons® Italian All Natural Salad Dressing & Recipe Mix. The directions located on the back of the box (Figure 3.11) were followed and the list of ingredients and materials used are shown in Table 3.3.



Figure 3.11. Box directions

Table 3.3

Ingredients and preparation/cooking items used to prepare pasta salad

Ingredients	Preparation Items
Good Seasons® Italian All Natural Salad Dressing & Recipe Mix	Mason jars with lids
White distilled vinegar	Measuring cups
Water	Tablespoon
Canola oil or cranberry seed oil	

Mason jars were used to mix the ingredients of the salad dressing instead of the Good Seasons® cruet as instructed on the box directions. Two batches of salad dressing were prepared, batch one using canola oil and batch two using cranberry seed oil. A total of eight cups of salad dressing were made in each batch. One seasoning packet made one cups of dressing. Two cups of dressing were prepared in each mason jar, using a total of eight mason jars for both batches.

To make batch one, $\frac{1}{2}$ cup of distilled white vinegar was added to the mason jar along with six tablespoons of water. Two seasoning packets were added to the liquid ingredients. The cover was placed tightly on the mason jar and the jar was shaken vigorously for approximately one minute to thoroughly blend the vinegar, water, and seasoning mix. Next, the cover was removed and one cup of canola oil was added to the mixture. The cover was then placed back on the mason jar and the jar was vigorously shaken for approximately one minute to thoroughly blend the oil with the mixture. These steps were repeated three more times using three separate mason jars to make a total of 64 fluid ounces of salad dressing. Batch two was made following the same steps as batch one, but substituting cranberry seed oil for canola oil. A mason jar from each batch of salad dressing is shown in Figure 3.12. Both batches were stored in the refrigerator overnight.



Figure 3.12. Salad dressing with canola oil (left), salad dressing with cranberry seed oil (right)

Subject Selection and Description

Subjects for the sensory evaluation were chosen on a volunteer basis and were at least 18 years of age. Flyers were placed throughout the UW-Stout Home Economics building advertising the need for participants in the study. The flyers were also sent out via email to the entire UW-Stout student body and faculty. In addition to the flyers and email announcement,

there were several UW-Stout professors in the Home Economics building that announced the study to their students. Although this study was open to the public, advertisement for the study was primarily focused on the campus. Any knowledge of the study by the general public was made possible through word of mouth.

This study was granted approval by the IBR (Institutional Review Board) prior to the sensory evaluations. Also, participants were asked to read a consent form before taking part in the survey to ensure an understanding of risks, benefits, confidentiality, and age requirements associated with the study.

Sensory Evaluation

Sensory evaluations for all three food products were based on a paired preference two-sided directional difference test in which two samples were compared, one sample prepared with canola oil and one sample prepared with cranberry seed oil. The objective of this test was to determine if consumers preferred one sample over the other.

A survey was made for each sensory evaluation. There were a total of three sensory evaluations, each held on a separate day. All samples were given random three digit codes, which are shown in Table 3.3.

Table 3.3

Sample, variable and their corresponding assigned code number

Sample	Variable	Assigned Code Number
Chocolate Cupcake	Canola Oil	557
Chocolate Cupcake	Cranberry Seed Oil	482
Pasta Salad	Canola Oil	112
Pasta Salad	Cranberry Seed Oil	705
Salad Dressing	Canola Oil	353
Salad Dressing	Cranberry Seed Oil	465

Participants who were interested in partaking in the study were directed by volunteers to the sensory lab. They were seated in private individual booths and asked to read the instructions for participation. Instructions given are listed below. The same instructions were given for all three sensory evaluations; however, the name of the sample given was changed to the correct sample for the given sensory evaluation.

For all three sensory evaluations, the order in which the participants tasted the samples was randomized, meaning that half of the participants tasted one variable first, while the other half tasted the other variable first. For example, 50% of the participants in the cupcake sensory evaluation tasted sample 557 first, the other 50% of participants tasted sample 482 first. This was done to minimize bias.

Instructions:

1. Turn on the **green light** when you are ready. (Switch is on center wall.)
2. A consent form will be slid over to you. Read the consent form carefully. If you agree to participate, slide the form back through. If you do not wish to participate, please place the consent form on the back table under the sign.
3. After you slide your consent form back, the cupcake samples will be sent over to you. Please follow the instructions on the survey.
4. When you are all finished, **please slide your tray through, turn off the red light**, and help yourself to a treat.

Chocolate cupcake. The chocolate cupcake sensory evaluation was held in the sensory lab (room 252) of the UW-Stout Home Economics building. The morning of the evaluation the cupcakes were put onto small paper plates that were labeled with their corresponding variable code. The samples were placed onto trays that contained the survey (example on page 40), a pen, a napkin, and room temperature water used to rinse the pallet between tasting samples (Figures 3.13 & 3.14).

Participants were asked to read the instructions, fill out the survey, and then return the survey to the volunteers. Time commitment for participation was approximately five to ten minutes.



Figure 3.13. Cupcake samples on trays with all needed materials

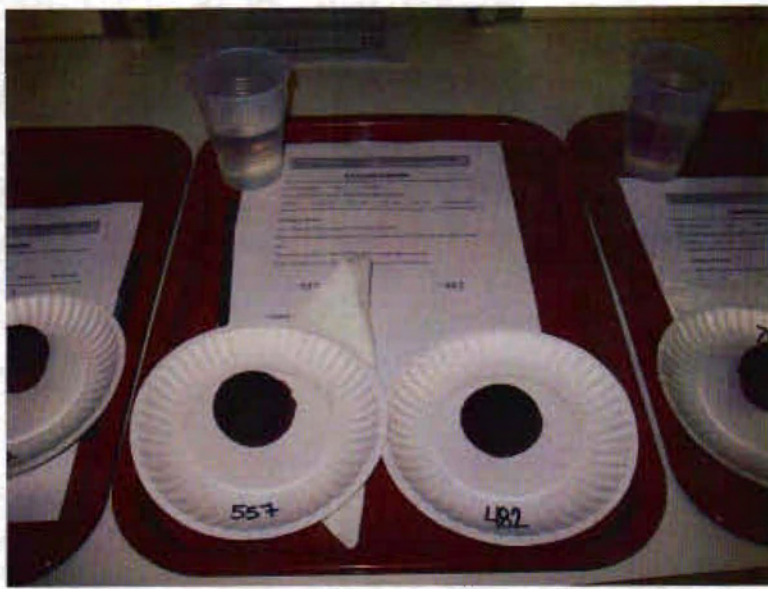


Figure 3.14. Cupcakes labeled with codes

Cupcake

Please Check One: Male Female

Please indicate your age by checking the appropriate box:

18-24 25 – 29 30 – 39 40 – 49 50 –59 60 or older

INSTRUCTIONS:

You will be given two samples of chocolate cupcakes.

Please taste the sample on the left first, rinse with water, and then taste the sample on the right.

After sampling, please check the box of the sample that you prefer.

In the comment section, please indicate your reason for preference.

557

482

COMMENTS:

Thank you for your time.

Pasta salad. The pasta salad sensory evaluation was held on Thursday April 5th, 2007 in the sensory lab (room 252) of the UW-Stout Home Economics building. The morning of the evaluation the pasta salad was spooned into two ounce clear plastic sample cups that were labeled with its corresponding variable code. In order to keep the samples tasting fresh and consistent, the pasta salad was stored in the refrigerator and was removed as needed. The samples were placed onto trays that contained the survey, a pen, a napkin, a plastic fork, and room temperature water used to rinse the palate between tasting samples.

Participants were asked to read the instructions, fill out the survey (example on page 42), and then return the survey to the volunteers. Time commitment for participation was approximately five to ten minutes.

Pasta Salad

Please Check One: Male Female

Please indicate your age by checking the appropriate box:

18-24 25 – 29 30 – 39 40 – 49 50 –59 60 or older

INSTRUCTIONS:

You will be given two samples of pasta salad.

Please taste the sample on the left first, rinse with water, and then taste the sample on the right.

After sampling, please check the box of the sample that you prefer.

In the comment section, please indicate your reason for preference.

112

705

COMMENTS:

Thank you for your time.

Salad dressing. The pasta salad sensory evaluation was held on Tuesday April 10th, 2007 in the sensory lab (room 252) of the UW-Stout Home Economics building. The morning of the evaluation the salad dressing was spooned into two ounce black plastic sample cups that were labeled with its corresponding variable code. Black sample cups were used to mask the color differences between the two samples in order to minimize any bias in regards to appearance. Carrots chips were served in clear plastic cups with the salad dressing to function as a carrier, meaning that the participants were asked to dip the carrot chips into the salad dressing sample in order to taste the salad dressing. To keep samples fresh and the temperature consistent, all samples along with the carrot chip were stored in the refrigerator until needed (Figure 3.15). The samples were placed onto trays that contained the survey (example on page 45), a pen, a napkin, and room temperature water used to rinse the palate between tasting samples (Figure 3.16). The tray was then slid through the window to the participant (Figure 3.17).

Participants were asked to read the instructions, fill out the survey, and then return the survey to the volunteers. Time commitment for participation was approximately five to ten minutes.



Figure 3.15. Samples and carrot chips stored in refrigerator



Figure 3.16. Placing samples on tray



Figure 3.17. Sliding tray and items to participant

Salad Dressing

Please Check One: Male Female

Please indicate your age by checking the appropriate box:

18-24 25 – 29 30 – 39 40 – 49 50 –59 60 or older

INSTRUCTIONS:

You will be given two samples of salad dressing.

Please taste the sample on the left first by dipping the carrot chip into the dressing. Rinse with water, and then taste the sample on the right using the carrot chip.

After sampling, please check the box of the sample that you prefer.

In the comment section, please indicate your reason for preference.

465

353

COMMENTS:

Thank you for your time.

Data Analysis

The data from the surveys was analyzed using the critical number of correct responses in a two-sided directional difference test, ($p < 0.05$). The critical number was found using Table 12 (*Critical Number of Correct Responses in a Two-Sided Directional Difference Test*) from the textbook, *Sensory Evaluation Techniques* 3rd Edition (Meilgaard, et al., 1999).

Limitations

Since this study was held on the University of Wisconsin-Stout campus in Menomonie, WI, and consisted mostly of UW-Stout students and faculty over the age of 18 years, the results of this study are not representative of the general population.

Chapter IV: Results & Discussion

The results of the three sensory evaluations performed in this study are discussed in this chapter.

Chocolate Cupcake

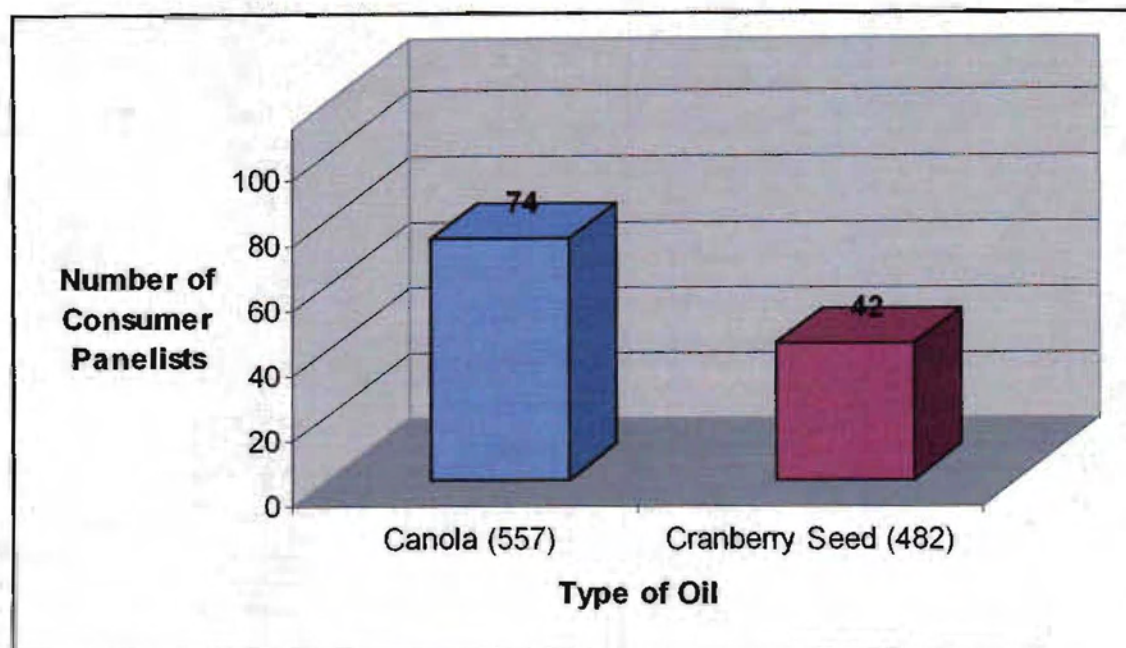
The participant size for this sensory evaluation was 116 participants. The preference of chocolate cupcakes is shown in Figure 4.1. According to the critical number of correct responses from Table 12 in the textbook, *Sensory Evaluation Techniques 3rd Edition* (Meilgaard, et al., 1999), there was a significant difference in preference of chocolate cupcakes in favor of sample 557, the cupcake made with canola oil. However, of the 74 respondents that preferred sample 557, twenty of those respondents stated in the survey comments section that they could not tell a difference between the two samples and they liked both of the samples equally. Even though they did not have a preference, the paired comparison test forced the participants to make a choice between the two samples. Taking this into consideration, the data could be altered to say that there is no substantial difference between the two samples and canola oil and cranberry seed oil could be used interchangeably. This data does not indicate if either of the samples were actually liked, it only states a preference and does not determine why specifically one sample was chosen over the other.

Since canola oil and cranberry seed oil undergo different means of extraction, their flavor and color are different. Canola oil has the most volatiles and color stripped during the refining process whereas cranberry seed oil retains most of its natural flavor and color after being cold-pressed (Stauffer, 1996; Luke, 2006). Since the cupcakes are dark brown, no color difference was evident, but the flavor could have come through to affect the overall flavor of the cupcake. This could have affected the consumer's cupcake preference. To better evaluate flavor changes

in the cupcakes produced by the different oils, it is suggested that trained sensory panelists evaluate the flavor profile of the cupcakes to depict if any off flavors may exist.

One more speculation is that off flavors could easily exist after a product with cranberry seed oil is heated. The cupcakes were baked at 350°F. Cranberry seed oil is comprised of over 90 percent monounsaturated and polyunsaturated fatty acids which are much less stable than saturated fats. With an increase in temperature, the double bonds in these fatty acids become much more reactive and more likely to oxidize, creating flavor reversion. This could decrease the overall flavor quality of the cupcake. It is suggested to analyze the fatty acid profile of the cupcakes after baking to determine if by-products of oxidation exist.

Chemical analysis and studies have shown that cranberry seed oil has a long shelf life (24 months from date of manufacture), is comparable or surpasses the stability of other common cooking oils, is low in saturated fat, high in mono and polyunsaturated fats, has a balanced ratio of 1-3:1 of omega-6 to omega-3 fatty acids, is high in antioxidants and contains other phytonutrients. No studies have been conducted to determine if cranberry seed oil itself has an effect on human health conditions. It is recommended that clinical research be performed to determine if health claims can be made regarding cranberry seed oil consumption through food products.



$n = 116, (p < 0.05)$

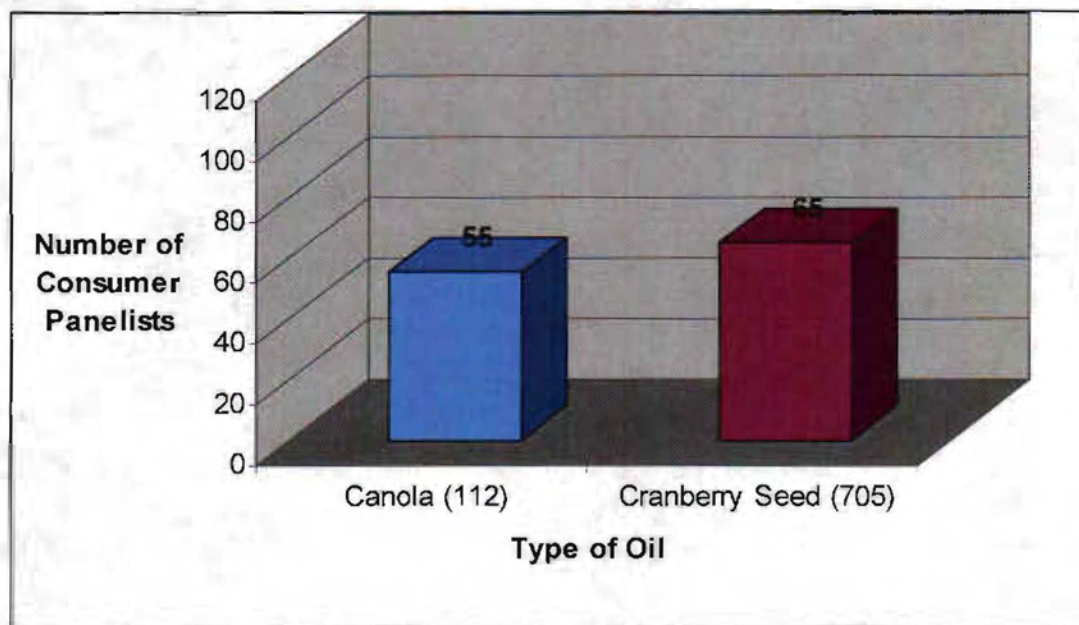
Figure 4.1. Preference of chocolate cupcakes made with either canola oil or cranberry seed oil

Pasta Salad

The sample size for this evaluation was 120 participants. Results of the evaluation are shown in Figure 4.2. Overall, more consumers (65) preferred the pasta salad prepared with cranberry seed oil than canola oil (55). However, according to the critical number of correct responses (72) from Table 12 in the textbook, Sensory Evaluation Techniques 3rd Edition (Meilgaard et al., 1999), 65 participants is not enough to make the preference statistically significant ($p < 0.05$). Therefore, there is no statistically significant difference in preference of the pasta salad made with cranberry seed oil compared to the pasta salad made with canola oil. These means that cranberry seed oil and canola oil can be used interchangeably in pasta salad without affecting the consumer.

An additional note was that many consumers claimed that sample 705 tended to be more flavorful than sample 112. Although these were subjective comments, sample 705 could in fact

be more flavorful due to the cold-pressed processing technique of the cranberry seed oil allowing it to retain its natural flavors.



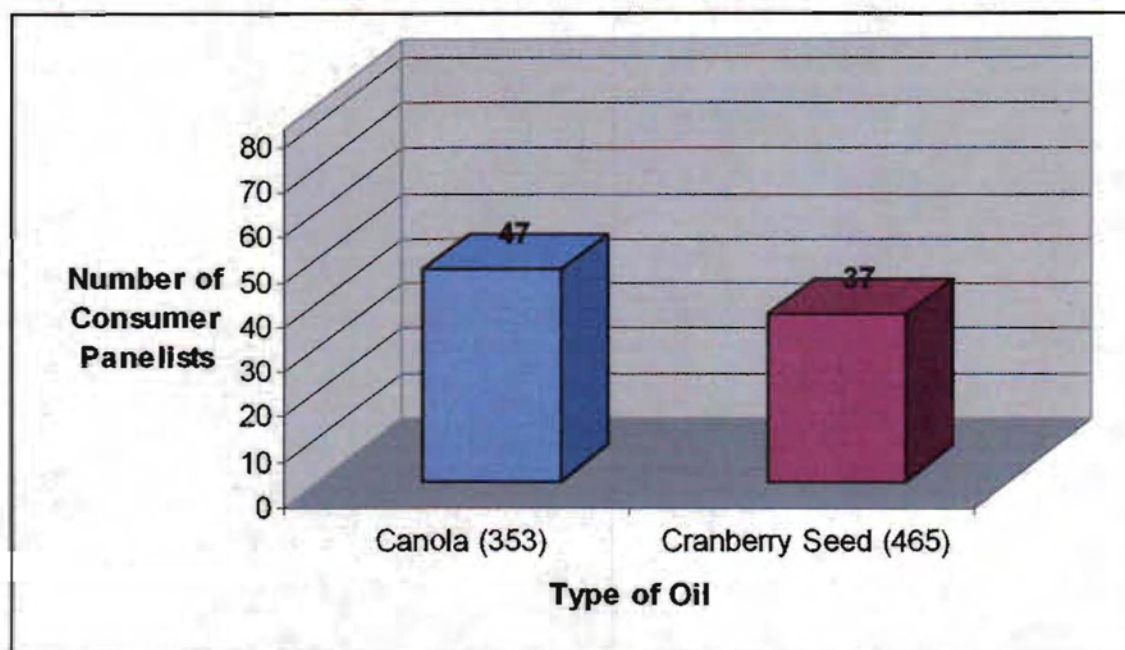
$n = 120, (p < 0.05)$

Figure 4.2. Preference of pasta salad made with either canola oil or cranberry seed oil

Salad Dressing

The sample size for this evaluation was 84 participants. Results of the evaluation are shown in Figure 4.2. Overall, more participants (47) preferred the salad dressing made with canola oil over the salad dressing made with cranberry seed oil (37). However, this does not indicate a statistically significant difference ($p < 0.05$) in preference between the two variables. Since using Table 12 in the textbook, Sensory Evaluation Techniques 3rd Edition (Meilgaard, et al., 1999) no significant difference occurred, this indicates that cranberry seed oil could be substituted for canola oil in this salad dressing and would still be acceptable to consumers. There were mixed responses among participants as to which salad dressing was more flavorful and

some stated that sample 465 had a distinct flavor. Cranberry seed oil does have a “distinct flavor” when compared to canola oil due to the processing techniques. Canola oil is essentially flavorless after it is processed and refined. Since the paired preference test does not provide any more information on the “why” behind choosing one sample over the other, as well as not indicating how likeable the product is, a subsequent hedonic test is recommended to quantify specific attributes.



$n = 84, (p < 0.05)$

Figure 4.3 Preference of pasta salad made with either canola oil or cranberry seed oil

Chapter V: Conclusion

Cranberry seed oil has the potential to be incorporated into food products. Two out of the three sensory evaluations indicated that there was no significant difference in preference of products prepared with canola oil and products prepared with cranberry seed oil. The nutrition of these food items, pasta salad and salad dressing, could greatly be increased by using cranberry seed oil.

It is also recommended that more complex sensory evaluation be performed. Trained sensory panelists should perform descriptive analysis on cranberry seed oil to get a better understanding of its flavor profile and how this flavor profile changes over its shelf life and in various storage conditions. Also, it is unknown how the flavor profile of cranberry seed oil may develop the flavor of the foods cranberry seed oil is incorporated into. Since cranberry seed oil does have a unique flavor that is not removed during processing, it is uncertain if it will have a positive effect or negative effect on the foods in which it is incorporated. It seems it would be highly dependent on the type of food. Olive oil is known have being a flavorful oil and is often used in salad dressings. As seen from the results of this study, cranberry seed oil was more acceptable in the salad dressing and the pasta salad and was not preferred over canola oil in the cupcake evaluation. It is unknown if cranberry seed oil is best used in hot or cold products or if heating the oil has an effect on the flavor. Also, it is uncertain if cranberry seed oil tastes better when paired with spices and salty items instead of sweet foods. These are ideas that could be further examined.

Due to its prolonged shelf life and stability there is a potential to incorporate cranberry seed oil into many foods. However, there is much research that needs to be done. Since cranberry seed oil retains much of its natural color, odor, and flavor, studies would need to be conducted on

specific food items to determine how cranberry seed oil would affect the color, odor, and flavor of these food items. Also, it is unknown if cranberry seed oil has an effect on objective measures such as moisture content, water activity, density, viscosity, pH, cooking/baking times, etc., for specific food items. It is recommended that these types of objective measures be analyzed to see if cranberry seed oil increases or decreases the quality of the food item.

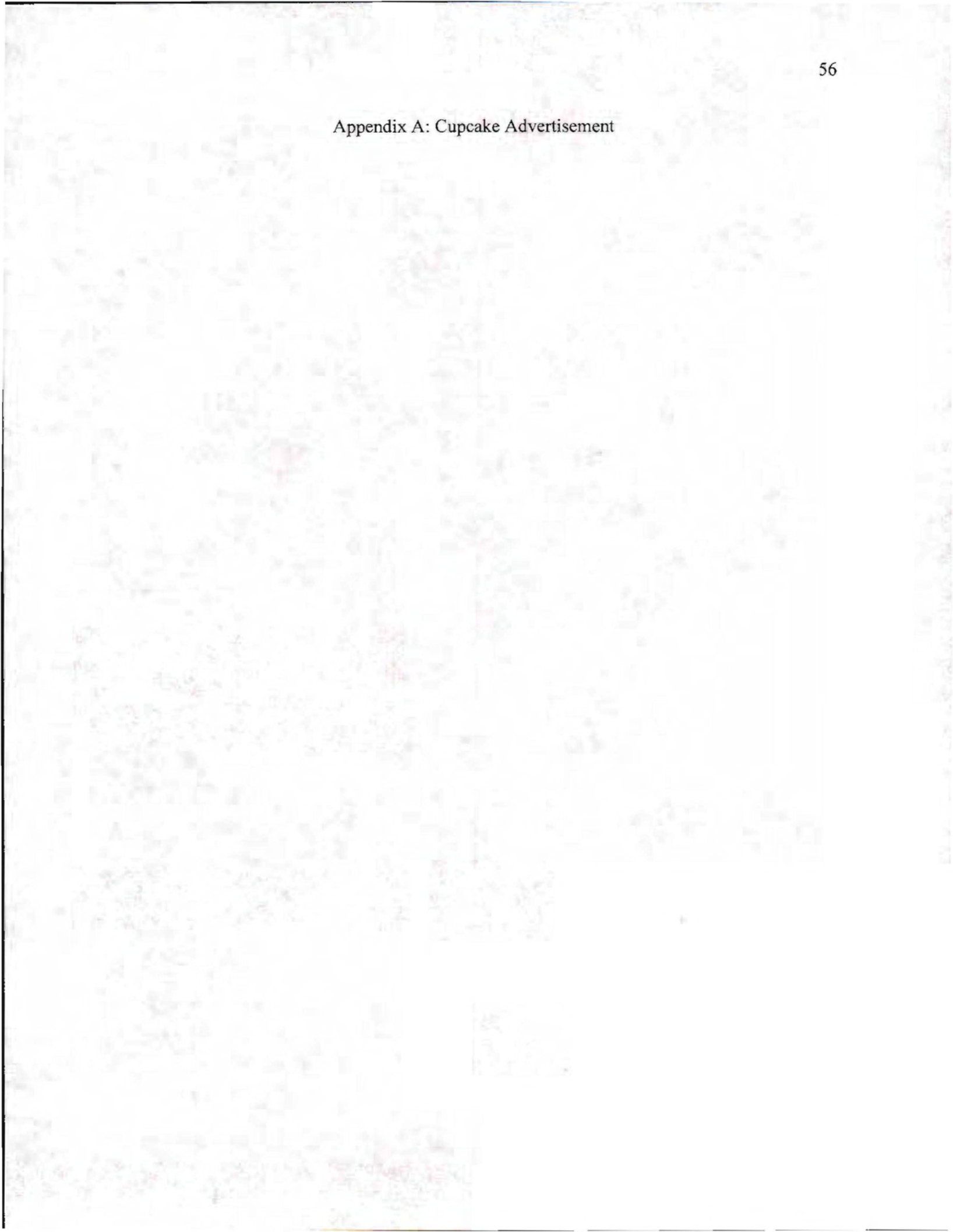
In summary, from information gathered regarding consumer preferences, cranberry seed oil may potentially have a place in consumers' modern lifestyles and in new food products. With the little research that has been performed regarding cranberry seed oil, it has shown positive qualities and potential. More chemical, sensory, and clinical testing is needed to determine how the nutritional qualities of cranberry seed oil can be incorporated into foods and how this will affect the lives of consumers ingesting these food products.

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Appendix A: Cupcake Advertisement



Participate in Sensory Evaluation of Chocolate Cupcakes



What? Taste two different types of chocolate cupcakes and simply choose which cupcake you prefer.

Who? All students, faculty, and the public are open to attend.
***MUST** be at least 18 years of age to participate.

When? Tuesday April 3rd from 11:00 am to 3:00 pm.

Where? Home Economics Building, Room 252

Why? Participants are needed to help gather data for a thesis.

- Participating in this study will take approximately 10 minutes of your time.
- **All participants will receive a treat!!!!!!!!!!!!!!!!!!!!!!**

*If you have any questions regarding this study, please contact Allyson via email: tarta@uwstout.edu or Dr. Rohrer: rohrc@uwstout.edu

Appendix B: Salad Dressing Advertisement

Participate in Sensory Evaluation of Italian Salad Dressing



What? Taste two different types of Italian salad dressing and simply choose which salad dressing you prefer.

Who? All students, faculty, and the public are open to attend.
***MUST** be at least 18 years of age to participate.

When? Tuesday April 10th from 11:00 am to 3:00 pm.

Where? Home Economics Building, Room 252

Why? Participants are needed to help gather data for a thesis.

- Participating in this study will take approximately 10 minutes of your time.
- **All participants will receive a treat!!!!!!!!!!!!!!!!!!!!!!**

*If you have any questions regarding this study, please contact Allyson via email: tarta@uwstout.edu or Dr. Rohrer: rohrc@uwstout.edu

Appendix C: Pasta Salad Advertisement



Participate in Sensory Evaluation of Pasta Salad



What? Taste two different types of Italian pasta salad and simply choose which pasta salad you prefer.

Who? All students, faculty, and the public are open to attend.
***MUST** be at least 18 years of age to participate.

When? Thursday April 5th from 11:00 am to 3:00 pm.

Where? Home Economics Building, Room 252

Why? Participants are needed to help gather data for a thesis.

- Participating in this study will take approximately 10 minutes of your time.
- **All participants will receive a treat!!!!!!!!!!!!!!!!!!!!!!!!!!!!**

*If you have any questions regarding this study, please contact Allyson via email: tarta@uwstout.edu or Dr. Rohrer: rohrenc@uwstout.edu

Appendix D: IRB Approval Letter



Research Services
152 Voc Rehab Building

University of Wisconsin-Stout
P.O. Box 790
Menomonie, WI 54751-0790

715/232-1126
715/232-1749 (fax)
<http://www.uwstout.edu/rs/>

Date: March 29, 2007
To: Allyson Tart
Cc: Dr. Cynthia Rohrer
From: Sue Foxwell, Research Administrator and Human Protections Administrator, UW-Stout Institutional Review Board for the Protection of Human Subjects in Research (IRB)
Subject: **Protection of Human Subjects**

Your project, "*Consumer Acceptance of Cranberry Seed Oil in Several Food Formulations*," has been approved by the IRB through the expedited review process. The measures you have taken to protect human subjects are adequate to protect everyone involved, including subjects and researchers.

Reviewer comment: Very well done!

Please copy and paste the following message to the top of your survey form before dissemination:

This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

This project is approved through March 28, 2008. Modifications to this approved protocol need to be approved by the IRB. Research not completed by this date must be submitted again outlining changes, expansions, etc. Federal guidelines require annual review and approval by the IRB.

Thank you for your cooperation with the IRB and best wishes with your project.

***NOTE: This is the only notice you will receive – no paper copy will be sent.**

SF:dd

Appendix E: Consent Form

Consent to Participate In UW-Stout Approved Research**Title:** Consumer Acceptance of Cranberry Seed Oil in Several Food Formulations**Investigator:**

Allyson Tart
715-864-6209
tarta@uwstout.edu

Research Sponsor:

Dr. Cynthia Rohrer
368 Home Economics Building
232-2088
rohrerc@uwstout.edu

Description:

Cranberry seed oil has been shown to contain high levels of polyunsaturated fatty acids, a 1:1 ratio of omega 3 to omega 6 fatty acids, and is rich in many vitamins and natural antioxidants. Due to its excellent nutritional value, consumption of cranberry seed oil could prove to be beneficial to human health. Currently cranberry seed oil is mainly sold in supplement form. The purpose of this study is to determine if consumers will accept or prefer food products made with cranberry seed oil.

Risks and Benefits:

By participating in this study, you will be asked to consume a food product. If you have any food allergies, please check with the researcher or volunteer to ensure that there are not ingredients in the food product that you may be allergic to. By participating in this study, your input will be used to determine if use of cranberry seed oil in food product formulation is acceptable to consumers.

Special Populations:

You must be at least 18 years of age to participate in this study.

Time Commitment and Payment:

Your participation in this study should take approximately 5 minutes. After you have completed the survey please help yourself to a treat located on the table by the door.

Confidentiality:

Your name will not be included on any documents.

Right to Withdraw:

Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. However, should you choose to participate and later wish to withdraw from the study, there is no way to identify your anonymous document after it has been turned into the investigator.

IRB Approval:

This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study please contact the Investigator or Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

Investigator:

Allyson Tart
715-864-6209
tarta@uwstout.edu

Advisor:

Dr. Cynthia Rohrer
232-2088
rohrerc@uwstout.edu

IRB Administrator

Sue Foxwell, Director, Research Services
152 Vocational Rehabilitation Bldg.
UW-Stout
Menomonie, WI 54751
715-232-2477
foxwells@uwstout.edu

Statement of Consent:

By completing the following survey you agree to participate in the project entitled, ***Consumer Acceptance of Cranberry Seed Oil in Several Food Formulations.***