ACCEPTABILITY OF FOOD PRODUCTS CONTAINING ALMOND OIL IN PLACE OF SOYBEAN OIL

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To the Dean of the Graduate School:

I am submitting herewith a thesis written by Megan E. Kier entitled "Acceptability of Food Products Containing Almond Oil in Place of Soybean Oil." I have examined this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of a Master of Science with a major in Nutrition.

John Radcliffe

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ABSTRACT

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ACCEPTABILITY OF FOOD PRODUCTS CONTAINING ALMOND OIL IN PLACE OF SOYBEAN OIL

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The effect of replacing soybean oil (SBO) with almond oil (AO) on the hedonic characteristics (appearance, taste, texture, and overall likeability) of four products (carrot muffins, bread, cornbread, and chocolate chip cookies) was determined in 71 participants (40 female; 30 male). A split plot factorial analysis of variance design was used to avoid order effects. Products were rated on a nine-point hedonic scale (1 = Dislike Extremely; 9 = Like Extremely). With the exception of the values for texture, taste, and overall likeability for bread (for which values were significantly [$p < .05$] higher for the AO than the SBO product), there were no significant between-product differences. Gender had no effect on product rating. For both sets of products, the ranking from the highest (4) to lowest (1), using values for overall likeability was: cookies (4); muffins (3); cornbread (2); and bread (1). Thus, replacement of SBO with AO had no appreciable effect on the assessed hedonic characteristics for either gender or on within set, or oil type, ranking.

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CHAPTER I

INTRODUCTION

Vitamin E is a fat-soluble vitamin involved in many vital functions; most importantly, it serves as an antioxidant in vivo. The body's cell membranes are composed of polyunsaturated fatty acids that are easily destroyed by oxidation (Kearney & Frei, 1994). Vitamin E, however, has the ability to protect human cellular tissue and membranes from destructive damage caused by oxidative free radicals, which are highly reactive oxygen species with unpaired electrons. Interaction with other nutrients is also critical; vitamin E mediates with vitamin K by preventing blood clotting and also assists in directing the proper use and storage of vitamin A. For these reasons, the incorporation of vitamin E into the diet is crucial.

Eight naturally occurring forms of vitamin E are established: four tocopherols (alpha, beta, gamma, and delta) and four tocotrienols (alpha, beta, gamma, and delta). It has recently been demonstrated, however, that alpha-tocopherol is the form of vitamin E that is preferentially maintained in plasma (Pruthi, Allison, & Hensrud, 2001). Other naturally occurring forms of vitamin E (beta, gamma, and delta-tocopherols and the tocotrienols) do not contribute toward meeting the vitamin E requirement because (although absorbed) they are not converted into alpha-tocopherol by humans and are recognized poorly by the alpha-tocopherol transfer protein (alpha-TTP) in the liver (Institute of Medicine [IOM], 2000). For this reason, beta, gamma, and delta-tocopherol, as well as the four tocotrienols, do not contribute a significant amount of vitamin E activity (Maras et al., 2004). Heart disease is among the top three causes of death in the United States. There is published evidence that alpha-tocopherol may help lower the risk of developing coronary artery disease (CAD), possibly by acting as an antioxidant in the body (Rimm et al., 1993). The American Heart Association (AHA) states that CAD, also known as coronary heart disease (CHD), is a reduction of blood flow through the coronary arteries to the heart muscle (AHA, 2005). Antioxidants such as vitamin E are hypothesized to prevent atherosclerosis by blocking the oxidative modification of low-density lipoproteins (LDLs) and by removing destructive free radicals. Numerous epidemiological studies show that increased intakes of certain nutrients, including vitamin E, are associated with statistically significant decreases in the incidence of CAD.

It has been suggested that the protective effect of vitamin E against CAD may occur primarily from consumption of vitamin E obtained from foods, with no additional benefits from supplementation (Maras et al., 2004). However, the dietary intake of alpha-tocopherol in the United States is limited among adults; many do not meet the Recommended Dietary Allowance (RDA) for vitamin E and, thus, do not reap the benefits of a vitamin E-rich diet. (The RDA is established by the Food and Nutrition Board of the National Academy of Sciences. It is the nutrient intake level that is adequate to meet the average daily nutritional needs of most healthy persons according to age group and gender.) Maras et al. reported that the mean consumption of vitamin E for men is estimated to be 51% to 60% of the RDA, and for women, 37% to 40% of the RDA. In addition, the main source of tocopherols in the American diet is gamma-tocopherol, which does not contribute toward meeting the RDA for vitamin E. Maras et al. found that the top food contributors of vitamin E intake for men and women are fortified breakfast cereals and sweet baked products. Most baked products, however, are prepared with soybean oil, which contains lower concentrations of alpha-tocopherol than many other dietary oils, such as cottonseed oil, sunflower seed oil, and almond oil.

Using just one tablespoon of almond oil per day will provide over one-third of the RDA for men and women. Because almond oil is not as widely available as soybean oil, its use in baked products has been limited. Many people are reluctant to try a new product or are accustomed to using certain ingredients when cooking. However, the substitution of almond oil for soybean oil in baked food products could result in a substantial increase in vitamin E content. Increasing the dietary intake of vitamin E would increase the intake of this protective antioxidant, which may reduce the risk of developing CAD. Thus, consumption of oils rich in alpha-tocopherol at levels that meet or exceed the RDA may provide considerable health benefits. If almond oil replaces soybean oil in baked products, it would be useful to know if there would be any change in overall product acceptability. If acceptability were adversely affected, then this substitution would not be a feasible way to increase vitamin E intake. The overall acceptability of products can be effectively assessed using a sensory evaluation test.

Hypothesis

The hypothesis is that baked products (carrot muffins, bread, cornbread, and chocolate chip cookies) prepared with almond oil will be more acceptable than baked products prepared with soybean oil. That is, for a majority of the products tested (at least three out of four), the overall rating scores and overall preference for products containing almond oil will be significantly greater than for the corresponding products containing soybean oil.

Null Hypothesis

There will be no statistically significant difference in the overall acceptability of products prepared with almond oil compared to ones prepared with soybean oil.

CHAPTER II

REVIEW OF LITERATURE

Heart Disease

The American Heart Association estimated that, in the year 2002, more than 70 million Americans had some form of cardiovascular disease (CVD) (AHA, 2005). CVD is a term used to describe a number of cardiovascular events, including high blood pressure, stroke, and CHD/CAD. Among other variables, cholesterol levels and atherogenesis have been recognized as factors that influence the risk of CHD development (Kushi, 1999). In 2002, heart disease claimed the lives of nearly one million Americans, which is greater than the combined number of deaths caused by cancer, automobile accidents, and human immunodeficiency virus/acquired immune deficiency syndrome. Although there was a decline in death rates from CVD from 1992 to 2000, an effort must be made to further reduce death rates.

Atherosclerosis, defined as the narrowing of the coronary arteries due to an accumulation of plaque, is the primary cause of CHD (AHA, 2005). The development of atherosclerosis is slow, yet progressive over a lifetime, and may begin as early as ten years of age. Although genetic factors contribute to the process of atherosclerotic development, other factors, including nutrient intake, are associated with heart disease risk (Rao, 2002). Eight stages of the disease (I through VIII) have been defined on the basis of lesion classification. Once stage VI lesions develop, morbidity and mortality is likely to occur (Brigelius-Flohe et al., 2002).

Tribble (1999) described the complex process of atherosclerosis as the deposition of plasma lipoproteins and the proliferation of cellular elements in the arterial wall. Atherosclerosis advances through a series of stages beginning with fatty streak lesions composed of macrophage foam cells; progression ultimately leads to plaque formation, consisting of lipid cell debris. Over time, plaque accumulation provides a barrier to arterial blood flow (Rao, 2002). Untreated CHD leads to angina pectoris, and eventually myocardial infarction may occur. The AHA (2005) estimates that in 2005, 43% of people who experience a myocardial infarction (MI) in a given year will die as a result of their underlying atherosclerotic diseases.

Epidemiological studies have confirmed that low-density lipoprotein (LDL) produced from the liver can cross the endothelium of the arterial wall. When this occurs, LDL becomes trapped in the artery's extracellular matrix (Tribble, 1999). If LDL remains trapped for a sufficiently long period of time, it undergoes oxidative changes that damage the endothelium. When this injury occurs, further entry of LDL into the arterial wall is favored, and, thus, the disease process continues.

Oxidative Stress

Oxidative stress, defined as the process of removing electrons from atoms or ions, is thought to play an important role in atherosclerotic vascular disease (Carr, Ben-Zhan, & Frei, 2000). Van Tits, Demacker, Graff, Hak-Lemmers, and Stalenhoef (2000) stated that LDL cholesterol is especially known to induce the atherosclerotic process due to oxidation. According to Pryor (2000), oxidation can occur by one-electron pathways involving radicals, such as the hydroxyl radical, or by two-electron pathways that involve nonradical oxidants such as hydrogen peroxide. Kaul, Devaraj, and Jialal (2001) stated that oxidized LDL in vitro is positively correlated with the progression of atherosclerosis.

Tribble (1999) reported that the typical LDL particle contains approximately 2,700 fatty acid molecules of various lipid categories. The majority of these fatty acid molecules are derived from polyunsaturated fatty acids (PUFAs), which are extremely sensitive to oxidation. Pryor (2000) reported that oxidized LDL particles lead to foam cell formation because they are marked for uptake by macrophages in the body. Macrophages are critical cells present at all stages of atherogenesis and, when stimulated, can have a profound influence on the progression of atherosclerosis (Kaul et al., 2001). This process inhibits macrophages from exiting the artery, which, in turn, induces endothelial cell damage. Because oxidative stress places a burden on the entire cell or organ, the redox balance (defined as a reaction in which one of the reactants gains one or more electrons and the other reactant loses one or more electrons) of other cells may also be affected (Pryor). Although oxidant formation is an inevitable feature of aerobic life, it is possible to reduce this process with certain components.

Antioxidants

Tribble (1999) described antioxidants as a diverse group of compounds with multiple characteristics. The main function of antioxidants is to inhibit oxidant formation. In addition, antioxidants intercept oxidants once they have formed and have the ability to repair cellular injury induced by oxidation. The prevention or reduction of LDL oxidation by antioxidant action is well documented and has recently been reviewed in detail (Tribble). Support for the protective effect of antioxidants also comes from the observations that men and women with CHD exhibit lower levels of circulating antioxidants (Rao, 2002). Rajasekhar, Rao, Latheef, Siababa, and Subramanyam (2004) point out that of the multiple beneficial actions of vitamin E, antioxidant capacity and cholesterol-lowering ability, are of special interest.

Although the antioxidant defense system includes both endogenously and exogenously derived compounds, dietary antioxidants have received the greatest attention with regard to CHD prevention (Tribble, 1999). The ability of alpha-tocopherol to inhibit oxidation of LDL in vitro has been shown unequivocally; numerous epidemiologic studies have shown an inverse association between antioxidant intake and the risk of cardiovascular diseases (Carr et al., 2000).

Observational studies have provided support for the potential health benefits of antioxidants; yet to date, there are an insufficient number of randomized trials to make conclusive statements about the optimal levels of antioxidants to prevent CHD. The Cambridge Heart Antioxidant Study (CHAOS) was a secondary prevention trial in which high-doses of natural alpha-tocopherol (an antioxidant and the most active form of vitamin E) was given to 2,002 patients with evidence of previously established coronary atherosclerosis. Subjects received either 800 International Units (IUs) or 400 IU (537 mg and 268 mg, respectively) of naturally occurring (or RRR) alpha-tocopherol or placebo daily (Hasnain & Mooradian, 2004). The primary endpoint of the trial was the combination of cardiovascular death and nonfatal myocardial infarction (MI) or nonfatal MI alone. Participants in the study group were found to have a 77% reduction in fatal myocardial infarctions compared to the control group. A total of 55 non-fatal MIs were observed during the study period; only 14 MIs occurred in the alpha-tocopherol recipient group whereas 41 MIs occurred in the placebo group (Stephens et al., 1996). Studies such as CHAOS may provide further verification for the benefits of antioxidant therapy.

Vitamin E

The vitamin E family can be divided into two groups, the tocopherols and the tocotrienols. Tocopherols differ from tocotrienols in that tocopherols have three chiral centers (at positions 2, 4, and 8 from the alpha carbon) while tocotrienols have only one chiral center (at position 2 from the alpha carbon) and three double bonds in the tail. Therefore, the tocotrienols possess polyunsaturated phytyl side chains. In addition, scientists have also devised a systematic way of naming stereoisomers based on the concept of absolute configuration. Absolute configuration is defined as the three dimensional arrangement of the atoms around the chiral center of an atom and is designated as either R (from rectus, for right-handed) or S (from sinister, for left-handed.) If the atom groups can be traced directionally to the right in order of molecular weight around the chiral center, the absolute configuration is denoted as R. If the atom groups can be traced directionally to the left in order of molecular weight around the chiral center, the absolute configuration is denoted as S (IOM, 2000). A demonstration of the eight stereoisomers of alpha-tocopherol is depicted in Figure 1.

Because tocopherols have three chiral centers, there are eight possible stereoisomer combinations. The natural form of vitamin E is from food sources and includes four tocopherols: RRR, RSR, RRS, and RSS-tocopherol. Synthetic forms of alpha-tocopherol are found in fortified foods and vitamin supplements. The synthetic

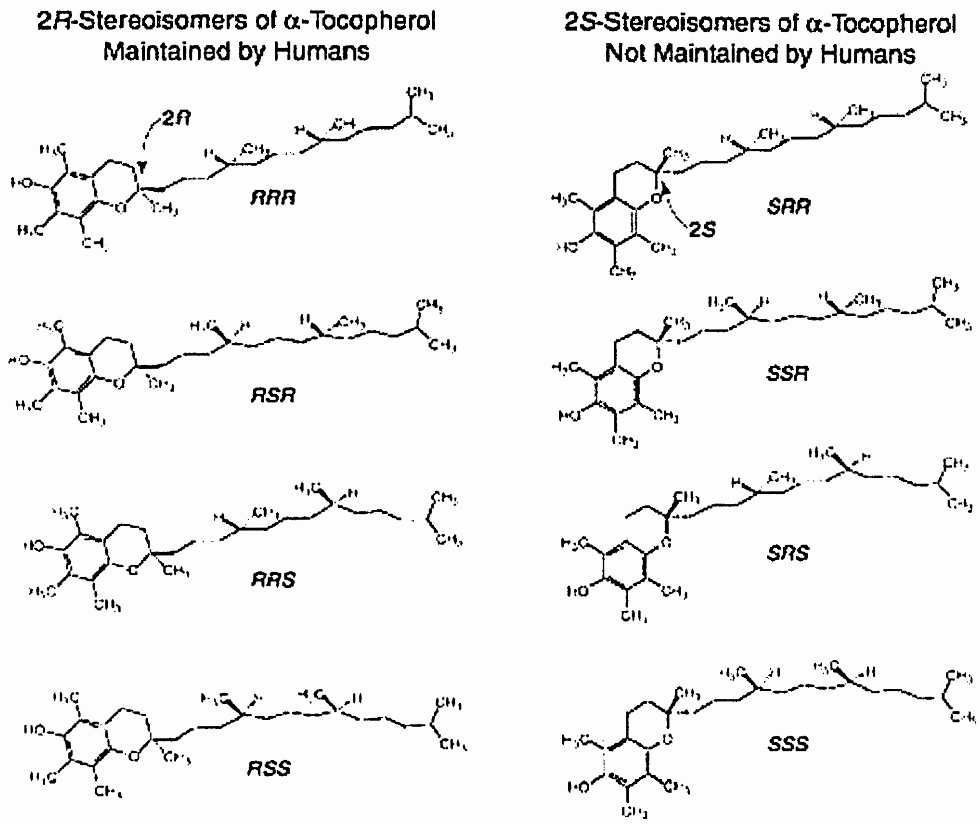

Figure 1. The eight stereoisomer illustrations of synthetic vitamin E are available on page 189 of the IOM Vitamin E chapter data file. The 2R forms of alpha-tocopherol are maintained in human plasma; the 2S forms of alpha-tocopherol are not maintained in human plasma. The R abbreviation is from rectus (for right-handed), and the S abbreviation is from sinister (for left-handed).

mixture is known as all-rac-alpha-tocopherol and contains eight stereoisomers. Four of the stereoisomers are in the 2R (RRR, RSR, RRS, and RSS alpha-tocopherol) form and four of the stereoisomers are in the 2S (SSS, SRS, SSR, and SRR alpha-tocopherol) form (IOM, 2000). The number 2 indicates that the attachment is at the second carbon from the chiral center. For the purposes of assessing compliance with the Recommended Dietary Allowance (RDA) or the Estimated Average Requirement (EAR), vitamin E is defined as and limited to only the 2R stereoisomeric forms of alpha-tocopherol. Most of the alpha-tocopherol added to foods and used in supplements is in the all-rac form (IOM, 2000).

Before 1980, the United Stated Pharmacopeia (USP) stated that 1 IU of vitamin E activity equaled 1 mg of all-rac-alpha-tocopheryl acetate (the acetate ester of all-rac-alpha-tocopherol), while 1 mg RRR-alpha-tocopherol was calculated to be equivalent to 1.49 IUs of vitamin E (see Table 1). The all-rac-alpha-tocpheryl acetate form is produced by the acetylation of the tocopherol form. After 1980, the IU term was changed to the USP unit; one USP unit of vitamin E was stated to have the activity of 1 mg of all-rac-alpha-tocopherol, 0.67 mg RRR-alpha-tocopherol, and 0.74 mg alpha-tocopheryl acetate. The USP unit was defined before studies were published indicating that 2S stereoisomers of all-rac-alpha-tocopherol are not maintained in plasma or tissues. Therefore, the previously used USP unit has been redefined to include only the 2R forms based on the knowledge that only the 2R forms of alpha-tocopherol contribute to plasma vitamin E level (IOM, 2000).

Alpha-tocopherol is of particular interest because it is carried within LDL particles (Tribble, 1999). Enrichment of the diet with alpha-tocopherol has been shown to

Table 1

Factors for Converting IUs to mg of Alpha-Tocopherol

	USP conversion factors		α -tocopherol factors
Vitamin E form	IU/mg	mg/IU	mg/IU
All-rac-α-tocopheryl acetate[a]	1.00	1.00	0.45
All-rac-α-tocopherol[a]	1.10	0.91	0.45
RRR-α-tocopheryl acetate[b]	1.36	0.74	0.67
RRR-α-tocopherol[b]	1.49	0.67	0.67

Note. [a] = synthetic vitamin E. [b] = natural vitamin E.

increase LDL oxidative resistance in vitro. Rock, Jacob, and Bowen (1996) reported that the molar ratio of alpha-tocopherol to LDL is six-to-one in a well-nourished individual. This ratio could allow alpha-tocopherol to play a crucial role in preventing and reducing LDL oxidation and atherosclerosis. Data from CHAOS suggests that even patients with established atherosclerosis may benefit from alpha-tocopherol therapy (Van Tits et al., 2000).

Kearney and Frei (1994) reviewed six studies in which vitamin E was given to humans and the oxidizability of their LDL was measured ex vivo. In all six studies, supplementation with vitamin E was found to reduce LDL oxidizability. Macrophage uptake, which is ultimately responsible for foam cell formation, was also reduced after vitamin E supplementation. The antioxidant abilities of vitamin E may limit the progression of atherosclerosis by stabilizing plaque and preventing its rupture. It is of note that the benefits of vitamin E in patients with existing CHD and low dietary antioxidants intake are pronounced (Pryor, 2000).

Rimm et al. (1993) have extensively studied the effects of vitamin E consumption and the risk of CHD in men; of particular interest is the Health Professionals Follow-up Study, completed in 1986. A total of 39,910 American male health professionals between the ages of 40 and 75 who were free of diagnosed CHD, diabetes, and hypercholesterolemia completed detailed dietary questionnaires concerning their usual intake of vitamin C, beta-carotene, and vitamin E. Although specific information on the form of vitamin E (synthetic versus natural) was not collected, portion sizes and brands of food consumed were carefully documented by the participants. The men were followed for a duration of four years. During this time, all cases of coronary disease, MI, coronary artery bypass grafting, and percutaneous transluminal coronary angioplasty were recorded. Regression and multivariate logistic models were used to test for significant trends in the number of coronary events with regards to the intake of vitamin C, beta-carotene, and vitamin E. All of the participants in the two highest quintile groups for vitamin E intake used multivitamins or specific vitamin E supplements. The multivariate risk of CHD in men taking vitamin E supplements in doses of at least 100 IUs per day for two or more years was 0.63 (95% confidence interval; $p < .003$) compared to nonusers of vitamin E supplements. It is of note, however, that the form of supplemental vitamin E consumed in this study was not stated. For men who had taken vitamin E supplements for 10 or more years also, there was an inverse trend of CHD. The relative risk of developing CHD was 0.65 for supplement users compared to nonusers. The authors also found that reduced serum alpha-tocopherol calculations correlated with an increased incidence of angina. In addition to the strong association with vitamin E supplements, Rimm et al. found a moderate reduction in the risk of CHD with increasing intake of nonsuppplemental dietary vitamin E.

A similar study concerning vitamin E consumption and the risk of CHD in women was conducted by Stampfer et al. (1993) in 1980. Over 87,000 female nurses between the ages of 34 and 59 participated; all were free of diagnosed CHD. Dietary questionnaires assessed the consumption of a wide range of nutrients, including vitamin E. The women were followed for 8 years; during this time, their vitamin E intake was calculated every 2 years. Women who took vitamin E supplements for at least 2 years had a relative risk of major CHD of 0.59 (95% confidence interval; $p < .001$) as compared to those women with the lowest vitamin E intake. A statistically significant difference was observed in the risk of major CHD among women with a high vitamin E intake of 21.6-1000 IUs total intake, including synthetic vitamin E (equivalent to 9.72-450 mg RRR-alpha-tocopherol) per day, as compared to women with a low intake of 1.2-3.5 IUs total intake, including synthetic vitamin E (equivalent to 0.5-1.6 mg RRR-alpha-tocopherol) per day. These authors report that the best evidence for the mechanism by which vitamin E can reduce CHD is through a reduction in the development of atherosclerosis. The authors found that use of vitamin E for more than 2 years was associated with a decrease risk of CHD by 41%. These findings imply that the utilization of vitamin E as an antioxidant has statistically significant heart health benefits.

Recommended Dietary Allowance

The 1989 RDA for vitamin E was based on alpha-tocopherol equivalents (ATEs). The term ATE was created by the Food and Nutrition Board in order to account for all eight members of the vitamin E family, but may only be used when describing foods, and not supplements. One ATE equals 1 mg of RRR-alpha-tocopherol. Levels of 8 and 10 milligrams of ATEs were set for women and men, respectively. One milligram of RRR-alpha-tocopherol was equal to 1 ATE. However, the new Dietary Reference Intakes (DRIs), released in 2000, call for 15 mg of the 2R isomers of alpha-tocopherol per day for both men and women (Maras et al., 2004). This is equivalent to 15 mg of ATEs, or 22.5 IUs RRR-alpha-tocopherol. The new DRI is substantially more than what is usually obtained in the typical US diet (Jambazian et al., 2005). The 2000 DRIs are based solely on the 2R isomers of alpha-tocopherol rather than all forms of alpha-tocopherol and other tocopherols because of the recognition that the 2R forms contribute the highest degree of vitamin E activity. These other tocopherols are no longer considered useful in meeting requirements.

In order to obtain the RDA of 15 mg a day of vitamin E, as defined in the IOM report, one must consume either 15 mg RRR-alpha-tocopherol or 30 mg all-rac-alpha-tocopherol. The IU labeling system is still used when labeling vitamin supplements. Therefore, it is necessary to clarify the conversion of IUs to mg of 2R isomers. In order to determine the weight of 2R isomers in a supplement labeled in IUs, one of two conversion factors must be utilized (see Table 1). If the form in the supplement is natural, RRR-alpha-tocopherol, the conversion factor is 0.67 mg per IU. Based on this definition, 30 IUs of RRR-alpha-tocopherol would equal 20 mg of alpha-tocopherol (30 IUs multiplied by 0.67). However, if the supplement is in the form of all-rac-alpha-tocopherol, the conversion factor is 0.45 mg per IU, which reflects the inactivity of the 2S stereoisomers. Thus, 30 IUs of all-rac-alpha-tocopherol would equal 13.5 mg of alpha-tocopherol (30 IUs multiplied by 0.45).

Pruthi et al. (2001) reported that the upper limit is 1000 mg per day of any form of supplemental alpha-tocopherol, including all eight stereoisomers of all-rac-alpha-tocopherol. This is equivalent to 1500 IUs of RRR-alpha-tocopherol or 1100 IUs of all-rac-alpha-tocopherol. Commercially available vitamin E consists of either a mixture of naturally occurring tocopherols and tocotrienols, RRR-alpha-tocopherol, synthetic alpha-tocopherol (all-rac-alpha-tocopherol), or their esters (Brigelius-Flohe et al., 2002).

Sources of vitamin E

Vegetable oils are the primary source of vitamin E (as RRR-alpha-tocopherol) in Western diets (Rock et al., 1996). Relative to other oils, soybean oil contains large amounts of gamma-tocopherol (approximately 1.10 mg per tablespoon), and alpha-tocopherol accounts for only 7 to 15% of the weight of tocopherol in soybean oil. According to the United States Department of Agriculture (USDA) Standard Release 15 ([SR 15], 2002), alpha-tocopherol is found in much higher concentrations in oils such as safflower (4.6 mg per tablespoon), cottonseed (4.8 mg per tablespoon), and in particular, almond oil (5.3 mg per tablespoon).

The oil nonsaponifiable fraction of all grains, seeds, and nuts contain alpha-tocopherol (Haas, 1992). Foods high in alpha-tocopherol include almonds, sunflower seeds, hazelnuts, and wheat germ (Jambazian et al., 2005). Vitamin E is easily lost in food processing because it is contained in the germ, or outermost layer of the seed, and the germal layer is often removed. Haas reports that for alpha-tocopherol to be preserved, extraction of the oil from nuts and seeds must be done naturally, as by cold pressing, rather than by the more commonly used heat or chemical extraction processes. Due to the nature of the American diet, intake of natural sources of alpha-tocopherol is often very low. The challenge to dietetic professionals is to design diets within the recommended amounts of this important nutrient. When intake is sufficient, the risk of developing deficiency symptoms is depleted.

The Food and Drug Administration (FDA) recently approved the first qualified health claim for conventional food, stating that 1.5 ounces nuts a day, including almonds, may reduce the risk of heart disease when part of a diet low in saturated fat and cholesterol. Jaceldo-Sielg, Sabaté, Rajaram, and Fraser (2004) studied the impact of long-term almond supplementation in 43 healthy men and 38 healthy women. All subjects were followed for 1 year; in the second 6 months of the study, subjects added almonds to their diets (approximately 52 g daily), increasing their alpha-tocopherol intake by an average of 66% per day. Intake of saturated fat decreased by 3%, and consumption of monounsaturated fat and polyunsaturated fat increased by 42 and 24%, respectively. In spite of the increased total fat intake in the almond supplemented diets by an average of 20%, changes in the dietary fatty acid profile were favorable. The shift in a healthier fat intake (i.e., less saturated fat and more monounsaturated fat and polyunsaturated fat) in those who consumed 52 g of almonds per day was accompanied by a decreased cholesterol intake, with final intake being than 200 mg cholesterol per day. This cholesterol intake level is within the AHA's recommendation for those individuals who have an increased risk of developing CHD. Table 2 shows the fatty acid profile of almond oil and soybean oil.

Benefits from the Composition of Nuts

Kris-Etherton et al. (1999) reported that the energy content of nuts ranges from 23.7 to 29.3 kilojoules (kJ) per g (161 to 199 kilocalories [kcal]) per ounce). Approximately 79% of the energy in nuts comes from fat. However, it is important to note that in some nuts such as almonds, monounsaturated fatty acids (MUFAs) are more abundant than saturated fatty acids (SFAs). Nuts are also sources of several cardioprotective nutrients, including manganese, copper, magnesium, zinc, and arginine.

Table 2

Fatty Acid Profile and Alpha-Tocopherol Content of Almond Oil and Soybean Oil

Oil	SFA(g)	MUFA(g)	PUFA(g)	Alpha-tocopherol(mg)
Almond	1.11	9.51	2.37	5.33
Soybean	2.04	1.49	6.16	1.25

Note. Values given are per one tablespoon of oil. SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids.

Diets low in SFAs have been shown to reduce the process of atherosclerosis development. These events lead to lessened risk of developing CHD in both males and females of all ages.

Hyson, Schneeman, and Davis (2002) found that the effects of whole almonds and almond oil had similar effects on plasma lipids and LDL oxidation in men and women. There was a significant reduction in total plasma cholesterol by 4% and a reduction in LDL cholesterol by 6% in groups who consumed whole almonds or almond oil when compared with baseline total and LDL cholesterol readings for the group who did not consume the almond products. The magnitude and direction of lipid changes associated with whole almonds did not differ from those of almond oil. This research demonstrates that the favorable effect of almonds is mediated by components in the oil fraction of the nut, which includes alpha-tocopherol and other nonsaponifiable compounds. According to Lonn and Yusuf (1999), reducing serum cholesterol levels has been shown to be an effective strategy for preventing CHD. When total cholesterol is lowered, the availability of LDL particles is reduced, and therefore there is a lessened chance that oxidization of LDL will occur.

Jambazian et al. (2005) designed a randomized, controlled feeding trial demonstrating dose-response enrichment of erythrocyte alpha-tocopherol levels and total plasma cholesterol levels through ingestion of a single alpha-tocopherol rich food. This study was designed to assess the effect of almond intake on plasma and erythrocyte tocopherol concentrations in healthy adults. Sixteen men and women who were not taking vitamin E or multivitamins were studied. The subjects were fed three diets for 4 consecutive weekly cycles: a control diet (in which almonds were not part of total energy intake), a low almond diet (comprising of 10% of total energy intake), and a high almond diet (comprising of 20% of total energy intake) (Jambazian et al., 2005). High pressure liquid chromatography was used to determine plasma alpha-tocopherol levels. By incorporating almonds into the diet, participants were able to meet the RDA of 15 mg alpha-tocopherol per day; erythrocyte alpha-tocopherol concentrations were increased as a result. The authors found that total blood cholesterol levels were reduced when the high almond diet was consumed versus both the control and low almond diets.

Intake

It is important to establish the optimum dose of vitamin E needed to provide protection against heart disease. According to Haas (1992), establishing this dose is a difficult task, however, for the reason that each trial contains different populations and, thus, many different intakes of vitamin E are required to provide optimum protection. Because atherosclerosis often begins at a young age, possible benefits of prolonged vitamin E supplementation starting early in life is one method that may serve as a primary prevention of CHD (Pryor, 2000). Haas stated that the amount of vitamin E required depends upon body size and the level of polyunsaturated fats in the diet. Air pollution, supplemental estrogen, and increased intake of refined and fried foods result in amplified needs for vitamin E. According to Kaul et al. (2001), the minimum dose of alpha-tocopherol required to obtain a beneficial effect on LDL has been found to be 400 IUs of synthetic vitamin E per day (equivalent to 268 mg RRR-alpha-tocopherol). Pruthi et al. (2001) reported that the amount of vitamin E necessary to protect against CHD has been estimated at 100-400 IUs (equivalent to 67-268 mg) of RRR-alpha-tocopherol per day, based on previous clinical trials. It is acknowledged, however, that the exact intake needed to prevent CHD has not been scientifically determined thus far.

It has been suggested that vitamin E is safe at levels up to 800 IUs (synthetic form) per day (Pryor, 2000),which is equivalent to 536 mg RRR-alpha-tocopherol. Synthetic vitamin E has been documented to decrease platelet adhesion at levels of supplementation above 400 IUs (equivalent to 268 mg RRR-alpha-tocopherol) per day in human studies. Animal studies involving rabbits (Pryor, 2000) that consumed 0.5% synthetic (all-rac-alpha-tocopherol) vitamin E-enriched feed reduced the extent of ex vivo oxidation of LDL by 32%. In a study by Varlangieri and Bush (1992), male monkeys that were given 108 IUs (equivalent to 72 mg) of the RRR-alpha-tocopherol form per day for 3 years showed significant improvement in the progression of atherosclerosis. Animals given the vitamin after the development of arterial narrowing showed no further progression of CHD. In addition, the monkeys experienced a decrease in the degree of arterial narrowing. It is possible that the effects seen in animal studies may be replicated in human subjects as well.

Trials

The Women's Health Study, conducted by the National Institutes of Health (NIH) beginning in 1992, involved 39,876 women in the health care profession who were free of diagnosed CHD at the time of entry into the trial (Pruthi et al., 2000). All participants were at least 45 years of age and were assigned at random to consume 50 mg beta-carotene, 600 IUs synthetic vitamin E (equivalent to 402 mg RRR-alpha-tocopherol), 100 mg aspirin, and/or placebos on alternate days. Follow-up questionnaires were sent 6 months and every 12 months thereafter requesting information on relevant end points. The study was completed in 1995; results are currently undergoing analysis (National Heart, Lung, and Blood Institute [NHLBI], 2005).

The Women's Antioxidant and Cardiovascular Study conducted by the NHLBI began in 1993 and involved 8,172 women who have reported a history of some form of CHD. Baseline dietary assessments were made using food frequency questionnaires, and information was obtained on aspirin use. The study provided women in the experimental group with 500 mg of vitamin C or a placebo daily, 600 IUs synthetic vitamin E (equivalent to 402 mg RRR-alpha-tocopherol) or placebo on alternate days, and/or 50 mg of beta-carotene or placebo on alternate days. Endpoints were followed by mail for 4 years. All major cardiovascular events, such as non-fatal MI, non-fatal stroke, a coronary revascularization procedure, and cardiovascular mortality were recorded. The study concluded in 1996; analysis of the data is currently underway. The trial may demonstrate if antioxidant and/or aspirin use correlates with a decreased number of cardiac episodes (NHLBI, 2005).

Increasing Intake

Because most Americans do not meet the RDA for vitamin E by diet alone, it is important to find ways in which vitamin E may be incorporated naturally and efficiently into the diet, particularly if they do not take a multivitamin. One way to increase the intake of vitamin E is by substituting products high in alpha-tocopherol for those that are lower in alpha-tocopherol, rather than finding other dietary sources of the vitamin. Baked products often call for vegetable (soybean) oil in standard recipes. However, soybean oil is not a rich source of alpha-tocopherol. Products such as almonds and almond oil are considered to be among the best sources of alpha-tocopherol. According to the USDA Standard Release 17 (SR 17), almond oil and soybean oil contain 5.3 and 1.10 milligrams of alpha-tocopherol per tablespoon, respectively (USDA, 2002). Using just one tablespoon of almond oil per day will provide over one third of the RDA for men and women.

Food Product Testing

Penfield and Campbell (1990) previously established a series of guidelines for food sample evaluation. The guidelines state that it is necessary to provide the food at its customary serving temperature because the sense of taste is not as accurate at extreme temperatures. White or clear containers used to hold the samples are superior to other colors, and a coding system is needed to prevent sample bias. Finally, because individuals tend to rate the first samples the highest, randomizing the product order helps eliminate order effects. According to Penfield and Campbell's research, it is best to test samples midmorning or midafternoon so that hunger and satiety are less likely to influence the participants' decisions. Water and crackers may be provided between samples to cleanse the palate and to remove residue from the mouth (Penfield & Campbell, 1990).

Sensory Evaluation

The overall acceptability of products can be effectively assessed using sensory evaluation. According to Popper, Rosenstock, Schraidt, and Kroll (2004), the level of consumer acceptability is often assessed by asking consumers to rate how much they like a product overall. One rating method is known as the hedonic test. The nature of this test involves a nine-point rating scale in which categories range from "like extremely" to "dislike extremely" ("Sensory Evaluation," 2005). In the 1950s, considerable work was done at the U.S. Army Quartermaster Food and Container Institute to establish methodology for predicting soldiers' food choices The relevance and reliability of the hedonic scale method, based on known rating scale methods used in psychology, were established through extensive field testing of army rations of all types (IOM, 2002). Since the development of the technique, the nine-point hedonic scale has been used extensively and validated by numerous studies of food products. Hegenbart (1992) points out that hedonic tests are very flexible and can vary in design to determine preference for many different attributes. For this reason, studies frequently include questions about other product attributes. In terms of food acceptability, these questions may be related to the sensory properties of the food, such as its flavor, texture, and appearance (Popper et al.).

Mattes (1993) has extensively researched the methods required when conducting a sensory test. Initially, all costs involved with the experiment must be estimated. Available resources, including space, facilities, and support staff, should be determined. Mattes stated that the principal investigator must determine the eligibility and exclusionary criteria for subjects, and approval from the university's Institutional Review Board (IRB) must be obtained before initiating the research. Because a strict time schedule is required when the data collection takes place, it is important to prepare all instructional materials, response forms, consent forms, and similar items in advance; participant's individual packets should be pre-assembled so that the data collection will run efficiently. Mattes' research suggested higher success rates in data collection reliability if "randomization orders are used when assigning testing conditions" to each participant. A master sheet of sample presentation orders and label sample presentation containers with blinding codes are recommended. Finally, Mattes indicated there is a need to overestimate the attrition rate when recruiting subjects so that the final sample will meet the projected power requirements.

CHAPTER III

METHODOLOGY

Human Subjects Approval

Approval for this study was obtained from the Institutional Review Board (IRB) of Texas Woman's University (TWU) – Houston (see Appendix A).

Participants

Participants were recruited from TWU – Houston Center and surrounding Texas Medical Center institutions by word-of-mouth and posted flyers. Each participant was seated at an individual table with cardboard partitions to ensure privacy and prevent distraction during testing. Both verbal and nonverbal interaction were discouraged. A glass of water and four unsalted crackers were placed at each table in order to cleanse the palate between samplings. Subjects were informed that they were taking part in a research study examining the likeability of various baked products prepared with both soybean oil and almond oil. Each participant was assigned a coded number to ensure anonymity.

Food Products

Eight food products were tested. These were carrot muffins, bread, cornbread, and chocolate chip cookies made with almond oil or soybean oil. Two of the recipes (cornbread and chocolate chip cookies) were obtained from the Better Homes and Gardens cookbook. The other two recipes (carrot muffins and bread) had previously been used to prepare food products in feeding studies for the Department of Nutrition and

Food Sciences at TWU. The recipes are given in Appendix B. The carrot muffins were 33% of the standard serving size given in the recipe and were prepared as mini muffins. The bread was 100% of the standard serving size given in the recipe. The cornbread was 50% of the standard serving size given in the recipe. Chocolate chip cookies were 100% of the standard serving size given in the recipe. Table 3 displays the usual and actual serving sizes utilized for this experiment, along with the mean, median, and range of the cooked weights for each product. The nutrient content of food products was estimated using nutrient values obtained from the SR 17, as well as other sources. Adjustments were then made for loss of moisture and loss of alpha-tocopherol and gamma-tocopherol due to the cooking (see Table 4).

Questionnaires

Participants first filled out Part I of the study questionnaire (see Appendix C), which served as a consent form. Participants were asked to indicate if they were allergic to any of the food items; if a response of "yes" was given, subjects were asked to notify the study director and were not allowed to participate in the study. The consent form also asked the participants to indicate if they were at least 18 years of age; if a response of "no" was given, subjects were asked to notify the study director and were not allowed to participate. A final component of the consent form asked participants to indicate their gender by checking as response next to "male" or "female." Participants were then asked to fill out Part II of the questionnaire (see Appendix D). Part II of the questionnaire consisted of a nine point hedonic scale used to evaluate four hedonic characteristics: texture, appearance, taste, and overall likeability. Individuals were asked to check the box

Table 3

Standard and Actual Serving Sizes; Mean, Median, and Range of Product Weights

	Serving per recipe		AO			SBO		
Product	Standard	Actual	Mean	Median	Range	Mean	Median	Range
CM	8 muffins	24 mini	20.6[a]	20.2	12.1-25.0	20.6	20.4	12.1-25.0
Bread	16 slices	16 slices	27.6	29.7	18.2-36.6	27.9	18.4	22.8-39.0
CB	8 slices	16 slices	34.9	35.7	19.4-47.2	34.9	27.8	21.8-47.2
CCC	36 cookies	36 cookies	24.4	23.1	20.1-26.4	22.9	6.3	24.3-30.5

Note. AO = almond oil; SBO = soybean oil; CM = carrot muffins; CB = cornbread; CCC = chocolate chip cookies. [a] = grams per 1 serving per actual servings used.

Table 4

Wet Weight, Cooked Weight, and Estimated Tocopherol Concentration per One Serving

Product	Wet weight(g)	Cooked weight(g)	ML on cooking(g)	Alpha-tocopherol(mg)	Gamma-tocopherol(mg)
Carrot muffins					
AO	92.9	61.68	31.2	3.60	.32
SBO	92.9	61.68	31.2	.90	7.62
Bread					
AO	32.52	27.59	4.93	1.04	.04
SBO	32.52	29.67	2.85	.55	1.14
Cornbread					
AO	43.27	34.91	8.36	1.32	.17
SBO	43.27	35.73	7.54	.30	3.16
Chocolate chip cookies					
AO	50.07	23.08	26.99	4.44	4.49
SBO	50.07	24.41	25.66	1.23	11.58

Note. Carrot muffin values are based on the standard muffin serving size. Changes in moisture and losses of tocopherol during cooking were taken into account when calculating the tocopherol concentrations of the food products. The retention factor used for alpha-tocopherol and gamma-tocopherol was 75%.

AO = almond oil; SBO = soybean oil.

that best described their degree of like/dislike/neutral feelings for the food sample. The numbers one, two, and three indicated negative ratings; the numbers four, five, and six indicated neutral ratings, and the numbers seven, eight, and nine indicated positive ratings. Each hedonic scale sheet corresponded to one food item: carrot muffins, bread, cornbread, and chocolate chip cookies. In addition, participants were asked to choose which of the two products they preferred.

The order in which participants sampled the products was predetermined by the order of the hedonic scale sheets in their packets. There were eight possible sequences in which products were offered. These sequences were based on a Latin square design, which ensured counterbalancing of products so that order effects could be minimized. Products were color-coded as red, representing almond oil, or blue, representing soybean oil (see Appendix E). This design was chosen because, on the advice of a statistician, the taste effects of the chocolate in the chocolate chip cookies could have possibly have affected the taste of subsequent food products. Products were always tested in pairs. A space was provided for open-ended comments at the end of each questionnaire.

Statistical Tests

The values obtained from the Likert scales were analyzed by Analysis of Variance (ANOVA) using the Statistical Package for the Social Sciences (SPSS) computer statistical tool, version 11.5. The steps used to analyze the data for this study by means of SPSS is given in Appendix F. A split plot factorial ANOVA (similar to a paired t test) with regards to the F test was used in this experiment because there was a possibility of an interaction (main effect) of oils due to sampling error. In addition, the split plot

ANOVA was used in place of a classic ANOVA because the split plot is designed specifically for experiments in which there is: (a) at least one variable that is between subjects and at least one variable that is within subject; (b) multiple sub-plots, and (c) restriction on the randomization of the order in which the products are presented (from "The Split Plot ANOVA," 2005). Thus, the split plot factorial ANOVA revealed any differences in the order in which products were tested (order effects) and determined if significant differences existed in the rating scores for each product in terms of texture, appearance, taste, and overall likeability. Appendix G gives a summary of the split plot ANOVA design used in this study. The design scheme demonstrates that there are multiple treatment layers and sub-plots. In order to determine if differences existed in between males and females with regards to texture, appearance, taste, overall likeability, and overall preference, an independent t-test was used. The significance level was set at $p \leq .05$ for each statistical test analyzed. The raw data for SPSS are given in Appendix H.

CHAPTER IV

RESULTS

Population

Seventy-one participants consisting of 31 males (43.7%) and 40 females (56.3%) were included in the study.

Results of Likert Rating Scores for Almond Oil and Soybean Oil Products: Main Effects

Table 5 displays the mean, standard deviation, and coefficient of variation for carrot muffins prepared with almond oil and soybean oil, as well as the results for the hypothesis test. No significant differences were observed. Table 6 displays the mean, standard deviation, and coefficient of variation for bread prepared with almond oil and soybean oil, as well as the results for the hypothesis test. Regarding texture, taste, and overall likeability, all reached the specified .05 significance level, being $F(1, 62) = 5.66$, $p = .020$; $F(1, 62) = 4.16$, $p = .046$; and $F(1, 63) = 7.32$, $p = .009$, respectively. Table 7 displays the mean, standard deviation, and coefficient of variation for cornbread prepared with almond oil and soybean oil, as well as the results for the hypothesis test. No significant between-product differences were observed. Table 8 displays the mean, standard deviation, and coefficient of variation for chocolate chip cookies prepared with almond oil and soybean oil, as well as the results for the hypothesis test. No significant differences were observed.

Table 5

Results of Hedonic Rating Scores for Almond Oil and Soybean Oil Carrot Muffins

	Almond oil			Soybean oil			Test of hypothesis		
Variable	*M*	*SD*	*CoV(%)*	*M*	*SD*	*CoV(%)*	*F*	*df*	*p*
Texture	6.9	2.0	29.0	6.7	2.1	31.3	.479	1	.491
Appearance	6.9	1.7	24.3	6.9	1.9	27.5	.025	1	.875
Taste	6.3	2.3	36.6	6.6	2.2	33.3	.374	1	.941
Overall likeability	6.5	2.1	31.4	6.9	1.9	27.5	1.54	1	.219

Note. Test of hypothesis reveals if significant differences were observed in the mean rating hedonic scale scores. M = mean scores based on the hedonic scale ratings; SD = standard deviation; CoV = coefficient of variation (SD/M*100%); F = *F* test; df = degrees of freedom.

Table 6

Results of Hedonic Rating Scores for Almond Oil and Soybean Oil Bread

	Almond oil			Soybean oil			Test of hypothesis		
Variable	*M*	*SD*	*CoV(%)*	*M*	*SD*	*CoV(%)*	*F*	*df*	*p*
Texture	5.8	2.4	40.4	5.2	2.4	46.2	5.66*	1	.020
Appearance	6.1	1.8	29.5	6.0	1.9	31.7	.956	1	.332
Taste	5.4	2.5	46.3	4.9	2.4	49.0	4.16*	1	.046
Overall likeability	5.6	2.4	42.9	4.9	2.3	47.0	7.32*	1	.009

Note. Test of hypothesis reveals if significant differences were observed in the mean rating hedonic scale scores. M = mean scores based on the hedonic scale ratings; SD = standard deviation; CoV = coefficient of variation (SD/M*100%); F = *F* test; df = degrees of freedom.

*$p < .05$.

Table 7

Results of Hedonic Rating Scores for Almond Oil and Soybean Oil Cornbread

	Almond oil			Soybean oil			Test of hypothesis		
Variable	*M*	*SD*	*CoV(%)*	*M*	*SD*	*CoV(%)*	*F*	*df*	*p*
Texture	6.7	1.7	25.4	6.8	1.9	27.9	.233	1	.693
Appearance	7.1	1.6	22.5	7.2	1.4	19.4	.758	1	.387
Taste	6.2	2.0	32.3	6.2	2.1	33.9	.167	1	.684
Overall likeability	6.6	2.0	30.3	6.6	1.7	25.8	.183	1	.670

Note. Test of hypothesis reveals if significant differences were observed in the mean rating hedonic scale scores. M = mean scores based on the hedonic scale ratings; SD = standard deviation; CoV = coefficient of variation (SD/M*100%); F = *F* test; df = degrees of freedom.

Table 8

Results of Hedonic Rating Scores for AO and SBO Chocolate Chip Cookies

	Almond oil			Soybean oil			Test of hypothesis		
Variable	*M*	*SD*	*CoV(%)*	*M*	*SD*	*CoV(%)*	*F*	*df*	*p*
Texture	7.1	1.9	26.8	7.1	1.9	26.8	.035	1	.852
Appearance	7.2	1.6	22.2	7.0	1.8	25.7	.849	1	.360
Taste	7.4	1.6	21.6	7.2	1.8	25.0	.627	1	.432
Overall likeability	7.4	1.5	20.3	7.1	1.7	23.9	1.71	1	.190

Note. Test of hypothesis reveals if significant differences were observed in the mean rating hedonic scale scores. AO = almond oil; SBO = soybean oil; M = mean scores based on the hedonic scale ratings; SD = standard deviation; CoV = coefficient of variation (SD/M*100%); F = *F* test; df = degrees of freedom.

Order Effects for Almond Oil versus Soybean Oil Products: Main Effects

Table 9 reveals that there were no statistically significant ($p \leq .05$) differences in the F test for the carrot muffins, bread, cornbread, and chocolate chip cookies based on the order in which products were taste-tested.

Overall Preference of Almond Oil versus Soybean Oil Products: Main Effects

Table 10 shows the outcome for overall preference selection for almond oil versus soybean oil products. Some of the participants did not fill out this section of the questionnaire. No statistically significant differences ($p \leq .05$) were found between the overall preferences for almond oil products versus soybean oil products.

Gender Differences: Main Effects

No significant differences were observed in the mean rating scores given by males versus females based on the independent samples t test (see Table 11).

Comments Given by Participants

Participants were invited to make comments concerning each of the baked food items. The comments for the carrot muffins are given in Table 12 (soybean oil) and Table 13 (almond oil); comments for the bread are given in Table 14 (soybean oil) and Table 15 (almond oil); comments for the cornbread are given in Table 16 (soybean oil) and Table 17 (almond oil); and comments for the chocolate chip cookies are given in Table 18 (soybean oil) and Table 19 (almond oil).

Table 9

Determining if the Order that Products were Received Makes a Significant Difference

	Appearance			Texture			Taste			Overall likeability		
Product	*F*	*df*	*p*	*F*	*df*	*p*	*F*	*df*	*p*	*F*	*df*	*p*
CM	1.01	7	.432	.815	7	.491	.374	7	.456	.686	7	.684
Bread	.616	7	.740	.573	7	.775	.641	7	.720	.774	7	.611
CB	.084	7	.773	1.18	7	.330	.555	7	.789	.585	7	.765
CCC	.343	7	.931	.713	7	.645	.356	7	.924	.490	7	.838

Note. F = *F* test; df = degrees of freedom; CM = carrot muffins; CB = cornbread; CCC = chocolate chip cookies.

Table 10

Overall Preference for Almond Oil versus Soybean Oil Products

Product	Almond oil[a]	Soybean oil[a]	Missing responses	*p*
Carrot muffins	34	32	5[b]	.902
Bread	35	29	7[c]	.532
Cornbread	34	31	6[d]	.804
Chocolate chip cookies	36	32	3[e]	.625

Note. No significant results were found between the products prepared with almond oil versus the products prepared with soybean oil. [a]N = 71 total participants. [b] = 2 males and 3 females. [c] = 3 males and 4 females. [d] = 3 males and 3 females. [e] = 2 males and 1 female.

Table 11

Average Hedonic Rating Scores for Males versus Females

	Soybean oil		Almond oil	
Product	Males ±*SD*	Females ±*SD*	Males ±*SD*	Females ±*SD*
CM texture	6.4 ±2.2	6.9 ±2.0	6.9 ±2.1	7.0 ±2.0
CM taste	6.7 ±2.5	6.8 ±2.0	6.7 ±2.3	6.1 ±2.4
CM appearance	6.4 ±2.2	7.2 ±1.6	6.7 ±1.8	7.2 ±1.6
CM overall likeability	6.7 ±2.2	7.1 ±1.7	6.7 ±2.2	6.4 ±2.0
Bread texture	5.1 ±2.5	5.3 ±2.5	5.4 ±2.3	6.2 ±2.4
Bread taste	4.6 ±2.6	5.1 ±2.3	4.9 ±2.1	5.8 ±2.7
Bread appearance	5.9 ±2.2	6.1 ±1.8	5.9 ±1.9	6.3 ±1.8
Bread overall likeability	4.6 ±2.2	5.2 ±2.3	5.1 ±2.1	6.0 ±2.6
CB texture	7.0 ±1.6	6.5 ±1.9	6.9±1.4	6.5±1.9
CB taste	6.2 ±2.0	6.3 ±2.2	5.9 ±1.9	6.3 ±2.1
CB appearance	7.4 ±1.3	7.1 ±1.4	7.1 ±1.3	7.0 ±1.7
CB overall likeability	6.7 ±1.6	6.6 ±1.8	6.4 ±1.8	6.6 ±2.1
CCC texture	6.9 ±2.2	7.3 ±1.5	6.7 ±2.2	7.3 ±1.9
CCC taste	7.5 ±1.3	7.1 ±1.9	7.4 ±1.3	7.5 ±1.7
CCC appearance	6.8 ±2.0	7.2 ±1.7	7.1 ±1.6	7.2 ±1.8
CCC overall likeability	7.1 ±1.7	7.1 ±1.7	7.3 ±1.2	7.5 ±1.6

Note. Scores are based on a 9-point scale with 1 representing the lowest score and 9 representing the highest score. SD = standard deviation; CM = carrot muffins; CB = cornbread; CCC = chocolate chip cookies.

Table 12

Carrot Muffins Prepared with Soybean Oil

Comment	Number of times repeated
Positive	
Good	2
Flavorful	1
Richer taste than the red	1
Loved the texture	1
Sweeter than the red	1
Moister than the red	1
Very good	1
Negative	
Dry	5
Texture is too dense	1
Weird aftertaste	1
Bitter aftertaste	1
Faint greenish-blue color	1
Disgusting	1
Mushy	1
Do not like the large chunks of carrot	1
Neutral	
Has more raisins than the red	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

Table 13

Carrot Muffins Prepared with Almond Oil

Comment	Number of times repeated
Positive	
Good	2
Sweeter than the blue	1
Very good	1
Moister than the blue	1
Negative	
Has an aftertaste	2
Not much flavor	2
Dry	2
Do not care for appearance	1
Disgusting	1
Do not like taste	1
Needs more sweetness	1
Greasy	1
I do not like the large chunks of carrot	1
Somewhat powdery	1
Neutral	
Lighter in color than the blue	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

Table 14

Bread Prepared with Soybean Oil

Comment	Number of times repeated
Positive	
Blue is drier	3
Very good	1
Negative	
Tastes like dough	8
Undercooked	3
Pale	2
Bad taste	2
Gummy texture	2
Too chewy	1
Strong yeast taste	1
Somewhat bitter taste	1
Little flavor	1
Too moist	1
Disgusting	1
I can taste the flour	1
I do not like the smell of the bread	1
Greasy	1
Mushy	1
Not my taste	1
Neutral	
Hard to tell a difference	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

Table 15

Bread Prepared with Almond Oil

Comment	Number of times repeated
Positive	
Tastes very good	3
Negative	
Tastes like dough	5
Has little flavor	3
Gummy	3
Undercooked	2
Pale	2
Too moist	2
Disgusting	1
Strong yeast taste	1
I do not like the smell of the bread	1
Not as dense or mushy as the blue	1
Not my taste	1
Neutral	
It's hard to tell a difference	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

Table 16

Cornbread Prepared with Soybean Oil

Comment	Number of times repeated
Positive	
Moister than the red	3
Sweeter than the red	1
Better taste than the red	1
Cornbread is my favorite food	1
Softer than the red	1
Very good	1
Better texture than the red	1
I like the taste	1
Negative	
Needs more cooking time	2
Has a funny aftertaste	2
Texture was a little too dense	1
Not good	1
Needs a little more sugar	1
Mealy texture	1
Brown spots inside the cornbread	1
Neutral	
Stronger taste than the red	1
Looks lighter in color	1
Tastes similar to the red	1
Distinct, nutty flavor	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

Table 17

Cornbread Prepared with Almond Oil

Comment	Number of times repeated
Positive	
Good taste	3
Moister than the blue	3
Cornbread is my favorite food	1
Excellent flavor	1
Negative	
Lacked flavor	1
Funny aftertaste	1
Too gummy	1
Neutral	
Tastes similar to the blue	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

Table 18

Chocolate Chip Cookies Prepared with Soybean Oil

Comment	Number of times repeated
Positive	
Great taste	4
Less crumbly	1
Soft	1
I would buy this	1
Like the taste	1
I like the texture better than the red	1
Negative	
Too many chocolate chips to assess taste	1
Too sweet	1
Left an oily aftertaste	1
Too hard	1
Tastes funny	1
Terrible aftertaste	1
Too thick and round	1
Tastes salty	1
Has a faint greenish-blue color	1
Neutral	
This has more chips than the red	2
Not as many chips as the red	1
Chewy	1
Lighter in color than the red	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

Table 19

Chocolate Chip Cookies Prepared with Almond Oil

Comment	Number of times repeated
Positive	
Very good	2
Soft	2
Has a nice golden color	1
Great taste	1
Tasty	1
I would buy this	1
Better tasting than the blue	1
I loved the taste of this cookie	1
Like the texture	1
Sweeter than the blue	1
Negative	
Crumbly	2
Seems saltier than the blue	2
Felt oily	2
Too sweet	1
Dry	1
I prefer cookies that are chewier	1
Neutral	
Chewy	2
Lighter in color than the blue	1

Note. Participants were unaware of the type of oil used in each product; food products were color-coded. A blue label indicated the product was prepared with soybean oil; a red label indicated that the product was prepared with almond oil.

CHAPTER V

DISCUSSION

The hypothesis is that baked products prepared with almond oil will be more acceptable than baked products prepared with soybean oil. That is, for a majority of the products tested (at least three out of four), the overall rating scores and overall preference for products containing almond oil will be significantly greater than for the corresponding products containing soybean oil. However, this study found that, based on responses given by the study population, products prepared with almond oil were not significantly more acceptable in terms of rating scores and overall product preference than products prepared with soybean oil. Thus, the hypothesis is rejected.

Only the whole wheat bread prepared with almond oil in place of soybean oil produced statistically significant results; for all other products for every parameter (taste, appearance, texture, and overall likeability), no statistically significant differences were found. With regards to texture, the bread prepared with almond oil received significantly higher scores than the bread prepared with soybean oil for texture ($p = .02$), taste ($p = .046$), and overall likeability ($p = .009$). Because participants gave higher scores for these three parameters for the almond oil bread versus the soybean oil bread, it would be reasonable to say that the participants preferred the taste of the bread made with almond oil to the one made with soybean oil using hedonic scores as the criteria of acceptability. Although more subjects preferred the bread made with almond oil to the one made with soybean oil (35 versus 29), subjects did not indicate a statistically significant preference for the bread made with almond oil. With regards to overall preference of the pairs of carrot muffins, bread, cornbread, and chocolate chip cookies, no statistically significant differences were observed. This may be because participants were unable to detect large differences in the products prepared with almond oil in place of the more commonly-used soybean oil.

The order in which participants received the food items did not affect the rating scores for texture, appearance, taste, overall likeability, or overall product preference. The Latin square design prevents order effects by counterbalancing, making it a statistical tool useful for this study. Counterbalancing is of interest because it can determine if the sampling of food products in different orders by different individuals is affected by which product is eaten first, second, third, and so forth. The method of using counterbalancing is a technique used by researchers to ensure unbiased responses; examples can be found in the literature relating to the use of different food products. One example, published in the American Journal of Clinical Nutrition, is entitled *Snacks consumed in a nonhungry state have poor satiating efficiency: Influence of snack composition on substrate utilization and hunger* by Marmonier, Chapelot, Fantino, and Louis-Sylvestre (2002.) The authors describe the use of counterbalancing the foods consumed by eight men at various times of the day. The counterbalanced Latin square design was necessary to ensure complete randomization of the order in which the men received the food items. The method of counterbalancing utilized by these authors is similar to the design used in the present research study.

Some individual participants did not indicate which product they preferred overall on their hedonic score rating sheets (see Table 10). At least one male and at least one female gave missing data for each product. It is possible that the participants who did not provide an answer to the question of overall product preference simply did not prefer one product versus another, and therefore chose not to indicate a response. Other possibilities as to why data may be missing for the overall preference question is that the participants overlooked this item due to their being in a hurry or possibly becoming distracted during the sensory analysis. However, it is important to note that the number of overall missing data responses for each product was minimal.

Statistically significant gender differences were not observed; it was determined that males (31 total), in comparison to females (40 total), did not have significantly different Likert rating scores with regards to texture, appearance, taste, and overall likeability; scores given were very similar for both genders (see Table 11). This is not unexpected because there is no known information in the literature suggesting that carrot muffins, bread, cornbread, and chocolate chip cookies are preferred by one gender more than the other. The foods used in this experiment are generally thought of as being familiar to both males and females, and therefore, it is logical that the Likert rating scores given by males and females were not statistically different. According to Haskell and Kiernan (2000), statistical power can be increased by enlarging the sample size. Therefore, it is possible that the use of more subjects may show statistically significant differences between the genders for one or more of the hedonic parameters studied.

There is little information available in the literature concerning the use of Likert scales and the randomization of food products. Numerous searches were attempted using the PubMed database, Agricola database, WorldCat database, and the National Agriculture Library to locate journal articles and periodicals containing protocols for the design of a taste-test experiment similar to the one used in this study. Key word searches included "hedonic tests," "food analysis," "research design," "taste," "Likert scale," "baked food products," and "sensory evaluation."

Eight relevant articles were found in the Journal of the American Dietetic Association between 1993 and 2000 that mention ingredient substitution or hedonic testing. The eight articles are: a) *Eating quality of muffins, cake, and cookies prepared with reduced fat and sugar* by Fulton and Hogbin (1993); b) *Effect of packing, equipment, and storage time on sensory characteristics of beef stew* by Pizzimentin and Cremer (1994); c) *Effect of fat replacement on sensory attributes of chocolate chip cookies* by Charton and Sawyer-Morse (1996); d) *Acceptability of oatmeal chocolate chip cookies prepared using pureed white beans as a fat ingredient substitute* by Rankin and Bingham (2000); e) *Acceptability of peanut butter cookies prepared using mungbean paste as a fat ingredient substitute* by Adari, Knight, and Gates (2001); f) *Acceptability of reduced-fat brownies by school-aged children* by Swanson, Perry, and Garden (2002); g) *Moisture retention and consumer acceptability of chocolate bar cookies prepared with okra gum as a fat ingredient substitute* by Romanchik-Cerpovicz, Tilmon, and Baldree (2002); h) *Pureed cannellini beans can be substituted for shortening in brownies* by Szafranski, Whitting, and Bessinger (2005). However, the majority of the articles located did not give specific information with regards to product randomization. Only one article located gave details as to the exact type of statistical design used to determine product order. This was entitled *Eating quality of muffins, cake, and cookies prepared with reduced fat and sugar* by Fulton and Hogbin. The participants in this study rated the texture and shape of muffins, texture and moistness of cake, and color of cookies using 9-point hedonic scales. The statistical design utilized was noted to be a balanced incomplete block. The balanced incomplete block is a means of ensuring that every pair of treatments occurs together; this design ensures accuracy in the treatment regimens (Vinthanage, 2005). The incomplete block design used in Fulton and Hogbin's study is similar to a Latin square design. Fulton and Hogbin's research indicates that control over the order in which food products are received is necessary and may be achieved through a statistical design. An additional article from the Journal of the American Dietetic Association entitled *Acceptability of reduced-fat brownies by school-aged children* by Swanson, Perry, and Garden describes the use of a 9-point hedonic scale in which children rated various sensory attributes of a low-fat brownie. The method of product presentation is described as "randomized" and "sequential," but the specific statistical design tool used to randomize the products is not stated. Therefore, it is difficult to determine if a Latin square design or other technique was used in this study to determine the order in which products were received. A similar indistinct pattern concerning the type of statistical design utilized is noted in the article by Rankin and Bingham entitled *Acceptability of oatmeal chocolate chip cookies prepared using pureed white beans as a fat ingredient substitute.* Ninety-two untrained panelists used a 9-point hedonic scale to rate each cookie for appearance, flavor, texture, and overall acceptability. Rankin and Bingham state that four cookie variations were prepared each day of the study according to a randomized plan. The panelists were given four cookies that were coded with four randomly selected letters; coding letters changed for each replication. Rankin and Bingham do not, however, explicitly state the statistical design tool utilized to determine the randomization of product order. Without such information, it is difficult to draw conclusions as to what might be the best or most commonly-used procedure of product randomization in the field of hedonic testing. A specific protocol would be useful for experiments involving taste-tests and hedonic scales so that consistency would be maintained in the field of food product testing.

It is of note that the participants in the present study are believed to be from a highly-educated segment of the population. Silventoinen, Sarlio-Lahteenkorva, Koskenvuo, Lahelma, and Kaprio (2004) point out that education-associated disparities effect the perceptions of certain foods. The majority of the participants in the present study were likely to haven been students from TWU who would have been pursuing degrees of higher education. Participants were also recruited from other Texas Medical Center institutions. These participants would have been highly-educated and included medical students. In addition, the study population was not equivalent in terms of the number of males and the number of females. TWU's enrollment is predominantly female; this is a partial explanation of the higher percentage of women versus men for this study. Because of the higher percentage of decidedly educated particpants and a ratio of males to females that was not one-to-one, results may or may not be generalizable to the overall population. If an evenly-divided study population consisting of the same number of males versus females were desired, perhaps an institution containing a larger percentage of males could be utilized. The number of male and female participants could also be controlled to ensure that there is equality in the representation of men and women.

The number of comments ranged from 12 to 33 responses (for the almond oil cornbread and soybean oil bread, respectively). Comments made by participants can be generally classified as positive, negative, or neutral (see Tables 12 through 19). The number of positive comments ranged from 3 to12 (for the soybean oil bread and almond oil chocolate chip cookies, respectively). The number of negative comments ranged from 3 to 16 (for the almond oil cornbread to the soybean oil bread, respectively). The number of neutral comments ranged from 1 to 5 (the almond oil carrot muffins, almond oil bread, almond oil cornbread, soybean oil carrot muffins, and soybean oil bread all received one neutral comment and the soybean oil cornbread, and soybean oil chocolate chip cookies, received four neutral comments, respectively.) Based on the comments received for all four types of baked food products, it is apparent that there is a wide range of acceptability in the study population.

Table 4 gives the estimated values for the alpha-tocopherol and gamma-tocopherol content for the cooked products. There were higher estimated values for alpha-tocopherol for products made with almond oil than for the corresponding products made with soybean oil. However, the products prepared with soybean oil contained higher levels of gamma-tocopherol than the corresponding products made with almond oil. Both the carrot muffins and cornbread prepared with almond oil would provide approximately 8.7% of the RDA for vitamin E per serving while the chocolate chip cookies would provide 29.3% of the RDA for vitamin E per serving. The bread would provide 6.9% of the RDA for vitamin E per serving. These estimated values indicate that cooking with almond oil rather than soybean oil is a simple method of incorporating greater levels of vitamin E into the diet.

Almond oil yields nutritional advantages over soybean oil not only in terms of alpha-tocopherol levels but also in distribution of MUFAs and SFAs. Almond oil contains 69.9 g MUFAs per 100 g and 17.4 g PUFAs per 100 g, while soybean oil contains 10.98 g MUFAs per 100 g and 57.9 g PUFAS per 100 g (USDA SR 17). MUFAs are documented to be beneficial for heart health, yielding nutritional advantages over PUFAS (AHA, 2005).

The content of SFAs, MUFAs, and PUFAS for the food products are given in Table 20. Because of the differences in the levels of alpha-tocopherol and the levels of fatty acids in soybean oil and almond oil, it may be implied that almond oil is a more advantageous type of oil to use in baking with regards to heart health (Kris-Etherton et al., 1999). Alpha-tocopherol has been postulated to have a cardioprotective effect by reducing free radical damage in tissues. The antioxidant properties of this compound aid with the maintenance of endothelial integrity (Tribble, 1999). Per tablespoon, almond oil contains 5.33 mg alpha-tocopherol (39.17 mg/100 g alpha-tocopherol and .92 mg/100g gamma-tocopherol) while soybean oil contains 1.25 mg alpha-tocopherol (7.46 mg/100g alpha-tocopherol and 79.67 mg/100g gamma-tocopherol). Thus, almond oil is a better source of alpha-tocopherol than to soybean oil. Almond oil is an excellent source of

Table 20

Fatty Acid Profile and Alpha-Tocopherol content of Food Products per One Serving

Product	SFA(g)	MUFA(g)	PUFA(g)	Alpha-tocopherol(mg)
CM				
AO	.93	6.27	1.68	3.60
SBO	1.47	5.1	4.05	.90
Bread				
AO	.21	1.25	.50	1.19
SBO	.31	.45	1.45	.65
CB				
AO	.49	2.57	.76	1.41
SBO	.71	.99	2.14	.33
CCC				
AO	4.55	7.77	3.56	2.73
SBO	4.92	4.94	6.02	.80

Note. Values given for the carrot muffins are based on a regular muffin serving size. SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; CM = carrot muffins; AO = almond oil; SBO = soybean oil; CB = cornbread; CCC = chocolate chip cookies.

vitamin E as it provides more than 20% of the Daily Value (30 IUs or 20.1 mg of alpha-tocopherol per day per serving of one tablespoon). The food items prepared with almond oil in this study produced products with an alpha-tocopherol content that were approximately 77% higher than food items prepared with soybean oil.

As stated previously, it may be difficult for men and women to meet the RDA of 15 mg of the 2R isomers of alpha-tocopherol without supplementation or deliberately incorporating vitamin E-rich products (such as almond oil) into the diet (Maras et al., 2004). One way to increase the levels of vitamin E intake may be the substitution of oils low in vitamin E with oils having higher levels in commonly consumed products. These could include muffins, bread, cornbread, and cookies. Factors that determine the feasibility of this approach include the simplicity of substituting almond oil for soybean oil in recipes and the consensus from this study that doing so produces acceptable products. Simple diet modifications, including the use of use of almond and almond oil, will provide numerous heart health benefits, such as a reduction in atherosclerosis by means of inhibition of LDL oxidation (Carr et al., 2000). Oils such as almond oil that contain alpha-tocopherol in generous quantities maybe utilized not only in baked products, but also in the preparation of salad dressings, marinades, and food items that call for oil to be mixed with the ingredients. There is an abundance of ways in which almond oil may be used for consumption on a daily basis to promote heart health.

Limitations

One limitation of the study could be that the products used were of such a nature that other flavors in the recipe overpowered the oil flavor, and therefore, differences would not be detectable. The chocolate chip cookies were prepared with semi-sweet chocolate chips. The nature of the chocolate taste likely could have masked any differences in detecting the oil taste. The carrot muffins contained raisins, which may have created a product that is too sweet for taste testers to detect differences in the oil used. Therefore, there are products that might show differences because of less strong-tasting ingredients. These could include plain muffins or cookies that do not require chocolate chips. In addition, products in which oil would be a major ingredient, such as salad dressings or pasta, where recipes call for oil to be drizzled on the food, may yield more detectable differences in texture, taste, appearance, and overall acceptability.

A limited number of statistically significant between-product differences were found in the present study (differences were found for the bread only). Perhaps with a larger number of participants, statistically significant data would have been obtained. The degree of hunger was also not considered; participants' responses may have been affected by their current state of fullness. Responses to the questionnaires may have been influenced by the eagerness to eat the products simply to provide satiety. In the future, studies want subjects to rate their hunger subjectively at the time of the tasting.

Future research

Because the results for the texture, taste, and overall likeability of the bread had statistically significant results when $p \leq .05$, it is proposed that additional research be carried out with this baked product. Other recipes for bread could be modified. Because the frequent consumption of grain products is emphasized in the dietary guidelines, an increase in the vitamin E content of grain products like bread could result in significant increases of vitamin E intake.

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APPENDIX A

IRB Approval Form

TWU
TEXAS WOMAN'S UNIVERSITY
DENTON DALLAS HOUSTON

The Graduate School
P.O. Box 425649, Denton, TX 76204-5649
940-898-3415 Fax 940-898-3412

April 12, 2005

Ms. Megan E. Kier
8330 El Mundo St Apt 1023
Houston TX 77054

Dear Ms. Kier:

I have received and approved the prospectus entitled "Acceptability of Food Products Containing Almond Oil in Place of Soybean Oil" for your Thesis research project.

Best wishes to you in the research and writing of your project.

Sincerely yours,

Jennifer Martin

Jennifer L. Martin, Ph.D.
Dean of the Graduate School

ekd

cc: Dr. John D. Radcliffe, Department of Nutrition and Food Sciences-Houston
Dr. Carolyn Bednar, Chair, Department of Nutrition and Food Sciences

APPENDIX B

Recipes

CARROT MUFFINS

Recipe:

Ingredients:

1 ½ cup	grated carrots
1 cup	all-purpose flour
¼ cup	stone ground whole wheat flour
1/3 cup	white sugar
½ cup	raisins
¼ cup + 1 T	soybean oil (use almond oil for almond oil products)
2 tsp	baking powder
¼ tsp	salt
1	medium egg, beaten
½ cup	skim milk
1 tsp	cinnamon

Method: Mix the following ingredients together and bake at 375° F for 18-21 minutes. (Yield: 8 standard size muffins or 24 mini muffins.)

Energy and nutrients per one standard muffin serving size analysis:

	Soybean oil:	**Almond oil:**
Energy (kcal)	232.14	232.14
Protein (g)	3.90	3.90
Carbohydrate (g)	34.83	34.83
Total fat (g)	9.39	9.39
Vitamin E (mg) (alpha-tocopherol)	0.90	3.60

*Note: Alpha-tocopherol levels reflect the 25% loss due to the baking retention factor.

BREAD

Recipe:

Ingredients:

1 cup	all-purpose flour
1 cup	stone ground whole wheat flour
¼ cup	wheat germ
1 Tsp	sugar
½ tsp	salt
¾ cup + 2 T	warm water
1 ¼ tsp	rapid rise yeast
1 T	vital gluten
2 T	soybean oil (use almond oil for almond oil products)

Method: Mix yeast and warm water (100-110° F) together and leave 15 minutes. Mix all other ingredients. Add yeast/water mixture to dough and knead for 8 minutes. Let rise until double in bulk. Punch down and let rise again until double. Bake at 375° F for 18-20 minutes. (Yield: 16 standard size servings.)

Energy and nutrients per one standard serving size analysis:

	Soybean oil:	**Almond oil:**
Energy (kcal)	77.31	77.31
Protein (g)	2.37	2.37
Carbohydrate (g)	15.02	15.02
Total fat (g)	2.11	2.11
Vitamin E (mg) (alpha-tocopherol)	0.49	0.89

*Note: Alpha-tocopherol levels reflect the 25% loss due to the baking retention factor.

CORNBREAD

Recipe:

Ingredients:

1 cup	all-purpose flour
2 Tbsp	sugar
1 Tbsp	baking powder
½ tsp	salt
¼ cup	soybean oil (use almond oil for almond oil products)
2	medium eggs, beaten
1 cup	skim milk
1 cup	cornmeal

Method: Spray bottom and sides of 9x9x2 or 8x8x2 inch baking pan. Stir together flour, cornmeal, sugar, baking powder, salt. Make a well in the center, set aside. Combine eggs, milk, and cooking oil; add to dry mixture. Spoon batter into pan. Bake at 425° F for 18-25 minutes or until wooden toothpick inserted in center comes out clean. Cool on wire rack. (Yield: 8 standard size servings or 16 small servings.)

Energy and nutrients per one standard serving size analysis:

	Soybean oil:	Almond oil:
Energy (kcal)	109.88	109.88
Protein (g)	2.75	2.75
Carbohydrate (g)	15.27	15.27
Total Fat (g)	4.19	4.19
Vitamin E (mg) (alpha-tocopherol)	0.25	1.06

*Note: Alpha-tocopherol levels reflect the 25% loss due to the baking retention factor

CHOCOLATE CHIP COOKIES

Recipe:

Ingredients:

1 cup	packed brown sugar
1 cup	white sugar
1 cup	shortening
1 cup	soybean oil (use almond oil for almond oil products)
2	medium eggs, beaten
2 tsp	vanilla extract
4 cups	all-purpose flour
4 tsp	cream of tartar
2 tsp	baking soda
1 tsp	salt
2 cups	semisweet chocolate chips

Method: Preheat oven to 350° F. In a medium bowl, beat together brown sugar, white sugar, shortening, and oil until smooth. Stir in eggs and vanilla, beating well after each addition. Combine flour, cream of tartar, baking soda, and salt. Stir into sugar mixture. Fold in chocolate chips. Drop by heaping spoonfuls onto a greased cookie sheet. Bake 8-10 minutes. Remove from baking sheet and cool on wire racks. (Yield: 36 standard size cookies.)

Energy and nutrients per one standard serving size analysis:

	Soybean oil:	**Almond oil:**
Energy (kcal)	249.67	249.67
Protein (g)	2.13	2.13
Carbohydrate (g)	28.24	28.24
Total Fat (g)	14.93	14.93
Vitamin E (mg) (alpha-tocopherol)	0.60	2.05

*Note: Alpha-tocopherol levels reflect the 25% loss due to the baking retention factor

APPENDIX C

Questionnaire Part I: Consent Form

QUESTIONNAIRE – PART ONE
CONSENT FORM

COMPLETION OF THIS QUESTIONNAIRE WILL BE CONSTRUED AS INFORMED CONSENT.

The purpose of this consent form is to determine eligibility for the study. Your name is not requested to ensure anonymity and you may withdraw at anytime. You will be asked to taste a total of 10 baked food items for the study. No risks are involved. Information from this study may be used for future research. Thank you for your participation.

Are you allergic to the following items used in this study?

- Skim milk
- Active dry yeast
- Baking powder
- Chocolate
- Carrots
- White Sugar
- Wheat germ
- Ground cinnamon
- Shortening
- Chocolate
- Salt
- Raisins
- Crackers
- All-purpose white Flour
- Whole wheat flour
- Cream of tartar
- Brown Sugar
- Baking Soda
- Vanilla
- Corn meal
- Almond oil
- Soybean oil
- Eggs
- Vanilla extract
- Almonds
- Vital Gluten

YES_______ NO_______ (check one)

If you checked yes, STOP, do not continue. Raise your hand to notify the study director. If you checked no, please continue.

Are at least 18 years of age?

YES_______ NO_______ (check one)

If you checked no, STOP, do not continue. Raise your hand to notify the study director. If you checked yes, please continue.

Please indicate your gender: (check one) _____ Male _____ Female

APPENDIX D

Questionnaire Part II: Hedonic Scale Sheets

Participant ID # ________

QUESTIONNAIRE – PART TWO

PLEASE READ DIRECTIONS BEFORE SAMPLING

1. Check that you are evaluating the right product by matching the name of the products on top of each page.

2. When sampling a specific product, please follow the color order listed on your ratings sheet. (You will be asked to sample either the red or the blue products in a different order for different products)

3. Sample both items of the same product before proceeding to the next item.

4. Water and crackers are provided in order to cleanse your palate between item sampling.

5. Raise your hand when you are finished in order to notify the study director.

CARROT MUFFINS

Rate the **TEXTURE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **APPEARANCE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **TASTE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **OVERALL LIKEABILITY** (including appearance, texture, and taste) of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Which of the two products do you prefer OVERALL? (Circle one) red blue

Comments:____

BREAD

Rate the **TEXTURE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	□	□	□	□	□	□	□	□	□
blue	□	□	□	□	□	□	□	□	□

Rate the **APPEARANCE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	□	□	□	□	□	□	□	□	□
blue	□	□	□	□	□	□	□	□	□

Rate the **TASTE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	□	□	□	□	□	□	□	□	□
blue	□	□	□	□	□	□	□	□	□

Rate the **OVERALL LIKEABILITY** (including appearance, texture, and taste) of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	□	□	□	□	□	□	□	□	□
blue	□	□	□	□	□	□	□	□	□

Which of the two products do you prefer OVERALL? (Circle one)   red   blue

Comments:____

CORNBREAD

Rate the **TEXTURE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **APPEARANCE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **TASTE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **OVERALL LIKEABILITY** (including appearance, texture, and taste) of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Which of the two products do you prefer OVERALL? (Circle one) red blue

Comments:____

CHOCOLATE CHIP COOKIES

Rate the **TEXTURE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **APPEARANCE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **TASTE** of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Rate the **OVERALL LIKEABILITY** (including appearance, texture, and taste) of the following products by checking the appropriate box.

	Dislike Extremely				Neither like nor dislike				Like extremely
red	☐	☐	☐	☐	☐	☐	☐	☐	☐
blue	☐	☐	☐	☐	☐	☐	☐	☐	☐

Which of the two products do you prefer OVERALL? (Circle one) red blue

Comments:____

APPENDIX E

Latin Square Design

Latin Square Design

GROUP 1

participant #

	R B	B R	R B	B R
1	A	B	D	C
	B R	R B	B R	R B
2	B	C	A	D
	R B	B R	R B	R B
3	C	D	B	A
	B R	R B	B R	R B
4	D	A	C	B

GROUP 2

participant #

	B R	R B	B R	R B
5	A	B	D	C
	R B	B R	R B	B R
6	B	C	A	D
	B R	R B	B R	B R
7	C	D	B	A
	R B	B R	R B	B R
8	D	A	C	B

KEY

A = Carrot muffin
B = Chocolate chip cookie
C = Bread
D = Cornbread

R = Almond oil
B = Soybean oil

APPENDIX F

Steps to Analyze SPSS Data

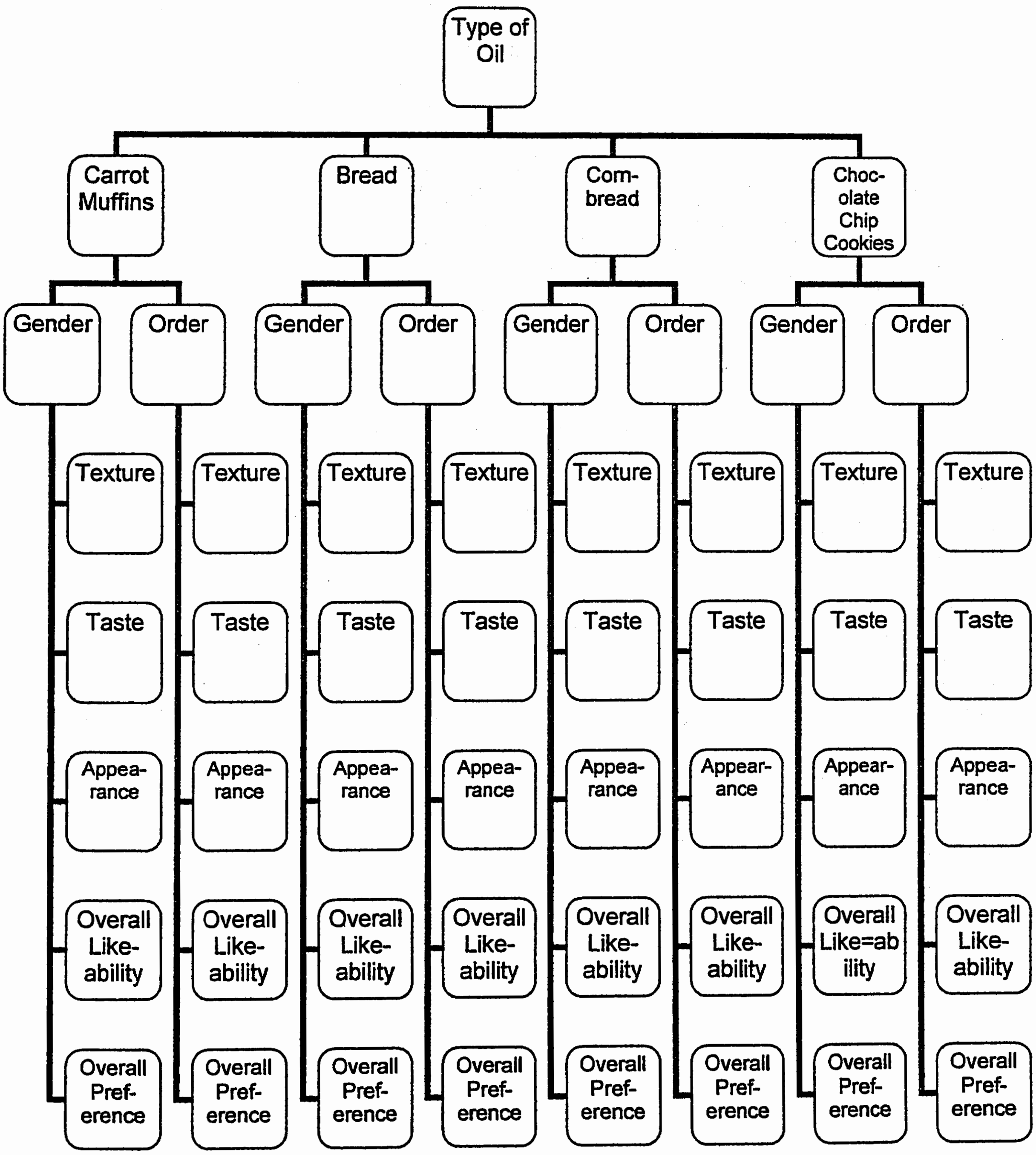
Steps to Analyze Data by Means of SPSS

1. Enter variables as vertical column headings
2. Enter participant number as horizontal column headings
3. Choose "analyze"
4. Under the general linear model option, choose "repeated measures"
5. Under the within subjects factor name, type "oil"
6. Select the variables to be analyzed by highlighting each in the left-hand box, then clicking the arrow to move the variables to the right-hand box
7. Under the between subjects factor, type "group"
8. Under the options heading, check the box next to "descriptive statistics"
9. Press "continue," then "ok"

APPENDIX G

Analysis of Variance Chart and Explanation

Split Plot Analysis of Variance (ANOVA) Data Design for Acceptability of Food Products Containing Almond Oil in Place of Soybean Oil[a]



[a]The split plot ANOVA design was used in place of a classic ANOVA design in this experiment because the split plot is utilized specifically for experiments in which there is (a) at least one variable that is between subjects and at least one variable that is within subjects; (b) multiple sub-plots, and (c) restriction on the randomization of the order in which the products are presented (http://www.ship.edu). Thus, the split plot ANOVA revealed if there were differences in the order in which products were tested (order effects) and determined if significant differences existed in the rating scores for each product in terms of texture, appearance, taste, and overall likeability.

APPENDIX H

SPSS Raw Data

RAW DATA: SPSS

subject	gender	group	cmtextso	cmtexao	cmappso	cmappao	cmtastso	cmtastao	cmlikeso	cmlikeao	cmprefer	cctexso	cctexao
8	1	8	9	9	9	9	9	9	9	9	2	9	
12	1	4	9	9	9	9	9	9	9	9	1	9	9
14	1	6	6	7	5	5	2	2	3	4	2	7	7
15	1	7	4	8	5	7	5	8	6	8	2	8	9
16	1	8	5	5	7	7	7	8	7	8	2	8	4
18	1	2	6	4	4	4	7	7	7	6	1	4	3
20	1	4	6	8	4	8	6	8	4	8	2	7	8
21	1	5	3	2	4	4	2	2	3	2	1	6	6
22	1	6	3	5	2	5	2	6	2	6	2	7	9
26	1	2	8	9	6	6	8	8	8	9	2	6	7
28	1	4	8	9	8	8	9	8	8	8	1	8	7
29	1	5	9	9	9	9	9	9	9	9	2	8	7
30	1	6	8	7	9	8	8	9	8	8	2	7	7
31	1	7	3	4	2	4	2	6	3	5	2	3	6
35	1	3	7	8	8	8	7	8	7	8	2	6	8
37	1	5	6	6	6	6	6	6	6	6	2		
38	1	6	9	9	9	9	9	9	9	9	2	7	8
41	1	1	7	5	7	7	7	6	7	4	1	3	6
42	1	2	7	7	7	6	7	2	7	7	1	9	4
45	1	5	7	4	5	7	7	3	7	4	1	9	7
49	1	1	2	9	5	5	2	9	3	8	2	9	3
51	1	3	8	6	8	8	8	6	8	6		8	7
53	1	5	8	8	8	3	8	4	8	4	1	1	4
54	1	6	4	3	4	4	4	4	4	4	1	5	6
56	1	8	7	7	8	8	7	6	8	7	1	9	8
60	1	4	7	9	9	9	7	9	7	9	2	9	9
61	1	8	7	8	8	7	7	8	7	8	2	8	7
63	1	7							9		1	9	
66	1	2	8	9	8	7	8	7	8	9	2	7	7
68	1	4	2	7	3	8	2	7	7	2	1	3	7
70	1	6	8	8	7	7	7	7	7	7		8	8

Average	6.37	6.93	6.43	6.73	6.27	6.67	6.61	6.70	1.59	6.90	6.71
Std Dev	2.16	2.07	2.21	1.78	2.45	2.25	2.09	2.17	0.50	2.19	1.74

RAW DATA: SPSS

subject	gender	ccappso	ccappao	cctastso	cctastao	cclikeso	cclikeao	ccprefer	brtexso	brtexao	brappso	brappao	brtastso
8	1	9		9		9		1	8	7	9	8	8
12	1	9	9	9	9	9	9	1	1	5	1	5	1
14	1	4	7	8	6	8	7	1	4	4	7	7	2
15	1	8	9	7	8	7	8	1	6	7	3	4	3
16	1	8	4	9	4	9	4	1	4	4	4	4	7
18	1	7	7	7	6	7	6	1	5	6	6	6	3
20	1	6	7	7	9	7	8	2	4	4	6	6	6
21	1	6	7	7	7	6	7	1	1	1	1	2	1
22	1	7	9	7	9	7	9	2	2	5	5	5	3
26	1	4	5	8	8	7	8	2	4	6	8	8	6
28	1	8	7	8	7	8	7	1	7	7	7	7	6
29	1	8	7	8	7	8	7	1	8	9	8	9	8
30	1	8	8	8	8	7	7	2	3	3	4	4	2
31	1	3	6	7	8	7	8	2	3	2	6	6	4
35	1	8	8	8	8	7	8	2	5	2	8	8	2
37	1	6	6	6	6	5	5	2	1	1	4	4	1
38	1	9	8	3	7	5	8	2	9	9	5	5	3
41	1	5	5	2	6	2	7	2	6	6	6	6	6
42	1	9	7	9	8	9	7	1	2	2	3	2	2
45	1	7	5	9	7	8	6	1	5	6		6	4
49	1	5	8		6	3	6	1	9	6	9	6	9
51	1	8	8	9	9	9	9		5	8	8	6	8
53	1	3	7	7	8	5	8	2	8	8	8	8	5
54	1	4	5	6	6	6	6	1	7	6	4	4	8
56	1	9	9	8	9	9	9	1	4	6	6	8	6
60	1	9	9	8	8	8	8	1	2	5	5	5	1
61	1	7	8	9	9	9	9	1	8	3	8	3	7
63	1	9		8	8	8	7	1	8	9	8	8	2
66	1	9	9	8	7	6	8	2	7	7	6	8	7
68	1	5	7	8	8	8	8		7	6	6	6	7
70	1	5	6	7	6	7	6	1	5	6	7	8	5

Average	6.84	7.14	7.47	7.40	7.10	7.33	1.38	5.10	5.35	5.87	5.87	4.61
Std Dev	1.97	1.43	1.61	1.25	1.74	1.24	0.49	2.47	2.29	2.16	1.89	2.55

RAW DATA: SPSS

subject	gender	brtastao	brlikeso	brlikeao	brprefer	cbtexso	cbtexao	cbappso	cbappao	cbtastso	cbtastao	cblikeso	cblikeao
8	1	8	8	8	1	8	9	9	8	8	9	8	9
12	1	5	1	5	2	9	9	9	9	9	9	9	9
14	1	4	4	4	2	7	7	6	6	4	5	5	6
15	1	4	4	5	2	9	7	9	7	9	4	9	5
16	1	8	7	7	2	5	5	5	5	8	2	8	2
18	1	5	4	5	2	8	7	6	6	7	6	7	6
20	1	4	6	5	1	8	8	8	8	6	6	7	6
21	1	1	1	1	1	2	4	5	5	2	4	2	4
22	1	3	3	4	2	7	7	7	7	3	4	5	5
26	1	6	7	6	1	8	8	8	8	9	8	8	9
28	1	6	5	5	1	8	8	8	8	7	6	7	7
29	1	9	8	9	2	6	6	6	6	6	6	6	6
30	1	3	3	4	2	8	7	9	9	7	6	8	7
31	1	3	3	2	1	7	7	8	8	6	7	6	7
35	1	6	3	4	2	7	6	6	6	7	8	6	7
37	1	1	1	1	2	6	6	6	6	5	5	5	5
38	1	3	2	3	2	5	7	8	8	4	7	4	7
41	1	6	6	6	1	5	5	5	5	4	4	5	5
42	1	2	3	3		7	7	7	7	3	3	6	7
45	1	4	5	6	2	6	5	8	6	7	6	5	7
49	1	5	6	6	1	8	4	9		9	5	9	5
51	1	5				8	8	7	7	5	8	6	8
53	1	5	6	6	1	8	5	8	5	3	3	7	3
54	1	8	8	8	1	7	8	6	6	7	8	7	8
56	1	7	6	8	2	4	6	7	7	6	6	7	6
60	1	3	2	4	2	7	8	8	8	7	7	7	7
61	1	4	8	3	1	7	8	8	9	6	8	7	8
63	1	3	3	3		9	9	9	9	8		9	8
66	1	8	6	8	2	5	7	7	9	7	7	7	8
68	1	6	5	6	1	9	9	8	8	9	7	8	9
70	1	7	5	7	2	8	6	8	8	5	3	6	3

Average	4.90	4.63	5.07	1.57	6.97	6.87	7.35	7.13	6.23	5.90	6.65	6.42
Std Dev	2.12	2.19	2.10	0.50	1.62	1.43	1.28	1.33	2.01	1.90	1.60	1.84

RAW DATA: SPSS

subject	gender	cbprefer
8	1	2
12	1	1
14	1	2
15	1	1
16	1	1
18	1	1
20	1	1
21	1	2
22	1	2
26	1	1
28	1	1
29	1	
30	1	1
31	1	2
35	1	2
37	1	2
38	1	2
41	1	1
42	1	2
45	1	1
49	1	1
51	1	2
53	1	1
54	1	2
56	1	1
60	1	2
61	1	2
63	1	
66	1	2
68	1	1
70	1	1

Average	1.48
Std Dev	0.51

RAW DATA: SPSS

subject	gender	group	cmtextso	cmtexao	cmappso	cmappao	cmtastso	cmtastao	cmlikeso	cmlikeao	cmprefer	cctexso	cctexao
8	1	8	9	9	9	9	9	9	9	9	2	9	
12	1	4	9	9	9	9	9	9	9	9	1	9	9
14	1	6	6	7	5	5	2	2	3	4	2	7	7
15	1	7	4	8	5	7	5	8	6	8	2	8	9
16	1	8	5	5	7	7	7	8	7	8	2	8	4
18	1	2	6	4	4	4	7	7	7	6	1	4	3
20	1	4	6	8	4	8	6	8	4	8	2	7	8
21	1	5	3	2	4	4	2	2	3	2	1	6	6
22	1	6	3	5	2	5	2	6	2	6	2	7	9
26	1	2	8	9	6	6	8	8	8	9	2	6	7
28	1	4	8	9	8	8	9	8	8	8	1	8	7
29	1	5	9	9	9	9	9	9	9	9	2	8	7
30	1	6	8	7	9	8	8	9	8	8	2	7	7
31	1	7	3	4	2	4	2	6	3	5	2	3	6
35	1	3	7	8	8	8	7	8	7	8	2	6	8
37	1	5	6	6	6	6	6	6	6	6	2		
38	1	6	9	9	9	9	9	9	9	9	2	7	8
41	1	1	7	5	7	7	7	6	7	4	1	3	6
42	1	2	7	7	7	6	7	2	7	7	1	9	4
45	1	5	7	4	5	7	7	3	7	4	1	9	7
49	1	1	2	9	5	5	2	9	3	8	2	9	3
51	1	3	8	6	8	8	8	6	8	6		8	7
53	1	5	8	8	8	3	8	4	8	4	1	1	4
54	1	6	4	3	4	4	4	4	4	4	1	5	6
56	1	8	7	7	8	8	7	6	8	7	1	9	8
60	1	4	7	9	9	9	7	9	7	9	2	9	9
61	1	8	7	8	8	7	7	8	7	8	2	8	7
63	1	7							9		1	9	
66	1	2	8	9	8	7	8	7	8	9	2	7	7
68	1	4	2	7	3	8	2	7	7	2	1	3	7
70	1	6	8	8	7	7	7	7	7	7		8	8

Average	6.37	6.93	6.43	6.73	6.27	6.67	6.61	6.70	1.59	6.90	6.71
Std Dev	2.16	2.07	2.21	1.78	2.45	2.25	2.09	2.17	0.50	2.19	1.74

RAW DATA: SPSS

subject	gender	ccappso	ccappao	cctastso	cctastao	cclikeso	cclikeao	ccprefer	brtexso	brtexao	brappso	brappao	brtastso
8	1	9		9		9		1	8	7	9	8	8
12	1	9	9	9	9	9	9	1	1	5	1	5	1
14	1	4	7	8	6	8	7	1	4	4	7	7	2
15	1	8	9	7	8	7	8	1	6	7	3	4	3
16	1	8	4	9	4	9	4	1	4	4	4	4	7
18	1	7	7	7	6	7	6	1	5	6	6	6	3
20	1	6	7	7	9	7	8	2	4	4	6	6	6
21	1	6	7	7	7	6	7	1	1	1	1	2	1
22	1	7	9	7	9	7	9	2	2	5	5	5	3
26	1	4	5	8	8	7	8	2	4	6	8	8	6
28	1	8	7	8	7	8	7	1	7	7	7	7	6
29	1	8	7	8	7	8	7	1	8	9	8	9	8
30	1	8	8	8	8	7	7	2	3	3	4	4	2
31	1	3	6	7	8	7	8	2	3	2	6	6	4
35	1	8	8	8	8	7	8	2	5	2	8	8	2
37	1	6	6	6	6	5	5	2	1	1	4	4	1
38	1	9	8	3	7	5	8	2	9	9	5	5	3
41	1	5	5	2	6	2	7	2	6	6	6	6	6
42	1	9	7	9	8	9	7	1	2	2	3	2	2
45	1	7	5	9	7	8	6	1	5	6		6	4
49	1	5	8		6	3	6	1	9	6	9	6	9
51	1	8	8	9	9	9	9		5	8	8	6	8
53	1	3	7	7	8	5	8	2	8	8	8	8	5
54	1	4	5	6	6	6	6	1	7	6	4	4	8
56	1	9	9	8	9	9	9	1	4	6	6	8	6
60	1	9	9	8	8	8	8	1	2	5	5	5	1
61	1	7	8	9	9	9	9	1	8	3	8	3	7
63	1	9		8	8	8	7	1	8	9	8	8	2
66	1	9	9	8	7	6	8	2	7	7	6	8	7
68	1	5	7	8	8	8	8		7	6	6	6	7
70	1	5	6	7	6	7	6	1	5	6	7	8	5

Average	6.84	7.14	7.47	7.40	7.10	7.33	1.38	5.10	5.35	5.87	5.87	4.61
Std Dev	1.97	1.43	1.61	1.25	1.74	1.24	0.49	2.47	2.29	2.16	1.89	2.55

RAW DATA: SPSS

subject	gender	brtastao	brlikeso	brlikeao	brprefer	cbtexso	cbtexao	cbappso	cbappao	cbtastso	cbtastao	cblikeso	cblikeao
8	1	8	8	8	1	8	9	9	8	8	9	8	9
12	1	5	1	5	2	9	9	9	9	9	9	9	9
14	1	4	4	4	2	7	7	6	6	4	5	5	6
15	1	4	4	5	2	9	7	9	7	9	4	9	5
16	1	8	7	7	2	5	5	5	5	8	2	8	2
18	1	5	4	5	2	8	7	6	6	7	6	7	6
20	1	4	6	5	1	8	8	8	8	6	6	7	6
21	1	1	1	1	1	2	4	5	5	2	4	2	4
22	1	3	3	4	2	7	7	7	7	3	4	5	5
26	1	6	7	6	1	8	8	8	8	9	8	8	9
28	1	6	5	5	1	8	8	8	8	7	6	7	7
29	1	9	8	9	2	6	6	6	6	6	6	6	6
30	1	3	3	4	2	8	7	9	9	7	6	8	7
31	1	3	3	2	1	7	7	8	8	6	7	6	7
35	1	6	3	4	2	7	6	6	6	7	8	6	7
37	1	1	1	1	2	6	6	6	6	5	5	5	5
38	1	3	2	3	2	5	7	8	8	4	7	4	7
41	1	6	6	6	1	5	5	5	5	4	4	5	5
42	1	2	3	3		7	7	7	7	3	3	6	7
45	1	4	5	6	2	6	5	8	6	7	6	5	7
49	1	5	6	6	1	8	4	9		9	5	9	5
51	1	5				8	8	7	7	5	8	6	8
53	1	5	6	6	1	8	5	8	5	3	3	7	3
54	1	8	8	8	1	7	8	6	6	7	8	7	8
56	1	7	6	8	2	4	6	7	7	6	6	7	6
60	1	3	2	4	2	7	8	8	8	7	7	7	7
61	1	4	8	3	1	7	8	8	9	6	8	7	8
63	1	3	3	3		9	9	9	9	8		9	8
66	1	8	6	8	2	5	7	7	9	7	7	7	8
68	1	6	5	6	1	9	9	8	8	9	7	8	9
70	1	7	5	7	2	8	6	8	8	5	3	6	3

Average	4.90	4.63	5.07	1.57	6.97	6.87	7.35	7.13	6.23	5.90	6.65	6.42
Std Dev	2.12	2.19	2.10	0.50	1.62	1.43	1.28	1.33	2.01	1.90	1.60	1.84

RAW DATA: SPSS

subject	gender	cbprefer
8	1	2
12	1	1
14	1	2
15	1	1
16	1	1
18	1	1
20	1	1
21	1	2
22	1	2
26	1	1
28	1	1
29	1	
30	1	1
31	1	2
35	1	2
37	1	2
38	1	2
41	1	1
42	1	2
45	1	1
49	1	1
51	1	2
53	1	1
54	1	2
56	1	1
60	1	2
61	1	2
63	1	
66	1	2
68	1	1
70	1	1

Average	1.48
Std Dev	0.51

RAW DATA: SPSS

subject	gender	group	cmtextso	cmtexao	cmappso	cmappao	cmtastso	cmtastao	cmlikeso	cmlikeao	cmprefer	cctexso	cctexao	ccappso
1	2	1	8	7	6	5	8	7	8	7	1	9	6	4
2	2	2	6	7	7	6	6	8	7	7	2	6	8	9
3	2	3	5	9	9	9	5	9	6	9	2	2	3	2
4	2	4	5	7	6	8	7	6	8	6	1	6	8	7
5	2	5	2	7	5	6	2	5	3	7	2	5	7	6
6	2	6	6	7	7	8	7	8	7	8	2	6	7	7
7	2	7	5	6	7	8	8	6	7	7	2	8	7	8
9	2	1	9	7	9	9	9	7	9	8	1	8	9	9
10	2	2	5	9	5	9	5	9	5	9	2	9	9	9
11	2	3	8	9	9	9	8	9	8	9	2	9	9	8
13	2	5	7	6	7	7	7	6	7	6	1	5	7	7
17	2	1	8	8	8	8	3	3	6	7	2	7	8	5
19	2	3	3	4	3	3	2	7	2	7	2	8	9	9
23	2	7	8	8	8	9	7	4	8	5	1	8	8	8
24	2	8	8	7	8	8	8	5	8	7	1	7	8	7
25	2	1	5	1	9	5	5	1	5	1	1	9	5	9
27	2	3	8	2	5	8	7	2	6	4	1	8	3	3
32	2	8	9	7	7	5	8	2	8	3	1	8	9	8
33	2	2	1	8	8	4	8	7	7	6	2	7	8	8
34	2	2	9	7	8	7	9	8	8	7	1	7	9	8
36	2	4	6	9	7	6	7	8	8	5	2	9	9	5
39	2	7	9	2	9	5	9	1	9	3	1	8	5	8
40	2	8	7	6	4	6	5	7	6	6	2	7	8	8
43	2	3	5	5	5	5	2	1	4	2	1	8	1	8
44	2	4	9	9	9	7	9	7	9	7	1	8	7	7
46	2	6	8	5	9	9	8	4	8	5	1	7	8	9
47	2	7	8	8	7	6	6	6	7	7	2	8	9	6
48	2	8	7	6	6	7	7	7	7	7	2	7	7	7
50	2	2	7	7	8	8	7	7	7	7	1	8	8	8
52	2	4	9	9	9	9	8	5	9	4	1	9	9	9
55	2	7	4	6	6	6	5	6	5	6	2	4	6	5
58	2	7	8	7	8	7	7	6	8	7	1	8	6	7
59	2	7	8	8	8	8	9	8	9	8	1	8	8	8
62	2	2	9	9	9	9	9	9	9	9		9	8	9
64	2	8	8	9	7	7	7	8	8	9	2	6	9	8
65	2	1	7	9	5	5	7	9	8	9	2	8	9	6

67	2	3	8	8	8	8	9	9	8	8		8	8	7
69	2	5	8	7	8	6	8	4	8	4	1	6	4	8
71	2	8	9	9	9	9	8	7	8	7		8	8	8
Average			6.90	6.95	7.23	7.03	6.82	6.10	7.13	6.41	1.47	7.33	7.28	7.23
Std Dev			2.04	2.01	1.60	1.63	1.99	2.39	1.66	2.00	0.51	1.51	1.93	1.69

RAW DATA: SPSS

subject	gender	ccappao	cctastso	cctastao	cclikeso	cclikeao	ccprefer	brtexso	brtexao	brappso	brappao	brtastso	brtastao	brlikeso
1	2	6	8	7	7	8	2	5	7	5	7	5	7	6
2	2	9	8	7	7	6	1	7	7	7	7	7	6	7
3	2	7	5	9	5	8	2	9	8	7	5	9	7	8
4	2	7	2	9	2	8	2	4	6	4	4	1	3	2
5	2	8	7	8	7	8	2	4	2	5	4	4	2	4
6	2	8	7	7	7	7	2	7	8	8	8	7	7	7
7	2	4	8	7	8	7	1	2	4	7	6	6	7	7
9	2	9	8	9	8	9	2	3	9	5	5	7	9	4
10	2	5	5	9	5	7	2	9	9	5	5	5	9	5
11	2	9	8	9	8	9	2	2	8	6	7	8	7	8
13	2	7	5	7	5	7	2	4	3	5	5	3	2	3
17	2	6	3	4			1	4	4	3	3	1	1	2
19	2	9	9	9	8	9	2	3	3	7	7	3	3	4
23	2	8	9	8	8	8	1	6	4	7	7	6	3	6
24	2	8	6	8	7	8	2	8	8	8	8	7	8	8
25	2	5	9	5	9	5	1	5	9	5	9	5	9	5
27	2	8	3	8	5	7	2	3	1	5	5	2	3	2
32	2	8	9	9	9	9	2	5	5	1	1	7	1	5
33	2	7	7	8	7	8	2	1	8	3	7	7	8	2
34	2	9	8	9	8	9	2	8	7	8	8	8	7	8
36	2	4	9	7	8	6	1	4	6	8	8	2	5	3
39	2	4	8	4	8	4	1	3	7	4	7	1	7	1
40	2	9	7	9	7	8	2	6	8	7	7	6	8	6
43	2	1	6	1	7	1	2	3	2	5	5	2	2	2
44	2	7	8	7	8	7	1	3	8	6	7	4	8	4
46	2	8	8	6	8	8	1	9	8	8	8	6	9	6
47	2	8	9	9	8	9	2	8	8	6	8	7	8	7
48	2	7	7	7	7	7	2	6	5	5	4	5	4	5
50	2	8	8	8	8	8	2	1	1	5	5	1	1	1
52	2	9	9	9	9	9	2	9	9	9	9	7	9	9
55	2	8	4	7	4	7	2	8	9	8	8	7	8	8
58	2	7	9	9	9	9	2	6	8	8	9	6	9	7
59	2	8	8	6	8	6	1	7	5	5	6	5	4	5
62	2	9	8	7	7	8	1	7	7	7	7	7	7	7
64	2	8	9		9		1	9		9				9
65	2	7	8	9	9	9	2	2	4	4	6	2	4	2

67	2	7	7	8	8	9	2	3	8	8	6	3	6	4
69	2	8	3	7	2	7	1	7	7	8	8	8	8	7
71	2	8	7	7	7	7		7	7	7	5	5	5	5
Average		7.23	7.08	7.45	7.13	7.46	1.66	5.31	6.24	6.10	6.34	5.05	5.82	5.15
Std Dev		1.75	1.95	1.74	1.74	1.63	0.48	2.47	2.40	1.83	1.79	2.34	2.66	2.33

RAW DATA: SPSS

subject	gender	brlikeao	brprefer	cbtexso	cbtexao	cbappso	cbappao	cbtastso	cbtastao	cblikeso	cblikeao	cbprefer
1	2	7	2	8	8	7	6	7	7	8	7	1
2	2	6	1	6	6	6	6	6	6	6	6	2
3	2	6	1	6	6	6	8	8	9	7	9	2
4	2	3	2	5	5	5	5	5	7	4	7	2
5	2	2	1	7	6	8	8	7	6	7	6	1
6	2	7	2		6	7	7	6	7	5	7	
7	2	4	1	6	8	7	7	6	7	6	7	2
9	2	9	2	9	8	9	9	9	8	9	7	1
10	2	9	2	5	9	5	9	5	5	5	5	2
11	2	7		8	6	8	8	8	7	8	7	
13	2	2	1	4	4	5	5	4	4	4	4	1
17	2	2	1	8	8	6	7	7	8	6	7	2
19	2	4	1	8	7	6	6	8	7	8	7	1
23	2	5	1	7	8	8	8	7	8	7	8	2
24	2	9	2	8	8	8	8	7	3	6	8	1
25	2	9	2	1	1	5	5	1	1	1	1	1
27	2	3	1	8	4	7	4	8	5	7	4	1
32	2	1	1	9	7	9	1	7	9	7	9	1
33	2	8	2	1	7	8	7	4	6	6	7	2
34	2	8	1	9	9	8	9	9	9	9	9	2
36	2	5	2	4	4	7	7	3	5	4	5	2
39	2	7	2	5	5	5	5	1	8	4	8	2
40	2	8	2	5	8	7	8	2	8	3	8	2
43	2	2	1	8	7	8	5	8	1	8	1	1
44	2	8	2	8	7	8	8	7	8	8	8	2
46	2	8	2	9	8	9	9	8	7	8	7	1
47	2	8	2	9	9	7	9	9	8	8	9	1
48	2	5	1	9	9	8	8	8	8	8	8	2
50	2	1		8	8	8	8	8	8	8	8	1
52	2	9	2	8	8	8	8	8	4	8	5	1
55	2	8	2	6	6	8	8	7	6	7	6	1
58	2	9	2	7	7	9	9	7	7	9	9	1
59	2	6	1	4	4	8	8	5	7	6	7	2
62	2	7	1	7	6	7	7	7	7	7	7	1
64	2	9	1	5	5	3	5	3	5	8	9	2
65	2	4	2	4	8	8	7	4	7	7	8	2

67	2	8	2	8	4	8	7	8	4	8	4	1
69	2	7	1	5	3	5	5	5	2	6	2	1
71	2	5			8	8	8	8	7	7	7	
Average		6.03	1.53	6.54	6.54	7.10	6.97	6.28	6.31	6.62	6.62	1.47
Std Dev		2.56	0.51	2.13	1.89	1.41	1.72	2.16	2.07	1.79	2.09	0.51