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"Role of Healthy Oils in the Diet"
NuSun™ Sunflower Oil Product White Paper
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Executive Summary

A large body of scientific evidence now supports including a higher proportion of unsaturated fat and less saturated fat in the diet in order to lower risk of cardiovascular disease. More recently, there have been study findings suggesting that slightly more unsaturated fat in the diet, and subsequently less carbohydrate, may be beneficial to health. In addition, a National Academy of Science (NAS) report, released in September 2002, recommends limiting the amount of trans fat in the diet as much as possible. In the face of all of these health recommendations, choosing a type of fat or oil for commercial use can be challenging. The Food and Drug Administration (FDA) just announced that they will require manufacturers to list trans fat on the Nutrition Facts panel. Considering the scientific research, nutritional guidelines, and regulatory issues, a newly developed variety of sunflower oil, called NuSun™, can provide manufacturers with a unique, naturally trans-free alternative that delivers optimal health benefits, great taste, and performance characteristics needed for commercial use and the demands of frying.

I. Unsaturated Fats and Oils in Diets

- Epidemiological Data—
  Epidemiological studies are large population studies often conducted to look at associations between diet and disease. If the outcomes of these studies are compelling, clinical studies are often conducted to further examine the research question.

  - The landmark Seven Countries Study was among the first to highlight the association between dietary fatty acids and atherosclerosis and coronary heart disease (CHD). It showed that monounsaturated fatty acids (MUFAs) were strongly and inversely correlated with elevated cholesterol levels and CHD.[1]

  - Other epidemiological studies that have controlled for many potentially confounding variables have reported protective effects of MUFA against CHD.[2,3]

- Clinical Research—
  Clinical studies are conducted to look at a specific smaller population within a controlled setting to examine disease outcomes.

  - Several studies have shown that MUFAs protect low-density lipoprotein (LDL) cholesterol against oxidation in many different populations: normal, [4,5] diabetic,[6] and post-menopausal people.[7] MUFAs also have been shown to reduce HDL oxidation.[8]

  - Kris-Etherton et al.,[9] tested healthy subjects who consumed one of five types of diets: a low-fat diet, one including olive oil, one including peanuts and peanut butter, one including peanut oil, and a typical American diet. Results show that the diet including peanuts /peanut butter, the one including peanut oil, and the diet including olive oil, all low in saturated fat and cholesterol, and high in MUFA, lowered total cholesterol and LDL (bad) cholesterol. Further, each of these three high MUFA diets lowered triglyceride levels, but did not lower the beneficial HDL cholesterol. While the low fat diet was successful in lowering LDL cholesterol, it also lowered "good" HDL cholesterol and increased triglyceride levels.

  - Kris-Etherton et al.,[10] summarized the research on MUFA and risk of cardiovascular disease and found that compared with saturated fatty acids, MUFAs lower total and LDL cholesterol levels, and relative to carbohydrate, they increase HDL cholesterol levels and decrease plasma triglyceride levels.

II. Unsaturated Fats and Oils as a Replacement for Saturated Fat or Carbohydrate

A. Epidemiological Data—
- The Nurses' Health Study[11] at the Harvard School of Public Health shows that for every 5% increase in saturated fat, coronary heart disease (CHD) risk is increased by 17%, whereas for every 5% increase in monounsaturated fat, CHD risk is decreased by 24%.

B. Clinical Research—
- Grundy, et al.,[12] and Mensink RP et al.,[13] reported the cholesterol-lowering effects of a high-fat diet rich in MUFA (about 40%) and low in saturated fat (4 to 10%), and a low-fat/carbohydrate-rich diet (~20% of energy from fat and ~7% of energy from saturated fat). Although both diets lowered total and low-density lipoprotein (LDL) cholesterol, the high-MUFA diet did not lower high-density lipoprotein (HDL) cholesterol or increase triglycerides, as did the low fat/carbohydrate-rich diet. The low-fat/carbohydrate-rich diet lowered HDL cholesterol by 14% to 22% and elevated triglycerides (22% to 39%).

- In a meta-analysis of 27 trials, replacement of dietary carbohydrate by saturated fat was found to increase total, LDL and HDL cholesterol and decreases triglyceride levels. Conversely, replacing carbohydrates with MUFAs or polyunsaturated fatty acids (PUFAs) generally reduces total cholesterol, LDL, and triglyceride, and increases HDL levels.[14]

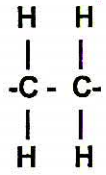
- Diabetic patients fed weight-reducing MUFA-enriched diets as opposed to weight-reducing low-fat, high-carbohydrate diets, had improved lipid profiles and less LDL oxidation in vitro, suggesting that these MUFA-enriched diets may have additional benefits independent of weight loss.

III. Trans Fat in Diets

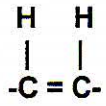
A. Background on Trans Fatty Acids

- Trans fatty acids are unsaturated fatty acids that contain at least one double bond (C=C) in the trans configuration. The *trans* double bond configuration results in a greater bond angle than the *cis* configuration. This results in a molecular structure that is more similar to that of saturated fatty acids. Partial hydrogenation results in an increase in the trans fatty acid content and the hardening of fat. Thus, foods containing hydrogenated oils tend to have a higher trans fatty acid content than those that do not contain hydrogenated oils.[15]

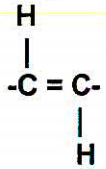
Chemical Structure of Saturated Fatty Acids



Chemical Structure of *Cis* Unsaturated Fatty Acids



Chemical Structure of *Trans* Fatty Acids



B. Clinical Research

- Mensink et al.[16] and Troisi et al.[17] both found that trans fatty acid intake was directly related to total serum and low-density-lipoprotein (LDL) cholesterol, and inversely related to high-density-lipoprotein (HDL) cholesterol.

- Judd et al[18] found that when compared with a high-oleic diet, LDL cholesterol increased 6%, 7.8%, and 9% after moderate trans fatty acid, high trans fatty acid, and saturated diets, respectively. HDL cholesterol was unchanged after the moderate trans fatty acid diet, but was slightly lower (2.8%) after the high trans fatty acid diet. HDL cholesterol after the saturated fat diet was 3.5% higher than after the oleic diet.

- According to Ascherio and Willett, [19] in the past 5 years, a series of metabolic studies has provided unequivocal evidence that trans fatty acids increase plasma concentrations of low density lipoprotein cholesterol and reduce concentrations of high density lipoprotein cholesterol relative to the parent natural fat. In these same studies, trans fatty acids increased the plasma ratio of total to HDL cholesterol nearly twofold compared with saturated fats.

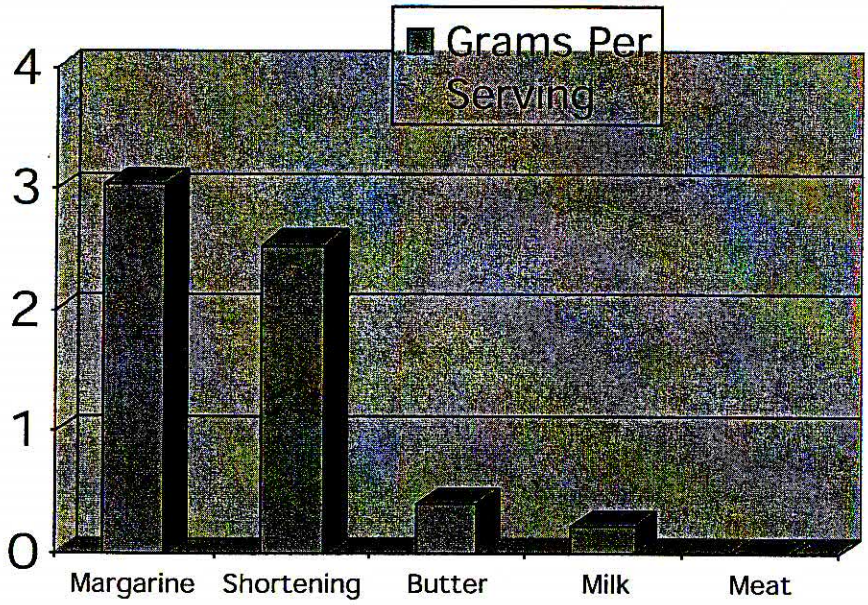
- Lichtenstein et al.[20] found that after consuming each of six diets in random order for 35-day periods, the LDL cholesterol was reduced on average by 12%, 11%, 9%, 7%, and 5% respectively, after subjects consumed the diets enriched with soybean oil, semi-liquid margarine, soft margarine, shortening, and stick margarine. The HDL cholesterol was reduced by 3%, 4%, 4%, 4%, and 6%, respectively. Ratios of total cholesterol to HDL cholesterol were lowest after the consumption of the soybean-oil diet and semi-liquid margarine diet and highest after the stick-margarine diet. Thus, the consumption of products that are low in trans fatty acids and saturated fat has beneficial effects on serum lipoprotein cholesterol levels.

C. Trans Fatty Acids in Foods

Traditional stick margarine	1.8-3.5 g/serving
Soft margarine (tub)	0.4-1.6 g/serving
Vegetable shortening	1.4-4.2 g/serving
Salad Dressings	0.06-1.1 g/serving
Doughnuts	0.3-3.8 g/serving
Microwave popcorn	2.2 g/serving
Chocolate Chip cookies	1.2-2.7 g/serving
Vanilla wafers	1.3 g/serving
French fries (fast food)	0.7-3.6 g/serving
Snack crackers	1.8-2.5 g/serving
Snack chips	0-1.2 g/serving
Chocolate candies	0.04-2.8 g/serving

Ready-to-eat cereals	0.05-0.5 g/serving
Milk	0.22 g/serving*
Butter	0.40 g/serving*
Meat	0.01 g/serving*

* Source: NAS/IOM report
All others: FDA/CFSAN (http://vm.cfsan.fda.gov/~dms/qatrans.html)



Source: NAS Letter Report, 2002.

D. National Academy of Sciences' Report on Trans Fat

- A report issued in September 2002 by the National Academy of Sciences' (NAS) Institute of Medicine (IOM) recommends limiting trans fat in the diet as much as possible. The report concludes that trans fatty acid intake is associated with total and "bad" low density lipoprotein (LDL) cholesterol, and therefore increased risk of coronary heart disease (CHD). Since trans fats occur naturally in small amounts in some nutrient-rich foods, such as meat and dairy products, it is recommended that consumption of processed foods containing relatively larger amounts of trans fat be decreased as much as possible.[21]

E. Trans Fat Labeling

- The Food and Drug Administration (FDA) just announced that it will require manufacturers to list the amount of trans fat in a product on the Nutrition Facts panel. Manufacturers will have until January 1, 2006, to comply, giving

them time to reformulate their products, if necessary, to lower the amount of trans fat. The labeling regulations and subsequent educational activities will increase interest in alternative healthful oils to improve the nutritional quality of foods.

IV. Dietary Recommendations on Fats and Oils

A. General Dietary Recommendation

- For over a decade, nutrition scientists have been investigating the role dietary fat plays in health. Recently, major dietary recommendations have shifted focus from the *amount* of fat in the diet to *type* of fat in the diet.

B. US Department of Agriculture/Health and Human Services (USDA/HHS)

2000: Choose a diet that is low in saturated fat and cholesterol and moderate in total fat.[22]

1995: Choose a diet low in fat, saturated fat, and cholesterol.

- The USDA/HHS Dietary Guideline on fat points out that you need some fat in the foods you eat, but advises consumers to choose fats sensibly. The guideline goes on to say, "Some kinds of fat, especially saturated fats, increase the risk of coronary heart disease by raising cholesterol. In contrast, unsaturated fat (found mainly in vegetable oils) do not increase blood cholesterol."

C. American Heart Association

2000: Limit foods high in saturated fat and cholesterol and substitute unsaturated fat from vegetables, fish, legumes and nuts.[23]

- The American Heart Association (AHA) dietary guidelines place an increased emphasis on foods and overall dietary patterns with broad health benefits. Like the USDA Dietary Guidelines, they advise consumers to decrease saturated fat and cholesterol in the diet, but go one step further and suggest that for some individuals replacing saturated fat with unsaturated fat (instead of carbohydrate) may be more beneficial to health. More specifically, the AHA advises limiting foods high in saturated fat and cholesterol and substituting unsaturated fat from vegetables, fish, legumes, seeds and nuts. The AHA recognizes that, "The major food components that raise LDL cholesterol are saturated fatty acids, trans-unsaturated fatty acids, and, to a lesser extent, cholesterol. Dietary factors that lower LDL cholesterol include polyunsaturated fatty acids, monounsaturated fatty acids (when substituted for saturated fatty acids), and, to a lesser extent, soluble

fiber and soy protein." To look at the complete picture of factors affecting CVD outcomes, the AHA also addresses how dietary factors relate to beneficial high-density lipoprotein (HDL) cholesterol levels and triglycerides. The guidelines recognize that low-fat, high-carbohydrate diets can result in reductions of HDL cholesterol levels in certain individuals, and that many of the factors that lead to decreased HDL are also associated with relative increases in plasma triglyceride.[24, 25]

D. National Cholesterol Education Program

Polyunsaturated fat	*Up to 10% of total calories*
Monounsaturated fat	*Up to 20% of total calories*
Saturated Fat	*Less than 7% of total calories*
Total Fat	*25-35% of total calories*

- The National Cholesterol Education Program (NCEP) at the National Institutes of Health has also revised their guidelines for people needing to lower their cholesterol. As in the past, the guidelines are clear in encouraging consumers to lower their daily intake of saturated fat to less than 7% of calories, and to limit dietary cholesterol intake to less than 200 mg a day. What is new is that the NCEP dietary guidelines now allow for up to 35% of calories from fat, raised from 25% of calories from fat, provided most of it is the good, unsaturated fat.[26]

E. National Academy of Sciences/Institute of Medicine (NAS/IOM)

"There is a positive linear trend between trans fatty acid intake and total and LDL cholesterol concentration, and therefore increased risk of CHD, thus suggesting a tolerable Upper Intake Level of zero."

- There is no Daily Value for trans fat, but the "Letter Report on Dietary Reference Intakes for Trans Fatty Acids" from NAS/IOM suggests trans fat should be as low as possible in the diet. Researchers now agree that enough evidence exists to support minimizing consumption of trans fat as much as possible and making information on the trans fatty acid content of foods available to consumers.[27]

V. Nutrients in Unsaturated Fats and Oils

A. Vitamin E

- Vitamin E is an antioxidant that may protect against heart disease by getting rid of harmful molecules called free radicals. According to the National Academies of Science, at this time there are insufficient data on which to base a recommendation for vitamin E that is beyond the Recommended Daily Allowance.[29] It's easy to meet the Daily Value for vitamin E from food

sources such as sunflower seeds and healthy vegetable oils. Sunflower seeds are the best whole food source of vitamin E. Just one ounce of sunflower seeds provides 76% of the Recommended Dietary Allowance.[30]

B. Phytochemicals

- Phytochemicals, or beneficial plant chemicals, are thought to inhibit cancer growth, protect against heart disease, and may offer protection from colon, prostate and breast cancer. Research from Virginia Polytechnic Institute and State University suggests that sunflower seeds are high in many phytochemicals like choline, lignan, phenolic acids, betaine, and the amino acid arginine.[31]

  Currently there is no set Daily Value for phytochemicals, but nutrition scientists recommend eating more whole foods, like sunflower seeds and oil, that are abundant in these beneficial plant chemicals.

VI. NuSun™ Sunflower Oil Product Advantages

A. Advantages for Consumers

- Nutrient Profile

  NuSun™ sunflower oil fits a healthful fat profile and provides the commercial cooking capabilities needed to produce tasty, high-quality food products. NuSun™ sunflower oil is a mid-level oleic sunflower oil, and its fat profile is predominantly monounsaturated, with oleic acid accounting for the majority of its fat profile (approximately 65 percent). It is also low in saturated fat (less than 10 percent) and a good source of linoleic acid (approximately 26 percent) an essential fatty acid.

- Characteristics

  NuSun™ sunflower oil was developed by standard breeding techniques and is therefore, a natural, non-transgenic cooking oil. It does not require hydrogenation and is naturally trans fat free. NuSun™ sunflower oil works extremely well in commercial cooking and frying with a smoke point of 450° and a clean light taste. In addition, the natural stability of NuSun™ sunflower oil gives excellent fry-life and shelf-life characteristics.

- Taste

  Because taste is the number one driving factor in consumer food choice, NuSun™ sunflower oil benefits consumers by providing a highly palatable product. Beyond taste, the trans fat-free nature of NuSun™ sunflower oil and the predominantly unsaturated fatty acid content of NuSun™ sunflower oil contribute health benefits to consumers.

NuSun™ Sunflower Oil vs. Other Fats and Oils

	Mono-unsaturated	Poly-unsaturated	Saturated	Stability AOM** (hours)
High Oleic Sunflower Oil	82%	9%	9%	35-40
Olive Oil	77%	9%	14%	<5
NuSun™ Sunflower Oil	**65%**	**26%**	**9%**	**20-25**
Canola Oil*	62%	32%	6%	12-15
Peanut Oil	49%	33%	18%	25-28
Lard	47%	12%	41%	<5
Beef Fat	44%	4%	52%	2-3
Butter Fat	34%	2%	64%	<5
Corn Oil	25%	62%	13%	15-19
Soybean Oil*	24%	61%	15%	12-15
Linoleic Sunflower Oil*	20%	69%	11%	10-12
Cottonseed Oil	18%	55%	27%	15-19
Safflower Oil*	13%	77%	10%	10-12

* These oils are usually hydrogenated when used for commercial frying.
** AOM is a measure of the oxidative stability of an oil; the higher the AOM hours, the better the oil stability.

B. Advantages for Industry

In addition to its optimal health benefits, NuSun™ sunflower oil has many advantages for industry over its competitors.

- Frying Stability

  In a study conducted by the United States Department of Agriculture's (USDA) National Center for Agricultural Utilization Research, mid-level oleic sunflower oil (NuSun™ Sunflower Oil) was compared with linoleic (traditional) sunflower oil, high oleic sunflower oil and hydrogenated soybean oil. Even after 10 hours of batch frying raw tortilla chips at 190 degrees Celsius, the percentage of total polar compounds (an index to oil fry life) in NuSun was only 11% which was significantly less than linoleic

sunflower oil and was similar to high oleic sunflower and hydrogenated soybean oil.

- Flavor

  Most importantly, the flavor of the food fried in NuSun™ sunflower oil is desirable. Fatty acid composition has a significant effect on the flavor of fried foods. Foods fried in oils containing polyunsaturated linolenic acids (C18:3) can have a fishy flavor. Rather, polyunsaturated linoleic fatty acids (C18:2) contribute a positive flavor derived from partial decomposition during frying. On the other hand, oils containing high amounts of saturated or monounsaturated fatty acids can lack the desirable flavor that is typical of high linoleic sunflower and other polyunsaturated oils.

  Another consideration in taste is hydrogenation, which is said to impart a distinctive flavor to the oil, making foods waxy, fruity and sweet. Frying tests with linoleic sunflower oil, mid-level oleic sunflower oil (NuSun™) and hydrogenated soy oil were conducted. Initially, potatoes fried in hydrogenated oil were described as waxy and fruity, whereas, potatoes fried in linoleic or mid-level oleic sunflower oils had significantly overall better flavor quality scores. The overall quality scores for the potatoes fried in mid-level oleic sunflower oil (NuSun™) did not change over frying time. However, the flavor quality of the potatoes fried in linoleic sunflower oil decreased significantly.

- Storage Stability and Extended Shelf-Life

  When the tortilla chips were stored for four months at 25°C, the panelists found no differences in overall flavor quality between mid-level oleic (NuSun™) and high-oleic sunflower oils, indicating comparable storage stability from the two oils.

  Another frying study conducted over a three-year period showed that mid-level oleic sunflower oil (NuSun™) was superior to nonhydrogenated vegetable oils (soy, canola, corn, and cottonseed). Mid-level oleic sunflower oil exhibited equal frying performance to partially hydrogenated vegetable oils (soybean, canola, and corn oil) and nonhydrogenated peanut oil. In all cases, the flavor profile of potatoes fried in mid-level oleic sunflower oil was superior to that of the tested oils. In addition to excellent flavor and oxidative stability, mid-level oleic sunflower oil exhibited less color formation during deep-frying.

VII. Research Results

A. Preliminary Research Results

- Animal feeding studies and preliminary results from a controlled clinical trial in humans have yielded positive results.

In a controlled clinical trial, researchers at The Pennsylvania State University compared healthful diets with either NuSun™ or olive oil, to the average American diet. The NuSun™ sunflower oil and olive oil diets were moderate in total fat (30%), low in saturated fat (about 8%), and low in cholesterol (less than 300mg). The average American diet contained 34% total fat, 11.2 % saturated fat, and 300 mg cholesterol.

The study consisted of thirty-one men and women with slightly elevated cholesterol. Each participant followed each of the three diets for four weeks. The study showed a 4.7% and 5.8% reduction in total and LDL cholesterol with the NuSun™ diet versus the Average American, whereas the Olive oil diet lowered cholesterol by only 0.5% and 0.2%, respectively ($p<0.01$). [32]

B. Summary of Study Conclusions

- Substituting 2 tablespoons of NuSun™ sunflower oil daily in place of saturated fat had a significantly better cholesterol lowering effect than substituting a similar amount of olive oil.

- The greater total and LDL cholesterol lowering of the NuSun™ oil diet could be explained by its increased polyunsaturated fat (PUFA) content compared to the Olive oil diet.

- PUFA is an important component of a cholesterol-lowering diet. Therefore, food sources chosen to replace saturated fat in the diet should include a balance of unsaturated fatty acids by including both monounsaturated fat (MUFA) and an adequate amount of PUFA.

VIII. Conclusions

By making the *trans*-ition to NuSun™ sunflower oil, it is possible to choose a natural oil that fits a healthful fat profile and provides the commercial cooking capabilities needed to produce tasty, high-quality food products.

For more information on sunflower seeds or NuSun sunflower oil, contact:
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