Phytochemicals in Sunflower (*Helianthus annuus*) Kernel

Literature Review

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Methodology

A comprehensive search of major databases was conducted during the period November 1999 - January 2000 to retrieve available information about the phytochemical content of sunflower (*Helianthus annuus*) kernel. The databases searched included MEDLINE (1); AGRICOLA, Plant Science, and Conference Papers Index (2); Dr. Duke's Phytochemical and Ethnobotanical Databases (3). Information on selected nutrients (fatty acids, minerals, vitamins, amino acids, etc.) was also retrieved, since some of these components have been associated with health benefits (e.g. cancer prevention, cardiovascular disease prevention, blood pressure reduction) and may be of interest. However, the primary focus of this review is on phytochemicals other than macronutrients, vitamins, and minerals in sunflower kernel.

Preliminary surveys were done to identify types of phytochemicals associated with health benefits (Table 1) and phytochemicals reported in sunflower kernel (Appendix A). These chemical classifications and chemical names were included as keywords in subsequent database searches for information on individual phytochemicals in sunflower kernel. Search strategies were also designed to retrieve any information on phytochemicals in seed kernels of plants within the same genus (*Helianthus*) or family [Asteraceae (Compositae)]. Additionally, some information on phytochemical activity and occurrence was located to provide an indication of the potential biological significance of components ingested as part of sunflower kernels.

All literature values for a given constituent were converted to common units (e.g. mg/100g, g/100g) for ease of comparison. When data were for portions of the whole sunflower kernel (e.g. commercial oil, crude lipid extract, defatted meal), the concentration in the whole kernel was estimated by calculation[1]. These calculations used the average protein (22.8 g/100g) and total fat (49.6 g/100g) content of sunflower kernel reported in the USDA Nutrient Database for Standard Reference (4).

Results and Discussion

Table 2 summarizes phytochemicals reported in sunflower kernel. Some of the compounds identified are phenolic acids, protease inhibitors, dietary fiber, phytosterols, phytic acid, phospholipids, saponins, triterpenes (α- and β-amyrin), tocopherols, isoflavones, and lignans. Table 3 shows the nutrient composition of sunflower kernel as reported in the USDA Nutrient Database for Standard Reference (4).

Major phytochemicals in sunflower kernel[2].

Phenolic acids.

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[1]A compilation of original values for the assayed seed part has been maintained.

[2]Structures of selected phytochemicals are illustrated in Appendix B.

Sunflower kernel appears to be a rich source of phenolic acids[3]. The kernel has been reported to contain up to 3194 mg/100g (906 mg/28.35g) total phenolic acids, predominately chlorogenic acid (Table 2). Sabir et al. (5) measured 1940 - 2080 mg/100g chlorogenic acid in defatted sunflower meal samples, which (assuming 49.6% total fat in whole meal; ref. 4) is equivalent to 978 - 1048 mg/100g in whole sunflower meal. Felice et al. (6) reported 1316 mg/100g chlorogenic acid in sunflower meal. Other phenolic acids found in sunflower kernel, at concentrations of 200mg/100g and lower are caffeic acid (3,5,7) cinnamic acid (3), *trans*-cinnamic acid (3,5), p-coumaric acid (3,5), 3,5-dicaffeoylquinic acid (7), isoferulic acid (3,5), o-hydroxybenzoic acid (3), p-hydroxybenzoic acid (3), sinapic acid (5), and syringic acid (3). The phenolic acids in sunflower kernel are primarily hydroxycinnamic acid derivatives, compared to the hydroxybenzoic acid derivatives (e.g. gallic acid, ellagic acid) that predominate in fruits and vegetables (8).

Phenolic acids are found in a broad range of plant foods, including legumes, grains, nuts, green pepper, olive oil, rosemary, fruits, coffee, and tea (9,89). King (8) summarized the phenolic phytochemical content of some plant foods; the highest level of phenolic acids in the fruits and vegetables cited was 211 mg/100g in blueberries, and in grape juice 79 - 110 mg/L phenolic acids (primarily ellagic and gallic acids) were noted. Figure 1 illustrates the relative phenolic acid content of sunflower kernel compared to selected fruits and vegetables. Additionally, coffee beans have a particularly high phenolic acid content (5600 mg/100g), largely chlorogenic acid (8). Eggplant flesh has been reported to contain 948 mg/100g chlorogenic acid (10). Clifford (90) has also reported on the chlorogenic acid content of foods and diets.

In foods phenolic acids are primarily flavor compounds, while chlorogenic acid also contributes to enzymatic and non-enzymatic browning reactions (9). Phenolic acids also function as antioxidants (11,12). They are precursors in the synthesis of lignin, a plant cell wall component and are also found esterified to cell wall polysaccharides (13). Chlorogenic acid tends to concentrate in the outer layer of grain kernels (8,14). Phenolic acids, and in particular the hydroxycinnamic acid derivatives (e.g. chlorogenic acid, caffeic acid, ferulic acid, p-coumaric acid), have been reported to be anticarcinogenic (15). They protect against nitrosation, a process believed to promote colon carcinogenesis (9,16).

Protease inhibitors.

Sunflower meal contains significant protease inhibitor activity (Table 2). Other foods noted for protease inhibitor content are soybeans and other legumes, cereal grains, seeds, and tubers (17-19). Protease inhibitors bind to intestinal proteases (e.g. trypsin, chymotrypsin, pepsin) and thus interfere with protein digestion. In this respect protease inhibitors are considered anti-nutritional, by decreasing the bioavailability of protein (20). They have also been shown to induce pancreatic hyperplasia when consumed in large quantities (20). However, beneficial effects have also been attributed to protease inhibitors, including inhibition of tumor growth (21), and they have been recognized as a phytochemical class associated with health promotion (22). Protease inhibitors generally are destroyed by heat treatment (19).

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[3]See Appendix B.

Dietary fiber.

Sunflower kernel is rich in dietary fiber (3 g/28.35g, Table 2). The non-starch polysaccharides in de-fatted sunflower kernel are primarily xylans, xyloglucans, and pectins (polygalacturonans) (23). Dietary fiber has been shown to lower blood cholesterol (24), and epidemiological studies have correlated high-fiber diets with decreased incidence of cancer, hypertension, and obesity (24). Dietary fiber also increases satiety and helps control appetite (25).

Phytosterols.

Sunflower kernel is a good source of phytosterols[4], as are other nuts, seeds, and their oils (26). A total sterol content of 564 mg/100g has been reported for sunflower kernel, comprising predominately β-sistosterol (26). This content is substantially higher than that of other commonly consumed nuts, legumes, and seeds (except sesame) (Figure 2). The reported total sterol contents of soybean, peanut, almond, cashew, walnut, and sesame seed are 161, 220, 143, 158, 108, and 714 mg/100g, respectively (26). Sunflower oil also differs in that it contains a relatively higher concentration of Δ^7-avenasterol (22 mg/100g), which is found at levels of 2 mg or less in other commonly consumed vegetable oils (Fig. 2), including olive, palm, rapeseed, coconut, corn, cottonseed, peanut, and soybean (26).

Phytosterols occur primarily as free sterols, but also as steryl esters, steryl glucosides, steryl ethers, and acylated steryl glycosides (27). The predominant phytosterols in the human diet are β-sitosterol, stigmasterol, and campesterol. Sitosterol glucoside (daucausterol) has been identified but not quantified in sunflower seed (3), and steryl glycosides have been measured in some foods (28,29). The physiological effect of dietary steryl glycosides has not been determined, but a supplement containing a mixture of β-sitosterol and β-sitosterol glucoside has been demonstrated to have immunomodulatory effects greater than the equivalent amounts of the individual components (30,31). Hypocholesterolemic and anticarcinogenic effects have been demonstrated for phytosterols *in vivo* in milligram-gram per day amounts (32-38).

Phytic acid.

The phytic acid content of sunflower kernel is ~60 mg/100g (Table 2). Phytic acid (myoinositol hexaphosphate)[4] and its mixed potassium-calcium-magnesium salts (phytin) have been reported in various oilseeds (39,40), legumes (including soybeans) (40,41), and cereal grains (21,40). The phytic acid content of corn, defatted soybean meal, and defatted sesame meal are 890, 1520, and 5180 mg/100g, respectively (40).

Phytic acid and phytin store phosphorous in plants and may account for >70% of kernel phosphate (41). The primary biological effect of ingested phytate is binding of divalent cations (e.g. Fe^{++}, Ca^{++}, Zn^{++}). This chelation can be considered negative insofar as decreasing the

[4]See Appendix B.

bioavailability of essential minerals. However, binding of iron inhibits iron-catalyzed hydroxyl radical formation (41), and this mechanism has been cited as protective against colorectal cancer (42). Phytate may have other chemopreventive and therapeutic value against cancer by influencing mammalian cellular inositol phosphate metabolism (43). Phytate has also been reported to reduce blood cholesterol, and to serve as an antioxidant and preservative in foods (41). Phytate is a rich dietary source of inositol, which is released by phytase during digestion (44).

Phospholipids.

Sunflower seed is a good source of phospholipids, primarily phosphatidylcholine (lecithin) and phosphatidylethanolamine (cephalin)[5], with reported contents of 38.5 - 230 mg/100g and 61.5 - 123 mg/100g, respectively (Table 2). Lecithin from plant sources contains unsaturated fatty acids, whereas saturated fatty acids predominate in lecithin from animal sources such as egg yolk (45).

Soy lecithin has been shown to decrease lipoprotein cholesterol and atherogenesis, independent of its fatty acid composition (46). Phosphatidylcholine is hydrolyzed in the intestine by phospholipase C, and provides a dietary source of choline. Choline is a membrane phospholipid, and provides a choline reserve for neurotransmitter (acetylcholine) synthesis (45). Though choline is not currently considered essential for human nutrition it is important for normal liver function, and deficiencies of choline have been associated with liver cancer (45), and dietary reference intakes have recently been established (47).

α- and β-*Amyrin.*

α- and β-amyrin are triterpenes[5] that are synthesized in or secreted into the coverings of some plants (48). Amyrins have been found in vegetable oils derived from nuts and seeds (48). α- and β-amyrin have been reported in sunflower seed (3), but it is unclear whether they occur mainly in the hull (pericarp) or kernel, and quantitative data are not available. Pharmacologic preparations of α- and β-amyrin and their fatty acyl esters have anti-dopaminergic and antidepressant (49,50), antinflammatory and antiarthritic (51,52), and antiviral (53) activity.

Saponins.

Saponins are glycosides of steroids or triterpenoids and vary widely in the aglycone and carbohydrate moieties (54). Triterpenoid saponins[5] have been identified in sunflower seed, though quantitative data are lacking (3,55). In addition to sunflower seed, some commonly consumed foods containing saponins are soybeans (500mg/100g; ref. 54, p. 191); spinach, chickpeas, and mung beans (56); and sugar beet and alfalfa (2000-3000mg/100g; ref. 54, p. 178);

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[5]See structure in Appendix B.

licorice (55); and peanuts (54). Recent studies have demonstrated antitumoral and immunomodulatory effects of triterpenoid saponins (57). Saponins also have the capacity to bind bile salts (56,58) and thus may exert a hypocholesterolemic effect by interfering with enterohepatic cholesterol recirculation.

Tocopherols.

Sunflower kernel contains tocopherols[6], including the α and β isomers (~14 and 12 mg/100g, respectively) and trace amounts of the γ- and δ-tocopherols (<2 mg/100g) (Table 2). Other dietary sources of tocopherols include vegetable oils, whole grains, wheat germ, fruits, and vegetables. Tocopherols have been well-studied as antioxidants. They may protect against cardiovascular disease by preventing oxidation of low-density lipoprotein cholesterol (9) and against exercise-induced oxidative muscle damage (59). Tocopherols also inhibit oxidation of unsaturated fatty acids in sunflower oil (60). Dietary tocopherols have been associated with decreased risk of cancer as well (16).

Phytoestrogens.

The two primary classes of "phytoestrogens" are isoflavones (e.g. genistein, daidzen) and lignans (e.g. secoisolariciresinol, matairesinol) (74). Though sunflower seed has a relatively low genistein and daidzein content, it contains 610 mg/100g secoisolariciresinol (61). This concentration is high compared to other nuts, legumes, seeds (other than flaxseed), and grains (61), as illustrated in Figure 2. Secoisolaricisresinol occurs mainly as the diglycoside[6] (74). Antitumorigenic activity has been shown for secoisolariciresinol diglycoside from flaxseed (62) .

Prominent nutrients in sunflower kernel

The average nutrient composition of sunflower kernel reported in the USDA Nutrient Database for Standard Reference is shown in Table 3. Appendix C summarizes a report of the nutrient composition of sunflower kernel and other nuts (63). Sunflower kernel appears to be an excellent source of the following nutrients.

Fatty acids.

On average, sunflower kernel contains 49.6 g/100g total fat (5.2 g/100g saturated fatty acids, 9.5 g/100g monounsaturated fatty acid, and 32.7 g/100g polyunsaturated fatty acids, respectively) (4). The major fatty acid in sunflower kernel is linoleic acid ($C_{18:2n-6}$) (32.6 g/100g) (4). Palmitic acid ($C_{16:0}$)(2.8 g/100g) and stearic acid ($C_{18:0}$)(2.2 g/100g) account for most of the saturated fatty acids, and almost all of the monounsaturated fat is oleic acid $C_{18:1n-9}$)(9.4 g/100g).

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[6]See structure in Appendix B.

The Asteraceae (Compositae) family to which sunflower (*Helianthus annuus*) belongs is known for the unusual fatty acids found in some of its members (64).

Protein.

Sunflower kernel is a notable source of non-animal protein (6.46g/28.35g) (Table 3). Though not a complete source of all essential amino acids, sunflower protein contains methionine which is a limiting amino acid in legume proteins (ref. 65, p.148). The combination of sunflower kernel as a complementary protein source increases the biological value of vegetable proteins in vegetarian diets (65), and it has been used in the production of low-cost plant-based protein foods for consumption in developing countries (66).

Vitamins and minerals.

Sunflower kernel is an excellent source [>10% recommended daily intake (RDI) per 28.35 g serving] of thiamin (43% RDI), folate, vitamin B6 (pyridoxine), vitamin E (38% RDI), pantothenic acid, iron, phosphorous, magnesium (25% RDI), zinc copper (25% RDI), and relative to other nuts it has a high selenium content (see Table 3 and Appendix C). Several of these micronutrients have been linked to health benefits. For example, selenium deficiency has been associated with cancer and cardiovascular disease (67), and selenium is recognized to work synergistically with vitamin E as an antioxidant (68). Folate has been of interest in preventing elevated blood homocysteine levels which have been linked to cardiovascular disease (69), and to cancer prevention (70). Although currently there is no recommended dietary allowance for copper, copper deficient diets have been associated with bone disease and cardiovascular disease, and increasing foods rich in copper has been recommended in such cases (71).

References

1. MEDLINE®. (1999), via Internet Grateful Med. V.2.6.3 (1999). National Library of Medicine, Bethesda, MD. http://igm.nlm.nih.gov

2. Cambridge Scientific Abstracts. Internet Database Service (1999). Cambridge Scientific Abstracts (CSA), Bethesda, MD. http://www.csa.com

3. Duke, J., Beckstrom-Sternberg, S. (1999). Dr. Duke's Phytochemical and Ethnobotanical Databases. US Department of Agriculture-Agricultural Research Service, http://www.ars-grin.gov/duke/

4. US Department of Agriculture. November 1999. Nutrient Database for Standard Reference, Release 13. Nutrient Data Laboratory Research Service, Riverdale, MD. http://www.nal.usda.gov/fnic/foodcomp/Data/index.html

5. Sabir, M.A., Sosulski, F.W., Kernan, J.A. (1974). Phenolic constituents of sunflower flour. J. Agric. Food Chem., 22:572-574.

6. Felice, L.J., King, W.P., Kissinger, P.T. (1976). A new liquid chromatographic approach to plant phenolics. Application to the determination of chlorogenic acid in sunflower meal. J. Agric. Food Chem., 24:380-382.

7. Mikolajczak, K.L., Smith, C.R., Jr., Wolff, I.A. (1970). Phenolic and sugar components of Armavirec seed variety sunflower (*Helianthus annuus*) seed meal. J. Agric. Food Chem., 18:27-32.

8. King, A., Young, G. (1999). Characteristics and occurrence of phenolic phytochemicals. J. Amer. Diet. Assoc., 99:213-218.

9. Guhr, G., Lachance, P.A. (1997). Role of phytochemicals in chronic disease prevention. In: *Nutraceuticals: Designer Foods III. Garlic, Soy, and Licorice*, Lachance, P.A. (Ed.), Trumbull, CT: Food & Nutrition Press, Inc., pp.311-364.

10. Paganga, G., Miller, N., Rice-Evans, C. (1999). The polyphenolic content of fruits and vegetables and their antioxidant activities. What does a serving constitute? Free Rad. Res., 30: 153-162.

11. Croft, K.D. (1998). The chemistry and biological effects of flavonoids and phenolic acids. Ann. New York Acad. Sci., 854: 435-442.

12. Rice-Evans, C.A., Miller, N.J., Paganga, G. (1996). Structure-antioxidant activity relationships of flavonoids and phenolic acids. Free Rad. Biol. Med., 20: 933-956.

13. Wallace, G., Fry, S.C. (1994). Phenolic components of the plant cell wall. Int. Rev. Cytol., 151: 229-267.

14. Dimberg, L.H., Molteberg, E.L., Solheim, R., Frolich, W. (1996). Variation in oat groats due to variety, storage and heat treatment, 1: phenolic compounds. J. Food Sci. 24: 263-272.

15. Hirose, M., Takahashi, S., Ogawa, K., Futakuchi, M., Shirai, T. (1999). Phenolics: blocking agent for heterocyclic amine-induced carcinogenesis. Food Chem. Toxicol., 37: 985-992.

16. Stavric, B. (1994). Role of chemopreventers in the human diet. Clin. Biochem., 27:319-327.

17. Bankowski, A., Roszkowska-Jakimiec, W., Worowski, K. (1998). Inhibitors of pepsin, trypsin, and chymotrypsin in seeds of plants consumed by humans and animals. Roczniki Akademii Medycznej W Bialymstoku, 43:278-286.

18. Shewry, P.R. (1999). Enzyme inhibitors of seeds: types and properties. In *Seed Proteins*, P.R. Shewry and R. Casey, Eds., Dordrecht, Holland: Kluwer Academic Publishers.

19. Liener, I.E., Kakade, M.L. (1969). Protease inhibitors. Ch. 2 in Toxic Constituents of Plant Foodstuffs, I.E. Liener (Ed.), New York: Academic Press, pp. 7-68.

20. Liener, I.E. (1995). Possible adverse effects of soybean anticarcinogens. J. Nutr., 125: 744S-750S.

21. Fjeld, C.R., Lawson, R.H. (1999). Food, phytonutrients, and health: rationale for the conference and workshop. Nutr. Rev., 57: (II)S1-S12.

22. Beecher, G.R. (1999). Phytonutrients' role in metabolism: effects on resistance to degenerative processes. Nutr. Rev., 57: S3-S6.

23. Dusterhoft, E.-M., Posthumus, J.A., Voragen, A.G.J. (1992). Non-starch polysaccharides from sunflower (*Helianthus annuus*) meal and palm-kernel (*Elaeis guineensis*) meal - investigation of the structure of major polysaccharides. J. Sci. Food Agric., 59:151-160.

24. Prosky, L., Devries, J. (1992). *Controlling Dietary Fiber in Food Products*. New York: Van Nostrand Reinhold, pp. 17 -37.

25. Anderson, J.W., Hanna, T.J. (1999). Impact of nondigestible carbohydrates on serum lipoproteins and risk for cardiovascular disease. J. Nutr., 129: 1457S-1466S.

26. Weihrauch, J.L. and Gardner, J.M. (1978). Sterol content of foods of plant origin. *J. Amer. Diet. Assoc.*, 73: 39-47.

27. Akihisa, T., Kokke, W.C.M.C., and Tamura, T. (1991). Naturally occurring sterols and related compounds from plants. Chapter 7 in *Physiology and Biochemistry of Sterols*, G.W. Patterson and W.D. Nes (Eds.), Champaign, IL: American Oil Chemists' Society, pp. 172-228.

28. Jonker, D., van der Hoek, G.D., Glatz, J.F.C., Homan, C., Posthumus, M.A., and Katan, M.B. (1985). Combined determination of free, esterified and glycosilated plant sterols in foods. Nutr. Rep. Intl., 32: 943-951.

29. Toivo, J., Maatta, K., Lampi, A.-M., Piironen, V. (1999). Free, esterified, and glycosylated sterols in Finnish cereals. Proc. Euro Food Chem X, Vol. 2. Budapest, Hungary: Hungarian Scientific Society for Food Industry, FECS Food Chemistry Division.

30. Bouic, P.J., Etsebeth, S., Liebenberg, R.W., Albrecht, C.F., Pegel, K., van Jaarsveld, P.P. (1996). Beta-sitosterol and beta-sitosterol glucoside stimulate human peripherol blood lymphocyte proliferation: implications for their use as an immunomodulatory vitamin combination. Int. J. Immunopharmacol., 18: 693-700.

31. Bouic, P.J., Clark, A., Lamprecht, J., Freestone, M., Pool, E.J., Liebenberg, R.W., Kotze, D., van Jaarsveld, P.P. (1999). The effects of β-sitosterol (BSS) and β-sitosterol glucoside (BSSG) mixture on selected immune parameters of marathon runners: inhibition of post marathon immune suppression and inflammation. Int. J. Sports. Med., 20:258-262.

32. Grundy, S.M., Mok, H.Y.I.. (1976). Effects of low dose phytosterols on cholesterol absorption in man. In: Greten, H. (Ed.), *Lipoprotein metabolism*. New York: Springer-Verlag, pp. 112-118.

33. Heinemann, T., Leiss, O., von Bergmann, K. (1986). Effect of low-dose sitostanol on serum cholesterol in patients with hypercholesterolemia. Atherosclerosis, 61:219-223.

34. Raicht, R., Cohen, B., Fazzini, E., Sarwal, A., Takahashi, M. (1980). Protective effect of plant sterols against chemically induced colon tumors in rats. Cancer Res., 40:403-445.

35. Rao, V.A., Janezic, S.A. (1992). The role of dietary phytosterols in colon carcinogenesis. Nutr. Cancer,18:43-52.

36. Pelletier, X., Belbraouet, S., Mirabel, D., Mordret, F., Perrin, J.L., Pages, X., Debry, G. (1995). A diet moderately enriched in phytosterols lowers plasma cholesterol concentrations in normocholesterolemic humans. Ann. Nutr. Metab., 39:291-295.

37. Pollack, O.J., Kritchevsky, D. (1981). Sitosterol. In: Clarkson, T.B., Kritchevsky, D., Pollack, O.J. (Eds.). *Monographs on Atherosclerosis*. Vol. 10. New York: S. Karger: pp. 70-71.

38. Moghadasian, M.H., Frohlich, J.J. (1999). Effects of dietary phytosterols on cholesterol metabolism and atherosclerosis: clinical and experimental evidence. Amer. J. Med., 107: 588-594.

39. Eklund, A. (1975). The contents of phytic acid in protein concentrates prepared from nigerseed, sunflower seed, rapeseed, and poppy seed. Upsala J. Med. Sci., 80:5-6.

40. deBoland, A.R., Garner, G.B., O'Dell, B.L. (1975). Identification and properties of "phytate" in cereal grains and oilseed products. J. Agric. Food Chem., 23:1186-1189.

41. Zhou, J.R., Erdman, J.W. (1995). Phytic acid in health and disease. Crit. Rev. Food Sci. Nutr., 35:495-508.

42. Owen, R.W., Weisgerber, U.M., Spiegelhalder, B., Bartsch, H. (1996). Faecal phytic acid and its relation to other putative markers of risk for colorectal cancer. Gut, 38: 591-597.

43. Shamsuddin, A.M. (1995). Inositol phosphates have novel anticancer function. J. Nutr., 125: 725S-732S.

44. Holub, B.J. (1982). The nutritional significance, metabolism, and function of *myo*-inositol and phosphatidylinositol in health and disease. Adv. Nutr. Res., 4: 107-141.

45. Canty, D.J., Zeisel, S.H. (1994). Lecithin and choline in human health and disease. Nutr. Rev., 52: 327-339.

46. Wilson, T.A., Meservey, C.M., Nicolisi, R.J. (1998). Soy lecithin reduces plasma lipoprotein cholesterol and early atherogenesis in hypercholesterolemic monkeys and hamsters: beyond linoleate. Atherosclerosis, 140: 147-153.

47. Yates, A.A., Schlicker, S.A., Suitor, C.W. (1998). Dietary Reference Intakes: the new basis for recommendations for calcium and related nutrients, B vitamins, and choline. J. Amer. Diet. Assoc., 98: 699-706.

48. Jeong, T.M., Itoh, T., Tamura, T., Matsumoto, T. (1975). Analysis of methylsterol fractions from twenty vegetable oils. Lipids, 10: 634-640.

49. Subarnas, A., Tadano, T., Kisara, K., Ohizumi, Y. (1993). An α-adrenoceptor-mediated mechanism of hypoactivity induced by β-amyrin palmitate. J. Pharm. Pharmacol., 45: 1006-1008.

50. Subarnas, A., Tadano, T., Ashima, Y., Kisara, K., Ohizumi, Y. (1993). Pharmacological properties of β-amyrin palmitate, a novel centrally acting compound isolated from *Lobelia inflata* leaves. J. Pharm. Pharmacol., 45: 545-550.

51. Kweifio-Okai, G., DeMunk, F., Rumble, B.A., Macrides, T.A., Cropley, M. (1994). Antiarthritic mechanisms of amyrin triterpenes. Res. Comm. Mol. Path. Pharmacol., 85: 45-55.

52. Kweifio-Okai, G., Bird, D., Eu, P., Carroll, A.R., Ambrose, R., Field, B. (1994). Effect of α-amyrin palmitate on adjuvant arthritis. Drugs Expt. Clin. Res., XX(1):1-5.

53. Rao, G.S., Sinsheimer, J.E. (1974). Antiviral activity of triterpenoid saponins containin acylated β-amyrin aglycones. J. Pharm. Sci., 63: 471-473.

54. Birk, Y. (1969). Saponins. Ch. 7 in *Toxic Constituents of Plant Foodstuffs*, I.E. Liener (Ed.), New York: Academic Press, pp. 169-210.

55. Basu, N., Rastogi, R.P. (1967). Triterpenoid saponins and sapogenins. Phytochem., 6: 1249-1270.

56. Oakenfull, D.G., Fenwick, D.E. (1978). Adsorption of bile salts from aqueous solution by plant fibre and cholestyramine. Br. J. Nutr., 40:299-309.

57. Plohmann, B., Bader, G., Hiller, K., Franz, G. (1997). Immunomodulatory and

antitumoral effects of triterpenoid saponins. Pharmazie, 52: 953-957.

58. Malinow, M.R., McLaughlin, P., Kohler, G.O., Livingston, A.L. (1977). Prevention of elevated cholesterolemia in monkeys. Steroids, 29: 105-110.

59. Goldfarb, A.H. (1999). Nutritional antioxidants as therapeutic and preventive modalities in exercise-induced muscle damage. Can. J. Appl. Physiol., 24: 249-266.

60. Fuster, M.D., Lampi, A.-M., Hopia, A., Kamal-Eldin, A. (1998). Effects of α- and γ-tocopherols on the autooxidation of purified sunflower triacylglycerols. Lipids, 33: 715-722.

61. Mazur, W. (1998). Phytoestrogen content in foods. Clin. Endocrinol. Metab., 12: 729-742.

62. Thompson, L.U., Seidl, M.M., Rickard, S.E., Orcheson, L.J., Fong, H.H.S. (1996). Antitumorigenic effect of a mammalian lignan precursor from flaxseed. Nutr. Cancer, 26: 159-165.

63. Unpublished data received from National Sunflower Association, October 1999.

64. Tsevegsuren, N., Aitzetmuller, K., Vosmann, K. (1997). Unusual fatty acids in Compositae: γ-linolenic acid in *Saussurea* spp. seed oils. J. High Resol. Chromatogr., 20: 315-320.

65. Kreutler, P.A. (1980). *Nutrition in Perspective*, Englewood Cliffs, NJ: Prentice Hall, Inc.

66. Agren, G., Lieden, S.-A. (1968). Some chemical and biological properties of a protein concentrate from sunflower seeds. Acta Chem. Scand., 22: 1981-1988.

67. Foster, L.H., Sumar, S. (1997). Selenium in health and disease: a review. Crit. Rev. Rood Sci. Nutr., 37:211-228.

68. Vannucchi, H. (1991). Interaction of vitamins and minerals. Arch. Latinoam. Nutr., 41:9-18.

69. Langman, L.J., Cole, D.E. (1999). Homocysteine. Crit. Rev. Clin. Lab. Sci., 36:365-406.

70. Kim, Y.I. (1999). Folate and cancer prevention: a new medical application of folate beyond hyperhomocysteinemia and neural tube defects. Nutr. Rev., 57:314-321.

71. Klevay, L.M. (1998). Lack of a recommended dietary allowance for copper may be hazardous to your health. J. Amer. Coll. Nutr., 17:322-326.

72. Steinmetz, K.A., Potter, J.D. (1996). Vegetables, fruit, and cancer prevention: A review. J. Amer. Diet. Assoc. 96:1027-1039.

73. Velioglu, Y.S., Mazza, G., Gao, L., Oomah, B.D. (1998). Antioxidant activity and total phenolics in selected fruits, vegetables, and grain products. J. Agric. Food Chem., 46:4113-4117.

74. Tham, D.M., Gardner, C.D., Haskell, W.L. (1998). Clinical Review 97: Potential health benefits of dietary phytoestrogens: a review of the clinical, epidemiological, and mechanistic evidence. J. Clin. Endocrinol. Metab., 83:2223-2235.

75. Speek, A.J., Schrijver, J., Schreurs, W.H.P. (1985). Vitamin E composition of some seed oils as determined by high-performance liquid chromatography with fluorometric detection. J. Food Sci., 50:121-124.

76. Dionisi, F., Prodolliet, J., Tagliaferri, E. (1995). Assessment of olive oil adulteration by reversed-phase high-performance liquid chromatography/amperometric detection of tocopherols and tocotrienols. J. Amer. Oil Chem. Soc., 72:1505-1511.

77. Nagao, A., Yamazaki, M. (1983). Lipid of sunflower seeds produced in Japan. J. Amer. Oil Chem. Soc., 9:1654-1658.

78. Phillips, K.M. (1997). Unpublished data (analyses performed for National Sunflower Association).

79. Johansson, A., Appelqvist, L.-A. (1979). The sterol composition of freshly harvested compared to stored seeds of rape, sunflower, and poppy. J. Amer. Oil Chem. Soc., 56:995-997.

80. Johansson, A. (1979). The content and composition of sterols and sterol esters in sunflower and poppyseed oils. Lipids, 14:285-291.

81. Sekhon, K.S., Gupta, S.K. (1976). Chemical composition of sunflower seed. J. Food Sci. Tech., 13:322-324.

82. Vaintraub, I.A., Lapteva, N.A. (1988). Colorimetric determination of phytate in unpurified extracts of seeds and the products of their processing. Anal. Biochem., 175:227-230.

83. Luckett, S., Santiago Garcia, R., Barker, J.J., Konarev, Al.V., Shewry, P.R., Clarke, A.R., Brady, R.L. (1999). High-resolution structure of a potent, cyclic proteinase inhibitor from sunflower seeds. J. Mol. Biol., 290:525-533.

84. DellaGatta, C., Piergiovanni, A.R. (1996). Technological and nutritional aspects in hyperproteic bread prepared with the addition of sunflower meal. Food Chem., 4:493-496.

85. Roy, D.N., Bhat, R.V. (1974). Trypsin inhibitor content in some varieties of soya bean (*Glycine max L.*) and sunflower seeds (*Helianthus annuus L.*). J. Sci. Food Agric.,

25:765-769.

86. McGill, A.S., Moffat, C.F., Mackie, P.R., Cruickshank, P. (1993). The composition and concentration of n-alkanes in retail samples of edible oils. J. Sci. Food Agric., 61:357-362.

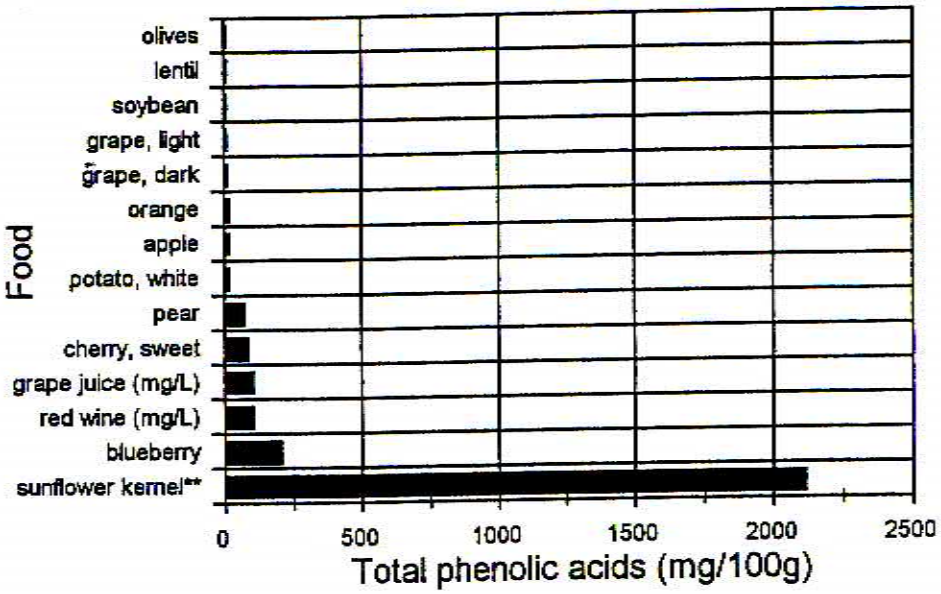
87. Swain, A.R., Dutton, D.P., Truswell, A.S. (1985). Salicylates in foods. J. Amer. Diet. Assoc., 85:950-960.

88. Kiosseoglou, V., Boskou, D. (1990). Separation and fatty acid composition of steryl and wax esters in hexane extracts of sunflower seed, soybeans, and tomato seeds. Food Sci. and Tech., 23:340-342.

89. Sondheimer, E. (1958). On the distribution of caffeic and the chlorogenic acid isomers in plants. Arch. Biochem. Biophys. 74:131-138.

90. Clifford, M.N. (1999). Chlorogenic acids and other cinnamates- nature, occurrence and dietary burden. J. Sci. Food Agric., 79:362-372.

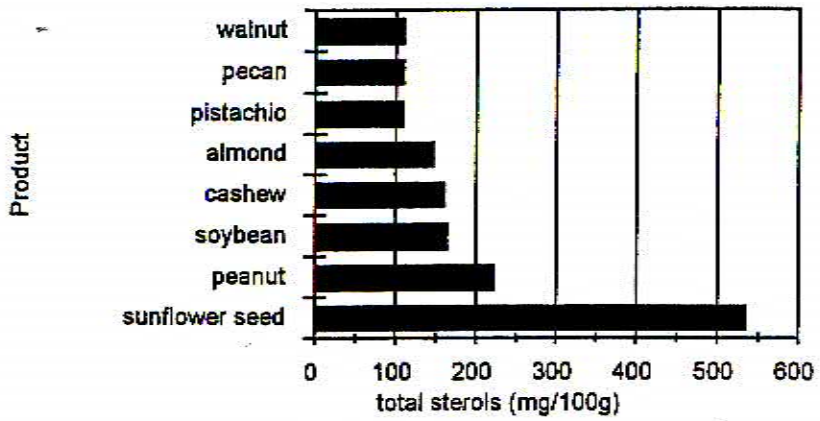
Figure 1. Phenolic acid content of selected foods[7].



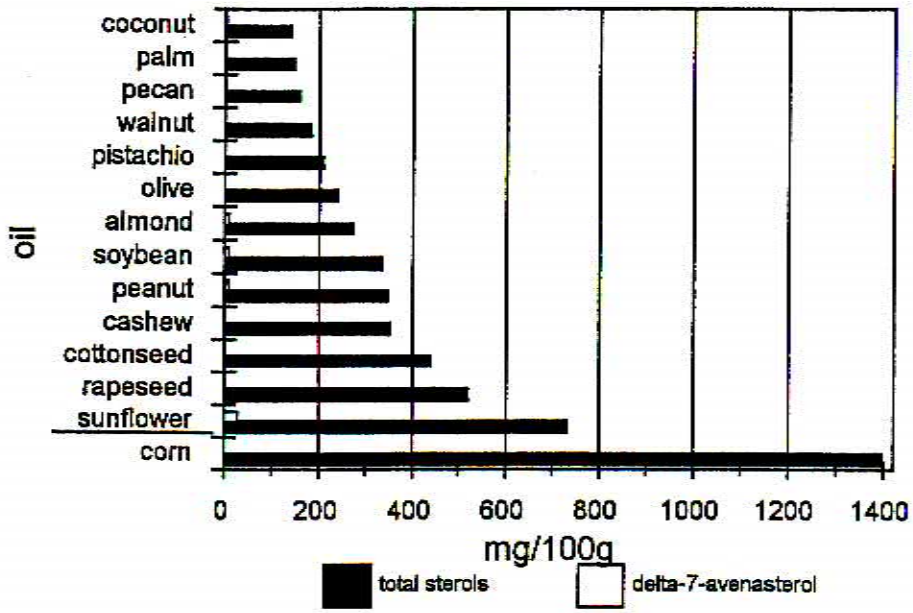
[7]The value for sunflower kernel is the average of high and low shown in Table 2. Data for all other foods are taken from reference 8.

Figure 2. Sterol content of selected nuts, seeds, and legumes and their oils[8].

A. Total sterols in nuts, seeds, and legumes.

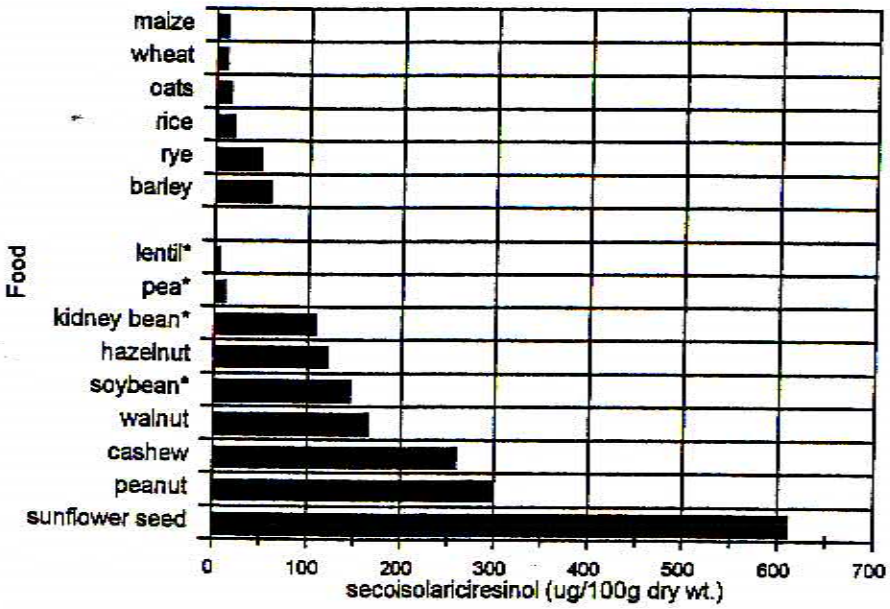


B. Total sterols and Δ^7-avenasterol in nut, seed, and legume oils (unrefined).



[8]Selected data from reference 26.

Figure 3. Secoisolariciresinol content of selected nuts, seeds, legumes, and grains[9].



**Value shown is the average of the high and low of concentration range cited.

[9]Selected data from reference 61. In cases in which a concentration range was reported, the average of the high and low values is shown.

Table 1. Categories of phytochemicals with potential health benefits[10].

Compound class	Examples	Common food sources
Flavonoids	quercetin, rutin, tangeretin, hesperetin	tea, fruits and vegetables, most plants
Isoflavonoids	genestein, daidzein, formononetin, equol	soybeans, flaxseed, licorice root
Lignans	matairesinol, sesamin, secoisolaricircsinol	flaxseed, oilseeds, cereals
Indoles, glucosinolates	indole-3-carbinol, glucobrassicin	cruciferous vegetables, some oil seeds
Saponins	soyasaponin-A, -B, -E; degalactotigonin; gitonin-F; eruboside B; sativosides -R1, -R2.	soybeans, licorice, *Allium* vegetables, alfalfa, dry peas, amaranth seeds
Organosulfur compounds	allyl sulfide, allyl mercaptan	*Allium* vegetables (e.g. garlic, onion, leeks)
Phenolic acids	(mainly as glycosides): ellagic acid, chlorogenic acid, caffeic acid, ferulic acid	coffee, tea, strawberries, grapes (and other fruits), walnuts, bran, cruciferous vegetables
Polyphenols, tannins	castalagin, epicatechin-gallate, resveratrol	tea, wine, grapes, nuts, other fruits, legumes
Phytosterols	sitosterol, campesterol, stigmasterol, sitostanol, avenasterol	vegetable oils, nuts, seeds, legumes
Protease inhibitors	trypsin inhibitor, Bowman-Birk protease inhibitor	seeds, legumes, grains
Quinones	carnosol, miltirone	spices
Terpenes	limonene, carvone, limonin, nomilin	citrus fruits and oils, spices

[10]Compiled using information from references 9, 22, and 72.

Table 1, continued.

Compound class	Examples	Common food sources
Tocopherols	α-, β-, δ-, and γ-tocopherol	vegetable oils, nuts, seeds, legumes, wheat germ
Tocotrienols	α-, β-, δ-, and γ-tocotrienol	barley, rice bran, palm oil
Carotenoids	α-, β-, and γ-carotene, lutein, cryptoxanthin, lycopene, phytoene, zeaxanthin, phytofluene, echinenone	red and yellow fruits and vegetables (e.g. tomatoes, cantaloupe, carrots, pumpkin)
Coumestans	coumestrol	beans, sprouts, spinach
Psoralens (furocoumarins)	8-methoxypsoralen, bergapten, psoralen	celery, parsley, other umbelliferous vegetables; grapefruit
Chlorophyll, Chlorphyllin		green vegetables, algae (e.g. spirulina)
Isothiocyanates	sulforaphane	cruciferous vegetables
Polyacetylene	falcarinol	carrots and other umbelliferous vegetables
"Fiber" (non-starch polysaccharides)	pectin, β-glucan, cellulose	fruits, whole grains, vegetables
Omega-3 fatty acids	α-linolenic acid, eicosopentaenoic acid	Fish oils, canola oil
Individual amino acids	tryptophan, tyrosine, glutamic acid, aspartic acid	protein-containing foods (levels vary)
Minerals	selenium, calcium, potassium, magnesium, manganese, copper	most foods (levels of different minerals vary among foods)
Vitamins	vitamin C	citrus fruits, green peppers

Table 2. Phytochemicals reported in sunflower kernel.

Compound	Seed parts assayed[1]	units[2]	Amount[2,3,4] (per 100g)	Amount [4] (per 28.35g)	Reference(s)
Phenolic Acids					
Total phenolics	ds, dfm	mg	745 - 3480	211 - 987	5,6,7,73
chlorogenic acid (3-caffeoylquinic acid)	s, dfm	mg	190 - 2800	54 - 794	3,5,6,7
caffeic acid (3,4-dihydroxycinnamic acid)	s, dfm	mg	81 - 101	23 - 29	3,5,7
cinnamic acid	s		nr	nr	3
trans-cinnamic acid	s, dfm	mg	25 - 35	7 - 10	3,5
p-coumaric acid (4-hydroxycinnamic acid)	s, dfm	mg	45 - 55	13 - 16	3,5
hydroxycinnamic acid sugar ester	dfm	mg	76 - 101	22 -29	5
3,5-dicaffeoylquinic acid	dfm	mg	15	4	7
isoferulic acid	s, dfm	mg	71 - 86	20 - 24	3,5
o-hydroxybenzoic acid	s		nr	nr	3
p-hydroxybenzoic acid	s		nr	nr	3
syringic acid	s		nr	nr	3
sinapic acid	s, dfm	mg	242 - 287	69 - 81	3

[1] nr = not reported; s = "seed"; ds = de-hulled seed; dfm = defatted meal; o = oil; co = crude oil; k = dried kernel; pc = protein concentrate; pi = protein isolate

[2] Since values from different references were reported in different units in some cases (e.g. ppm *vs.* µg/100g), all values were converted to the units shown to make a uniform summary.

[3] When seed part assayed was other than kernel (e.g. defatted meal, crude oil, protein concentrate), the concentration in kernel was estimated using the average kernel total fat and protein contents of 49.6% and 22.8%, respectively from the USDA Nutrient Database for Standard Reference (4). If values were reported for "seed", these values were used as the estimate for concentration in kernel (i.e. assumed that the edible portion of the seed was assayed).

[4] Concentration ranges (low - high) shown are based on all data reported in the reference(s) indicated.

Table 2, continued.

Compound	Seed parts assayed[1]	units[2]	Amount[2,3,4] (per 100g)	Amount[4] (per 28.35g)	Reference(s)
Phytoestrogens					
Isoflavones:					
daidzein	s	µg	8	2	61
genistein	s	µg	14	4	61
Lignans:					
total lignans	s	µg	400	113	74
secoisolariciresinol	s	µg	610	173	61
Tocopherols					
α-tocopherol	nr, o	mg	10.9 - 48	3 - 14	75,76,77
β-tocopherol	s, o	mg	0 - 42.7	0 - 12	75,77
β- + γ-tocopherol	o	mg	1 - 4	0.3 - 1	76
γ-tocopherol	s, o	mg	0 - 2	0 - 1	75,77
δ-tocopherol	s, o	mg	0 - 1	0 - 0.3	75,76,77

[1] nr = not reported; s = "seed"; ds = de-hulled seed; dfm = defatted meal; o = oil; co = crude oil; k = dried kernel; pc = protein concentrate; pi = protein isolate

[2] Since values from different references were reported in different units in some cases (e.g. ppm *vs.* µg/100g), all values were converted to the units shown to make a uniform summary.

[3] When seed part assayed was other than kernel (e.g. defatted meal, crude oil, protein concentrate), the concentration in kernel was estimated using the average kernel total fat and protein contents of 49.6% and 22.8%, respectively from the USDA Nutrient Database for Standard Reference (4). If values were reported for "seed", these values were used as the estimate for concentration in kernel (i.e. assumed that the edible portion of the seed was assayed).

[4] Concentration ranges (low - high) shown are based on all data reported in the reference(s) indicated.

Table 2, continued.

Compound	Seed parts assayed[1]	units[2]	Amount[2,3,4] (per 100g)	Amount [4] (per 28.35g)	Reference(s)
vitamin E		mg_A TE			
Sterols					
total phytosterols	s, k	mg	199 - 564	56 - 160	3,4,26,78
total free sterols	co	mg	169	48	79
total esterified sterols	co	mg	139	39	80
steryl glycoside	s		nr	nr	81
daucausterol (sitosterol glucoside)	s		nr	nr	3
β-sitosterol	s, k	mg	143 - 349	40.5 - 99	26,78
campesterol	s, k	mg	19 - 61	5.4 - 17	26,78
stigmasterol	s, k	mg	19 - 75	5.4 - 21	26,78
Δ^7-avenasterol	o	mg	11	3	26
Δ^7-stigmastenol	o	mg	30	9	26
Δ^5-avenasterol	o, k	mg	14 - 17.4	4 - 5	26,78

[1] nr = not reported; s = "seed"; ds = de-hulled seed; dfm = defatted meal; o = oil; co = crude oil; k = dried kernel; pc = protein concentrate; pi = protein isolate

[2] Since values from different references were reported in different units in some cases (e.g. ppm *vs.* μg/100g), all values were converted to the units shown to make a uniform summary.

[3] When seed part assayed was other than kernel (e.g. defatted meal, crude oil, protein concentrate), the concentration in kernel was estimated using the average kernel total fat and protein contents of 49.6% and 22.8%, respectively from the USDA Nutrient Database for Standard Reference (4). If values were reported for "seed", these values were used as the estimate for concentration in kernel (i.e. assumed that the edible portion of the seed was assayed).

[4] Concentration ranges (low - high) shown are based on all data reported in the reference(s) indicated.

Table 2, continued.

Compound	Seed parts assayed[1]	units[2]	Amount[2,3,4] (per 100g)	Amount[4] (per 28.35g)	Reference(s)
Phytic Acid					
phytic acid (myoinositol hexaphosphate)	s, pc, pi	mg	25 - 201	7 - 57	39,82
phytin	s		nr	nr	3
Phospholipids/Choline					
phophatidylcholine (lecithin)	s	mg	38.5 - 230	11 - 65	3,81
phophatidylethanolamine (cephalin)	s	mg	61.5 - 123	17 - 35	3,81
phophatidylinositol	s		nr	nr	81
phosphatidylserine	s		nr	nr	3,81
phosphatidic acid	s		nr	nr	81
choline	s		nr	nr	3
Fiber					
Total dietary fiber	s	g	10.5	3	4

[1] nr = not reported; s = "seed"; ds = de-hulled seed; dfm = defatted meal; o = oil; co = crude oil; k = dried kernel; pc = protein concentrate; pi = protein isolate

[2] Since values from different references were reported in different units in some cases (e.g. ppm *vs.* μg/100g), all values were converted to the units shown to make a uniform summary.

[3] When seed part assayed was other than kernel (e.g. defatted meal, crude oil, protein concentrate), the concentration in kernel was estimated using the average kernel total fat and protein contents of 49.6% and 22.8%, respectively from the USDA Nutrient Database for Standard Reference (4). If values were reported for "seed", these values were used as the estimate for concentration in kernel (i.e. assumed that the edible portion of the seed was assayed).

[4] Concentration ranges (low - high) shown are based on all data reported in the reference(s) indicated.

Table 2, continued.

Compound	Seed parts assayed[1]	units[2]	Amount[2,3,4] (per 100g)	Amount[4] (per 28.35g)	Reference(s)
Saponins	s		nr	nr	3,55
Triterpenes					
α-amyrin	s		nr	nr	3
β-amyrin	s		nr	nr	3
cycloartenol	s		nr	nr	3
calenduladiol	s		nr	nr	3
unspecified	s				
Protease Inhibitors					
trypsin inhibitor	dfm				17,83,84,85
pepsin inhibitor	dfm				17
chymotrypsin inhibitor	dfm				17
Carotenoids					

[1]nr = not reported; s = "seed"; ds = de-hulled seed; dfm = defatted meal; o = oil; co = crude oil; k = dried kernel; pc = protein concentrate; pi = protein isolate

[2] Since values from different references were reported in different units in some cases (e.g. ppm *vs.* µg/100g), all values were converted to the units shown to make a uniform summary.

[3] When seed part assayed was other than kernel (e.g. defatted meal, crude oil, protein concentrate), the concentration in kernel was estimated using the average kernel total fat and protein contents of 49.6% and 22.8%, respectively from the USDA Nutrient Database for Standard Reference (4). If values were reported for "seed", these values were used as the estimate for concentration in kernel (i.e. assumed that the edible portion of the seed was assayed).

[4] Concentration ranges (low - high) shown are based on all data reported in the reference(s) indicated.

Table 2, continued.

Compound	Seed parts assayed[1]	units[2]	Amount[2,3,4] (per 100g)	Amount[4] (per 28.35g)	Reference(s)
β-carotene	s	µg	30	9	3
Sugars					
arabinose	s		nr	nr	3
rhamnose	s		nr	nr	3
stachyose	s		nr	nr	3
raffinose	dfm	mg	958	270	7
sucrose	dfm	mg	2218	630	7
α-, α'-trehalose	dfm	mg	1058	300	7
Other					
abscisic acid	s		nr	nr	3
trans-abscisic acid	s		nr	nr	3
alkanes	s				3,86
ascorbic acid	k	mg	1.4	0.4	4
citric acid	s		nr	nr	3

[1] nr = not reported; s = "seed"; ds = de-hulled seed; dfm = defatted meal; o = oil; co = crude oil; k = dried kernel; pc = protein concentrate; pi = protein isolate

[2] Since values from different references were reported in different units in some cases (e.g. ppm *vs.* µg/100g), all values were converted to the units shown to make a uniform summary.

[3] When seed part assayed was other than kernel (e.g. defatted meal, crude oil, protein concentrate), the concentration in kernel was estimated using the average kernel total fat and protein contents of 49.6% and 22.8%, respectively from the USDA Nutrient Database for Standard Reference (4). If values were reported for "seed", these values were used as the estimate for concentration in kernel (i.e. assumed that the edible portion of the seed was assayed).

[4] Concentration ranges (low - high) shown are based on all data reported in the reference(s) indicated.

Compound	Seed parts assayed[1]	units[2]	Amount[2,3,4] (per 100g)	Amount[4] (per 28.35g)	Reference(s)
dihydrophaseic acid	s		nr	nr	3
dioxindole-3-acetic acid	s		nr	nr	3
gibberellins	s		nr	nr	3
gossypol	s	mg	1.00	0.28	3
jasmonic acid	s		nr	nr	3
nuclein (nucleic acid)	s	mg	510	145	3
pentan-2-one	s		nr	nr	3
quinic acid	s		nr	nr	3
salicylates	s	mg	0.23	0.07	87
shikimic acid	s		nr	nr	3
squalene	s		nr	nr	3
tartaric acid	s		190	54	3
wax esters	s		nr	nr	88

[1] nr = not reported; s = "seed"; ds = de-hulled seed; dfm = defatted meal; o = oil; co = crude oil; k = dried kernel; pc = protein concentrate; pi = protein isolate

[2] Since values from different references were reported in different units in some cases (e.g. ppm *vs.* µg/100g), all values were converted to the units shown to make a uniform summary.

[3] When seed part assayed was other than kernel (e.g. defatted meal, crude oil, protein concentrate), the concentration in kernel was estimated using the average kernel total fat and protein contents of 49.6% and 22.8%, respectively from the USDA Nutrient Database for Standard Reference (4). If values were reported for "seed", these values were used as the estimate for concentration in kernel (i.e. assumed that the edible portion of the seed was assayed).

[4] Concentration ranges (low - high) shown are based on all data reported in the reference(s) indicated.

Table 3. Nutrient composition of sunflower kernel (from USDA Nutrient Database for Standard Reference, Release 13, 1999 (4).

Seeds, sunflower seed kernels, dried
NDB No: 12036
Scientific Name: *Helianthus annuus*

Nutrient	Units	Value per 100 grams of edible portion	Sample Count	Std. Error
Proximates				
Water	g	5.360	21	0.341
Energy	kcal	570.000	0	
Energy	kj	2385.000	0	
Protein	g	22.780	21	0.749
Total lipid (fat)	g	49.570	21	0.788
Carbohydrate, by difference	g	18.760	0	
Fiber, total dietary	g	10.500	0	
Ash	g	3.530	9	0.212
Minerals				
Calcium, Ca	mg	116.000	2	24.266
Iron, Fe	mg	6.770	2	0.628
Magnesium, Mg	mg	354.000	1	
Phosphorus, P	mg	705.000	2	12.085
Potassium, K	mg	689.000	0	
Sodium, Na	mg	3.000	1	
Zinc, Zn	mg	5.060	2	0.417
Copper, Cu	mg	1.752	2	0.198
Manganese, Mn	mg	2.020	1	
Selenium, Se	mcg	59.500	10	1.489
Vitamins				
Vitamin C, ascorbic acid	mg	1.400	0	
Thiamin	mg	2.290	1	

Table 3, continued.

Nutrient	Units	Value per 100 grams of edible portion	Sample Count	Std. Error
Riboflavin	mg	0.250	1	
Niacin	mg	4.500	1	
Pantothenic acid	mg	6.745	0	
Vitamin B-6	mg	0.770	0	
Folate	mcg	227.400	0	
Vitamin B-12	mcg	0.000	0	
Vitamin A, IU	IU	50.000	0	
Vitamin A, RE	mcg_RE	5.000	0	
Vitamin E	mg_ATE	50.270	0	
Lipids				
Fatty acids, saturated	g	5.195	0	
4:0	g	0.000	0	
6:0	g	0.000	0	
8:0	g	0.000	0	
10:0	g	0.000	0	
12:0	g	0.000	0	
14:0	g	0.051	14	
16:0	g	2.795	169	
18:0	g	2.202	169	
Fatty acids, monounsaturated	g	9.462	0	
16:1	g	0.049	15	
18:1	g	9.356	169	
20:1	g	0.048	10	
22:1	g	0.000	0	
Fatty acids, polyunsaturated	g	32.735	0	
18:2	g	32.632	169	
18:3	g	0.069	12	
18:4	g	0.000	0	
20:4	g	0.000	0	
20:5	g	0.000	0	
22:5	g	0.000	0	

Nutrient	Units	Value per 100 grams of edible portion	Sample Count	Std. Error
22:6	g	0.000	0	
Cholesterol	mg	0.000	0	
Phytosterols	mg	534.000	0	
Amino acids				
Tryptophan	g	0.348	25	
Threonine	g	0.928	41	
Isoleucine	g	1.139	41	
Leucine	g	1.659	41	
Lysine	g	0.937	44	
Methionine	g	0.494	40	
Cystine	g	0.451	26	
Phenylalanine	g	1.169	40	
Tyrosine	g	0.666	31	
Valine	g	1.315	41	
Arginine	g	2.403	35	
Histidine	g	0.632	35	
Alanine	g	1.117	26	
Aspartic acid	g	2.446	26	
Glutamic acid	g	5.579	26	
Glycine	g	1.461	26	
Proline	g	1.182	25	
Serine	g	1.075	26	

Appendix A

Preliminary Search Results for Phytochemicals in Sunflower Seed (3)[11]

Component	Some significant activities noted[1]
α-amyrin	anti-inflammatory, antiedemic, anti-tumor
β-amyrin	antiedemic
β-carotene	antioxidant, cancer preventive
cephalin	hemostat
chlorogenic acid	anticancer, immunostimulant
choline	antiedemic, hypotensive, antidiabetic, anti-dementia
cinnamic acid	anti-inflammatory, cancer preventive
cycloartenol	anti-inflammatory, antirheumatism, hypocholesterolemic
daucosterol	anti-tumor, hypoglycemic
Δ^7-avenasterol	antioxidant
β-sitosterol (and other phytosterols)	antiprostatitic, hypolipidemic, cancer preventive
γ-tocopherol	antioxidant
α-tocopherol	hypocholesterolemic, antioxidant, immunostimulant, cancer preventive
iso-ferulic acid	anti-edemic, anti-inflammatory, hypothermic
stearic acid	hypocholesterolemic
squalene	cancer preventive, immunostimulant
linoleic acid	antiarteriosclerotic, antifibrilytic

[11]Note that information was reported for the "seed", and it was not specified in reference 3 whether or not the shell was included.

Appendix A, continued.

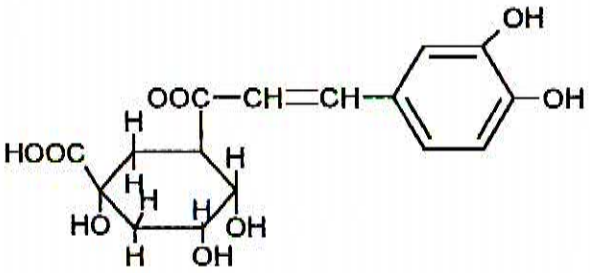
Component	Some significant activities noted[1]
lecithin	anti-dementia, hypocholesterolemic, antioxidant
shikimic acid	analgesic, antioxidant, cancer preventive
para-hydroxy-benzoic acid	antioxidant, antibacterial
phytic acid	antiaggregant, anti-cancer, antioxidant,
neo-cholorogenic acid	anti-inflammatory
selenium	antioxidant
tryptophan	anti-depressant, anti-anxiety
abscisic acid	(none reported)
jasmonic acid	(none reported)
δ-tocopherol	(none reported)
dioxindole-3-acetic acid	(none reported)
dihydrophaseic acid	(none reported)
gibberellins	(none reported)
hexan-1-al	(none reported)
o-hydroxybenzoic acid	(none reported)
n-alkanes (various)	(none reported)
nuclein	(none reported)
pentane-2-one	(none reported)
phytin	(none reported)

[1]Note that citations of biological activity in many cases may refer to studies of that chemical in isolation or in a different food or matrix

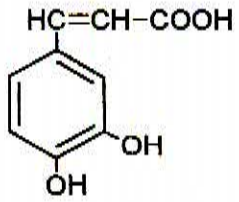
Appendix B

Structure of Some Phytochemicals in Sunflower Kernel

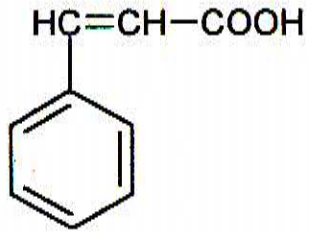
Phenolic acids:



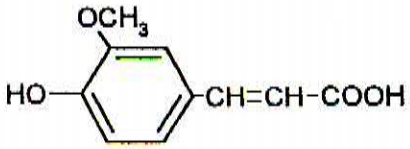
chlorogenic acid



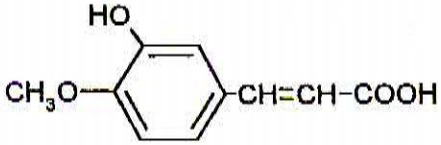
caffeic acid



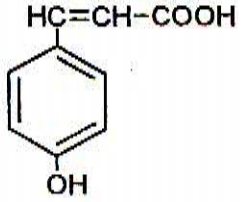
cinnamic acid



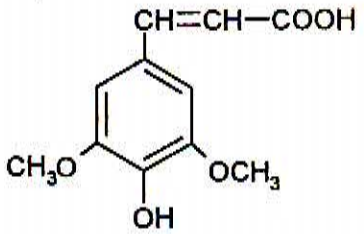
ferulic acid



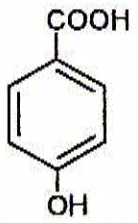
isoferulic acid



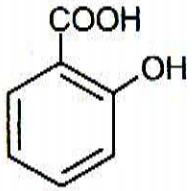
p-coumaric acid



sinapic acid

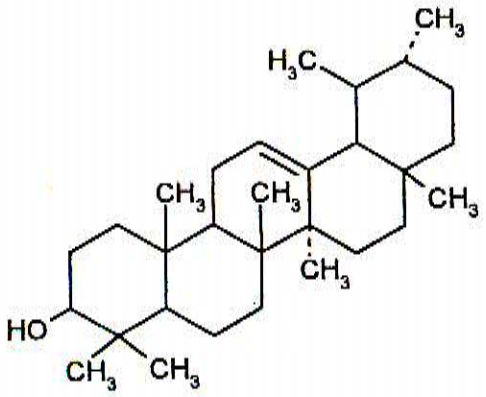


p-hydroxybenzoic acid

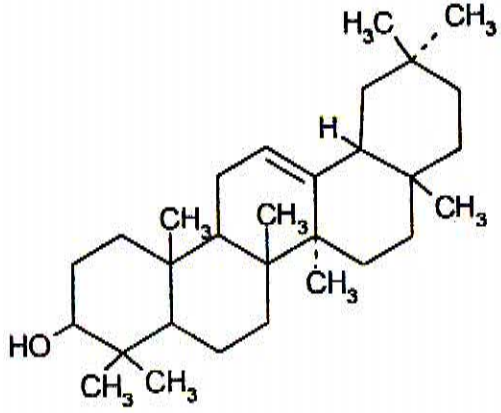


o-hydroxybenzoic acid

Triterpenes:

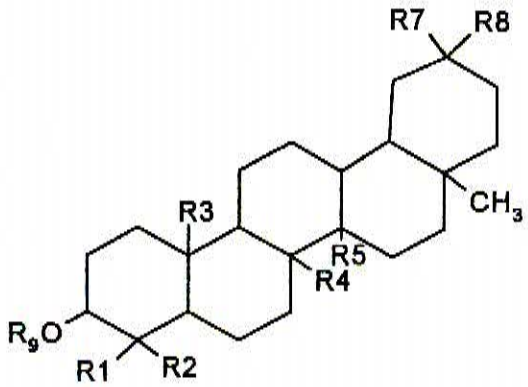


α-amyrin

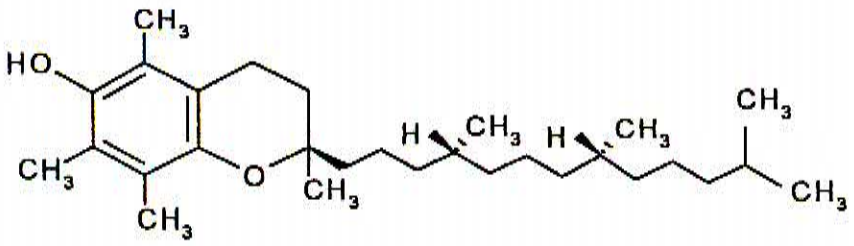


β-amyrin

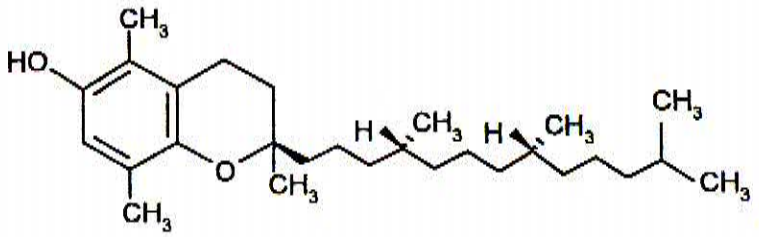
Triterpenoid Saponins:



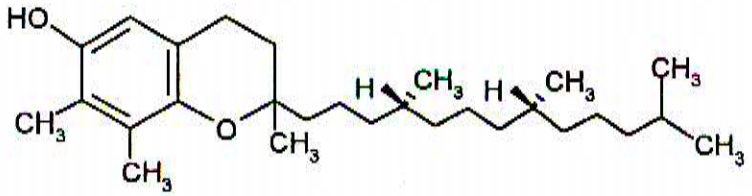
Tocopherols:



α-tocopherol

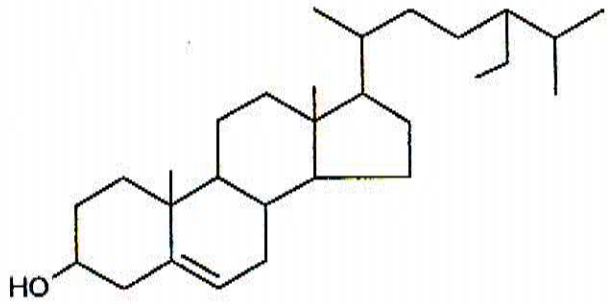


β-tocopherol

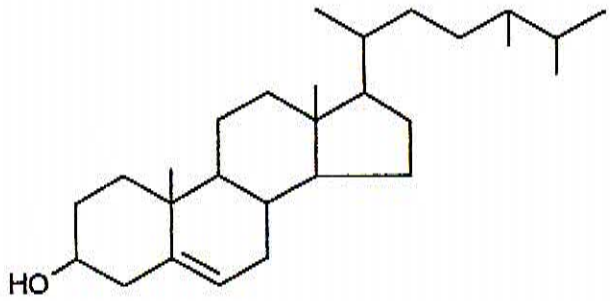


γ-tocopherol

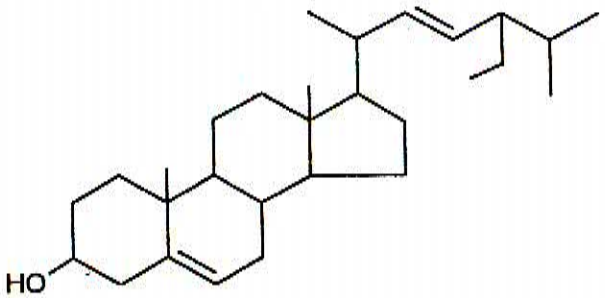
Phytosterols:



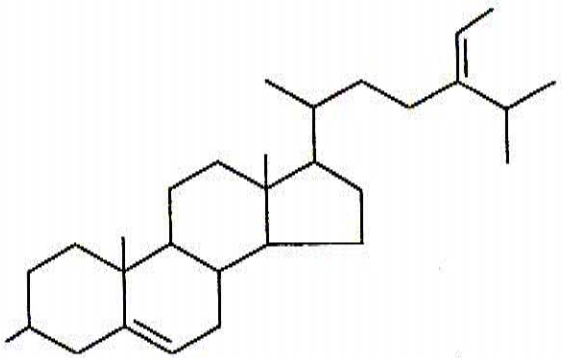
β-sitosterol



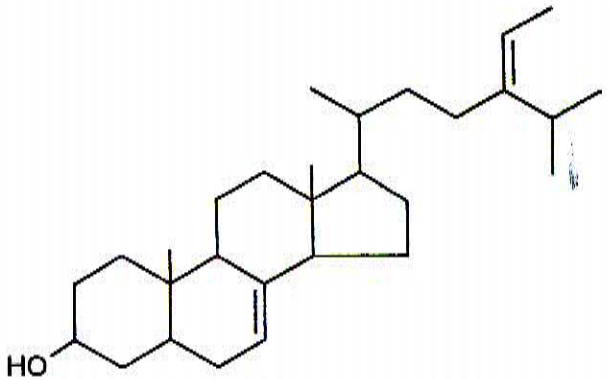
campesterol



stigmasterol

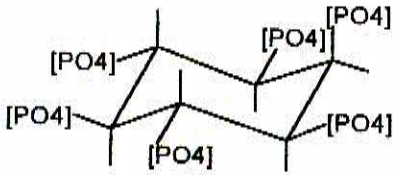


Δ^5-avenasterol

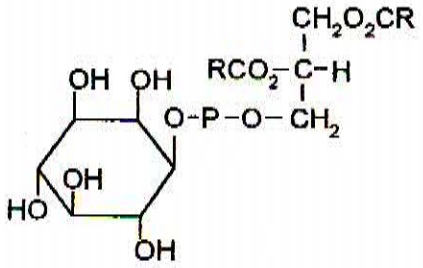


Δ^7-avenasterol

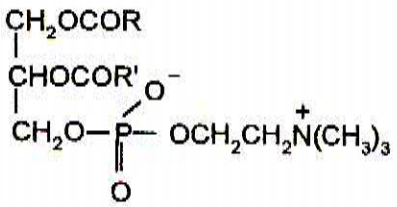
Phytic Acid (myoinositol hexaphosphate):



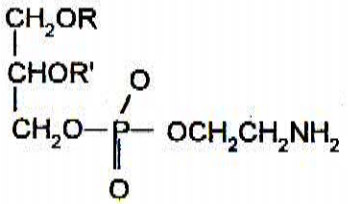
Phospholipids:



phosphatidylinositol

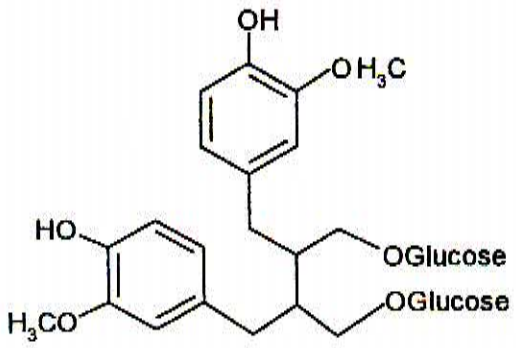


phosphatidylcholine
(lecithin)



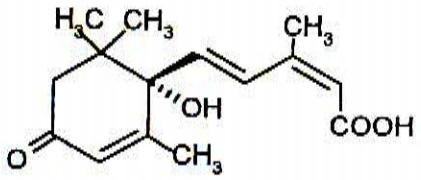
phosphatidylethanolamine
(cephalin)

Lignans:

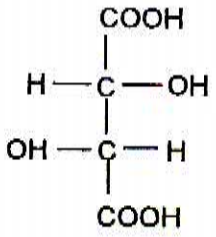


secoisolariciresinol diglucoside

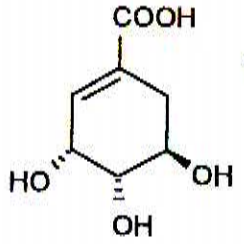
Other phytochemicals:



abscisic acid



L-tartaric acid



shikimic acid

Appendix C

Summary of Nutrient Content for Sunflower Kernel and Other Nuts, Seeds, and Legumes
(report received from National Sunflower Association, October 1999)

Nutrient	Units	DV/RDI	Sunflower 28.35 g	% DV/RDI	Almonds 28.35 g		Peanuts (SP) 28.35 g		Peanuts (VA) 28.35 g		Walnuts (e/p) 28.35 g		Hazelnuts 28.35 g		Pistachio 28.35 g		Pecans 28.35 g		Macadamia 28.35 g	
Calories	kcal	2000	162	8%	167	8%	162	8%	160	8%	182	9%	179	9%	164	8%	189	9%	199	10%
Total fat	grams	65	14	22%	15	23%	14	22%	14	21%	18	27%	18	27%	14	21%	19	30%	21	32%
Saturated fat	grams	20	1.5	7%	1.4	7%	2.2	11%	1.8	9%	1.6	8%	1.3	7%	1.7	9%	1.5	8%	3.1	16%
Polyunsaturated fat	grams		9.3		3.1		4.9		4.2		11.1		1.7		2.1		4.7		0.4	
Linoleic	grams		9.3		3.0		4.9		4.2		9.0		1.7		2.0		4.5		0.4	
Linolenic	grams		0.0		0.1		0.0		0.0		1.9		0.0		0.1		0.2		0.0	
Monounsaturated fat	grams		2.7		9.6		6.3		7.2		4.0		13.9		9.3		12.0		16.5	
Oleic	grams		2.7		9.4		6.2		7.0		3.8		13.8		9.1		11.7		11.7	
Trans fatty acids	grams														0					
Cholesterol	mg	300	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Phytosterols	mg		151		41						31		0		31		31			
Sodium	mg	2400	1	0%	3	0%	6	0%	3	0%	3	0%	1	0%	2	0%	0	0%	1	0%
Total Carbohydrate	grams	300	5	2%	6	2%	4	1%	5	2%	5	2%	4	1%	7	2%	5	2%	4	1%
Dietary Fiber	grams	25	3.0	12%	3.1	12%	2.7	11%	2.4	10%	1.4	5%	1.7	7%	3.1	12%	2.2	9%	2.6	11%
Sugars	grams		1												0					
Protein	grams	50	6.5	13%	5.7	11%	7.4	15%	7.1	14%	4.1	8%	3.7	7%	5.8	12%	2.2	4%	2.4	5%
Vitamin A	IU	5000	14	0%	0	0%	0	0%	0	0%	35	1%	19	0%	66	1%	36	1%	0	0%
Vitamin C	mg	60	0.4	1%	0.2	0%	0.0	0%	0.0	0%	0.9	2%	0.3	0%	2.0	3%	0.6	1%	0.0	0%
Vitamin E	mg	30	11.3	38%	6.8	23%		0%		0%	0.7	2%	6.8	23%	1.5	5%	0.9	3%	0.1	0%
Thiamin	mg	1.5	0.649	43%	0.060	4%	0.191	13%	0.185	12%	0.108	7%	0.142	9%	0.233	16%	0.240	16%	0.099	7%
Riboflavin	mg	1.7	0.071	4%	0.221	13%	0.038	2%	0.037	2%	0.042	2%	0.031	2%	0.049	3%	0.036	2%	0.031	2%
Niacin	mg	20	1.276	6%	0.953	5%	4.515	23%	3.508	18%	0.295	1%	0.322	2%	0.306	2%	0.251	1%	0.607	3%
Folate	mcg	400	64.5	16%	16.6	4%	68.0	17%	67.7	17%	18.7	5%	20.4	5%	16.4	4%	11.1	3%	4.5	1%
Vitamin B6	mg	2	0.218	11%	0.032	2%	0.099	5%	0.098	5%	0.158	8%	0.174	9%	0.071	4%	0.053	3%	0.056	3%
Vitamin B12	mcg	6	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Pantothenic acid	mg	10	1.912	19%	0.134	1%	0.502	5%	0.499	5%	0.179	2%	0.325	3%	0.337	3%	0.484	5%	0.124	1%
Calcium	mg	1000	33	3%	75	8%	30	3%	25	3%	27	3%	53	5%	38	4%	10	1%	20	2%
Iron	mg	18	1.9	11%	1.0	6%	1.1	6%	0.7	4%	0.7	4%	0.9	5%	1.9	11%	0.6	3%	0.7	4%
Phosphorus	mg	1000	200	20%	147	15%	110	11%	108	11%	90	9%	88	9%	143	14%	82	8%	39	4%
Potassium	mg		195		208		211		196		142		126		310		111		104	

Appendix C, continued.

Nutrient	Units	DV/RDI	Sunflower		Almonds		Peanuts (SP)		Peanuts (VA)		Walnuts (e/p)		Hazelnuts		Pistachio		Pecans		Macadamia	
			28.36 g	% DV/RDI	28.36 g		28.36 g		28.36 g		28.36 g		28.36 g		28.36 g		28.36 g		28.36 g	
Magnesium	mg	400	100	25%	84	21%	53	13%	48	12%	48	12%	81	20%	45	11%	36	9%	33	8%
Zinc	mg	15	1.435	10%	0.828	6%	0.601	4%	1.256	8%	0.774	5%	0.680	5%	0.380	3%	1.551	10%	0.485	3%
Copper	mg	2	0.497	25%	0.267	13%	0.255	13%	0.315	16%	0.393	20%	0.428	21%	0.337	17%	0.335	17%	0.084	4%
Selenium	mg		16.868		1.332		2.041		2.013		1.304		1.134		1.814		1.474		1.304	
Chromium	mg		0				na						0		0					
Manganese	mg		0.573		0.644		0.748		0.481		0.822		0.571		0.093		1.277		0.167	