

*Natural Health Products and Functional Foods
A Growing Market for Canadian Oilseeds*

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New scientific knowledge regarding the role that diet may play in preventing disease is rapidly emerging as information continues to reveal components within food that not only promote general health and well being but can also reduce the risk of illness. These findings are resulting in an increased desire to incorporate "functional" ingredients, either individually or in combinations, into supplements and foods. For the Canadian oilseed industry, natural health products (regulated in the US as "dietary supplements") and functional foods represent a significant opportunity to add value to "traditional" crops such as canola, soybean, sunflower and corn as well as to further capitalize on markets for "specialty" oilseeds such as flaxseed, borage, evening primrose and hempseed.

Natural health products and functional foods represent one of the fastest growing markets in the developed world. The principal driving force behind this opportunity is an increase in the expectation of consumers that food should provide health benefits beyond simple nutrition. In Canada, the newly formed Natural Health Products Directorate will regulate natural health products that are defined as products manufactured, sold or represented for use in the diagnosis, treatment, mitigation or prevention or prevention of a disease or used in maintaining or promoting health. They include homeopathic products, substances used in traditional Chinese and North American aboriginal medicine (1). It is also assumed that natural health products will include the category of "nutraceuticals" which initially were proposed to be products isolated or purified from foods and generally sold in medicinal forms not usually associated with food (2).

Functional foods are similar in appearance to a conventional food and have demonstrated physiological benefits, and/or reduce the risk of chronic disease beyond basic nutritional functions. Functional foods are being treated as a separate legislative area in Canada and are the responsibility of the Food Directorate (3).

The interest in, and market growth of, natural health products and functional foods are being facilitated by a number of factors including incorporation into the diet as a means to mitigate health care costs. Dietary concerns of an aging population have moved from preventing deficiency diseases to longer-term prevention of chronic disease. Consumers are becoming more aware of the relationship between diet and disease and are increasingly more interested in "natural" rather than "synthetic" medications. In recent years, there has been growing consumer dissatisfaction and mistrust of drugs prescribed by physicians and a demand for more affordable treatments. Expanding scientific and

clinical research validating the effectiveness and safety of natural health products and functional foods, and increasing media coverage of such research, are also contributing to this trend

In 2000, the global market for natural health products and functional foods was estimated to be approximately \$140 billion. The U.S. is the largest importer of Canadian natural health products and functional foods. In the U.S., the sale of nutrition products consisting of dietary supplements and herbs, natural and organic foods, functional foods and natural personal care products, generated \$49.5 billion in consumer sales in the year 2000 compared to \$44.5 billion in 1999 (4).

The U.S. supplement market generated \$16.8 billion in 2000, an increase from \$15.4 billion in 1999. Functional foods amounted to about \$17.2 billion in 2000 in comparison to \$16.1 billion in 1999. In the area of "natural" personal care products, the industry grew at a rate of 6% from 1999 to a level of \$4 billion (4). These market sectors represent an exciting opportunity to develop "functional ingredients" from agricultural components.

The Canadian natural health product and functional food industry is dynamic and is making a transition from a niche market status to the main stream. Canadian market data is difficult to interpret as much of it is extrapolated from U.S. sales and adjusted downwards to take into consideration the belief that U.S. consumers are more ardent users of dietary supplements than are Canadians. In 1998, however, Canadians purchased approximately \$1 billion worth of dietary supplements, natural health products and functional foods (5). The fastest growing market segment in Canada are natural health products, primarily vitamins and specialty supplements such as essential fatty acids.

Lipids in Natural Health Products and Functional Foods

Fats and oils, in particular vegetable oil sources, have been a topic of keen interest over the past 20 years. The role of dietary fats in human nutrition has created widespread interest among consumers, clinicians, researchers, health educators, food producers, and food processors and distributors. Concern with the type of fat (such as saturated fat and *trans* fatty acids) as important dietary risk factors in coronary heart disease have been a major impetus for the development of specially modified fats and oils. Other factors that contributed to this interest in specially designed fats and oils include the demonstration that: (1) monounsaturated fatty acids were equally as effective as polyunsaturated fatty acids in lowering blood cholesterol levels; (2) the *trans* fatty acids found in hydrogenated fats may have negative health effects; (3) omega-3 fatty acids play a role in early development; and (4) there is a relationship between specific fatty acids, such as α - and γ -linolenic acids, and positive responses in certain disease states.

Canola Oil

One of the early developments in the production of designer vegetable oils for health benefits was the introduction of modified or property-enhanced oils through the use of traditional plant breeding techniques. Canola oil was the first modified vegetable oil to achieve large-scale commercial production and in my opinion is one of the first true "functional foods". Canola oil, a low-erucic acid rapeseed oil, was developed because of nutritional concerns in animals with the fatty acid, erucic acid.

In canola oil, oleic acid (C18:1n-9) replaced the erucic acid found in traditional rapeseed oil. The relatively high level of oleic acid (approximately 61% of total fatty acids) together with the low level of total saturated fatty acids (approximately 7%) probably account for the blood cholesterol-lowering effects of canola oil in humans (6). The canola industry has successfully exploited these favorable health benefits in the global marketplace.

Plant breeding efforts have resulted in further modification of the fatty acid profile of canola oil. Low α -linolenic acid (18:3n-3; 2% vs. traditional 10%) and high-oleic acid (up to 86%) cultivars have been developed during the past decade and are the subject of a paper in this Bulletin. These oils have been developed in response to the demand for frying oils with low levels of saturated and *trans* fatty acids and relative high stability to oxidative changes without having to be hydrogenated (7).

Sunflower Oil

Another example of a vegetable oil modified for improved nutritional characteristics is high-oleic acid sunflower oil with levels of approximately 85%. Due to negative agronomic and cost issues, these varieties have not met with commercial success to date.

A new mid-level oleic acid sunflower oil called NuSun has been recently commercialized in North America. In the 2001 crop year, about 40% of the U.S. sunflower acres were seeded to this new oilseed. As with the modified canola oils, NuSun was developed in response to the need for a stable, low-saturated, non-hydrogenated frying oil. The fatty acid composition of the oil is approximately 67% oleic and 25% linoleic acid. Palmitic and stearic acids were present at 3-6% (8).

In a recent feeding study conducted in hamsters, NuSun oil lowered total cholesterol and LDL-cholesterol as much as olive oil and more than a traditional linoleic sunflower oil diet (9). A human study is currently underway to evaluate the effects of NuSun oil on plasma lipids and lipoproteins (8). It is anticipated that NuSun acreage will increase in North America as its health benefits are substantiated and the oil gains greater acceptance within the food industry.

Specialty Oils in Natural health products and Functional foods

Increased attention to the possible role of specific fatty acids in health and disease has created an interest in specialty oils, in particular, sources of α -linolenic acid (ALA; 18:3n-3) and γ -linolenic acid (GLA; 18:3n-6).

Flaxseed Oil

The natural health products market for the omega-3 fatty acid, α -linolenic acid is well established. α -linolenic acid is found in high levels (55 - 58%) in flaxseed oil that is sold encapsulated and in bottles. α -linolenic acid has been found to be effective in lowering blood cholesterol levels; reducing the clotting of blood platelets and lowering blood pressure (10). Ground flaxseed fed in muffins also reduces blood cholesterol levels (11) and LDL-cholesterol while maintaining the amount of “good” cholesterol, HDL (12). Flax may also protect against strokes by reducing blood clotting and platelet aggregation. In a recent analysis (13), omega 3 fatty acids including α -linolenic acid were shown to be associated with a lower risk of stroke in middle-aged men at high risk for coronary heart disease.

Flaxseed is unique among oilseeds because it contains an exceptionally high concentration of phytoestrogenic compounds known as lignans. In the process of digestion, intestinal bacteria convert the main lignan secoisolariciresinol diglycoside or SDG into estrogen-like compounds called enterolactone and enterodiol. Lignans are able to bind to estrogen receptors and also have weak estrogenic and anti-estrogenic properties. Available research suggests that the anti-estrogenic effects of lignans may contribute to anti-cancer properties of flaxseed diets (14). Several studies have shown that flax lignans also act as antioxidants thus lowering the promotion and synthesis of free radicals which can cause damage at the cellular level (15).

Flax products are currently one of the most popular functional foods in the natural health market and are available as oil, as whole seed or as milled seed. Flaxseed flour, ground or whole flaxseeds can be added to breads, muffins and cereals.

Borage, Evening Primrose & Black Currant Oils

Research during the past decade, has indicated that γ -linolenic acid may play an important role in the etiology of a number of diseases. For example, treatment of rheumatoid arthritis patients with borage oil or a concentrate of γ -linolenic acid has been found to result in a reduction in the signs and symptoms of the disease (16). The beneficial effect of γ -linolenic acid has been attributed to increased tissue levels of 1-series prostaglandinins, namely, PGE₁, which has been shown to suppress chronic inflammation. Likewise, γ -linolenic acid has been found effective in the treatment of diabetic neuropathy (17), a common complication of both insulin-dependent and noninsulin-dependent diabetes mellitus. There also is increasing evidence that γ -linolenic acid and its metabolites play an important role in the integrity of the epidermis and can

help reduce symptoms common in skin disorders such as atopic eczema and dermatitis (18).

In animals, γ -linolenic acid is formed from linoleic acid by the $\Delta 6$ -desaturase enzyme. However, very little accumulates in the tissue lipids of animals because it is rapidly elongated and desaturated to longer chain omega 6 fatty acids. Due to the identification of several health benefits for γ -linolenic acid, there has been interest in dietary sources of the fatty acid. The primary sources are plant oils, namely, borage (22-25%), evening primrose (8-10%), black currant (approximately 15%) and hempseed (2-3%). Borage and hemp represent interesting diversification options for Western Canadian farmers and production of both crops is currently contracted by several companies.

Hempseed Oil

Hempseed was introduced into production in Canada in 1998. Hempseed oil is quite unique in that it contains both γ -linolenic acid as well as α -linolenic acid at levels of approximately 2-3% and 15-20%, respectively. Interest in the health benefits of hempseed oil has been generated in part based upon the positive clinical efficacy of essential fatty acids found in other oils such as borage and flaxseed. Hempseeds provide high levels of protein and also contain all of the essential amino acids. Shelled hempseed and oil are increasingly used in natural food products, such as corn chips, nutrition bars, hummus, nondairy milks, breads and cereals. The market for hempseed oil as a topical ingredient in natural body care and cosmetic products is growing. Estimated retail sales for hemp food and body care products in the U.S. has been reported to be over \$25 million in 2000, up from less than \$1 million in the early 1990's (19).

Novel Nutraceuticals in Oilseeds

The potential exists to produce elevated levels of nutraceutical products such as Vitamin E (α -tocopherol) in canola oil. Tocopherols are natural antioxidants and essential nutrients in the diet. Evidence from clinical trials in humans and epidemiological studies suggest that α -tocopherol may be beneficial in the prevention and treatment of atherosclerotic disease. Canola oil contains two tocopherol isomers, γ and α , of which α is the most important to human health as it possesses the highest Vitamin E activity. Shintani and DellaPenna (20) have reported the cloning of the final enzyme in plant α -tocopherol synthesis, γ -tocopherol methyltransferase (γ -TMT). Overexpression of γ -TMT in *Arabidopsis* seeds shifted tocopherol synthesis in favor of α -tocopherol. Seeds of the lines overexpressing the largest amounts of γ -TMT contained greater than 95% of their total tocopherol pool as α -tocopherol. The authors indicated that the enhanced α -tocopherol levels in oilseed crops such as canola could be possible through the utilization of this technology.

Phytosterols have received a great deal of attention in natural health food markets for their nutritional properties. In early clinical studies, the plant sterol, sitosterol and its derivatives such as sitostanol or acylated esters, all of which are natural components of vegetable oils and fats, were demonstrated to lower total as well as LDL-cholesterol

levels in patients by 10-15% (21). More recent clinical studies have confirmed these initial results and have shown that both plant sterol and stanol esters can effectively lower cholesterol levels in humans (22-24). Take Control™ with plant sterol esters derived from soybean and Benecol™ with plant stanol esters derived from wood pulp of pine trees, are two margarine products that are currently marketed in the US with health claims that indicate reduced risk of coronary heart disease. Brassicasterol, a phytosterol unique to canola is currently used in cosmetic products due to its ability to reduce water loss from the surface of the skin and to enhance moisture penetration (25).

Researchers are applying molecular biology and biotechnology approaches to produce soy and canola oils enriched with sitostanols (26). Vegetable oils containing 2-5% phytosterols/stanols have been generated by expressing the gene encoding the rate-limiting enzyme for sterol synthesis, hydroxymethylglutaryl-CoA reductase, in seeds of crop plants (27).

Conclusion

Natural health products and functional foods represent the next generation of agricultural based growth industries for many sectors of the Canadian economy. Consumer interest will continue to drive the market which will be increasingly supported by health professionals, as more scientific information is available on the effectiveness and long term health benefits of these products. Nutritional research itself has had a tremendous impact on the development and successful commercialization of modified vegetable oils. As the category of natural health products and functional foods develops, it is clear that there will be a significant role for fats and oils in formulating and developing products that will maintain well being and reduce the risk of disease. Oilseeds and their constituents developed as functional foods or as sources of nutraceuticals provide benefits for consumers and food processors, and represent a significant opportunity for biotechnology and plant breeding companies.

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