

# Hemp Seeds for Nutrition

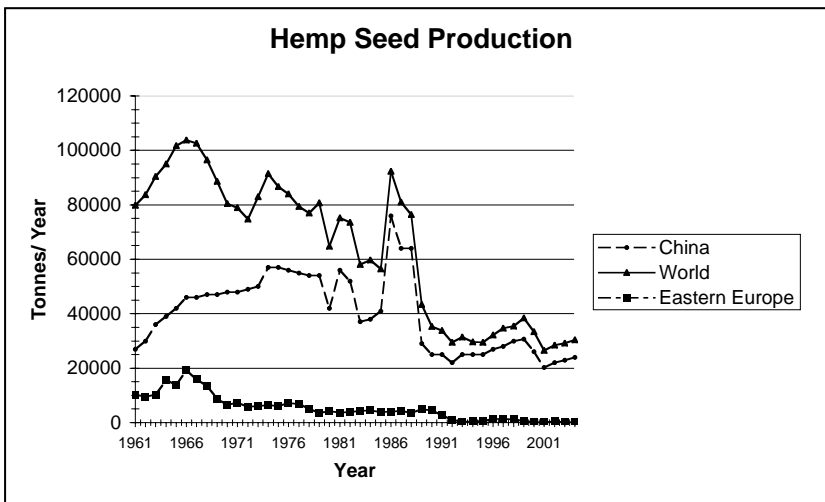
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## ***Introduction***

In several Western countries, hemp seeds and oil are gradually making a comeback as ingredients in food and cosmetics products. The best example is North America, where the recent steady increase in Canadian hemp acreage is driven almost exclusively by demand from the U.S. market for “natural foods”. But also in the UK and Germany, hemp foods, i.e., any food products containing hemp seeds or oil, are beginning to appear in stores and receive press coverage. In the 1990s, much of the mentioning of hemp foods was driven by hype or, in the U.S., the issue of contamination by trace amounts of THC, the major psychoactive ingredient of marijuana. Nowadays, the potential health benefits and taste of hemp foods have become an important buying consideration. This chapter reviews the drivers for the recent expansion of the hemp food market and discusses the opportunities and challenges it offers to the global hemp industry.

While the use of hemp as a fiber source for example in ancient China is well documented, less is known about the use of hemp seeds as a food source. However, European sources and archeological finds suggest that hemp seeds were used both for food and for medicinal applications by the first centuries AD. Despite the lack of written records, it is most likely that in European and Asian countries, wherever hemp was grown for fiber, the by-product seeds were also always used as food ingredient. An indication is the still common traditional use of roasted hemp seeds as snacks in China and Turkey. In recent centuries, hemp seeds were an ingredient in traditional recipes in rural Central and Eastern Europe. Examples include a “hemp soup” described in a German recipe and a hemp butter used traditionally in Baltic countries. Historical sources from all over Europe describe medicinal applications of hemp seeds to treat symptoms such as stomach or ear pain, coughing and incontinence. However, it is not clear whether these benefits were derived from the nutrients provided by the seeds or from the cannabinoids, including THC, which may have been present and incorporated into the formulation. Since fiber quality was usually best for textiles before the seeds were fully mature, hemp seeds were often not harvested and probably never a major food source but a welcome addition to the often-monotonous makeup of rural cooking. Hemp seeds were used extensively as bird feed and the oil as a drying oil with properties similar to those of linseed oil.

As the farming and use of hemp for fiber declined in Europe even long before World War II, the use of hempseeds for food also gradually disappeared. Figure 1 shows that, in recent decades, China has been producing the vast majority of the world’s hemp seed crop, mostly for birdfeed. Much smaller quantities were produced for example in France as a by-product of hemp fiber for pulp and used for fish and bird food.



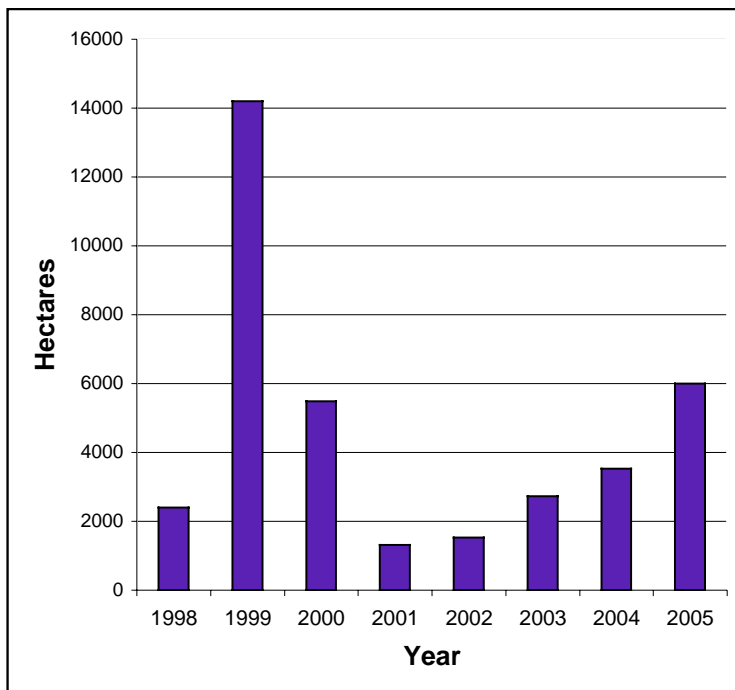
**Figure 1. World production of hemp seeds**

Source: <http://faostat.fao.org>

### ***Revival of Hemp Foods***

This situation changed as Europeans and North Americans rediscovered hemp stalks in the early 1990s as a versatile source of fiber and hurds. Subsequently, more attention was also paid to the nutritional composition of hemp seeds, particularly of their fatty acid spectrum, which was found to have a unique and possibly health promoting balance of so-called omega-3 and omega-6 fatty acids (see below). Because of the “hemp hype” in the mid 90s and these early findings on potential health benefits, whole hemp seeds and cold-pressed hemp oil items became available in North America, in Germany and the UK. Initially, seeds and oil came from China and Eastern Europe. Because of their high content of triple-unsaturated fatty acids, hemp seeds and oil are very sensitive to oxidation, i.e., their fat becomes rancid if seeds are not properly stored and processed. Particularly in China, quality control for birdseed was not a high priority. Consequently, seeds and oil were often of poor quality, had a short shelf life, unpleasant taste and were not well accepted by consumers. In addition, many of the varieties grown in China and even in the EU contained sufficiently high levels of THC to produce measurable amounts of the drug in seeds and oil. This created concern with the authorities about inadvertent exposure of consumers to THC, the resulting health impacts and the potential for producing false positive results in workplace drug tests for marijuana, which are common in the U.S. This situation again has changed since commercial hemp farming became legal again in Canada and as European hemp producers increasingly began harvesting and utilizing hemp seeds as a food source and for use in cosmetics. The following gives a brief overview of developments in North America and Europe, the two major emerging markets for hemp foods and cosmetics.

## North America



**Figure 2. Hemp farming area in Canada since legalization**

The 1998 legalization of commercial hemp farming in Canada has strongly affected global trends in production and use of hemp. While Canadian hemp acreage in 1998-2000 was largely driven by speculation, since 2001, total hemp farming area has consistently increased from 1,300 to about 6,000 hectares in 2005. Figure 2 shows the Canadian hemp acreage since 1998. Unlike in the EU, where hemp acreage is driven largely by fiber production, the vast majority of Canadian hemp is grown to supply the increasing demand for hemp foods in the U.S. market for *natural foods and body care products*. A recent survey indicated that retail sales of hemp foods in the U.S. grew by over 60% compared to 2003. Total U.S. retail sales are now estimated at US\$12 million/year for foods and \$50 million for cosmetics. This volume is still small but its consistent upward trend suggests that demand for hemp seeds may ultimately become as important a driver for global hemp demand as the fiber. The growth in North America demand for hemp foods is driven by several factors.

- **Product Diversity**

Since 1997, hemp processors and food manufacturers in Canada and the U.S. have developed a wide range of hemp seed derivatives, finished food and cosmetics products containing hemp seeds and oil. Particularly the tasty and versatile hulled hemp seeds – also called hemp nuts – are increasingly sold in bulk to bakeries and manufacturers of nutrition bar, and packaged directly to consumers. The defatted and milled seedcake is now sold as protein rich flour – at a good profit. Table 1 lists the most common hemp foods materials and products available in North America.

- **Improved Product Quality**

The Canadian Prairies, where large areas of flax and rapeseed are grown, offer a good infrastructure for the cleaning and processing of oilseeds. Thus, Canada now produces the hemp seeds of high quality and low THC content necessary to meet the demands of U.S. consumers. Particularly the shelf life and the flavor of these products are much improved over those offered a decade ago.

- **Increased Visibility of Hemp Foods through Court Battle**

Irritated by the growing popularity of seeds from a plant, which looks like marijuana and still cannot be legally grown in the U.S., the federal Drug Enforcement Administration (DEA) passed a rule in 2001 which would have banned the sale of all food items containing “any amount of THC”. Because all hemp seeds contain measurable trace amounts of THC, this would have outlawed all hemp foods and destroyed the fledgling North American hemp industry. However, the industry successfully challenged the DEA in federal court and, based on legal and technical grounds, ultimately won in 2004. This court battle generated much media attention and awareness of hemp foods by U.S. consumers.

**Table 1. Hemp food raw materials and products.**

**Raw Materials:**

Whole seeds (raw, toasted)  
 Cold pressed hemp oil  
 Hulled seeds (nuts)  
 Defatted seedcake – protein flour

**Food Products**

Cereals (Muesli)  
 Snack/nutrition bars  
 Bread, cookies, pretzels, chips  
 Nut butter, pasta  
 Salad dressings  
 Ice-cream

**Body Care Products**

Soap, cream, lip balm, shampoo

- **Health Attributes**

This publicity also drew attention to the nutritional composition of hemp seeds and oil, which appears to offer potential health benefits and is in line with several emerging trends in nutritional science (see below). The strong U.S. retail network for “natural” foods, including several chains of supermarkets has been a natural ally in bringing hemp foods to retail customers.

By developing the domestic food market, the North American hemp industry followed a uniquely different route, from which Europeans may benefit. Conversely, there are signs that the hemp fiber grown in the Canadian Prairies, and which is now either plowed under or burned will increasingly find technical uses. In its growth, the North American hemp foods industry now faces two main challenges: 1. Supplying the fast growing demand for seeds while maintaining quality and 2. Making sure that demand continues to expand by educating customers about the culinary and potential health benefits of hemp foods.

***EU***

In the EU, the demand for hemp foods has grown much more slowly than in North America. This is despite the fact that whole seeds and oil have been available to consumers, particularly in Germany since 1995 and that hemp has been legal to grow in most member countries since 1997. As in North America, the inconsistent and often poor quality of early hemp products, combined with the hype in the 1990s likely made many consumers skeptical. Furthermore, many of the national European food

markets are more traditional and thus slower to respond to novelty. Unlike in the U.S. and Canada, distribution to supermarket customers has started only recently in the UK. In addition, while European governments have generally been reasonable about regulating THC levels in hemp foods, the lack of a high profile court battle, as in the U.S. ironically has also created less visibility for hemp foods.

However, since 2003, hemp food companies in Germany and the U.K. experience growing demand for hemp seed oil and snacks containing hemp seeds or nuts. Moreover, as in North America, the drivers increasingly are the proclaimed health benefits and taste of hemp foods.

### ***Culinary Uses of Hemp Seeds and Oil***

Even in North America, hemp foods are still in their infancy and the range of culinary uses hasn't been fully exploited. The basic raw material is of course *whole hemp seed*. Because of their crunchy shell, seeds have never become very popular with food manufacturers and consumers. Some roasted whole hemp seeds are used as snacks, salted, with a caramel coat, or as a minor ingredient in energy bars. Several U.S. firms also sell coffee blends containing a portion of roasted seeds. The main use of whole seeds is as the raw material for cold pressed hemp oil, hulled seeds (often called hemp nuts) and the defatted seed cake or meal.

*Hemp oil*, when pressed from mature undamaged seeds has a delicious nutty flavor. Depending on the variety, it may have a slight grassy or bitter component to it. Hemp oil can be used for almost anything for which olive oil is used. Because of its high content of triple unsaturated fatty acids, it does not tolerate longer exposure to temperatures above 160° C and develops off-flavors and possibly toxic by-products. Thus, hemp oil should not be used for frying, while light sautéing of vegetables and other moisture containing foods is acceptable. Currently, the main *finished* product made with hemp oil is salad dressing. The oil is also by far the main hemp ingredient in a wide range of cosmetics products: liquid and bar soaps, creams, lotions, lip balm and others.

*Hemp nuts* are emerging as the dominant hemp seed derivative in North America. They are slightly larger than sesame seeds and, if hulled properly, contain little shell. If eaten raw their taste resembles that of sunflower seeds. Yet, a *very* light roast in a pan brings out their full flavor potential. Hemp nuts can replace other nuts in any recipe except where larger chunks are needed. Nuts go well in soups and salads, in the sauces for meat and tofu dishes, over vegetables, in deserts, baked into bread and pastries. Major finished products made with hemp nuts are bread and pastries, breakfast cereals, a large number of snack or energy bars and hemp nut butter.

The defatted seedcake was initially considered a by-product and used for animal feed and as flour in specialty breads and pastry. In 2003, several Canadian manufacturers started selling the flour as "protein powder" or "protein flour". Depending on how well the larger hull pieces are screened out after crushing, the flour may contain up to 50% protein by weight. Since protein powders are widely used in the U.S. by athletes and the general population, hemp flour did not have to create a new product category. Even though the protein content is low compared to whey or soy protein concentrates or isolates, the dietary fiber and small amounts of hemp oil make this product an attractive nutritional package – and one of the best selling hemp foods in North America.

### ***Composition and Nutritional Attributes of Hemp Seeds***

To be sure, much less research has been conducted on the nutrient composition of hemp seeds and oil, compared to other common oil seeds. However, the limited data now available indicate that

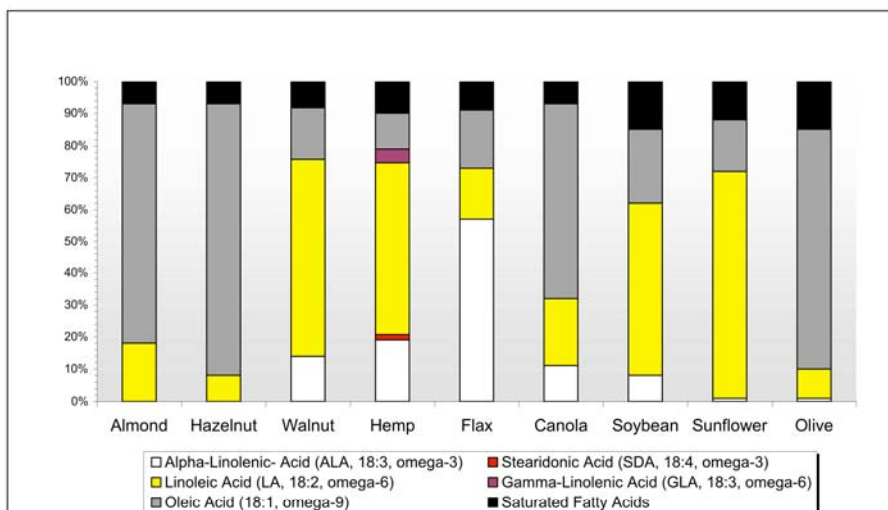
hemp seeds in fact have a rather unique composition and their consumption may offer considerable health benefits.

## Fatty acid spectrum

Best researched of all nutritional properties of hemp seeds is their fatty acid composition. Relative dominance of fatty acids will vary with hemp variety and growing conditions, yet the comparison with other nut and oil seeds shown in Figure 3 is typical. Hemp oil contains the two *essential fatty acids* (EFA), linoleic acid and alpha linolenic acid, the origins of the omega-3 and omega-6 fatty acid families, in a desirable ratio of about 3:1. EFAs cannot be produced by our body and, like vitamins, they or their metabolites must be consumed with the diet.

In addition to these EFA, hemp oil contains gamma linolenic acid (GLA) and stearidonic acid (SDA), two nutritionally relevant “higher” omega-6 and omega-3 fatty acids, respectively. What is so significant about the omega-3 to omega-6 ratio? Mounting scientific evidence links many common ailments in Western societies to an imbalance in omega-3 vs. omega-6 fatty acids in the typical Western diet. Put simply, we eat *too much omega-6 and not enough omega-3*. The typical North American diet contains 10 to 30 times more omega-6 than omega-3 fatty acids, yet nutritional scientists recommend maintaining a ratio of between 2:1 to 4:1, i.e., a much higher *relative* omega-3 consumption.

Many clinical studies implicate this imbalance as a key factor in the rising rate of inflammatory disorders and have demonstrated the benefits of a balanced dietary omega-3/omega-6 intake. Such benefits include a reduced risk of atherosclerosis, sudden cardiac death, and some forms of cancer, alleviation of the symptoms of rheumatoid arthritis, mood improvement in bipolar disorders, and optimized development in infants. It is this proven need to increase relative omega-3 intake that ultimately drives public attention and growing demand for plant and animal based sources of omega-3 fatty acids.



**Figure 3: Fatty acid composition of nut and seed oils**

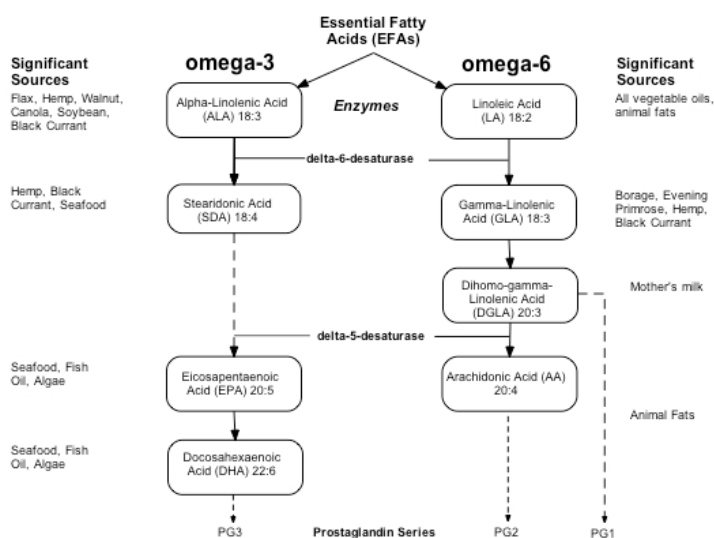
Source: Leson & Associates, 2005.

Note: Fatty acid spectrum of hemp is for Finola variety

As Figure 3 shows, most common cooking oils contain significant amounts of linoleic acid, the basic omega-6 fatty acid, but little if any omega-3s. The reason is not malignance or ignorance on the part of food companies, rather convenience. As a triple-unsaturated fatty acid, the main plant-derived omega-3 fatty acid ALA (alpha-linolenic acid) oxidizes, or turns rancid, rapidly, something neither

producers nor consumers like. A high ALA content also limits the versatility of food oil, as it cannot be used for frying. To improve the stability of cooking oils, industry has over the last decades moved to the use of oils with lower omega-3 content. This was done through plant breeding or hydrogenation (hardening) of the omega-3 present e.g. in soybean oil. That process is still the main source of trans fatty acids in our diet, increasingly a suspect contributor to cardiovascular disease.

Figure 4 visualizes the metabolic pathways for the omega-3 and -6 families. Part of the EFAs are converted to longer and more unsaturated fatty acids and ultimately to eicosanoids, a series of potent hormone-like substances, such as the well-known prostaglandins, which control the process of inflammation, fever and pain, reduce blood pressure and affect the coagulation of thrombocytes. A severe shortage in omega-3 will shift the balance in some functions controlled by these prostaglandins – with the above listed health consequences. In addition, the omega-3 fatty acid DHA is abundant in brain tissue and required for brain development and special neural functions.



**Figure 4. Metabolism of omega-3 and -6 fatty acids in humans**

Not all omega-3s are equally “potent”. Clinical studies show that even healthy persons convert only a fraction of ingested ALA to the ultimately needed omega-3s EPA and DHA and their respective prostaglandins. The “metabolic bottleneck” is the conversion of ALA to SDA by the delta-6-desaturase enzyme, with an efficiency of only 20%. This enzyme’s effectiveness in producing “higher omega-3s” is further inhibited in older people and by diabetes, obesity, excessive omega-6 intake, and elevated levels of insulin, coffee, trans fatty acids, and alcohol. These common conditions further aggravate omega-3 deficiency symptoms, while direct intake of SDA, DHA, and EPA would alleviate them. Unfortunately, only marine organisms contain DHA and EPA. These fatty acids are commonly consumed with fish or fish oil supplements. The predominant omega-3 fatty acid supplied by plants is ALA, while only a few seed oils, among them hemp as the *only food oil*, also offer SDA, an omega-3 fatty acid with a “potency” about 5 times that of ALA.

To summarize the nutritional attributes of hemp oil: Hemp oil offers the two EFAs in a very desirable LA to ALA ratio of about 3:1 and contains both SDA and GLA in nutritionally relevant amounts, thus making up for a potentially impaired fatty acid metabolism. According to the current scientific thinking about fat nutrition, no other plant-based oil offers such desirable composition. In addition, cold pressed unrefined hemp oil adds flavor to many dishes – and some people even enjoy taking an occasional tablespoon of the oil, both for health and for taste. Cold pressed oil also contains significant amounts of gamma-tocopherol, a member of the Vitamin E group, whose

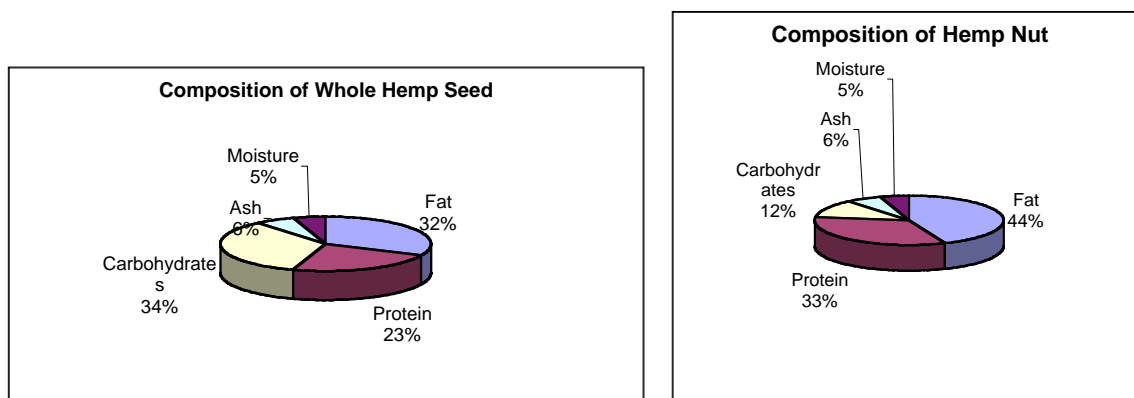
importance compared to the long preferred alpha-tocopherol is only recently recognized. Finally, hemp oil contains relatively high concentrations of phytosterols, compounds known to reduce total and LDL cholesterol.

## Protein, Vitamins, Minerals and Other Micronutrients

We know much less about composition and content of other nutrients in hemp seed and oil, particularly vitamins, minerals and other micronutrients. The scattered data do not yet provide a comprehensive picture of the level of some of these nutrients and their variability as a function of variety and growing conditions. The following section summarizes what we know today.

- **Macronutrients**

Figures 5 and 6 show the typical composition of whole and hulled hemp seeds. Most carbohydrates are present in the hull, i.e., non-digestible dietary fiber, rather than sugar or starch. The fat or oil content in whole seeds may vary between 30 and 34%.



**Figures 5 and 6: Typical composition of whole and hulled hemp seeds (nuts)**

- **Protein**

Hemp protein contains all nine essential amino acids in a reasonably well-balanced ratio. As is common with other vegetable proteins, except for soya protein, hemp protein contains a lower proportion of the essential amino acids leucine and lysine than meat, egg white and soya. In contrast, it has a higher content of arginine, an amino acid, which boosts the production of nitric oxide, a compound that relaxes blood vessels, and thus may help treat angina and other cardiovascular problems. Thus, one would not want to rely on hemp seeds as the only source of protein, rather complement it with meat, dairy or tofu.

- **Minerals and Vitamins**

Table 2 summarizes typical concentrations of minerals and vitamins in whole and hulled hemp seeds. It also shows the percentage of the reference daily intake of key nutrients supplied by 30 grams of whole or hulled seed. Compared to their energy content of about 8% of typical daily intake, hemp seeds and nuts provide a much higher fraction of the daily needs of phosphorus, potassium, magnesium, manganese and several B vitamins. This makes hemp seeds *nutrient dense* and good or even very good source of several of these nutrients. Particularly interesting is their comparatively high magnesium content, as magnesium is deficient in the diet of many Westerners and is also not sufficiently available in commonly taken multivitamin/mineral pills. As with other nuts, hemp seeds are not a good source of Vitamins A and D. The table indicates that hemp oil is not a particularly good source of Vitamin E. Yet, this results from the calculation method by which tocopherols, i.e., the members of the Vitamin E complex, are converted into Vitamin E equivalents. Hemp oil does not contain much alpha-tocopherol, associated with the highest Vitamin E potency, but has high levels of gamma-Tocopherol, a strong antioxidant,



which according to recent studies has anticarcinogenic properties.

**Table 2. Concentrations of vitamins and minerals in hemp seeds and nuts**

	RDI (mg/day)	Whole Seeds		Hulled Seeds (Nuts)	
		mg/100 g	30 g Seeds = % RDI	mg/100 g	30 g Nuts = % RDI
<i>Energy</i>	2,000 kCal	5.0 kCal/g	150 kCal (7.5%)	5.6 kCal/g	170 kCal (8.5%)
Phosphorus	1000	1100	33%	1600	48%
Potassium	2000	900	14%	1100	17%
Magnesium	400	450	34%	670	50%
Calcium	1000	150	5%	80	2%
Iron	18	12	20%	11	18%
Manganese	5	10	60%	10	60%
Zinc	15	7	14%	11	22%
Copper	2	1	15%	0.5	8%
Thiamine (B1)	1.5	1.3	26%	1.3	26%
Riboflavin (B2)	1.7	1.2	21%	1.2	21%
Pyroxidine (B6)	2	0.5	8%	0.5	8%
Vitamin C	60	1.7	1%	1.7	1%
Vitamin E	30	6	6%	8	8%
No Reference daily intake (RDI) established, approx. safe/adequate intake shown.					

Sources:

Various suppliers of hemp foods, Callaway, 2004, FDA (U.S. Food and Drug Administration), List of Reference Daily Intakes (RDI)

• **Other Phytochemicals**

Several other phytochemicals are known or suspected to be present in hemp seeds or oil, yet there is not much information about their typical levels and the chemical form in which they are present. These compounds include phytoestrogens, i.e., flavonoids and lignans, compounds present in soybeans and flax seeds, and the above mentioned phytosterols. Hemp seeds also contain smaller amounts of so-called antinutrients, i.e. compounds, which interfere with the digestion of protein. One such antinutrient present in hemp is phytic acid. However, its levels are comparable to those in flax seeds and soybeans and recent research suggests that phytic acid may even have anticarcinogenic properties. Certainly, the nature and potential health benefits of phytochemicals in hemp seeds requires further research.

**Research Needs and Marketing**

The above summary indicates that hemp seeds and oil offer a unique nutritional composition: they have a balanced fatty acid spectrum including several higher fatty acids, which some people may not generate in sufficient quantities. Hemp protein is, as far as vegetable protein goes, reasonably complete. Finally, hemp seeds apparently contain relatively high concentrations of some vitamins and minerals. Even though very few clinical studies have so far been undertaken to demonstrate the health benefits of hemp, the available information suggests that hemp is a nutrient dense, wholesome and healthy food. Since the recent interest in hemp foods appears to be largely driven by health considerations, further growth of the food uses of hemp require that its nutritional attributes are

better documented and evaluated for its nutritional benefits. This is particularly important as journalists, which write about nutritional health in the ever growing number of food and health magazines, now often ask for scientific validation of the claims made for example by manufacturers and distributors of “health foods”.

To address that need, the Canadian Hemp Trade Alliance (CHTA) initiated in 2004 a comprehensive research program. The CHTA represents about 60 members from all sectors of the North American hemp industry, including farmers, processors, distributors, retailers, and researchers. The research program includes the following major elements:

1. Protein Characterization

This study evaluates the amino acid composition of hemp seeds from all relevant hemp varieties grown in Canada. Subsequently, the digestibility of the protein in whole seeds, nuts and protein powder is evaluated in rat feeding trials. The findings from this study will allow assessing the variability of the amino acid composition of hemp protein as a function of variety and growing conditions. It will also provide a comparison of the nutritional value of hemp protein with that of other animal and plant protein sources.

2. Minerals, Vitamins and Phytochemicals

This study will quantify typical levels of key vitamins, minerals and nutritionally relevant phytochemicals in hemp seeds, oil, nuts and protein powder. Again, samples will be collected from all relevant commercial hemp varieties grown in Canada.

3. Assessment of Nutritional Value of Hemp by Expert Panel

To date the high cost of controlled clinical studies have prohibited such studies of the potential health benefits of hemp seeds. In order to obtain a credible assessment of the benefits expected based on the composition of hemp seeds alone, a panel of recognized experts on various aspects of nutritional health will convene, review the results from Studies 1 and 2 and other evidence and then discuss the potential benefits conveyed by the nutrients present in seeds and oil.

The results from these studies will be published in scientific journals. Summaries of the results will also be made available to industry members for their use in advertising and customer education.

## ***Future Prospects***

The limited information we have today on the composition of hemp seeds and its derivatives, oil, nuts and flour indicate that they are very compatible with current trends in nutritional health. These trends favor foods that are “nutrient dense” and offer these nutrients in a balanced form. Of course, as with all foods, they should also be tasty. Hemp seeds seem to meet these requirements par excellence. In order for hemp foods to contribute to the gradual expansion of the cultivation of hemp in Europe, North America and elsewhere, nutritional characteristics and their respective benefits must be better documented and the results communicated to the media and the marketplace. If the many companies involved in the fledgling hemp food industries in Canada, the U.S. and the EU succeed in conveying their message, hemp foods may become much more than just a sideshow in the recent evolution of industrial hemp

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