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Prospects for Growth in Global Nutraceutical and Functional Food Markets: A Canadian Perspective

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Abstract: There is growing recognition of the potential role for nutraceuticals and dietary supplements in helping to reduce health risks and improve health quality. In the global marketplace nutraceuticals and functional foods have become a multi-billion dollar industry and estimates within Canada suggest that the Canadian nutraceutical and functional food industry has potential to grow to $50 billion US. In this paper we examine current nutraceutical and functional food literature from a Canadian perspective to identify the potential for distinctive niche markets and growth of the industry in Canada as well as it's potential contribution to international markets. Internationally, significant limitations to growth in this area are resulting from a necessity to properly label and assess the health effects of nutraceutical and functional foods. Food safety, quality, and a better understanding of interactions among foods, medicines and dietary supplements are central requirements in Canada for development of less restricted access to our national markets and for successful expansion into the international marketplace. Exploitation of genetic and ecotype variability associated with natural populations of nutraceutical and functional foods, in particular plants, has potential to allow us to develop niche markets distinctive to Canada which are of value to consumers throughout the world. Many variants of plants exhibit population-based broad range productivity for specific chemical constituents. Selection for consistent production of high and low productivity of active plant components within specific ecological regions will allow development of alternative nutraceuticals and functional foods with distinctive and more reliable health and food properties. We believe that development of nutraceuticals and functional foods with distinctive genetic and ecotype traits has potential to deliver unique products to Canadians and the world at large. These commodities have potential to stabilize economic return to local producers without having to compete with generic products already being marketed. Development of better characterized and research proven products will help enhance consumer confidence in nutraceutical and functional food products in Canada and in the rest of the world.

Keywords: Canada, consumers, functional foods, market, novel foods, nutraceuticals, pharmaceuticals, phytochemicals, regulations

INTRODUCTION

A Global Picture of the Nutraceutical Industry:

The functional food and nutraceutical industry represents in excess of a $75.5 billion US industry (Just-food, 2007) with prospects of growing to $167 billion by 2010 (Just-food, 2004). Operationally, the industry relies upon a network of supportive stakeholders (Fig. 1) with a vested interest, in one form or another in providing consumers with alternative health products with potential to prevent diseases resulting from nutrient deficiencies or with products that have beneficial physiologic effects beyond those simply attributed to their nutrient content. Support from groups within the network is essential to development and maintenance of a strong popularized consumer base within the industry and is one of the key factors behind establishment, ongoing operation, expansion and commercialization of the global functional food and nutraceutical industry. Although popularity of products marketed as functional foods and nutraceuticals is highly variable and often dependent upon historical if not local allegiances, the industry as a whole has an international presence and operates in many countries and has potential to grow in a major way in some (Fig. 2).

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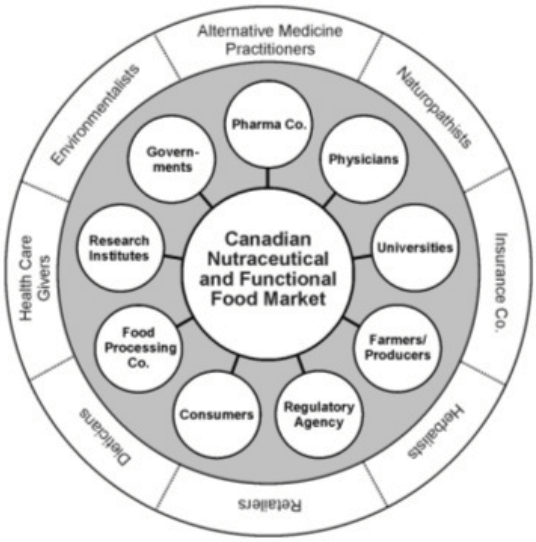

Fig. 1: Principal stake-holders in the emerging global nutraceutical and functional food industry.

Fig. 2: Global nutraceutical and functional food markets (map not to scale). Countries playing a major role in nutraceutical and functional food industries are identified in the map. Each circular dot represents a niche market in the globe. The triangles represent the areas with most rapid expansion. The size (width and length) of the triangles indicates projected proportional expansion of the key nutraceutical markets within the next ten years.

The United States of America (USA) currently possesses the largest and most rapidly expanding functional food and nutraceutical market in the world (World Nutraceuticals, 2006). In 2006 value of the industry was $21.3 billion (Datamonitor, 2007). Its strong domestic market supports major imports from Japan, North and South Korea, China, India, Brazil, the European Union (EU), Australia, New Zealand and other parts of the world (World Nutraceuticals 2006). For the USA it has been suggested that about 50% of its multi-billion dollar food market can be related to use of nutraceuticals and functional food products (Belem, 1999). By comparison the Canadian nutraceutical and functional food market is relatively young and is growing. In 2003 Canadian trade in nutraceuticals and functional foods represented 3% of the global market compared to the USA (35%) and EU (32%) (D'Innocenzo, 2006). According to a Statistics Canada survey (2003) conducted in 2002, the majority of Canadian functional food and nutraceutical exports are to the USA, Japan and the EU. Elsewhere, in Central, Latin and South America, functional food and nutraceutical markets are still developing

and lack popularity. Still, scattered markets have been recognized in Mexico, Brazil, Uruguay and Argentina (World Nutraceuticals, 2006).

Nutraceutical and functional food markets in the EU have grown over the past eight years, from about $1.8 billion out of a $5.7 billion global market in 1999 (Kleter *et al.,* 2001) to $8 billion (Datamonitor, 2007) out of a global market of $75.5 billion (Just-food, 2007) in 2006. While growth in this market has been significant, it appears to be trailing in growth seen in other parts of the world; *i.e.*, world market share in 1999 was about 30% but, in 2006 only represented about 10% of total estimated world expenditures. While growth of functional food markets within the EU was estimated to be only 2-5 fold in 2001 (Kleter *et al.,* 2001), it reached more than 10 fold in 2006 (World Nutraceuticals 2006). A number of factors have contributed to restricted growth within the industry throughout the EU. Strict regulations governing food labelling, product formulation, food processing, packaging, marketing, registration and licensing details are all strictly monitored in the EU and have been identified as restricting the size of the consumer market in these countries (Breithaupt, 2004; Kleter *et al.,* 2001; Moon & Balasubramanian, 2003; World Nutraceuticals, 2006). Major trading partners with the EU are the USA, Japan, south, south-east, far east and middle east Asia and Pacific regions (Japan's Nutarceuticals, 2003; World Nutraceuticals, 2006).

Eastern cultures have a long history of use of traditional medicines associated with health foods in forms of recognized nutritional foods, food supplements, medicinal herbs, and crude powdered drugs derived from plant, animal and marine sources (Datta Banik & Basu, 2002; Dhanukar, Kulkarni & Rege, 2000). India and China are the two most important countries known for their production of traditional functional food products and nutraceuticals. Both of these countries have large populations, in particular in rural, remote and inaccessible areas which are totally dependent upon herbal remedies and other naturally available bio-resources which they use to treat common ailments, and as general preventive and protective medications (Dhanukar, Kulkarni & Rege, 2000).

In India the most common forms of functional foods and nutraceuticals are available as traditional Indian Ayurvedic Medicines (IAM); these are marketed under different brand names (Patwardhan *et al.,* 2005). India is the home of a large number of medicinal herbs, spices and tree species that have a substantially large domestic market with no major foreign competition at present (Datta Banik & Basu, 2002; Patwardhan *et al.,* 2005). However, it is important to note that there are no strict pharmaceutical regulations on Ayurvedic and nutraceutical health products in India. Most of these products are available to consumers directly over the counter without need for a medical prescription (Patwardhan *et al.,* 2005). India has a large share of the international functional food and nutraceutical market, and exports products to the far east, south-east, west and middle east Asia as well as to parts of north Africa and the EU. However, India's major export destination is the USA and Japan (Patwardhan *et al.,* 2005). Labelling, and strict control over formulations and branding are still not required for most products. In addition cost of production typically is low, making this produce highly competitive in Asian and African markets (World Nutraceuticals, 2006). Estimated value of the industry is $10 billion per annum with exports of $1.1 billion per annum making a significant contribution to the export market (Singh, Singh & Khanuja, 2003).

A similar profile for the industry can be developed for China. Both functional foods and nutraceuticals are part of the traditional Chinese diet and are also a large component in Traditional Chinese Medicine (TCM). The industry is represented by around 1000 small to medium sized enterprises located throughout China (AAFC, 2002; Patwardhan *et al.,* 2005). There is a steady demand for functional foods and nutraceuticals in the country and a friendly business environment. Branding and labelling are not under stringent control and ironically, foreign-made preparations of Chinese medications have been reported to have better health and nutritional qualities than those produced in China. However, because of less stringent regulations, cheap labour, lower production costs and the enormous market involved, China has the potential to emerge as a leader in the international market (AAFC, 2002; Patwardhan *et al.,* 2005). Japan, Hong Kong, Korea and Singapore are major importers of TCMs and represent 66% of Chinese plant drug exports (Report of the Chinese Ministry of Commerce, 2003). The annual Chinese herbal drug production is estimated at $48 billion, with estimated exports of $3.6 billion (Handa, 2004).

Japan is the second largest market in the world for nutraceutical products after the United States. Its nutraceutical market has exhibited a steady average growth rate of 9.6% per annum for the past decade, and in 2006 its functional food industry was estimated to have a value of $27.1 billion (Functional Food Japan, Project Report, 2006). The Japanese people invented use of modern functional foods in the early 1970's and ever since the Japanese functional foods' industry has been a leader within the global marketplace. The per-capita consumption of nutraceuticals by the Japanese is actually higher ($166.00 per annum) than that seen in the USA ($136.00 per annum) and in the EU ($92.00 per annum). Two types of functional foods have been approved by the Japanese government; *i.e.*, those with approved health claims or FOSHU (Foods for Specified Health Use) and foods that may provide health benefits (without any health claims).

Other large, emerging international markets in south and south-east Asia are seen in Taiwan, Sri Lanka, Thailand, the Philippines, Vietnam, Lagos, Kampuchea, Indonesia, Malaysia, North and South Korea (World Nutraceuticals, 2006). In addition Australia and New Zealand are emerging quickly as international competitors. Investment in research and development of high quality functional food and nutraceutical products along with promotional support from both the industry and government has helped in rapid establishment of the industry in these two countries and in their catching a share of the expanding global market (Heasman, 2004; FRST, 2003).

Potential markets also can be found in oil rich middle-eastern or gulf countries like Saudi Arabia, the United Arab Emirates, Qatar, Oman and Kuwait (World Nutraceuticals, 2006). It is estimated that demand for functional food and nutraceutical products will grow internationally by about 6% per annum through 2010, and that China and India will be the fastest growing markets, while the USA will continue to be the largest, followed by Japan. African markets are still not well organized, although functional food and nutraceuticals are part of the African diet and culture. Scattered opportunities also have been identified in parts of northern and sub-Saharan Africa and in some southern African nations (Global Market Review of Functional Food, 2005).

Increasing Prospects for the Functional Food Industry:

Production of functional foods is being recognized as the number one global food industry as changing trends in population demography, consumer affluence, increased education, life expectancy and improved healthcare give rise to a rapidly emerging diet and health conscious consumer clientele (Belem, 1999, Childs 1999; Dillard & German, 2000; Drouin & Gosselin 2002). Increasing health consciousness has been one of the most important stimulating factors for rapid global growth of the nutraceutical and functional food industry (Hasler, 2000). In a survey of public opinion conducted in 1998 by the International Food Information Council (IFIC), about 95% of the participants expressed a view that some foods are capable of reducing health risks and that consumption of these foods can result in an improved quality of life (Schmidt, 1999). In another survey the American Dietetic Association / ADA (2000) reported that 85% of participants believe that nutrients and diet are important to them. Moreover, personal use of Alternative Medicines (AM) in the United States of America (USA) doubled (to 40%) during a period of seven years from 1990 - 1997 (Hasler, 2000). Nutraceuticals and functional foods have been reported to have significant biological actions and their use across the globe continues to increase due to historical and more recent reports of clinical success through use of these products (Acharya & Thomas, 2007; Hardy, Hardy & Ball, 2003).

Primary factors associated with increased popularity of nutraceuticals and functional foods that have generated interest within the public have been reported by a number of different scientific groups as well as government agencies (Belem, 1999; Breithaupt, 2004; Childs, 1999; De Felice, 1995: DellaPenna, 1999; Drouin & Gosselin, 2002; Elliott & Ong, 2002; Govt of Canada, 2003; Hardy, Hardy & Ball, 2003; Hasler, 2000; LFRA, 2001; McNamara, 1997; Peterson & Dwyer, 1998). Some of the most important are:

An Increase in Public Health Consciousness:

Increased access to information through education and an enquiring media has resulted in a rapidly emerging self-care movement among consumers. As well, our understanding of the mode of action, health promoting effects and value added properties of food and non-food products is increasing rapidly. When coupled with increased economic prosperity, health awareness is driving more consumers to take a more proactive role in managing their health; people are less willing to simply wait and implement health care advice provided by a medical community in response to health problems.

An Aging Population:

Increase in age of the baby-boomer birth cohort and recognition of their limited mortality is precipitating need for a more responsive, if not sympathetic health care system that promises to help them manage the vast array of age-related maladies that this group now is facing.

Escalating Health Care Costs:

Exponential increase in expenditures within the health care system and concern for maintenance and sustainability of the system is forcing many consumers to seek out more cost-effective alternatives to those being provided by traditional forms of high cost professional and structured medicine.

Recent Advances in Research and Technology:

Advances in the areas of food technology, food biochemistry and the nutritional sciences (including nutritional genomics) are providing consumers with access to fresh and often supplemented produce with recognizable health benefits that previously were not available. New methods being used by the functional food industry to isolate, characterize, extract and purify nutraceuticals from bacterial, plant and animal sources are resulting in decreased costs to the industry as well as providing new options for use of functional food products.

Changes in Government Regulations and Accountability:

Changes in policies and laws governing distribution and marketing of food are recognizing the current shift in attitude towards consumer awareness and accountability of government to the people it represents.
Increased Recognition of Functional Food Benefits: increased numbers of reports now recognize health and clinical benefits associated with access to high quality and nutritional foods.

Expansion of the Global Marketplace:

Better communications and transport for marketable goods is resulting in a more accessible global marketplace and an increase in international business opportunities. This, coupled with increased recognition for proprietary patented products is resulting in a more business-friendly environment for expansion of industry.

A Sympathetic Media:

A supportive and promotional environment is being generated by the media in response to significant advances being made in research and development of food, its processing, packaging and transportation.

Together these changes are resulting in sweeping global acceptance and demand for functional foods and nutraceutical derivatives.

Science-based Evidence Is Contributing to the Popularity of Functional Foods:

There is increasing recognition of the need for scientific evidence to support nutritional and medicinal claims being made within the functional food and nutraceutical industry (Acharya & Thomas, 2007). In 1997 Clydesdale called for development of an international dialogue on the types of validation required to recognize health claims being made for functional foods and food components. Since then there has been considerable discussion on the need for better characterization of functional foods and food products as well as need for clinical trials demonstrating medicinal claims, and better labelling of products whose active agents may vary considerably in concentration due to genotypic variation, response to environment and/or processing during preparation of a product (Acharya & Thomas, 2007; Hasler, 2000).

According to Dillard & German (2000) the health promoting effects of phytochemicals and nutraceuticals and/or functional foods likely are due to a complex mix of biochemical and cellular interactions which together promote overall health of the individual. They suggest that these agents may function: as substrates in metabolic reactions or cofactors of key metabolic enzymes; as ligands that promote or compete with biochemical interactions at the cell surface or with intercellular receptors which can enhance absorption and assimilation of important macro and micro nutrients; and as agents which selectively promote the growth of bacteria with health benefits in the gastrointestinal system and compete with or partially eliminate the growth of harmful bacteria. In addition these agents may act as enzyme inhibitors, absorbents or toxicant scavengers that can associate with and help remove damaging substances or toxins from the body. Major chemical groups now recognized as having potential health promoting effects, at least under some circumstances are the phenolics, flavonoids, alkaloids, carotenoids, pre- and pro-biotics, phytosterols, tannins, fatty acids, terpenoids, saponins, and soluble and insoluble dietary fibres (Burt, 2004; Dahanukar *et al.,* 2000; Datta Banik & Basu, 2002; Patwardhan *et al.,* 2005). A list of important phytochemicals (nutraceuticals) commonly promoted and sold in the global market is presented in Table 1. While this list seems to expand on a daily basis, considerable more work is required to support claims that often times have been made locally in support of herbal or other traditional medicines but cannot be supported globally due to biological variation in genotype and ecotypic responses (Acharya & Thomas. 2007). While considerable research may have been done with individual biological isolates, this same research often fails to recognize the vast diversity of biological organisms and consumer products derived from them.

Table 1: Important phytochemicals (nutraceuticals), their corresponding plant sources and medicinal properties

Phytochemicals: Chemical groups	Plant sources	Medicinal property
	Alkaloids	
Quinine	Cinchona	Anti-malarial
Tropane alkaloids	Solanaceous members : Deadly night shade, Datura	In treatment of heart ailments
Morphine	Opium poppy	Antidepressant, pain killer
Ergot alkaloids	Fungus: *Claviceps purpurea*	Abortifacients
Vincristine	Periwinkle	Antineoplastic
Vinblastine	Periwinkle	Antineoplastic
Coumarin,	Fenugreek	Hypoglycaemic
Scopoletin	Fenugreek	Hypoglycaemic
Fenugreekine	Fenugreek	Hypoglycaemic
Trigonelliine	Fenugreek	Hypoglycaemic
	Carotenoid terpenoids/ Isoprenoids	
α-carotene	Carrots	Antioxidants, anticarcinogenic
β-carotene	Fruits & vegetables	Antioxidants
β-cryptoxanthin	Oranges & tangerines	Antioxidants, anticancer
Lutein	Vegetables (kale, spinach, watercress, parsley)	Reduce risk of macular degeneration, protect against colon cancer
Zeaxanthin	Corn, avocado	Protects eye from macular degeneration and cataracts
Lycopene	Tomatoes, pink grapefruit, watermelon, guava, papaya	Reduces risk of prostrate cancer in males
	Non-carotenoid terpenoids	
Perillyl alcohol	Cherries & mints	Anticancer
Saponins	Legumes (Chicks, peas, fenugreek, all pulse crops)	Reduces cholesterol levels in blood
Terpenol	Carrots	Anticancer
Terpene limonoids	Peels and membranes of citrus fruits	Anticarcinogenic
	Flavonoid polyphenolics	
Anthocyanins	Stawberries, raspberries, cherries, cranberries, pomegranate, apples, red grapes	Antioxidants
Betacyanins	Beet root	Antioxidant
Catechins	Tea	Antioxidant
Flavonones	Citrus fruits	Antioxidant
Flavones	Fruits & vegetables	Anticancer
Isoflavones	Soybean	Anticancer
Hesperetin	Citrus fruits	Antioxidant
Naringin	Grapefruit	Reduces cholesterol
Rutin	Asparagus, buckwheat & citrus fruits	Protects against cardio vascular ailments
Quercitin	Red onions, buckwheat, red grapes, green tea, apple skins	Anti-sitaminic, antioxidant
Silymarin	Artichoke & milk thistle	Anti-atherosclerotic
Tangeretin	tangerines	Anticancer
Tannins	Cranberries, pomegranate, cocoa & tea	Reduces blood cholesterol,
	Phenolic acids	
Ellagic acids	Strawberries & raspberries	Prevents colon cancer
Chlorogenic acids	Blueberries, tomatoes, grapes & bell peppers	Antioxidant
p-coumaric acids	Red and green ball peppers, legumes	Antioxidant, anticancer
Phytic acids	Legumes and whole seed grains	Lowers blood glucose
Ferulic acids	Seeds of brown rice, whole wheat and oats, apple, artichoke, orange, peanut & pine apple	Antioxidant, anticancer
Vanillin	Vanilla bean	Antioxidant, anticancer
Cinnamic acid	Cinnamon, balsam tree resins	Antibacterial, antifungal
Hydroxycinnamic acid	Grapes, blueberries & blackberries	Antioxidant, anticancer
	Non-flavonoid polyphenolics	
Curcumin	Curcuma	Anti-microbial, anticancer, antioxidant
Resveratrol	Grapes	Anti-inflammatory, anticancer
Lignans	Plant cell walls	Reduces skin cancer
	Glucosinolates	
Isothiocyanates	Horseradish, radish & mustard	Anticancer
Phenethyl isothiocyanate	Watercress	Anticancer
Sulforaphene	Broccoli	Anticancer
Indoles	Broccoli	Anticancer
Thiosulfonates	Garlic & onions	Anticancer, antimicrobial, reduces blood pressure and blood cholesterol
Phytosterols (plant sterols)	Peanuts, cashews, almonds, peas, kidney beans & avocados Anticancer, blocks cholesterol absorption	

Table 1: Continued

	Anthraquinones	
Senna	Legumes and pulses	Purgative,
Barbaloin	Aloe	Laxative, anti-helminthic
Hypericin	St. John's wort	Analgesic
Capsaicin	Capsicum (hot peppers)	Anticancer, anti-inflammatory, anti-apoptotic
Piperine	Black peppers, jalapeno peppers	Helps in digestion
	Terpenes	
Menthol (Monoterpene)	Plants of mint family	Topical pain reliever & anti-pyretic
Borneol (Monoterpene)	Pine oil	Disinfectant
Santonin (Sesquiterpene)	Wormwood	Photosensitizer
Gossypol (Sesquiterpene)	Cotton	Contraceptive

Recognition of variation in functional food and nutraceutical composition will provide opportunity for the industry to give consumers a variety of new products that can be developed for niche or specialized markets. Development of new products with distinctive genetics, ecotypic response and reliable health benefits also could provide local producers with access to more stable and specialized markets similar to those already seen in the coffee and wine marketplace where regionally produced variants of these products have been successfully marketed based on their unique regional attributes. In any case, as scientific studies which reveal new discoveries with potential health benefits are identified by potential consumers and the media, more support, credibility and demand for functional foods and nutraceuticals is being generated. This is resulting in a marketplace with considerable potential for growth and many new opportunities within the industry both internationally and at a regional level.

The Stakeholders of the Industry:

A conceptual portrait of the stakeholders dealing with the global functional food and nutraceutical industry and the inter- and intra-relationships is presented in Fig. 1. The stakeholders can be grouped under two core groups: primary (inner circle) and secondary (outer circle). The primary stakeholders include the producers (farmers/growers) of the plant products, food processing and pharmaceutical companies who manufacture products and byproducts, the consumers who directly or indirectly buy them for the purpose of willful consumption, the government and regulatory agencies who have the responsibility to assure proper development of the industry and scrutinize and/or certify the quality of food for human consumption, university and research institutes for developing innovative ideas, approaches and techniques to survive in an environment of intense global competition and physicians to help patients to make the right choice to take appropriate food as a life style change rather than going for conventional and expensive medications each time that they fall ill. This core group is responsible for survival and wellbeing of the industry. The secondary group consists of stakeholders that help in further expansion of the industry. This includes dieticians, alternative health practitioners, naturopathists, and herbalists who advocate for nutraceutical and functional food products making them acceptable and desirable to the common public, insurance companies who provide security to the manufacturing companies, retailers who help in the rapid sale and distribution of the manufactured products and environmentalists who promote the industry by supporting use of these products. The two core groups of stakeholders rotate around the central industrial pivot for this emerging industry. Some stakeholders have tight linkages while some work independently. However, all of them influence the center of this circle and ultimate success of the industry.

With Scientific Acceptance There Is Need for Vigilance in Use of Terminology:

With increasing consumer awareness, there is need for those within the industry to become more vigilant in their use of terminology as it applies to terms such as nutraceutical, functional, medical and novel foods. A list of important definitions is included in Table 2. In simple terms, nutraceuticals and functional foods are those foods or parts of foods that provide health and/or medical benefits to the target consumers, including prevention, protection and treatment of a disease (Belem, 1999). It is important to the development of consumer confidence that functional foods and nutraceuticals are properly categorized. Formal characterization of products provides government and other regulatory agencies with the opportunity to implement controls such as labeling and verification within the industry. While movement in this direction has been taken in some countries (Health Canada, 1998), it is important that those involved in the science and industry be proactive in order to avoid unnecessary conflict and to provide consumers with produce that they can both trust and depend upon.

Table 2: Important definitions associated with the nutraceutical and functional food industry

Terminology	Definition	Source
Bioactive compounds	Naturally occurring chemical compounds contained in, or derived from, a plant, animal or marine source, that exert the desired health/wellness benefit.	Shambrock Consulting Group Inc. & Kelwin management Consulting (AAFC bulletin, 2006)
Functional ingredients	Standardized and characterized preparations, fractions or extracts containing bioactive compounds of varying purity, that are used as ingredients, by manufacturers in the food (human and pet) and fractions or extracts containing bioactive compounds of varying purity, which are used as ingredients by manufacturers in the cosmetics and pharmaceutical sectors.	-
Industrial ingredients	Standardized and characterized preparations, fractions or extracts of agri-commodities of varying purity that are used as ingredients by manufacturers of non-food products.	-
Natural Health Products (NHP)	Includes homeopathic preparations, substances used in traditional medicines, minerals or trace elements; vitamins; amino acids; essential fatty acids; or other botanical, or animal or microoraganism derived substances. These products are generally sold in medicinal or "dosage" form to diagnose, treat, or prevent disease; restore or correct function; or to maintain or promote health.	-
Traditional Food Ingredients (TFI)	Standardized and characterized preparations, fractions or extracts of agri-commodities of varying purity, that originate from plant, animal or marine sources and are used as ingredients, by manufacturers in the food (human and pet) and NHP sectors.	-
Traditional Processed Foods (TPF)	Conventional foods that have been manufactured by the traditional food processing industry and sold to the public through established distribution systems for generations.	-
Traditional Whole Foods (TWF)	Conventional foods that have been grown by agricultural producers for generations	-
Designer Foods	Foods that naturally contain or are enriched with cancer-preventing substances such as phytochemicals (Coined in 1989 by National Cancer Institute, USA)	-
Novel Foods	Products that have never been used as food; foods that result from a processes that has not previously been used for food; or, foods that have been modified by genetic manipulation	Health Canda (1998)
Nutraceuticals	A product isolated and purified from foods that is generally sold in medicinal forms are usually associated with food. A nutraceutical is demonstrated to have a physiological benefit or provide protection against chronic disease (Coined originally by Stephen DeFelice in 1989, founder and chairman of the Foundation for Innovation in Medicine, USA)	-
Functional Foods	A functional food is similar in appearance to. Or may be, a conventional food, is consumed as part of a usual diet, and is demonstrated to have physiological benefits and/or reduce the risk of chronic disease beyond the basic nutritional functions	-
Phytochemicals / phyto-nutrients	A nonnutritive bioactive plant substance, such as a flavonoid or carotenoid, considered to have a beneficial effect on human health.	American Heritage® Stedman's Medical Dictionary (2004)
Medical Foods	Special dietary food intended for use solely under medical supervision to meet nutritional requirements in specific medical conditions (Coined in 1992 by the Institute of Food Technologists Expert Panel on Food Safety and Nutrition).	Food Technol (1992). 46:87-96.
Phyto-pharmaceuticals	Chemicals in their natural from isolated from medicinal plants with potential benefits in human health and disease prevention.	Association of Saskatchewan Home Economists (2006)
Dietary Supplements	A product that is intended to supplement the diet that bears or contains on or more of the following dietary ingredients: a vitamin, a mineral, a herb or other botanical, an amino acid, a dietary substance, for use by man to supplement the diet by increasing the total daily intake, or concentrate. Metabolite, constituent, extract. Or combinations of these ingredient; intended for ingestion in pill, capsule, tablet, or liquid form; not represented for use as conventional food or as a sole item of a meal or diet; labelled as dietary supplement; includes products such as approved new drug, certified antibiotics, of licensed biologic that marketed as a dietary supplement or food before approval, certification, of license (unless a product is redefined through regulatory government agency)	Mueller (1999)

Canada as an Emerging Player Within an International Market:

The functional foods and nutraceuticals industry in Canada employs around 25,000 individuals (AAFC News Release, 2007). In 2005 the retail market for the industry was about $2 billion US, with Canadians spending about $200 annually on nutritional food products (AAFC, 2005; AAFC News Release,

2007; Rodriguez, 2002). While a number of active research groups can be identified within Canada, industry supporters still are emerging and sometimes have been recognized as lacking in coordination and focus (AAFC, 2005; Acharya & Thomas, 2007; McCutcheon & Fitzpatrick, 2004).

A 2003 survey of the functional food and nutraceutical industry in Canada (Statistics Canada, 2003) found that about 46% of companies had some involvement with nutraceuticals while 28% were involved with functional foods; the remaining were involved with both. About 75% of these companies were private corporations (Tebbens, 2005). Of these, 51% of the firms in Canada are involved in production, distribution or sales of nutraceuticals of plant origin. Unfortunately only about 37% of the companies questioned acknowledged investing in research and development on nutraceuticals while only 34% had invested in research related to functional foods. Approximately 300 Canadian companies currently are involved in the nutraceutical and functional food business with market focus both at regional as well as international levels. With respect to human resources, around 30% are estimated to be small firms (< 10 employees), 30% medium firms (10-49 employees) and around 30% large firms (≥ 50 employees) (Tebbens, 2005).

Companies within the Canadian nutraceutical and functional food industry produce a wide range of products. Some of the highest profile ones include high quality fatty acids and oil products from agricultural and fisheries companies which contain omega-3-fatty acids; alternative produce containing oatmeal and rolled oats which contain dietary fibres such as b-glucan; alternative produce containing blueberries and cranberries possessing anti-oxidants such as flavonoids which contain anthocyanidins; and production of yogurts which contain pre- and probiotic bacteria such as *Lactobacilli* and *Bifidobacteria* (AAFC, 2005; AAFC News Release, 2007; Burn, 2005).

Some Canadian companies have foreign partners and/or collaborators. This is allowing local farms to expand their market share through distribution of their produce to an international consumer base. According to Statistics Canada (2003) more than 50% of Canadian functional food and nutraceutical companies export their produce. The bulk of this produce (75%) goes to the USA, followed by Japan, North and South Korea, Taiwan, Australia and/or New Zealand, Hong Kong and China.

The functional food and nutraceutical market in Canada may be viewed as an emerging industry. Its focus still is fairly narrow, being primarily targeted to address high profile health concerns such as heart disease, high blood glucose and cholesterol levels, hypertension, cardiovascular ailments, osteoporosis, gastrointestinal problems, menopause and lactose intolerance (Rodriguez, 2002). Although the industry has considerable potential, basic research as well as applied clinical and production engineering, and marketing are needed to support current aspirations and to help popularize and/or commercialize products being developed for both domestic and foreign markets (AAFC News Release, 2007; McCutcheon & Fitzpatrick, 2004).

Lack of highly trained technical personnel, as well as a need for more research nodes and better networking has been identified as another weakness within Canada (McCutcheon & Fitzpatrick, 2004; Rodriguez, 2002). Canada will require many more scientists, engineers and market experts who are familiar with the functional food industry if it is going to expand significantly into this area. In addition, failure of the industry to recognize opportunities associated with public demand for better labelling, testing and characterization of its claims and products through accredited research is resulting in distrust on the part of consumers and, is compromising stable growth and development within this sector. For example, many plant products marketed as functional foods and nutraceuticals either lack properties attributed to them in the popular press (Thomas, Basu & Acharya., 2006), or contain highly variable amounts of active biochemicals that significantly contribute to their functional food and nutraceutical properties (Acharya, & Thomas, 2007). Through use of recognized research methodology there is opportunity to identify and develop unique sources of functional foods and nutraceuticals with stable biochemical properties and reliable attributes. Such foods show significant promise for sales into niche markets. In a recent bulletin put out by Agriculture and Agri-Food Canada (AAFC, 2006) nutraceutical and functional foods were recognized as having the potential to provide better health for Canadians, reduce the expenses of the current health care system, promote financial success in the rural community and provide an alternative to growers to diversify their crops. However, combined scientific support from independent, university and government laboratories for product claims in this area is needed to develop a high level of confidence among Canadian consumers. Canada is currently lagging behind other countries such as the USA, Japan, Australia and the United Kingdom in government recognition of health claims backed by scientific evidence; e.g., in the USA 17 different health claims have been accepted and are reflected in promotion and labelling of functional food and nutraceutical products (Rodriguez, 2002). In a survey of Canadian companies involved in the functional food and nutraceutical industry, 60% of those questioned believe recognition of heath claims by the government would lead to higher sales within the industry (Tebbens, 2005).

One of the problems preventing rapid growth and expansion of the Canadian nutraceutical and functional food industry appears to be the cumbersome regulatory framework associated with acceptance and marketing of these products in Canada; strict directives and regulations governing approval and packaging of products as outlined within the Canadian Food and Drugs Act (Natural Health Products Regulations, 2003) are being perceived as discouraging new product development and introduction of historically recognized functional food products with potential health benefits (Statistics Canada, 2003; Tebbens, 2005). Health Canada is developing standards of evidence which will allow companies to make scientifically validated health claims, specific to individual products. However, Natural Health Product Regulations (2003) in Canada make it mandatory for companies to obtain a product license for marketing of any nutraceutical or functional food product. As a result of this strict regulatory approach, coupled with slow response times for approval of products within government, there are few incentives for potential investors to consider supporting Canadian companies. If Canada is going to compete effectively with other trading partners such as the USA and Japan, a significant commitment to working with the industry must be made. To this end, recent investments by the Federal Government and Provinces in the Nutri-Net Canada Project amounting $1.5 million may be viewed a positive step towards addressing deficiencies within the industry (AAFC News Release, 2007).

Consequently, to promote development of the functional food and nutraceutical industry within Canada it is important that we promote research and development within the industry that will:

- address food safety issues and promote development of technologies that ensures safety and quality of the functional food and nutraceutical products e.g., development of suitable extraction techniques and proper characterization of food ingredients within the products is imperative for the future success of this industry in Canada.
- help develop a more comprehensive understanding of interactions that can occur among foods, medicines and dietary supplements; e.g., promotion of research into biomarkers, bioinformatics and nutrigenomics within Canada will allow better assessment of functional food and nutraceutical contributions to the overall health of consumers, leading to a more vibrant and profitable industry within Canada.
- help develop more efficient and cost-effective manufacturing and production processes for raw products available within Canada; e.g., development of Canadian certified produce which is reliably sourced and well formulated will help ensure development of a strong and stable market both within Canada and abroad.
- attempt to exploit natural genetic and ecotype variability associated with populations of plants and/or crops producing nutraceuticals and functional foods in Canada. Since many variants of plants/crops exhibit population-specific broad range productivity for different chemical group(s), it is important to recognize that selection for stable and consistent production of phytochemicals within different eco-regions where the plant is grown could allow development of nutraceuticals and functional foods with distinctive, efficient and reliable, health and food values.

Future Directions:

Explosive growth in use of nutraceutical and functional food products has made it necessary for the industry to develop new more global supply chain relationships (Hobbs, 2002). Access to “credible quality” produce is needed to deal with rising consumer scepticism and to promote international growth within the industry (Hobbs 1962). Application of modern approaches in genomics, proteomics and metabolomics to the study of genetics and the biochemistry of functional foods derived from plants and animals has potential to allow us to characterize these products better. Moreover, these approaches will enable us to modify product characteristics with precision. Using marker assisted breeding and the application of genetic engineering new products with potentially better characterized and optimized benefits to human and animal health can be developed over relatively short periods of time (Baima, 2006; Laroche, 2007).

Considerable attention now is being paid to characterization of the natural organismal diversity found throughout the planet. Natural diversity in growth and biochemical makeup of organisms presents us with unique opportunities to expand the product base within the functional food and nutraceutical marketplace. Plants in particular, present us with opportunities to alter their biochemical makeup to adapt to new applications and challenges, as well as providing us with a diverse array of growth responses that can be exploited to allow their use under many different regional ecotypic conditions.

A number of research groups in Canada, have been working in this direction. For example, we have been working with fenugreek (*Trigonella foenum-graecum* L.), an annual legume commercially grown as a spice in India, but also possessing medicinal properties with potential for use in lowering blood glucose and cholesterol levels in humans, in particular in diabetics (Acharya, Thomas & Basu, 2006). The plant is well

adapted for growth in arid regions such as those found in the southern part of western Canada, but normally requires about 120 days to mature. As these regions of Canada only exhibit about 90 to 100 frost free days, the plants often do not have sufficient time to set commercially viable amounts of good quality seed. To address this problem we used a combination of selection and mutation breeding (Acharya, Thomas & Basu, 2007) to optimize the plants for growth in prairie regions of western Canada, and now are working to identify plants with unique biochemical properties for commercialization (Bandara *et al.,* 2007). Because different plant cultivars can respond to local soil and climatic conditions by significantly altering their biochemical content (Taylor *et al.,* 2002) this is allowing us the opportunity to provide local producers with specialty crops that have limited capacity for exploitation outside the region. These crops will possess distinctive genetic and ecotype traits with reliable health and nutritional benefits. Development of niche markets based on these types of plants has potential to allow countries like Canada to compete effectively within the global marketplace by appealing to both local and international consumers by providing them with biochemically uniform produce with highly predictable health and nutritional properties. This approach also will benefit local producers by providing them with more stable markets similar to those seen in the coffee and wine industry. Moreover, by selecting plants with uniform performance over a wide range of environments, marketing agencies can label their products reliably and consumers can benefit from more predictable health and nutritional effects. Development of better characterized and research proven products will help enhance consumer confidence in functional food and nutraceutical products produced in Canada and elsewhere and this will help these products in the global marketplace.

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