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Canadian Technological Roadmap On Functional Foods and Nutraceuticals

Presented to:

Canada Economic Development

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*Faculté des sciences de l'agriculture et de l'alimentation,
Université Laval*

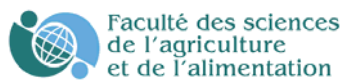
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The members of the Steering Committee are:

André Gosselin	Study Coordinator, Faculté des sciences de l'agriculture et de l'alimentation, Université Laval
Kelley C. Fitzpatrick	Chair of Steering Committee, Saskatchewan Nutraceutical Network
Georges Arseneau	Economic Development Canada
Margaret Cheney	Health Canada
Jean-Claude Dufour	Faculté des sciences de l'agriculture et de l'alimentation, Université Laval
P. Robin Flockton	Canadian Institute of Food Service and Technology
Murray McLaughlin	Foragen Technologies Management Inc.
Jean Mercier	Société de promotion économique du Québec métropolitain
Kutty Kartha	Plant Biotechnology Institute, National Research Council Canada
Angèle St-Yves	Agriculture and Agri-Food Canada
Guy Felio	Steering Committee Support, National Research Council Canada

Prepared by:

KPMG LLP	Alain Drouin, CA, EEE Lucie Couturier, Ing. MBA Jean-François Lasnier, L.Ib. MBA Isabel Côté, CA
----------	---

and in collaboration with :

André Gosselin, Ph.D., Université Laval
Mary Ellen Hodgins,
Hodgins & Company Management Consultants Inc.



EXECUTIVE SUMMARY

Functional Foods and Nutraceuticals in Canada

In recent years, consumers and the agri-food industry have shown a growing interest in foods not only for their nutritive properties but also for their health related benefits. Consumers have now a better understanding of the relation between a balanced diet and disease prevention, in a context where the population is aging, health related costs are on the rise, and in which nutrition science and food technologies are more sophisticated.

These factors propel the functional foods and nutraceuticals (FFN) market, which is large, international, and in full expansion. The Canadian market represents approximately 3% of the global nutrition market at US \$4 billion (including natural and organic products). In 2000, the United States occupied close to 36% (US \$49 billion) of the global market evaluated at US \$138 billion.

Canada benefits from a world-class research network as well as from its highly consistent and secure bio-food production systems. In the pursuit of international positioning, Canada can benefit from its strengths in channelling its research efforts in areas where results will tend to have an impact on agriculture revenues (which would permit diversification in culture options), the introduction of new cultures (which would offer farmers a better return), and possibilities for participating in downstream agricultural exploitation and transformation.

Current FFN research has generated measurable impacts on the lives and health of Canadians. FFN have shown great applications to the reduction of cholesterol levels, cardiovascular diseases and osteoporosis, and in areas related to child development, arterial hypertension, diabetes, gastro-intestinal disorders, menopause, and lactose intolerance.

“Functional foods and nutraceuticals offer opportunities for the agri-food sectors in Canada to become the ‘pharmacy for disease prevention’ as the pharmaceutical industry represents the pharmacy for disease management.”¹

¹ “Potential Benefits of Functional Foods and Nutraceuticals to Reduce the Risk and Costs of Diseases in Canada”. Report submitted to Agriculture and Agri-Food Canada, Food Bureau by Dr. Bruce Holub, Guelph University, June 2002.

FFN Sector Needs

This study aims to identify technology opportunities to support the short and long term development and growth of the FFN industry in Canada.

The first step in the study was an update of the North American market trends and evolution of regulations and their influence on the competitiveness of the Canadian industry.

This update confirms that North Americans are becoming more aware of the benefits derived from a healthy diet as well as the effects of certain active ingredients on disease prevention. Functional foods accounted for 35% of the United States nutrition market in 2000, closely followed by the dietetic supplement sector. Many large American food companies are progressively targeting these lucrative market sectors.

The American market that, as mentioned before, represents 36% of the worldwide market largely influences the Canadian FFN industry. However, Canadian accessibility is rather limited. Canadian regulations do not favour the sale of products in either market. Also, the Canadian industry is highly fragmented and composed of a few large and many smaller food and pharmaceutical research orientated companies. In recent years, many initiatives aimed at networking or creating industry groups have emerged to better represent the industry on the North American market.

In this study, more than 250 companies from the FFN sector in Canada were invited to complete a survey, which permitted the identification of technological needs that would foster industry growth. In general, these companies have developed different product expertise, capabilities and related technologies largely based on their geographical location and availability of materials.

Four focus groups were also held in Toronto, Saskatoon, Vancouver and Quebec City to establish a convergence of technological needs for the whole Canadian industry. They are:

- Development of applications to ensure the safety of functional foods;
- Development of technologies for safety/quality/efficacy;
- Extraction processes and characterization of bioactive ingredients;
- Studies on the interactions of foods, medicines and dietetic supplements;
- Low cost demonstration of *in vitro* bioactivity (bioassay platform);
- Biological markers;
- Efficient and low-cost extraction/manufacturing/production processes;
- Innovative technologies for differentiation;

- Automation (production, processing and packaging);
- Bio-informatics and genomics;
- Formulation and micro encapsulation;
- Certification.

The focus groups also permitted to identify other needs related to the industry's organization development, such as an in-depth review of legislation and regulations with respect to FFN, the government's recognition of this emerging industry, incentives to facilitate the creation, attraction and retention in Canada of FFN companies, better research synergy and a more efficient technology/knowledge transfer to the industry.

With respect to R&D, existing capacity was classified to allow the identification of the Canadian technology supply. In fact, Canada has many centres, laboratories and research networks involved in FFN as well as some interactions at the international level.

Beyond this study's objectives, establish a technology roadmap for the Canadian FFN industry, the project's Steering Committee brings forth a development model for the FFN industry and research sectors in Canada as well as an action plan for the model's implementation. The proposed investment will ensure that opportunities in this emerging sector are grasped as well as respond to the industry's needs. Thus supporting the development of the FFN sector in Canada and generating extremely beneficial economic and quality of life impacts.

Impacts

Savings of CA \$3 billion in the Health System

Total health expenditures in Canada are approximately CA \$100 billion annually, which are increasing yearly by 7%. These expenditures represent approximately 10% of Canada's gross domestic product.

“As an example of the health care savings, we compare the daily ingredient cost and expected disease reduction for nutraceutical ingredients that lower blood cholesterol with a drug that lowers cholesterol; the author estimates reduced health care expenditures of over CA \$3 billion per year.”¹

¹ “Potential Benefits of Functional Foods and Nutraceuticals to Reduce the Risk and Costs of Diseases in Canada”. Report submitted to Agriculture and Agri-Food Canada, Food Bureau by Dr. Bruce Holub, Guelph University, June 2002.



A saving of CA \$3 billion due to FFN not only represents about 3% of the annual total health care bill but also represents about 20% of Canada's annual drug bill, evaluated at approximately CA \$15 billion.

“Unilever, for example, cites research estimating that the regular use of a sterol-enriched margarine that can reduce LDL (“harmful”) cholesterol by 14%, if sustained over a five-year period, would yield a reduction in coronary risk in the UK (United Kingdom) population of around 25%. If this ‘risk reduction’ was achieved in practice this would reduce UK heart disease patient numbers by 250,000 ‘saving’ the UK health care system £433 million.”¹

“Functional foods containing efficacious and safe nutraceutical components can dramatically reduce the prevalence of chronic disease in Canada (cardiovascular disease, type 2 diabetes, various cancers, etc.), and provide dramatic savings in health care costs without overall dietetic changes.”²

These benefits can only be achieved by widespread use and consumption of FFN. According to Health Canada representatives, the economic benefits within the health system for FFN may be of lower impact but still remain significant. However, the above analysis does not quantify the significant increase in quality of life resulting from better wellness.

Economic Impacts of CA \$3.5 billion

The global FFN market should reach US \$500 billion by 2010. If Canada maintains its market share of 3% and even increases it, FFN retail sales will reach and likely exceed US \$15 billion. This growth will generate significant business activities in manufacturing companies and could potentially create 130,000 direct and indirect jobs in Canada.

From these new positions, and when this industry growth materializes an additional income from income taxation and taxes for the Government of Canada are alone estimated at more than CA \$3.5 billion (US \$2.2 billion) annually.

¹ “Can functional foods/nutraceuticals make a major contribution to public health?” New Nutrition Business, Volume 7, Number 3, December/January 2002.

² “Potential Benefits of Functional Foods and Nutraceuticals to Reduce the Risk and Costs of Diseases in Canada”. Report submitted to Agriculture and Agri-Food Canada, Food Bureau by Dr. Bruce Holub, Guelph University, June 2002.

The economic impacts on the agri-food sector are not to be neglected, since according to these same growth projections revenues could exceed from CA \$1 billion in 2002 to reach CA \$3 billion by 2010.¹

Recommendations

Considering that:

- Substantial improvements in quality of life and economic savings can be achieved in a preventive oriented health care system by the use of beneficial FFN;
- The FFN sector constitutes a growing market in Canada, not only to stimulate the agri-food system and associated export sectors but also as an effective means of substantially reducing health costs in Canada;
- Canadian companies have clearly identified their technological needs, short and long term, as well as the necessary conditions required to support their growth;
- There is already a strong R&D infrastructure to build upon to make of Canada a world leader. The R&D expertise in the FFN sector has been identified with respect to research activities and agri-food inputs for each region of Canada.

It is recommended that:

1. A Canadian strategy be established in terms of FFN development with the objective of reducing health costs and increasing added value to the food and agriculture industry.
2. Canadian legislation on FFN be rapidly renewed and modernized to recognize the beneficial effects of FFN on health in order to stimulate the development of new FFN products for Canadian and international markets, and avoid the exodus from Canada's FFN companies abroad.
3. An investment of CA \$300 million to CA \$500 million over five years be made by the Canadian government, in partnership with the provinces and the private sector, to create an independent organization "FFN Canada" to ensure a development structure and coordination of FFN activities. The return on investment for the government could be in the order of CA \$100 for every CA \$1 invested based on Agriculture and Agri-Food Canada's reports previously quoted.

¹ "Potential Benefits of Functional Foods and Nutraceuticals to the Agri-Food Industry in Canada". Report submitted to Agriculture and Agri-Food Canada, Food Bureau by Scott Wolfe Management, March 2002.

- 3.1 In respect to addressing the FFN sector's technological needs, a Canadian R&D Network of Excellence be created from the most active Canadian research centres and institutions while maintaining ties at the international level;
 - 3.2 A Canadian network representing companies linked to the provincial networks be set up in order to address industry's concerns for future development and growth;
 - 3.3 Education, training and branding initiatives targeted to industry, professionals and public at large be developed and implemented.
4. Specific measures (grants and tax credits):
 - 4.1 Be put in place through various ministries to permit companies to qualify for GMP, GCP, GLP and other certification processes.
 5. Specific incentives be implemented by the Ministry of Finance:
 - 5.1 As already successfully implemented in Quebec, initiate a refundable tax credit for companies to compensate for training costs for employees in the areas of research, development, management and marketing;
 - 5.2 Initiate grants and tax credits to conduct clinical studies.
 6. A multidisciplinary, multi stakeholder working group be created and whose mandate will be to examine the implementation of these recommendations.



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1. GROWTH OF THE FUNCTIONAL FOODS AND NUTRACEUTICALS SECTOR IN CANADA

In recent years, consumers and the agri-food industry have shown a growing interest in foods not only for their nutrition properties but also for their health related benefits. Consumers have now a better understanding of the relation between a balanced diet and disease prevention, in a context where the population is aging, health related costs are on the rise, and in which nutrition science and food technologies are more sophisticated.

These factors propel the functional foods and nutraceuticals (FFN) market, which is large, international, and in full expansion. The Canadian market represents approximately 3% of the global nutrition market at US \$4 billion (including natural and organic products). In 2000, the United States occupied close to 36% (US \$49 billion) of the global market evaluated at US \$138 billion.

Canada benefits from a world-class research network as well as from its highly consistent and secure bio-food production systems. In the pursuit of international positioning, Canada can benefit from its strengths in channelling its research efforts in areas where results will tend to have an impact on agriculture revenues (which would permit diversification in culture options), the introduction of new cultures (which would offer farmers a better return), and possibilities for participating in downstream agricultural exploitation and transformation.

It is believed that farmers and agri-food input producers receive a relatively lower proportion of the consumer value of FFN than for conventional foods. However, this may represent a larger total received per unit production, since estimates are that input producers receive from 5% to 25% of the value of the end product.

According to a recent Canadian study¹, “It is estimated that up to CA \$1 billion of farm production value goes to supplying ingredients for functional foods and nutraceuticals (excluding marine bioresources). The largest apparent opportunity for functional foods and nutraceuticals exists in the Prairie region in the grains and oilseeds industry, where approximately CA \$290 million of the value of commodity production goes into the functional food and nutraceutical market. Pulses and legumes also represent a significant opportunity for the Prairies. Other areas of opportunity include dairy, herbs and botanicals throughout Canada, vegetables in Quebec and Ontario, and fruit in Ontario and British Columbia”.

¹ “Potential Benefits of Functional Foods and Nutraceuticals to the Agri-Food Industry in Canada”. Report submitted to Agriculture and Agri-Food Canada, Food Bureau by Scott Wolfe Management, March 2002.



It may be essential for food companies in the short term, and commodity growers in the longer term, to become involved in producing FFN simply to maintain a market share on the national and international scene. This involvement may become a necessity for food companies as the food industry becomes more dominated by FFN.

Scientific research and technology development are often the driving force behind FFN product development, and commercialization takes on an added significance. Numerous research facilities have been established over the past five years across Canada to address the opportunities provided by the FFN industry. However, coordination of research efforts is a key factor for the growth and competitiveness of the industry in Canada as well as for the transfer of technology to the industry.

FFN research has been shown to generate economic activities and measurable beneficial impacts in the health as well as in the quality of life of Canadians. Cholesterol reduction, cardiovascular diseases and osteoporosis have been the primary targets for the nutraceuticals, followed by child development, arterial hypertension, diabetes, gastrointestinal, menopause and lactose intolerance.

“Functional foods and nutraceuticals offer opportunities for the agri-food sectors in Canada to become the ‘pharmacy for disease prevention’ as the pharmaceutical industry represents the pharmacy for disease management”¹.

The University of Guelph study shows that lifestyle-related chronic disorders (cardiovascular diseases, type 2 diabetes, many cancers, and others) are major components of our present and mounting health care expenditures. The proportion of disease onset attributable to diet is estimated at approximately 40 to 50% for cardiovascular disorders (cardiovascular disease including risk factors – blood cholesterol, blood triglyceride, hypertension, and others) and diabetes, while 35 to 50% of all cancers are directly related to dietetic factors (including colo-rectal, prostate, and breast cancers). Approximately 20% of osteoporosis is diet-related.

Total health expenditures in Canada today are approximately CA \$100 billion annually, which is up 7% from the previous year and represent approximately 10% of Canada’s gross domestic products.

¹ “Potential Benefits of Functional Foods and Nutraceuticals to Reduce the Risk and Costs of Diseases in Canada”. Report submitted to Agriculture and Agri-Food Canada, Food Bureau by Dr. Bruce Holub, Guelph University, June 2002.



In health care, expenditures for pharmaceutical drugs were second only to hospital costs and surpass all other categories including physician costs. These record expenditures represent approximately CA \$15 billion annually, of which CA \$12 billion are for prescribed drugs. Drug expenses represent one of the fastest growing categories of expenditures in both the public and private sectors.

The Canadian pharmaceutical trade deficit is soaring due to rapidly increasing drug import costs. The Canadian pharmaceutical trade balance (exports minus imports) was negative CA \$4.7 billion in 2001, up by two-and-a-half times from 1997. The development and use of FFN will help reduce costly drug imports. Finland, who also has a negative pharmaceutical trade balance, has adopted a strong, national functional food program aimed at improving health and therefore reducing drug costs.

“Unilever, for example, cites research estimating that the regular use of a sterol-enriched margarine that can reduce LDL (“harmful”) cholesterol by 14%, if sustained over a five-year period, would yield a reduction in coronary risk in the UK (United Kingdom) population of around 25%. If this ‘risk reduction’ was achieved in practice this would reduce UK heart disease patient numbers by 250,000 ‘saving’ the UK health care system £433 million”¹.

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The widespread use of functional foods represents a reduction of about 3% (saving of CA \$3 billion) of the annual total healthcare bill and represents approximately a 20% reduction of Canada's annual drug bill, which is estimated at CA \$15 billion.

“Functional foods containing efficacious and safe nutraceutical components can dramatically reduce the prevalence of chronic disease in Canada (cardiovascular disease, type 2 diabetes, various cancers, and others) and provide dramatic savings in health care costs without overall dietary changes.”²

2. ECONOMIC IMPACTS

The global FFN market should reach US \$500 billion by 2010. If Canada maintains its market share of 3% and even increases it, FFN retail sales will reach and likely exceed US \$15 billion. This growth will generate significant business activities in manufacturing companies and could potentially create 130,000 direct and indirect jobs in Canada.

From these new positions and when this industry growth materializes an additional income from income taxation and taxes for the Government of Canada alone are estimated at more than CA \$3.5 billion (US \$2.2 billion) annually.

The economic impacts on the agri-food sector are not to be neglected, since according to these same growth projections revenues could exceed from CA \$1 billion in 2002 to reach CA \$3 billion by 2010.¹

3. ROADMAP CONTEXT

The FFN sector is emerging in Canada as well as throughout the world. In recent years, many Canadian initiatives have come to life such as industry networks (e.g., Saskatchewan Nutraceutical Network SNN, British Columbia Functional Food and Nutraceutical Network BCFN); specialized research programs (e.g., at NRC's Plant Biotechnology Institute PBI, University of Guelph Functional Food Center); setting up research networks (e.g., Institut des nutraceutiques et des aliments fonctionnels INAF) and many others.

¹ “Potential Benefits of Functional Foods and Nutraceuticals to the Agri-Food Industry in Canada”. Report submitted to Agriculture and Agri-Food Canada, Food Bureau by Scott Wolfe Management, March 2002.



A first study conducted in Quebec in 1999 and demonstrated the market potential of FFN at a worldwide level as well as a growth opportunity for the industry in Canada and in Quebec. It also brought to light a number of technological challenges and specific requirements needed for the growth of this emerging industry, especially in Quebec.

Mandate

Based on the results from the 1999 study, the present technological roadmap was brought forth in order to obtain a better understanding of the Canadian industry's technological needs and challenges in order to meet its planned growth. The study also aimed at evaluating how the existing technology infrastructure can fulfil these needs and to develop an action plan on the infrastructures necessary for the development and growth of the industry across Canada.

Methodology

An update of the national and international market trends and a follow-up of the evolution of North American FFN related regulations were done. Thereafter, more than 250 companies were invited to report their short and long-term needs with respect to their technology development. The survey results were then validated and modified as necessary at various focus group meetings held in Toronto, Saskatoon, Vancouver and Quebec City.

The consultations permitted to establish convergence for the technological needs and also to identify issues associated with the FFN industry growth and competitiveness. Furthermore, an inventory of the Canadian technology activities helped identify the R&D capacity and strengths within the country. Sources of financial support to the R&D and industry sectors were also identified through this inventory.

Considering the National scope of information collected through this roadmap, a multi stakeholder and regionally representative steering committee was formed with high-level members of the FFN community, representing industry, ministries, universities, the financial sector, economic development associations and related organizations.

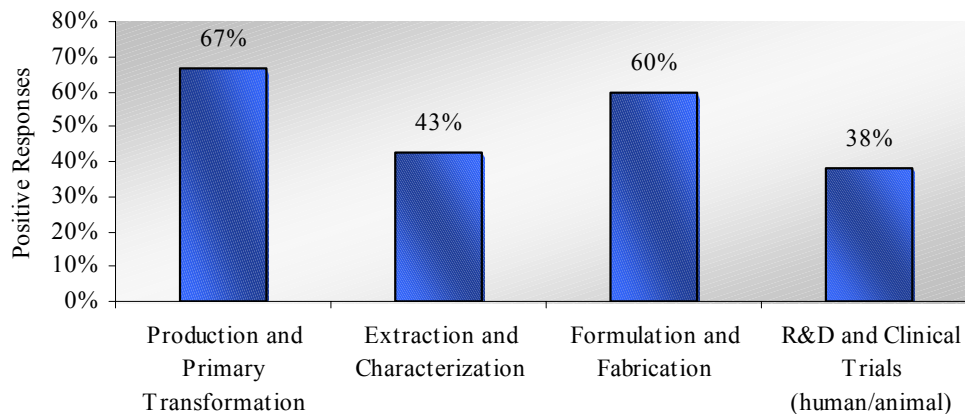
4. CANADIAN INDUSTRY EMERGENCE

These factors propel the FFN market, which is large, international, and in full expansion. The Canadian market represents approximately 3% of the global nutrition market at US \$4 billion (including natural and organic products). In 2000, the United States occupied close to 36% (US \$49 billion) of the global market evaluated at US \$138 billion.

A third of Canadian sales, as with the United States, are in the functional foods sector. The Canadian market development is highly influenced by the American market (see Section 1) not only because of its geographical proximity but also due to American regulations facilitating the arrival of new products on the market (see Section 2).

The Canadian FFN industry is characterized by a great number of small companies and a few large companies. Many of them have focused their technological developments towards the discovery of new ingredients having health benefits. In fact, close to 90% of the survey respondents (see Section 3) have R&D activities. The smaller companies invest more in R&D in proportion to their revenues than do large companies.

Overall, 72% of companies surveyed are involved in more than one activity sector as follows:



More than 74% of companies manufacture more than one product. However, depending on inputs sources and regions, company products are varied. British Columbia, Ontario and Quebec have a keen interest in the production of dietetic supplements, and natural and functional foods; while the Prairies produce more herb based products, as does Nova Scotia, which is also a producer of dietetic supplements, and natural and functional foods.



The consumption trends for these products should increase over the next few years due to the following factors:

- Governments' tendency towards a preventive approach to public health;
- Continuously increasing health care costs;
- Aging of population in the industrialized countries;
- Desire to maintain health and activities by Baby-Boomers;
- Increasing interest of consumers to consume alternate products;
- Increased consumer awareness of FFN benefits and a healthier way of life;
- Movement towards health and healthier foods;
- Better quality products, for which efficacy is supported scientifically and with more effective marketing;
- Increased interest from large companies in the industry's innovation.

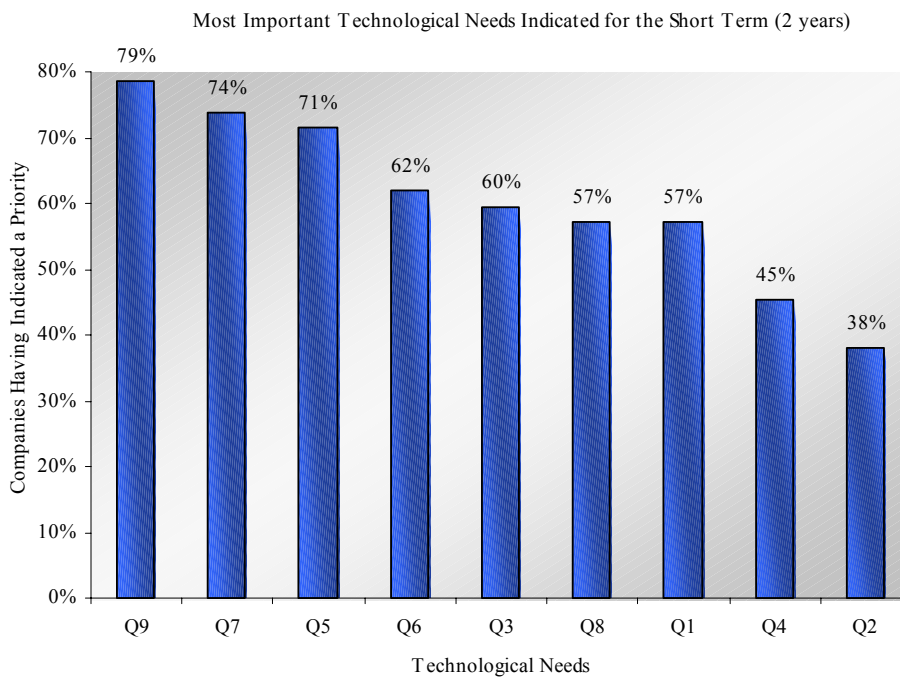
5. CANADIAN INDUSTRY CONCERNS

To ensure their growth and positioning in the global market, companies identified their technological needs but also indicated their perception with respect to regulations, research and development, and other business concerns.

Technological Needs

Through the questionnaire, companies expressed (see Section 3) their technological needs in the short term as well as for a 10-year span. The similarities between the short and long term indicates companies do not perceive significant market trend changes that justify a modification of priorities of technological needs in the long run.

The results for a 2-year span are presented below:



Legend:

- Q1: Production and primary transformation**
- Q2: Genomics, genetics and proteomics transformation**
- Q3: Extraction and purification**
- Q4: Characterization**
- Q5: Transformation, formulation and food production**
- Q6: Bio-assay platforms**
- Q7: Nutritional and toxicological studies**
- Q8: Short series production for the marketing of functional foods and nutraceuticals**
- Q9: Expertise with the establishment of various good practices**

These results were validated through a unique forum of industry stakeholders (manufacturers, suppliers, researchers, government agencies) who shared their views and achieved consensus on key business imperatives to their industry's growth.

The participants identified more specifically the technological needs related to the industry's development. Depending on the regions of the country, some needs were more emphasized. Listed below are the principal needs:

- Development of applications to ensure the safety of functional foods;
- Development of technologies for safety/quality/efficacy;
- Extraction processes and characterization of bioactive ingredients;
- Studies on the interactions of foods, medicines and dietetic supplements;
- Low cost demonstration processes of *in vitro* bioactivity (bioassay platform);
- Biological markers;
- Efficient and low-cost extraction/manufacturing/production processes;
- Innovative differentiation technologies;
- Automation (production, processing and packing);
- Bio-informatics and genomics;
- Formulation and micro encapsulation.

Business Concerns

The regional focus groups also permitted the identification of other business concerns (see Section 4) having an impact on the development of the FFN industry. These concerns were grouped under four principal themes and are listed below:

1. Canadian Strategy

The stakeholders agree that the FFN sector should be recognized by the governments as an industry, first to leverage initiatives and investments in the FFN sector and consequently to create a real economic driving force, which means:

- Convert research investments in FFN into economic activities and measurable benefits for the health care system as well as for the quality of life of Canadians;
- Create a provincial/federal consensus for the development of this industry;
- Reinforce Canada's credibility in terms of performance and safety in bio-food production systems by accelerating knowledge development;
- Set up the necessary measures to support the growth of FFN to attract new strategic alliances and investments;
- Create value added in the food process chain to maintain and increase market share;
- Ensure a connection of the FFN industry with the international food industry trends, which are generally dictated from outside Canada;
- Improve market and distribution networks through developing partnerships with multinational companies.

2. Modern Legislation and Regulations

The stakeholders agree that the regulatory environment is an important factor for the industry's ability to respond to increasingly sophisticated consumer demands and rapid technological change. They consider that the governments should:

- Develop new legislation and regulations which would permit the Canadian industry to position itself in its own market and also in the North American market;
- Make Canada Food and Drugs Regulations better aligned and harmonized to those of its major trading partners, especially the US;
- Accelerate Health Canada's regulatory decision-making processes, particularly in cases where an equivalent national body (such as the United States' Food and Drug Administration FDA) has made a ruling permitting new products, process or technology or health claims;
- Deliver quality certificates within deadlines, which meet market requirements and industry needs;
- Ensure product quality, and establish product traceability, mechanisms.

3. Research and Development

Research and development (R&D) is crucial in the industry's growth strategy. However, the stakeholders also recognize that R&D is difficult to access and fragmented at a national level. They realize that an action plan must be brought forward in order to:

- Promote, at a national and international level, the quality and diversity of Canadian R&D in order to create strength in attracting companies and investments;
- Establish a research network in Canada (evaluate the model of Genome Canada) to promote high level research, concentrate efforts and avoid duplication across Canada;
- Concentrate major investments in FFN research and development based on international and industry trends to create strong intellectual property and Canadian R&D leadership;
- Ensure scientific leadership in fundamental research areas such as genomics, proteomics, bio-informatics, and metabolism profile and biosafety.

4. Business Development

The stakeholders believe that an environment favouring the FFN development will have a major economic impact on the industry of agri-foods and health. They consider it essential to:

- Claim incentives (grants and tax credits) be established and investment strategies made to prevent migration of the FFN industry to the United States;
- Ensure the transfer of expertise and scientific knowledge to the industry through multidisciplinary training (medicine, pharmacy, nutrition, agriculture), develop and promote research centres spin-off models and facilitate the creation of new SMEs;
- Identify high technology applications that will support industry growth and invest in them to create Canada's own driving force in FFN expertise;
- Facilitate networking (alliances) and increase international industry marketing including the monitoring and follow-up on industry and technological developments.

In parallel to the identification of these needs, an inventory of the Canadian technology supply was performed in order to identify ways to respond to the companies' needs.

6. TECHNOLOGY SUPPLY

Research is the basis of technological innovation and development processes. Initially in the faculties of agriculture, the FFN has attracted the attention from the food and nutrition departments, faculty of pharmacy and medical schools. Progression in this sector's research requires the establishment of multidisciplinary approaches that permit evolution throughout the whole food transformation chain.

FFN research and development is present in Canada but fragmented as is the industry. The following tables show the significant research strengths within Canada as well as their specializations. Section 5 gives a description of each centre, institute and network.

Agriculture and Agri-Food Canada (AAFC)

	Atlantic Food and Horticulture Research Centre	Food Research and Development Centre	Horticultural Research and Development Centre	Eastern Cereal & Oilseed Research Centre	Southern Crop Protection and Food Research Centre	
Location	Kentville, Nova Scotia	St Hyacinthe, Quebec	Saint Jean sur Richelieu, Quebec	Ottawa, Ontario	Guelph, Delhi	London, Vineland
Specialties	fruits and vegetables	milk products, meat products, fruits and vegetables	fruits and vegetables	cereals, oleaginous	fruits and vegetables, cereals	medicinal plants
Genomics, proteomics and bioinformatics			X	X	X	
Production and primary processing	X		X	X	X	
Processing, formulation and food production	X	X			X	
Extraction, purification and characterization	X	X		X		X
Nutritional and toxicological studies (clinical assays)						
Bioassay platforms						
Short serie production for commercialization of functional foods and nutraceuticals		pilot plant				

Agriculture and Agri-Food Canada (AAFC)

	Greenhouse and Processing Crops Research Centre	Saskatoon Research Center	Lacombe Research Centre	Lethbridge Research Centre	Pacific Agri-Food Research Centre
Location	Harrow, Ontario	Saskatoon, Saskatchewan	Lacombe, Alberta	Lethbridge, Alberta	Summerland, British Columbia
Specialties	vegetables, soya	field crops	meat products	beef, cereals	fruits and vegetables, medicinal plants
Genomics, proteomics and bioinformatics	X	X	X	X	X
Production and primary processing	X	X	X	X	X
Processing, formulation and food production					X
Extraction, purification and characterization	X	X	X	X	X
Nutritional and toxicological studies (clinical assays)					
Bioassay platforms					
Short serie production for commercialization of functional foods and nutraceuticals					

In summary, we may conclude that Agriculture and Agri-Food Canada:

1. Is mostly involved at the production, processing and characterization levels.
2. Has three main nutraceutical research centres:
 - 2.1 Food Research and Development Centre (St Hyacinthe, Quebec);
 - 2.2 Southern Crop Protection and Food Research Centre (London, Guelph, Vineland and Delhi, Ontario);
 - 2.3 Pacific Agri-Food Research Centre (Summerland, British Columbia).
3. Networks on bioproduct (and bioprocess) and food safety.

National Research Council of Canada (NRC)

	Institute for Marine Biosciences	Institute for National Measurement Standards	Institute for Chemical Process and Environment Technology	Plant Biotechnology Institute*
Location	Halifax, Nova Scotia	Ottawa, Ontario	Ottawa, Ontario	Saskatoon, Saskatchewan
Specialties	marine biology	metrology, analytical chemistry	process technologies, food and natural products	plants and crops
Genomics, proteomics and bioinformatics	X	X		X
Production and primary processing	X			X
Processing, formulation and food production	X			
Extraction, purification and characterization	X	X	X	X
Nutritional and toxicological studies (clinical assays)				
Bioassay platforms				
Short serie production for commercialization of functional foods and nutraceuticals			pilot plant	

* Responsible for the research network on functional foods and nutraceuticals in Canada.

In summary, we may conclude that NRC:

1. Is a Canadian leader in genomics and bio-informatics.
2. Sponsors a FFN technological cluster (Western provinces) lead by the Plant Biotechnology Institute (PBI), Saskatchewan.
3. Has a bio-resources technology cluster under development in Prince Edward Island.

Universities and Other Research Centres

	Food Technology Centre	Food Research Centre, University of Moncton	Nova Scotia Agricultural College	Marine Biotechnology Research Centre	Nutraceuticals and Functional Foods Institute	Centre for Human Nutrition, University of Western Ontario	Guelph Centre for Functional Foods	Human Nutraceutical Research Unit	Guelph Food Technology Centre
Location	Charlottetown, Prince Edward Island	Moncton, New Brunswick	Truro, Nova Scotia	Rimouski, Quebec	Quebec, Quebec	London, Ontario	Guelph, Ontario	Guelph, Ontario	Guelph, Ontario
Specialties	food and marine products	marine products, milk products, fruits and vegetables	fruits and vegetables, animal productions	marine biomolecule	milk products, marine biology, fruits and vegetables	cancer and cardiovascular diseases	functional foods, nutraceuticals	new foods, natural health products	food
Genomics, proteomics and bioinformatics					x				
Production and primary processing			x		x		x		
Processing, formulation and food production	x	x	x	x	x		x		x
Extraction, purification and characterization	x	x		x	x		x		x
Nutritional and toxicological studies (clinical assays)					x	x		x	
Bioassay platforms					x	x			
Short serie production for commercialization of functional foods and nutraceuticals					pilot laboratory				pilot plant

	Department of Nutritional Sciences, University of Toronto	National Centre for Agri-Food Research in Medicine, St-Boniface General Hospital Research Centre	Millennium Centre for Functional Food and Nutraceutical Research, University of Manitoba	POS Pilot Plant Corporation	University of Saskatchewan	University of Alberta	Food Processing Development Centre	Olds College Centre for Innovation	Food Processing Resource Centre, British Columbia Institute of Technology	Faculty of Agricultural Sciences, University of British Columbia
Location	Toronto, Ontario	Winnipeg, Manitoba	Winnipeg, Manitoba	Saskatoon, Saskatchewan	Saskatoon, Saskatchewan	Edmonton, Alberta	Leduc, Alberta	Olds, Alberta	Burnaby, British Columbia	Vancouver, British Columbia
Specialties	chronic disease and nutrition	clinical tests	functional foods and nutraceuticals	fractionation, extraction, purification and modification	research program on natural health products	food chain and its effect on human health	meat, transformation process in humid and dry environment	natural fibre, crops	product and process development	health safety, nutrition
Genomics, proteomics and bioinformatics			x					x		
Production and primary processing						x	x	x	x	
Processing, formulation and food production			x	x		x	x	x	x	
Extraction, purification and characterization		x	x	x	x	x	x			x
Nutritional and toxicological studies (clinical assays)	x	x			x	x				x
Bioassay platforms	x	x			x					x
Short serie production for commercialization of functional foods and nutraceuticals			pilot plant	pilot plant			pilot plant	pilot plant		

In summary, we may conclude that Canadian universities:

1. Are the only organizations involved in nutrition and clinical research.
2. Favor an interdisciplinary approach from production to consumption.
3. Have three Canadian leaders:
 - 3.1 Institut des nutraceutiques et des aliments fonctionnels (Quebec and the Maritimes);
 - 3.2 Universities of Guelph and Toronto in Ontario;
 - 3.3 University of Manitoba and the Millennium Centre for Functional Food and Nutraceutical Research.
4. Are leaders of multiple networks:
 - 4.1 Probiotics;
 - 4.2 Natural health products;
 - 4.3 Cardiovascular diseases.

Research Networks in Canada

Although R&D in the FFN sector have not been perfectly coordinated across Canada, many specialized regional or institutional networks have been established and others have been considered.

1. Networks on bioproducts and food safety with Agriculture and Agri-Food Canada.
2. Network with the Institut des nutraceutiques et des aliments fonctionnels (Quebec and the Maritimes).
3. Network on probiotics.
4. Network on natural health products.
5. Network on cardiovascular diseases.
6. NRC technological cluster (PBI).
7. Network in Ontario on functional foods and nutraceuticals.
8. Network on marine biomass utilization.

7. RECOMMENDATIONS

Considering that:

- Substantial improvements in quality of life and economic savings can be achieved in a prevention oriented health care system, by the use of beneficial FFN;
- The FFN sector constitutes a growing market, not only in Canada to stimulate the agri-food system and also associated export sectors but also as an effective means of substantially reducing health costs in Canada;
- Canadian companies have clearly identified their technological needs, short and long term, as well as the necessary conditions required to increase their growth;
- There is already a strong R&D infrastructure to build upon to make of Canada a world leader. The R&D expertise in the FFN sector has been identified with respect to research activities and agri-food inputs for each region of Canada.

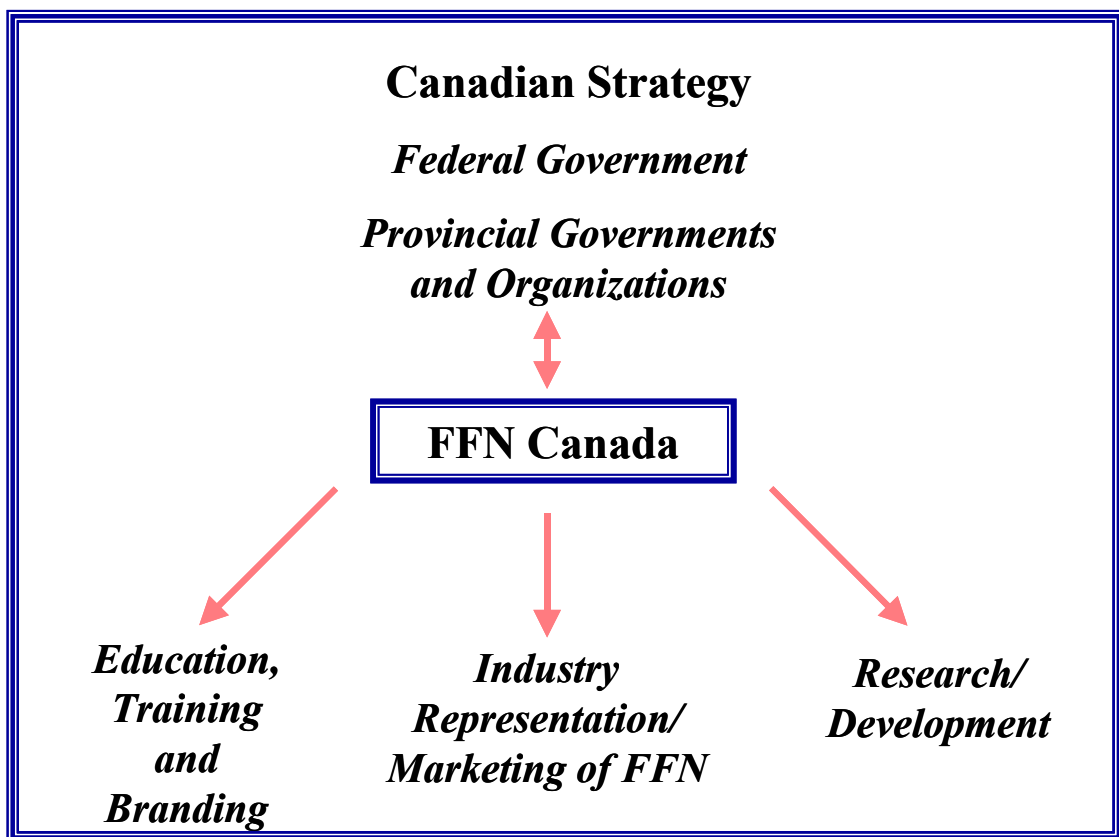
It is recommended that:

1. A Canadian strategy be established in terms of FFN with the objective of reducing health costs and increasing added value to the food and agriculture industry.
2. Canadian legislation on FFN be rapidly renewed and modernized to recognize the beneficial effects of FFN on health in order to stimulate the development of new FFN products for Canadian and international markets, and avoid the exodus from Canada's FFN companies abroad.
3. An investment of CA \$300 million to CA \$500 million over 5 years be made by the Canadian government, in partnership with the provinces and the private sector, into an independent organization "FFN Canada" to ensure a development structure and coordination of FFN activities. The return on investment for the government could be in the order of CA \$100 for every CA \$1 invested based on Agriculture and Agri-Food Canada's reports previously quoted.
 - 3.1 In respect to addressing the FFN sector's technological needs, a Canadian R&D Network of Excellence be created from the most active Canadian research centres and institutions while maintaining ties at the international level;
 - 3.2 A Canadian network representing companies linked to the provincial networks be set up in order to address industry's concerns for future development and growth;

- 3.3 Education, training and branding initiatives targeted to industry, professionals and the public at large.
4. Specific measures to meet actual regulation be defined:
 - 4.1 Considering current and anticipated delays in regulatory applications, financial measures (grants or tax credits) as well as advisory services should be put into place through various ministries to permit companies to qualify for GMP, GCP, GLP and others.
5. Specific incentives be implemented by the Ministry of Finance:
 - 5.1 As already successfully implemented in Quebec, initiate, for companies, a refundable tax credit to compensate for training costs for employees in the areas of research, development, management and marketing;
 - 5.2 Initiate a tax credit or grant to conduct clinical studies.
6. A multidisciplinary, multi stakeholder working group be created and whose mandate will be to examine the implementation of these recommendations.

8. CANADIAN FUNCTIONAL FOODS AND NUTRACEUTICALS DEVELOPMENT MODEL

The FFN sector's strengths and weaknesses identified in the technological needs and business success factors, as well as in technology supply, bring forth a need to organize the Canadian industry. This diagnosis suggests a development model "FFN Canada" to support the growth and competitiveness of this industry.



Canadian Strategy

Considering the FFN beneficial impacts on the population's health, on the cost of the health care system and impacts on global business, it is essential that the Federal Government and its partners consider a strategy for the development of Canadian FFN.

The strategy should:

- Assure coherence in FFN development through its orientation and means to be put in place by various ministries (Agriculture and Agri-Food Canada, Health Canada and Industry Canada) and organizations;
- Assure proaction in the regulatory development and promote Canadian leadership on the international level;
- Support favourable conditions for the development of the FFN industry;
- Act on its ramifications in the technological innovation process.

FFN Canada Strategic Orientations

This Canadian strategy will give birth to FFN Canada. This new entity (non-profit organization) shall be mandated to coordinate the FFN development in Canada, through the collaboration of federal and provincial ministries and industry organisations.

FFN Canada, based on a Canadian wide strategy and a budget permitting the realization of its mandate, will coordinate and develop initiatives related to:

1. Representation of the industry and the marketing of FFN.
2. Research and development.
3. Education, training and branding.

1. Representation of the industry and marketing of FFN

Strategic Approach:

Create a Canadian Network of Companies by bringing together provincial and regional networks in order to facilitate exchanges, such as:

- A better industry representation to governments:
 - Ensure that companies are well represented during the establishment of the Canadian Federal government's legislation and regulations as well as in foreign regulations;
- A better national and international positioning of the industry (marketing of the industry):
 - Facilitate FFN companies' access to national and international markets by marketing products and services throughout the Canadian Network of Companies,
 - Ensure representation of Canadian industry in foreign markets and in international economic interest groups,
 - Identify the needs and the members (inventory) of the Canadian FFN industry and keep statistics on this sector (data base);
- A better exchange of information between research and the industry:
 - Ensure technological and business transfer opportunities are identified and disseminated,
 - Ensure technological and commercial monitoring.

Action:

Undertaken in collaboration with provincial and national development organizations involved in FFN.

2. Research and Development

Strategic Approach:

Create a world-class centre of excellence in the FFN sector, which will attract and help retain local and foreign companies:

- Proceed with the financing of R&D projects submitted by members of the FFN Centre of Excellence;
- Establish an R&D coordination process that will manage intellectual property and technological transfer mechanisms;
- Ensure the alignment of R&D efforts with the industry's needs:
 - Clinical and toxicology studies including bioassays available to demonstrate the efficacy and safety of new products,
 - Development of new products which maximize bioactive ingredients' integrity and bioavailability,
 - Extraction, purification and characterization of active ingredients,
 - Studies on possible interactions between medicines and plant based products;
- Put to contribution the infrastructure and human resources already available in the genomic, proteomic and bio-informatic sectors for FFN development;
- Ensure that through the projects supported by FFN Canada, the R&D physical and human infrastructures be supported by:
 - Availability of clinical assay and bioassay investigations in Eastern Canada,
 - Pilot scale production lines of products (juice, bars, probiotics, etc.) in the premarketing phase. This installation could be located in the centre of the country in order to service the whole of Canadian companies,
 - Marine biomass valuation in Eastern and Western Canada.

Action:

Complimentary to existing initiatives at both national and provincial levels.

- Also proceed in activities such as:
 - Filing network research activities (data base),
 - Marketing of research activities at the national and international levels,
 - Networking of the research and Canadian business networks.

3. Education, Training and Branding

Strategic Approach:

Create an environment favourable to innovation, and consumption of FFN:

- Encourage the creation of training programs within universities and colleges;
- Encourage the creation of continued training programs for health professionals in the bio-food sector;
- Define terminology of FFN that are more acceptable to the consumer, and
- Create more education programs addressed to the Canadian population.

9. ACTION PLAN

In order to support the results from this study and grasp the existing momentum within the industry, it is recommended that:

- A summary be prepared and integrated within the Canada's Innovation Strategy (September 2002);
- Meetings be organized (September 2002) with ministers involved in the FFN sector's development in order to:
 - Convene an immediate Canadian strategy while considering the technological innovation strategy,
 - Establish the most important principles for establishing FFN Canada and its financing;
- A short-term budget be obtained from the Federal Government to ensure the operating of an expanded steering committee and to draft a business plan (October 2002);
- The expanded committee receive a mandate to develop and promote the business plan (2003).