CAPI
The Canadian Agri-Food Policy Institute

ICPA
L'Institut canadien des politiques agro-alimentaires

Finding Common Ground

Food for a Healthy Population and a Healthy Agri-food Sector

A Technical Report

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Canadian Agri-food Policy Institute

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TABLE OF CONTENTS

1 Preface 2

2 Brief History of Nutrition and Health Policy in Canada 3

3 Evolution of Dietary Fat Policies and Programs in Canada 14

4 Food Safety Issues 27

5 A Review of Selected Approaches and Initiatives for an Integrated Food and Health Policy 37

6 A Review of Five-a-Day Programs to Promote Consumption of Fruit and Vegetables 55

7 Short Food Supply Chains 60

8 Functional Foods and Nutraceuticals: Linking Agriculture to Public Health 77

9 Nutrigenomics: Reducing Chronic Diseases in Canada by Linking Genomics with Nutrition 102

10 System Thinking: A Conceptual Framework for Integrated Food and Health Policy 111

1. Preface

Early in 2007, the Canadian Agri-food Policy Institute launched a project to identify initiatives that could provide Canadians with improved health benefits while contributing to the economic wellbeing of the agricultural and food sector. The project team reviewed food and health initiatives, in Canada and abroad, that have impacted (or likely will impact) the health of the population and the agrifood sector. The team examined strategies, policy instruments, programs and policies, products, and governance. The results of that work are presented in a separate synthesis report.

This Technical Report presents some of the background work that underpins the synthesis report. This report contains nine selected papers prepared for the CAPI Food and Health project by members of the project team. These papers have been edited for length and consistency in presentation, but the contents and ideas are those of the authors. Each paper can be considered a "stand alone" document with its own references.

The work of the authors is sincerely acknowledged, as is the editorial wizardry of our editor, David Wylynko of West Hawk Associates. Apologies are extended to the authors in the event that the Project Manager overlooked or misinterpreted any material in the preparation of the Synthesis Report.

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2. Brief History of Nutrition and Health Policy in Canada

Lise Dubois[1]

1 Introduction

In recent decades, Canada's federal, provincial, and municipal governments have put in place different nutrition policy elements (laws, rules, regulations, policies, programs, interventions, etc.), creating a framework of governmental interventions to protect the health of the population. All together, these elements can be referred to as a nutrition policy, even if no formal integrated nutrition policy exists in Canada.

A paper published in 1977 by Health Canada[2] indicates that the development of a national nutrition policy in Canada, which has evolved from the 1930s, includes:

- A set of recommended nutrient intakes: originally referred to as the Dietary Standards which is a scientific summary of quantitative nutrient requirements based on scientific knowledge, economic forces, food supplies, and feeding practices;
- A food guide: providing the translation of the recommendations for nutrient intakes into actual foods;
- A set of nutritional recommendations for public education;
- A mandatory food fortification program;
- Food consumption surveys for nutritional monitoring;
- And a policy on nutrition labeling.

Health Canada is responsible for:

- Establishing policies, setting standards and providing advice and information on the safety and nutritional value of food;
- Promoting the nutritional health and well-being of Canadians by collaboratively defining, promoting and implementing evidence-based nutrition policies and standards;
- Administering the provisions of the *Food and Drugs Act* that relate to public health, safety and nutrition;
- Evaluating the safety, quality and effectiveness of veterinary drugs.

Nutrition has always been an important determinant of population health. For this reason, over time countries have developed different laws, rules, regulations, policies, programs, and interventions to ensure food safety, to ensure everyone receives a sufficient amount of food, and to make sure that the variety of food is adequate to cover energy and nutrient needs in accordance with sex, age and activities.

In Canada, nutrition policies have followed from the development of health policies. Over the years, health policies have evolved as a result of growing scientific knowledge and a growing awareness of the main health problems in societies. The history of nutrition policy can be attributed to four important health policy developments in Canada:

- Public health: from mid-1800 century;
- Deficiency disease prevention: since the first half of the 20th century;

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[2] Fischer, 1977

- Health promotion and chronic disease prevention: since the second half of the 20th century;
- Population health and reduction of social health inequalities: since the mid-1990s.

These health policy developments are cumulative, and coexist to offer the best health promoting and nutritional surroundings to the population. For each health policy development, we present a short overview of the relevant health policy issues, the general diet related aspects, and the main government interventions developed to address the diet related and health aspects.

2 Public Health

2.1 Relevant health policy issues

After colonization, and a subsequent period of mere survival, a public health vision emerged that was based on Pasteur's work on the development of epidemics.

2.2 General diet related aspects

Initially, the priority was general public protection, the control of epidemics and food contamination, and the reduction of maternal, infant and childhood morbidity and mortality.

2.3 Main government interventions

- The government established different norms to ensure the hygienic quality of food and to reduce foodborne diseases (milk pasteurisation and meat inspection programs);
- An Act to prevent adulteration of foods, drinks, and drugs was developed;
- Public health nutrition education programs were developed for mothers and children.

3 Deficiency Disease Prevention

3.1 Relevant health policy issues

During the Great Depression that started in 1929, food was available but many people could not afford to purchase enough for basic sustenance. To study this issue and to possible solutions, the Canadian Council on Nutrition was first appointed in 1937 by the Department of Pensions and National Health. This followed the publication by the Health Organization of the League of Nations of the first food standards, which were based on consideration of physiologic needs and designed for international use. The international standards were adapted by the Council to apply to the Canadian situation.

3.2 General diet related aspects

In view of new scientific knowledge on the chemical composition of foods, and on the physiological role of nutrients in the human body, the federal government acted to prioritize the food nutritional quality of food and to prevent diseases that result from nutritional deficiencies (energy-protein deficiency and specific nutrient deficiencies). The "new nutrition" era, based on caloric and protein requirements, was followed by the "newer nutrition" era, based on the nutrient content of foods (vitamins and minerals).

3.3 Main government interventions

- The federal government developed its first food enrichment and fortification programs in 1942; regulations were introduced that set minimum levels for vitamin additions to foods. In 1949, maximum limits also were also introduced to protect consumers from excessive amounts. The addition of nutrients to standardized foods was controlled by the standards set for those foods. Iodized salt was made available in Canada in the 1930s, the enrichment of evaporated and dried milks with vitamin D was permitted as of 1950, and a standard for enriched flour was promulgated in 1952. In 1964, regulations were promulgated restricting the addition of vitamins, minerals and amino acids to the foods named in the Food and Drug regulations. The regulations also specified the vitamins, minerals and amino acids permitted in each food[3].
- Food labelling indicating the nutrient content of food was regulated (revision in 1945, new regulation in 1960-1962);
- The government developed rules to control fraudulent food labelling;
- Nutrition education programs were developed for different population groups to prevent growth retardation, energy-protein deficiency and nutrient deficiency;
- During the war, programs were developed to guide Canadian families in suitable food purchases and food preparation methods;
- The Canadian Dietary Standards were first adopted by the Canadian Council on Nutrition in 1937. The recommendations included information regarding total caloric intake in relation to energy expenditures associated with work, recommended intakes for protein (50% should be from animal sources), fat (not less than 30% of total calories), calcium, iron, iodine (use of iodized salt was recommended), ascorbic acid and vitamin D. A specific recommendation was made for milk consumption as it was a good source of protein, fat, vitamin D and calcium. Specific recommendations were developed for pregnant and lactating women;
- Following the first edition of the Recommended Dietary Allowances (RDAs) published in the United States in 1941, the Canadian Council on Nutrition adopted the RDAs for uniformity in 1942. However, due to misuse of the RDAs in evaluating group intakes, the Canadian Council on Nutrition advised discontinuing their use in Canada. A new Canadian standard was released in 1945;
- Canada's Official Food Rules (1942) was released as part of a wartime nutrition program[4]. The goal was to improve the health of Canadians by promoting better eating habits, with a focus on patterns of eating that would provide adequate amounts of essential nutrients to Canadians. Since then, the food rules were revised regularly in line with new knowledge on nutrient requirements. They were revised in 1944 and 1949 under the name 'Canada's Food Rules.'

4 Health Promotion And Chronic Disease Prevention

4.1 Relevant health policy issues

The Lalonde Report, *A new perspective on the health of Canadians,* presented in the House of Commons on April 1, 1974 was an important milestone in the development of a new direction for future health care policy in Canada. The paper identified two main health-related objectives: the health care system; and, the

[3] Cheney and Lee, 1994
[4] Health Canada 2002

prevention of health problems and promotion of good health. It proposed integrating these two aspects of health in health care policy development, and it detailed five main strategies and 74 proposals to meet this objective. The Lalonde Report proposed that changes in lifestyles or social and physical environments would likely lead to more improvements in health than would be achieved by spending more money on existing health care delivery systems. The Lalonde Report gave rise to a number of highly successful and proactive health promotion programs. These programs increased public awareness of the health risks associated with certain personal behavior and lifestyles (e.g., smoking, alcohol, nutrition, fitness). In the 1980s, nutrition became one of the federal government's six priorities for health promotion.

4.2 General diet related aspects

Until the 1970s, nutrition recommendations in Canada were designed to prevent nutrient deficiencies. The 1970-1972 Nutrition Canada Survey was the first national nutritional survey. It indicated that nutrient deficiency diseases were no longer an issue for Canada. The global nutritional quality of the diet became a topic of interest following emerging knowledge on chronic diseases, which had replaced infectious and deficiency diseases as the main cause of mortality in the population. The "negative nutrition" era became the norm: to avoid excessive amounts of fat, sugar, salt, and animal products; and to eat more fibre, fruits, and vegetables. The public's preoccupation with these issues fostered the development of the "health food" industry.

4.3 Main government interventions

Based on cumulative scientific data, the nutrition standards were periodically updated from 1948 to 1990. In 1977, the dietary guidelines added a focus on the prevention of chronic diseases to nutrient deficiency prevention. *Canada's Food Guide* was revised in 1961, 1977 and 1982. In 1983, the release of a new food guide, and the Recommended Nutrient Intakes for Canadians were integrated into dietary guidelines for consumers. For the first time, chronic disease prevention was added to nutrient deficiency prevention in the Recommended Nutrient Intakes and to Canada's food guide. Some messages were added to help consumers make healthy food choices by consuming a variety of foods, balancing energy intake with energy expenditure, and moderating the consumption of fat, salt, sugar and alcohol. A voluntary nutritional labelling system was proposed to the food industry in 1988, but health claims were still prohibited.

From 1987 to 1990, two new advisory committees were created within Health Canada. The Scientific Review Committee had the mandate to describe the dietary patterns that would supply recommended levels of essential nutrients while reducing the risk of chronic diseases; it resulted in the publication of updated *Nutrition Recommendations for Canadians.* The recommended nutrient intake was also updated. For the first time in Canada, a review of nutrient requirements and a review of the role of diet in disease prevention were conducted concurrently. The new recommendations consisted of 8 statements outlining the desired characteristics of the Canadian diet pertaining to: energy consumption for a healthy body weight; recommendations on all essential nutrients; recommendations suggesting that no more than 30% of energy be derived from fat and no more than 10% from saturated fat; 55% of energy should be derived from carbohydrates; the reduction of overall sodium intake; the consumption of alcohol such that it composes 5% or less of energy intake; recommendations on caffeine intake, proposing that no more than the equivalent of 4 cups a day should be consumed; and, recommendations proposing that the community water supply be fluoridated if fluoride levels were lower than 1mg/liter.

The **Communications and Implementation Committee** (representatives of the academic community, industry, NGOs) was put in place to translate the scientific *Nutrition Recommendations* into dietary advice for the public and proposed implementation strategies. Its work resulted in *Canada's Guidelines to Healthy Eating*, which offered five statements that were key nutrition messages for healthy Canadians aged 2 years and older. *Canada's Food Guide to Healthy Eating* emerged from this process in 1992. The five statements stipulate: the enjoyment of a variety of foods; an emphasis on cereals, breads, other grain products, fruits and vegetables; choosing lower fat dairy products, leaner meats, foods prepared with little or no added fat; the achievement and maintenance of a healthy body weight; and limiting intake of salt, alcohol and caffeine.

Following the 10th edition of the RDAs published in 1989 by the U.S. National Research Council, the process of harmonization of Canada–U.S. nutrition recommendations began.

- In 1993, the Food and Nutrition Board (FNB) of the Institute of Medicine (IOM), National Academy of Sciences, held a symposium and public hearing entitled "Should the Recommended Dietary Allowances Be Revised?". Based on comments and suggestions from this meeting, FNB proposed changes to the process of developing the RDAs;
- In 1994, FNB published the concept paper "How Should the Recommended Dietary Allowances Be Revised?" (IOM, 1994) and held workshops at which experts discussed the development of nutrient-based reference values;
- In April 1995, a multi-sectoral Canadian symposium reviewed the pros and cons of harmonizing Canada's dietary standards with those of the U.S. and reached consensus in support of harmonization. As a result, Health Canada approached the FNB to collaborate on the development of the harmonized nutrient-based recommendations;
- In 1995, FNB began a close collaboration with Health Canada. The Standing Committee on the Scientific Evaluation of Dietary Reference Intakes was appointed to oversee and conduct the project. The Standing Committee devised a project structure that involved expert nutrient group panels and two overarching subcommittees. The standing Committee announced that seven expert nutrient group panels would review major nutrients, vitamins, minerals, antioxidants, electrolytes, and other food components;
- In 1996, a subcommittee on Upper Reference Levels of Nutrients and the first nutrient panel, on calcium and related nutrients, were established. The full series of DRI reports was developed over a span of time, with the first report released in 1997. Reports describing the use of the DRIs in dietary assessment and dietary planning also were published.

5 Population Health And The Reduction Of Social Health Inequalities

5.1 Relevant health policy issues

Population health builds on a long tradition of public health initiatives. In 1986, the *Ottawa Charter for Health Promotion* (World Health Organization, 1986) and *Achieving Health for All: A Framework for Health Promotion* (Jake Epp, 1986) expanded on the Lalonde Report (1974) by focusing on the broader social, economic and environmental factors that affect health. These factors, or "determinants of health", suggested that significant influences on health include income level, education, and the physical environment where one lives and works. In 1989, the *Canadian Institute for Advanced Research (CIAR)* introduced the population health concept, proposing that individual determinants of health do not act in isolation. It is the complex interaction among determinants that can have a far more significant effect on

health. For example, unemployment can lead to social isolation and poverty, which in turn influences one's psychological health and coping skills. Together, these factors can then lead to poor health. As experts learn more about how these interactions affect health, they will better understand why and how policies and different health approaches affect the health of a population. They will also better understand why some groups within populations are healthier than others, even though all Canadians have access to the health care system. In 1994, the population health approach was officially endorsed by the federal, provincial and territorial Ministers of Health in a report entitled *Strategies for Population Health: Investing in the Health of Canadians*. The report, which summarizes current knowledge about the broad determinants of health, also lays out a framework to guide the development of policies and strategies to improve population health. As part of a departmental restructuring and realigning of priorities, the Public Health Agency of Canada has made promoting the population health approach one of its four business mandates.

5.2 General diet related aspects

In the 1990s, following new scientific knowledge on the relationship between social determinants and the health of populations, social inequalities and related nutritional inequalities became a concern for the federal government. The document *Nutrition for health: an agenda for action*, published in 1996, is generally referred to at Health Canada as the first nutrition policy in Canada. This policy followed an international meeting where participating countries endorsed a *World Declaration on Nutrition* and a *Global Plan of Action for Nutrition*. The *World Declaration on Nutrition* affirms that "access to nutritionally adequate and safe food is a right of each individual." It further identifies nutrition as a precondition for the development of societies and a key objective of progress in human development. Asserting that nutritional well-being "must be at the centre of ... socio-economic development plans and strategies," the Declaration called on countries to set measurable goals and timeframes for action on nutrition and food issues, with the overall goal of "nutritional well-being for all people in a peaceful, just and environmentally safe world." The *Global Plan of Action* sets out the following as universal objectives:

- Ensuring continued access by all people to sufficient supplies of safe foods for a nutritionally adequate diet;
- Achieving and maintaining health and nutritional well-being of all people;
- Achieving environmentally sound and socially sustainable development to contribute to improved nutrition and health;
- Eliminating famines and famine deaths.

To support the attainment of these universal objectives, the *Global Plan* proposed nine theme areas for action, spanning the health, social, economic, environmental and foreign policy domains:

- Incorporating nutrition objectives, considerations and components into development policies and programs;
- Improving household food security;
- Protecting consumers through improved food quality and safety;
- Preventing and managing infectious diseases;
- Promoting breastfeeding;
- Caring for the socio-economically deprived and the nutritionally vulnerable;
- Preventing and controlling specific micro-nutrient deficiencies;
- Promoting appropriate diets and healthy lifestyles;
- Assessing, analyzing and monitoring nutrition situations.

Nutrition policies can play a central role in the reduction of nutrition and health inequalities in and between countries[5]. A multi-sectoral approach is important in a population health perspective; and with regard to nutrition, such an approach should include health, agriculture, education, industry, environment, and finance[6]. In view of globalization, nutrition policies that affect many countries require attention. Food standards, food labeling, and nutrition recommendations must be harmonized for food products to go freely from one country to another. Such processes of standardization are already under way in Europe and in North America. A monitoring system capable of measuring the trends in nutritional inequalities at the population level would be important to ensure that these processes of standardization will not impair the nutritional health of some nations. As nutrition policies may impact other countries, such policies should not be developed in silos. It is also important that they be evaluated during their implementation by experts from outside a given country and adjusted to that country's ever-changing social needs[7]. See Appendix 1 for a framework of population health that has been adapted to consider nutrition, and for a list of indicators that are proposed for a Canadian nutrition surveillance system that is in line with the nutrition policy.

Nutrition for health: an agenda for action recognises that powerful economic and social forces, combined with individual practices and capacities, influence what foods are available, and what foods people choose. The population health model has applications to nutritional health.

Food choices, which play a direct role in nutritional health, significantly influence an individual's overall health status. Taking personal responsibility for one's health is important. However, food choices are not simply a matter of personal choice. Economic and social forces, together with factors related to the physical environment, influence what foods are available and a person's individual capacity to make choices.

Policy makers and community leaders must consider all determinants of health, and must base their actions on a foundation that includes research, information and public policy. This approach includes how individual factors, such as basic biology, genetic endowment, health status and individual health practices, impact on nutritional health. Nutrition programs have long recognized the importance of knowledge, attitudes and skills in developing positive health practices such as appropriate food choice behavior. The individual's capacity to adopt a healthy pattern of eating is influenced by both the availability and understanding of information provided by sources such as food labels or Canada's Food Guide to Healthy Eating. Individual capacity involves more than knowledge about what to eat; it includes food preparation skills, time to prepare, and personal buying power, all of which are profoundly influenced by the following environmental factors.

Collective factors include**:**

- **Social and Economic Environment:** Economic conditions influence the ability of individuals to acquire a healthy diet. Unemployment and inadequate financial resources reduce an individual's capacity to meet the daily requirements for food. The social environment, with its diverse social norms, cultural values, support networks, traditions and practices, influences people's food choices. Settings vary -- home, school, workplace, recreational sites, restaurants -- each affecting food choices. Advertising and the media are key sources of nutrition information.
- **Physical Environment:** Food is part of the physical environment. The type of food available in grocery stores, workplaces, schools and within the food service sector is a powerful influence on

[5] Illsley 1990; Acheson et al. 1998
[6] Milio 1990
[7] James 1997

food choices. The composition of food can support the consumption of a diet consistent with nutrition guidelines, while label information can assist consumers in making healthy food choices. Not all consumers are in a position to choose their own food. Many people are in environments where food is provided, such as: children at home, in day care and at school; individuals in hospitals and chronic care facilities; prison inmates; military personnel; individuals receiving meal services, such as Meals on Wheels; those in congregate dining programs, and others fed in institutional settings.

- **Health Services:** Public access to the full range of health, social and community services, including nutrition services, is essential. Appropriate nutrition services encompass healthy eating programs, public education, and access to individual care and counselling. Those with special nutrition needs or health conditions, such as pregnant women, breastfeeding mothers, the elderly, the sick and those with therapeutic nutrition needs, require access to care, counseling and education. The collective and individual factors are intrinsically connected to the third component of the Framework for Population Health, the tools and supports that are the foundation for action.

5.3 Main government interventions

- Poverty and food insecurity became an important concern for the government, spurring the development of *Canada's Action Plan for Food Security*;
- Healthy child development became a priority and new recommendations for nutrition during pregnancy, breastfeeding and infant feeding were developed;
- Effort was made to integrate nutritional considerations into health, agriculture, education, social and economic policies and programs with the Canada nutrition plan based on *Nutrition for health: an agenda for action*;
- A mandatory nutrition labelling system and permission for health claims were established in 2003.
- The review of the food guide was undertaken in 2002, and *Eating well with Canada's Food Guide* was issued in 2007;
- Public health preoccupations include food safety in general and the safety of novel foods (e.g. nutraceuticals) and genetically modified foods. The Government developed the *Action plan of the Canadian Government for the future of biotechnology.*

6 Conclusion

Canada is recognized as a world leader in the development of health policies. The Lalonde Report has been cited in health policies of different countries, and the most recent population health framework. With its emphasis on the social determinants of health at the population level, recommendations from the report have been adopted in different countries and at the World Health Organization. A food and nutrition policy based on the population health approach, inclusive of different dimensions of people's lives, will help to improve the health of the Canadian population, reduce nutritional inequalities between social groups, and will have the potential of being well recognized at the international level.

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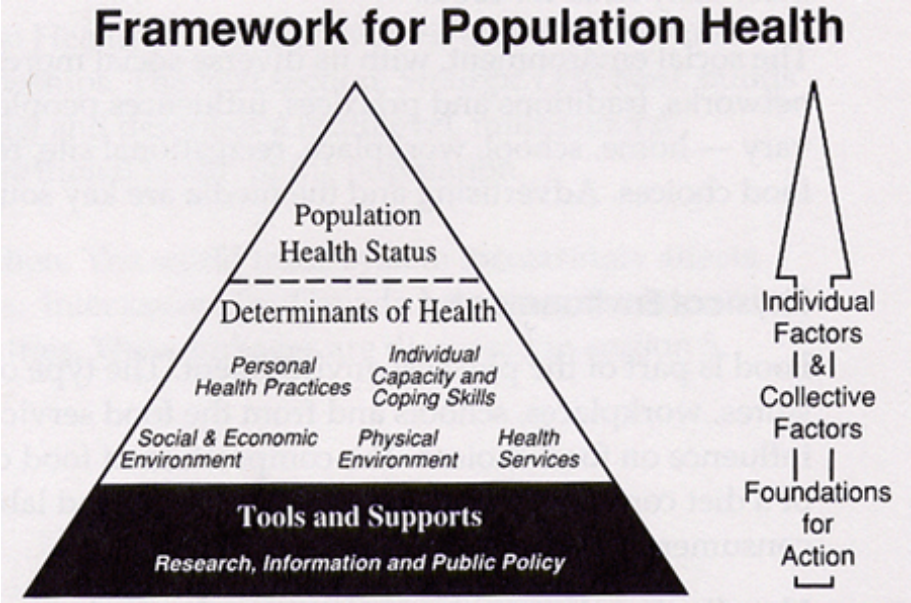
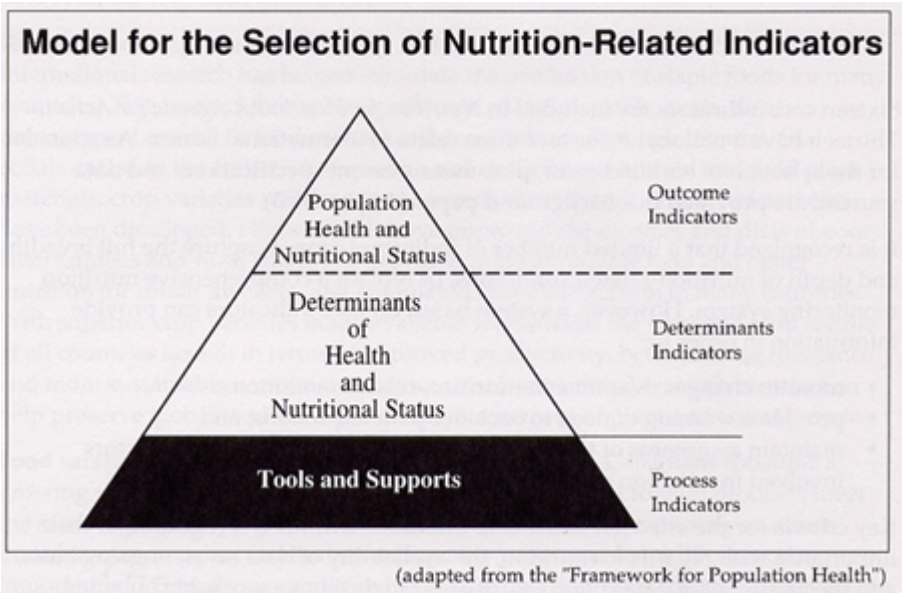
APPENDIX 1

The Framework for Population Health can be used for the development of national core indicators, and also provides a model for the collection of data according to the needs of different jurisdictions.





Based on this framework, the core-nutrition-related indicators proposed in the *Nutrition for Health – An Agenda for Action* document, are:

NATIONAL
Outcome Indicators:

potential years of life lost due to ischemic heart disease and stroke prevalence of hypertension
incidence of certain site-specific cancers
incidence of low birth weight
prevalence of overweight and underweight

Determinant Indicators:

estimated intake of grains, fruits and vegetables
estimated intake of fat
level of recreational physical activity
initiation and duration of breastfeeding
nutrition awareness/attitudes
food bank use
cost of a "nutritious food basket" in relation to income

Process Indicator:

existence of a national multisectoral co-ordinating network

INTERNATIONAL

Outcome Indicators:

prevalence of iodine deficiency disorders worldwide
prevalence of vitamin A deficiency worldwide

Process Indicator:

Canada's total Official Development Assistance (ODA) as % of GNP and proportion of ODA allotted to Basic Human Needs

3. Evolution of Dietary Fat Policies and Programs in Canada
Agri-Food and Health Policies – 1985 to Present

Bruce McDonald, Lise Dubois and Bernie Sonntag[8]

1. Background

Since the 1960s, developed countries have been concerned with the high incidence of cardiovascular disease in and the relationship of coronary heart disease (CHD) to the amount and type of fat in the diet. The conclusion of the seven countries study[9] of a relationship between dietary fat intake, blood cholesterol level and the incidence of mortality due to CHD focused this concern. Added concern with the amount of fat, in particular saturated (viz., animal) fat, in the diet came from metabolic studies that quantified the relationship between saturated fat and blood cholesterol[10, 11]. However, it was the cholesterol consensus conferences of the 1980's that gave rise to consumer interest in the relationship of dietary fat to disease risk and to policies and programs to address this issue. The first cholesterol consensus conference took place in the United States in December 1984[12]. This conference prompted the launch of the National Cholesterol Education Program (NCEP; National Heart, Lung and Blood Institute, NIH)[13].

2. Canada's Consensus Conference on Cholesterol

Canada held its own Consensus Conference on Cholesterol in March 1988[14]. The conference was sponsored by the Department of National Health and Welfare, the Canadian Atherosclerosis Society, the Canadian Heart Foundation and the Heart & Stroke Foundation of Ontario. Additional support was provided by seven drug companies, four life insurance companies, the Canadian Egg Marketing Agency, Burns Foods Inc. and the Stephen R. Roman Foundation. Participants in the Conference came from a broad cross section of government agencies, non-governmental agencies and organizations, food processing and manufacturing agencies and organizations, food commodity groups, clinicians, public health and other health professionals, and academic researchers.

The dietary recommendations arising from the Conference paralleled those previously articulated by expert panels in the United States and Europe. The primary recommendations called for:

- a reduction in total fat to 30% or less and saturated fat to 10% or less of energy intake;
- protein in the range of 10 to 15% of energy intake; and
- the balance of the energy from carbohydrate (with an emphasis on a variety of foods containing dietary fibre).

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[8] Bruce E. McDonald, Prof. Emeritus, Dept. of Human Nut'l Sciences, Univ of Manitoba; Lise Dubois, Assoc. Prof. & Canada Research Chair in Nutrition and Population Health, Dept of Epidemiology and Community Med., Univ. of Ottawa; and Bernie Sonntag, Professional Agrologist, Sonntag Agricultural Services.

[9] Keys A (ed)

[10] Hegsted DM

[11] Keys A

[12] Consensus Development Conference

[13] National Cholesterol Education Program Expert Panel

[14] Canadian Consensus Conference on Cholesterol: Final Report

The expert panel also recommended that the agriculture and food industry be encouraged to "*increase its efforts to produce foods that will make it possible to achieve lower levels of blood cholesterol in the Canadian population*." The panel also recognized the "*need for comprehensive dietary guidelines for Canadians to further develop the recommended strategy to reduce population risk*" for CVD; specifically, for a reduction in total and saturated fat intakes. The panel further recommended that "*government agencies at all levels (federal, provincial and local) and voluntary agencies give high priority to the development of health promotion programs*".

3. Policies and Programs in the Aftermath of the Consensus Conference

A host of activities, aimed at reducing total and saturated fat in the Canadian food supply, were undertaken by the government, producers, food manufacturers, and non-governmental agencies (e.g., Heart and Stroke Foundation) following the Consensus Conference on Cholesterol. An important motivator of these activities was the heightened consumer awareness of the importance of the amount and type of dietary fat following the consensus conferences of the 1980s. Some of the government policies and programs pre-dated the Consensus Conference. Certain initiatives, such as nutrition guidelines and nutrition labeling (Health Canada) and beef and pork grading standards aimed at increasing lean yield (AAFC), had been under consideration for a number of years. However, implementation and refinement of these policies and programs were significantly accelerated by consumer interest and concern with the role of dietary fat in CVD and by the national goal to reduce dietary fat, in particular saturated fat, intake. Although both Health Canada and AAFC played major roles in efforts to reduce CVD risk among Canadians, there is little evidence of any notable cooperation between the Departments. Food manufacturers responded to the challenge issued by the Consensus Conference, namely to produce foods that would help Canadians achieve lower levels of blood cholesterol, by substituting partially hydrogenated vegetable oils (PHVO) for saturated fats in their formulations and by developing a host of low fat and fat-free foods. PHVO, also, replaced saturated fats in deep-frying applications (fast food preparation and the production of snack foods, such as potato chips). The prevailing science at the time held that trans fats, at least at the level in the average diet, had little or no effect on CVD risk.

3.1. Agriculture policy and program initiatives.

The production of lean meat and a reduction of the fat content of the carcass have been a major aim of the livestock (beef and hog) industry in Canada over the past 20 to 25 years. Agriculture and Agri-Food Canada played a strategic role in this plan: in the evolution of carcass grading standards; and in the development of breeding systems (e.g., cross breeding) for beef and swine that capitalized on price premiums and discounts associated with the grading systems. AAFC also did a lot of work on production management (e.g., performance of breed crosses, feedlot management, disease and pest management, etc.) aimed at improved beef and hog performance.

AAFC also played a pivotal role in the development of canola, a vegetable oil crop adapted to the climate and agricultural practices that prevail in Canada. The transition from a small wartime crop to a major export crop and the predominant vegetable oil in Canada is another facet of the dietary fats and oils story. AAFC made major contributions to the development of canola cultivars and to the establishment of the nutritional properties of canola oil through in-house programs and the support of research at Canadian universities and by the food processing industry. The Department also provided significant resources for the Canola Council of Canada's successful application for GRAS (Generally Recognized As Safe) status in the United States.

Another institute that played an important role in the canola story was the NRC Plant Biotechnology Institute in Saskatoon (formerly the NRC Prairie Regional Lab).

3.1.1. Livestock grading standards and development of lower fat beef and hogs. Although a national beef grading system was introduced in 1947 and an indexing (yield x weight classes) hog grading system in 1968, it was the Canada Agricultural Products Act of 1988 that provided the government with the authority to regulate the marketing of agricultural products (imports, exports and those in inter-provincial trade). The Act established national standards and grades for all agricultural products, including federal livestock grading regulations. Major amendments to the Act in 1992 established the basis of the current beef grading system. Hog grading standards, which are based on yield indices (prediction of lean content) for a range of carcass weight categories, were last changed in 1996. The equations for expressing yield were based on the National Hog Carcass Cutout Trial carried out by AAFC between 1992 and 1994. The Federal Government withdrew from livestock grading programs in 1996. The Canadian Beef Grading Agency assumed responsibility for delivering a privatized grading system for beef, veal and bison while individual provinces and individual abattoirs developed their own settlement grids for hogs.

Beef and hog grade standards, which were developed to reflect product characteristics valued in the marketplace, also have served as a basis for payment to the producer. As a result, the livestock grading system had a significant and direct impact on the meat industry in Canada. Both the beef and hog industry benefited from publicly-funded research in meat science, animal breeding and production systems carried out at several AAFC research centers and some agricultural colleges at Canadian universities. The new breeding and production technologies facilitated targeting the grading system and the price premiums and discounts reflected by it. By 1994, 91 percent of the graded beef fell into the Canada A grade and by 2000 over 95 percent of the Canada A carcasses fell into the two upper grade categories (AA & AAA/Premium). In addition to the health advantages of the lower fat beef carcasses, improved quality has resulted in significant monetary gains to beef producers.

The Beef Information Center and the Canadian Pork Council, which represent the beef and pork industry to the consumers, are active participants in the Heart and Stroke Foundation's Health Check™ program. The Health Check™ program is designed to help consumers make quick, healthy food choices. The program is based on Canada's Food Guide to Healthy Eating. Use of the Health Check™ symbol requires that the food product meet strict standards (e.g., maximum fat content in the case of meat products). The inclusion of meat products in the Health Check™ program reflects the success of initiatives by the livestock industry intended to reduce the fat content of beef and pork.

3.1.2. Development of a high quality vegetable oil adapted to Canadian conditions. Although canola was an established Canadian oilseed crop when the Consensus Conference on Cholesterol was held in Ottawa in 1988, the recommendations of the Conference, namely that Canadians reduce the level of saturated fat in their diets, gave canola oil a significant boost. Canola oil is characterized by a very low level (< 7 %) of saturated fatty acids; the lowest level among common fats and oils. Canola oil contains about half the level of saturated fatty acids present in soybean oil, olive oil, or corn oil and about one-sixth to one-seventh the level present in animal fats (viz., lard and tallow).

During WW II, Canada experienced an acute shortage of dietary fat. This situation was an important factor underlying efforts to develop a domestic vegetable oil industry following the war. Canada turned to rape, a crop adapted to northern latitudes that had been successfully introduced into Canada during the war;

rapeseed oil provided feedstock for lubricants required by ships transporting troops and supplies to England. From humble beginnings, rape production flourished under government and industry support to become an important crop in Western Canada. Public money provided most of the early investment for the transformation of rapeseed oil from a feedstock for industrial lubricants to a high quality vegetable oil for human consumption.

Although there were hints of adverse nutritional (health) properties associated with the oil during its introduction and development, Health & Welfare Canada concluded, in the early 1960s, that there was no convincing evidence that the oil posed any risk to human health. However, in 1970 the industry was jolted when Unilever made public its studies on a "fatty heart condition" in weanling rats fed rapeseed oil[15]. The department suggested that it would be prudent to replace traditional rape with low-erucic cultivars. Plant breeders at the University of Manitoba and the AAFC research center in Saskatoon had developed low-erucic acid cultivars of rape[16] but their selections were inferior in yield and other agronomic traits to traditional rape and hence were not adopted by farmers. Canada made the change-over of the entire rape crop to low-erucic acid varieties in two years and by the mid-1970s had combined the low-erucic trait with the low-glucosinolate[17] attribute to produce what became known as canola. AAFC also developed agronomic and pest management technologies that complemented the advances in plant breeding.

Studies which found canola oil equivalent to soybean oil in lowering blood total cholesterol levels in healthy young men were explained on the basis of the low saturated fatty acid (SFA) content of canola oil[18]. However, research in the mid-to-late1980s[19,20], which showed monounsaturated fatty acids (MUFA) equal to polyunsaturated fatty acids (PUFA) in lowering blood total and LDL cholesterol levels, provided a more plausible explanation. The prevailing theory at this time held that SFA resulted in an increase and PUFA a decrease in blood total and LDL cholesterol, and that MUFA were neutral. Canola oil is characterized by a high level of MUFA (second only to olive oil among common vegetable oils) and an intermediate level of PUFA. The demonstration that MUFA were equal to PUFA in reducing risk factors for CVD, and that canola oil was a high-oleic acid oil, resulted in canola oil being linked with the health merits of the Mediterranean diet.

Canola oil was originally introduced into the United States on the basis of its very low SFA content. It was considered a unique (novel) oil by US authorities. Since its progenitor was rape, FDA approval (GRAS status) was required before canola oil would be allowed into the US market. Application for GRAS status was initiated by the Canola Council of Canada but AAFC was an important partner in the preparation and presentation of the application to FDA - a continuation of the Federal Government's backing for a domestic vegetable oil industry. The ultimate tribute in the development of canola, from an industrial oilseed crop during WW II to an internationally acclaimed high quality vegetable oil, was the recent granting of quality health claim (QHC) status by the US Food and Drug Administration. Canola oil is now eligible to bear a QHC on the basis of its ability to reduce the risk of coronary heart disease.

3.2. Health policy and program initiatives

[15] Abdellatof AMM
[16] Stefansson BR
[17] Glucosinolates are goitrogenic substances that limited the value of rapeseed meal as a protein supplement in livestock feeds.
[18] McDonald BE
[19] Mattson FH
[20] Mensink RP

For 30 years, the development of policies and programs directed to the prevention of chronic diseases has been a major priority of Health Canada. Prior to the 1970s, nutrition recommendations were meant to prevent nutrient deficiencies. However, the 1970-1972 Nutrition Canada Survey revealed that nutrient deficiencies were no longer an issue for Canada. Chronic diseases, many with nutritional implications, had replaced infectious and deficiency diseases as the main causes of morbidity and mortality. Yet, desired characteristics of the Canadian diet for reducing the risk of chronic diseases wasn't official policy until the publication of "Nutrition Recommendations for Canadians" in 1990. The recommendations for fat were those recommended by the Consensus Conference on Cholesterol, namely, that no more than 30 percent of energy be derived from fat and no more than 10 percent from saturated fat. Among the key nutrition messages in "Canada's Guidelines to Healthy Eating," the companion publication to Nutrition Recommendations for Canadians was the recommendation that Canadians choose lower fat dairy products, lean meats, and foods prepared with little or no added fat. Over the subsequent 15 years, although more conservative than the United States, Canada introduced regulations for nutrition labeling and nutrition claims.

3.2.1. National nutrition policy. No formal integrated nutritional policy exists in Canada. However, over the years the Canadian government, in conjunction with the provinces and municipalities, has put in place different nutrition policy elements (laws, rules, regulations, policies, programs, interventions, etc.) which taken together might be considered a nutrition policy. Health policies and programs in Canada have evolved over the years. During the first half of the 20th century emphasis was on the prevention of deficiency diseases whereas during the latter half of the 20th century emphasis shifted to health promotion and the prevention of chronic diseases. Since the mid-1990s, the focus has been on population health and the reduction of social inequalities.

The Lalonde Report, "A New Perspective on the Health of Canadians (1974)," was an important milestone in the development of a new direction for future health care policy in Canada. The paper identified two main health-related objectives: the health care system; and, the prevention of health problems and the promotion of good health. The Lalonde Report set the stage for the 1990 publication "Nutrition Recommendations for Canadians", which reviewed, concurrently, nutrient requirements and the role of diet in chronic disease prevention. The recommendations outlined the desired characteristics of the Canadian diet: energy consumption for a healthy body weight; recommended levels of all essential nutrients; and the desired level of total and saturated fat. "Canada's Food Guide to Healthy Eating (1992)" that emerged from the Nutrition Recommendations and the companion document "Canada's Guidelines to Healthy Eating" put an emphasis on cereals, breads and other grain products, and fruits and vegetables. The Food Guide also recommended that Canadians partake of a variety of foods and that they choose lower fat animal foods (dairy products and meats). For the first time, the Guide made a lifestyle recommendation, namely that Canadians achieve and maintain a healthy body weight.

"Nutrition for Health: An Agenda for Action," which was published in 1996, is generally regarded by Health Canada as the first comprehensive nutrition policy in Canada. It recognizes that powerful economic and social forces combine with individual practices and capacities to influence what foods are available and what foods are chosen. In fact, the nutrition plan based on Nutrition for Health made an effort to integrate nutrition considerations into health, agriculture, education, social and economic policies and programs. An example of the effort by Health Canada to integrate nutrition policy was the revision of Canada's Food Guide to Healthy Eating. In addition to consultations with a broad cross-section of stakeholders from across

Canada, Health Canada put together an Interdepartmental Working Group. The IWG was made up of 13 representatives from federal departments for which changes to the Food Guide would have an impact. AAFC was represented by the Food Bureau, Market and Industry Services Branch. The IWG worked with the Office of Nutrition Policy and Promotion to provide a broader Government of Canada perspective on all aspects of the revision process. The new food guide "Eating Well with Canada's Food Guide"[21,22] was released in 2007.

"Eating Well with Canada's Food Guide" presents eating patterns that specify the amount of each nutrient and the calories needed for good health and the prevention of chronic diseases. The eating patterns fall within the acceptable intake ranges for the macronutrients (fat, protein and carbohydrate) contained in the Dietary Reference Intakes (DRIs)[23]. In the revision of these DRIs, Health Canada recognized that a range of intakes for the macronutrients coincide with a healthy diet. The acceptable intakes for fat for adults range from 20 to 35 percent of total energy. Eating Well with Canada's Food Guide encourages individuals to choose low fat foods in order to reduce the total amount of fat in their diets and to reduce their consumption of saturated and trans fat. The Guide lists foods that are sources of saturated fat (fatty meats, high fat dairy products, butter, hard margarine, etc.) and of trans fat (deep fried foods, fast foods, salty snacks, baked goods, etc.). It also presents suggestions for alternatives to foods that are sources of saturated and trans fats (e.g., substitution of soft [non-hydrogenated] margarine for hard margarine and butter). In addition, the Food Guide notes – in keeping with recently implemented mandatory nutrition labeling (see Sec. 2.2, below) – that the amount of total, saturated and trans fat can be found in the Nutrition Facts table on pre-packaged foods.

Although the new Food Guide recommends limiting total fat and saturated and trans fats, it recommends that individuals include a small amount of unsaturated fat (30 to 45 ml - 2 to 3 tablespoons) each day as part of a healthy eating pattern that otherwise includes mainly lower fat foods. In fact, the Food Guide recommends individuals consume mainly unsaturated fats (polyunsaturated and monounsaturated) found in vegetable oils, soft non-hydrogenated margarines, and foods such as nuts, seeds and fish which are important sources of essential (omega-3 and omega-6) fatty acids. While the new Food Guide puts appreciable emphasis on the type of fat (unsaturated vs. saturated and trans), it continues to place significance on total fat even though the Guide is based on the DRIs which give an acceptable range (20-35% of energy) for dietary fat. In this regard the new Food Guide retains vestiges of the earlier recommendation which limited fat intake to a prescribed amount.

The new Food Guide includes trans fat along with saturated fat as a risk factor for chronic diseases, such as cardiovascular disease. Nonetheless, Canada has been slow to address trans fat. In contrast to the situation in Canada and other countries, the Danish government and Danish margarine producers reacted in the early 1990s. Danish margarine manufacturers agreed in the mid-1990s to voluntarily reduce the industrially produced trans fat content of their products. However, a review in 2001 concluded that this action had had very little impact. As a result, the Danish government passed legislation in 2004 that prohibited the use of industrially produced fats and oils containing more than two percent of trans fat. Two years later, analyses of foods that traditionally had been significant sources of trans fat found them virtually free of trans fats. It also is interesting to note that international fast food companies had reduced the amount of trans fats in foods

[21] http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/context/rev/rev_proc_e.html#2
[22] http://www.hc-sc.gc.ca/fn-an/alt_formats/hpfb-dgpsa/pdf/pubs/res-educat_e.pdf
[23] http://www.hc-sc.gc.ca/fn-an/nutrition/reference/index_e.hmtl

sold in Denmark while they continued to sell the same food containing high levels of industrially produced trans fats in other countries.

Canada also considered eliminating or reducing processed trans fats in foods sold in Canada to the lowest possible levels. In response to a motion by the House of Common in November 2004[24], a Trans Fat Task Force was formed early in 2005 with the mandate to advise the Minister of Health on trans fats. The Task Force recommended in a report to the Minister in June 2006 that Canada limit the level of trans fat in vegetable oils and margarines sold to consumers or used in the preparation of foods on site by retailers or food service establishments to 2 percent or less and in all other foods to 5 percent or less of total fat[25]. The Minister accepted the Task Force report (press conference, June 20, 2007) but did not implement its recommendations as trans fat levels in the Canadian food supply had decreased appreciable over the past decade. However, the food industry was given notice that it had two years to voluntarily reduce trans fats to the levels recommended by the Trans Fat Task Force or Health Canada would regulate their reduction.

AAFC played an active role in the deliberations of the Task Force. It was a member of the Task Force; a multi-stakeholder body with representatives from the federal government, food manufacturing and food service sectors, commodity groups, consumer groups, non-governmental health organizations, oilseed producers and processors, and academia. AAFC also commissioned two studies[26] that were provided to the Task Force as an aid in understanding the issues involved in the elimination of trans fats or their reduction to the lowest levels possible.

3.2.2. Nutrition labeling and nutrition claims. A voluntary nutrition labeling system was introduced in Canada in 1988, following 5 years of development and consultation. Central to the discussion was how to initiate nutrition labeling and how to incorporate nutrition information pertaining to fat. The new regulation permitted listing the cholesterol content of a food item on the label based on the assumed need by consumers for this information. However, there was intense discussion surrounding whether the monounsaturated fat content should be prohibited, permitted or mandatory. The legislative changes introduced in 1988 permitted nutrient content claims (e.g., a food was "a good source of fiber" or was "low in saturated fat") and nutrition information tables (i.e., amount of energy, protein, fat, and carbohydrate per serving) but did not permit health claims (an implied relationship, such as suggesting that a healthy diet low in saturated and trans fat reduces the risk of heart disease). Canada was much slower in implementing mandatory nutrition labeling than the United States. Nutrition labeling became mandatory in the US in 1994 (Nutrition Labeling and Education Act; NLEA) whereas Canada did not implement mandatory labeling until 2005. However, Canada did implement mandatory trans fat labeling before the US (December 12, 2005 vs. January 1, 2006). Nevertheless, implementation of mandatory labeling for trans fat was extremely slow. Although Canada was the first country to put into practice mandatory labeling of trans fat, the adverse effect of trans fatty acids on blood LDL and HDL levels had been reported 15 years earlier[27].

4. Effect of Agri-Food and Health Policies on Diet and Cardiovascular Disease.

[24] http://www.parl.gc,ca/38/1/parlbus/chambus/house/journals/030_2004-11-23/030Votes_e.html
[25] http://www.healthcanada.ca/transfat
[26] 1) "Food industry perspective on eliminating trans fats in food products"; and 2) "Methods and opportunities for reducing or eliminating trans fats in foods"
[27] Mensink RP

It is difficult, if not virtually impossible, to attribute the effect of policies aimed at one component of the diet (viz., dietary fat) on a multi-factorial disease such as cardiovascular disease (CVD) without the application of sophisticated analysis methodology. The task is doubly difficult when no provision for systematic evaluation is included in the original policy plan. In addition, the process is confounded by the slow evolution and implementation of policies and programs and by the changing scientific, economic, social and cultural environment in which they evolve. For example, the replacement of saturated fats by partially hydrogenated vegetable oils, in answer to the recommendations of the Canadian Consensus Conference on Cholesterol[14], took place because, at the time, trans fat was considered neutral in its effect on CVD risk. Nonetheless, this section will attempt to examine the changes that have occurred with respect to the Canadian diet, in particular the amount and type of dietary fat consumed by the average Canadian, and the trends in CVD mortality over the past 20 years.

4.1 Dietary fat intake patterns over past 20 years

Dietary fat consumption changed very little over the decade 1981 to 1991. Total fat available (adjusted for losses[28]) from the Canadian food supply was 85.3 g/person/day in 1981 versus 86.3 g/person/day in 1991[29] (approx. 34.7 and 35.0% of total energy[30], resp.). By contrast, there was a considerable increase in total fat available in the Canadian food supply between 1991 and 2001; 86.3 versus 101.1 g/person/day (35.0 vs. 36.0% of energy). The nearly 15 g apparent increase in fat intake[31] was due primarily to increases in monounsaturated (7.4 g) and polyunsaturated (5.2 g) fats, although there also was a small increase in saturated fat (1.5 g). Total fat available in the Canadian food supply over the next 5 years (2001-2006) decreased linearly from 101.1 to 94.8 g/person/day (36.0 vs. 35.0% of energy). The decrease was due primarily to a decrease in MUFA (4.2 g). There also was a small decrease in available PUFA (1.2 g) and SFA (0.8 g).

The increase in total fat available during the period 1991 to 2001 reflected a major increase in the apparent per capita consumption of salad oils (sometimes referred to as "salad and cooking oils"). The consumption of salad oils more than doubled during this period; from 3.68 to 8.20 kg/person/year[29] which translates to an increase from 10.1 to 22.5 g/person/day[32]. There was very little change between 1991 and 2001 in the apparent per capita consumption of butter, margarine, and shortening and shortening oils. The apparent consumption of shortening and shortening oils increased from 17.4 to 18.8 g/person/day whereas consumption of margarine decreased from 12.0 to 10.6 and butter from 6.5 to 6.1 g/person/day.

There are a number of features of the data summarizing the chronological changes in dietary fat consumption that deserve comment. During the 1990s, apparent total fat intake increased appreciably. This increase occurred despite concerted efforts by Health Canada, non-governmental groups (such as the Heart and Stroke Foundation of Canada), and various food companies (development of low-fat and fat-free alternatives) to encourage and assist consumers to reduce fat intake, in particular saturated fat intake. The

[28] Data were adjusted for retail, household, cooking and plate loss. Statcan advises to use data with caution.
[29] http://www.statcan.ca/english/freepub/21-020-XIE/2006001 [Statistics Canada – Cat. No. 21-200, 2006]
[30] Percent of energy from fat was calculated by multiplying the grams of fat by 9 and then expressing this number as a percentage of the available energy value in the Statcan table.
[31] The values cited in this section do not represent actual nutrient intakes. Rather, they are estimates of the energy and nutrients (adjusted for losses, see Footnote 28) available per person per day or year at each time period. However, the amounts available are a reflection of probable per capita consumption and, in turn, are a reasonable representation of the pattern of change in energy and nutrients intakes over time.
[32] Values calculated by dividing the kg/person/year by 365.

increase in fat intake was accompanied by a significant increase in total energy intake. As a result, fat intake, as a percent of energy intake, remained relatively constant at 35 to 36 percent of total calories[33]. Essentially all of the increase in fat intake during this period was associated with a marked increase in the consumption of salad oil. In fact, butter and margarine consumption decreased more or less linearly over the 25 year period 1981 to 2006 (combined decrease of approx. 3.0 kg/person/year or 36 percent). However, the picture with respect to total fat intake has improved over the past 5 years. Total apparent fat consumption has decreased approximately 6.25 percent due largely to a decrease in the consumption of shortening and shortening oils and margarine (especially shortening and shortening oils) of 4.8 g/person/day (11.6 %). On the other hand, there has been only a very modest decrease in saturated fat intake (0.8 g/person/day or 0.3% of calories). The latter is puzzling in light of the decrease in butter, margarine and shortening consumption although the picture with respect to available dietary fat in the Canadian food supply is complex.

The apparent consumption of red meat and chicken and milk and milk products over the past 20 years is an example of the complexity of the impact of changes in the available food supply on fat intake. Red meat consumption (boneless weight; adjusted for losses) decreased slightly (approx. 1 kg/person/year) during the period 1991 to 2006. The decrease was due equally to a decrease in beef and pork intake. By contrast, apparent chicken consumption increased 3.2 kg/person/year during the same period. The relatively small decrease in red meat consumption would not be expected to have much of an effect on saturated fat intake, as beef and hog grading standards did not change appreciably after 1992. By contrast, the increased consumption of chicken may have actually increased saturated fat intake because much of the increase in chicken consumption during this period was associated with the addition of chicken entrees (most of which were "breaded" and deep-fried) to fast food restaurant menus. On the other hand, the expected decrease in saturated fat intake due to changes in fluid milk consumption was offset by changes in the consumption of other dairy products. The consumption of fluid milk changed dramatically from 1991 to 2006; overall, consumption decreased 14.5 percent (9.3 liters/person/year). Major decreases in the consumption of standard milk (3.25%) and 2% milk (38 & 31%, resp.) were partially off-set by increases in the consumption of 1% and skim milk (110 and 38%, resp.). However, the total expected decrease in saturated fat intake was largely counterbalanced by a substantial increase in the consumption of cereal, table and whipping creams and cheese. For example, there was a 6-fold increase in the consumption of table cream (0.35 to 2.10 liters). The latter has been attributed to the marked increase in coffee consumption over this period which points up the complexity of changes in nutrient intake patterns.

Changes in the pattern of consumption of trans fats are difficult to summarize. Statistics Canada does not include trans fat as part of its food survey data. In addition, there are major obstacles in estimating trans fat intakes. Food products in the same category have been found to vary widely in trans fat levels[34] (e.g., soft margarines can vary from 0 to 40 g trans fat/100g). As a result, the estimation of trans fat intake on the basis of food frequency questionnaires or individual food intake records can have large errors. The picture is further complicated by major reductions, over the past decade and in particular the past couple of years, in the trans fat content of many food products. The rapid increase in the market share of trans free, non-hydrogenated margarine is a classic example of such changes. Once mandatory labeling of trans fats was announced, snack food manufacturers and fast-food service companies switched their deep frying operations from partially hydrogenated frying fats to mid- and high-oleic acid vegetable oils (viz., mid-oleic sunflower and low-linolenic, high oleic canola). However, complicating this problem was the sluggishness with which

[33] By contrast, fat intake as a percent of total calories in the US decreased. However, the apparent decrease in fat intake in the US was the result of a much greater absolute increase in total energy consumption (carbohydrate intake) than occurred in Canada.
[34] Innis SM

governments reacted to the potential adverse effects of trans fats. As pointed out above (see Sec. 3.2.1), Canada and all countries, except Denmark, were slow to react to the scientific reports on the potential adverse health effects of trans fats.

Health Canada scientists first reported estimates of trans fat intakes by Canadians in 1994[35]. The average trans fat intake of adult Canadians (18-74 years) was estimated at 8.4 g per day (3.7% of energy). It was further estimated that the average daily intake of trans fat by young adult males could be much higher (*ca.* 12.5 g per day) because of their high fat intake. On the basis of the discussion above, trans fat consumption would be expected to have decreased since 1994. In fact, Health Canada estimates that trans fat intake in Canada has decreased 40 percent over the past decade; from 8.4 to 4.9 g per day (press conference, Minister of Health, June 20, 2007).

4.2 Changes in cardiovascular disease mortality over the past 20 years.

There has been a dramatic and nearly linear decrease in mortality rates for diseases of the circulatory system during the past two decades. During the period 1979 to 2002, overall mortality from diseases of the circulatory system[36] decreased from 835 to 393 deaths per 100,000 population for men 20 years or older. During the same period, deaths for adult women decreased from 506 to 249 per 100,000 population. However, in spite of these remarkable improvements in mortality, deaths from diseases of the circulatory system remained the leading cause of mortality for adults (for both men and women) at 311 per 100,000 population; cancer ranked second at 273 deaths per 100,000. In 2002, 32 percent of all male and 34 percent of all female deaths in Canada were due to diseases of the circulatory system[37]. Coronary heart disease accounted for 54 percent of all cardiovascular deaths, stroke 21 percent, other forms of heart disease 16 percent, and vascular problems, such as high blood pressure and hardening of the arteries 9 percent. Deaths due to heart attacks (ischemic heart disease) decreased from approximately 330 to 106 per 100,000 population from 1979 to 2002 and to 96 deaths per 100,000 by 2004 (the last year for which Stats Canada gives mortality data). Other heart diseases contributed another 30 deaths per year per 100,000 population. However, deaths due to congestive heart disease, the main contributor to the latter, have not changed appreciably over the past 25 years. By contrast, mortality due to strokes has decreased over the past 25 years but much less dramatically than for heart attacks.

It is difficult to estimate the degree to which diet, in particular dietary fat and more specifically saturated fat and trans fat, has been a factor in the decrease in mortality due to diseases of the circulatory system. Improved medical treatment is probably a major contributor to the decrease in mortality rate. Other lifestyle changes besides diet, such as the decrease in smoking, undoubtedly have contributed to the improvement in cardiovascular deaths. Furthermore, any contributions to the decrease in CVD mortality as a result of changes in the amount and type of fat in the diet may have been offset by the marked increase in obesity and diabetes, both of which have been shown to have a major impact on CVD. In addition, the fact that diseases of the circulatory system develop over a relative long period of time, it follows that any improvement in morbidity and mortality associated with a decrease in total or saturated and trans fat intake would take a number of years to become evident.

5. Summary and Conclusions

[35] Ratnayake WMN
[36] Diseases of the circulatory system – heart diseases, stroke and diseases of the blood vessels
[37] http://ww2.heartandstroke.ca/Page.asp?PageID=110&ArticleD=1077&Src=news

Health Canada and Agriculture and Agri-Food Canada have been committed to policies and programs aimed at a reduction in total and saturated fat in the diet for over 20 years. These efforts, especially for Health Canada, were given a major boost by the Consensus Conference on Cholesterol in 1988. The Consensus Conference recommended that Canadians reduce total dietary fat intake to 30 percent and saturated fat intake to 10 percent or less of total calories. The food industry also joined the effort by developing low fat and fat free foods and by substituting partially hydrogenated vegetable oils (PHVO) for saturated fat sources. AAFC's programs were directed to a reduction in fat and an increase in lean of beef and hog carcasses and to continued development of canola as a major crop in Canada. Health Canada, in turn, concentrated on policies and programs designed to help consumers choose foods and diets with lower total and saturated fat levels (e.g., dietary guidelines, nutrition labeling, and nutrient content claims). Although focused on a common goal, there is little evidence of any obvious cooperation between Health Canada and AAFC.

AAFC played a major role in the development of standardized grading systems aimed at increasing the lean and reducing the fat of both beef and hog carcasses. The Department also played an important role in the development of production systems for beef and hogs. Livestock grading standards, which also served as a basis for payment to producers, were designed to reflect product characteristics valued in the market place. Improved carcass quality not only resulted in monetary gains to producers but enabled the beef and pork industries to promote their products as healthy food choices through initiatives such as the Heart and Stroke Foundation's Heart Check^{TM} program.

AAFC also made a major contribution to the development of canola as a viable oilseed crop, originally to meet domestic needs and subsequently as an alternative crop to wheat and other cereals and as an export commodity. Although canola was an established crop at the time of the Consensus Conference, the Conference gave confidence to initiatives aimed at promoting its superior nutritional qualities. The healthy fatty acid profile of canola oil, in particular its low level of saturates and high level of oleic acid, was an important factor in its adoption as a high quality vegetable oil for human consumption in Canada and other countries. AAFC played an important part in support of the promotion of these qualities, in particular obtaining GRAS status in the United States. Since canola was considered a novel crop, the US FDA required health clearance for its addition to the US food supply. Securing GRAS status gave canola oil a tremendous lift as a high quality healthy vegetable oil.

The initiation of policies and programs by Health Canada that were aimed at the prevention of chronic diseases, such as coronary heart disease, coincided with the Consensus Conference on Cholesterol. The Conference gave this thrust a considerable boost. In the 1990s, Health Canada designed and introduced dietary guidelines to help consumers reduce their intake of total and saturated fat while meeting nutrient levels consistent with good health. These guidelines were accompanied by the introduction of voluntary nutrition labelling. HC also implemented legislative changes that permitted nutrient content claims. However, the Department was relatively slow in requiring mandatory nutrition labelling and in introducing legislation that permitted nutrition claims. Likewise, Canada, like other developed countries except Denmark, was slow to react to the evidence that built during the 1990s on the adverse health effects of trans fat. The food industry responded to the challenge issued by the Consensus Conference on Cholesterol, namely to help Canadians reduce total and saturated fat intakes, by replacing saturated fat with PHVO in food manufacturing and preparation (e.g., deep frying). Although trans fat was considered neutral in its effect on CVD risk at the time of the Consensus Conference, reports on the adverse effects of trans fat on CVD risk factors appeared soon after the Conference. Even though Canada was the first country to require

mandatory labeling of trans fat, this action came fifteen years after reports of their adverse effects on blood lipid patterns.

Despite significant effort by AAFC and Health Canada, non-governmental groups, such as the Heart and Stroke Foundation, and the food industry, there is little evidence of any effect of their policies and programs, at least over the first decade following the Consensus Conference, on total and saturated fat intakes or on CVD mortality. In fact, total fat intake, as reflected by the dietary fat (corrected for retail, household, cooking and plate loss) available in the Canadian food supply, actually increased from 86 to 101 g/person/day over the decade 1991 to 2001. Essentially all of this increase was due to an increase in the intake of unsaturated fat although there also was a small increase in the availability of saturated fat. The consumption of salad oils more than doubled during this period; from 10.1 to 22.5 g/person/year. By contrast, there was very little change in the apparent consumption of solid fats, such as, margarine, butter, and shortening and shortening oils. However, there has been a decrease in total fat intake recently (2001 to 2006) from 101 to 95 g/person/year, due primarily to a decrease in the intake of unsaturated fat (although there also was a small decrease (0.8 g) in the intake of saturated fat).

The picture associated with changes in fat consumption is complex. This complexity is illustrated by changes in the consumption of dairy products during the period 1991 to 2006. The consumption of standard and 2% milk decreased while the consumption of 1% and skim milk increased. However, the expected decrease in saturated fat intake was largely off-set by a marked increase in the consumption of cereal, table and whipping creams and cheese. The increase in the consumption of table cream (0.35 to 2.10 l/person/yr) has been attributed to the marked increase in coffee consumption over this period which points up the complexity of nutrient intake patterns. Another example is the significant decrease in trans fat intake (approx. 40%) over the past decade due largely to changes in product formulation and preparation (e.g., replacement of PHVO by hi-oleic canola and mid-oleic sunflower oils in deep frying) in response to announced mandatory inclusion of trans fat information on nutrient content labels.

Mortality rates for diseases of the circulatory system (heart diseases, stroke and diseases of the blood vessels) have decreased dramatically over the past two and a half decades (from 806 to 393 for men and 506 to 249 for women per 100,000 population from 1979 to 2002). However, there is little evidence that dietary fat, in particular saturated and trans fat, has been a significant factor in this decrease. On the other hand, it is important to acknowledge the difficulty of estimating the effect of a single factor on mortality associated with a multi-factorial disease such as CVD. Factors such as improved medical treatment and changes in lifestyle (e.g., decrease in smoking) undoubtedly played a major role in the decrease in mortality rate over the past 25 years.

In Canada, policies and programs directed at helping the population decrease total and saturated fat intakes do not appear to have had any notable effect in reducing mortalities caused by diseases of the circulatory system. Yet it is important not to overlook the recent decrease in total per capita dietary fat intake by Canadians. As well, it is notable that diseases of the circulatory system develop over a relative long period of time. Therefore, any improvement in morbidity and mortality would presumably not become evident for many years.

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4. Food Safety Issues

Lise Dubois[38]

1. Food safety issues

During the past two decades, foodborne diseases have emerged as an important and growing public health and economic problem in many countries. Foodborne diseases can be caused by microorganisms, chemicals and toxins. Contamination of food may occur through environmental pollution (air, water, soil), from naturally occurring toxicant (from production to table), and use of chemicals (food additives, pesticides, veterinary drugs).

Contamination of foodstuffs by elements such as bacteria, fungi, parasites, viruses or chemicals through contaminated food may occur at any stage of the process from food production to preparation.

Zoonoses are of specific concern as about 75% of the new communicable diseases that have affected humans over the past 10 years have been causes by pathogens originating from an animal or from products of animal origins.

The interactions among infectious agents, nutrients and xenobiotics have also become a public health concern. From a public health perspective, the risk assessment of xenobiotics in our food and environment, and the synergetic effects among microorganisms, nutrients and xenobiotics, have to be considered.

New technology can improve food production, food quality, food safety and the nutrient content of food. Existing foods can be transformed and new ingredients and new foods can be developed. New interest in the potential of health promotion and disease prevention benefits of foods is related to an aging population, emerging science, information technology, advances in food technology, consumerism, and rising health care cost. There is a new interest in whole foods, and in nutritive and nonnutritive food components as possible health modifiers, above and beyond natural nutritive value and health benefits of foods. Safety of the food component must be assessed before using it to improve health. A food-derived substance could be a whole food, a food extract, a concentrate of a food derived ingredient, or a specific component of a food. Two health issues are addressed: to maintain normal health, or to reduce risk of chronic diseases (e.g. CVD, osteoporosis, cancers, allergies) or of their risk factor (e.g. high blood cholesterol level, obesity). Another issue may be enhancing normal health and body functioning (e.g., enhance brain functioning, anti-aging products).

Proof of food safety must be made using *in vitro* studies, *in vivo* studies, clinical intervention trials, epidemiological or observational studies (prospective or cohort studies, retrospective or case-control studies, cross-sectional surveys). A positive impact seen at the individual level may not be seen at the population level.

Food functionality can be related to nutrient and non-nutrient compounds. Some foods are fortified with various nutrients, while others are manipulated using their physiochemical properties to make them

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functional: texture, color, taste, odor, and other physiochemical properties which can affect overall quality and acceptance of food products.

New food technology can contribute, for example, to higher agricultural productivity, lower food prices, prolonged food preservation, and better food nutritional value. For example, the potential benefits of Genetically Modified Organisms (GMOs) to population health include: increased agricultural productivity; improved nutritional value of food to human health; decreased agricultural chemical usage; increased farm income; and increased crop sustainability and food security, especially in developing countries.

Future trends in GMOs include:

- Pests and disease resistance
- Altered nutrition and food composition: e.g. vitamin A enhanced rice; “high iron” rice; improved protein content (e.g. in vegetables such as potatoes); removing allergens and antinutrients; altered starch and fatty acid profile; and increased antioxidant content
- Microorganisms

The principal guiding safety assessment of GM foods should include:

- Direct health effect: toxicity
- Tendency to provoke allergic reaction: allergenicity
- Specific components thought to have nutritional or toxic properties
- Stability of the inserted gene
- Nutritional effects associated with specific genetic modification
- Any unattended effects which could result from the gene inserted

2. Food safety and population health

Foodborne diseases generate a wide spectrum of illnesses, including gastrointestinal, neurological, gynecological, immunological, multi-organ failure, and cancer. Chemicals in food may affect human metabolism. Human exposure to toxic chemicals and nutritional imbalances are known or suspected to be responsible for promoting or causing cancers, kidney and liver dysfunction, hormonal imbalance, immune system suppression, musculoskeletal diseases, birth defects, premature births, impeded nervous and sensory system development, reproductive disorders, mental health problems, cardiovascular diseases, genitor-urinary disease, old-age dementia, and learning disability. These conditions may all be to some extent attributable to past and current exposure to chemicals in the food we eat.

Foodborne diseases are acute and chronic. Pathogens are disease-causing microorganisms that include bacteria, fungi, parasites, and viruses. Most cases of foodborne illnesses are classified as "acute." These are usually self-limiting and of short duration, although they can range from mild to severe. Gastrointestinal problems and vomiting are common acute symptoms of many foodborne illnesses. Deaths from acute foodborne illnesses, while rare, are more likely to occur in the very young, the elderly, or patients with compromised immune systems (such as those suffering from AIDS or cancer). However, the U.S. Food and Drug Administration (FDA) estimates that 2 to 3 percent of all acute cases develop secondary long-term illnesses, called "chronic sequellae."

Chronic sequellae of foodborne illness can occur in any part of the body and subsequently affect the joints, nervous system, kidneys, or heart. These chronic illnesses may afflict the patients for the remainder of their

lives or result in premature death. For example, in the U.S., *Campylobacter* infections are estimated to be responsible for 20 to 40 percent of Guillain-Barré syndrome (GBS) cases (a major cause of paralysis unrelated to trauma). About 1.5 percent of *E. coli* O157 disease patients develop hemolytic uremic syndrome (HUS), which usually involves red blood cell destruction, kidney failure, and neurological complications, such as seizures and strokes.

Food contaminants can also impair immune function and the reproductive system, and cause DNA damage for more than one generation.

3. Related health care costs

The Centers for Disease Control and Prevention (CDC) estimates that foodborne diseases cause approximately 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths in the United States each year. In 2000, the estimated annual cost from the five bacterial foodborne pathogens *Escherichia coli* O157 and other STECs (Shiga toxin producing *E. coli*) and associated hemolytic uremic syndrome, *Campylobacter* and associated Guillain-Barré syndrome, *Listeria monocytogenes*, and *Salmonella* was $6.9 billion. The cost estimate included medical costs, productivity losses from missed work, and an estimate of the value of premature death that takes into account the age distribution of those taken ill. The costs only include a selected number of microbial foodborne health risks. Moreover, these costs were underestimated as they did not include travel costs in obtaining medical care, lost leisure time, time lost from work caring for sick children, pain and suffering, and the costs of certain other chronic complications, such as reactive arthritis in the case of *Salmonella*. They also did not include either the food industry costs or the public health sector costs. See Appendix 2 for a model for foodborne diseases, exposure and types of costs.

The global burden of foodborne diseases needs to be better estimated. At the moment, foodborne diseases are generally under-reported, and data is lacking for some specific items such as zoonoses and diseases caused by chemical hazards.

4. The most vulnerable groups

The most at-risk people for foodborne diseases are the elderly, pregnant women, immune-compromised people, children and youth. New migrants not previously exposed to some contaminants and people experiencing food insecurity and malnutrition may also be at higher risk.

Recently, international concern has become more acute regarding specific exposures of children and adolescents to toxicants (Bolt, 2002). Children under 5 years are more affected by foodborne diseases than adults (Koehler, 2006). See Appendix 1 for a declaration on the long term consequences of toxicology in children. Food allergens are also a preoccupation, especially for children, and new concerns are raised when new components are added to food.

The maximal dose of a nutrient that can be added to food needs to be assessed. Some nutrients added to food to increase intake in some population groups may be unnecessary or even harmful.

More than 30 million people in the United States are likely to be particularly susceptible to foodborne diseases, since they are either very young or elderly or they have a compromised immune system (U.S. Department of Health and Human Services 2000). A relationship has also been found between

socioeconomic status and the risk of experiencing foodborne illnesses. In the United Kingdom, one report indicated that hospital admissions for gastrointestinal infections increased with increasing socioeconomic deprivation (U.S. Department of Health and Human Services 2000).

In the years to come, social and nutritional concerns will include:

- The aging of the population: increased need for nutrient-dense, low energy foods
- Ethnic differences and migration: need for culturally acceptable foods
- Poverty: food availability at acceptable cost
- People living in remote areas and aboriginal populations: food availability, food cost
- Chronic diseases and obesity: prevention via more healthy food, less unhealthy food
- Early origin of chronic diseases: prevention of adult chronic diseases from pregnancy and early childhood
- Food sufficiency in a country, and worldwide: growing world population (estimated to be 8-10 billion in 2050), more people living in large cities.

5. Growing concerns in food safety

Increasingly, acute foodborne disease infections and intoxications are a concern for governments and industry due to:

- Identification of new agents that have caused life-threatening conditions
- The finding that traditional agents are being associated with foods that were of no concern before
- An increasing number of large outbreaks being reported
- The impact of foodborne disease on children, the aging population and the immunocompromised
- Migrant population demanding their traditional foods in their country of settlement
- The ease of worldwide shipment of fresh and frozen food
- The development of new food industry products. (Todd 1997).

Foodborne illnesses could be more of a problem in the years to come (U.S. Department of Health and Human Services 2000), particularly in light of new lifestyles, globalization, new types of pathogens, and the increasing drug resistance of existing pathogens (Danish Ministry of Health 1999; U.S. Department of Health and Human Services 2000; Organisation Mondiale de la Santé 1999; Tamblyn 2000). Some pathogens may travel rapidly from one country to another, raising concern for food safety at the population level. The recent mad cow disease crisis raised the public and governmental preoccupation with public health related food safety. Even if such a crisis in Canada had no direct consequences on the health of individuals, it nevertheless affected the economy of the Canadian food and agriculture industry. Furthermore, the price of food may be affected by such situations, and access to some types of food (e.g. meat) for some groups of the population may become more difficult.

Adding to these concerns has been the recent development of novel foods, including genetically modified foods. The use of biotechnology in the food industry is not new, but new biotechnologies are making possible the manipulation of plants and animals in unprecedented ways, including genetic manipulation. It is now possible, for example, to transfer a gene from a plant into an animal, and vice versa (Goodyear-Smith 2001). Such developments raise ethical issues and public health concerns about the potential toxicity and unknown impact of these products on the health of populations (Meningaud et al. 2001). In fact, few systematic studies have been done on the impact of novel foods on population health. The development of food from biotechnology may also increase nutritional inequalities in and between populations. For example,

laboratories that develop genetically modified foods aimed at preventing cardiovascular diseases or cancer- which is good for health - will likely sell these high-tech foods at a higher price than traditional foods. A part of the population from lower socioeconomic groups may then not have access to these benefits, while the more economically advantaged groups will have access. Moreover, in developing countries, when novel foods replace traditional foods, populations become less self-sufficient and more dependent on international conglomerates.

6. Better control to ensure food safety

In any country, the protection of our diet from foodborne diseases must be considered one of the essential public health functions. Over the past 125 years, important changes have occurred in food and agriculture to meet the demand and to improve food quality, safety, and availability. Around 1900, regulations were introduced to protect consumers from fraudulent practices and low quality food. Nevertheless, it proved difficult to control the use of food additives, food colors, agricultural chemicals (including pesticides and pesticide residue), and the content of various drugs.

Over the years, food standards and other food regulations were developed to control food quality.
Due to worldwide exchanges, controlling products and diseases related to them has become increasingly difficult, and new regulations have been needed (Organisation Mondiale de la Santé 1999). Countries have had to establish a permanent domestic surveillance of contaminants, toxic materials, pesticides, drugs for animals, agrochemicals, and antibiotics for animals.

Governments must take into account issues related to adequate food production, food trade (importation of safe foods, exportations of surpluses), and consumer concerns about food quality and safety.

New regulations on food traceability and labeling are being developed in Europe and at the International level. They are warranted based on different events related to weak European control of problems with food, animal feed and animal diseases. Also, there is the desire to restrict the production or use of foods or feed ingredients that are derived from biotechnology, and for the labeling of products containing ingredients and foods derived from biotechnology.

The government administered the laws governing the quality and safety of foods and pre-market clearance of food additives, food colors, pesticides, veterinary drug residue in foods, rules to control food contamination, food hygiene, and food labeling. The responsibility of compliance is placed on all persons involved in food production, storage, processing, marketing, etc. Education needs to be done from producers to consumers.

For the consumers, important elements include food availability and prices, food safety (minimal risk), food nutritive value (to maintain good health, to prevent diseases), food quality, and food commodity (e.g. prepared food). The consumers' risk perception is associated with household income, sex, and race (Dosman et. al, 2001).

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USDA: http://www.ers.usda.gov/Briefing/FoodborneDisease/overview.htm

APPENDIX 1 The Faroes statement[39]

Human health effects of developmental exposure to environmental toxicants
http://www.pptox.dk/Consensus/tabid/72/Default.aspx

Background

Fetal life and early infancy are periods of remarkable susceptibility to environmental hazards. Toxic exposures to chemical pollutants during these windows of increased susceptibility can cause disease and disability in infants, children, and across the entire span of human life. Among the effects of toxic exposures recognised in the past have been congenital malformations and other adverse pregnancy outcomes. These outcomes may be readily apparent and have been linked to toxicant exposures during or prior to pregnancy. Even subtle effects caused by chemical exposures during early development may lead to important functional deficits and increased risks of disease later in life. The notion of developmental plasticity of organ functions and disease risks has gained much support from both experimental and epidemiological studies. The timing of exposure – with an emphasis on critical windows of susceptibility – has therefore become a crucial factor to be considered in toxicological assessments.

During May 20-24, 2007, researchers in the fields of environmental health, environmental chemistry, developmental biology, toxicology, epidemiology, nutrition, and paediatrics gathered at the International Conference on Fetal Programming and Developmental Toxicity, in Torshavn, Faroe Islands. The conference goal was to highlight new insights into the effects of prenatal and early postnatal exposure to toxicants, and their sustained effects on the individual throughout their lifespan. The Conference brought together, for the first time, key researchers to focus on human data and translation of laboratory results to elucidate the environmental risks to human health.

Research state of the art

The developing fetus is extraordinarily susceptible to perturbation of the intrauterine environment. Fetal development is adjusted to the intrauterine environment of nutrients and energy supply to fit the anticipated postnatal environmental conditions. If a disparity arises between prenatal and postnatal environments, it can cause abnormalities in energy metabolism, endocrine functions, and organ development. Evolution seems to have favoured a “thrifty” phenotype that optimizes the energy use, but which, in an environment with ample food and limited energy expenditure, can increase the likelihood of developing obesity, metabolic syndrome, and associated diseases.

The physiological mechanisms involved in the development of energy and nutrient metabolism are also highly vulnerable to the toxic effects of environmental chemicals. Chemical exposures during prenatal and early postnatal life can bring about important effects on gene expression, which determines normal development and also predisposes adolescents and adults to disease risks. Many environmental chemicals can alter gene expression by DNA methylation and chromatin remodelling. These epigenetic changes can cause lasting functional changes in specific organs and tissues and increased susceptibility to disease that may even affect successive generations.

[39] *Note: This statement has been developed by the International Scientific Committee of the conference, taking into account comments and suggestions from the conference participants. The statement (pending minor editorial revision) will be included in the conference proceedings.*

New research on rodent models shows that developmental exposures to toxic chemicals – such as the hormonally active substances, diethylstilbestrol, tributyl tin, bisphenol A, and genistein – can increase the incidence of reproductive abnormalities, metabolic disorders, including obesity and diabetes, and cancer, presumably through epigenetic mechanisms that do not involve changes to DNA sequences but may be heritable.

Prenatal exposure to diethylstilbestrol, an estrogenic drug no longer used on pregnant women, causes an increased risk of vaginal, uterine, and breast cancer. Low-level developmental exposure to a plastics ingredient, bisphenol A, can result in increased susceptibility to breast cancer or prostate cancer. Prenatal exposure to vinclozoline, a common fungicide, also promotes later development of cancer. These substances are only weak carcinogens, if at all, in the adult organism but are nonetheless hazardous to the growing fetus. In addition, when exposure to a carcinogenic substance occurs during early development, the expected life-span will exceed the normal latency period for development of the disease.

Functioning of the human reproductive system is highly vulnerable to changes in the intrauterine hormonal environment. In men, increasing occurrence of testicular cancer, poor semen quality, and cryptorchidism have all been linked to developmental exposures to maternal smoking and endocrine disrupting chemicals, such as diethylstilbestrol. Additional risk factors include fertility treatment of the mother, phthalate exposure, and occupational exposure to pesticides with suspected estrogenic and antiandrogenic activity. Perinatal exposure to endocrine disrupting chemicals, such as polychlorinated or polybrominated biphenyls, endosulfan, or DDT compounds, may affect puberty development and sexual maturation at adolescence. Expression of some of these effects may be promoted by predisposing genetic traits.

The brain is particularly sensitive to toxic exposures during development, which involves a complex series of steps that must be completed in the right sequence and at the right time. Slight decrements in brain function may have serious implications for social functioning and economic activities, even in the absence of mental retardation or obvious disease. Each neurotoxic contaminant may perhaps cause only a negligible effect, but the combination of several toxic chemicals, along with other adverse factors, such as maternal stress or decreased thyroid function, may trigger substantial decrements in brain function and may predispose individuals to the development of serious degenerative disease.

The immune system also undergoes important development both before and after birth. New evidence suggests that exposure to some immunotoxic chemicals, such as polychlorinated biphenyls and atrazine, and maternal stress may cause aberrant reactions of the immune system to foreign proteins, including vaccines. Such effects may be related to a shift in immune system balance, with an increased susceptibility to infections and an increased risk of development of allergy in the child.

While the research on developmental toxic effects has thus far emphasized maternal exposures and the neonatal environment, the possibility exists that paternal exposures may also affect the child's development. Experimental studies suggest that ionizing radiation, smoking, and certain chemicals may be of importance, and some exposures may also affect the sex ratio of the children.

Conclusions

- Three aspects of children's health are important in conjunction with developmental toxicity risks. First, the mother's chemical body burden will be shared with her fetus or neonate, and the child is

then likely to be exposed to larger doses relative to the body weight. Second, susceptibility to adverse effects is increased during development, from preconception through adolescence. Third, developmental exposures to toxicants can lead to life-long functional deficits and manifestations of increased disease risks.

- Research into the environmental influence on developmental programming of health and disease has therefore led to a new paradigm of toxicologic understanding. The old paradigm, developed over four centuries ago by Paracelsus, was that "the dose makes the poison". However, for exposures sustained during early development, the most important issue is that "the timing makes the poison". This extended paradigm deserves wide attention to protect the fetus and child against preventable hazards.
- Part of the new insight derives from numerous animal studies on fetal programming being responsible for reproductive, immunological, neurobehavioural, cardiovascular, and endocrine dysfunctions and diseases, as well as certain cancers and obesity. These adverse effects have been linked to chemical pollutants at realistic human exposure levels similar to those occurring from environmental sources.
- Among the mechanisms involved, particular concern is raised about changes in gene expression due to altered epigenetic marking, which may not only lead to increased susceptibility to diseases later in life, but the effects may also be passed on to subsequent generations.
- Most chronic disease processes are characterised by multi-causality and complexity. Understanding such processes requires a more holistic approach that focuses on systems and tissue biology.

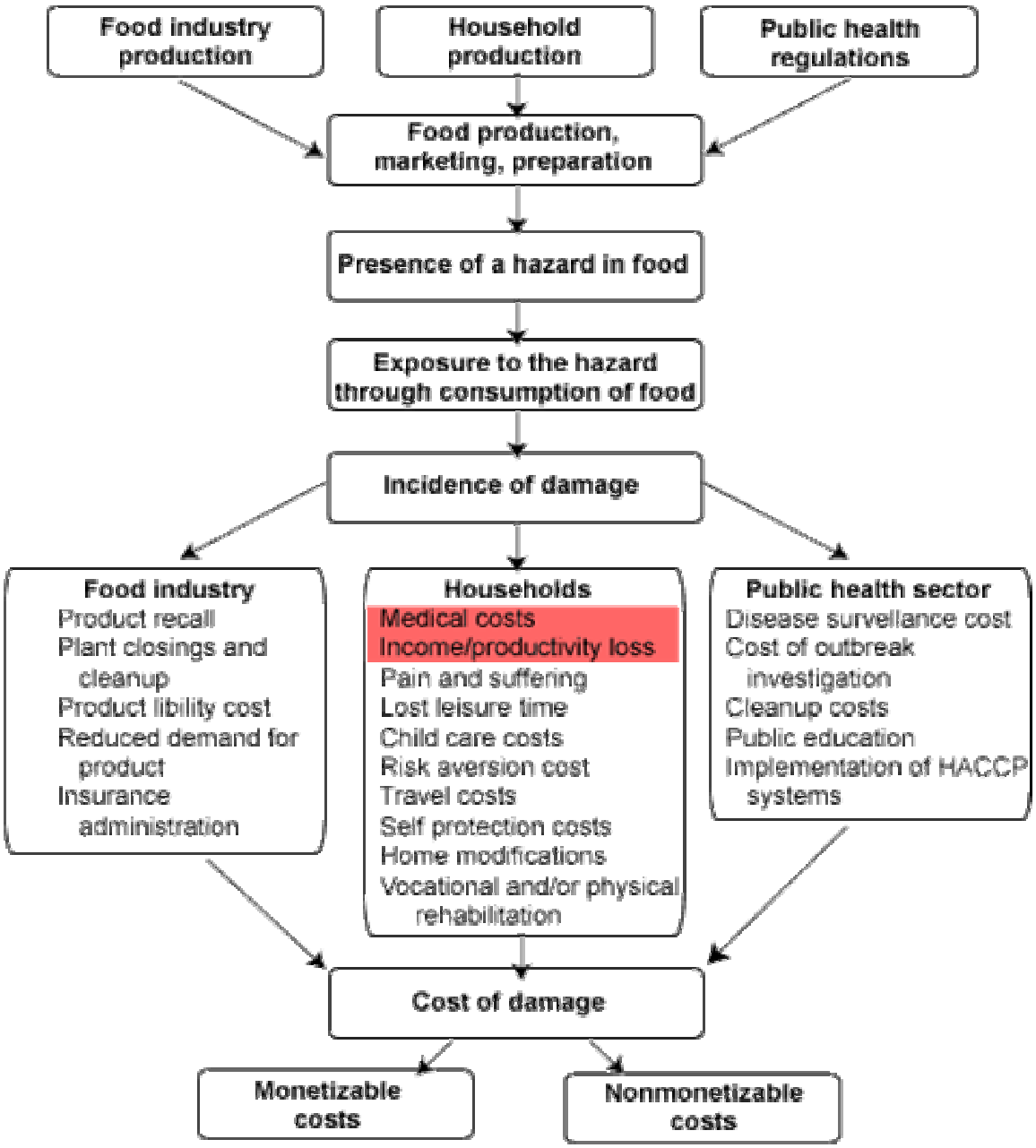
Recommendations

- Studies on the etiology of human disease need to incorporate early development and characterize appropriately the factors that determine organ functions and subsequent disease risks. Such associations can best be examined in long-term prospective studies, and existing and planned birth cohorts should be utilized for this purpose.
- Cross-disciplinary approaches and translation of animal data on exposure biomarkers and disease susceptibility need to be promoted for application in studies of the etiology of human disease. Communication and clarification of key concepts and terms needs to be stimulated between the scientific disciplines involved and between these scientists and policymakers.
- Environmental chemical exposure assessment should emphasize the time period of early development. Exposure data already routinely collected need to be optimized for application in epidemiological studies. Cord blood, cord tissue, human milk and other biological samples can be applied for assessment of exposure biomarkers and for determination of gene expression changes.
- Since humans are exposed to numerous chemicals during development and throughout life, mixed exposures need to be considered in a life-course approach to disease. Furthermore, the interaction due to other life-style factors, such as intake of essential nutrients and societal environment, needs to be explored. This research should also involve the impact of genetic variation and genetic predisposition to disease.
- Toxicological tests and risk assessment of environmental chemicals need to take into account the susceptibility of early development and the long-term implications of adverse programming effects. Although test protocols exist to assess reproductive toxicity or developmental neurotoxicity, such tests are not routinely used, and the potential for such effects is therefore not necessarily considered in decisions on safety levels of environmental exposures.
- The accumulated research evidence suggests that prevention efforts against toxic exposures to environmental chemicals should focus on protecting the fetus and small child, as these are highly vulnerable populations. Given the ubiquitous exposure to many environmental toxicants, there needs

to be renewed efforts to prevent harm. Such prevention should not await detailed evidence on individual hazards, because the delays in decision-making would then lead to the propagation of toxic exposures and their long-term consequences. Current procedures therefore need to be revised so that the most vulnerable life stages can be protected through greater use of precautionary approaches to exposure reduction.

APPENDIX 2

Foodborne disease, exposure, and types of costs



http://www.ers.usda.gov/Briefing/FoodborneDisease/overview.htm

5. A Review of Selected Approaches and Initiatives for an Integrated Food and Health Policy

Synthesis of "Review of Integrated Food Policy" (Unpublished University of Guelph Report prepared for the CAPI Health and Food Project under the Direction of Spencer Henson)[40]

1. European Initiatives

The investigators of the CAPI Health and Food Project conducted a 'scan' of existing policies and programs in the US and select European countries. The objective was to identify initiatives that provide a country's citizenry with health benefits while improving prospects for the agri-food sector. The investigators' review of the available literature – which is limited and recent – and these initiatives indicated that no 'magic bullet' exists. There are, however, numerous examples of recent initiatives that can help Canada's federal policymakers chart a path toward the integration of the health and agri-food sectors.

a. Nordic countries

A number of Nordic countries – Finland, Sweden and Norway – are much celebrated in the public health policy literature for their efforts to inject a human health dimension into their food supply to reduce the incidence of diet-related disease and illness. Although they've met with varying results, these policies serve as models of what can be achieved and the barriers that have to be overcome.

The first set of national dietary goals or guidelines were compiled by a group of Nordic nutrition professors and published in Swedish in 1969, but they only became official government policies years later (Truswell 1996; Wheelock 1996). The gestation period for the Nordic policies has been long, a reminder of the need to take a long view in food and health. The first set of documents calling for change in diet were back in 1962 and focused only on fat intake.

Norway's official Nutrition and Food Policy began in 1975. It was designed to combat the incidence of cardiovascular disease, which accounted for around half of all deaths (Norum 1997). The main goal was to reduce the proportion of fat in the diet from 40% to 35% of the energy supply, a goal first achieved in 1991 (National Nutrition Council 1994; Helsing 1993). The farm lobby saw the value of adapting to the emerging diet-health paradigm and helped introduce an effective national food policy, linking policies on agricultural, food processing, consumers, health and rural affairs (Helsing 1987; RNMA 1975).

In the early 1970s, Finland had the highest recorded coronary mortality in the world (Pietinen 1996). And within Finland, the region of North Karelia had the worst record. Through a project in North Karelia, the Finnish government and health services set out to tackle the cost (Puska 1995). The project targeted smoking, blood pressure control and diet, and started preventive activities throughout the country. Over two decades, the dietary intake of Finns has been monitored, and recorded a sizeable increase in vegetable consumption, even to the point that it doubled in a single decade (National Nutrition Council 1992).

In Finland, the proportion of saturated fats in total fat consumption declined, while fish consumption rose. These and other dietary shifts were generated by public policy support. Significantly, the health agencies

[40] Synthesis prepared by David Wylynko

worked with the food industry to alter the food supply, thereby linking the push of supply with the pull of demand. A 55% decline in male mortality from coronary heart disease, for example, has been recorded in the period of 1972-92. Changes have been even greater for women (Pietinen 1996). All of this health improvement occurred "without the need for extra resource allocation" (Pietinen 1996). The secret is close integration between health agencies and other agencies. For example, once dietary guidelines were designed for schools (for use in lunches), others were developed and implemented for other social groups ranging from day care facilities to the elderly to the armed forces. This strategy was rolled into a systematic, planned approach with a clear overall vision.

Sweden's move toward an integrated food and health policy was initially instigated by a food safety crisis. A dreadful outbreak of salmonellosis occurred which killed 100 people in the early 1950s. This led to the formation of the country's National Food Administration and much more effort to link good, safe production with high health standards. Swedish farmers accepted the fact that it was in their long-term interests to meet tougher health criteria than were internationally stipulated (Vail 1994). It took just 100 deaths to create a policy shift in Sweden. By contract, today the US records thousands of annual deaths through food poisoning, but has not introduced an integrated policy.

In the 1990s, Sweden launched an imaginative attempt to integrate public and environmental health with employment and food quality objectives, following heavy criticism about monoculture in forestry and farming (Vail 1994). Both the Agriculture and Environment ministries are developing programs to reduce fossil fuel and energy use and to meet health targets (Commission on Environmental Health 1996). This is based on the Factor Four approach of the Club of Rome, which calls for trying to reduce resources needed to produce goods by a factor of four through increasing technological sophistication (von Weizacher 1997). As a country, Sweden has a plan to halve resource use by 2021 (Swedish Environmental Protection Agency 1999). Sweden is also exploring how to achieve tough targets on reducing greenhouse gases emitted from the entire food supply chain (Carlsson-Kanyama 1998). This is one of the public health recommendations of the WHO, the World Meteorological Organisation and the United Nations Environment Programme (McMichael 1996).

In all these three countries, the effort to integrate food and agricultural policies with health goals has happened due to considerable professional and personal energy and debate. Such policies do not just happen, but must be made to occur by concerned parties. Interestingly, Sweden, like Norway, recognizes the importance of the cultural dimension of food policy. They both permit no TV food advertisements targeted at children under 12 years of age (EASA 1995). This policy is much admired elsewhere for its protection of children from junk food advertising, though viewed unfavorably by the world advertising industry.

Such efforts to integrate food and health are under some strain, partly due to EU membership and also due to pressure from globalization and the need to meet the dictates of the GATT. The Nordic experience does have its limitations. The North Karelia initiative, for instance, would be harder to implement today. In the 1970s, for example, US culture was less of a force on youth culture. Finland was outside the EU. There was no multi-channel, satellite tv beaming in commercial messages. The Nordic experience may yet prove to have been the apogee of interventions led by public health doctors in food and health. Doctors are physicians, not ecologists, although the argument that health is socially determined and ecologically linked could unlock new approaches to the elite health professions (McMichael 2001).

For all their limitations, the Nordic experiments are enormously important. They show that: policy battles can be won by health interests; public and environmental health can be fused with food and agricultural policy; improvements in health can go hand in hand with sound economies; and a culture dimension is central.

b. EU

The EU has established a principle that EU policies should not interfere with policies that promote public health. The EU also has a platform on diet, activity, and health, but not in an integrated fashion. The EU has engaged the retail and food processing sectors to address these topics. Engaging the agricultural industry, however, is more of a challenge since there does not seem to be a single main contact. The agriculture sector is not as highly organized as sectors such as manufacturing. The EU also doesn't have jurisdiction in the health area. Generally, the EU attempts to influence the behaviour of its members, but doesn't regulate or allocate funds to enforce any particular policies. The Common Agricultural Policy (CAP) is a long-established policy that tries to serve many varying interests.

- **Program of Community Action**

The EU is mandated by the Treaty of Amsterdam to ensure a high level of human health protection in the definition and implementation of all Community policies and activities. The Commission sees its actions as complementary to the activities of member states, and focuses on initiating and standardizing information collection and coordinating trans-national activities. In 2000, the European Commission proposed a program of Community action in the field of public health (EU 2000). The program is a response to the emergence of new health challenges and is based on public health actions stemming from a 1993 framework. Its three broad objectives are: improve health information and knowledge; respond rapidly to health threats; and address health determinants (lifestyle, socio-economic factors, and the environment). The program's lifestyle-related health determinants – concerning physical activity, nutrition and food consumption – point to the same priorities for action identified in the Healthy People 2010 initiative in the US and the WHO First Action Plan for Food and Nutrition Policy. In 2005, the EU produced a Green paper promoting healthy diets and physical activity, focused on preventing excess weight, obesity and chronic diseases (EU 2005). The Green Paper highlights the structures and tools dealing with nutrition and health at the EU level.

- **Health across EU policies**

The EU has put several procedures in place so that health is considered in various policy areas (EU 2005: 5ff.). For example, the Health and Consumer Protection Directorate General is systematically consulted on major policy proposals from other Commission services. As well, the Commission has established an impact assessment procedure for increased quality and coherence of the policy development process that includes the assessment of health impacts.

In response to health, obesity and nutrition issues, changes to the EU Common Agricultural Policy (CAP) have been proposed in the Commission's White Paper on A Strategy for Europe on Nutrition, Overweight and Obesity related health issues (EU 2007). The strategy states that as part of the reform of the Common Market Organization for fruit and vegetables, the Commission will promote children's consumption of fruit and vegetables in its proposal to permit the distribution of surplus production to educational institutions and children's holiday centres. The Commission also proposes to increase EU co-financing to 6% for promotion

projects aimed at young consumers (children under 18). Typically, surplus production of fruit and vegetables in the EU is destroyed to avoid prices falling below certain levels.

Finally, the most recent EU CAP reform largely decoupled support payments from producing specific crops, thereby reducing the distortions in agricultural commodity price ratios. The supply management and production quota regimes for milk and sugar production are under continuous scrutiny for reform. In the past they have contributed to higher price levels in the EU than on the international market, thus having a decreasing effect on consumption.

- **The EU Platform on "Diet, Physical Activity and Health"**

The EU Platform on "Diet, Physical Activity and Health" was launched in March 2005. It brings together industry, consumer groups and health experts to find ways to combat obesity. Its emphasis is on self-regulation and voluntary commitments from stakeholders. Within their areas of work, the platform's members have committed themselves to taking steps to contributing to reducing obesity. The majority of commitments have been made by three groups of actors: food and beverage manufacturers (coordinated through the Confederation of the Food and Drink Industries of Europe); medical, health, nutrition and sport and leisure organizations; and wholesale and retail organizations. The UK is the only EU member state whose government is directly involved in the platform. The commitments come under one or more of eight areas. Of these, the promotion of and education on healthy lifestyles attracted the greatest number of commitments, followed by commitments in labeling and nutrition and in advertising and marketing. Distribution has been fairly even across the remaining five categories: product development and reformulation, including portion sizes; dissemination activities; policy development; research, monitoring and surveillance; and other (training, vending). In conclusion, the EU has chosen to focus on an approach of self-regulation and voluntary commitments until 2009/10. Further steps will be decided once the platform's performance has been assessed.

- **Health Impact Assessments (HIA) of Agriculture**

A Health Impact Assessment (HIA) is a policy tool that has been applied to the Common Agricultural Policy (CAP) within the European Union (EU) to assess public health outcomes of agricultural policies. The first and only study to attempt such an approach upon an agricultural policy was published by Sweden's National Institute of Health in 1996. A follow-up study and report were published in 2003. The updated 2003 report acknowledges that CAP as become more health-oriented since 1996 in terms of food safety (largely driven by the BSE outbreak which put a new impetus on food safety and public health within the EU). However, the 2003 report also states that, when it comes to the major health determinants, like nutrition, EU agricultural and food policies continue to counteract public health ambitions. In particular, the report says: "The CAP is biased in favour of producer interests and to the disadvantage of especially low-income consumers through high prices" (p. 85). The first attempt to apply an HIA at a country level was undertaken by the Republic of Slovenia to inform the country's negotiation strategy over agriculture as it prepared to join the European Union in 2002. A report on this effort was published in 2003. This process revealed that the health implications of agricultural policies are a complex policy area, one requiring effective cross-government cooperation at the national and regional level.

c. England

England has produced the closest example the CAPI investigators found to an integrated model. It has a policy that combines agricultural incomes, the welfare of farm works, and nutrition and health outcomes. The policy includes strategic outcomes and indicators, all of which can be monitored online. The stimulus for an integrated policy has emerged from the BSE and foot-and-mouth disease problems. The government wanted to restore public trust in the food system. The policy is reinforced by a strong overarching government policy promoting sustainability. The country also has individual policies for the food, retail, and processing sectors. It also has a 5-a-day policy. The program is a food-systems approach driven by the market. The policy is fairly unique and not necessarily applicable to Canada. One difference involves price. In Canada, the retail sector is price-driven. In England, price is important but not paramount. It is certainly worthwhile to examine how the food standards agency in England reports directly to Parliament. Canada has two agencies concerning health and agriculture, and they are generally at odds.

- **The Curry Commission**

The UK, and England specifically, has probably moved further than most industrialized countries in implementing an integrated agricultural and food policy. This effort followed a long history of vocal criticism from consumer organizations and other elements of civil society, suggesting an inordinate focus on the interests of agriculture over the broader societal and consumer interest. The policy is aimed at food safety, public health and the environment. The impetus for re-examining agricultural and food policies came from a history of 'scares' such as the Bovine Spongiform Encephalopathy (BSE) crisis of the 1980s and 1990s, and the outbreak of foot and mouth disease in 2001. These events led to institutional reform in the form of the reorganization and renaming of certain government ministries. In particular, a new Food Standards Agency (FSA) was established that reports directly to Parliament.

In 2001, the UK government established an Independent Policy Commission on the Future of Farming and Food. The 'Curry Commission' was led by Sir Don Curry. The Commission made wide-ranging recommendations on the food supply, the environment, animal welfare, public health and workers in the agri-food system. The recommendations called for the coordination of the activities of several government departments and bodies: the Department for the Environment, Food and Rural Affairs (DEFRA), the Food Standards Agency (FSA) and the Department of Health, the food sector, public procurement agencies, and the Department of Education and local education authorities. The UK government accepted the Curry recommendations and consulted widely on how they might be incorporated into a new agricultural and food policy. Simultaneously, an economic and statistical analysis was undertaken of the agri-food sector and its wider socio-economic impacts, leading to the launch of a Strategy for Sustainable Farming and Food (SSFF) in 2002.

- **Strategy for Sustainable Farming and Food (SSFF)**

The 2002 SSFF has eight broad principles designed largely to foster a sustainable farming community and the production of safe and nutritious food products. The strategy's implementation is organized around nine strategic outcomes that illustrate its objective of achieving a high level integration of agri-food policies, environmental concerns, public health and wider social objectives. In 2006, the SSFF Implementation Group published a review of progress to date on the implementation of the strategy. It highlighted areas in which specific actions under the SSFF had been taken, including: the implementation of an Environmental Stewardship Scheme; adoption of a whole farm approach in regulating agricultural production; and the development of sector ad issue-specific 'daughter strategies' (for example Animal Health and Welfare

Strategy, Food Industry Sustainability Strategy and 'Choosing a Better Diet'). The review also identified key challenges, including the need for more effective communication of the strategy among stakeholders, the critical role of leadership in key stakeholder groups, the need to prevent the SSFF from being seen solely as an 'agricultural' policy, and the importance of maintaining strong governance of the strategy and its implementation while working through local delivery. The review concluded that achieving the desired outcomes would be a challenge. Putting the situation in England in context, the government had to be 'seen' to be doing something radical in view of the protracted period of food safety and animal health management failures. Perhaps a 'good scandal' is needed in order to induce fundamental shifts in policy and move decision-makers toward an integrated agri-food policy. Ultimately, it is too early to judge whether the SSFF has achieved its defined outcomes and impacts. However, it does provide some positive guidance for the future direction of agri-food policy in Canada.

d. Scotland

Scotland has a history of poor diet and diet-related health problems. It has one of Europe's highest mortality rates from heart disease, and obesity is at the forefront of current health concerns. The Scottish Diet Action Plan (SDAP) – Eating for Health: A Diet Action Plan for Scotland – was published in July 1996. Its recommendations have been the basis on which population-based food and health action in Scotland have been shaped over the past 10 years. The SDAP followed from a previous consultation process that resulted in the 'Scottish Diet' report (James Report), which called for substantial changes in Scotland's consumption of food and nutrients. The report proposed a systemic approach to food and health policy in Scotland, insisting that health was a broad societal issue, not one limited to consumers or health educators. It stated that changing Scotland's diet and food culture would require a coordinated, partnership approach between government public services, consumers, farmers, and others in the food supply chain. By adopting a systems approach to change – suggesting that change in one area requires changes in other sectors – the report was seen to assume a modern pioneering role in UK food and health policy.

The SDAP, building on the James Report, recommended 71 actions across nine sectors in an effort to achieve the Scottish dietary targets. Overall, the SDAP made increasing the consumption of fruit and vegetables as the goal of greatest importance. In 2004, the SDAP was updated by the Scottish Executive, and one of the action points called for in the update was a formal review to examine progress in implementing the SDAP. The review was a unique exercise: the review Panel examined the scope and impact of food and nutrition policy in an entire country for a 10-year period. The review resulted in a final report and a framework for future food policy in Scotland.

Unfortunately, over the 10-year period the SDAP goals have largely fallen short. The targets were not met for 2005 and the Panel expressed doubt that they will be met in an newly extended timeframe for 2010. For example, although fat as a source of energy fell over the 10 years, sugars increased and no change occurred in the intake of complex carbohydrates. The intended increase in daily consumption of fruit and vegetables per person did not occur. Similarly, intended increases did not occur in the consumption of oil-rich fish or breakfast cereals, and instead of increasing potato and bread consumption fell. The consumption of saturated fatty acids fell, but not as much as the SDAP intended. Overall, the consumption levels of the 'healthy' foods targeted to increase were significantly lower in the poorest groups of the population.

The Panel identified the "most plausible explanations" for these failures. These explanations have noteworthy implications for future approaches to improving dietary intake:

- The directions required to achieve the level of change defined by the dietary targets underestimated the impact of inequalities; resources and initiatives were spread too thinly across a broad range of actions rather than a few priority areas;
- The broad range of actions recommended by the SDAP was not transparently or consistently linked to the narrow range of food and nutrient targets identified;
- The SDAP adopted a wholly consensual, partnership approach to 'working with' the food industry and thus underplayed the powerful role of the food supply chain in shaping food content, access, availability and consumer demand over the last 10 years. This role was punctuated by a period of rapid restructuring of the food industry and undermining of health messages by the powerful marketing and advertising of foods and drinks. The SDAP did not deploy the full set of policy tools available, most notably exercising the regulatory and legislative powers of government to control the food supply chain and help create demand;
- The areas where little or no progress was made with implementation suggests that, until the recent public health debate about rapidly rising obesity, the food supply chain has not been fully engaged with the need to change; institutions and leadership across the supply chain were not aligned effectively;
- At the regional level, the SDAP implementation and prioritization appeared uneven, accountability for local implementation has been unclear, and linkages with other relevant policy strands were inadequate.

The Panel did find four particular areas of what it describes as "successes" for the SDAP: improving breast feeding rates and support for women of child-bearing age; improving food and diet in schools under the umbrella of the Scottish Executive's *Hungry for Success* (Scottish Executive 2003) initiative; supporting community food initiatives; and producing health education resources and marketing campaigns. The CAPI investigators reviewed these successes for areas directly pertinent to agri-business and the food industry. Notably, no reference was made in these successes to the agricultural sector or any role it might have played, even though the provision of free fruit in all state primary schools in Scotland was introduced in 2003 and the *Hungry for Success* initiative specifically promotes healthy foods and drinks in schools through marketing, education and active encouragement.

The review produced several valuable lessons for future efforts to integrate the agriculture and food sectors:

- To achieve population level impacts, a more focused and prioritized approach to policy and implementation may prove more effective than a broad range, or scattergun, set of initiatives;
- Given the complexity of modern food systems and their dynamics, action needs to be co-ordinated across all levels of food governance, from local to international levels;
- The actions need to be more plausibly linked to policy outcomes and targets and founded upon the over-arching strategic themes or 'directions of travel' with which all stakeholders (state, food supply chain, consumers) can engage;
- Lines of accountability, monitoring and performance reporting on policy implementation needs to be improved using a wider range of shared intermediate outcomes to help evaluate progress toward targets across sectors;
- A greater use of regulatory powers and incentives can be an appropriate way to set goals for the food supply chain and build consumer demand.

The Panel considered evidence of the impact of the SDAP on agriculture. Despite the emphasis of the SDAP on increasing fruit and vegetable consumption, this goal hasn't influenced the country's agricultural sector.

In fact, since 1993 the hectares devoted to growing soft and orchard fruits and vegetables has declined even though Scotland has favourable conditions for growing a wide variety of fruits and vegetables. The SDAP made a number of recommendations to stimulate consumer demand for fruit and vegetables. Yet this recommendation has not been embedded into policies on agricultural and farming. No action points to prioritize fruits and vegetables were included in the Scottish Executive 2001 report, nor were fruits and vegetables included in Scotland's 2003 Organic Action Plan.

Overall, the Panel found that the food supply chain was not fully engaged with SDAP implementation. For example, no reduction occurred in the production of dairy fat or finding alternative non-food markets for butter fat. Nor was the sugar and fat content in processed foods and drinks reduced. No basic training occurred in nutrition for people working in the food industry and the hospitality management curriculum. Finally, the SDAP fell short in increasing consumer demand for fruit and vegetables by primary producers or via the catering service.

The SDAP review identified four over-arching themes to guide Scotland's future food policy. The first theme suggests increasing the integration between the policy goals directed at enhancing Scotland's diet-related health and those of social justice, sustainable development, and agriculture. A second theme advocates making the principle of equality central to the proposed new Sustainable Food and Health Policy. The third theme focuses on the need to re-establish the grounds for engagement with the food industry in Scotland so that public health and sustainability are over-riding drivers of food production and supply. Finally, the fourth theme points to the need to develop new multi-level governance structures, institutions and leadership. Under this theme, the review argues that a policy commitment to food-related health improvement in Scotland needs to be renewed across all levels and sectors/departments. To achieve this goal, the review cited the examples of breastfeeding and tobacco control, where the government sent strong signals that health must be a priority (including legislative support).

e. Germany

- **Sustainability Council and Guide**

In Germany, food and nutrition policies have been seen as a subordinate area of German agricultural policy. Dominated by food shortages during and after World War II, food security was the main objective of food policy. This perspective has only started to change in the past decade, fueled by the BSE and other food scares in the EU and the first genuinely German BSE case in 2000. In 2001, the Federal Government installed the Sustainability Council, consisting of 15 scientists advising the government of the development of a sustainability strategy for publication in 2002. Based on input from national, international, and EU levels, the government developed a sustainability guide in which environmental, economic and social goals were given equal consideration. Healthy nutrition was one of ten focus areas addressed in the guide. But in 2006, the Federal Statistics Office published a sustainable development indicator report for Germany. It didn't include a single nutrition-related indicator, showing that the country had a long way to go in developing an integrated food policy action plan. In 2007, Germany and 29 other European countries signed the Badenweiler Declaration, which set out the following concrete goals. By 2010:

- An added 10% of the population is to act on the recommendation to have half an hour of physical activity a day;

- An added 20% of the people are to eat five servings of fruit and vegetables each day, thereby increasing the proportion of fruit and vegetables in their daily diet;
- An added 30% of facilities which involve mass catering (such as kindergartens, schools, cafeterias and retirement homes) are to offer healthy meals.

These initiatives are intended to stop the increase in the rate of overweight children, and reduce the number of overweight people in Europe, by 2020. The steps needed to implement these recommendations include: establishing healthy lifestyles as a social value, teaching useful facts about nutrition and physical activity as early as possible, enhancing overweight prevention in adults, and improving the quality of mass catering.

- **Plattform Ernaehrung und Bewegung (PEB, Platform Nutrition and Activity)**

In 2004, Germany established the PEB to promote a healthy lifestyle early in childhood development, including a balanced diet and lots of exercise as well as a joyful and relaxed eating culture. PEB developed an action plan with six main activities at the local level for early and effective intervention to prevent children from becoming overweight. These activities include: reaching children and parents in high risk groups, producing information and providing support for young parents, investigating food consumption patterns/habits and food supply, approaching pre-school day care and kindergarten facilities, approaching children directly, and supporting networks for nutrition and physical activity in communities. No systematic monitoring has been carried out to assess the effectiveness of the PEB projects. However, an overview of evaluation results of PEB projects did indicate that the collaboration of teachers and external experts is effective, and that health promotion should be positioned as an integral part of school development. The CAP research revealed no connection between the PEB initiative and the agricultural sector. The only link appears to through information material provided by the Central Marketing Agency for German Agriculture about agricultural production as part of efforts to increase children's awareness of the natural production process in agriculture.

2. US

a. Healthy People 2010

Healthy People 2010 is a strategic population health management tool in the US that identifies the nation's most significant preventable health threats and focuses public and private sector efforts to address those threats. It is sponsored by the US government through the Office of Disease Prevention and Health Promotion and the US Department of Health and Human Services. 'Nutrition and Overweight' constitutes one of the 20 focus areas defined by Healthy People 2010. Its goal is to promote health and reduce chronic disease associated with diet and weight. The project has identified numerous objectives and targeted health outcomes, largely addressing nutrition and weight issues involving young people.

b. Wingspread: scan of integrated food policies

The Wingspread Conference was a recent US initiative designed to grapple with national food policy issues. The conference was called "Contributions of US Food and Agriculture Policy to the Obesity Epidemic: Opportunities and Recommendations." It was convened by the Robert Wood Johnson Foundation, the W.K. Kellogg Foundation, the Institute for Agriculture and Trade Policy, the Yale University-based Rudd Center for Food Policy and Obesity, and The Johnson Foundation. Forty leading experts on child obesity, nutrition,

public health and agriculture met at the Wingspread Conference Center in Racine, Wisconsin on March 7-9, 2007 to: understand and clarify impacts of federal agriculture and food policies on public health, nutrition and obesity; identify areas for policy analysis and research across agricultural, food, health and obesity-related issues; and develop obesity prevention recommendations related to federal agricultural and food policies. A major driver for the conference was the forthcoming 2007 reauthorization of the Farm Bill in the US, which is reauthorized every five years. The Farm Bill costs tens of billions per year, and includes not only crop subsidies but also funding for environment and nutrition programs and research. But only 8% of the research budget goes to research focused on improved health and nutrition; much potential exists to increase this emphasis.

Final summary documents from Wingspread are not yet available. However, several draft recommendations were produced that are relevant to agri-food integration and the CAPI project. For example, broad-level recommendations included: the development of a vision of health in agriculture; the generation of revenue (e.g. through taxes) to create a fund for the reduction and prevention of obesity and diet-related disease (as has been done for tobacco); and matching food marketing to children with equal funds to obesity and chronic disease prevention. Overall, the conference provides a rich resource for ideas that might be addressed with carefully selected components in an integrated food policy. The conference does not provide a complete model that could serve as a benchmark for Canada.

c. The Special Supplement Food Program for Women, Infants and Children (WIC)

The WIC program is one of the most well-known initiatives for pregnant women, infants and children in the US. It was established as a pilot program in 1972 and made permanent in 1974. It is administered at the Federal level by the Food and Nutrition Service of the US Department of Agriculture (USDA). It is also administered by 90 state agencies, through approximately 46,000 authorized retailers. Most State WIC programs provide vouchers that participants use at authorized food stores. The WIC mission is to safeguard the health of low-income women, infants, and children up to age 5 who are at nutrition risk by providing: nutritious foods to supplement diets, information on healthy eating and food safety, and referrals to health care. Associated with the WIC program is the WIC farmers' market nutrition program. It offers a variety of fresh, nutritious, unprepared and locally grown fruits, vegetables and herbs to WIC participants (purchased with coupons). The program has been evaluated on different occasions, with its positive impact on birth weights demonstrated. A 1990 study showed that women who participated in the program during pregnancy had lower Medicaid costs for themselves and their babies than women who did not participate in the program. WIC participants were also linked with longer gestation periods, higher birth weights and lower infant mortality.

3. WHO European Action Plan for Food and Nutrition Policy

In September 2000, the WHO Regional Committee for Europe endorsed the First Action Plan for Food and Nutrition Policy for the WHO European Region, 2000–2005 calling for the development of food and nutrition policies in Member States. The second action plan, to have been published in September 2007, aims to strategically adapt and renew the first plan for the period 2007-2012. The second Action Plan sets out a series of implementation 'actions' to meet nutrition, food safety, dietary, and food security goals for the WHO European region – that is, for a region consisting of 53 countries with more than 880 million people. The objectives and goals of the second action plan are to:

- promote healthy lifestyles in the European population by improving dietary habits and physical activity, ensuring food safety and food security, and preventing nutrition-related and foodborne diseases.
- address the following health challenges:
  - obesity and nutrition-related noncommunicable diseases
  - micronutrient deficiencies
  - food insecurity and undernutrition
  - foodborne diseases.
- address the challenge to equity both across countries and within countries.

The second action plan also sets out a series of what are termed 'guiding principles'. One of these is of direct relevance for the CAPI project and reads:
"Sustainable development underpins food and nutrition policy in agreement with commitments already taken by Member States within Agenda 21. Actions will consider the need to ensure sustainable agriculture and to promote rural development and healthy local economies." (p5)

There are six areas for action set to address the nutrition and food safety challenges in the WHO European Region; these are:

- Supporting a healthy start
- Ensuring safe and healthy and sustainable food supply
- Providing comprehensive communication to consumers
- Improving energy balance by increasing the opportunities for physical activity
- Strengthening nutrition and food safety in the health sector
- Monitoring trends and evaluating the implementation and the effectiveness of the actions

The proposed action plan in particular singles out actions directed towards the young, from the nutritional status of mothers, infant health, to actions that address young people as they get older.

Of particular relevance to the CAPI project is Action area 2: ensuring a safe and healthy and sustainable food supply. Here agricultural policies are seen as both part of the problem and as having an essential role to play in the implementation of the actions outlined. Agriculture is seen as influencing public health by affecting the supply, local availability, safety and affordability of foods.

Specific actions linked to Action Area 2 are:

- Improvement in food supply and food safety in public institutions
- Provide support to local horticulture
- Promote the reformulation of food products
- Establish targeted programmes for the protection of vulnerable groups
- Promote the micronutrient fortification of staple food items
- Develop guidelines on the location and size of catering establishments and food retail shops
- Explore the use of economic tools (taxes, subsidies)
- Ensure the establishment of adequate food regulations
- Ensure good food hygiene from farm to table
- Establish food control systems (e.g. inspection services)

- Establish monitoring and surveillance systems for microbial and chemical hazards in the food chain and for foodborne diseases

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6. A Review of Five-a-Day Programs to Promote Consumption of Fruit and Vegetables[41]

Andreas Boecker[42]

1. Overview

In recent years, numerous programs and projects have been initiated aimed at individual and collective health behaviour worldwide. Many countries identified threats to human health and have subsequently implemented multiple interventions at the state, national, and international levels. At the same time, an unbalanced diet has been the subject of local, regional, national, and international studies. In particular, there has been increasing publicity about the health benefits of consuming diets rich in fruit and vegetables. Nutritional factors such as eating a diet rich in fruit and vegetables are widely accepted to play a role in the risk reduction of cardiovascular diseases (CVD), the number one killer in the industrialized world. According to Lock et al. (2004), the global burden of disease attributed to low fruit and vegetable consumption accounts for approximately 2.7 million deaths, and 1.8 percent of the total worldwide disease burden. Accordingly, increases in consumption of fruit and vegetable intake could reduce the burden of ischemic heart disease by 31 percent and ischemic stroke by 19 percent (Pomerleau *et al*., 2005). Other studies (Tobias, 2001; Mathers *et al*, 2001; National Institute of Public Health, 1999) showed that inadequate fruit and vegetable intake was responsible for 2.4 percent, 2.8 percent, and 3.5 percent of the burden of disease in New Zealand, Australia, and the European Union, respectively.

Our review of the existing literature suggests that countries emphasized the importance of fruit and vegetables for a plummeting risk of both cancer and heart disease. For several years, national and provincial/state/local fruit and vegetable promotion initiatives have been established in most advanced countries. Most countries adopted multiple initiatives (5 a day, Eat Well, Food Guides, etc.) at multiple levels (i.e., national, provincial/state, local, county). Table 1 provides a summary of initiatives in four selected countries: Australia, Canada, England and Germany. The '5 a day' target across the four countries reviewed is to improve public health through:

- Increasing individuals' and communities' awareness (and attitudes) of intake of fruit and vegetables (i.e., access to nutrition information);
- Improving access to and ensuring availability of fruit and vegetables (i.e., supply side); and
- Increasing intake of fruit and vegetables (i.e., demand side).

Some of the barriers that are thought to deter the consumption of more fruit and vegetables are:

- Budget constraints;
- Lack of preparation time, particularly to prepare fresh vegetables;
- Taste of food and preferences for eating meat;
- Likes and dislikes of other family members;
- Lack of confidence in cooking skills which deters some people from cooking;
- Misinformation about recommendation and terminology, i.e., lack of knowledge of the number of portions to be eaten in a day, what constitutes a portion, what 'counts' as a fruit or vegetable (frozen, chilled, canned and dried fruit and vegetables) (Table 2);

[41] Summary of Report prepared by Andreas Boecker for the CAPI Health and Food Project
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- Perceptions that vegetables are eaten only with evening meals;
- Belief that recommended quantities are too big.

Most of the initiatives aimed at achieving the '5 a day' goal have attempted to break down barriers to fruit and vegetable consumption. This effort was undertaken via complementary, multi-component programs such as increasing access to food at reasonable prices, providing effective training on cooking, provide recipe, changing school food services, and securing industry involvement and support.

Table 1 National "5 a day" Fruit and Vegetable Promotion Initiatives in Four Selected Countries

Country	Initiatives	Activities	Website link
Australia	Go for 2&5	Three television commercials, one radio commercial in ten languages other than English, two print advertisements, shopping centre and cart advertisements, consumer booklets, posters, recipe cards, campaign website, 1-800 number, fact sheets and media partnership activities.	http://www.gofor2and5.com.au/
Canada	5 to 10 a day	Three years media including TV, radio stations, and print media. Information material distributed to health officers, schools, grocery retail stores and dieticians.	http://5to10aday.com/
England (UK)	5 a day	Media campaign, written information, school fruit scheme, local "5 a day" community projects and local workers, work with retails sector applying "5 a day" logo on food stuffs.	http://www.5aday.nhs.uk/
Germany	5 am tag	Media campaign, written information, school fruit schemes during awareness week and in one Bundesland (province), local "5 am Tagy" community projects; retailers and manufacturers can use "5 am Tag" logo on food stuffs, if requirements are met.	http://www.5amtag.de

Table 2: Guidelines and Portion Definitions for Selected Countries

Country	Guidelines and portion definition
Canada	5-10 servings of vegetables and fruits (overall); One serving: 1 medium-sized fruit or vegetable (banana, apple, carrot), 1 slice of melon; half cup of fresh, frozen or canned vegetables (broccoli); a cup of salad; half cup of juice. Volume reference: a cup = 250 ml.
Australia	4-8 servings of vegetables, 2-4 servings of fruit. One serving of vegetables equals 75 g; one serving of fruit equals 150 gm.
United Kingdom	At least 5 portions of fruit and vegetables overall (adult); Portions equivalent to 80 gm. 3 tablespoonful of cooked vegetable (carrots, peas); 2 tablespoons of pulses; 1 cereal bowlful of mixed salads; one overage slice very large fruit (melon); half large fruit (grapefruit); 1 medium fruit (apple); 2 small fruits (plum); 1 tablespoon of very small fruits (blueberries); 1 average handful of dried fruit (raisin); a small glass of 100% fruit juice. Volume reference: tablespoon = 15 ml; handful/bowl =300 ml; small glass = 150 ml;
Germany	At least 5 servings of fruit and vegetables a day, if possible in ratio of 3 vegetable and 2 fruit servings. A serving is roughly equal to 100 g, but should be adjusted to person's size. A rule of thumb states that what fits in one's hand is an appropriate serving size. Processed food and juices qualify for the "5 am Tag" logo, if they meet the requirements of maximum fat contents (3%) and maximum portion of added energy in total energy (30%). No adjustments for dried fruits mentioned, probably because dried fruit are not a typical part of the diet in Germany.

2. Outcome of '5 a day' Interventions

In order to measure the impact of '5 a day' promotion intervention one needs to define key indicators. Our reviews revealed that countries used two key indicators as a measure of the success of '5 a day' promotion interventions: 1) changes in awareness/knowledge/attitude; and 2) changes in behavioural (i.e., increased consumption of fruit and vegetable). The '5 a day' promotion is entirely targeted at public health promotion. The agriculture sector may receive a spill over benefit based on the proportional increase in fruit and vegetable consumption coming from domestic production. However, none of the countries explored

established an impact on the agri-food industry. The '5 a day' campaign in all jurisdictions investigated do not distinguish between locally grown and imported fruit and vegetables. In addition, it is unsubstantiated or dangerous to attribute the meagre changes in fruit and vegetable consumption to the '5 a day' interventions, as many other factors shape consumer purchase decisions, such as relative prices disposable income, tastes and preferences, and convenience.

In all four countries, the aim and the success of the '5 a day' promotion intervention rests on significantly raising awareness about the importance of fruits and vegetables towards improving health. Most of the countries were successful in communicating the message "*eat 5 or more a day*". In some countries, a significant proportion of parents and children claimed to have taken action because of the campaigns. In terms of achieving behavioural change, the findings are less clear. Overall, although there is evidence suggesting that the majority of individuals are aware of the '5 a day' intervention, there was not a significant change in fruit and vegetable consumption. This inconsistency may be a result of the fact that behavioural change takes longer than changes in awareness or attitude. It is likely that a longer term intervention would be necessary to see a significant change in behaviour. In addition, factors such as convenience, taste and preference, income constraints, and relative prices may act as a barrier to the success of the intervention.

From a farming point of view, the following question remained unanswered: Where does Canada make a difference with respect to '5 a day'? Why wasn't there a link between '5 a day' and local agriculture? If this link was established, would Canadian agriculture benefit from a 5 a day program?

3. Synthesis

Despite the growing popularity of '5 a day' interventions and the increasing scientific evidence that low fruit and vegetable intake is a key risk factor for several non-communicable diseases, our review shows that less than a third of individuals in countries we examined eat the amount of fruit and vegetables that their respective government recommends. Based on our review a few aspects may be highlighted: 1) '5 a day' intervention has increased the awareness about the benefit of eating more fruit and vegetable; 2) the impact of '5 a day' on behavioural change is not clear at the moment. This may have to do with the short duration of most of the intervention; and 3) the impact on the agri-food sector is not clear and depends on a multitude of factors (e.g., domestic production vs. import, the size of the country, and the degree of value added activities).

Countries around the world adopt multiple strategies (such as providing training and information, TV program, school programs, and coupon intervention) to increase the intake of fruits and vegetables. Our review suggests that improving awareness of and access to fruits and vegetables at reasonable prices are essential to increasing consumption. In particular, low-income individuals may be more likely to increase their fruit and vegetable consumption behaviour when incentives such as coupons improve affordability. Making fruit and vegetables the easy choice for consumers requires the support of the food industry. At the same time, in addition to the health benefits, the '5 a day' intervention may offer opportunities for the local economies. The benefit to the local economy (particularly the farming community) depends on the size of the fruit and vegetable economy in the country. In the case of Canada, given that we are a net importer of fruits and vegetables, the direct benefits that accrue to Canadian farmers may be trivial. Although interest in the benefit of '5 a day' program to the agriculture sector has been emerging, producers, policy makers, and even academics have a poor understanding of the benefits to the local fruit and vegetable growers. The lack

of understanding comes from the fact that the '5 a day' intervention stems from a public health orientation without a period of discussion and assessment to ensure benefits accrue to the local agricultural sector.

In summary, the 'lack of significant' success in meeting national goals for enhancing fruit and vegetable consumption may indicate a need for additional measures to educate and motivate citizens to make healthier dietary choices. 'Five a day' interventions should go beyond increasing individual awareness and should:

- Target the family, local community, and overall society to eliminate barriers to increasing fruit and vegetable consumption;
- Provide support for individuals who are making positive changes;
- Increase resources for populations with budget constraints;
- Recognize heterogeneity across individuals and cultural differences across communities;
- Emphasize nutritional, health and agricultural policies that have an impact on the local communities; and
- Build on strategic partnerships with private organization, NGOs, producer associations and public sectors at the local, state, regional, and national levels to remove barriers to a healthy lifestyle. This focus may provide opportunities to attain the "*at least 5 a day'* goal.

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7. Short Food Supply Chains

Michael Heasman[43]

1. Introduction

The concept of a Short Food Supply Chains has been developed as part of the recent surge in interest over the past decade in local food economies (LFEs) in North America and Europe. The local food economy (LFE) can be described as a system in which foods are grown, produced, or processed and then distributed or sold within a similar area. The area might be defined as a particular distance from the producer to food retailer or consumer, or by a geographic area such as a municipality or state[44].

Viable local food economies are proposed as a solution to revive flagging rural economies and to improve the incomes of small-scale farmers and producers. Local food economies are seen as processes that connect food producers to food consumers through 'short food supply chains' or 'alternative food networks.' There are at least two important notes of caution to bear in mind when talking about local food. One is simply a case of definitions, the other much more serious. Addressing the former, there is an important distinction when considering the local: the definition of regional specialty products is a separate category from the concept of local food discussed here. Regional specialty products, while closely tied to particular regions, often use this designation to protect the quality and identity of products in national and export markets. For example, within the European Union there is legal protection for such products which are termed Protected Designation of Origin a term used to describe foodstuffs which are produced, processed and prepared in a given geographical area using a particular type of know-how.

The serious aspect of discussion of the local is that 'local' in and of itself is not necessarily something better. Just because something is local it does not mean of itself that it is conducive to environmental and social sustainability or that local businesses provide good working conditions and living wages: the local can be a site of inequality as in any other economic arena. Policy and commerce has to move beyond the local unless the local is part of addressing wider economic, social and environmental issues. A further downside of the 'local' is that it can be used or seen as a reactionary and defensive stance against a perceived external threat from globalization and different 'others'.

Unfortunately, there is no one simple definition of the local food economy and there are in practice many types of local food economy activities. The recent academic literature on LFEs has been ravaged by contradictory interpretations: some researchers argue that LFEs represent authentic Alternative Food Networks while others state the LFE, in its characteristics, is no different from 'conventional' (that is industrial) food value chains. Other literature suggests that LFEs are somehow a 'hybrid' food system which "dips in and out" of both industrial and alternative food systems. Evidence exits supporting all of these positions.

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[44] Studies of local food economies do not usually include 'country of origin' as part of the local food economy, but it is interesting to note that local in this sense is also becoming more important. For example, in May 2007 the Australian government unveiled a new initiative and logo for food products grown in the country and with all significant ingredients grown there. The scheme aims to boost sales of home-grown foods in the country.

This report therefore focuses on just the concept of Short Food Supply Chains (SFSCs) as they are described in the literature and examples of SFCHs/LFEs in practice from Canada and the UK, to show how LFEs are gaining much business, public health and other policy attention. Many see LFEs as an important future trend, not least in contributing towards 'healthy eating' and future sustainable food systems.

Some recent examples of LFE/SFSC headlines illustrate these trends:

- The March 12th 2007 Canadian cover of TIME magazine sums it up: "Forget Organic. Eat Local". The headline is not exactly right, since locally produced organics are an important part of local food economies[45], but the TIME story correctly positions 'eat local' as becoming the: "ideal that promises healthier bodies and a healthier planet" (Cloud, 2007);
- in the UK, the retailer Marks & Spencer announced in January 2007 that 50% of all the food it retails will be from local sources by 2012;
- in the United States, Whole Foods, the country's fastest growing food retailer of recent years, sourced 16.4% of the US$1 billion in produce the company sold in 2006 from local sources, up from 14.9% in 2005 (Cloud, 2007);
- 2006 research in British Columbia shows that the number of farmers' markets in the province have grown from 60 to 100 since 2000, generating an economic benefit of $118.6 million to the local economy in 2006 (Connell et al, 2006);
- in Alberta "alternative" agricultural markets were estimated as generating retail sales of $963.6 million in 2004 and forecast to grow to $1.7 billion by 2010 (Ag-Entrepreneurship, 2004);
- at the end of 2006 the University of Toronto became the first Canadian university to stipulate conditions for locally sourced food products as part of its institution-wide food service contract.

2. Why local food economies are seen as important?

Local food economies and SFSCs sound like a good idea because they offer the potential for three main benefits (Pretty, 2001):

- Environmental – sustainable production and reduced transport externalities ("food miles')
- Economic – through greater incomes for farmers and more financial contributions to local economies
- Social benefits – to consumers and producer groups

Criteria that might be used to describe a "sustainable' food system from a consumer perspective include[46]:

- *Proximate*, originating from the closest practicable source or the minimization of energy use
- *Healthy* as part of a balanced diet and not containing harmful biological or chemical contaminants

[45] Recent research from the Organic Agriculture Centre of Canada published May 31st 2007 shows that retail sales of certified organic food in Canada were worth more than $1 billion in 2006. Supermarkets and mainstream grocery chains are the main outlets for organic sales accounting for 40% of organic food sold in Canada. Direct sales of certified organic produce at farmers' markets across Canada and at the farm gate are estimated to be worth at least $50m, while sales at large natural food store chains and independent health food stores account for $329m, and organic food box delivery companies add another $20m.

[46] SUSTAIN (www.sustainweb.org). Quoted in: *Ilbery and Maye (2005a) p. 333*

- *Fairly or co-operatively traded* between producers, processors, retailers and consumers
- *Non-exploiting* of employees in the food sector in terms of rights, pay and conditions
- *Environmentally beneficial* or benign in its production (e.g. organic)
- *Accessible* both in terms of geographic access and affordability
- *High animal welfare standards* in both production and transport
- *Socially inclusive* in of all people in society
- *Encouraging knowledge and understanding* of food and food culture

Recent discourse on LFEs can only be fully understood, as Pretty (2001) points out, when the economic, social and environmental factors are seen as part of the totality of the local food systems' literature. From this perspective local food systems, and the 'relocalisation' of the food economy, is often described as essential for agriculture and food economy 'sustainability', for community economic development and cohesion, and for providing the foundation for healthy eating and healthy lifestyles through the provision of local fresh and nutritional foodstuffs. For example, strengthening local food economies is put forward as important for addressing not only specific local economic concerns, such as rural and community economic development, but also for tackling social and environmental challenges, such as community food security or 'food miles'(Feenstra 2002).

Pretty (2001), one of the world's leading experts on sustainable food systems, says the basic challenge of a more sustainable agriculture is to make best use of available natural and social resource. He writes:

"Farming does not have to be dislocated from local rural communities, as sustainable agriculture, with its need for increased knowledge, management skills and labor, offers new upstream and downstream job opportunities for businesses and people in rural areas. This suggests a logical need to emphasize agriculture's connections to local ecologies and communities."

Pretty, importantly, points out that the marginalization of farmers in terms of income and of local food economies, is a relatively recent aspect of food supply: 50 years ago, farmers in Europe and North America received 45-60% of the money that consumers spent on food, today that proportion has dropped to just 7% in the UK and 3.5% in the U.S (Pretty, 2001).

In addition, the relocalisation of food is seen as characterized in a very different manner from 'global' food systems. Table 1 summarizes these different attributes between the local and global food system:

Table 1: Attributes associated with "Global" and "Local"

• *GLOBAL*	• *LOCAL*
Market economy	Moral economy
An economics of price	An economic sociology of quality
TNCs dominating	Independent artisan producers prevailing
Corporate profits	Community well-being
Intensification	Extensification
Large-scale production	Small-scale production
Industrial models	"Natural" models
Monoculture	Bio-diversity
Resource consumption and degradation	Resource protection and regeneration
Relations across distance	Relations of proximity
Commodities across space	Communities in place
Big structures	Voluntary actors
Technocratic rules	Democratic participation
Homogenization of foods	Regional palates

Source: *Hinrichs (2003) p. 36*

3. What are Short Food Supply Chains (SFSC)?

Local food economies in recent years have been conceptualized in the academic literature as "alternative food networks" (AFN) and "short food supply chains" (SFSC). The central notion of both AFN and SFSC literature is that they attempt to address what is seen as pivotal changes in local food economic activity. The fundamental interest in AFNs and SFSC is how they embody alternatives to the more standardized industrial mode of agriculture and food supply. Thus by their nature SFSC and AFNs are theorized to employ different social constructions with ecology, locality, region, quality conventions, and consumer culture (Renting et. al 2003).

AFNs and SFSCs "attempts to establish 'closer' or more 'connected' relationships between food producers/production and consumers/consumption, and represent modes of food provisioning which in various ways are different from, or alternatives to, the prevalent, supermarket mode of provisioning in countries like the UK" (Holloway et al 2007 p.2).

SFSCs, by contrast with 'alternative', are described as food chains where the producer-consumer relationship is 'shortened' and redefined by giving clear signals on the provenance and quality attributes of food and by constructing transparent chains in which products reach the consumer with a significant degree of value-laden information. In addition, SFSCs 'shorten' the relations between food production and locality, thereby potentially enhancing a 're-embedding' of farming towards more environmentally sustainable modes of production (and in this sense organic farming is seen as important).

With this in mind Marsden et al (2000, see also Renting et al, 2003) describe three categories of SFSC: what they call "face-to-face interaction", "relations of proximity", and "extended relations" – these categories are

captured in Figure 1. These SFSC chains construct value and meaning, rather than solely focusing on the product itself.

- Face-to-face: consumer purchases a product direct from the producer/processor on a face-to-face basis. Authenticity and trust are mediated through personal interaction.
- Spatial proximity: products are produced and retailed in the specific region (or place) of production, and consumers are made aware of the 'local' nature of the product at the point of retail.
- Spatially extended: where value and meaning laden information about the place of production and those producing the food is translated to consumers who are outside the region of production itself and who may have no personal experience of that region.

Figure 1. Different mechanisms for extending short food supply chains (SFSCs) in time and space.

Face-to-face SFSCs ⮜---⮞	Proximate SFSCs ⮜----------⮞	Extended SFSCs
farm shops	farm shop groups	certification labels
farmers markets	regional hallmarks	production codes
roadside sales	consumer cooperatives	reputation effects
pick your own	community supported agriculture	
box schemes	thematic routes (articulation in space)	
home deliveries	special events, fairs (articulation in time)	
mail order	local shops, restaurants, tourist enterprises	
e-commerce	'dedicated' retailers (for example, whole food, speciality, or dietetic shops)	
	catering for institutions (canteens, schools)	
	sales to emigrants	

Source: *Renting et al. (2003) p. 399*

The concern of this report is with the first and second categories – that is face-to-face and spatial proximity and whether they have differing cost/benefit implications and specific obstacles to their full economic development.

4. The impetus behind Short Food Supply Chains

While LFE economies in one form or another have been around a long time, there is growing evidence that they are gaining more consumer, producer and policy attention, particularly with respect to their economic development potential and their capacity to deliver both environmental and human health benefits.

The key driver has been consumer demand and certain producer interests (usually smaller-scale operations). The community food security movement[47] has for a long time advocated for locally based sustainable food

[47] The definition and concept of food security has seen many forms and variations. In Canada those working in the field of community food security (CFS) tend to prefer the definition: "Community food security exists when all citizens obtain a safe, personally accepted, nutritious diet through a sustainable food system that maximizes healthy choices, community self-reliance and equal access for everyone" (Hamm and Bellows 2003). This locates CFS in the heart of a viable and sustainable local food economy in the sense the definition addresses what are the two dimensions of food security: firstly, the ability of individuals to reliably access food, and secondly, the production and supply of food. Recent policy initiatives in Canada, driven largely by public

systems. More recently local food has been made more popular by up-scale chefs and restaurants and tourism departments have latched onto the importance of culinary tourism. In Canada, there has been growing interest in LFEs from agricultural ministries, but often on a piece meal basis. It is probably still fair comment to say that at the federal level LFEs barely register on the agricultural policy radar.

In the United States, SFSCs are gaining increasing prominence in local government circles, ironically in many States dominated by industrial agri-business, as a vehicle for local economic development, a way to help farmers, and to provide nutritious foodstuffs to local consumers. For example, in 2006, Michigan's State Governor Jennifer Granholm launched a Buy Michigan First policy that requires state institutions to give priority to local produce and products.

Consumer demand is a key driver in many countries. Characteristics of local food economies from a consumer perspective are that consumers perceive products as being fresh, 'tasty', and healthier. In addition, consumers want to help local farmers, support their local food economy, and they want the 'trust' and knowledge of a 'face-to-face' encounter with producers through their food purchases. In some of the academic literature this multifaceted consumer relationship with local food economies is described as a "quality-turn" in food consumption behavior.

'Local food economy' consumers and producers alike attribute particular 'values' or distinct quality attributes to local food that they would not express for other foodstuffs. For example, a study by Ipsos Reid (published December 2006) found that Canadians believe locally grown food has benefits over 'regular' food. The study found that the majority of Canadians described the benefits of buying locally grown fruits and vegetables as:

- Help their local economy (71% of respondents),
- Support family farms (70% of respondents),
- Taste better (53% of respondents), and
- Are cheaper (50% of respondents).

(n=representative random sample of 1091 adult Canadians)

A recent review included these features as important for consumers[48]:

- Freshness
- Knowledge of origin
- Products have "faces" (that is stories)
- Cover the whole chain from production to consumption
- Available only on a local basis (not nationally distributed)
- Regionality and maintenance of regional food traditions

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health agencies, have put renewed focus on local food economies in relation to CFS. A prominent example is the fact that food security has been designated by British Columbia's Ministry of Health Services as one of B.C.'s 21 core functions towards achieving population health and wellness as part of the 2005 Framework for Core Functions in Public Health (Ministry of Health Services 2005). The document outlines what it regards as a 'local food system' in very broad terms, saying this includes all or some of the following: community gardening/urban agriculture, roof-top gardens, food boxes, food co-ops, farmers markets, gleaning, community-supported agriculture, food festivals, community kitchens, preserving farmland, organic production, and ensuring access to grocery stores.

[48] Adapted from Forsman and Paananen, 2005

- Small-scale production
- Artisan entrepreneurship
- Regional and community development
- High quality (including minimum processing such as use of additives)
- 'home made' style and craft products
- short distances between food chain links
- clear differentiation from mass production
- seasonal products
- educational value
- employment of local people
- authentic taste
- natural products (and purity)
- transparency of the food chain

The evidence suggests that for most local food economies, it is the urban-rural linkage that is critical. Urban consumers want the 'quality-turn' of local food produce, suggesting that Canada's main LFE markets will be around its core urban hubs: the Greater Golden Horseshoe in Southern Ontario, Greater Montreal, Greater Vancouver and Canada's fast growing cities, such as Calgary and Edmonton.

5. Outcomes for agri-food sector

The scale of economic activity ranges from very small single businesses to collective activity such as farmers' markets. Such activities can generate large food markets. For example, in Ontario farmers' markets and direct farm marketing together generated sales of $761 million in 2005.[49]

The Ag-Entrepreneurship Division of Alberta Agriculture, Food and Rural Development has estimated the provincial market value of alternative agricultural markets – that is, farmers' markets, regional cuisines, farm direct, on-farm activities, and off-farm activities combined - to be $963.6 million in 2004.[50] If this figure was extrapolated for the rest of Canada it would suggest the country's LFE is valued at around $9 billion, but a more detailed analysis should be undertaken to validate this extrapolation (estimate derived by extrapolating from Ag-Entrepreneurship assumption of number of households in Alberta purchasing local foods across a similar percentage of all Canadian households using census data).

Economic studies of LFE activities in Canada also suggest important multiplier benefits arising from LFEs. For example, in British Columbia a 2006 study of farmers' markets found the markets generated sales of $65.3 million, but an additional $53 million was spent by the farmers' market customers at neighboring businesses as well.[51]

For most producers and farmers operating in local food economies, research suggests the need for developing a different mindset: such as producing crops for food, not for commodities or animal feed, growing and innovating with a greater diversity of produce, working towards ecological and sustainable

[49] McElhone 2007
[50] Ag-Entrepreneurship 2004
[51] Connell et. Al 2006

agricultural goals, and wanting to engage directly with consumers. Business goals are not to increase yields of monoculture crops per acre, but increase the value of crops per acre through diversity of production.

Local food economies tend to be closely associated with smaller agricultural and food-related enterprises and 'sustainable' agricultural initiatives (Ross, 2006). Types of local food schemes that fall into this type of activity include:

- Community supported agriculture
- Box schemes
- Consumer co-ops
- Producer co-ops
- Growing your own
- Local/specialist shops
- Farm shops (including 'pick your own')
- Farmers markets
- Public procurement of food

An area yet to gain momentum is for local institutions such as universities, schools, hospitals, government, etc. to write food service procurement contracts that stipulate a percentage of local food sourcing. Also important and growing, from an economic perspective, are local foods and culinary tourism, and the use of local foodstuffs in local restaurants and by leading chefs.

6. Examples of SFSC activities in Canada

This section provides some examples of SFSC activities in Canada. There are many initiatives taking place in Canada. This is a representative sample of those with a food and health policy component.

Waterloo Public Health

One of the more forward thinking and innovative policy approaches to SFSCs, food and health has been undertaken by the work of the Region of Waterloo Public Health. Waterloo Public Health has taken the lead over a number of years to undertake research and make recommendations for interventions that would strengthen the ability of its local food system to feed the local population, particularly as this is expected to grow by 50% over the next 40 years. The Region of Waterloo Public Health has carried out the following local food system studies:

- Growing Food and Economy Study 2003
- A Glance at Access to Food 2004
- Local Food Buying in Waterloo Region 2004
- The Marketing and Branding of Buy Local! Buy Fresh! 2005
- Food Flow Analysis 2005/06
- Food Miles Study 2005/06
- Urban Agriculture Feasibility Study 2005/06
- Redundant Trade Study 2006

A key motivation for the focus on local food systems is that a viable and fully developed local food system will help to improve the health of the population in a number of ways including the provision of fruits and vegetables. These are the kind of issues this work has addressed:

- An Optimal Nutrition Environment study: examined the recommended nutritional needs of the population and the potential for meeting those needs through local agriculture. The research found that an optimal nutrition environment by 2026 could be achieved for the Waterloo Region by shifting 10% of currently cropped land to production of whole grains (oats, rye), white beans, and fruits and vegetables that grow well within the region;
- A food flow study: which investigated the percentage of food consumed in the Waterloo region which had been grown, raised or processed in the area;
- Food miles study on the average distance food currently travels to reach the region;
- A redundant trade study: looking at the potential for replacing some imported foods with local foods in the future;
- Local food branding: assessing how consumers in the Waterloo region would respond to a local food label.

Consumer research in the Waterloo Region found that 87.1% of residents indicated that buying local food was either somewhat or very important to them. The reasons they bought were: supporting local farmers (86.6%), freshness (58%), and preserving local farmland (43.6%). Consumers in the region were purchasing local foods (in order of importance) at farmers' markets, local produce in stores, and buying directly from farms. However, there were barriers to buying local foods, the four main reasons cited were: food they like doesn't grow locally (66.4%), it is not always available (64.4%), much of it is seasonal (58.4%), and it costs more (20.8%). Overall, this study concluded that availability is a significant barrier to buying local food.[52]

Becoming self-sufficient in British Columbia

A study by the B.C. Ministry of Agriculture and Land (2006) investigated the ability of the province's primary producers to provide food for B.C. inhabitants in light of a change to healthy eating and the expected rise in population. Using 2001 production and consumption data the study estimates that B.C. farmers currently produce 48% of all foods consumed in B.C. and produce 56% of foods consumed that can be economically grown in B.C. However, when relating current production by types of produce to recommended consumption patterns suggested by Canada's guide to Healthy Eating, B.C.'s food self-reliance drops to 34%, that is, the province would need to produce, for example, a much greater volume of fruits and vegetables if everyone in the Province were to eventually follow Canada's healthy eating suggestions and to reduce consumption of other (not so healthy) foodstuffs. This has implications for the balance of trade as well, for example, currently B.C. imports three times as much fruit as it exports. The study concludes that to maintain the current level of self-reliance through to the year 2025, farmers will need to increase production by 30% over 2001 levels and this increased production will be concentrated on the land that has access to irrigation, land that is typically near urban centres.

Greater Toronto Area

[52] Region of Waterloo 2004

Seccombe (2007) in his recent report on Ontario agriculture identifies some key challenges to local food economies.[53] For example, he points out how the Greater Toronto Area has lost a lot of its best farmland to other land pressures – in the three decades between 1966 and 1996, more than 1.5 million hectares of agricultural lands were lost to non-agricultural uses in Ontario. From 1976 to 1996 GTA alone lost 2000 farms and 150,000 acres of farmland went out of production. He also points out the scale of Ontario's trade surplus: the province imports three dollars of food products for every two dollars exported. Food exports in Ontario grew 32% between 1999 and 2006 while exports grew 28% over the same period.

However, recent years have seen a concerted range of actions to develop a strategic vision and plan for agriculture in the GTA area, which will include direct implications for the region's LFE. Following extensive consultations, a GTA Agricultural Action Plan was developed (GTA Agricultural Action Plan, 2005) and all four GTA Regional Councils formally endorsed the proposed action plan in principle. As well, the GTA Federations of Agriculture, OMAFRA, the Ministry of Municipal Affairs and Housing, and Agriculture and Agri-Food Canada all indicated their support and commitment to its implementation.

Alberta's alternative agricultural markets

In 2004, the Ag-Entrepreneurship Division of Alberta Agriculture, Food and Rural Development undertook a study to quantify the value and potential growth of alternative agricultural markets which included farmers' markets, on- and off- farm direct marketing, agricultural tourism and regional cuisine markets in Alberta. The current value of all five of these markets is estimated as $964 million (Table 2) with farmers' markets being valued at $232.9 million (there are currently around 100 Alberta Approved Farmer's Markets, and they are the top agricultural tourism attraction in Alberta). It was calculated these alternative agriculture markets could nearly double in value by 2010 to $1.7 billion.[54]

Table 2: Alternative Agricultural markets in Alberta May 2003-April 2004

Regional cuisine - $214.0 million
Farmers' markets - $232.9 million
Farm direct - $191.1 million
On-farm activities - $51.6 million
Off-farm activities - $274 million
TOTAL = $963.6 million

These market figures were calculated through consumer research investigating what households spent on 'alternative' agricultural products.[55] The market size was defined by the number of households that purchased each product over a 12 month period (May 2003-April 2004). When projected to the total provincial population of 1.24 million households, results suggested that 1.0 million households (around 80.6%) in Alberta made purchases from at least one of the alternative agricultural channels. If this were to be extrapolated to Canada as a whole, based on taking 80.6% of 2001 census data which calculated there were a total of 11,767,180 households in Canada, this would suggest a national LFE market with more than $9 billion in consumers sales, although this figure clearly needs further verification to justify such an extrapolation.

[53] Seccombe 2007
[54] Ag-Entrepreneurship 2004
[55] Infact 2004

Farmers' markets in Canada

In Canada the growth in farmers' markets has been impressive, almost doubling since the late 1980s to around 425 in total, with Ontario showing the greatest increase going from 60 to 130 by 2002.

Ontario Farmers' Markets, founded in 1991, estimate that the region's 120 or so farmers' markets generate sales of $600 million leading to an economic impact of $1.8 billion. More than 27,000 people in Ontario are involved in preparing and selling produce for farmers' markets. Research also shows that 60-70% of market-goers visit neighborhood businesses on their way to and from the market. More up-to-date figures from the Ontario Ministry of Agriculture, Food and Rural Affairs shows further growth in Ontario's farmers' markets, suggesting there are currently some 200 farmers' markets in Ontario, generating sales revenue of $645 million in 2005, a growth rate of five percent over the previous three years. Roadside farm sales venues in Ontario generated annual sales of $116 million and provide seasonal employment for 10,000 workers and nearly 1,000 full time jobs. More than 25 farms in Ontario operate CSA schemes, with 50 to 200 shares per farm. Share prices range from $400 to $600 and boxes of produce are available 20-24 weeks per year.[56]

New evidence from British Columbia shows the economic impact and growth of farmers' markets. In BC there are 100 known markets, up from 60 in 2000. Research by Connell et. al (2006), based at the University of Northern BC, estimates that the total annual economic impact of farmers' markets in BC to be $118.6 million; $65.3 million through consumer expenditure at the markets themselves, and a further $53.3 million spent by farmers' markets' customers at neighboring businesses.[57] Other highlights from their research which investigated the activity of 28 markets, are:

- More than 131,000 people make more than 3.1 million visits to BC farmers' markets during a market season;
- Average amount spent at the market per customer: $18.18;
- 46.5% of respondents to their consumer survey visit farmers' markets at least 2-3 times per month.

Connell et al (2006) also asked a sample of people attending the farmers' markets what factors they consider when purchasing food, the most important factors (ranked in order) were found to be:

- Nutritional content
- In season
- Grown/produced locally
- Food safety
- Grown/produced in BC
- Animal welfare
- Appearance of product

The researchers also found that people visiting the farmers' markets liked to spend time talking to others as well as doing their shopping.

Local Flavour Plus - Bringing the local to foodservice

[56] McElhone 2007
[57] Connell et. al 2006

One recently launched Canadian initiative that has a lot of potential to grow local food economies is Local Flavour Plus (LFP). Local Flavour Plus, based in Toronto, is a non-profit organization that has attracted more than $1 million in funding and is committed to building and fostering local sustainable food systems by certifying farmers and processors and linking them with local purchasers. The first major success for LFP was in September 2006 when the University of Toronto announced it will partner with LFP to ensure that its campus food service will include locally sourced foods. The University of Toronto is the first Canadian university to require that local food be part of its menu offerings, with a number of residences and cafeterias at the University serving seasonably available, fresh food items and dishes made with certified local ingredients.

LFP acts as a 'facilitator' between producers and consumers and has set up a point system standard for producers to be locally certified with LFP. LFP defines local as province-wide but also offers the definition of local foods as those produced and processed within a 200km radius of the point of consumption. The LFP certification process aims to provide a system to enable producers to show they are both environmentally and socially responsible. The certification criteria are based upon:

- Employing sustainable production systems that reduce or eliminate synthetic pesticides and fertilizers, avoid the use of hormones, antibiotics, and genetic engineering, and conserve soil and water;
- Provide safe and fair working conditions for on-farm labor;
- Provide healthy and humane care for livestock;
- Protect and enhance wildlife habitat and biodiversity on working farm landscapes;
- Reduce food related energy consumption and greenhouse gas emissions through energy conservation, recycling, minimal packaging, and local sales.

LFP sees the best strategy for the present is to focus on institutional purchasers and this builds on successful schemes in the United States where more than 200 universities, colleges and schools in 16 states have implemented farm-to-school programs that emphasize local food purchasing and often include a sustainability component. LFP says in its promotional materials it is: "committed to working with institutions in Canada to develop similar programs for the benefit of local farmers, the environment, public health, the local economy and our quality of life."[58]

7. Examples of SFSC policy and market activity in the UK

In the UK, there has been a coming together of national and local government policy, NGO push, local producer involvement and corporate interests that is seeing a potential renaissance for the local food economy. A major policy push towards the local followed the publication of the *Policy Commission on the Future of Farming and Food* report (the Curry report) in 2002 following the earlier foot and mouth outbreak in the UK. Among its many recommendations, the Curry report spoke of the need to reconnect producers with consumers and that this is a way forward for rural development. For example the report said: "We believe that one of the greatest opportunities for farmers to add value and retain a bigger slice of retail sale prices is to build on the public's enthusiasm for locally-produced food, or food with a clear regional provenance."[59]

[58] Local Flavour Plus 2007
[59] Policy Commission 2002

Following from the Curry report one of the activities undertaken was a review of LFEs by The Working Group on Local Food. The Working Group carried out a detailed review of the local food economy in England and its report is one of the few pieces of research that investigates from a national perspective (England) the local food economy and different market areas (2003). In the English context, the report points out, there are few strategies or frameworks within which local food is explicitly mentioned in public policy at a regional or national level. In its interviews with key local food players across the country, the Working Group found the scope of the local sector difficult to pin down, and that it is complex and interacting.

The Working Group found that organizations and individuals who facilitate links between enterprises at a local scale and provide conduits for co-ordination at regional and national level, play a central role in the sector currently and are essential for its further development. Local food enterprises are largely small businesses and thus share many of the barriers and difficulties common to such businesses. The Working Group identifies a number of policy areas to which local food economies are linked. These would include:

- Public Health – diet and healthy eating
- Rural economy and rural development
- Sustainability agendas
- Tourism
- Environment
- Community development
- Planning
- Quality of life
- Food safety and standards
- Education
- Farming and agriculture
- Competition and business development
- Entrepreneurship and innovation
- Employment, skills and training

The Working Group also identified what it called the 'system connections' in local food economies. These are:

- Production methods
- Product
- "green/sustainability" agenda
- health
- business
- relationship between producers and consumer
- social factors

This study in the UK found it hard to define the 'boundary' of local food economies. That is, the researchers found that with a wide variety of definitions and expectations of local food it was difficult to define accurately the scope and the extent of the local food sector.

The report identifies, based on its interviews across the UK, a number of obstacles or major barriers facing the local food economy and for it sustainable economic development. These can be summarized as:

- the current structure of food and drink sector inhibits the development of the local food sector;

- overcoming the restrictions on consumers access to local food and improved marketing of local food to consumers;
- sector currently fragmented and there is a need for further co-ordination and networks and appropriate structures to support processing, distribution and marketing of local products;
- getting the 'right' people in the right places is a limiting factor;
- lack of funding support and support;
- the need for a "more supportive" policy framework especially towards smaller business needs;
- research support.

However, in the UK like other countries there is a lack of detailed empirical research into the extent and impact of local food initiatives or analysis of this evidence and the development of critique.

Examples of how UK corporate food retailers enter local food economies to develop SFSCs

What is currently happening among UK food retailers is setting something of a benchmark. For years it has been an open secret in the UK that local food would probably be a major development in food retailing, yet the past 12 months in particular have seen a new wave of sustainability consciousness sweeping through the UK retail sector. And Wal-Mart, through its UK owned retail chain ASDA, has been in a leadership role. The UK food retail market is highly concentrated with four players dominant – Tesco, ASDA, Sainsbury's and Morrisons. Other influential retailers, but with relative small food market shares, are the Co-Op, Waitrose and Marks & Spencer.

Below are brief descriptions of some of the more recent announcements relevant to local food economies and SFSCs: the most dramatic of these have related to the environment. For example, when Tesco, the UK's largest food retailer, made a pledge in January 2007 to become a leader in creating a low-carbon economy and promised a "revolution in green consumption" saying it wanted to "take the green movement into the mass market."

One of its big moves toward this revolution will be to put carbon labels on every one of the 70,000 products it sells, allowing shoppers to compare the carbon costs of products in the same way as they might compare calorie counts. Tesco also announced that air freighted food – mainly fruits and vegetables – will carry a symbol informing consumers of this carbon footprint. This follows Tesco's 'good neighbor' plan, unveiled in 2006, which included, among other things, sourcing more local food and encouraging healthier eating and opening up of six new regional buying offices to increase local sourcing and to make it easier for small producers to sell goods through Tesco.

In the UK, through its chain ASDA the UK's second largest retailer, Wal-Mart has a particular focus on the local. For example, in 2004 the company so impressed the judges it won the prestigious BBC Food and Farming National Retailer of the Year Award in 2004 for its work on sourcing local foods. ASDA had launched its local sourcing team in 2001 and has set up what it calls local hubs across the UK. There are now 10 operating in different regions of the UK. Hubs work by setting up community-based contracts, in the case of its Best of Kent hub, 80 local products are sold by ASDA stores in the area, delivered direct from the farm. The company also helps in marketing the local foods. Last July, for example, it hosted Local Celebration Weeks, offering local food producers the chance to get onto the shop floor and showcase local products to customers.

Across the UK, the company is currently working with more than 300 local suppliers, presenting 3,000 local products. Local foods can, in turn, have a big impact on multinational brands. For example, in ASDA's Kendall store, the local brand of ice cream English Lakes outsells Ben and Jerry's – owned by corporate giant Unilever – 30 to one. In the region of Cornwall in SW England, local brand clotted cream Roddars, outsells ASDA own brand clotted cream 50 to one.

But there are other big things going on, and they are all connected. For example, Sainsbury's, the UK's third largest supermarket, is converting this year all its banana supplies to fair trade and sustainable sourcing, making it, in one stroke, the largest seller of fair trade bananas in the UK and increasing its fair trade purchasing five-fold. Bananas are one of the most popular purchases in UK supermarkets and Sainsbury's alone sell half a billion bananas a year. Last year Marks & Spencer changed all its tea and coffee products to fair trade.

Marks & Spencer launched it Plan A 'eco-plan' on January 15th 2007. This is a GBP200 million ($440m) five year commitment that will mean by 2012 the company will become carbon neutral, send no waste to landfill, extend sustainable sourcing, set new standards in ethical trading, and help customers and employees live a healthier lifestyle. Marks & Spencer is an up-market food retailer and the company has a larger non-food business, but it works with 10,000 farms through its supply chains and its new strategy does show what a business can set out to do.

Briefly, some of the company's food-related commitments from its 100 point eco-plan, include:

- M&S will clearly label the food it imports by air (mainly fruit and veg) and seek to minimize the amount it now air freights;
- UK, regional and local food sourcing will be a priority: Committing to buy as much food from the UK and Ireland as possible, double regional food sourcing within 12 months and grow its existing local supply networks;
- Initiating 5 new research and development projects with our UK growers to develop production techniques and varieties to reduce the amount of food we import;
- It will trial the use of food waste to power its stores by top sending food waste to landfill and use it to generate green energy from our stores, via anaerobic digestion;
- Converting all its fresh turkey, geese, duck and pork to Free Range, building on its industry leading position of only using Free Range shell eggs and eggs used as an ingredient;
- Selling only fish which is certified by the Marine Stewardship Council (MSC) or another independently certified source, adding to the steps it has already taken and building on its position as Greenpeace's no.1 responsible fish retailer;
- Tripling sales of organic food and launching organic cotton, linen and wool;
- Ensuring its produce and livestock farmers meet an independent environmental standard;
- Reducing the water use in stores, offices and distribution centres by 20% and working with suppliers via the Supplier Exchange to reduce water use during the growing, production and manufacture of its products;
- Building on the success of Fairtrade coffee and tea by offering Fairtrade bananas, jam and bagged sugar and moving into other vulnerable supply chains like those for sugar cane and cocoa used across its food range;
- Working with farmers to extend its existing industry leading Milk Pledge pricing scheme into new farming sectors;

- Launching the M&S Supplier Exchange to support its suppliers – by sharing best practice, stimulating innovation and helping them secure funds for investment.

These retailer commitments are not to rack up prices, as M&S say: "We will do this without passing on the extra cost to our customers." And the other retailers have said the same. However one views the intervention of major supermarkets into local food economies in the UK, these are far reaching new commitments and actions by food retailers cannot be ignored. These changes are significant, and will continue to be so and if other players in local food economies fail to respond they will be hurt commercially.

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8. Functional Foods and Nutraceuticals: Linking Agriculture to Public Health

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1. Background

In order to improve public health and wellness, dietary changes have become an important public policy goal. This goal is driven largely by escalating public health costs related to 'preventable' non-communicable diseases. For example, about one-fifth of the total health care costs in Canada are associated with cancer, diabetes and cardiovascular diseases (Health Canada, 1997), all of which have a diet-related connection. Along with weight control and physical activities, diet is widely sanctioned by the scientific community as a modifiable factor that could restrain escalating health care costs[61] related to these diseases and promote public wellbeing. It has been estimated that exercise and caloric intake-related mortality in the United States is second only to tobacco consumption in terms of the number of deaths that could be prevented through behavioural change (McGinnis and Foege, 1993). Furthermore, a number of recent expert reviews have highlighted the role of dietary change alongside physical activity in promoting public health including World Cancer Research Fund (1997), American Cancer Society (Kushi *et al*, 2006), World Health Organization (WHO, 2003).

Functional foods and nutraceuticals (FFN) have been promoted as potential components of public policy aimed at promoting public health and wellbeing. Recent consumer research suggests that consumers are increasingly aware of functional foods and nutraceuticals and value the potential health benefits associated with a range of functional ingredients (West *et al.* 2002; AAFC 2004; Health Canada 2005; Labrecque *et al*. 2006). In a recent Health Canada Survey (Health Canada, 2005), it was reported that about 71 percent of the Canadian population are supplement users, while about 77 percent perceive that natural health products could be useful to maintain or support health. This suggests that, alongside broader changes in diet in accordance with current guidelines, functional foods and nutraceuticals might play a role in reducing the incidence of certain diet-related diseases. Taking this perspective, public policy needs to address the availability and affordability of such products. Further, there is a role for policy in supporting innovation and commercialization of functional ingredients, whether through functional foods and/or nutraceuticals. Certainly, policy towards agriculture and the agri-food sector has a direct bearing on the demand for, and supply of, functional foods and nutraceuticals. Yet research that explores these linkages is only now emerging in the literature (Cash *et al.* 2006).

An overarching objective of this review is to explore whether current regulatory regimes are evidence-based and, in turn, whether these policies are based on a 'reasonable' link between the assessment criteria of the evidence (such as evidence from clinical experiments) versus the beneficial effects that are plausible at the population level. It also reflects on whether there is a mismatch between: current regulatory regimes governing the Canadian functional foods and nutraceutical sector, the innovation and commercialization activities of firms in this sector, and the policy goals of public health enhancements.

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[61] For instance, Malla, Hobbs and Perger (2005) estimate potential annual savings by switching to trans-fat free canola oil from the traditional canola oil in Canada are in the range of $280 million to $1.09 billion as a result of lower incidence of coronary heart diseases.

2. Functional foods and nutraceutical: products, markets and the consumer

The term functional food is generally used to describe food products that deliver a health benefit beyond providing sustenance and nutrition. A somewhat broader definition is provided by Doyon and Labrecque (2005) using the Delphi technique on 28 definitions found in the literature and iteratively seeking consensus among a set of experts, thus:

> "A functional food is, or appears similar to, a conventional food. It is part of a standard diet and is consumed on a regular basis, in normal quantities. It has proven health benefits that reduce the risk of specific chronic diseases or ill states in addition to its basic nutritional function." (p.14)

Nutraceuticals are such a diverse product category that various synonyms are found internationally. In Canada, nutraceuticals come under the broad umbrella of Natural Health Products (NHPs). They are defined as:

> "(n)aturally-occurring substances that are consumed for the purpose of diagnosing, treating or preventing illnesses, or maintaining or promoting health. Natural health product substances include plant, algal, fungal, or animal materials or extracts of these or vitamins, minerals, amino acids, essential fatty acids, and probiotics. They are usually sold in dosage form such as capsules, pills, tablets or liquid extracts" (Canada Gazette Part II, 2003 June 18th).

In the United States, nutraceuticals are classified as dietary supplements. The definition in the EU cuts across both of these scenarios, classifying nutraceuticals as either food supplements or traditional herbal medicines. Functional foods and nutraceuticals can be derived in a variety of ways; Table 1 provides some examples. These products can range from the unchanged natural status of the original food (such as Oats) to changes through genetic modification (such as genetically-modified golden rice) and other novel processing methods (such as Omega-3 enriched eggs from innovative animal feeding programs). The processing and extraction methods employed are rapidly changing.

Functional foods and nutraceuticals have registered impressive market growth since the late 1990s. Globally, the functional food sector registered almost double-digit growth during the period 1999 to 2003; twice as fast as growth in sales of dietary supplements that includes vitamins, minerals, herbs and other botanicals and sports drinks and meal replacements (Table 2). The total global sales of nutrition products was estimated at about US$ 180 billion in 2003, of which US$66.5 billion was functional foods (Table 3). A significant share of the global nutrition market, as well as functional food in particular, is in developed countries, most notably Japan, North America and Europe.

To provide a more detailed picture of how markets for functional foods and nutraceuticals are evolving, the Nutritional Business Journal (2006) reports that, in the US alone, the nutrition industry grew from a market value of about US$20 billion in 1990 to US$75.4 billion in 2005. In this case, the nutrition industry includes supplements (US$21.3 billion), natural and organic foods (US$20.8 billion), functional foods (US$26.7 billion), and natural and organic personal care products (US$6.6 billion). To put this in context, however, the US market for food products was valued at US $518 billion in 2005, of which functional foods only represented about seven percent. Furthermore, the Nutrition Business Journal defines functional foods rather broadly, including all foods with a valid claim, with added ingredients for health benefits, or that are marketed or perceived to have a significant health or performance benefit.

Table 1. Selected examples of functional foods:

Type of Functional Food	Example	Benefit to Health/Wellbeing
A food that naturally contains sufficient amounts of a beneficial nutrient or non-nutrient component	Oats (beta-glucan) Tomatoes (Lycopene) Fish (Omega-3)	Heart health Reduce risk of Cancer Heart health
A food in which one of the components has been naturally enhanced through special growing condition, new feed composition (animals), genetic manipulation, or otherwise	Eggs with increased omega-3 content achieved by altered chicken feed	Heart health
A food with a modified recipe formulation that incorporates a functional ingredient	Margarine fortified with plant sterol	Lowering elevated blood cholesterol
A food in which the nature of one or more components or their bioavailability in humans has been modified by means of specialized food processing technologies	Fermentation with specific bacteria to yield bioactive peptides	Lower blood pressure and improved gut health and nutrition absorption
A food form which a deleterious component has been removed, reduced or replaced with another substance with beneficial effects	Chewing gum sweetened with xylitol instead of sugar	Helps prevent dental caries

Source: Kotilainen and Rajalahti, 2006 p. 7.

Table 2. Global dietary supplements and functional foods sales (US $ million):

Nutrition Sector	1999	2000	2001	2002	2003	Growth Rate*
Total supplements	50534	51460	53360	56850	60190	4.6%
Functional Foods	46380	50630	55210	61000	66530	9.5%

Source: Nutritional Business Journal 2004 (Oct/Nov, p.4)
*compound annual average growth rate

In 2003, Canada accounted for less than one percent of global sales of functional foods, suggesting that the market is highly under-developed compared to other industrialized countries (Table 3). However, it is estimated that the broader Canadian nutrition sector grew eight percent over the period 2002 and 2003, with an estimated value of nearly US$5 billion in 2003 (Table 4). This rate of growth was, nevertheless, lower than that of most other industrialized country markets, such as the US and Japan.

Table 3. Global nutrition industry, 2003 (Consumer Sales in US $ million):

Country	Vitamins/ Minerals	Herbs/ Botanicals	Sport/Meal/ Home Specialty	Total supplements	Natural and Organic Food	Natural Personal care	Functional Foods	Total Nutrition
	(1)	(2)	(3)	(1+2+3)				
USA	8410	4200	7210	19820	16240	4920	22370	63710
Europe	5900	6220	2970	15090	16290	4640	20710	56730
Japan	4220	2900	2960	10080	2610	2420	16420	31520
Canada	580	400	330	1310	1100	400	2010	4830
China	1900	2400	600	4900	340	900	790	6940
Rest of Asia	1360	1760	1040	4160	930	1190	1360	7640
Latin America	800	310	310	1470	1250	430	530	3670
Australia/New Zealand	600	360	360	1300	780	290	840	3210
Eastern Europe/Russia	500	290	290	1250	370	80	550	2250
Mid-East/Africa	440	220	220	820	230	100	590	1740
Global	**24710**	**19060**	**16420**	**60200**	**40140**	**15370**	**66530**	**182240**

Source: Nutritional Business Journal 2004 (Oct/Nov, p.3)

Functional ingredients are being made available in a wide variety of functional food products, reflecting the various levels and forms of transformation outlined in Table 1. These include dairy, cereal and bakery products, soft drinks, spreads and confectionary products. Van Kleef *et al*. (2005) report that, out of ten possible 'carriers' of functional ingredients, consumers found yoghurt, margarine and brown bread to be the most appealing. These results might explain why functional bakery and cereal products, dairy products and soft drinks saw the largest number of product launches over the period during 2001 to 2005 (Saddler, 2005). Furthermore, AC Neilsen (2005) has identified functional dairy-based beverages as a particularly strong area of growth in demand among North American consumers. With respect to functional ingredients, Omega-3, antioxidants, isoflavones, probiotics and lycopene are considered to have the greatest market potential. Thus, these ingredients have recorded the largest rates of new product introductions over the period 2001 to 2005 (Saddler, 2005).

Consumer acceptability of functional foods and nutraceuticals is governed by a variety of factors including beliefs, nutritional knowledge, attitudes and the socio-demographic characteristics of consumers (see for example Frewer *et al*., 2003a; Saddler, 2005; Verbeke, 2005; Labrecque *et al*., 2006). In the literature some common themes have emerged in consumer acceptability that cut across countries. While consumers are heterogeneous in their perceptions of the health-enhancing abilities of these products, females tend to hold stronger beliefs and are more sustainable users of such products (Saddler, 2005; Bogue *et al*. 2005; Batte *et al*. 2007). This reflects the fact that, more generally, the disease risk perceptions of consumers and their belief about the effectiveness of functional foods and nutraceuticals in lowering this risk is significant in shaping the consumer acceptability of these products (Bredahl, 2001; Frewer *et al*., 2003; Larue *et al.*, 2004).

Table 4. Growth in global nutrition industry (sales US $ million):

Country	2002	2003	2003 Growth %
USA	58520	63710	8.9
Europe	53570	56730	5.9
Japan	28280	31520	9.4
Canada	4480	4830	7.8
China	6040	6940	14.8
Rest of Asia	6860	7640	11.3
Latin America	3350	3670	9.7
Australia and New Zealand	2990	3210	7.4
Eastern Europe and Russia	1930	2250	16.3
Middle-East	800	880	10.1
Africa	790	860	8.8
Global	**168160**	**182240**	**8.4**

Source: Nutritional Business Journal 2004 (Oct/Nov)

It is evident that consumer demand for functional foods and nutraceuticals is based on *perceptions* of their ability to decrease the risk of degenerative diseases, supplement nutritional inadequacies and/or to enhance the beneficial effects of organic functions that are unlikely to be accomplished through regular foods (Roberfroid, 2000; Frewer *et al*., 2003; Roos, 2004). Thus, consumer demand in the United States has tended to be strongest for functional ingredients that have gained significant scientific agreement and endorsement from the US Food and Drugs as reducing the risk of specific disease, for example Omega-3 fatty acids (heart disease), fibre (cancer), plant sterols (heart disease) and calcium (osteoporosis). Such endorsements, arguably, provide basis to consumer perceptions and to the fact that the claimed impacts may be difficult to verify (Chadwick *et al*. 2003).

Functional foods usually have a considerable price premium (Saddler, 2005), such that there is a strong relationship between income and consumer demand (Frewer *et al*., 2003a). However, other variables, such as convenience, time constraints and time preferences, influence this income effect demand (Blaylock *et al*. 1999). Thus, the effect of higher income on consumption of functional foods and nutraceuticals can be mixed and, indeed, there are contradictory results on the relationship between 'willingness-to-pay' for health-enhancing foods and consumer income (Munane 2005; Teratanavat 2005).

One of the glaring gaps is the paucity of systematic research exploring the relationships between differing regulatory regimes for functional foods and nutraceuticals, consumer perceptions and market demand. We might argue that a more liberal, but credible, system of regulated claims will enhance consumer demand by fostering perceptions of the benefits of such products. Thus, a restrictive regime for product claims might be expected to curtail growth in the market for functional foods and nutraceuticals. This is certainly what the Canadian industry claims. At the same time, to the extent that functional foods and nutraceuticals are recognized as integral elements of efforts towards enhancing public health, controls on claims are needed to ensure that consumers make appropriate product choices. This is the critical trade-off that Canada is currently contending with.

3. Regulatory frameworks for functional foods and nutraceuticals in key markets

Regulatory regimes for functional foods and nutraceuticals have evolved around the issue of scientific uncertainty regarding the safety of novel foods, ingredients or processing methods and the health and/or physiological effects (efficacy) that are directly attributable to the constituent in question. In general, regulations aim to establish a reasonable scientific agreement about such effects. While the safety concerns of novel foods, ingredients, or processing methods are driven by toxicity and/or the allergenic effects of products, concerns in relation to the efficacy of those products is driven by the potential for fraudulent behaviour by manufacturers. Reaching a scientific consensus on both of these issues has been the cornerstone of regimes governing functional foods and nutraceuticals[62].

This scenario suggests that regulations governing functional foods and nutraceuticals can be logically grouped into those that deal with product safety versus those that address the efficacy of products and the related claims that are communicated to consumers. In the case of regulating safety of novel foods, ingredients, or processing methods, public authorities aim to validate whether the product is safe such that no harm is likely with 'normal' levels of consumption, while taking account of vulnerable population sub-groups. Here the burden of proof is usually with the manufacturer. In the case of efficacy, regulators aim to assess whether the product actually delivers what it claims. While the search for 'substantial' or 'adequate' scientific evidence of the cause-effect association often requires the sanction of a neutral third party, there are significant differences in the burden of proof across countries.

Across the regulatory regime for functional foods and nutraceuticals, the intent of safeguarding the public from fraud and deception has been an overarching drive of regulations governing functional foods, nutraceuticals and other dietary products in most countries (Hutt and Hutt, 1984; Law, 2003). The objectives of enhancing public health through such regulations are generally implicit and not well articulated in policy goals. Thus, foods and other dietary constituents have historically been prohibited from having claims in relation to preventing, treating or mitigating diseases (Heasman, 2006). Arguably, shifting the focus of such a traditional outlook toward public health goals requires a fundamental transformation of the policy formulation process.

3.1. Regulations for safety of novel ingredient or processing methods

Novel food, ingredient and processing methods are regulated by Health Canada on the basis of protecting public safety. These foods may originate from new or unusual sources, be processed using new processes and include foods derived through genetic modification. The Novel Foods Regulations promulgated under the Food and Drug Act in 1999 (Part II of the Canada Gazette, October, 27, 1999) provide the basis for regulating the safety of new foods or ingredients, with mandatory pre-market approval being required for novel food with 'major changes' (Guidelines for safety assessment of novel foods, 2006). The regulations define novel food to include:

[62] Nestle (2006) put this premise succinctly: "Complicated science is subject to interpretation, and interpretation depends on point of view. And point of view can reflect vested interest" (p. 16). The tension due to interpretations according to vested interests has been the dilemma faced by stakeholders in the health and nutrition debate thus evaluating evidences and policies based on such evidences are promoted in most of the developed countries.

> "Substances including micro-organism that does not have a history of safe use as a food; foods that have been processed with methods that have not been applied to food, or food that is derived from a plant, animal or micro-organism that has been genetically modified".

The interested party is required to inform Health Canada 45 days prior to the sale or advertising of the food in Canada (pre-market notification). This notification must include details of the 'major change', the history of use of the product as a food in a country other than Canada and information relied on to establish that the novel food is safe for consumption. After reviewing these materials the manufacturer is notified whether the novel food, ingredient or processing method is approved.

An alternative route for the approval of functional foods and nutraceuticals in Canada is under the Natural Health Product Regulations that became law in June 2003 (Canada Gazette Part II, June 18, 2003). Under the NHP regulations, firms are required to obtain licenses for Good Manufacturing Practices and appropriate sites. In these two licensing procedures firms are supposed to provide the complete lists of the ingredient and processing method that are intended to use in the manufacturing process of the natural health product. If these ingredients and/or the processing method is novel, the licensing procedure requires the firm to submit a detailed application proving the safety of the ingredients and the processing method.

In the European Union, Regulation (EC) N 258/97 on Novel Foods and Novel Food Ingredients was adopted in 1997 (Ottawa, 2006). Novel foods are considered to be foods or food ingredients that were not used for human consumption to a significant degree within the European Community before 1997. These regulations are quite similar to Canadian regulations as described above. Foods or ingredients that are new and have an intentionally- modified primary molecular structure and novel processed foods or ingredients containing genetically-modified organisms or produced from genetically-modified organisms are governed under these regulations. These novel foods and ingredients should be demonstrated to be safe for the consumer, not misleading to the consumer and not to be different from the existing substitutes to the point that consumers would be worse off nutritionally by switching to the novel food in question (Ottawa, 2006).

In the United States, regulations governing the safety of novel food ingredients are somewhat different to those in Canada and the EU. Novel food ingredients can be incorporated into the food after obtaining the status of a food additive with a petition submitted to the Food and Drug Administration under the Federal Food Drug and Cosmetic Act (FFDCA) or obtaining the Generally Recognized as Safe (GRAS) status. The implications differ significantly according to the product category. Dietary supplements that are governed under the Dietary Supplement and Health Education Act of 1994 (DESHA, 1994) can incorporate novel ingredients without getting approval as a food additive or GRAS status (Heller, 2001). However, novel ingredient in a food product governed under the FFDCA must obtain either food additive or GRAS status to prove the safety of the ingredient.

The GRAS status can be achieved in two ways. The GRAS system was introduced to the US Federal Food, Drug and Cosmetic Act through an amendment in 1958. Thus, if the ingredient has a history of safe use in food prior to 1958 the ingredient can obtain the GRAS status without providing evidence. Alternatively, the GRAS status can be obtained through a review by a panel of FDA qualified specialists by providing evidence that the ingredient is safe under the specific usage of the novel ingredient being proposed. The GRAS status is not conferred as general safety approval and is always usage specific. Thus a firm wishing to market a new functional food in the US needs to receive the GRAS status or seek approval as a food additive. Novel ingredients in dietary supplement do not, however, have to be approved by FDA or obtain

GRAS status (Heller, 2001). Thus, a number of manufacturers have taken the dietary supplement route to obtain approval for their products, including Benecol margarine containing plant sterols (McNeil) and Actimel containing probiotic cultures (Danone). This is perhaps similar to the novel foods versus natural health product route for approval of novel products in Canada.

In general, when a novel food or food ingredients and novel processing method is introduced, manufacturers are required to go through a rigorous process to demonstrate that the product is safe for human consumption. While there are differences across countries in terms of process, evidence-based decision-making is consistently applied to regulate novel foods or food ingredient and novel processing methods.

3.2. Regulation of efficacy - health and other types of claim

At an international level, nutrition labelling and health claims are governed by the Codex Alimentarius Commission through international standards and guidelines on the labelling of food products. Indeed, the WTO has recognized Codex Alimentarius as a reference point in the regulation of international trade under the SPS and TBT Agreements (WTO, 1994). While harmonization to the Codex standard is not required under the WTO, the regulatory regimes in most developed countries share a number of common elements with the respective Codex standards (Hawkes, 20046). Thus, there is substantial agreement among experts regarding the regulation of information on the efficacy of functional foods and nutraceuticals products, and for the need for scientifically sound evidence to support such information.

A claim on a food product is generally taken to be a much broader representation than a mere statement. The *Study on Nutritional, Health and Ethical Claims in the European Union* (Hill and Knowlton, 2000) provides a broader definition on claims:

> "A claim is any direct or indirect statement, symbol, suggestion, implication or any other form of communication (including the brand name) that a good has particular characteristics relating to its origin, properties, effect, nature, method of production, processing, composition or any other quality" (p.25).

Claims relating to foods, nutritional supplements and natural health products can be broadly grouped into nutrition claims and health claims, although grey areas exist between these two groups. Nutrition claims in general deal with either nutrient content and/or their role in general body functions. Two important sub-groups of nutrition claims are nutrient content claims and nutrient-related structure/function or biological role claims. In contrast, health claims deal with disease risk reductions, improvements in general health and/or management and control of specific disease conditions. Two important sub-groups of health claims are "generic" and "product-specific" disease risk reduction claims.

The Codex Alimentarius Commission has defined a health claim as "any representation that states, suggests or implies that a relationship exists between food or a nutrient or other substances contained in a food and a disease or health-related condition." In most countries such claims are highly regulated (Hawkes, 2004) and closely associated with controls on advertising. For instance, the Codex Alimentarius Commission prohibits claims:

> "As to the suitability of a food for use in the prevention, alleviation, treatment or cure of a disease, disorder, or particular physiological condition unless they are: (a) in accordance with the

> provisions of Codex standards or guidelines for foods under jurisdiction of the Committee on Foods for Special Dietary Uses and follow the principles set forth in these guidelines, or (b) in the absence of a Codex standard or guideline, permitted under the laws of the country in which the food is distributed."

The general premise of regulating health claims is to prevent the public from being misled through communication of erroneous information (Ogus, 1984; McNaughton and Symons, 2000). Codex Alimentarius General Guidelines on Claims (Codex Alimentarius, 2001) assert that:

> "The principle on which the guidelines are based is that no food should be described or presented in a manner that is false, misleading, or deceptive or is likely to create an erroneous impression regarding its character in any respect" (p. 25).

In the US, the Kellogg Company in the United States initiated the modern era of food product health claims in 1984[63], which was soon followed by the rapid proliferation of health claims by food manufacturers. In due course, this led to the promulgation of the Nutrition Labelling and Education Act 1990, mandating regulatory approval for health claims through the FDA (Calfee, 1997; Fulgoni, 2005). Other countries and regions have subsequently implemented regulations of health claims, including the European Union and Canada.

3.2.1 Regulation of different types of claims in Canada

Until relatively recently, the regulation of health claims in Canada was undertaken under more general provisions related to the advertising of foods. Section 2 of the Food and Drugs Act 1985 defines advertisement as "any representation by any means whatever for the purpose of promoting directly or indirectly the sale or disposal of any food, drug, cosmetic or device." The definition of a label is "any legend, word, or mark attached to, included in, belonging to or accompanying any food, drug, cosmetic or device or package." Sections 3 and 5 of the Food and Drugs Act establish requirements for food advertising. For example, Section 5 (1) declares that no person shall advertise "any food in a manner that is false, misleading, or deceptive or is likely to create an erroneous impression regarding its character, value, quantity, composition, merit or safety". The Canadian courts have interpreted this provision as imposing a strict liability offence which is subject to a defence of 'due diligence' (McNaughton and Symons, 2000 p. 95). Section 3 of the Act prohibits product-specific disease risk reduction claims, stating:

> "No person shall advertise any food, drug, cosmetic or device to the general public as a treatment, preventative or cure for any of the diseases, disorders or abnormal physical states referred to in Schedule A[64]."

In 1998, Health Canada made moves toward specific regulation of health claims in Canada when it published a *Policy Paper on Nutraceutical/Functional Foods and Health Claims on Food*,[65] proposing the

[63] The message on their All-Bran Cereal boxes claiming a "low fat, high fibre diet may reduce the risk of certain cancers" with the endorsement of the National Institute of Cancer (Ippolito and Pappalardo, 2003).
[64] Schedule A covers 40 diseases and conditions including, arthritis, asthma, cancer, diabetes, heart disease, hypertension, obesity, ulcer of the gastro-intestinal tract, etc.
[65] See http://www.hc-sc.gc.ca/fn-an/alt_formats/hpfb-dgpsa/pdf/label-etiquet/nutra-funct_foods-nutra-fonct_aliment_e.pdf.

use of generic health claims similar to those allowed in the United States. The Food and Drug Act was subsequently amended in 2003 to permit five generic health claims. Namely:

(1) A healthy diet containing foods high in potassium and low in sodium may reduce the risk of high blood pressure, a risk factor for stroke and heart disease;
(2) A healthy diet with adequate calcium and vitamin D, and regular physical activity, helps people achieve strong bones and may reduce the risk of osteoporosis;
(3) A healthy diet low in saturated and trans fats may reduce the risk of heart diseases;
(4) A healthy diet rich in a variety of vegetables and fruits may help reduce the risk of some types of cancer;
(5) Confectionary containing sugar alcohols and dental caries/tooth decay.

Generic health claims are applied to specific food groups (for example fruits and vegetables) or particular foods that have a specific compositional characteristic (such as fibre) and/or a specific nutrition (such as potassium) (Heasman, 2005). These claims, once authorized, can be used on any food product that fits the specified conditions and has the required composition without further scrutiny by Health Canada. However, such claims cannot make reference to a specific food product. Currently, product-specific disease risk reduction claims or product-specific biological role claims are allowed only as "therapeutic claims" that do not make references to any diseases or physiological states listed in Schedule A of the Food and Drug Act, including the majority of diet-related diseases.

Health claims are recognized under the Natural Health Product Regulations, which became law in Canada in June 2003 (Canada Gazette Part II, June 18, 2003). The Natural Health Products claim is defined as:

> "A statement that indicates the intended beneficial effect of a natural health product when used in accordance with the labeled dose (recommended dose), duration of use, and route of administration" (Health Canada, 2004)

The claims permitted for Natural Health Products are arguably the most liberal globally, including structure-function, disease risk reduction and treatment (including diagnosis, treatment and mitigation or prevention of a disease, disorder or abnormal physical issue or its symptoms in humans).

The supporting evidence differs significantly across types of claims. Depending on whether the product in question can claim to be "traditional" or "non-traditional", the required weight of evidence varies. Traditional products are defined as having been in use for at least 50 consecutive years in indigenous or different cultures for the purpose of disease prevention, diagnosis, or treatment. The traditional use claims must be backed by at least two independent references. Safety reports and information on adverse reaction effects must also be submitted for the traditional use claims. Non-traditional use products need to provide a much more stringent set of evidence about the cause-effect association including clinical studies, peer-reviewed publications, pre-clinical studies, reputable regulatory authority reports and/or expert opinion reports (Health Canada, 2006). Very specific criteria are used to evaluate the strength of the evidence supporting non-traditional claims under the Natural Health Product regulations. The strength of evidence is ranked from Level I (well-designed systematic reviews and meta-analyses of randomized controlled trails or other clinical trials or at least one well designed, preferably multi-centered, randomized controlled trail) to Level IV (evidence from reference to traditional uses).

In October 2001, the Health Products and Food Branch of Health Canada proposed a scheme to accommodate product-specific health claims for foods (Health Canada, 2001). This would approve product specific health on a case-by-case basis and grant a Claim Identification Number (CIN) for each claim. The evidence sought to support the claim would be assessed on the basis of six principles:

- Totality of the evidence about the claims (not merely supporting evidence);
- Evidence supportive of a causal relationship between the food intake and its health effect;
- Evidence relevant and generally applicable to the target population;
- A systematic approach used to ensure that all evidences are considered and conclusions are justified;
- High level of certainty of claim validity based on best practices in science review;
- Acceptable design and quality of studies based on best practices in scientific review.

The nature of the required evidence is elaborated in the proposed framework by Health Canada, where two types of evidence are proposed. Type 1, or direct evidence, includes the outcomes of controlled human trials of the food or biologically-active compound. This evidence should be consistent across reproducible human trials, have significant physiological and statistical differences, and provide estimates of the intake required to achieve the claimed effects (which should be based on dose response and there should not be any equally strong opposing re neutral evidence). Type 2 evidence encompasses reviews of human studies, where the similar cause-effect association is observed with reproducible trials. If the claim is for product-specific authorization of disease risk reduction, both Type 1 and Type 2 evidence is required, while for generic authorization Type 2 evidence is deemed adequate. This proposed regulatory approach for health claims in food is in the consultation process and unlikely to be promulgated in the near future.

1.2.2 Regulation of different types of claim in the United States

The use of health claims in food labelling in the US was first authorized by the Nutrition Labelling and Education Act of 1990 (NELA). Subsequently, however, revised legislation governing labelling and claims for dietary supplements was enacted under the 1994 Dietary Supplement Health and Education Act (DSHEA). It is argued that this reflected the fact that most dietary supplements could not withstand the rigorous scrutiny of the FDA in terms of product efficacy, in the same manner to the approval of claims on drugs (Wrick, 2006; Nestle, 2006). Indeed, the DSHEA arguably 'broke down' the regulatory barriers to market entry by creating a separate class of dietary ingredients, distinctly different from food additives and drugs (Wrick, 2006).

The DSHEA does not require manufacturers to submit a dossier of preclinical and clinical studies demonstrating product safety or efficacy where an approved structure-functional claim is used. However, manufacturers of a dietary supplement bearing a permitted claim are required to notify FDA no later than 30 days after the first marketing of the product. In 1997, the set of structure-function claims permitted under the DSHEA was extended by the Food and Drug Administration Modification Act (FDAMA). While the FDA must be convinced that a claim is truthful and not misleading, and that the product is not harmful, it is the FDA's responsibility to prove this in court on the basis of evidence from clinical trials or reports of harm to multiple individuals (Nestle, 2006, p.471).

In the US, a health claim is defined as any claim that expressly or by implication characterizes the relationship of a dietary substance to a disease or health-related condition. Such claims must be pre-approved under the FDAMA or must be issued as authoritative statements by an agency of the US

government with responsibility for dietary guidance or public health or by the National Academy of Sciences or one of its units.

Dietary supplements and food companies have the option to file a petition with the FDA for either an 'unqualified' or 'qualified' health claim. Both types of claims should be supported with sufficient evidence to meet the defined scientific agreement standards. While the products that are channeled as dietary supplements need not go through this process, such products cannot use health claims in relation to health improvement or disease management, but only generic structure-function claims as described above.

In proving a case for efficacy to substantiate a health claim, a variety of sources of information may be compiled. Though elucidation of a plausible biological mechanism is not absolutely required, it is generally regarded as valuable in substantiating the claim. Interventional studies involving placebo-controlled clinical trials are the gold standard for this evidence. The FDA has recently ranked the persuasiveness of the type of research supporting efficacy as follows:

1. Randomized controlled clinical trials.
2. Cohort (longitudinal) studies.
3. Case-control studies.
4. Cross-sectional studies.
5. Uncontrolled case or cohort studies.
6. Time series studies.
7. Ecological (cross population) studies.
8. Descriptive epidemiology.
9. Case reports.

Animal in-vitro studies alone or meta-analysis would not adequately support a health claim. When the NLEA was enacted, authorizing the use of health claims on food, the FDA maintained that it would approve health claims "only with significant scientific agreement among experts." In order to reach such an agreement, there must be a sufficient body of evidence that shows consistency across different studies and researchers. The evidence must help determine whether a change in the dietary intake of the substance will result in a change in a disease end point, and there must be agreement that the relationship is not likely to be reversed by new and evolving science.

A Significant Scientific Agreement (SSA) is the highest level of evidence entertained by FDA, which is the:

> "Agency's best judgment as to whether qualified experts would (be) likely to agree that the scientific evidence support(s) the substance/disease relationship that is (the) subject of (a) proposed health claim. (A) Significant Scientific Agreement means that the validity of the relationship is not likely to be reversed by new and evolving science, although the exact nature of the relationship may need to be refined" (p.3 Guidance by FDA)

The Significant Scientific Agreement then drives from the conclusion that there is a sufficient body of sound, relevant scientific evidence that shows consistency across different studies and among different researchers, and permits the key determination of whether a change in the dietary intake of the substance will result in a change in a disease endpoint. It is generally recognized that an SSA is apparent when a body of consistent, relevant evidence from well-designed clinical and/or epidemiologic and laboratory studies exists

and the weight of evidence is supportive. Further evidence accepted by federal scientific bodies or independent expert bodies as the basis for public health recommendations would include the opinions of the National Academy of Science, National Institute of Health, Centre for Disease Control, American Heart Association, American Cancer Association.

1.2.3 Regulation of different types of claims in Japan

In Japan, functional foods are regulated by the Ministry of Health, Labour and Welfare (MHLW) in the category of "Food for Specified Health Use" (FOSHU) under the Nutrition Improvement Law. In order to obtain the status of FOSHU, the manufacturer must provide documentation showing clinical and nutritional proof of the product and/or its functional components. The documentation must include human studies regarding the eating experience, and documentation concerning the stability of the product and its functional component.

An application for FOSHU status is submitted to the Japan Health Food and Nutrition Food Association (JHNFA) for review by an appointed committee of experienced specialists, generally from Japanese academia. The product application needs at least one clinical study showing efficacy in support of the requested health-related claim, evidence showing a history of safe food use of the functional ingredient and publication of the supporting information in a Japanese scientific journal. Since 2003, at least part of the evidence from the clinical data must be from Japanese subjects. The FOSHU application must explain how the food item in question improves the Japanese diet in general and enhances public health.

Until 2001, regulation of nutraceuticals and dietary supplements was not well established in Japan. At this time, legislation was introduced permitting structure-function claims, in a similar manner to the US. Thus, 'foods with health claims' (FHC) and 'foods with nutrient function claims' (FNFC) are permitted to carry claims relating to 12 vitamins and two minerals. These products encompass both traditional FOSHU products and novel foods and nutraceutical-type products, although a stipulation must be made that the products are not FOSHU and have not been evaluated as FOSHU.

1.2.4 Regulation of different types of claim in the European Union

In January 2007, a new scheme of European Community regulations was adopted for nutrition and health claims and disease risk reduction claims in the labeling, presentation or advertising of food. The regulations were to have come into force in July of 2007. Nutrition claims refer to statements suggesting or implying that a given food has beneficial nutrition properties by virtue of changes of the caloric value (reduced, increased, or does not provide) or changes in nutrients or other substances it contains (reduced, increased or does not provide), where other substances that have nutritional or physiological effects are something other than vitamins and minerals. A health claim is any claim that states, suggests or implies that a relationship exists between a food category, a food or one of its constituents, and health. A claim that posits that the product reduces the risk of disease is any health claim that states, suggests or implies that the consumption of a food category, a food, or one of its constituents significantly reduces a risk factor in the development of human diseases (European Council, 2007).

An extensive scheme has been developed in the EU to assess the scientific support for the claims on food. It is known as the Process for the Assessment of Scientific Support for Claims on Foods (PASSCLAIM). The general outline of the claim substantiation process emphasizes direct evidence of benefits to humans in the

context of their likeable use (as in a regular diet), using biomarkers as an intermediate indicator of effects when ideal end points are not accessible to measurement. The PASSCLAIM process focuses extensively on the measurement and understanding of changes in biomarkers, as a result of consuming the food constituent in question. In particular, with respect to disease risk reduction claims, when the true disease end point cannot be measured directly for ethical or practical reasons, the identification and validation of suitable markers has been emphasized.

Markers are classified as related to the exposure, target function or biological response and appropriate intermediate endpoint of an improved state of health and well-being, or a reduction in the risk of disease, or both. For instance, in the process of building up the PASSCLAIM scheme, the expert panels concluded that biomarkers such as LDL cholesterol and blood pressure are well-established markers generally acceptable to assess changes in the risk of cardiovascular disease. Thus, changes of these biomarkers can be used to substantiate a claim of heart health disease risk reduction. Six specific criteria have been developed defining the data requirements for the scientific substantiation of claims in EU (Aggett, *et al* 2005):

- The food or food component to which the claimed effect is attributed should be characterized.
- Substantiation of a claim should be based on human data, primarily from intervention studies the design of which should include the following considerations:
  - Study group that is representative of the target group.
  - Appropriate control.
  - An adequate duration of exposure and follow-up to demonstration the intended effect.
  - Characterization of the study group's background diet and other relevant aspects of lifestyle.
  - An amount of the food or food component consistent with its intended pattern of consumption.
  - The influence of the food matrix and dietary context on the functional effect of the component.
  - Monitoring the subject's compliance concerning intake of food component under test.
  - The statistical power to test the hypothesis.
- When the true endpoint of a claimed benefit cannot be measured directly, studies should use markers.
- Markers should be biologically valid, in that they have a known relationship to the final outcome and their variability within the target population is known; they should be methodologically valid with respect to their analytical characteristics.
- Within a study the target variable should change in a statistically significant way and the change should be biologically meaningful for the target group consistent with the claim to be supported.
- A claim should be scientifically substantiated by taking into account the totality of the available data and by weighing of the evidence.

Under these new regulations, Member States are required to compile a list of claims by January 2008 and, based on the lists provided by these members and after review by the European Food Safety Authority, the final list of allowable claims will be available by 2010 January (Richardson, *et al* 2007).

2. Implications for Canadian agriculture and agri-food processors

It is evident that crop and livestock producers and agro-food processing firms are responding to emerging markets in the functional foods and nutraceutical sector. A 2005 survey by Statistics Canada estimates that 389 firms are engaged in the sector. Of this total, 118 firms specialize in functional foods and 174 firms in nutraceutical products, while 97 firms undertake activities related to both types of product (Statistics Canada, 2007). Although many of these firms have diversified into functional foods and nutraceutical

product lines from established product markets, products with functional ingredients typically only represent a relatively small proportion of sales, suggesting considerable potential future growth. For example, the 118 firms that specialize in functional foods on average had less than five percent of their total sales of CND$18 billion from functional food products. Firms in the nutraceutical sub-sector, however, typically derive a greater proportion of their sales from these products, averaging 57 percent of sales of CND$2.8 billion.

The institutional environment in which firms in the functional foods and nutraceuticals sector operate has a direct influence on their innovation and commercialization activities and, in turn, their ability to respond to consumer demand. Product innovation and commercialization in the functional foods and nutraceuticals sector shares many of the characteristics of advanced food innovation more generally (Schaafsma and Kok, 2005). However, the sector also has certain unique challenges, such as the regulatory regime that firms face. Indeed, the need to streamline regulatory processes has been widely acknowledged, in both the international (Wrick 2005; Heasman 2005; Gray *et al*. 2003; Lewis-Taylor 2004) and in Canadian context (Doering 2005; Fitzpatrick 2005; Fitzpatrick 2004; Kondro 2004; Gnirss 2004; Ramsey 2002). Studies highlight the direct influence of regulations on the firms in the functional food and nutraceuticals sector including market choices, the disease focus of products, export and domestic market orientation, etc. No doubt, through such influences, regulatory regimes significantly affect the competitiveness and sustainability of the functional foods and nutraceuticals sector.

Hearth *et al* (2006a), using data from the 2003 Functional Foods and Nutraceutical Manufacturers Survey of Canada, found that the regulation of claims has significant impacts on product commercialization among functional food and nutraceutical manufacturers. With respect to generic health claims, firms find that such claims generate a positive impact on their business, and they have fewer product lines in total, as well as fewer product lines on the market, as a result. This situation suggests that the regulatory regime at the time of the survey had a negative impact on the innovative activities of functional food and nutraceutical firms in Canada. Many authors have argued that the regulatory regime in the United States, including DSHEA and NLEA governing dietary supplements, are more accommodating (Johns and Graf, 2001; Ramsay, 2002; Johns and Bourque 2003; Doering, 2005), compared to the Canadian context where public authorities[66] directly define and determine the safety and efficacy of health-enhancing novel products.

Recent amendments to the Canadian Food and Drug Regulations and Administrations that allowed five generic health claims, together with the implementation of the Natural Health Product Regulations, could enhance the conditions for innovation and commercialization of functional foods and nutraceutical in Canada. Indeed, the reform of regulations pertaining to dietary supplements in the United States (as described above) have been cited as a potential reason for the rapid expansion of dietary supplement sales (Table 5) in the post-DESHA period (Wrick, 2006).

Despite the need for a more accommodative regulatory regime, evidently products need to stand the market-based test of repeated purchases and be able to engender consumer confidence by delivering the expected beneficial effects. For example, US sales of herbs and botanicals have been less than expected, perhaps reflecting the fact that a plethora of products was launched without adequate assessments and demonstrations of their beneficial effects (Nestle, 2006). One could argue that the slower and more cautious approach in Canada, involving regulatory approvals of both product safety and efficacy in the case of natural health products, may be advantageous for the Canadian functional foods and nutraceuticals sector in the long

[66] In Canada, if a firm desires to have a claim about health and other physiological effects of the product, the firm should channel the product through the Natural Heath Product Directorate (see Boon, 2003).

run, whereby rigorous regulatory approval serves to establish and sustain consumer confidence in these products.

Table 5. Post-DSHEA growth in the US dietary supplement sales (US $ million):

Product Category	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Vitamins	3870	4250	4720	5320	5620	5900	5970	6025	6179	6648
	-	(9.8)	(11.1)	(12.7)	(5.6)	(4.9)	(1.2)	(0.8)	(2.6)	(7.6)
Herbs/Botanical	2020	2470	2990	3520	3960	4070	4260	4397	4276	4197
	-	(22.3)	(21.1)	(17.7)	(12.5)	(2.8)	(4.7)	(3.2)	(-2.7)	(-1.8)
Minerals	690	800	890	1020	1140	1290	1350	1392	1527	1765
	-	(15.9)	(11.3)	(14.6)	(11.8)	(13.2)	(4.6)	(3.1)	(9.7)	15.6)
Speciality/Other	540	710	860	990	1210	1730	2020	2230	2374	2715
	-	(31.5)	(21.1)	(15.1)	(22.2)	(42.9)	(12.1)	(10.4)	(6.5)	(14.4)
Total	**7120**	**8230**	**9460**	**10850**	**11930**	**12900**	**13600**	**14044**	**14356**	**15325**
	-	**(15.6)**	**(14.9)**	**(14.7)**	**(10.0)**	**(8.9)**	**(4.7)**	**(3.3)**	**(2.2)**	**(6.7)**

Note: percentage growth in parentheses
Source: Wrick, 2006 (p. 10)

Some characteristics of the functional foods and nutraceuticals sector suggest that firms also face non-regulatory barriers to innovation and commercialization. In Canada, the majority of firms are small and medium-sized enterprises (SMEs). In 2005, around 50 percent of firms had less than 20 employees, while 85 percent had less than 100 employees (Statistics Canada, 2007). Problems accessing capital is a predominant obstacle for SMEs seeking to finance their innovation activities or other working capital requirement through sources external to the firm (Carpentier and Suret, 2006; Berger and Udell, 2006; Westhead and Storey 1997; Hughes and Storey, 1994). More generally, there is frequently a lack of collateral because of the dominant role of human capital (in the form of highly educated and skilled scientists) in the functional foods and nutraceutical sector. This can constrain the ability of firms, and especially SMEs, to borrow in order to fund their innovation and commercialization activities.

Furthermore, the reluctance of innovative firms to reveal their ideas to financial markets, because of the non-rival nature of such information, reduces the quality of the signal the firm can deliver about the market potential of a new project (Bhattacharya and Ritter 1983). It is argued that, due to these informational asymmetries and moral hazard problems, innovative activities are difficult to finance in a freely-competitive market (Gompers 2001; Trester 1994; Arrow 1962; Nelson 1959). An added ramification to the signalling problem associated with raising capital for innovative activities is the significant informational rent created by the highly regulated nature of the functional food and nutraceutical sector, especially in the case of novel foods. Scientific uncertainty regarding the efficacy of functional foods and nutraceuticals can aggravate informational frictions between the lender and the borrower. Furthermore, there may be risks associated with the protracted process of approval of novel foods, especially where this process is not well understand and developed, such as in Canada. Innovative activities of this kind are hard to monitor due to information asymmetries and there is a significant potential for the misalignment of interests between the innovating firm and providers of external financing.

Hearth *et al*. (2006b) found that, all else being equal, firms with a high level of functional food and nutraceutical intensity (as measured by share of sales from such products) are more likely to seek external

financing, but to obtain less capital than a firm which has a lower level of dependency on functional food and nutraceutical products. This result may well reflect capital rationing by financiers based on uncertainty over the future. It is fair to say that the functional food and nutraceuticals sector is in its infancy. While growth rates have been strong, future trends are less certain. As markets for functional foods and nutraceuticals move through the product life cycle, growth rates will slow and returns will likely diminish. Furthermore, uncertainty with respect to the regulatory environment in Canada and abroad may give financiers cause to discount anticipated rates of return to firms heavily engaged in this sector. Both of these factors may lead to capital rationing for firms heavily engaged in the functional food and nutraceuticals sector.

The expansion of the functional foods and nutraceutical market is likely to have significant impacts on agricultural production in Canada, yet such effects are difficult to evaluate at this time. A 2002 study (Scott Wolfe Management Inc, 2002) estimates that about three percent of total Canadian agricultural production could be linked with functional foods and nutraceutical products. The estimated contribution of functional foods and nutraceuticals to major primary agricultural sectors are detailed in Table 6.

Table 6. Primary agricultural production and potential contribution to functional foods and nutraceuticals in Canada (Canadian $ million in 2000)

Region	Dairy & Poultry	Meats	Fruits & Vegetables	Grain & Oilseed	Pulse & Legumes	Herb & Botanical	Total
Maritimes	11.6	0.2	20.3	0.6	0	9	41.7
Quebec	56.6	1.3	23.9	20.0	0.1	9	110.9
Ontario	57.8	1.6	45.6	57.8	0.6	36	199.4
Prairies	26.6	5.5	19.1	290.3	12.0	18	371.5
BC	19.0	0.3	23.5	1.8	0	27	71.6
Canada	171.7	8.8	132.4	370.5	12.7	99	795.1
% of FFN	2.8%	0.1%	5.4%	5.2%	2.0%	90%	3.1%

Source: Scott Wolfe Management Inc. (2002) p.16

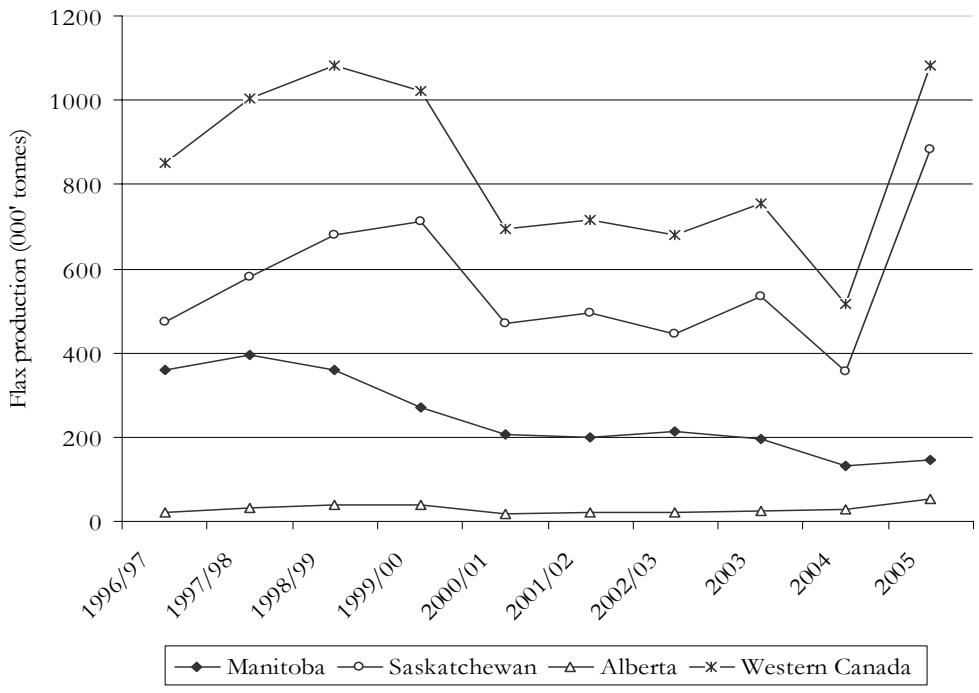
The commodity that is estimated to most gain from markets for functional foods and nutraceuticals is grains and oil seeds, accounting for around half of related sales (Table 6). This suggests that the major benefits are likely to be experienced in Prairie Provinces. For instance, flax production has been promoted by the FLAX 2015 initiative, which promotes this crop on the basis of its health-enhancing properties (Biocrop News, 2005). Traditionally, flax seed oil has been used for industrial purposes, such as oil-based paints and coatings, and linoleum flooring materials. Even today, such uses account for 80 percent of flax seed oil utilization. Key nutrients in flax seed are Omega-3 alpha linolenic acid (accounting for 55 percent of the total oil content) and fibre, with an ounce of flax seed providing 32 percent of the recommended daily fibre intake. According to the Flax Council of Canada, the use of flax in bakeries and cereals has tripled the demand for the flax in the North American food industry. Canada is the world's leading flax producer and exporter with about 2 million acres in 2005 producing about 1.035 million metric tons. Saskatchewan is the leading producing region in Canada (Figure 1).

Primary production agriculture is the main raw ingredients supplier for the functional foods and nutraceuticals sector (Statistics Canada, 2007). With the exception of herbs and fish, most of these raw materials are sourced in Canada. For example, supplies of oil seeds, grains and cereals supplied to the functional foods and nutraceuticals sector are dominated by Canadian production. A secondary impact on primary production may be through the general enhancement of consumer demand for agricultural and food

products. Thus, the inclusion of probiotic cultures in yogurt has acted to boost yogurt sales in Canada. As functional ingredients are encompassed in a wider range of dairy products, the aggregate demand for milk could be enhanced.

It is evident that markets for functional foods and nutraceuticals could have beneficial impacts on the Canadian agriculture sector, which itself can play a synergistic role in the growth of the sector. However, the scope for primary producers to act as ingredient suppliers, and the level and nature of their linkages with functional food and nutraceutical manufacturers, are unknown. Indeed, we know very little about the existing linkages between agriculture and the functional foods and nutraceuticals sector. Furthermore, policies aimed at the agricultural and functional food and nutraceuticals sector will play a role. Certainly, we need to explore whether policy changes are needed at AAFC and Health Canada. These departments need to work together to balance the objectives of protecting consumers against unsafe products and fraudulent claims, and promoting products that could contribute to the enhancement of health while contributing to the welfare of agricultural producers and, broadly, those engaged in the agri-food sector.

Figure 1. Flax production in Prairie provinces, 1996-2005:



Source: FLAX 2015

Table 7. Source of ingredients for Canadian FFN products (Number of firms)

Ingredient	Functional foods firms		Nutraceutical Firms		Both Sub-sectors		All firms	
	Canadian	Foreign	Canadian	Foreign	Canadian	Foreign	Canadian	Foreign
Dairy products	19	6	15	6	15	18	49	30
Oil seeds	45	-	37	-	25	6	107	20
Meat/poultry & other animal products	9	-	14	-	15	4	37	19
Seafood or marine species	8	0	24	37	11	9	43	46
Grains and cereals	40	-	15	13	30	12	85	27
Pulses and/or legumes	18	-	6	16	12	7	36	25
Fruits	17	-	11	20	23	9	51	32
Vegetables	16	-	3	10	17	8	37	23
Herbs and spices	5	3	28	56	18	37	51	97
Other	12	12	17	17	0	12	29	40

Source: Statistics Canada, 2007 (p. 29)

3. Summary and conclusions

Arguably, functional foods and nutraceuticals should be integral to public policy aimed at promoting healthy eating and public health, both to enhance wellbeing and reduce public health care costs. On the one hand, private food product and ingredient firms are already exhibiting significant rates of innovation and commercialization of new products, even within the constraints posed by the current regulatory regime for novel products and claims. Furthermore, the development of markets for functional foods and nutraceuticals could present potentially valuable opportunities for the Canadian agri-food sector. On the other hand, such products could potentially play a significant role in reducing the incidence of diet-related disease, especially in high-risk groups. At the current time, however, there is no coherent policy on functional foods and nutraceuticals in Canada. Essentially the government has defined a regulatory platform for such products but has not considered how they integrate into health promotion and agri-food policy.

The potential impact on the agri-food sector in Canada of growth in the market for functional foods and nutraceuticals is significant. A number of key agricultural products in Canada are potential sources of functional ingredients, such as soy, tomatoes, pulses, and flax. Furthermore, the demand for dairy and cereal food products could be enhanced through incorporation of functional ingredients. The market for these ingredients and products, both domestically and internationally, is likely to expand significantly over time. The critical issue for Canada is to establish and maintain a competitive position in key markets. The

regulatory regime for functional foods and nutraceuticals as well as broader policies, for example on research, innovation and intellectual property, will play a critical role in this regard.

While regulatory regimes generally aim to establish reasonable scientific agreements on product safety and efficacy, the standards of evidence required do differ and, as a consequence, the stringency of approval processes for products, ingredients and processes varies. The United States tends to be at one extreme of this regulatory regime, while Canada and the EU are at the other end. Granted, regulations afford significant protection to consumers. Yet new products can have considerable health benefits, and therefore costs can result from restricted and/or delayed availability. Likewise, with respect to the ability to make claims, there is a trade-off between protecting consumers from false information and allowing the free communication of potential benefits that might enhance consumption of such products. In the case of Canada, while nutraceuticals fall under the relatively liberal regime of the Natural Health products regulations, functional foods are more heavily restricted.

Considerable disagreement exists about the role of functional foods and nutraceuticals in the promotion of public health and, as a consequence, their position in an integrated agri-food policy that incorporates public health considerations. On the one hand, there are concerns about focusing on specific products rather than encouraging a total diet approach to enhanced nutrition. On the other, there are concerns about the efficacy of functional ingredients that are approved on the basis of clinical trials but for which the wider public health impacts are less well established. Putting such issues aside, critical issues for public policy include how to facilitate access to functional foods and nutraceuticals, especially in disadvantaged groups, and how to communicate the specific benefits of such products to 'at risk' groups.

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9. Nutrigenomics: Reducing Chronic Diseases in Canada by Linking Genomics with Nutrition

Ahmed El-Sohemy[67] on behalf of the Canadian Nutrigenomics Committee

1. Introduction

Over the last century, substantial improvements to human health have been made through improvements in the quantity and quality of available food. The average Canadian's lifespan has increased by 20 years and average IQs have increased by 20 points during this period[68]. While human longevity has increased through advances made by nutritional and public health sciences and agri-food production, the chronic diseases of obesity, diabetes, and related co-morbidities have reached epidemic proportions throughout the world.

Canadians have not escaped these epidemics:

- Cardiovascular disease killed over 72,000 Canadians in 2004[69], with the estimated total cost to the economy of ~ $20 billion[70].
- Type 2 diabetes affects nearly 1.5 million Canadians, costs the healthcare system an estimated $13.2 billion per year, and is expected to increase to ~$19 billion in 2020[71].
- Obesity costs Canadians $1.6 billion in direct and $1.7 billion in indirect costs per year[72].
- Cardiovascular disease, diabetes, and cancer cause suffering for many Canadians and cost the economy $55 billion per year[73].

The projected worldwide increases in preventable diseases are staggering. For example, it is estimated that over 340 million people will suffer from diabetes by 2030[74]. Other nutrition-related diseases are also increasing at alarming rates. The vast number of individuals with chronic diseases in industrialized as well as developing countries will soon overwhelm our healthcare systems. If nothing is done, the personal and societal costs will increase dramatically since obesity and diabetes and their related co-morbidities now occur more frequently in children and young adults. It is universally accepted that disease prevention is less costly and more desirable than disease treatment[75], and better nutrition is clearly an important strategy for disease prevention.

2. Nutrition and the Prevention of Chronic Diseases

Nutrition is one of the most important determinants of health. Establishing optimal dietary habits to maintain health requires a means of assessing the effects of macro- and micronutrients, toxins, and non-nutritive bioactive components of food in each individual. Our healthcare and public health system provides a remarkable success story for such personalized nutrition. Newborn screening for inborn errors of metabolism such as phenylketonuria (PKU) is one such example. Based on the groundbreaking research of Charles

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Scriver (McGill University) and others, newborns are routinely tested for the presence of abnormally high concentrations of the amino acid phenylalanine[76]. Excess levels of phenylalanine cause severe mental retardation and there are no treatments to reverse the long-lasting effects. Dietary restriction of phenylalanine in childhood permanently prevents intellectual disability, such that adult patients may relax the diet if they wish (except during pregnancy) and not suffer major consequences. PKU is caused by mutations in the gene responsible for metabolizing phenylalanine to tyrosine, or in related pathways that affect the cofactors that participate in the reactions. These original discoveries occurred in the field of rare metabolic disorders, yet demonstrated the principle that the deleterious effects of specific genetic variants could be overcome by dietary changes.

Obesity, diabetes, and cardiovascular diseases (CVD) are more complex than monogenic disorders like PKU, because chronic diseases result from contributions of many genes interacting with multiple environmental influences, such as nutrition. While population-based studies have associated excess calories and certain nutrients with incidence and severity of chronic diseases, a growing body of evidence now shows that individuals with different genetic profiles respond differently than the population average to the same nutrient intakes. Similarly, geneticists have identified gene variants that predict the risk of CVD, diabetes, obesity and other diseases, but the inconsistencies among these studies can also be explained, in part, by different environmental factors such as diet. The precise causes, therefore, cannot be uncovered by focusing on either nutrition or genetics alone.

3. Improving Health by Linking Genomics with Nutrition

The primary obstacle to developing nutrition-based prevention strategies is the lack of knowledge of how nutrients affect an individual's health. When nutritional epidemiological studies associate nutrient intakes with a measure of disease risk, the result is a statistical average of the variability in risk attributed to the consumption of these specific nutrients in that population. However, a large body of evidence has demonstrated that individuals react to and benefit from nutrition in very different ways; it has become clear that the different individual responses to nutrients are the result of our unique genetic profiles. This explains to some extent the important discrepancies among population-based studies that relate nutrient and food intake to health outcomes.

While nutritional and genetic sciences have individually made fundamental contributions to disease prevention and treatments, a more complete understanding of health and disease processes must now include the simultaneous analyses of nutrient intakes and genetic make-ups. Nutrigenomics differs conceptually and practically from traditional nutrition or genetic research in that both genotype and diet are assessed in each experiment to determine how genes and nutrients interact[77]. It is the combination that matters most, not the individual foods consumed or genes inherited. Such studies have become feasible only since the advent of high throughput genomic (genetic and transcriptomic), proteomic, and metabolomic technologies.

The promise of this field has not only been recognized by nutritional and genomic researchers, but by interested yet dispassionate observers such as The Nuffield Trust in the UK. They recently concluded that nutrigenomics "*has great potential to increase our understanding of the molecular mechanisms through which diet influences disease*."[78]

[76] Scriver, C.R.
[77] Ruth, L.W.
[78] The Nuffield Trust

4. Needed Research

While it is well known that the risk of developing the major chronic diseases is greatly enhanced by inadequate nutrition, the rate at which the scientific community has been able to identify the dietary factors that are most important for prevention has been slow. Also, nutrition and genetic research have often yielded conflicting conclusions due to differences in the genetic makeup of the populations studied, imprecise measures of dietary intake, and the complexity of biological processes that favour health or lead to disease. To understand these limitations, it is critical that future experimental strategies be designed to measure, quantify, and account for the genetic and environmental factors that contribute to health and disease. In this context, emerging "omics" technologies – the ability to measure many genetic variations in each individual as well as hundreds to thousands of metabolites, proteins, and RNA in biological fluids and tissues – are readily available and are required to unravel the complex interactions between genetic profiles and physiological responses to food and nutrient intake.

However, biomedical researchers are missing essential elements in the study of health and chronic diseases. These elements are validated biomarkers, which can be used to determine exposure to specific nutrients and non-nutritive dietary factors, and health in individuals at different ages, stages of development, and different ancestral backgrounds. A biomarker is defined as a characteristic that is objectively measured and evaluated as an indicator of normal biologic processes, pathogenic processes, or pharmacologic/nutritional responses to a therapeutic intervention. Biomarkers can be genetic (such as a single nucleotide polymorphism or SNP), a metabolite (e.g. cholesterol levels), RNA levels or patterns of expression, proteins (e.g. insulin levels), or other measures of a biological process (e.g. blood pressure, X-rays, MRIs). The use of biomarkers can be extremely informative because it can substitute for measured clinical endpoints (e.g., myocardial infarction), which generally require large, lengthy and costly population-based studies.

As indicated above, one of the major limitations in the study of nutrition and health is our inability to adequately assess food intake in population-based studies. Thus, validated biomarkers are a key missing element for the study of health and chronic diseases. There are currently no accepted and validated biomarkers of most nutrients in the healthy state and for different stages of chronic diseases for the different genetic profiles that constitute our nation or the world's populations. A large-scale initiative to identify and validate biomarkers associated with nutrient intakes is needed precisely because of the complexities of genetic variations, environmental factors, and biological processes. Typical research projects in nutrition generally do not have the resources to analyze these variables in a large enough population to produce accurate, sensitive, and reliable biomarkers linked to surrogate or clinical endpoints.

A distinct advantage for Canada to support a nutritional biomarkers initiative is the tremendous ethnic diversity in Canada and its universal health care system. Since gene-diet interactions directly depend on the alleles one inherits and the chances of inheriting specific alleles depends on ancestral lineage, a full understanding of how nutrients affect health can only come from studies in individuals of different genetic backgrounds. Canadian researchers, with appropriate consent from individuals, have access to many of the world's ethnic populations. Discoveries made here will not only help Canadians, but will be applicable to Canada's source populations (e.g., European, East Asian, South Asian, First Nations).

5. The Fundamentals of Nutrigenomics Research

The technologies employed in nutrigenomics research are identical to functional genomics – high throughput analyses of genotype, transcripts, proteins, and metabolites (i.e., omics technologies). These are complemented by analyses of nutritional, clinical, physiological, demographic, and environmental factors. Bioinformatics, defined as acquisition, management, storage and retrieval of high throughput datasets, and biocomputation, defined as the analyses of those datasets, are critical components of the research and application of nutrigenomic knowledge. While nutrigenomics encompasses the full spectrum of research strategies from basic cellular and molecular biology to whole body metabolism, clinical science, and population health, the key aspects of the experimental designs are the analyses of genotypes *and* nutrient intakes in humans or the systematic manipulation of genotype *and* nutrient intakes in model systems such as cell culture and laboratory animals. Nutrigenomic experiments can be conducted using primates, rodents, flies (*Drosophila* sp), worms (*C.elegans*), human and rodent cell cultures, and yeast (*S. cerevisiae*). Experimental systems have different strengths such as exact knowledge of genotype (e.g. inbred mice) and the ability to control environmental factors (including diets). In all cases, results from model systems need to be translated to human studies.

Numerous studies have shown that nutrients alter the expression of genetic information at the level of gene regulation, signal transduction, and through alterations of chromatin structure, enzymes, and proteins (rev. in[79]). In addition, population-based studies have shown reproducible gene-nutrient-phenotype associations demonstrating that individuals with different gene variants are affected differently by nutrient intakes (rev. in[80]). Many of these published studies rely on biomarkers (e.g. serum lipids) that are important components of the disease process, but do not include biomarkers of other processes that contribute to disease. The result is that we are missing important pieces of a partially completed, complex puzzle. The proposed initiative seeks to develop biomarkers to complete the picture of how disease occurs in each individual.

6. Nutrigenomics Roadmap

The scientific approach to nutrigenomics consists of two fundamental steps. The first is oriented towards data collection - the relationships among genes, the way we metabolize food, and disease. This work would be done through short-term, controlled clinical trials as well as long-term epidemiological studies. We would then be in a position to devise simple tests to classify a person's genotype, their propensity for chronic disease and guidelines on nutritional practices designed to optimize health. To progress in this area, we need to identify and validate biomarkers of nutrient intake. Bioinformatics and statistical tools are needed to help process the large amounts of data that will be generated. Important research facilities dedicated to clinical and population-based studies in nutrition are also required.

The second step involves relating the biomarkers of exposure to disease outcomes. This can be done in overlapping initiatives using cell culture and animal models of disease, human clinical trials and population-based studies. Each model system has distinct advantages and contributes key information about health and disease development. Identifying genetic variations that affect the absorption, distribution, metabolism and excretion (i.e., ADME) of nutrients will provide better estimates of nutrient exposure to the target cells/tissues of interest. The impact of nutrition on gene expression provides important information on potential molecular mechanisms of action. All of this research relies on techniques in genotyping, transcriptomics, proteomics and metabolomics. Together, they will require a systems biology approach to analyze the interrelationships among the complex data collected.

[79] Kaput, J.
[80] Corella, D.

Once this basic work is underway, there will be a need to develop and refine inexpensive methods for identifying the way that individuals respond to nutrition. This can be done by classifying sub-populations according to their genotype and analyzing food metabolites that associate with a given genotype. Dietary intakes will be assessed as a part of these analyses. Genotyping can be carried out inexpensively by developing tailor-made diagnostic kits, and metabolites can be identified through standard analytical methods carried out on either blood, saliva or urine.

7. Ethical, Economic, Environmental, Legal and Social (GE^3LS) Issues

The Canadian program of genomic, ethical, economic, environmental, legal and social (GE^3LS) issues related to nutrigenomic research and applications has received international recognition and acclaim. GE^3LS research will contribute significantly to the proposed Canadian nutrigenomics program, since one aspect of this research is to work with individuals from the community and in clinical settings. In articles, book chapters, and books[81], GE^3LS has identified key issues in nutrigenomics: ensuring that ethical guidelines regarding human genetic testing are followed; regulating the delivery and marketing of genetic testing services; regulating food products and nutritional supplements; industry oversight and consumer protection; capacity building for health professionals; models for incorporating nutrigenomic services into health systems; and public understanding and acceptance of nutrigenomics and related products and services.

Among the novel challenges that will require GE^3LS involvement and leadership will be (i) how to resolve informed consent issues about the amount and extent of personal, genetic, and physiological data that will be obtained and analyzed – in some cases on more than one occasion since health status needs to be measured over time and (ii) how to engage with and appropriately address the concerns of Canadian First Nations populations and the various ethnic groups. The incidence and severity of chronic diseases is greater in these populations and they suffer from disparities in access to quality healthcare[82]. For example, a Canadian study demonstrated that the onset of diabetes conditions (e.g., elevated glucose, lipids, and blood pressure) begins at a lower body mass index (BMI - a routinely used biomarker) of ~21 in Southeast Asians, Asians, and First Nation peoples compared to European descendents, where such conditions begin at BMI $\geq$ 25[83]. Nutrigenomic knowledge may improve individual and population health in these groups, but only if they actively participate in ethically-based research programs.

8. Biomarkers of Nutrient Intake

One of the significant limitations in developing preventive strategies for individuals is the lack of reliable biomarkers regarding nutrient intake. The typical disease focus of most research efforts has not provided data that links a specific diet or food with a metabolite, protein, mRNA, or gene variant that provides suitable information about the health status of the individual. Monitoring health would allow for ways to assess optimum diets for each individual. Such biomarkers do not currently exist. The combinations of improved experimental designs, omics' technologies, and multivariate analytical methods can overcome the challenges of genetic heterogeneity, the resulting physiological variability among individuals, and the chemical complexity of food to identify and validate these biomarkers.

[81] Castle, D
[82] Bramley, D
[83] Razak, F

When further developed and validated, the knowledge of nutrigenomics can be used to tailor nutrition to an individual's unique genetic make-up – much like the early life restriction of phenylalanine improves the health and longevity of individuals with PKU. The benefit that flows from targeting nutritional advice to population sub-groups or to individuals is referred to as "personalized nutrition". Recent discoveries in the field have created a demand for individualized dietary recommendations to manage chronic disease based on genetic profiling. Indeed, the US-based think-tank Institute for the Future forecasts that about one-third of the consumer market will focus on personalized nutrition and that "*a sizeable segment of consumers will be open to making day-to-day decisions about what to eat based on their particular genetic makeup.*" Creating evidence-based personalized nutrition advice will empower consumers to make individualized food choices that are best suited to their own genetic makeup. Identifying individuals that are most likely to benefit from specific dietary interventions will increase the efficiency of existing nutrition programs and clinical trials, and improve consistency among studies involving human populations. While appearing as a more distant objective, there is little doubt that personalized nutrition is one of the fundamental concepts and possibilities of future nutrigenomics efforts.

9. Chronic Disease Biomarkers

The undeniable contribution of nutrients to health and disease has significant implications for biomedical research designs and for the diagnosis for disease. A biomarker developed for health or for disease is, by definition, "context specific." The level of a metabolite or protein in the serum will depend upon a person's genetic make-up, their nutrient and environmental exposures, and the status of their health (or stage of disease). Many experimental strategies to define biomarkers rely solely on nutrient intake associations with a metabolite (dietary fat or cholesterol with serum lipids) or associations of a gene variant with disease (BRCA1 and breast cancer). We now know that the genotype matters in determining health and the need for nutrients to prevent disease (e.g., MTHFR C677T with the need for more dietary folate). By comprehensively analyzing genetic make-up, nutrient intakes and other environmental factors, and standard or omic clinical analyses of biological fluids, we will generate data for identifying novel biomarkers of health and disease. Given the complexities of the factors (genetic, environmental, biological), we anticipate that a panel of biomarkers will be generated for determining health or disease processes in individuals. These biomarkers will be most reliable when used in conjunction with tests of genetic profile (ancestry and individual genes involved in health or disease) and assessments of environmental exposures. This prediction is based on the known facts that genes and nutrients interact differently in individuals and hence the use of biomarkers must account for these interaction differences by assessing genetic and environmental factors. Scans of published literature and pharmaceutical industry websites indicate that this is a novel approach to biomarker identification, validation, and use.

10. Improvement in personal nutrition, Health, and Lower Healthcare Costs

Developing a knowledge base that links nutrient intakes and genetic make-ups with health or disease will improve individual health, population health, and in so doing, help control healthcare costs. One of the basic concepts of nutrigenomics is that gene-diet interactions differ among individuals, including between ethnic groups. Recognizing this concept is fundamentally important in producing a complete scientific understanding of how food enhances or alters health in individuals. The consequence of this scientific approach is that our Canadian initiative will identify sub-groups that share specific genomic/metabolic traits that may benefit from special nutritional guidance. For example, folate is added as a nutritional supplement to flour sold in Canada. It acts to prevent serious birth defects such as spina bifida, particularly in children

born to mothers with a specific variation in the MTHFR gene. Thus, while all mothers receive folate, the major beneficiaries are a sub-group of the population that share a genetic variation in MTHFR. As knowledge of nutrigenomics expands, genetic testing will allow sub-groups of the population to be identified that could benefit from special nutritional guidelines or food.

11. Impact on the Agri-Food Industry

Just as the scientific knowledge of gene-diet interactions in PKU led to improved health for specific patients and genetic screening of newborns, there are opportunities for many stakeholders to use the science and its applications for individual and public health through improved foods. The economic benefits of nutrigenomics could be realized in health care, agriculture, food manufacturing, nutritional supplements and evidence-based personalized nutrition testing.

Canada is uniquely positioned to have a major impact on the global functional foods market and production of functional food ingredients because of strong nationwide ties between industry and academia.

- Canada is one of the world's leading food producers, with 8.1% of the economy (~$80 billion) dependent on food production, processing, distribution and manufacturing [17]. The food industry provides a foundation to capitalize on the global functional food and nutraceutical market, which is expected to be US $500 billion by 2010 [17].
- Canada maintains a nutraceutical market share of 3% that, with modest increases of retail sales, will likely exceed US $15 billion per year and potentially creating 130,000 direct and indirect jobs in Canada [18].

In Canada, this innovative environment has led to (i) the development of new crops and foodstuffs that produce maximum yields of healthy oils, vitamins and other essential nutrients, (ii) one of the most comprehensive programs in food fortification, food safety, and food labelling in the world, and (iii) a strong regulatory environment. While the Natural Health Product Regulations establish high standards of evidence for claims and as well as for safety and quality of foods and natural health products, the evolving field of nutrigenomics is likely to aid in producing scientific data to support health claims. The Canadian nutrigenomic community is enthusiastic about actively participating in the refinement of procedures for regulating existing and novel foods.

An equally compelling reason for supporting the Canadian nutrigenomics initiative is the substantial investments in research and development in this field throughout the world. Nutrigenomics is currently on the agenda of or under active development in many major multi-national food and personal products companies, such as *Kraft, Unilever, Cargill, Danisco, Amway, Proctor & Gamble,* and *Nestlé*. Several of these companies interact or collaborate with nutrigenomic research initiatives funded by the EU, such as NuGO (http://www.nugo.org/), Lipgene (lipid metabolizing or regulatory genes - http://www.lipgene.org), and Diogenes (diet and obesity genes - http://www.diogenes.org). The European Union Framework 6 program (their funding cycle) supported 7 major projects related to nutrigenomics from 2004 through 2009 [19] at a level of €15 - €20 million for 3 – 5 years each. Nutrigenomics New Zealand also has a 6 year, ~NZ$18 million project that is developing a proof-of-concept process for developing medically relevant foods. To remain competitive in the global research community and food industries, Canada needs to invest in an innovative program linking foods to individual and public health. With the aging population of baby boomers in Canada and elsewhere, the growing epidemic of chronic diseases in transitional and developing economies, and the predicted rise in retail sales of processed foods in transitional and developing economies

[20], there will continue to be a strong demand for developing novel foods with added health benefits for the Canadian and worldwide economies.

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10. System Thinking: A Conceptual Framework for Integrated Food and Health Policy

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1. Introduction

There is a lack of integration between the knowledge generated to support the health system – encompassing researchers, health practitioners, policy makers and the public as a whole – and the application of such knowledge into innovations to improve the health of populations. The rapidly increasing numbers of people with chronic disease coupled with the related (projected) rates of mortality and morbidity have spurred calls to create, translate and apply new knowledge. System changes are needed to bridge the functions of knowledge *generation* – both through research and practice/experience – and knowledge *application* to improve the public's health through better decision-making and policy development.

Understanding evidence about effective policies in complex systems requires the ability to synthesize research and theory across diverse fields. There is a growing understanding of the need to balance traditional, "reductionist" scientific methods with more ecological, "whole system" integrative paradigms (National Cancer Institute, 2007). "Where the world is dynamic, evolving, and interconnected, we tend to make decisions using mental models that are static, narrow, and reductionist" (Sterman, 2006). See Table 1. The increasing emphasis on systems thinking as an organizing rubric reflects a confluence of trends among very different fields that have begun to emphasize systems thinking, including business, engineering, physics, military science, agriculture, weather forecasting and public health.

2. Why A Systems Approach?

Figure 1 shows some of the key features that need to be considered in developing integrated food and health policy. This social ecological framework highlights four critical requirements for an integrated food and health strategy:

- No one sector can succeed by itself. **Strategic collaboration** is key. Meaningful collaboration takes place among the stakeholders in agriculture, food and health. This can be interdepartmental in government, across different levels of government, internationally, and with industry, health organizations, research organizations and the public. Collaboration goes beyond perfunctory "consultative exercises", and includes the setting of goals and objectives, synergistic research collaboration, as well as "ownership of the policy" and resource commitment.
- No one level of government can succeed by itself. Through strategic collaboration, **multi-level alignment** of policy, strategy, and action will be key to success.
- Government cannot succeed alone. Effective action requires **broad based engagement** of the public and multiple sectors working together toward a shared understanding and vision (common mental models). This challenges currently siloed systems for both health care and agriculture.

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- The multiplicity and complexity of factors affecting food and health exceeds our current knowledge. There is sufficient evidence-based knowledge to design integrated food policy and strategy, but long-term success demands **integrating monitoring, research, and innovation platforms**.

Systems thinking has several key features that support integrated policy:

- Complex systems don't lend themselves to simple solutions. A **coordinated mix of effective strategies** is necessary to produce significant effects.
- **Diversity** is taken as a given. There is a recognition that "context counts," and there will be no magic bullet (no one-size-fits-all solution for different situations).
- The ingredients in a comprehensive policy don't interact in neat, linear ways. There will be a **dynamic interplay that changes over time** and often produces unexpected effects. Results can be anticipated and coordinated with careful modelling.
- By combining strategies at one level – e.g. home/family – new dynamics emerge at higher levels that are **more than the sum of the parts**.
- The systems involved in comprehensive food policy are multilevel and dynamics will translate from one level to another.
- Systems are **self-organizing** – integrated policy can start the process or steer the course, but cannot be managed with "command and control".
- Effective solutions are most likely when **built bottom up** – e.g. national policies grounded in the real world and priorities of the farmer or the low-income grocery shopper.
- Integrated policy requires built in **feedback loops** across levels and sectors so that effects and interactions can be observed, provide sources of learning, and be continuously refined, as effects are better understood.

Since the multiplicity and complexity of factors affecting food and health exceeds our current knowledge, **continuous evidence-based learning** through these feedback loops is a critical success factor. Learning in a complex system places emphasis on the anticipation of potential changes, rather than a prescription for change. Within a complex adaptive system, one can only anticipate change rather than predict it based on the available data. A traditional learning model, in contrast, emphasizes links between inputs (causes) and outputs (effects) in a more linear manner with attention paid to diagnosis, design and manipulation of the variables within a system as a means of achieving a desired output. The former views the system as dynamic, unpredictable, and interactive, whereas the latter holds the system as more static, controllable, and deterministic. These different perspectives are sometimes described as *complex* and *complicated* respectively. Complex systems view the parts as interrelated with problems resulting from interactions between them, requiring more holistic interventions. By contrast, complicated systems are those that recognize the influence of multiple agents in a process. But these systems view those influences as functioning in a relatively linear manner, whereby problems with each part can be diagnosed, targeted and remedied independent of the other parts.

Policy resistance to systems thinking arises because systems are:

- *Constantly changing.* Heraclitus said, "All is change." What appears to be unchanging is, over a longer time horizon, seen to vary. Change occurs at many time scales, and these different scales sometimes interact. A star evolves over billions of years as it burns its hydrogen fuel, but can explode as a supernova in seconds. Bull markets can rise for years, then crash in a matter of hours.

- *Tightly coupled.* The actors in a system interact strongly with one another and with the natural world. Everything is connected to everything else. "You can't do just one thing."
- *Governed by feedback.* Because of the tight couplings among actors, our actions feed back on themselves. Our decisions alter the state of the world, causing changes in nature and triggering others to act, thus giving rise to a new situation, which then influences our next decisions.
- *Nonlinear.* Effect is rarely proportional to cause, and what happens locally in a system (near the current operating point) often does not apply in distant regions (other states of the system). Nonlinearity often arises from basic physics: insufficient inventory may cause you to boost production, but production can never fall below zero no matter how much excess inventory you have. Nonlinearity also arises as multiple factors interact in decision-making: Pressure from the boss for greater achievement increases your motivation and effort—up to the point where you perceive the goal to be impossible. Frustration then dominates motivation—and you give up or get a new boss.
- *History-dependent.* Many actions are irreversible: you can't unscramble an egg (the second law of thermodynamics). Stocks and flows (accumulations) and long time delays often mean doing and undoing have fundamentally different time constants: during the 50 years of the Cold War arms race, the nuclear nations created more than 250 tons of weapons-grade plutonium (239Pu). The half-life of 239Pu is about 24,000 years.
- *Self-organizing.* The dynamics of systems arise spontaneously from their internal structure. Often, small, random perturbations are amplified and molded by the feedback structure, generating patterns in space and time. The stripes on a zebra, the rhythmic contraction of your heart, and persistent cycles in measles and the real estate market all emerge spontaneously from the feedbacks among the agents and elements of the system.
- *Adaptive and evolving.* The capabilities and behaviors of the agents in complex systems change over time. Evolution leads to selection and proliferation of some agents while others become extinct. People adapt in response to experience, learning new ways to achieve their goals in the face of obstacles. Learning is not always beneficial, however, but often superstitious and parochial, maximizing local, short-term objectives at the expense of long-term success.
- *Characterized by trade-offs.* Time delays in feedback channels mean the long-run response of a system to an intervention is often different from its short-run response. Low-leverage policies often generate transitory improvement before the problem grows worse, whereas high-leverage policies often cause worse-before-better behavior.
- *Counterintuitive.* In complex systems, cause and effect are distant in time and space, whereas we tend to look for causes near the events we seek to explain. Our attention is drawn to the symptoms of difficulty rather than the underlying cause. High-leverage policies are often not obvious.
- *Policy resistant.* The complexity of the systems in which we are embedded overwhelms our ability to understand them. The result: many seemingly obvious solutions to problems fail or actually worsen the situation.

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FIGURE 1 Robert Wood Johnson Foundation Social Ecology Framework for Food Strategy