Can increasing whole and fractioned pea flour consumption in Canada reduce healthcare expenditures?

by

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Abstract

The implication of increasing consumption of functional foods, such as pulse-containing products, reveals the potential to reduce the incidence of type 2 diabetes (T2D) and coronary heart disease (CHD) and thereby achieves the cost savings associated with treatment and productivity loss. This research investigates the economic impact of such an important aspect of dietary pulse intake.

The objective of the research is to determine the potential annual healthcare savings resulting from pulse flour consumption at Health Canada's recommended daily rates. This study employs a four-step cost-of-illness approach to estimate such savings: 1) estimation of success rate of the healthy food; 2) determination of lower glycemic index, insulin concentration reduction, and lower cholesterol; 3) assumption of reduction in prevalence of T2D and CHD; 4) calculation of cost savings with regard to reduced occurrence of T2D and CHD.

The findings demonstrate that annual cost savings ranging from \$ 43.8 to 317.8 million (T2D category) and \$ 154.9 to 958.0 million (CHD category) can be achieved for the Canada's health budgetary framework with the increased consumption of dietary pulses. The estimations of cost savings are contingent on four scenarios: ideal, optimistic, pessimistic, and very pessimistic. People susceptible to higher blood glucose, higher insulin, and higher total cholesterol could benefit considerably by substituting pulse-containing foods for unhealthy foods. The adaptation to a dietary pattern that includes pulses will result in significant expenditure reductions in Canada's publicly funded health care system, lessening the economic burden of illness in Canada.

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Chapter 1. Introduction

In Canada, the prevalence of type 2 diabetes (T2D) and coronary heart disease (CHD) has increased rapidly in the recent decades (Public Health Agency of Canada [PHAC] 2013; PHAC 2015). The consequences of this rise in chronic disease are substantial morbidity and mortality costs associated with productivity loss. In 1998, the prevalence of diabetes was projected to increase by 35 % over the upcoming 25 years. In addition to Canada, diabetes imposes a significant burden on health care system in other developed jurisdictions (King et al. 1998). Nutrient deficiency from undesirable food consumption is one of the major causes for such societal costs. Empirical evidence suggests that consuming more foods rich in components from pulse crops can contribute to significant reduction in circulating blood cholesterol and glucose levels (Anderson and Major 2002). Pulse crops are high in protein, fibre, antioxidants, and relatively low in carbohydrates and fat; these factors result in a significant reduction of T2D and CHD risk (Hu and Willett 2002; Willett 2008). As such, Health Canada (2013) recommends 2-3 servings of cooked legumes (one serving = ¾ cup of cooked legumes), 175 ml per day of protein products for the adult population.

Pulse flours could represent an innovative platform for Canadian to increase their consumption of pulses. Thus, an economic evaluation of the potential health benefits from foods containing pulse flour would have significant public policy implications, as increased uptake of these products could lead to significant direct healthcare savings within Canada's publicly-funded health care system. Given that the substantial economic burden of Canada's healthcare system (11.6 % of GDP in 2012), any reductions in associated expenditures would have important budgetary implications. Results of the research will provide an estimate of public expenditure savings that could be re-assigned to other priority areas including education and infrastructure.

While Canada represents the second largest pulse production in the world, in 2004 only 13 percent of Canadians reported that they consume pulses on a daily basis, according to data from the Canadian Community Health Survey (CCHS) (Pulse Canada 2012; Mudryj et al. 2011). For that study, pulse consumers across ten Canadian provinces totaling 20,156 adults were divided into four groups based on their average level of consumption: 13g per day, 47g per day, 99g per day, and 294g/day (half a cup is about 90g). Most Canadians reporting daily pulse consumption identified the products they consume as dry beans, peas, lentils, or chickpeas. Demographically, the highest consumption rate was in the 51-71 age bracket; with regards to cultural background, with the Canadian-Asian population consumes the largest amount of pulses, 3.6 times more than Caucasians.

Extensive consumption of unhealthy foods in Canada and elsewhere has galvanized widespread public debate over its damaging effects on society. Katzmarzyk and Janssen (2004) believe that the obesity pandemic in North America is mainly the result of inactive lifestyle and high caloric dietary choice. The authors also mention that it has been estimated that the obesity problem has become a significant societal burden on the healthcare system in Canada. Regardless, it is logical that taxpayers demand for ex-ante analysis to prevent likelihood of more costly outcomes. Consequently, without progressive action plans toward healthy food consumption, the foundation of a publically funded healthcare system will be threatened.

Among the many developed countries, Canada and Australia are the major contributors to significant amount of world’s pulse trade. This contribution is based on favourable agro-ecological environment, advanced agronomy techniques, and efficient market infrastructure (Jha et al. 2014). Additionally, the authors find that Canada alone produced approximately 35 % of world's traded pulses every year. Besides, pulse growers have responded to growing demand. In the Canadian agriculture census year of 2011, there was an eleven fold increase in the pulse seeded area in Canada compared to 1981 (Bekkering 2014).

Furthermore, pulses are often limited to certain foods, such as salads, soups, and spreads, but some researchers have recognized its potential for other practical food applications in pasta, noodles, and baked products (Marinangeli et al. 2009; Jha et al. 2014). Continuing efforts to find newly formulated food applications of pulse would imply increased opportunities for potential marketability. If the Canadian pulse industry recognizes the potential to be an innovative leader in this regard, this will certainly have the advantage of favourable agro ecological surroundings and strong societal supports from academia and business groups. Partnership between governmental bodies, private firms, academics and community leaders is critical in accomplishing institutional success in pulse marketing.

Other studies investigating the potential growth of pulses in the world market, such as Jha et al. (2014) and Reddy (2009) suggest that pulses can be a group of very distinctive commodities due to their affordability and eco-friendly nature. Moreover, these researchers also emphasize that pulses represent a complete set of nutrients, including protein, carbohydrates, micronutrients, and various vitamins and minerals. With respect to protein, where other animal-based protein sources, such as meat, dairy, and poultry are feasible, pulses can be economically viable options for low-income families around the world. For example, the most consumable protein source in India, with its sizeable vegetarian population, is pulses (Reddy 2009).

While the benefits of healthy diet are difficult to quantify, growing interests in the link between food and health have demonstrated the significant consequences of a poor diet on quality of life and the economy. However, a clear linkage between food and health is supported by a systematic review and meta-analysis of clinical trials (Sievenpiper et al. 2009; Jayalath et al. 2014; Ha et al. 2014). This link helps estimate potential health care savings of dietary interventions. The link also provides evidence-based dietary guidelines for health maintenance and disease prevention. Jayalath et al. (2014) found that five separate non-governmental bodies suggest changes in diet and lifestyle as one of the most effective ways to accomplish prevention and treatment of high blood pressure. Furthermore, these authors also found that each of the health promoting organizations specifically recommends consuming more dietary pulses including low-fat, dry seeds of leguminous plants including beans, peas, chickpeas, and lentils, which represent nutritionally distinctive ingredients as opposed to oilseeds high in fat, such as soybeans or peanuts to meet the dietary guidelines intended for curing or preventing high blood pressure.

Lenoir-Wijnkoop et al. (2010) assert that the food industry is faced with nutrition- and health-related challenges; its contemporary tactics are mainly divided into two practical ways of formulating food products. One is to remove or replace undesirable ingredients according to mandated regulations, for example, trans fats, salt, or added sugar. The second strategy is to incorporate health-promoting functional ingredients and bioactive substances into products. Examples from the second strategy would include, but are not limited to, “vitamins, n-3 fats, plant extracts, fibres, flavonoids, probiotics and prebiotics” (Lenoir-Wijnkoop et al. 2010). The importance of improved health and nutrition has been widely recognized in context of economically viable functional foods industry. As such, the growing research area of nutrition economics has drawn the interest in promoting evidence-based health care.

The rising costs of treating chronic diseases and the subsequent economic burden of illness are a major concern to society. This situation leads to instability within systems providing publicly funded healthcare, as shown in other jurisdictions including Canada. Policy makers have had to confront the issue of resource scarcity linked with rising healthcare costs; one study found that the increased rate of healthcare spending is much faster than the Gross Domestic Product (GDP) of most developed countries (Watson 2006). For example, the Canadian Institute for Health Information (2014) found that the total health expenditure in Canada has shown a significant increase over the years in terms of share of GDP. For example, forecasts indicate that health expenditure as a percentage of GDP has been rising from 7.0 % in 1975 to 11.3 % in 2012 and 11.2 % and 11.0 % for 2013 and 2014 respectively. In addition, from 2000 to 2012, the increase in total health expenditure was an average of $ 8.9 billion annually.

More importantly, if annual growth is taken into account, two rates of change in terms of changes in total health expenditure and GDP enable policy makers to derive the ratio of total health expenditure to GDP. This ratio can account for the relative economic burden of Canada's healthcare system. For example, the Canadian Institute for Health Information (2014) finds that health expenditure increased at the higher growth rate than it did for the GDP growth rate between 1998 to 2010, except the year of 2000. This has resulted in an upward trend of the health-to-GDP ratio for the decade 2002 to 2012; the rate peaked at 11.6 % in both 2009 and 2010. This ratio decreased slightly to 11.3 % 2012.

Therefore, it is reasonable to propose comprehensive methodologies that assess the economic impact of "poor" and "good" nutrition. Hence, the purpose of the following economic simulation is to inform stakeholders, such as taxpayers, business entities, government official, and academics and help catalyze meaningful changes in dietary habits. The agenda of nutrition economics should address consumer concerns premised on a saturated information market that is complicated and contradictory. To fulfill the policy priorities in nutrition economics, emphasizing pulse consumption, the objective of this paper is to determine the potential annual savings achievable in Canada's single-payer publicly funded healthcare system. As such, the next section follows the implications for pulse marketing and ongoing projects led by the institutions involved in the pulse business.

Chapter 2. Background & Literature Review

2.1. Functional foods: A brief overview

The term "functional food" is relatively new. Therefore, a discussion of its various interpretations will be helpful. Agriculture and Agri-Food Canada (AAFC) distinguishes a functional food from a natural health product. AAFC describes a functional food as "foods enhanced with bioactive ingredients which have demonstrated health benefits". A natural health product, on the other hand, is "derived from natural sources and which has demonstrated health benefits" (AAFC 2014). In other words, a functional food should maintain its original form and ingredients but should enrich a food beyond its basic nutrients to achieve additional nutritional values. Similarly, the Institute of Food Technologists [IFT] defines a functional food as "food that provides essential nutrients and often represents amounts beyond basic needs, growth, maintenance, and/or biologically active substances that promise characteristics of health benefits" (Institute of Food Technologists 2015). For example, functional foods in practical form can include naturally occurring components in fruits and vegetables, brans of whole grain and fibre in bakery or cereal products, added calcium in dairy products, and fortified foods and beverages in fluid milk. (IFT 2015).

The functional food industry has been growing rapidly over recent decades. The sale of functional foods in the U.S. markets was estimated to increase from 11.3 billion dollars in 1995 to 18.5 billion dollars in 2001 (Markosyan et al. 2009). Furthermore, an analytic paper revealed that functional foods have projected sales reaching as high as 49 billion dollars by 2010 (U.S. General Accounting Office 2000). Canadian suppliers of functional foods have evolved as global leaders in functional food and natural food products (FFNHP) and, furthermore, the growth of the Canadian FFNHP market is strong and is the fastest growing agricultural and agri-food sector (AAFC 2015). Eleven billion dollars is generated in revenue from over 750 private agents in Canada (AAFC 2015). In 2011, Statistics Canada reported an estimated total annual revenue of 16.4 billion dollars from all Canadian functional food and natural health product establishments (Khamphoune 2013).

Although Canadian policy makers have provided different definitions for functional foods and natural health products, the definitions are based on comparable scientific knowledge of the health benefits and disease reductions resulting from improved nutrition. In addition, regulatory agencies and associations tend to group functional food and natural health products together when they analyze the policy aspects of the products. This has been demonstrated in Canada with the 2011 Functional Food and Natural Health Products Survey by Statistics Canada (Khamphoune 2013) and the definitions of functional food and natural health products provided by AAFC (2015).

Thus, it is significant to note that the potential impact of further consumption of pulse flour and its functional applications discussed in this research should be distinguished from the consumption of natural health products. Natural health products are to determine, treat, or prevent disease whereas functional foods are to reduce the risk of disease occurrence (AAFC 2015).

2.2. Challenges in functional food production

Policy making in consumer health and food production has profound implications for consumer welfare and sustainable production. Golan and Unnevehr (2008) discuss two types of policies in the United States that have an impact on food attributes and corresponding health outcomes. Commodity policies in North America have affected input costs of agricultural production. Previously, fat reduction in milk and pork has created better quality products without alternating taste or price; corn syrup has replaced sugar in processed products, for instance, to reduce input cost. On the other hand, while information policy has resulted in positive consumer perception and increased welfare, it may have not led consumers towards nutritionally beneficial eating habits. Furthermore, high-income countries have conducted a group of recent policy strategies which demand healthier diets rather than basic needs; the key to successful policy implementation depends upon maintaining the same degree of price and taste. Additionally, Golan and Unnevehr (2008) argue that this balance between price and demand has not had a significant impact on the affordability of food even though it has created nutritionally positive outcomes. As such, ongoing policy focuses on optimizing retail prices, educating consumers, and implementing new regulations for public claims.

Cranfield et al. (2011) have found a lack of studies that address the idiosyncrasy or the determinants of consumer acceptance of functional foods: individuals often consume a variety of functional foods on a daily basis. The authors also mention that if studies were to focus on finding the targeted health outcomes due to a specific functional ingredient, the causal effect would have been almost warranted. However, such an approach disregards the fact that food consumers choose multiple food products to achieve desired health outcomes. As such, other studies suggest that food items can have multivalent effects and various positive outcomes should be taken into account when consuming the foods in combination (Jacques and Tucker 2001; Martinez-Gonzalez and Sanchez-Villegas 2004). Furthermore, not only do functional foods are required to be consumed regularly at the optimal level (Urala and Lahteenmaki 2007), but there also needs to be a balanced combination of those functional foods to optimize health (Hasler 2008).

Although some might think functional foods generally deliver positive health benefits, other consumers may reject the switch to functional food products, which involve new technology that can be perceived as risky or come with negative associations (Markosyan et al. 2009; Urala and Lahteenmaki 2003; Labraque et al. 2006). Some consumers think that foods are beneficial only if they are natural. In experiments, Markosyan et al. (2009) find that where most consumers have positive feelings towards health benefits, when it comes to purchasing, consumers are hesitant about functional food products, even with a significant discount on price. This exact same tendency was shown in the study on Belgian consumer's perception of bread by Dewettinck et al. (2008), as discussed in Step 1 of the economic simulation. Markosyan et al. (2009) asked consumers to report reasons for undesirable aspects of functional food products, and they stated that those foods seem "unnatural" and "potentially unsafe." Further investigation on what other undesirable factors lay on consumers' mind can effectively shed some light on the future consideration of pulse marketing.

Generally, consumers around the world have been concerned with genetically modified (GM) foods, showing largely negative responses. Curtis et al. (2004) found that consumers in developing nations tend to have generally positive perceptions of GM foods and that these attitudes originate from urgent basic needs for food security from a nutrition standpoint. On one hand, for those in developing countries, the three primary reasons for smaller perceived levels of risk in GM foods were trustworthy government, positively recognized science, and positively influential media. On the other hand, the authors also found that consumers in developed countries showed higher perceived levels of risk towards GM foods, resulting in lower levels of acceptance. In both North and South America, considerable consumer uncertainty, along with potential health and environmental complexity, are associated with the risks involved in genetically modified crops, especially the case of Roundup Ready soybeans (Moon and Balasubramanian 2004). In addition, referring to a nationwide survey in Canada, Laure et al. (2004) demonstrate that there might be a niche market opportunity for organic functional foods, whereas results indicate Canadians would avoid GM functional foods resulting in significant difficulty in attracting consumers. Thus, given the limitations and challenges of functional food, marketers who expect a niche market for pulse-enriched foods should always keep in mind that there could be negative perceptions surrounding new or novel foods due to cognitive, behavioural, and positional determinants of food consumers.

2.3. Utility, choice and opportunity costs in nutrition economics

Social benefits can be greater if research is able to quantify the level of consumer welfare in nutritional economics. Since the traditional approach in nutrition economics has focused on measuring the costs of avoided illness, research has identified the attributes of food that affect consumers' choice (Teisl et al. 2001). The purpose of this type of research is to determine all aspects of forgone opportunity costs associated with other alternate choices and to reflect individuals' adjusted behavior prior to future challenges. For example, studies demonstrate that nutrition labeling may not always lead consumers towards healthy food consumption. Taste is a significant factor in choice. For example, salad dressing and its excessive use could show an inverse relationship between healthy choice and subsequent health outcomes. The explanation for such a tendency is that, with the notion of segregating healthy and unhealthy products, consumers are exposed to maximizing their utility among the choices. In other words, expected welfare gain from healthy choices may be offset by product taste. Thus, determinants of consumer acceptance of functional foods could be far better off with careful consideration on a multi-disciplinary approach that redefines consumer behavior towards the new products, such as foods containing pulse flour.

2.4. Consumer trends

Studies suggest potential opportunities for new, healthy, flour-containing products (Marinangeli and Jones 2011) and the notion that a product is healthier may not guarantee its uptake by consumers due to its particular sensory characteristics. However, according to Marinangeli et al. (2009), the sensory characteristics of whole yellow pea flour are comparable to those experienced when consuming products made from whole wheat flour. Furthermore, yellow pea flour is readily available and affordable within the Canadian market. For example, dry peas, including Canadian grown yellow, green, maple, green marrowfat, and Austrian winter peas, have the largest production volume of all special crops in Canada (AAFC 2013); the principal pulse crops produced in Canada include dry beans (*Cicer ariettinum*), chickpeas (*Cicer arietinum*), lentils (*Lens culinaris*), and dry peas (*Pisum sativum*) (Tosh and Yada 2010). Similar to existing new foods with previously developed functional aspects, such as trans-fat free canola oil and plant sterol enriched foods (Health Canada 2015), pea flour has the potential to serve as a widespread functional food ingredient within the Canadian Marketplace.

Notable changes have occurred in consumer taste and preference particular to the flour market in Canada. The reason for such change can be explained by incorporating multiple different variables into econometric equations; to directly observe the relevant historical consumption patterns, some relevant time trends are shown in Figures 2.1. and 2.2. For example, the traditional flour market in Canada has fallen by 87 % for corn flour and meal between 2006 and 2014 (Statistics Canada 2015). In addition, over the last decade, the Canadian wheat flour market has shrunk to an annually available wheat flour of 56.93 kg per person from 66.81 kg per person in 2005; in other words, a decreased availability of 15 % (Statistics Canada 2015). This new trend in flour consumption can partially be explained by the substitution effect; the added health benefits of pulse flour are likely an option for healthy-food-seeking consumers.

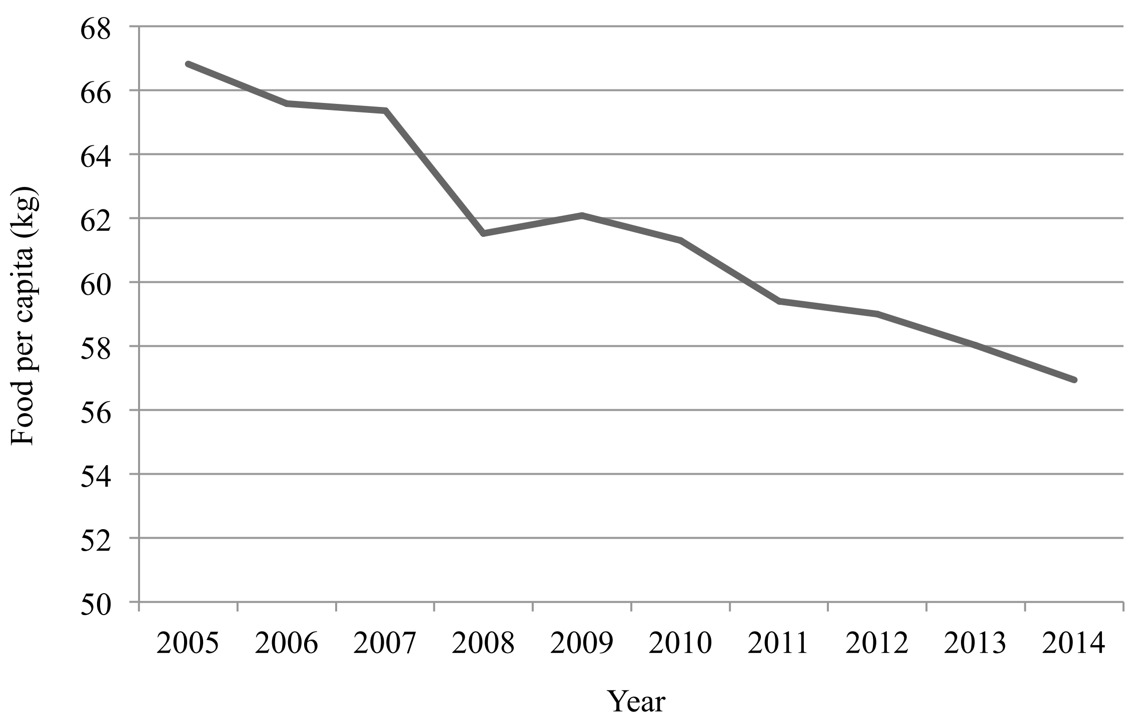

Figure 2.1. Food available per person (kg) - Wheat flour (Statistics Canada [STC] 2015)

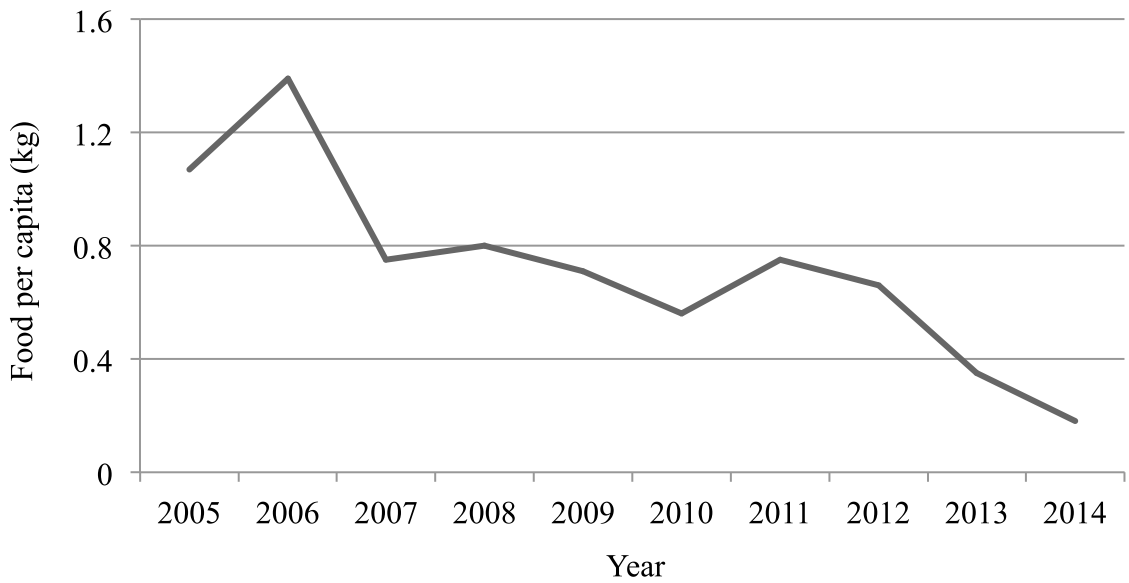

Figure 2.2 Food available per person (kg) – Corn flour and meal (STC 2015)

Aside from the traditional flour market in Canada, the consumption patterns of different types of pulse show a fairly consistent trend. The Agriculture Division of Statistics Canada provide food-per-capita statistics across various types of pulses, including baked and canned beans, wax and green beans (fresh, canned, and frozen), lima beans, and peas (fresh, canned, and frozen). In Canada, there has been a steady (but slightly lowering) demand for pulse consumption per person, with a fall from 5.6 to 4.7 kg annually for a decade; in other words, a 0.9 kg per person annual fall, or a 16 % decrease (between 2005 and 2014). Note that the data on the pulses does not include dry beans or dry peas, which are significant contributors to total pulse consumption; the exclusion of such commodities was due to the unreliability of publishing, according to Statistics Canada. The graphic figures (Figure 2.3, Figure 2.4, Figure 2.5, and Figure 2.6) show the 10-year consumption trend of the discussed pulses in Canada. As is shown, there is a fairly consistent consumption of pulse in Canada over the last decade.

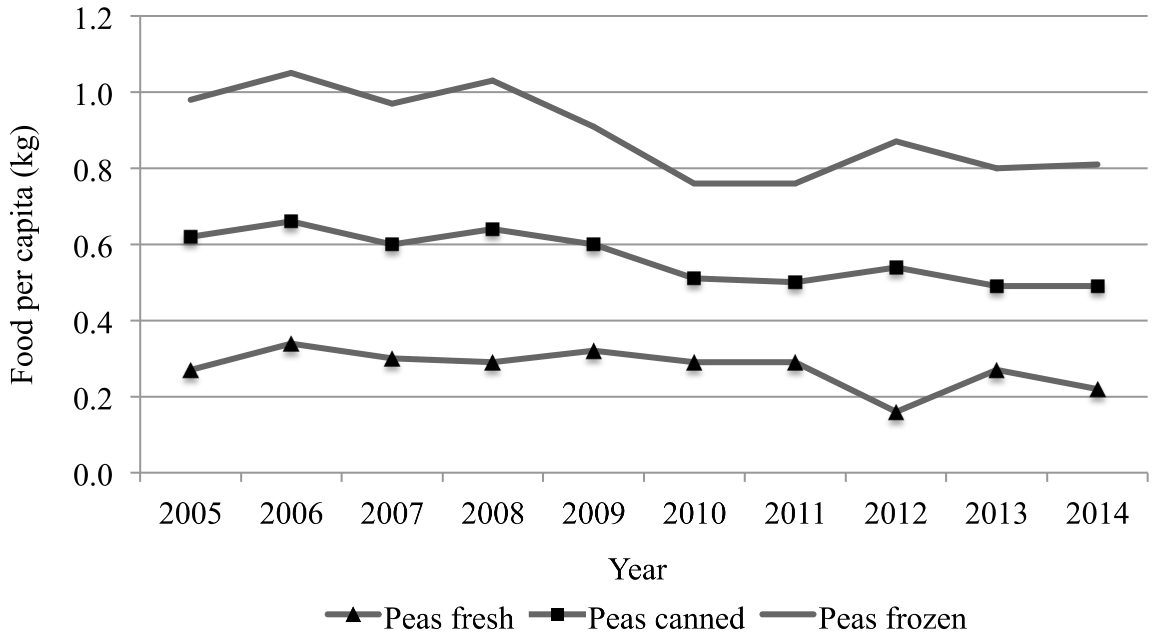

Figure 2.3 Food available per person (kg) – Peas (STC 2015)

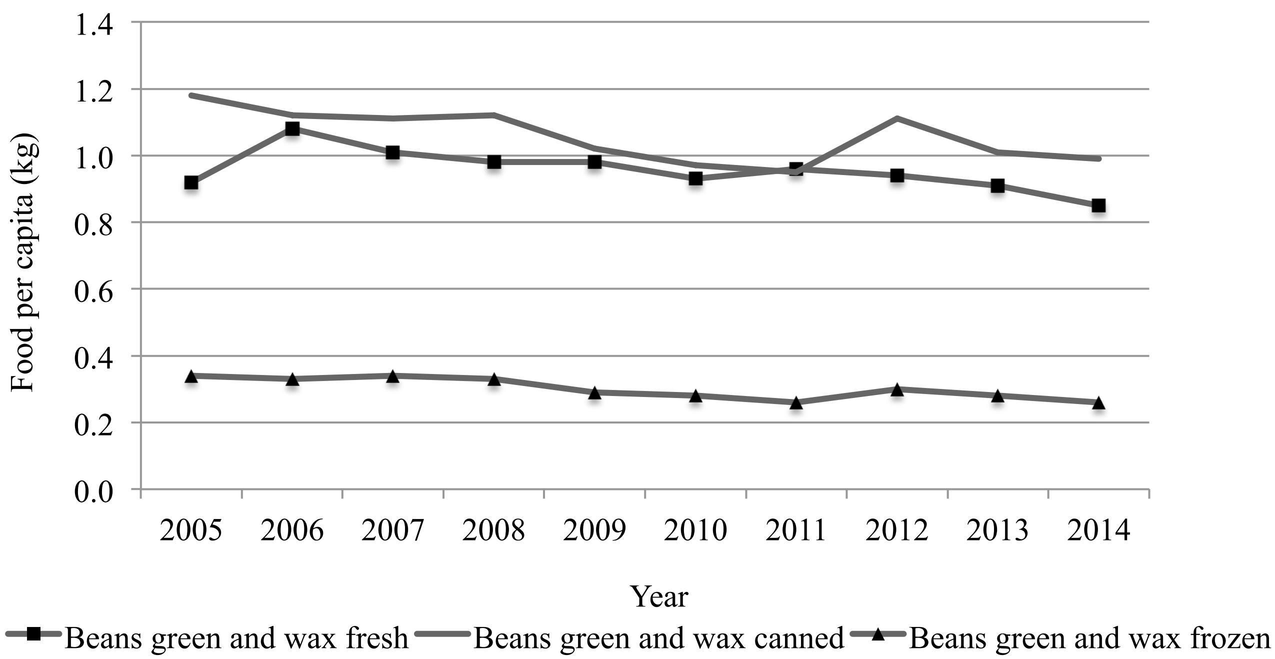

Figure 2.4 Food available per person (kg) – Beans green and wax (STC 2015)

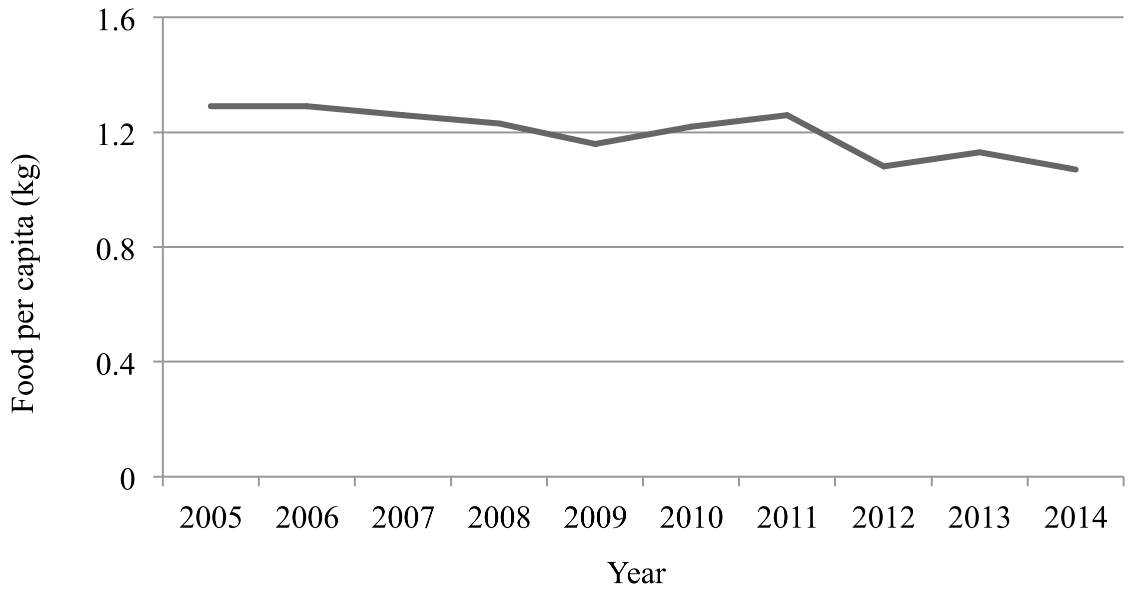

Figure 2.5 Food available per person (kg) – Baked and canned beans (STC 2015)

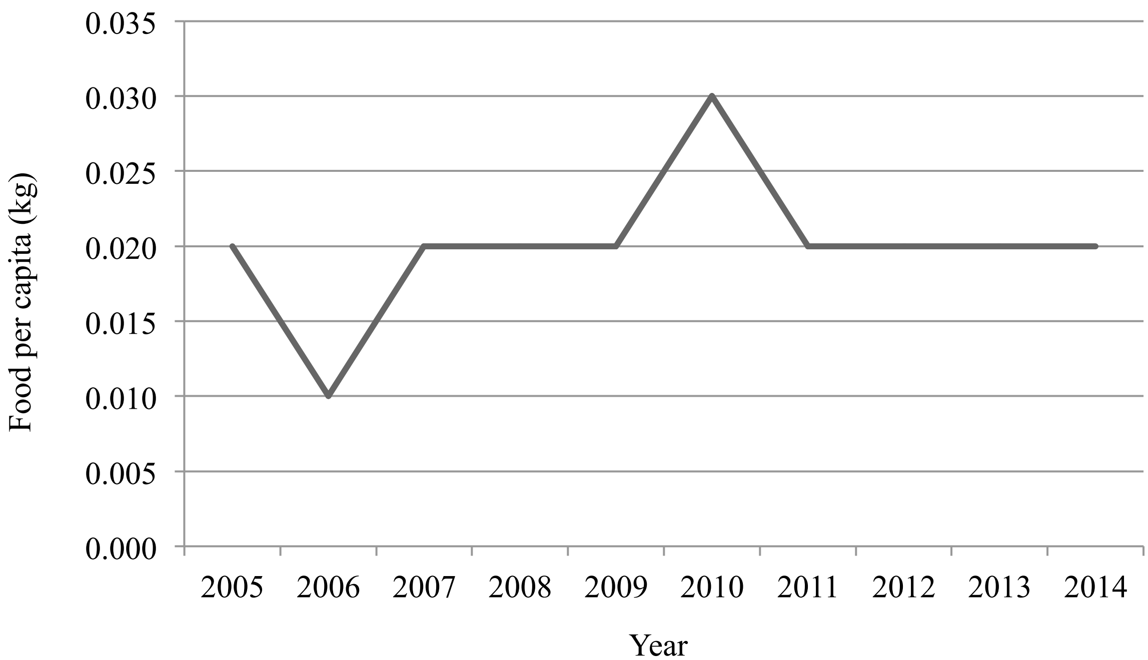

Figure 2.6 Food available per person (kg) – Lima beans frozen (STC 2015)

On the other hand, despite the many advantages of pulse on agriculture, health benefits, and functionality, Jha et al. (2014) argue that the recent global trend in pulses is troubling due to decreased production and patterns of consumption. For example, global production of chickpea and pigeon pea has been historically low for the last two decades. Chickpea and pigeon pea are considered to be nutritionally important to vulnerable poor communities in Asia. Where India still represents one of the highest per-capita pulse consumption rates in Asia, the per-capita consumption of pulses in India decreased by 31 g, from 61 g 1951 to 30 g in 2008 (Reddy 2009). Moreover, consumption of pulses in developing countries decreased similarly, particularly in Asia and sub-Saharan Africa (Food and Agriculture Organization [FAO] 2015). Such declining trends in pulses can be explained by increased consumption of livestock products, failure to promote further production in some countries, or a deterioration of overall quality of diets (FAO 2015). As one of major pulse exporters, Canada needs to be aware of future global trends as well as domestic consumption to help the decision making for pulse producers. Functional foods containing pulse flour could change a consumer perception that the taste of dry pulses can be prohibitive. Furthermore, with the realization of benefits from such foods promoting the prevention and treatment of diabetes and coronary heart disease, an upward consumer trend in the consumption of pulses could be foreseeable in near future.

2.5. Beneficial ingredients, novelty, functionality, and opportunities – pulses and pulse-enriched foods

Studies examining the purchase intentions of consumers with regard to specific functional ingredients could point to potential success rates of pulse-enriched foods. Specific functional ingredients discussed by the scientists include probiotics (Hailu et al. 2009), conjugated linoleic acid (CLA) (Herath et al. 2008), soy protein (Malla et al. 2016), fibre (Tosh and Yada 2010), Omega-3 (Verbeke 2008), plant sterols (Gyles et al. 2010), antioxidants (Markosyan et al. 2009), catechin (Moro et al. 2015), and anthocyanins (ACNs) (Bruschi et al. 2015). Other than the functional ingredients above and potentially other comparable functional foods, the feasibility of functionality in pulse-enriched foods in this research and its impact on human health should be dependent upon scientific reasoning from clinical trials. Pulses have been demonstrated to have known health benefits in terms of nutrition (Marinangeli and Jones 2011) and economic value in the supply chain (Jha et al. 2014).

One major benefit of pulse consumption is its high concentration of dietary fibre. The important nutritional functionality of fibre not only contributes to the health aspects but also serve as an ingredient for multiple food products. Tosh and Yada (2010) demonstrated that the fat and water retention capacity of pulse-derived dietary fibres enables pulses to alter and enhance the texture of food products. In addition, the hydration potential of pulse fibres improved functionality during processing by way of grinding or extrusion. The important characteristics of pulse fibres will be crucial for producing comparable food products that minimally alter existing consumer taste and preference trends.

The functionality of pulses across food processing platforms provides extensive opportunities for their use in various practical food applications. Tosh and Yada (2010) argue that studies continue to demonstrate the versatility of pulse flours and fibre fractions for enhancing the characteristics of foods for a variety of food application categories, including: fibre enrichment (e.g. bread, baked goods, and pasta), nutrient fortification (e.g. pasta and baked goods), fat binding and retention (e.g. ground beef and US Army calorie-dense beef-based rations), texture modification (e.g. texture modifying beef patties, low-fat fish products, and low-fat high-moisture meat products), and lastly non-food applications (e.g. renewable raw materials and feedstock). Clearly, the functionality of pulse flour is extensive and, given their widespread availability, this versatility in application can be applied across various food supply chains. Furthermore, the popularity of pulses as a protein substitute for North American consumers continues to increase (Bekkering 2014). Therefore, it is plausible to predict consumer acceptance of pulse products, as well as the anticipated health benefits and corresponding healthcare savings in Canada.

Another study investigating consumer perceptions and attitudes towards similar functional foods discusses that pasta sauce with added red lentil fibre would have a potentially strong marketability, aiming for enhanced nutritional and health benefits (Bugera 2011). Prior to this development, the researchers asked a particular age group, 'baby boomers', about their willingness to pay for this product, and for its general acceptability. In this study, the reason for choosing this particular demographic is owing to its keen interest in healthy-food-purchasing behaviour; baby boomers aim for clinical benefits, taste, price, and freshness (Krystallis et al. 2008; Verbeke 2006). The participants were recruited at Manitoba local farmer's markets. At the time of recruitment, the participants were provided with a sample of the red lentil pasta sauce to taste and rate (one serving, 125ml, with 250 g of pasta (rotini). To minimize compromising on consumer acceptability, the researchers strategically named the prepared product as Pasta Sauce Final (PSF); this takes into account important comparable characteristics of the optimal product in terms of color, aroma, taste, and texture. The sample consisted of locally supplied ingredients, such as red lentils (15 %, 4g of red lentil fibre added in formulation of PSF), vegetables, and canola oil, all grown in Saskatchewan and Manitoba. The participants were notified about this locality.

The baby boomer participants showed their willingness to pay an average cost of \$4.38 ± \$1.64 for a 750 ml jar of PSF. The cost premium depends on monthly use. The baby boomers who consume pasta sauce more than six times monthly showed their willingness to pay \$0.81 more, compared to other participants who consume less than 5 times a month. The survey also reveals that eighty-three participants are willing to buy the PSF when it becomes commercially available.

It is important to note that 4g of red lentil may not enough to fulfill Health Canada's recommendations for daily pulse consumption (¾ cup or 175 ml cooked legumes per day). However, food innovation can enhance the incorporation pulses into novel functional food products. For example, the pasta consists of adequate servings of whole yellow pea flour (30 % attributed to whole dry pasta amount), formulated by the Canadian International Grains Institute (Marinangeli and Jones 2011). The daily recommendation for pulse consumption is easily achievable with the partial use of yellow pea flour in the 250 g of pasta. Thus, the value of pulses, from the perspective of versatility and health, can have a strong influence on the demand for other type of novel pulse-based foods.

Additionally, the pulse containing products passed the satisfactory sensory testing among the consumers as three passing sensory attributes: appearance, taste, texture showed the passing acceptability with 'smell' having 9.4 % lower acceptability (Marinangeli et al. 2009). Accordingly, as far as the sensory characteristics of pea flour are concerned, the three whole yellow pea flour (WYPF)-formulated products (banana bread, biscotti, and pasta) were identified by participants as being comparable to the identical products made up of whole wheat flour, although there was an exception with the lower sensory score of smell in WYPF pasta. With continuing efforts in the industry for technological advancement, enhancing the taste and preference, the potential marketability of WYPF is expected to be a great deal in the future.

2.6. Linkages between food and health

Alongside other, healthful foods, pulses have been shown to increase the nutrient density of diets and decrease risk factors for chronic disease. Research by Leterme (2002) recommends pulse consumption to recognize various health benefits; the author also itemizes the various ways to incorporate pulses into typical diets. For example, the recognizable health benefits from frequent pulse consumption include reduction in serum cholesterol levels and much lower risks of coronary heart disease and diabetes. Furthermore, many health-promoting associations have utilized the "food guide pyramid" to help members successfully reformulate their diets. Depending on availability and preference, beans have been grouped as either a protein, fruits and vegetables, carbohydrate-type food. Regardless of its placement on the pyramid, Leterme strongly recommends pulse consumption for anyone who desires a healthy diet.

Surprisingly little exposure has been given to the health benefits of pulse consumption, particular for the products of yellow pea (Marinangeli and Jones 2011). Marinangeli and Jones (2011) demonstrated that whole and fractionated yellow pea flours (WYPF and FYPF) reduce fasting insulin and insulin resistance in hyperchloesterolemic and overweight human subjects. Among the different results from the human trials, the researchers found that WYPF and FYPF significantly reduced fasting insulin by 13.5 % and 9.8 %, compared to a whole wheat baseline. Another biomarker for assessing the cardiovascular disease risk is insulin resistance; the trial results for insulin homeostasis modeling assessment (HOMA-IR) revealed that the treatment group (with WYPF and FYPF) shows a decrease in HOMA-IR by 25 % as opposed to the control group fed whole wheat products. As a result, it would be very convincing to deploy these results in terms of the economic assumptions of the research in this paper. In other words, increasing yellow pea flour consumption will lead to significant reductions in the incidence of T2D and CHD, potentially stimulating considerable fiscal savings for Canada's healthcare system.

Studies examining the effect of legumes as part of a low glycemic index diet reveal a relationship between glycemic index (or glycemic load) and incidence of type 2 diabetes (Schulze et al. 2004) and glycemic control and cardiovascular risk factors in type 2 diabetes mellitus (Jenkins et al. 2012). Specifically, Schulze et al. (2004) ascertain that the relative risk of type 2 diabetes is negatively affected by cereal fibre intake and is positively affected by glycemic index. The researchers identified 741 cases of type 2 diabetes during eight years of follow-up. Holding other variables constant, an increase in glycemic index was a significant factor for a higher risk of diabetes; an increase in cereal fibre intake was also a significant factor for a lower risk of diabetes. The relative risk for combining two variables (cereal fibre intake and glycemic index) compared with the opposite extreme was 1.75. For example, among the compared patients, the group from the highest glycemic index quintile showed the 1.75 times higher risk of type 2 diabetes, compared with the group from the lowest glycemic index quintile. The authors admit that the exact magnitude of how certain amounts of high-glycemic-index foods alter the risk of type 2 diabetes may be unclear; however, it is very clear that the same weight of carbohydrates from high-glycemic-index foods will generate a steeper blood glucose curve, and therefore will require a greater demand for insulin than low-glycemic index foods. Pulse-containing low-glycemic-index foods do provide higher amounts of dietary fibre leading to health benefits for consumers. Thus, the relative risk ratios can be utilized to make assumptions that increased pulse consumption will lead to a reduction in incidence in T2D and CHD, turning into benefits and economic savings.

Jenkins et al. (2012) determined that participants with diabetes mellitus (DM) can reduce cardiovascular risk factors by replacing the low-glycemic index (GI) legume diet with a high wheat fibre diet. The low-glycemic index (GI) legume diet can reduce cardiovascular risk factors, HbA_{1c} values, by 0.5 % for DM subjects whereas a high wheat fibre diet can only reduce HbA_{1c} values by 0.3 %. In addition, after providing the participants with the low GI legume diet, the relative reduction in HbA_{1c} values was greater by -0.2 % than it is when the high wheat fibre diet was provided. The respective CHD risk reduction was -0.8 % for the low-GI legume diet, resulting from a greater relative reduction in systolic blood pressure highly correlated with the low-GI diet when compared with the high wheat fibre diet. The authors assert that, to their knowledge, legumes, including beans, chickpeas, and lentils, have never been specifically applied to lower the GI of the diet. Choosing wheat fibre as a control group and for a baseline decreased the treatment difference. Furthermore, the trial is the first to prove a blood pressure reduction from a legume diet in type 2 diabetes subjects; the study is also the first attempt to validate the effect of legume consumption on heart rate and one of the few trying to measure the impact of dietary intervention. Such effects are consistent with the continuing efforts of existing dietary intervention studies that associate low glycemic index products, which slowly transform carbohydrate into blood glucose, with a reduced risk of hypertension and coronary heart disease events in diabetic subjects.

Other studies conducting a systematic review and meta-analysis of randomized controlled clinical trials in people with and without a risk of chronic diseases such as diabetes and cardiovascular disease include Sievenpiper et al. (2009), Jayalath et al. (2014), and Ha et al.

(2014). These studies suggest that consumption of dietary pulse can have a strong effect on primary prevention and treatment for chronic diseases. Sievenpiper et al. (2009) identify consumption of dietary non-oil seed pulses (chickpeas, beans, peas, lentils, etc) as the exclusive reason behind lower markers of glycemic control in people with and without diabetes. As a consequence, the conducted systematic reviews and meta-analyses reveal that, in a total of 41 trials (39 reports), pulses alone (11 trials) lowered fasting blood glucose by -0.82 and insulin by -0.49 in standardized mean difference (SMD) compared with the control. Similarly, pulses in low-GI diets (19 trials) and high-fibre diets (11 trials) also show the improvements in the markers of glycemic control that help assess the evidence of health benefits from dietary pulses. The authors mention that dietary non-oil-seed pulses are an ideal source of gradually digestible carbohydrates, fibre and vegetable protein, and that this can result in significant improvement on markers of long-lasting glycemic control in humans.

Furthermore, pulses not only lower the risk of diabetes but also lower the risk of low-density lipoprotein (LDL) cholesterol and blood pressure as supported by research examining another effect of dietary pulse intake, particularly with health benefits due to the significant improvement on markers of cardiovascular health. As abnormal levels of lipids in blood are one of the most importantly and relatively adjustable risk factors of cardiovascular disease, consumption of non-oil seed pulses has been observationally studied in small trials to examine a possible reduction in cardiovascular disease (Ha et al. 2014). The authors indicate that, from the 26 randomized controlled trials, the satisfactory level that defines of the inclusion criteria to qualify for their meta-analysis. As such, the feeding trials that employed dietary pulse intake as intervention diets at a median dose of 130 g per day show a significant decrease in LDL cholesterol levels when measured against the mean difference in the control group. Moreover, elevated blood pressure is accounted for as a serious risk factor for stroke, cardiovascular disease, and kidney failure, but current diet guidelines do not specify the benefits of dietary pulses for lowering blood pressure (Jayalath et al. 2014). As such, to quantify benefits of dietary pulses in humans especially from lowering blood pressure levels and to encourage dietary guidelines to reflect on this, a systematic review and meta-analysis of controlled feeding trials was conducted by the authors. This research reveals that dietary pulses, alternatively replacing other foods during the trials, significantly lowered systolic and mean arterial blood pressure and diastolic blood pressure; the analysis showed a statistically significant mean difference comparing the treatment and control groups.

Several systematic reviews and meta-analyses of randomized controlled trials involving pulse intake have been conducted for assessing the risk of cardiovascular disease and diabetes (Ha et al. 2014; Jayalath et al. 2014; Sievenpiper et al. 2009). The series of relevant studies provide sufficient scientific evidence, which will enhance the merit of dietary guidelines. The authors in this type of study, however, emphasize the need for caution when interpreting results, since trials of longer duration would be needed to obtain a full evidencing of the argument.

2.7. Economic Impact

Studies investigating economic linkages between food and health disclose a relationship between reduced incidence of disease and economic savings (Dawson et al. 2002; Gyles et al. 2010; Malla et al. 2007; Malla et al. 2016). In 1998, the total economic cost of diabetes and associated chronic complication in Canada has been estimated to be between $4.76 and $5.23 billion dollars (US) (Dawson et al. 2002). The main causes behind this are direct medical expenses and productivity losses from mortality that were incurred by the diabetic subjects in

Canada in 1998; the major contributor for chronic complications and incurring costs was in fact cardiovascular disease directly linked to the costs of diabetes. Prior to this study, no published works related to linkages between health care savings and diabetes existed based on the Canadian data. However, this study showed remarkably similar patterns compared to relevant U.S.-based studies that obtain results from estimations based on the proportional allocation of incurred costs associated with diabetes—direct medical intervention and mortality. Furthermore, unlike previous studies that were limited to estimates based only on U.S. data, or other studies that did not fully reveal the cost of chronic complications of diabetes, this study has successfully included the local and national data, such as the epidemiology of diabetes as generated from the administrative database in Manitoba and nation-wide cost data. The authors also have taken into account the costs associated with diabetes prevalence for non-aboriginal subjects in Canada. As such, the results show that the cost of cardiovascular complications in Canada due to diabetes outweighs the direct and indirect costs for diabetes management. The diabetes costs incurred in Canada are about the same compared to the costs under the U.S. health care system although the estimates could be higher when counting undiagnosed diabetes patients. The paper also states that it has been estimated that 35% of populations could be undiagnosed diabetic patients, resulting in further challenges in calculating health care savings.

Gyles et al. (2010) carried out a significant economic evaluation of the potential healthcare savings associated with increased consumption of foods enriched with plant sterols in Canada. The authors imply that high blood cholesterol increases a risk level of developing coronary heart disease; risk factors such as high blood cholesterol have been regarded as the most accountable risk factor for heart disease and stroke. Since related studies in this area state that increased consumption of plant sterols has been shown to decrease blood cholesterol, this research ascertains that consumption of plant sterols should lead to a significant reduction in coronary heart disease. Furthermore, this study concludes that budgetary considerations are the most important motivation behind such research; Statistics Canada estimates that in 1998 physician services, hospital costs, labour productivity losses and other concerns associated with coronary heart disease accounted for a cost $18 billion. As such, with regards to policy implications, the objective of the research reported in this paper is to determine the potential annual savings that would be achievable in Canada's single-payer publicly funded health care system, subject to approval for plant sterols by Health Canada. As a matter of fact, despite scientific evidence and existing approval in other nations, plant sterol products have been not approved for use in Canada. The researchers estimated the annual savings in Canadian health care expenditures were between $38 million (very pessimistic scenario) and $2.45 billion (ideal scenario), in inflation-adjusted 2007 Canadian dollars.

Malla et al. (2007) conducted an economic evaluation of health benefits derived from substituting trans-fat free canola oil for non trans-fat free shortening and salad oil products. According to the authors, the private food industry has always been interested in opportunities for diversification, while policy makers and regulators deal with related health claims; these facts potentially discourage the consumers who already have the unhealthiest eating habits. For example, canola oil has provided consumers with improved health; in turn, consumers avoid foods that contain trans fatty acids and high cholesterol. As such, relevant studies and mounting scientific evidence have indicated that a higher risk of cardiovascular disease is highly correlated with an increase in trans fatty acids and elevated cholesterol levels. This study carried out an economic simulation involving four steps: 1) estimated possible trans fat intake reduction due to trans fat-free canola oil in Canada; 2) calculated the total cholesterol change due to reduction in trans fat intake; 3) calculated reduced incidence (risk) of CHD according to the given reduction of total cholesterol level; and 4) calculated total health care savings subject to the proportionate decrease in risk of CHD. The estimated health care savings (annually, in 1998 Canadian dollars), were around $1.09 billion for the base scenario, reflecting the changes due to the total cholesterol reduction. Therefore, with the budgetary concerns of countries with a publicly funded healthcare system, such as Canada in mind, the policy implication here would be very significant considering such crucial healthcare savings and potential gains from a standpoint of economic welfare. The estimation of public health-care savings is consequently worth investigating, since fiscal health is a large factor in policy.

Another study investigates potential economic benefits of new health claims in the case of soluble fibre and soy protein in Canada and finds nontrivial benefits by authorizing the therapeutic and disease risk reduction claims (Malla et al. 2016). The objective and methodological approach of the research is analogous to the previous discussion on the health benefits of canola oil. The authors state that Health Canada is responsible for regulating allowable health claims on foods. For example, the recent approvals (barley in 2012 and psyllium in 2011) by Health Canada officially explain the linkage between the consumption of soluble fibre from barley and psyllium and reduced/lower LDL cholesterol levels; a lower risk for heart diseases follows as a result. To the very same extent, the research finds that the health claims linking the consumption of soluble fibre and soy protein to lower LDL cholesterols levels could yield very significant benefits in a base scenario equivalent to $105 million and $549 million annual cost savings in 2013 Canadian dollars (for a barley soluble fibre and a soy protein respectively). Such figures can vary depending on the magnitude of economic variables and their impact of each scenario within the sensitivity analysis of the study. The economic savings range from $220 million to $1.25 in low/high scenarios. The authors assert that, in a situation where slow regulatory approval processes and administrative hurdles are present, it is valuable to utilize economic estimates of societal benefits to assure the need for a speedy and prioritized approval process for new health claims. The existence of credible health claims will promote a shift toward healthier foods and could ease the budgetary concerns over rising healthcare costs.

To summarize, the approved health claims of soybean protein are analogous to the case of dietary pulse consumption. It is therefore logical to expect significant healthcare savings as a consequence of two parametric sources of disease prevention: type 2 diabetes, and coronary heart disease.

Chapter 3. Theory & Conceptual Framework

Market failures in economics are explained by theories of externalities and information asymmetry. As a consequence, serious policy questions need to be addressed to the inefficiency of the market. Since external effects are not directly reflected in the market, the price of goods does not take into account external values to society. As a result, a firm produces too much or too little, and the market outcome remains inefficient. With market inefficiency, the total area of societal benefits would decrease, along with shifts in supply and demand. In the context of functional foods, Hobbs et al. (2014) identified externalities that appear between producers when technological spillover effects are present. The researchers refer to sunk costs that can be reduced by an individual firm that reduces entry costs for a product so that subsequent firms have to use the same health claim. In addition, externalities also arise between consumers and producers if regulatory hurdles result in low consumer confidence in the validity of health claims or uncertainty for the quality of products. The latter problem is a classic economic example of 'asymmetry'. Government certified health claims are one example of ongoing efforts that could mitigate such obstacles.

Nevertheless, the regulatory complexity and unintended consequences of nutrition policy can only partially explain the high economic burden in Canada's healthcare system. The price of the generic food market does not reflect on the external burden of healthcare costs associated with unhealthy food consumption. This type of externality is negative insofar as one group incurs costs external to another. A negative externality occurs, for example, when a food processing firm that produces inexpensive and unhealthy foods is held accountable for obesity and chronic diseases; the food consumers that depend on such foods for their daily eating are at high risk of morbidity and mortality. On the other hand, the exact opposite occurs where the action of one group can deliver benefits to another group. An example of a positive externality is the increased consumption of functional foods, which can bring substantial benefits to society along with the improvement of health outcomes of consumers, compared with the unhealthy food consumption scenario.

Since Canada provides a publicly funded healthcare system, the economic burden of illness is not directly passed onto the consumers. In other words, because external costs are rather passed onto the taxpayers, the costs can interchangeably turn into savings that can be allocated elsewhere for other public spending, such as infrastructure related to healthcare, transport or education. Externalities are often difficult to estimate since not all occasions are quantifiable in monetary terms. Considering the difficult nature of quantifying externalities, it is plausible to accept an economic simulation because the research methods effectively attempt to account for the most comprehensively related costs that have been successfully published by governmental experts. In other words, potential externality effects can be identified and examined for government policy analysis if a well-designed economic simulation is applied in this research. Promoting functional foods under the context of yellow pea or comparable dietary pulses, transforms the specific economic burden from externalities to the explicit cost savings; the estimated amounts will raise the important policy questions due to considerable budgetary implications.

In regards to the economic burden of illness, an illustrated point that new canola varieties producing oil that is low in trans fats highlights a significant economic concept of market failure in the agri-food industry (Malla et al. 2007). Notably, the example reveals a negative externality outcome and an information asymmetry problem. A negative externality arises when individuals that consume unhealthy foods do not fully bare the healthcare costs. Given that a functional food reduces the risk of chronic disease, there are fewer burdens on healthcare expenditure, resulting in decreasing dead weight loss (DWL) (from q1 to q*, the smaller triangle) and gaining economic welfare, described in Figure 3.1. The social benefit (gain from healthcare savings) is much smaller since it is inversely related to the quantity of trans fat, ($Q_{\text{Trans fat}}$). The price of trans fat-containing foods (P) is also inversely related to the quantity of trans fat as a high price of such foods discourages the consumption. The marginal cost curve (MC_{Private}) has an upward slope as a price rises producers have incentives to increase their production. The information asymmetry occurs when people are not aware of the adverse health effects of trans fat, so individuals would only realize the immediate benefit (MB private). The economic incentives of reducing trans fat for each individual does not exceed the social benefit, thus the new private benefit will shift down to some extent, but not as far as the social benefit curve proceeds. Thus, depending on the economic assumptions and how well the market failure is resolved, the quantity of unhealthy food consumption, such as trans fat, could remain at q* or q1.

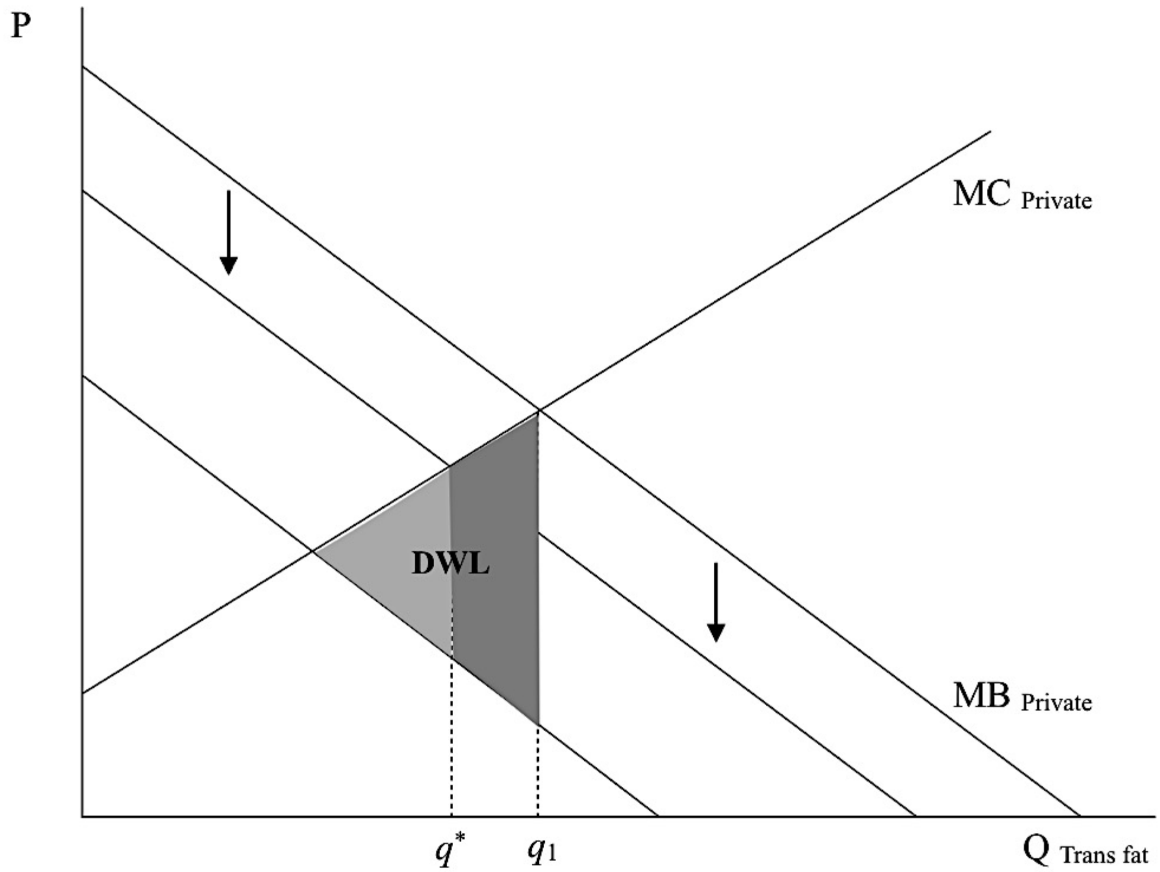

Figure 3.1 Negative externality related to trans fat consumption (Malla et al. 2007)

On the other hand, positive externalities lead to underachieving consumption of functional food, as the example of functional food consumption and improved health shows in the Figure 3.2. The horizontal axis measures the food consumers' spending on products with promising health claims. The marginal cost curve for public health (MC) represents the cost of healthcare per every patient visit; it remains horizontal since the cost is unaffected by the amount of functional food intake. The demand curve (D) shows the marginal private benefit of the functional food intake and improving health outcomes to the individual. The person would like to consume q1 of functional food where the demand curve meets the marginal cost curve to maximize the benefits. By consuming more of functional food, society would also externally benefit, as described on the marginal external benefit (MEB). The reason of the downward sloping of the curve is analogous to the notion of diminishing marginal rate of return, which means the marginal benefit is large (so as willingness to pay) for a small quantity of functional food but goes down as the consumption becomes considerably more extensive.

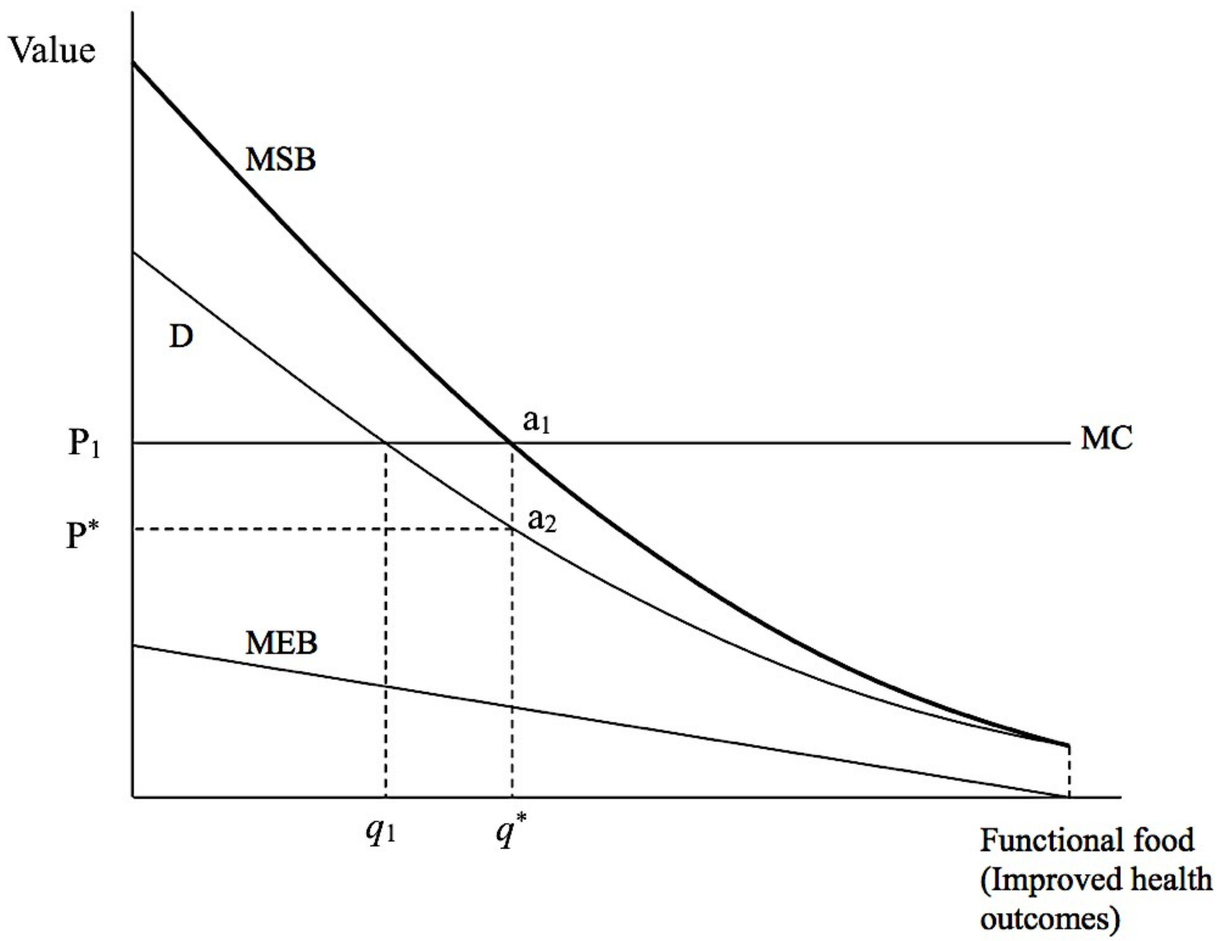

Figure 3.2 External benefits from promoting functional foods

The socially optimal equilibrium is achievable with the absence of market failures, and it can be determined at the intersection of marginal social benefit (MSB) and the marginal cost (MC) curves. To derive the MSB, adding the marginal external benefit to the marginal private benefit at every level of output is needed. Then, q* is where the socially optimal level of production occurs. However, in reality, the market has to deal with the arising inefficiency since the individual does not fully enjoy all the benefits of her investment in substituting quality foods. Consequently, to maintain at the social optimal level of functional food q*, the price P1 becomes too high for the individual; the individual would rather to have P* where it is corresponding to her private marginal curve.

It is possible to provide the P* level if a government subsidy program is present to fulfill the rectangular area of P1P*a1a2. In fact, the Canadian government has already provided the publicly funded healthcare, which seems to represent the rectangular area of economic theory to a limited degree. Evidently, the viability of subsidy will have to be dependent upon to the condition that such relevant economic graphs are practically available. The limitation of such method is that Canadians have never been asked to pay upfront for the medical treatment for a long period of time. In other words, it may be that their willingness to pay or reference price ranges may not practically exist.

The study method of this paper is not necessarily to estimate the equations and curves shown in Figure 3.2. but rather to utilize an alternative approach, 'cost-of-illness', which specifically reflects on the annual health care spending of the relevant disease category. Conversely, econometric regressions would rather cover a broad range for the continuous variables, and they are not really helpful for deriving the economic simulation, given the unknown functional food quantity demanded with respect to price variations. Thus, cost-of-illness will effectively serve as a practical study method, in support of the conclusion of the paper.

Chapter 4. Methods

The research employs a four-step cost-of-illness approach to quantify the direct and indirect costs of disease: (i) assessment of a "success rate" (proportion of prospective consumers willing to consume the recommended daily servings of pulses); (ii) estimate of associated health benefits including reduced glycemic index and reduced risk of type II diabetes; reduced insulin resistance and reduced risk of coronary heart disease, based on published meta-analyses (iii) expected reduction in relevant disease occurrence due to these health benefits; (iv) calculation of healthcare cost savings resulting from the reduced incidence of these diseases. Sensitivity analyses will be used to explore the wide range of potential variation, allowing four scenarios (ideal, optimistic, pessimistic, and very pessimistic) to be formulated. The Economic Burden of Illness in Canada (EBIC) database will be used to itemize related illnesses resulting from insufficient nutrient intake (PHAC 2014).

Changes in health conditions based upon recommended daily intake can be expressed as a percentage base, which can then be multiplied by the incidence of each disease, in order to calculate how likely the reduction is to take place. Finally, the calculated reduction rates of disease incidence must be converted into monetary terms in order to obtain a valid measure of total healthcare savings from increased pulse consumption. This final step of the procedure is to quantify health benefits following from promoting pulse-containing products in the Canadian market. The economic costs of disease broadly consist of direct and indirect components. Direct cost takes into account the incurred expenses for patients to be improving or/and coping with deteriorating symptoms within the health care system. Indirect cost reflects on productivity loss arising from morbidity and mortality costs in short and long term disability. To overcome misleading of a single measure of exact cost savings, a sensitivity analysis will allow demonstration of the consequences of varying model assumptions, based on peer-reviewed scientific evidence.

4.1. Step 1: Assessment of a "success rate"

Belgian consumer's perception of bread has been studied by Dewettinck et al. (2008). The researchers have conducted a survey of 251 bread consumers and analyzed it quantitively. The analysis focused on quality perception regarding factors of health, nutrition, and sensory experience. In the survey questionnaire, the main health factors were represented as follows: "Brown bread is healthier than white bread"; "Multi-grain bread is healthier"; and, "A description such as 'multi-grain' or 'sunflower seed' bread is more important than a label or brand". The researchers have classified a group of 127 respondents (out of 242, 52.5 % in total) as 'Health + sensory positive'. One reason for this classification is that, for example, the group preferred a clear description of the bread to a brand or label. In addition, the group is also attracted to the positive notion of sensory properties of bread, such as flavor, texture, and taste. Conversely, other groups are either health averse, which illustrates somewhat positive towards sensory factor, representing 44 respondents, 18.2 % in total. Another group can also be sensory adverse when bread taste will not change with additional filling and spread and or they have no preference for the healthy bread, representing 71 respondents 29.3 % in total. Thus, health has a determinate effect among these bread consumers. Given the lack of available consumer data on dietary pulse, it should be acceptable to examine the similar functional food markets in other countries, such as the Belgian one above.

As an alternative food application along with pulse, consumer research on healthy breakfast cereal (HBC) enhanced with soy protein has been taken into consideration. Lee et al.

(2007) have conducted research based on consumers in Illinois and have found various factors associated with choosing healthy breakfast cereals, such as ingredients, health claims, sensory benefits, brand names, and pricing. Among the investigated consumer groups, the “healthy choosy” segment is the largest segment, representing 47 % (n = 171) of the respondents. This particular segment of consumers is highly interested in healthy diet and living; this can be seen in their strong responses to health-giving ingredients in HBC (utility values of 9-21), and to a lesser extent their responses to health claim statements (utility values of 6-8). The survey measures quality based on the utility value. A utility value is “extremely important” if it is greater than 16. A utility value between 11 and 15 is “very important” and it can also be “significant and relevant” for 6 to 10. It becomes “marginal” between from 5 to 0 as “marginal” and any value below 0 is an element whose existence nowhere closer to interest.

Wansink et al. (2005) argue that knowledge about functional foods attributes is the most influential factor in persuading people to adopt functional foods. For example, the researchers assert that the acceptability of functional food is highly associated with hierarchical knowledge in nutrition, which takes on from attribute level knowledge (e. g. “soy exclusively contains phytosterols”) to knowledge of individual health consequences by consuming it (e.g. “soy will help lower my blood cholesterol and risk of heart diseases). As such, researchers have divided the respondents of a mail survey into four groups, depending on the level of knowledge the respondents had about soy. The four groups were segmented as ‘no knowledge of soy (n = 143)’, ‘only attribute knowledge of soy (n = 277)’, ‘only consequence knowledge of soy (n = 122)’, and ‘attribute and consequence knowledge of soy (n = 63)’ to derive the relationship between nutritional knowledge and consumption of functional foods.

As expected, when people move towards the higher level of nutritional knowledge, an increasing pattern of consumption of functional foods has followed. The mail survey by Wansink et al. (2005) captured this tendency. However, when it comes to 'beliefs' related to functional food products, there has been no clear increase in this variable between the four groups of survey respondents. Additional knowledge, such as the ability to connect food attributes with benefits, did not necessarily impact how consumers thought about soy. In other words, the difference between some groups with additional knowledge was minimal. For example, when people were asked to scale (1-9) "soy is healthy", the average point of 'no knowledge' group was 5.9. However, the average points of other groups were 7.7 (only attribute knowledge), 7.9 (only consequence knowledge), and 8.0 (attribute and consequence knowledge). Other than a significantly lower level of belief about soy in the 'no knowledge' group, all the other groups expressed similar levels of belief.

On the other hand, unlike the impact on beliefs, the survey results show a noticeable pattern of purchase across the knowledge groups. Categorized as 'consumption and purchase', the survey has determined the percentage of people who consume soy based on their knowledge level. 11 % in the "no knowledge" group, 15 % in the "attribute knowledge only" group, 24 % in the "consequence knowledge only" group, and 68 % in the "attribute & consequence knowledge" group have admitted that they consume soy on a consistent basis. This elevated consumption pattern clearly demonstrates the crucial relation between knowledge and behavior. In other words, to ultimately drive belief to consumption, the emphasis has to be given to the right combination of knowledge, rather than a wide range of it. Moreover, when a person moves towards a higher level of nutritional knowledge with no obvious increasing level of belief, one can purchase the food as long as the person knows it is good for her or him.

Various levels of purchase intention could imply how this research measures the success rates of a new food product. As such, for the purpose of calculating economic benefits, after obtaining the success rates (shown in Table 4.1) based on the evident pulse consumption level in Canada, 13 % (Mudryj et al. 2011), and the consumer studies (Lee et al. 2007; Wansink et al. 2005), the various sensitivity analysis scenarios employed the success rates to derive an estimate of success ratio. The key assumption behind those success rates originates from the idea that soy consumers would perceive pulse as an almost perfectly substitutable food, conveying the notion of pulse crops in general.

Table 4.1 Estimated pulse success rates

Assumption	Pulse consumption rate (%)	Source
Full potential consumers – HBC* study "healthy choosy" segment	47	Lee et al. (2007)
Average percentage who consume soy across all knowledge levels of soy, plus existing pulse consumers	34.4 (21.4[a] + 13[b])	[a]Wansink et al. (2005) [b]Mudryj et al. (2011)
Percentage who has no knowledge level of soy, plus existing pulse consumers	24 (11[a] + 13[b])	[a]Wansink et al. (2005) [b]Mudryj et al. (2011)

Notes: *HBC: Healthy breakfast cereal

4.2. Step 2: Presumption of lowered glycemia, improved glycemic control and lowered low-density lipoprotein (LDL) cholesterol due to consumption of foods containing pulse

The key health benefits of pulse consumption are not only reduction in glycemia but also reduction in markers of glycemic control, such as blood glucose, blood insulin, and insulin resistance, and reduction in low-density lipoprotein (LDL) cholesterol. The improvement of such markers results in a decreased incidence of two major diseases, diabetes and coronary heart diseases (CHD). Pulse consumption trials have been conducted, and can therefore be integrated into a meta-analysis for the purpose of sensitivity analysis.

Findings from past studies of insulin sensitivity affected by certain nutrient intake will provide helpful results. Specifically, they will provide corresponding changes in glycemic response, which will be needed for the second step of the economic simulation. For example, studies conducting a systematic review and meta-analysis of randomized controlled clinical trials provide the pooled effect of pulse diets on the markers of glycemic control. The mean value of the pooled effect then implies a statistically significant number that can precisely represent the potential impact of pulse diets on health conditions. Consequently, the potential impact on health can be quantified by investigating the results of relevant individual trials and by converting those metabolic changes into percentage changes.

4.2.1. Relationship between pulse consumption and glycemia (postprandial glycemic response)

A study conducted by the Marinangeli et al. (2009) reveals different glycemic responses to foods made up of whole yellow pea flour (WYPF) and white wheat flour (WWF). Among the three different food products (banana bread, biscotti, and pasta), the WYPF biscotti and WYPF banana bread produced a lower postprandial curve (IAUC). The IAUC values of those two food products were 61.9 % and 55.1 % lower than the values of white bread ($P < 0.001$). Furthermore, when comparing the corresponding WYPF and WWF products, IAUC for WYPF biscotti (glycemic index (GI) of 45.4) shows 29.2 % lower values than the WWF biscotti (GI of 63.9) at a statistically significant level ($p < 0.013$). Although the findings would be limited to a few food products, the notion of lower postprandial glycemic response from WYPF consumption could be applied to other multiple food products.

Thompson et al. (2012) found similar results in their study which examined the glycemic response of adults with type 2 diabetes who consumed either rice and beans or rice alone. Seventeen men and women with type 2 diabetes were evaluated in a randomized controlled 4 x 4 crossover trial that provides the pinto beans/rice, black beans/rice, and red kidney beans/rice meals as a treatment. Accordingly, postprandial areas under the curve for blood glucose show statically significant reductions in incremental are under the curve (IAUC) values for certain treatment diets. The IAUC values of pinto beans and rice and black bean and rice were 16.1 % ($p<0.01$) and 14.1 % ($p< 0.05$) lower respectively than the white control rice at 120 min postprandial; the IAUC values of same treatments were 22.2 % ($p<0.01$) and 19.7 % ($p<0.01$) lower respectively at 180 min compared with the white control rice.

4.2.2. Relationship between pulse consumption and glycemic response (blood glucose and blood insulin)

A systematic review and meta-analysis employed by Sievenpiper et al. (2009) investigate the effect of pulse diet on metabolic indices, such as fasting blood glucose (FBG), fasting blood insulin (FBI), HOMA of insulin resistance (HOMA-IR), and glycosylated blood proteins (GP). Accordingly, in a meta-analysis of 41 relevant randomized controlled trials, the authors found that the pooled analyses of the changing markers reveal pulses alone, as a principal treatment, significantly lowered FBG (standardized mean difference (SMD) −0.82, 95 % CI −1.36 to −0.27) and FBI (SMD −0.49, 95 % CI −0.93 to −0.04) whereas pulses did not lower HOMA-IR and GP at a statistically significant level. Among the subgroup studies associated with such pooled analyses, studies showing closely similar results to the SMD values will help build the percentage changes of economic simulation, particular with the second step of sensitivity analysis.

On one hand, among the relevant randomized controlled trials utilized in the systematic review and meta-analysis by Sievenpiper et al. (2009), a few of the experimental trials shows relatively close values to the SMD of -0.82 and -0.49 for FBG and FBI, respectively. For example, a study (Wursh et al. 1988) has an SMD reduction of -0.23 (-1.39 to 0.01, 95 % CI) on the FBI marker. Alternatively, this reduction range is closely located to the pooled effect of SMD, −0.49 (95 % CI −0.93 to −0.04), so it should be plausible to utilize results from the most relevant studies to derive an acceptable probability. The reason for such research methods is that figures from pooled effects of SMD do not provide percentage changes of any probabilities. The standardized mean difference can only indicate the direction of distribution and the degree of subject relevance by measuring a distance between group means. Obtaining the reduction percentage of glycemic markers is necessary, as needed for sensitivity analysis of economic simulation.

Wursh et al. (1988) find that, after bean meal digestion, statistically significant differences were observed in terms of much lower the magnitude of maximum glucose was (6.4 and 6.3 mmol/L, day 1 and day 7 respectively) and the lowered insulin responses (310 and 324 pmol/L, day 1 and day 7 respectively) compared with the control group (7.6 and 7.9 levels of maximum glucose (mmol/L) after potato meal, on day 1 and day 7 respectively; 672 and 730 levels of maximum insulin (pmol/L) after potato meal, on day 1 and day 7 respectively). Such metabolic indices strongly support the validity on Step 2 of the economic simulation, the reduction in markers of glycemic control due to pulse consumption. However, the figures can only partially represent the actual metabolic impact because they represent the maximum values. As such, research findings in similar context follow to measure the averages of plasma glucose and insulin responses.

The pattern of decreasing plasma glucose is also consistent with another randomly controlled feeding trial study (Anderson et al. 1984), which also belongs to the reasonable range of pooled effect of interventions resulting from the systematic review and meta-analysis by Sievenpiper et al. (2009). Such standardized range represents the SMD reduction of -0.68 (-1.37 to 0.01, 95 % CI) on the FBG marker, corresponding to -0.82 of pooled effect. The authors demonstrate that diets supplemented with oat-bran and bean selectively lowered the cholesterol levels of the study participants, including a 24 % decrease in LDL cholesterol level for hypercholesterolemic men. On the other hand, this study finds that oat and bean diets also significantly lower the fasting plasma glucose concentrations in the subjects with initial fasting serums triglyceride concentrations exceeding 200 mg/dl. For example, with the intake of oat-bran diets, fasting plasma glucose concentration decreased by 3 % (from 94 to 91 mg/dl, $p < 0.02$). Furthermore, when the bean diets were provided to the participants, the results show a 10 % reduction in fasting plasma glucose concentration (from 106 to 95 mg/dl, $p < 0.02$). This result from bean diets at the micro level of nutrition intervention points towards an impact on the general population.

For instance, researchers involved with the San Antonio Heart Study (Hanley et al. 2002) have utilized the same unit of metabolic index, fasting plasma glucose, among the various cardiovascular disease risk factors of the study participants. The relevant risk factors include mean values of fasting glucose that range from 81 mg/dl (quintile 1) to 92.8 mg/dl (quintile 5) across the quintiles of insulin resistance (HOMA-IR). Consequently, the blood glucose range between quintile 1 and quintile 5 can be interpreted as a 12.7 % reduction that is very comparable to the 10 % reduction obtained from the study mentioned above examining the relationship between bean diets and fasting plasma glucose concentrations (Anderson et al. 1984). Thus, such patterns of decreasing blood glucose level with respect to pulse consumption can be a stronger argument when research involves a greater number of randomly sampled participants. In other words, selectively investigating such relevant groups of randomized controlled trials utilized in the systematic review and meta-analysis of Sievenpiper et al. (2009) will make the argument more evidenced, resulting in true economic estimators used in the sensitivity analysis in Table 4.5 and 4.6.

Another study investigating reduced insulin demand due to consumption of whole grain and legume powder also provides sufficient evidence of the strong effect on the primary prevention and treatment for such chronic diseases. Jang et al. (2001) found that the isocaloric replacement of refined rice (220 kcal) with whole grain and legume powder lowered serum concentrations of glucose and insulin by 24 % and 14 %, respectively, while holding the body weight and energy intake constant and showing 25 % and 41 % increase of daily intake in fibre and vitamin E, respectively.

Thereby, for the purpose of finding the most relevant cardiovascular disease risk factors, fasting plasma glucose and fasting plasma insulin will be employed in Step 2 of the economic simulation and its sensitivity analysis to provide probabilities of glycemic control after pulse consumption. Consequently, the following impact on magnitude of health and disease occurrence rates will follow in Step 3, which specifically measures the relationship between the lowering metabolic indices and risk of chronic disease such as diabetes and coronary heart disease. Hence, the relationship can eventually link pulse consumption to prevention and treatment of people with and without a risk of chronic diseases such as diabetes and cardiovascular disease.

4.2.3. Relationship between pulse consumption and glycemic response (insulin resistance)

Another strong effect from consumption of dietary pulse can be seen in changes in other markers such as insulin resistance. Marinangeli and Jones (2011) compared whole pea flour (WPF) to fractionated pea flour (FPF) in terms of their contribution to reducing risk factors regarding cardio vascular disease and diabetes in overweight hypercholesterolemic individuals. As the current Health Canada recommendations for pulse consumption are half a cup per day (50 g dry yellow peas), the individuals were instructed to eat the two WPF treatment muffins, which contain the 50g of Health Canada daily serving of pulses, solely using dry yellow peas for the experiment.

The results have showed that insulin concentrations for WPF and FPF turned out to be lower (reduced fasting insulin by 13.5 % and 9.8 % respectively) compared to white wheat flour (WF). Secondly, the estimates of insulin homeostasis modeling assessment (HOMA) - insulin resistance (IR) were 25 % smaller in the WPF and FPF groups compared with the level of WF group. On the other hand, no significant findings were obtained with respect to the total cholesterol (fasting lipid) values. Among the significant percentage changes of relevant health indices, the percentage change of insulin resistance (HOMA-IR) due to increased pea flour intake is employed as one of the metabolic indices for the second step of the economic simulation.

4.2.4. Relationship between pulse consumption and low-density lipoprotein (LDL) cholesterol

The other primary benefit of consuming foods enhanced with pulse flour is a reduction in serum cholesterol concentrations and low-density lipoprotein (LDL) cholesterol. Similar to the proceedings of other biomarkers, the estimated reductions should involve the extrapolation of results derived from meta-analyses on human feeding trials of pulse products. Ha et al. (2014) conducted a systematic review and meta-analysis of 26 randomized controlled trials and identified that diets enhanced with dietary pulse intake meeting 1 serving of a day (a median dose 130 g/d) significantly lowered LDL cholesterol levels. When the treatment diets were compared with the control diets, the authors realized a mean difference of -0.17 mmol/L (95 % CI -0.25 to -0.09 mmol/L); in other words, an equivalence to a reduction of 5 % from baseline.

Another study included a randomly controlled feeding trial with respect to hypercholesterolemic effects (Anderson et al. 1984) found that, after 20 hypercholesterolemic men were randomly provided with a control diet and allocated to oat-bran and bean supplemented diets for a 21 days on a metabolic unit, both of the diets significantly lowered serum cholesterol concentrations and calculated lower-density lipoprotein (LDL) cholesterol. Particularly, the metabolic changes in the control group with the bean supplemented diets resulted in a 19 % reduction in serum cholesterol concentrations ($p < 0.0005$) and a 24 % reduction in calculated lower-density lipoprotein (LDL) cholesterol ($p < 0.0005$).

Thus, after carefully assessing the results of meta-analyses of available human pulse-feeding studies and approximating the reductions in biomarkers, Step 2 of assumptions and scenarios for sensitivity analysis with respect to Table 4.6 (CHD) will employ the most relevant metabolic indices of coronary heart diseases, such as blood glucose, blood insulin, insulin resistance and blood cholesterol to compile the reductions in markers of glycemic control due to pulse consumption. Moreover, Hanley et al. (2002) found that the relationship between insulin resistance and CVD incidence showed similar results with comparable magnitude and directions when each fasting insulin and fasting glucose replaced insulin resistance. These similarities provide a legitimate reason for applying several variables that assumes their ultimate reductions in CHD. The scenarios of the sensitivity analysis in Table 4.6 correspond to the assumption.

4.3. Step 3: Assumption of 1) reduction in incidence of diabetes due to decrease in glycemia and 2) reduction in incidence of CHD due to improvement on blood glucose, blood insulin, insulin resistance, and 3) low-density lipoprotein (LDL) cholesterol

No long-term studies have directly examined the relationship between pulse consumption and diabetes and coronary heart disease incidence. Thus, it is assumed that improvements in disease risk factors with pulse consumption in the form of lower levels of hyperglycemia and LDL-cholesterol and improved glycemic control, will correspond to a concomitant decrease in the incidence of diabetes and coronary heart diseases, respectively.

4.3.1. Relationship between glycemia and incidence of diabetes

To hypothesize the reduction in incidence of diabetes due to low glycemic diet, researchers have taken account of the impact of glycemic index and glycemic load (the glycemic index multiplied by the amount of carbohydrate in the food actually consumed) in assessing of a risk of type 2 diabetes, using prospective cohort studies. As such, Willet et al. (2002) have conducted a data analysis on glycemic index, load and diabetes risk, using large prospective studies of women and men. The researchers found that, after adjusting for age, body mass index, alcohol intake, physical activity, and cereal fibre intake, women belonging to the highest quintile of glycemic load (‘high’, greater than 165 glycemic load) are subject to a 40 % greater risk of diabetes ($p < 0.003$) than for women at the lowest quintile of glycemic load (‘low’, smaller than 143 glycemic load). In other words, the 40 % greater risk of diabetes can be essentially interpreted as 28.6 % reduced incidence of diabetes for the group without the factor. For example, the 40 % greater risk of diabetes is obtained from the relative risk (RR) value of 1.40, whereas the 2.0 scale of RR would mean a group with the factor has twice the risk of other group without the factor. The value 1.40 is interpreted as a 40 % increase, or it can generate a 28.6 % decrease, depending on where the original value and the new value are obtained for the percentage calculation. In this study, it is logical to interpret the RR value as the percentage decrease, as the purpose is to derive the reduced number of patients, by referring to the reduced risk with the increased dietary pulse intake. It is also reasonable to assume that the food intake for the people with a high risk of diabetes is around quintile 5 of GI value (e.g. 82.1, Willet et al. 2002) and that with other food intake, such as pulse, that potential people willing to accept falls into the lower quintiles.

The enhanced results from the meta-analysis of thirteen prospective cohort studies of GI and GL and type 2 diabetes (Dong et al. 2011) will be adopted for this particular relation to disease occurrence. They reveal the similar reported risk estimates (95 % CI), by examining associations between dietary GI and GL and the risk of type 2 diabetes. The authors found that the RR estimates of type 2 diabetes for the highest group of GI was 1.16 (95 % CI 1.06, 1.26; n=12) when compared to the lowest category, with moderate evidence of heterogeneity (P=0.02, I^2=50·8 %). For the case of GL, the RR of type 2 diabetes was estimated to be 1.20 (95 % CI 1.11, 1.30; n=12) with little evidence of heterogeneity (P=0.10, I^2=34.8 %). All of such RR estimates will have a strong influence on improving the probability of the scenarios in the sensitivity analysis.

Furthermore, the updated analyses from three large prospective cohort studies and meta-analyses (Bhupathiraju et al. 2014) involving 3,800,618 person-years follow-up and 15,207 documented cases of T2D incidence found that, in pooled multivariable analyses, subjects belonging to the highest quintile of GI of the energy-adjusted model had a 33 % higher risk of T2D (95 % CI: 26 %, 41 %) than it is for subjects in the lowest quintile of GI. Results from the subjects in the highest quintile of glycemic load (GL) of the energy-adjusted model showed a 10 % higher risk of T2D (95 % CI: 2 %, 18 %). On the one hand, participants who preferred a combination diet high in GI and GL but low in cereal fibre turned out to have an ~50 % higher risk of T2D. Each of three percentage risk factors above has to be converted to a percentage decrease to derive the conversion factors in Diabetes (type 2) reduction due to 1% reduction in glycemic index and load of Table 4.5. Such conversion factors can be derived as follows.

Since, in 2008/09, 2.4 million Canadians live with diabetes prevalence (6.8 % of total) (PHAC 2015), the study assumes a group of people suffer from diabetes is at 7 % of total Canadian population (7 out of 100 in absolute number). Accordingly, the RR value of 1.40 implies that if the suffered group is down to 5 % of the total, as the factor (unhealthy food consumption replaced by the treatment, e.g. yellow pea) is removed, then the *28.6 %* total reduction ((7-5)/7) is realized in terms of the incidence of disease. Similarly, three of higher-percentage-risk factors analyzed by Bhupathiraju et al. (2014), 50 %, 33 %, and 10 %, turn into reduced percentages of risk, such as 33 %, 25 %, and 9 %, resulting from each of the virtual decreasing-suffered-diabetic groups within the total Canadian population, such as 4.66 %, 5.26 %, and 6.36 % respectively.

The relationship between pulse consumption and glycemia (postprandial glycemic response) precedes conversion factors of Step 3 of the sensitivity analysis. Since the results from Step 2, such as reduced percentages of glycemia, 61.9 % - 55.1 % (WYPF biscotti and WYPF banana bread, in IAUC), 29.2 % (WYPF biscotti, in IAUC), and 22.2 % - 14.1 % (pinto and black bean/rice meals, in IAUC), can clearly explain the consistency of accepting a 13.3 % reduction in glycemic load (from 165 to 143, (165-143)/165 = 13.3, which illustrates percentage change from the highest category of GL to the lowest category) of the prospective cohort study examined by Willet et al. (2002).

Thus, the assumption regarding the reduction in the incidence of T2D due to decreased glycemia levels by 13.3 % can be readily available, with its sequential relation to each of 33 %, 25 %, 28.6 % and 9 % reduction in the incidence of diabetes. As a consequence, the diabetes reduction ratios due to 1 % reduction in glycemic index and load would be 2.48 (33/13.3), 2.15 (28.6/13.3), 1.87 (25/13.3), and 0.67 (9/13.3), which will be employed for the third step of the economic simulation with respect to diabetes, as shown in Diabetes (type 2) reduction due to 1 % reduction in glycemic index and load of Table 4.5.

4.3.2. Relationship between glycemic response (blood glucose, blood insulin, and insulin resistance) and incidence of CHD

Hanley et al. (2002) found a metabolic link between glycemic response and cardiovascular health and revealed the relationship of the homeostasis model assessment of insulin resistance (HOMA-IR), including insulin levels, and risk of morbidity and mortality of CVD, utilizing 8-year of follow-up the San Antonio Heart Study. This study found that the risk of a CVD event will increase as quintiles of HOMA-IR rise from quintile 1 to quintile 5, after adjusting for age, sex, and ethnicity ($p > 0.0001$, odds ratio [OR] 2.52, 95 % CI 1.46 – 4.36). To interpret the odds ratio in context of disease incidence rate, understanding how odds ratio is formulated is critical. The odds ratio (OR) of 2.52 refers to the ratio of the odds for CVD events with the risk factor to the odds for CVD events without the risk factor. Thus, the odds for CVD events within the highest quintile of HOMA-IR are about 152 % higher than the odds for CVD events with the lowest quintile of HOMA-IR. In 2009, 1.3 M Canadians had heart disease (4.8 % of total) (PHAC 2013). As such, a group of people who suffer from CVD is assumed at 5 % of total Canadian population (5 out 100 in absolute number). Accordingly, the OR value of 2.52 implies the suffered group will change to 2 % of the total when the factor is removed implying a scenario where unhealthy food consumption is replaced by treatment, e.g. yellow pea, leading to 60.0 % total reduction ((5-2)/5) in the incidence of disease. To complete the disease reduction ratio, the two specific points of the range of HOMA-IR, 1.025 (quintile 1) and 4.803 (quintile 5) were employed to derive the 78.7 % reduction ((4.803-1.025)/4.803). This reduction percentage will be inserted into the denominator of calculating the disease reduction ratio. In other words, the ratio appears to be 0.76 (= 60/78.7). Every 1 % decrease in HOMA-IR results in 0.76 % decrease in occurrence of CHD.

Glycemic control markers, such as blood glucose, blood insulin, and insulin resistance, will be important variables that correlate to the risk of coronary heart disease. In other words, although results of insulin concentrations and insulin resistance provide two different values, these two values tend to move along with a similar pattern. The reason is that insulin resistance still originates from a value of fasting insulin. For example, the estimation of insulin resistance was based on HOMA-IR index, which is determined by the multiplication of fasting insulin (U/ml) and fasting glucose (mmol/l) divided by 22.5 (Hanley et al. 2002). The San Antonio

Heart Study (Hanley et al. 2002) reveals a very similar pattern across quintiles for fasting insulin to the pattern of insulin resistance, with respect to the risk of CVD. Furthermore, from a correlative point of view, there is a near perfect correlation ($r = 0.99$) between HOMA-IR and fasting insulin concentration present. Consequently, CHD incidence can be prospectively predicted by risk factors of glycemic control even if such risk factors quantify the different aspects of metabolic indices. Difficulty with applying different units of measure can be mitigated only if all of the biomarkers can be represented in a percentage base.

As a result, the present analysis incorporates the percentage-based estimates into the calculation of reduced prevalence of CHD. The CHD-per-biomarker ratio is established as a suitable unit of measurement, such as the disease reduction ratio of 0.76. This ratio is available to help derive the percentage-based estimates, which connect the steps of economic simulation in the sequential scenarios. For example, the pre-assumed reductions of each biomarker in Step 2 can be multiplied with this ratio to determine the CHD reduction due to pulse flour consumption. As such, this method helps this research to overcome an obstacle where there are no such long term studies investigating the direct relationship between pulse consumption and reduction in incidence of diabetes and CHD.

Inevitably, the paper will privilege some markers of glycemic control as key variables leading to CHD reduction, for the purpose of economic simulation. For example, the average percentage decrease of FBG and FBI obtained from the systematic review and meta-analysis (Sievenpiper et al. 2009) will be incorporated as one subsequent percentage reduction for the corresponding Step 3 ratio, as shown in the pessimistic and very pessimistic scenarios of Table 4.6. Even though the assumed reductions in glycemic control result from various units of measurement for glycemic response, such as blood glucose, blood insulin, and insulin resistance, this paper groups them into one correlated variable. This procedure helps determine the percentage changes in biomarkers with respect to lowering a risk of coronary heart disease.

Furthermore, an epidemiological study examines the association of every increase in 6 grams of daily fibre with a 25 % reduction in ischemic heart disease mortality (Anderson and Hanna 1999). The authors also identify the reduced risk with people who maintained their daily diets that contain minimum amounts of 37 grams of dietary fibre. As such, since all of the dosage of dietary pulse from the meta-analyses utilized in Step 2 of economic simulation satisfy at least 6-g increase in daily fiber, it should be logical to have a range that is ≤ 25 % the reduction in the CHD reduction due to dietary pulse consumption of Table 4.6.

4.3.3. Relationship between a LDL cholesterol level and incidence of CHD

Pulse consumers can benefit not only from improved glycemic control, but can also expect to proportionately lower the low-density lipoprotein (LDL) cholesterol levels by increasing the servings of pulse diet. In fact, a number of studies have estimated the association between cholesterol-lowing foods and Canadian healthcare cost savings. For example, some of the permitted therapeutic health claims by Health Canada (2015) include canola oil, plantsterols, soluble fibre (β-glucan) and soy protein, which have been shown lower cholesterol levels. As such, in addition to effects on glycemic index and insulin levels, the health benefits of pulses on circulating cholesterol levels should be considered. Using the 1:1 assumed association between LDL-cholesterol reduction and a decrease in CVD mortality, a meta-analysis from Ha et al. 2014 demonstrated that the reduction of 5 % in LDL cholesterol (from the mean baseline) from pulses would imply a decreased risk of 5 to 6 % in major vesicular events. Therefore, considering employing the ratio of LDL-cholesterol reduction to a decrease in CVD events, that ranges from

1.00 to 1.20, this paper assumes every 1 % decrease in LDL-cholesterol results in 1 % decrease in occurrence of CHD. Thus, this relationship enables the Step 2 presumption to connect pulse consumption with the associated decrease in CVD mortality. A ratio of LDL-cholesterol reduction to CHD reduction, 1.0, is to complete the needed components of the ideal scenario in Table 4.6.

4.4. Step 4: Calculation of the reduction in costs originating from the diabetes and CHD reductions

The final step of economic simulation is to quantify the potential health benefits resulting from the promotion of low glycemic index food: exclusive consumption of pulse for Canadian food consumers. The primary source for completing this step is the Economic Burden of Illness (EBIC), which the PHAC periodically provides for public review; it extensively and closely measures the 'cost-of-illness' taking place in Canada. The key objective of EBIC is to deliver comparable and relevant information on the various levels of economic burden or cost of illness and injury. The estimates are classified in order of cost type and subcategory, diagnostic category, sex, age group, and province/territory. Among the categories, diagnostic category was chosen to associate 'cardiovascular diseases' and 'diabetes mellitus' with the burden of illness and injury. The EBIC is the only one of its kind. It enables public policy makers to utilize comparable cost estimates of the burden of illness and injury and also helps the policy makers prioritize their tasks.

The most recent edition of EBIC, the EBIC 2005 – 2008 report, is built upon the estimates for direct and indirect costs. Intangible costs, originating from pain and suffering, were not captured in the report. Direct costs are associated with health care spending to improve health conditions and prevent current situations from deterioration. Accordingly, three direct cost components in the report, such as hospital care expenditures, physician care expenditures, and drug expenditures, belong to tangible costs. Another significant side of direct costs is 'other direct health expenditures' (Canadian Institute for Health Information 2014); this considers other professionals, other institutions, administration, public health, and other health spending that should be taken into account to fully measure the burden of illness and injury, knowing that this segment presents 37.7 % of total 2008 cost of illness in Canada (71.1 billions out of 188.8 billions); none of these were attributable to EBIC categories (order of cost type and subcategory, diagnostic category, sex, age group, and province/territory). Thus, despite the importance of 'other direct health expenditures', the impact of such considerations is assumed to be minimal for the purpose of this study.

Table 4.2 Summary of costs attributed to *diabetes mellitus* in Canada ($ millions)

Cost category	2004 - 05[a]	2008[a]	2015*
Direct costs			
Hospital (2004)	341.4	492.7	613.7
Drugs (2005)	878.1	1,198.1	1,164.2
Physician care (2005)	377.1	487.3	607.0
Total direct costs	1,596.6	2,178.2	2,384.8
Indirect costs			
Mortality (2004)	11.1	12.3	15.3
Morbidity (2005)	122.3	132.9	165.5
Total indirect costs	133.4	145.2	180.9
Total costs	1,730.0	2,323.4	2,565.7

[a]Source: PHAC (2014)
Notes: *Adjustment is made using Statistics Canada's consumer price index for health and personal care (STC 2016)

Table 4.3 Summary of costs attributed to *coronary heart disease* in Canada ($ millions)

Cost category	2004 - 05[a]	2008[a]	2015*
Direct costs			
Hospital (2004)	3,864.9	5,068.0	6,312.6
Drugs (2005)	3,637.6	4,272.7	4,151.7
Physician care (2005)	1,861.4	2,352.0	2,929.6
Total direct costs	9,363.9	11,692.7	13,393.8
Indirect costs			
Mortality (2004)	84.8	92.4	102.5
Morbidity (2005)	234.5	269.6	299.1
Total indirect costs	319.3	362.0	401.7
Total costs	9,683.2	12,054.7	13,795.5

[a]Source: PHAC (2014)
Notes: *Adjustment is made using Statistics Canada's consumer price index for health and personal care (STC 2016)

The proportional rate, 1 % reduction of disease-related costs regarding the 1 % decrease in incidence of disease, is not always necessarily applicable for every cost component. In other words, rather than generalizing the proportional reduction ratio, it is much more appropriate to convey the specific nature of cost categories. As such, among the three direct cost components, hospital and drug costs should adopt non-proportional reduction rates, 0.16 % and 1.00 % respectively. They will correspond to reductions from 1 % disease reduction in related costs, the detailed cost structure of governing hospitals and drug types should be considered. The proportional reduction rate and its detailed structuring of drug cost categories follows next. For example, to run a hospital, hospitalization expenditures related to diabetes and CHD would have a sizeable fixed cost element, e.g. building maintenance or utilities, that is rarely affected by the number of heart attack patients waiting for a cure at the hospital. Accordingly, to implement the proportional reduction for the hospital cost category in Table 4.4, results from a study examining the fixed and variable cost structure of hospital administration are taken into account. Roberts et al. (1999) identified that hospital costs consist of approximately 84 % fixed and 16 % variable amounts, implying no impact on fixed cost from the reduction in T2D and CHD prevalence.

Calculation of the reduction in drug costs of CHD assumes that fewer individuals will be in need of CHD-related medications. However, not all the CHD-related medications will be affected by the same proportional disease reduction rate. Gyles et al. (2010) state that, as opposed to the association of plant sterol and its proven cholesterol reduction, a hypertensive condition will rarely be improved as a result of cholesterol reduction. Only 50.4 %, which is the remainder of total CHD drug costs (excluding the 49.6 % accounted for the treatment of hypertension), should be used in this calculation. In other words, the 50.4 % of drug costs related to CHD are to be proportionally reduced with respect to the reduction in the incidence rate of CHD. Nevertheless, the case of pulse could in fact be different from such a reduction; this proportionality is due to the multiple clinical benefits associated with pulse consumption (Pulse Canada 2015; Jones 2013). Thus, the association between lower blood pressure and pulse consumption needs to be investigated.

Research has revealed a significant risk of coronary heart disease for type 2 diabetes patients (Haffner et al. 1998). The results show that the seven-year incidence rates of myocardial infarction differ between diabetic subjects with, and other diabetic subjects without, previous myocardial infarction. Among the many relevant risk factors, a greater prevalence of hypertension is a determinant cause for subjects with type 2 diabetes; this can be seen in the 30.3 % difference regarding the occurrence of hypertension (non-diabetic group: 43.5 %; hypertensive and diabetic group: 66.9 % hypertensive; both groups featuring patients of prior myocardial infarction). The other groups with no prior myocardial infarction show a 23.4 % difference in terms of hypertension occurrence (non-diabetic group: 31.9 % hypertensive; diabetic group: 62.2 % hypertensive).

The marginal rates above suggest additional cost saving ratios with regards the drug cost category of the CHD. As such, the proportion of cost reduction for CHD drugs should be greater than 0.50, considering the potentially additional drug cost savings from a lesser incidence of hypertension drug purchases. To calculate the new ratio, it is necessary to estimate the reduced number of hypertensive patients proportionate to the reduction of diabetes incidence, as result of increased pulse consumption.

To locate the corresponding drug category reduction percentage, the question of how many hypertensive patients would likely suffer from diabetes needs to be answered. The Captopril Prevention Project (CAPPP) (Hasson et al. 1999) has conducted a randomized intervention trial for the efficacy of therapy on cardiovascular morbidity and mortality in hypertensive patients based in Sweden and Finland. The study demographic included men and women, aged 25-66y, who had been diagnosed as hypertensive and whose diastolic blood pressure is 100 mm Hg or higher on two separate blood tests. Among those hypertensive participants, 5.62 % (309 out of 5492, “Captopril” treatment group) and 4.78 % (263 out of 5493, conventional treatment group) reported that they had diabetes mellitus in their medical history. From the limited scope of this study, one can assume that hypertensive patients do not tend to be as vulnerable to diabetes risk since the range of 4.78 – 5.62 % diabetes occurrence in the hypertensive subjects does not significantly differ from the general Canadian population living with diabetes. In 2008-2009, 2.4 millions Canadians (6.8 %) are living with diabetes (PHAC 2015).

However, people living with diabetes show a much higher level of occurrence in terms of hypertensive risks, as demonstrated by Haffner et al. (1998): the proportion of people with hypertensive diabetics is 62.2–66.9 %. This reveals the other side of the interrelation between diabetes and hypertension. Furthermore, the meta analyses of dietary pulse trials on the effect on blood pressure (Jayalath et al. 2014) asserts that a median of 1 and 2/3 serving (162g) per day pulse intake (beans, peas, chickpeas, and lentils) have reduced the levels of systolic (-2.25 mm Hg) and mean arterial blood pressure (BP) (-0.75 mm Hg) at a statistically significant level. This study also finds a significant association between pulse diets and a lowered risk of heart disease that is highly correlated with BP. The results indicate risk factors which are 22 % and 11 % lower for CHD and cardiovascular disease, respectively.

At minimum, hypertension drug cost savings can be achieved by considering the extra 2.06 % reduction in a total number of diabetes patients that results from multiplying 6.8 % (number of diabetic patients in Canada) and 0.303 (the marginal rate in the reduced hypertensive patients). Approximating this reduction in hypertension drug costs assumes that less patients with type 2 diabetes patients will require blood pressure related medications. Moreover, there will be other hypertensive patients without diabetes that will aim to consume more foods with pulses. Nevertheless, taking into consideration the evidence of meta-analyses of eight different dietary pulse trials (Jayalath et al. 2014), and the finding of a significant reduction in hypertension risks via pulse intake, it should be logical to accept the proportion of cost reduction for CHD drug cost as 1.00; such a consideration will allow an equivalent proportionate reduction in hypertension drug cost savings, corresponding to the 1 % related disease reduction.

Aside from the direct costs, the EBIC report has shown indirect expenditures by constructing the monetary value associated with productivity loss due to illness, injury, or premature death. Productivity losses in labour market activities were the primary concern for this indirect cost component; presenteeism, non-labour market activities, and casual caregiving were excluded from the analysis. The cost components arise from either the value of productivity forgone due to premature mortality, or the value of productivity forgone due to morbidity. The economic modeling on which the EBIC 2005-2008 has based is 'friction cost method' takes into account the time from when an individual leaves their job due to illness, injury, or premature death until the position is replaced; this is opposed to assuming the full employment of affected individuals. In other words, 'the human capital method' that was used for the economic interpretation of prior editions of EBIC considers 'the present value of future earnings of individuals'; this disallows the replacement of a vacant position. Such a method fails to takes account of today's labour market, which is typically faced with a 6 to 10 % unemployment rate over time. As a consequence, using the human capital method results in inflation of estimated costs because it does not accept the rationality of contemporary corporate practices on morbidity and mortality cases. Carefully examining the impact of differentiating an economic method helps researchers understand why there is such a substantial disparity in the estimated indirect cost components between the recent EBIC editions (1998 and 2005-2008).

Table 4.4 Summary of disease cost reduction ratio according to a 1 % decrease in incidence of disease

Cost category	Reduction in cost (%) - Diabetes	Reduction in cost (%) - CHD
Hospital[a]	0.16	0.16
Drugs	1.00	1.00
Physician care	1.00	1.00
Other direct	-*	-*
Mortality	1.00	1.00
Morbidity	1.00	1.00

[a]Source: Roberts et al. (1999)
Notes: *Not attributable by EBIC categories

The cost relationship to reduced incidence of diabetes and CHD should be directly proportional when it relates to the characteristics of mortality and morbidity. In other words, a reasonable assumption suggests that, with the declining incidence of diabetes and CHD, the indirect cost components, mortality and morbidity costs, should be also reduced proportionately as the number of people confronted by premature death and disability declines correspondingly. As a consequence, the loss of human capital in relation to diabetes and CHD-related death and disability would have been prevented; the avoidance of a monetary loss then would turn into an economic saving. Thus, given the acceptance of this assumption, the reduction in cost according to a 1 % decrease in the incidence of the diseases should be obtained at 1 %, as shown in Table 4.4.

Table 4.5 Summary of assumptions and scenarios for sensitivity analysis – T2D

	Scenario			
Assumption	Ideal	Optimistic	Pessimistic	Very pessimistic
Success rate	47.0[b]	34.4[c]	24.0[c]	24.0[c]
Glycemic index and load reduction due to pulse consumption	13.30[d]	13.30[d]	13.30[d]	13.30[d]
Diabetes (type 2) reduction due to 1 % reduction in glycemic index and load	2.48[a]	2.15[d]	1.87[a]	0.67[a]
Diabetes (type 2) reduction due to pulse consumption	33.0	28.6	24.9	8.9

Sources: [a]Bhupathiraju et al. (2014), [b]Lee et al. (2007), [c]Wansink (2005), and [d]Willet et al. (2002).

Table 4.6 Summary of assumptions and scenarios for sensitivity analysis - CHD				
	Scenario			
Assumption	Ideal	Optimistic	Pessimistic	Very pessimistic
Success rate	47.0[e]	34.4[g]	24.0[g]	24.0[g]
Reduction in markers of glycemic control due to pulse consumption	24.00[d]	25.00[f]	14.00[d]	10.00[a]
CHD reduction due to 1 % reduction in insulin resistance, insulin level and blood cholesterol	1.00*[b]	0.76**[c]	0.76**[c]	0.76**[c]
CHD reduction due to pulse consumption	24.0	19.0	10.6	7.6

Sources: [a]Anderson et al. (1984), [b]Ha et al. (2014), [c]Hanley et al. (2002), [d]Jang et al. (2001) [e]Lee et al. (2007), [f]Marinangeli and Jones (2011), [g]Wansink (2005).
Notes: *A 1 % reduction in LDL cholesterol corresponding to a 1 % reduction in the incidence of CHD **Reduced percentage of disease occurrence-to-markers of glycemic control, obtained from the odds ratio; the markers of glycemic control are highly correlated.

The calculation of the reduction in costs associated with reduced disease prevalence would have to be based on approximation to the potential real outcomes. Since a number of assumptions were made for essential linkages, an analysis of peer-reviewed scientific literature enhances the validity of arguments for this paper. Furthermore, limiting to the only outcome in a finite number often losses the convincingness of argument; this analysis includes a series of calculations with possible sequential errors. As such, a sensitivity analysis is utilized here to allow the existence of variation in the estimation, along with the four scenarios ranging from the least possible to the best. Each point of reference for the four scenarios would differ depending on the magnitude of changing factors within the group; assigning the multiple scenarios would help successfully derive the much more reliable results than it is for a single scenario. An illustration of the sensitivity analysis is shown as summary of assumptions and scenarios for sensitivity analysis in Table 4.5 and Table 4.6.

Chapter 5. Results and Discussion

5.1. Reduction in Diabetes

These findings have significant implications for cardiovascular health and diabetes. The results in Table 5.1 correspond to the prospective scenarios of pulse consumption, in relation to health benefits for diabetes reduction. The ideal scenario is dependent upon the 47 % of success rate and 13.3 % reduction in glycemic index. Consequently, since the diabetes reduction ratios are 2.48, 2.15, 1.87. and 0.67, the concluding reductions in diabetes events, which can only occur over a period of years with long-term consumption of low-glycemic-index carbohydrates, turn into 33.0 %, 28.6 %, 24.9 %, and 8.9 % respectively. As such, Table 5.1 shows the range of monetary values derived to be proxy of the economic savings to Canada by allowing increased consumption of dietary pulse. For example, Table 5.1 projects a figure, $ 317.8 million, for the ideal scenario.

Table 5.1 Reduction in diabetes cost due to consumption of pulse enriched foods ($ millions in 2015 dollars)

Reduction in diabetes	Scenario			
Cost category	Ideal	Optimistic	Pessimistic	Very Pessimistic
Direct costs				
Hospital	15.2	9.7	5.9	2.1
Drugs	180.5	114.5	69.5	24.9
Physician care	94.1	59.7	36.2	13.0
Other direct	-	-	-	-
Total direct costs	289.8	183.9	111.6	40.0
Indirect costs				
Mortality	2.4	1.5	0.9	0.3
Morbidity	25.7	16.3	9.9	3.5
Total indirect costs	28.0	17.8	10.8	3.9
Total diabetes costs	317.8	201.7	122.4	43.8

Table 5.2 Reduction in coronary heart disease cost due to consumption of pulse enriched foods ($ millions in 2015 dollars)

Reduction in CHD	Scenario			
Cost category	Ideal	Optimistic	Pessimistic	Very Pessimistic
Direct costs				
Hospital	113.9	66.0	25.8	18.4
Drugs	468.3	271.4	106.0	75.7
Physician care	330.5	191.5	74.8	53.4
Other direct	-	-	-	-
Total direct costs	912.7	528.8	206.6	147.6
Indirect costs				
Mortality	11.6	6.7	2.6	1.9
Morbidity	33.7	19.6	7.6	5.5
Total indirect costs	45.3	26.3	10.3	7.3
Total CHD costs	958.0	555.1	216.9	154.9

To a lesser extent, but also significantly, the optimistic scenario shows a health care saving of $ 201.7 million. This is based on the 34.4 % success rate of pulse enhanced products, the presumption of 13.3 % glycemic index reduction, and the assumption of a 2.15 % diabetes reduction proportionate to the 1 % reduction in glycemic index. Identical to the calculation of the ideal scenario, multiplying the estimate of success ratio, diabetes reduction ratio and the total diabetes costs will calculate the health care savings of $ 201.7 million.

The pessimistic and very pessimistic scenarios carry the conservative estimates of conducting the framework. With a success rate 24 %, the following estimates discuss the lowered risk of diabetes. For example, a 24.9 % diabetes reduction is based on 13.3 % glycemia reduction and 1.87 diabetes reduction ratio. A 8.9 % diabetes reduction results from 13.3 % glycemia reduction and the 0.67 diabetes reduction ratio. Consequently, the associated health care savings are estimated to be from 122.4 (pessimistic) to 43.8 million dollars (very pessimistic). Whether or not the scenarios vary along with different assumptions, the potential economic savings impose significant budgetary considerations for the public's best interests and the policy implications.

5.2. Reduction in CHD

Potential pulse consumption and its benefits for cardiovascular health can also provide very significant healthcare savings. The results in Table 5.2 list the potential health care savings corresponding to four different scenarios of promoting pulse enhanced products, methodologically identical to the Table 5.1. The same set of success rates applies to the context of cardiovascular health since the consumers would simultaneously benefit from each serving of pulse-enhanced products. In other words, the intake of ¾ cup of 175 ml cooked legumes per day over a period of years would result in two different health benefits: reductions in both diabetes and CHD prevalence.

The ideal scenario of CHD reduction is based on a 47 % of success rate and a 24 % reduction in LDL cholesterol level. Consequently, since the CHD reduction ratio is 1.0, proportionate to a 1 % reduction in LDL cholesterol level, the following reduction in CHD events turns into 24 %. Thus, within the success-rate-adjusted consumers, the obtained reduction can be directly applied to the total CHD costs, resulting in a saving of $ 958 million as shown in Table 5.2.

The optimistic scenario in CHD reduction assumes significant health care savings of $ 555 million. This is based on a 34.4 % success rate from pulse-enhanced products, the presumption of 25 % insulin resistance and its level reduction, and the assumption of 0.76 %

CHD reduction proportionate to the 1 % reduction in changes of insulin. Similar to the calculation of the ideal scenario, multiplying 19 percent (multiplication of 25 % and 0.76 %) to the total CHD costs derives health care savings of $ 555 million.

The pessimistic and very pessimistic scenarios demonstrate the most conservative outcomes. The pessimistic and very pessimistic scenarios of cost reduction in CHD involve a success rate 24 %. The following estimates discuss the lowered risk of diabetes. For example, a 10.6 % CHD reduction is based on the multiplication of 14 % FBI reduction and 0.76 CHD reduction ratio. A 7.6 % reduction in CHD results from 10 % FBG reduction and the 0.76 CHD reduction ratio. Consequently, the associated health care savings are estimated to be from $ 216.9 million (pessimistic) to $ 154.9 million (very pessimistic).

As a result, the calculated potential economic savings represent very significant budgetary considerations that would allow for monetary allocation to other priority areas such as education or infrastructure. Note that the scenarios, again, vary along with the assumptions. However, among these scenarios, the optimistic scenario can be most likely as it is highly scored with the higher probabilities where a measure of effect size was most standardized. For example, the relevant randomized controlled trials (Jang et al. 2001; Marinangeli and Jones 2011) have provided the similar scope of reduction percentage estimates in glycemic control biomarkers, ranging from 24 to 25 %.

Chapter 6. General Discussion and Conclusions

The experimental findings demonstrate that substantial cost savings, ranging from $ 43.8 to 317.8 million and $ 154.9 to 958.0 million with regards to reduction in T2D and CHD respectively, can be achieved if consumers willingly accept a Health Canada's recommended dose of ¾ cup or 175 ml cooked legumes per day of pulses and pulse-flour-containing products. Such consumption can effectively reduce the level of glycemic index, fasting insulin concentrations, insulin resistance, and LDL cholesterol. The improvement in these biomarkers will, intuitively, result in a lowered risk of related diseases, such as T2D and CHD. Regarding Canadian healthcare expenditure that is publicly funded by taxpayers, the proportional reduction in prevalence of T2D and CHD is to be multiplied by the total costs of T2D and CHD to estimate the economic savings from promoting pulse products. These savings have serious policy implications. The ideal scenario alongside the highest success rate shows the largest amount of economic savings whereas the other scenarios and their estimations should not be underestimated for the implication of considerable cost recovery.

6.1. Limitations

Given this work is a modeling exercise, readers are advised of risk of bias. The outcome of the economic simulation in this paper is derived residually since data are extracted from administrative sources originating from the results of relevant studies. Sequential errors may occur at the extended multiple steps of economic simulation with several scenarios. Furthermore, techniques utilizing the meta-analyses and systematic reviews can be debatable due to the various assumptions within the pooled results and potential sampling errors. However, to obtain high methodological quality, most of the trials and their meta-analyses consist of the peer-reviewed published journal articles with sufficient duration of study. Important aspects of research method were to apply the most relevant biomarkers and their disease occurrence, with consideration on the correlation of variables.

The statistical distribution of potential outcomes for key variables could differ significantly from the uniform distribution that this paper has implied. Intuitively, from a statistical standpoint, a new way of assessing the relative probabilities of individual scenarios would capture positive and negative outliers that can have some advantages over discrete values. Thus, the data represented in this paper can be fitted to a continuous distribution to consider aspects of potential outcomes that are most convincing and achievable. However, arguably, such approach may pose ambiguities on confident outcomes and also increase variations in the quality of the scenarios. Since the distribution of the ideal scenario has been fitted as discrete, it is much more as likely to occur as the pessimistic scenario. It may be difficult or impractical to construct a customized distribution, but it may still be feasible to fit the data to an appropriate statistical distribution, to improve the results of this study.

On the other hand, relying only on a single variable of a regression model would be subject to risk of bias, resulting in low explanatory power of perspective. For example, research arguing pulse consumption for completely solving the problem of rising disease occurrence would be misleading. A number of socioeconomic and biological variables including lifestyle or genetic variations, could affect the outcome of research investigation. To address such concerns, the prospective cohort studies utilized in the third step of this economic simulation have incorporated other relevant variables for assessing the risk of disease; the model studying "HOMA-Insulin resistance in relation to the incidence of cardiovascular disease" (Hanley et al. 2002) has been adjusted in several ways, incorporating age, sex, and ethnicity for one model;

additionally for the second model, cholesterol level, triglyceride, blood pressure, smoking, alcohol consumption, exercise, and waist circumference were taken into consideration. All other meta-analyses used for this study share this common analogy.

The health benefits of pulse consumption should not only be limited to the areas discussed in the paper; potentially beneficial biomarkers, such as blood glucose, fasting insulin, blood cholesterol, and blood pressure, were the major focal point of this study. However, Jones (2013) has pointed out that the health benefits of dietary pulses should include not only lower blood glucose, lower insulin, lower blood pressure, and decrease total cholesterol, but also colorectal cancer prevention and lower body weight. Future studies should investigate other potential health benefits and associated disease risk reductions. Future implications of this issue could be very substantial as if a carefully designed study considers the potential economic savings and adequately addresses each impact of dietary pulse intake. Otherwise, potential multicollinearity problems between the variables could arise if one cannot be predicted from other variables. Several difficulties with this notion need to be taken into consideration from a methodological standpoint.

The dosage of dietary pulse varies across published human trials, so the expected results of such economic simulation would differ; this results in a possible disparity between studies revealing costs and benefits. Canada's Food Guide by Health Canada calls for 175 ml (3/4 cup) of cooked legumes, equivalent to the minimum effective dose of 130 g per day of beans that was utilized in studies intended for meta-analysis (Sievenpiper et al., 2009; Pulse Canada, 2015). From the human trials of pulse intake (Marinangeli and Jones 2011; Marinangeli et al. 2009), these authors have referred to a 50 g dose of dry pulse for their feeding trials, where such amount is approximately 2 servings, half a cup per day recommended by the United States Department of

Agriculture. Although the interactive impacts of different dosages of pulse intake cannot be captured, the human nutritional biomarkers, such as glycemic index and insulin resistance, can be considered as proxies across human interventions. To overcome the discrepancies in the data for dosage, the findings of meta-analyses (Sievenpiper et al. 2009) have provided standardized mean values of dietary pulse intervention across decreasing markers of glycemic control, such as fasting blood glucose, fasting blood insulin, HOMA of insulin resistance, and glycosylated blood proteins. Note that, considering 41 trials of meta-analysis intended for the derivation of multiple studies, their averaged results for fasting blood glucose and HOMA-IR share the boundary of probability that enable this research to support the presumption with regards to a possible glycemic index reduction and insulin resistance reduction.

Lacking empirical evidence regarding consumer taste and preference on pulse products, this research paper has rather incorporated an analysis of studies based on soybean consumers. As such, the final outcomes in the paper may be faced with a challenge in assuring the validity of its methodology.

6.2. Consideration for future research

Among the EBIC cost categories attributed to T2D and CHD, the 'other direct health expenditures' attribute in relation to T2D and CHD should not be underestimated. As previously mentioned, such attributes were estimated as taking up a significant portion of the total cost of illness in Canada, 37.7 % in total in 2008 (Canadian Institute for Health Information 2014); so, the assumption in this study, that is to minimize the impact of cost attribute in area of other professionals, other institutions, administration, public health, and other health spending, in fact, could be too substantial to ignore. Thus, despite the very important aspects of 'other direct health expenditures', readers should keep in mind that the impact of such considerations are assumed to be minimal for the purpose of this study. A careful assessment on the impact for such areas will help researchers reconsider the additional healthcare savings of T2D and CHD, as previously shown in the edition of EBIC published in 1998.

The employed research method, cost of illness, has been effective in supporting the purpose of this research to determine the potential benefits from promoting pulse-containing foods. On the other hand, promoting sustainable consumption may lead to premium pricing, which would impose higher costs on consumers. In this case, Gyles et al. (2010) assert that the costs of functional foods will not be captured in the medical system of Canada and would turn into a benefit to the financial side of publicly funded healthcare systems. In addition, the researchers advise that when an excessive premium pricing is present, the costs could outweigh the initial economic benefits to the society. Under such circumstances, other than applying the cost-of-illness method, the economic research methods, such as cost-effectiveness or cost-benefit analysis, will serve as much more realistic instruments to help address two or more alternative policy options for evaluation.

A number of specific groups would appreciate the health benefits of dietary pulse intake, and the functionality and versatility of pulse flour will serve a crucial role in further development of a pulse-containing product. For example, dietary pulse, such as beans, dried peas (e.g. yellow split pea), chickpeas, and lentils can be a very attractive option for consumers who are often concerned with "gluten-free products". Furthermore, Tosh and Yada (2010) find pulse flour can replace the rice, corn, and/or dried potato that are utilized for current gluten-free products on the shelves. The authors also find Kinniklnnick Foods (Edmonton, Canada), a major supplier of gluten-free products, prefers using pulse fibre in various food applications of their products.

In addition, pharmaceutical applications and medical treatment cannot always provide the treatment to people due to their reactions, such as allergies or possible withdrawals (Ha et al. 2014). For example, statin therapies are effective in lowering cholesterol but intolerable for some people; major health organizations do advise approaches consisting of dietary and lifestyle patterns for the prevention and management for the cardiovascular health.

Recently, Canadian policy makers have taken the level of public interest in functional foods into very serious consideration and have shown an effort to further release more therapeutic health claims in the past decade in a speedier manner (Health Canada 2015). However, beyond the release of official health claims, the policy makers and initiatives need to strategically address the remaining issues of market failure along with the societal inefficiency to warrant the maximum marketability of pulse along with consumers' full confidence in the quality of products. Implementing a successful, solid, and viable regulation process of food with scientifically proven human nutrition trials will be critical. The most recently approved health claim for soy protein and its cholesterol lowering properties has become a solid cornerstone that will expand the scope of already known health benefits from pulse consumption, including yellow pea products. However, the governmental approval process should not only be trustworthy, but should also prioritize based on the exigency of the application's claims. For example, in December 2011, Health Canada's Food Directorate received an application for a therapeutic claim about protein-rich soy foods and blood cholesterol lowering; it had taken more than three years to reach final approval.

Another possible direction of future research is to consider conducting detailed consumer surveys on various types of new pulse enhanced products in the context of the Canadian market. For instance, some interesting research questions may include, 'what food applications do pulse consumers like the most? for what reason? convenience, taste or design?', or 'which brand name is appealing to across variables, such as gender or socioeconomic status?' A group of agricultural and food marketing research expertise will be able to answer such questions by conducting a well-designed survey.

On one hand, if there is any reason for having an aversion to pulse, it should be captured by survey questionnaires. An example of potential aversion is shown on the Pulse Canada's web page (Pulse Canada 2015). The information script indicates a reputation of pulse being "musical fruit", which imposes challenges on some consumers. Cooking guidance on the web page advises that affected consumers discard the soaking water of pulses or take dietary supplements to help eliminate gas, which often imposes constraints on some consumers with busy and limited lifestyles for cooking. Evidently, findings from the study based on the taste and preference of Latin American pulse consumers reveals similar constraints. Leterme and Munoz (2002) argued that the softness of pulses is linked to aversion, so consumers prefer to choose pulse diets over other proteins. For example, people living near the altitude-increasing Andes and Central America are concerned with eating pulses due to the longer cooking time without having a pressure cooker. Since the higher the altitude is, the cooking time of pulse needs to be incremental. Furthermore, Leterme and Munoz (2002) argue that there has been changing trends of eating pulses in Latin America due to such factors including as busy lifestyle, less time to cook, substitutable foods, or increased accessibility of processed foods with excessive media advertisement.

Furthermore, low pulse consumption in Canadian market, the fact that only the 13 % of total Canadian population consumes pulses on daily basis (Mudryj et al. 2011), could be associated with the economic theory that emphasizes the relationship between quantity demanded and disposable income. According to this theory, goods can be classified as either normal goods if consumers want to buy more of them as their income increases, or inferior goods if consumers react vice versa. In other words, depending on the direction of linear patterns on the quantity of goods with respect to the changes in disposable income, a good can be classified as normal or inferior. Such a relationship can be illustrated by referring to Engel curves (Appendix 1) in the context of pulse consumption. The Engel curve could imply a relationship between the quantity of pulses consumed and income. In (a) of Appendix 1, food is a normal good as the Engel curve is positively related to increasing income. On the other hand, in (b), hamburgers a normal good for income less than \$20 per month but it becomes an inferior good for income greater than \$20 per month. Replacing hamburger with pulse, it might be interesting and worthwhile to undertake research on such relationships, expecting potentially similar outcomes. Nevertheless, it should be noted that this Engel curve example is only one conceivable theory for the purpose of partially explaining such low pulse consumption in Canada. However, some researchers find the following results similar to the Engel curve in a context of pulse consumption.

Studies investigating various factors affecting pulse consumption in other regions have been conducted. Leterme and Munoz (2002) and Jha et al. (2014) discuss that that the degree of income level can have a strong influence on the demand for pulse, resulting in quantity changes of meat demand. Leterme and Munoz (2002) find that factors explaining pulse consumption in Latin America include nutritional quality, tradition and culture, urbanization, consumers' preference, and most notably income. Beans are regarded as poor man's meat in Latin America because they are an inexpensive source of protein; people in low-income brackets tend to move back to beans and peas when meat is no longer affordable for them. The results indicate though, as their income increases, increase in meat consumption was seen. The authors also find that, in South America, it was estimated that a group in low-income bracket had an average of 20 % more pulse consumption compared with the highest income group. Comparably, the pulse consumption per person in India fell by approximately 50 % between 1951 and 2008, from 61g to 30g respectively (Jha et al. 2014). However, the authors revealed two contrasting consumption rates with respect to income levels of the Indian population. For example, between 2009 and 2010, a rising consumption pattern was shown in the poorest rural areas and mid-low income groups, as the upper middle class and the highest income groups continuously decreased their pulse consumption. Although relationships between consumption of pulses and income have yet to be proven by econometric equations, as this research paper takes into account only few of the relevant manuscripts, the prospective researchers may have a strong interest in incorporating the Engel curve theory into regional pulse consumption rates and corresponding income levels.

Innovative marketing campaigns, educational means, and public awareness will be helpful in encouraging more consumption of pulse. Furthermore, to enhance the nutritional quality and health benefits of pulse-based processed foods, initiating an alliance of public and private partnership, civil community, and academia is essential. Jha et al. (2014) identify a Pulse Innovation Partnership (PIP) in a strategic alliance between public sector leaders, producers and industry marketing groups, and private companies. According to the authors, PIP is organized in a collaborative manner bringing stakeholders together across all levels of the pulse value chain. In other words, PIP enables market players to reveal not only consumer demand drivers but also various useful factors on the production side towards processing techniques in order to maximize the accessibility, profitability, and attraction of improving nutrition quality at every position along the supply chain. Promoting such partnerships is a novel idea, which helps innovative leaders in the chain overcome challenges in the market and accelerate the launch of new pulse-based processed foods.

Furthermore, leaders in the pulse industry can construct further institutional innovations by exploring various forms of policy options. Notably, the Food and Agriculture Organization of the United Nations have declared the year 2016 as the "International Year of Pulses". Needless to say, for successful launching, this campaign requires strategic engagement with collective action from public and private partnership, academia, civil society, and industry organizations. Other institutional innovations might proceed to various forms, such as subsidies or coupons for introducing pulse-enhanced products, or targeting a specific group, e.g. child nutrition programs at school or community, such as "midday meal program" in India (Jha et al. 2014). Accordingly, Jha et al. (2014) assert that potential innovations could be mutually beneficial or would remain dormant at the same degree in isolation. In other words, the authors note that without organizational innovation, such as PIP, it would be very difficult to gain technological innovations at the individual level of scale. On the other hand, the researchers also note that the potential financial advantages from joining the institutional innovation would be a strong incentive and encouragement for food companies, reinforcing the existing structure of partnership. Thus, it is worth noting that society as a whole also benefits from the reinforcement of such innovative partnerships, contributing to economic growth and healthcare savings, as food consumers enjoy improved health conditions and quality of life.

The successful launch of a new food product is often not accomplished with ease due to potential challenges or uncertainty in the industry. The timing and speed of a launch depends on government approval and consumer confidence in the product; the products may not be the immediate success in near future. However, the ideal scenario can be achievable if the strategic marketing tactics were to take place for a sufficient period of time. Depending on the successful launching of product and acceptable increase in pulse intake, the extent of response that consumers who believe in such health claims will vary. However, the outcome of the new concept on pulse-containing products can be predictable along with the possible scenarios in the economic simulation.

The objective of the study has been exclusively tailored dietary pulse intake, more than any other variable, careful consideration of socioeconomic circumstances should be taken into account. In other words, the current agenda of food policy should be based on how customers value non-market factors, such as environmental, ethical, or socio-economical considerations. Unnevehr et al. (2010) assert that the historical initiation of food policy making has been quite dramatic due to various new types of consumer demand and related food production trends. Furthermore, relying only on price and income is inconsistent with the transforming structure of food and consumer economics. Thus, rather than focusing on the role of food assistance for poverty mitigation, new food policy agenda needs to be based on a model explaining unpredicted consequences of consumer behavior.

Similarly, another research paper provides a very insightful guideline for food and nutrition economists. Information policy has also contributed to promoting healthier diets while consumers are unaware of the changes (Golan and Unnevehr 2008). For example, mandatory disclosure of trans fat on product labeling or dietary guidelines of whole grain have influenced competition over new product lines. However, policy did not directly create new developments. The remaining question is whether such changes have led consumers to healthier consumption patterns. The researchers assert that a “halo effect” has become problematic as some consumers increase their dietary intake just because something is a healthy product. Moreover, low-fat products contain more sweeteners to maintain original tastes. Thus, policy makers need to be concerned with the side effects of new product attributes, as healthier diets may not necessarily lead communities towards nutritional health.

Recent discussions about the educational effects of food are highly connected to consumer behavior theory. In reality, policy making always faces unintended consequences, and the associated costs are often high. Imposing newer food policies has to take into account various types of social subjects as well as cultural or geographical attributes to minimize externality. In addition, one can argue that assigning a borderline between healthy and unhealthy products could be controversial since, unlike the policies on cigarettes, a recommended serving of any consumable food would not raise health concerns (Teisl et al. 2001). Where some nations are concerned with basic needs for food, others may be confronted with further healthier diets. As such, research in food and consumer economics would rather suggest a sophisticated approach, taking into account life expectancy, food availability, education, or access to healthcare. Health policy analysts are confronted with a dilemma: how to emphasize preventative approaches over granting direct assistance. Advocating preventative health programs, policy makers would alternate between traditional approaches and new approaches to promote healthier choices. The most useful advantage about this new alternative utilized by economists is the ex ante attitude regarding societal problems. Thereby, such issues can be more effectively addressed when proposing provisional public policy. As such, encouraging increased pulse consumption will be one of the most significant key action plans to initiate such preventative health policies.

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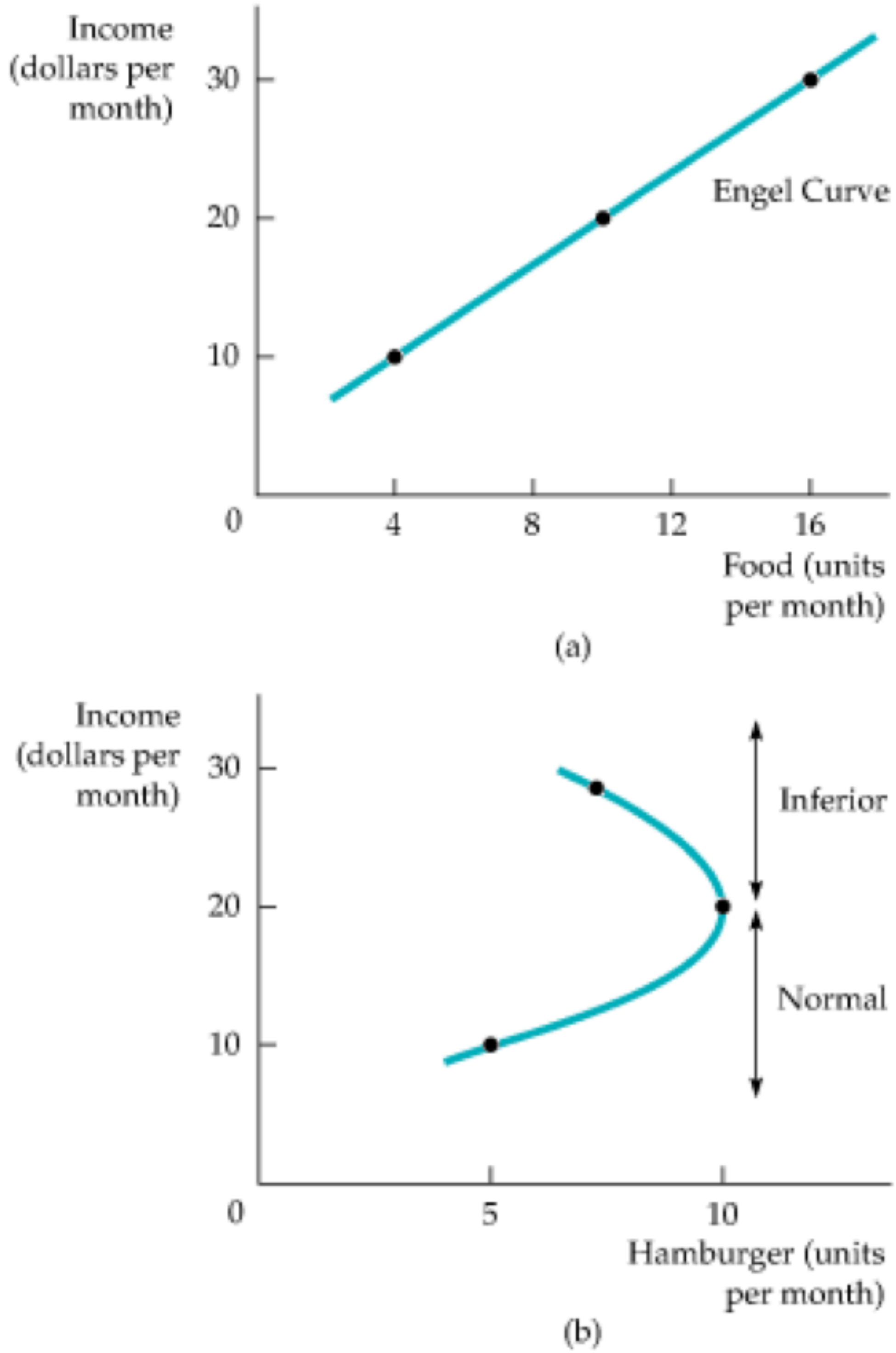

Appendix 1. “Engel Curve” (Pindyck and Rubinfeld 2005)