Examination of the sugars contents of Canadian prepackaged foods and the role that nutrition labelling can play in helping Canadians identify foods consistent with World Health Organization Guidelines

by

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Abstract

The World Health Organization (WHO) recommends free sugars intakes be limited to a maximum of 10% of energy intake. This thesis aims to characterize sugars in the Canadian prepackaged food and beverage supply and investigate whether the sugars information available on the food label (% Daily Value (%DV) and nutrient content claims) support the WHO free sugars intake guidelines. Three studies were conducted using the University of Toronto's Food Label Information Program (FLIP) 2013 database that contains nutrient composition and labelling information for a large representative sample of prepackaged foods and beverages (n=15,342). In the first study, a novel method for calculating the free sugars contents was developed and applied to products in FLIP 2013. Free sugars were present in 65% of foods and beverages and contributed on average, 20% of calories and 64% of products' total sugars content. In the second study, a free sugars DV of 50g, which aligns with WHO guidelines, was compared with a total sugars DV of 100g. A free sugars DV more consistently identified

products with ≥10% of calories from free sugars (82% vs. 55%) and with suboptimal nutritional composition as defined by the Food Standards Australia New Zealand nutrient profiling scoring criterion (70% vs. 45%), than a total sugars DV. In the third study, products with sugar-related nutrient content claims had more favourable nutrient profiles than those without these claims, but 48% had ≥10% of calories from free sugars. Findings suggest the need for nutrition labelling and the food supply to more reliably support identification and consumption of products consistent with WHO free sugars intake guidelines. Together these results represent significant advancements in the field of sugars research and the calculation and addition of free sugars levels to FLIP can inform an array of future studies and policy actions related to free sugars.

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List of Abbreviations

Alt.	Alternatives
CCHS	Canadian Community Health Survey
DV	Daily Value
%DV	Percentage of Daily Value
FLIP	Food Label Information Program
FOPS	Front-of-Package System
FSANZ	Food Standards Australia New Zealand
FSANZ - NPSC	Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion
FVNL	Fruit, Vegetable, Nut, Legume
FSI	Free Sugars Ingredient
MSSS	Manufacturer Stated Serving Size
NCDs	Non-Communicable Diseases
NFt	Nutrition Facts table
NP	Nutrient Profiling
PAHO	Pan-American Health Organization Regional Office of the World Health Organization
QUID	Quantitative Ingredient Declaration
RTE	Ready-to-eat
U of T	University of Toronto
US	United States
WHO	World Health Organization

Chapter 1

1 Introduction

In Canada and globally, diet-related non-communicable diseases (NCDs) are a leading cause of death and disability [1] and stifle social and economic development worldwide [2]. Unhealthy diets, broadly characterized by intakes of foods and beverages that are high in sodium, saturated fats, trans fats, and extrinsic sugars[1] (i.e. the sugars that are no longer intact in their naturally-occurring state), including free sugars[2] [3] and added sugars[3], are one of the leading modifiable risk factors for the prevention of NCDs [1]. Thus, the World Health Organization (WHO) recommends intakes of these nutrients and total energy be limited, while maintaining a diet with adequate and balanced intakes of other nutrients [4].

Sufficient evidence linking extrinsic sugars intakes to adverse health outcomes and unhealthy dietary patterns has led several authoritative bodies, including the WHO, to develop dietary guidelines recommending intakes of extrinsic sugars be limited to a maximum of 5 or 10% of total calorie intake [5-8]. However, it is estimated that Canadian added sugars intakes exceed these recommendations [9]. There are several factors thought to hinder the selection of foods in line with extrinsic sugars intake guidelines, including a global food environment characterized by an abundance and affordability of palatable high-sugar foods [10, 11], with studies from other countries demonstrating the ubiquitousness of extrinsic sugars in prepackaged foods [12, 13]. However, without a Canadian food composition database that properly characterizes the extrinsic sugars

[1] The over-arching term *extrinsic sugars* will be used throughout this thesis to describe both free and added sugars as in the literature they are often used interchangeably. When referring to a specific form of sugars, the precise term (i.e. free or added sugars) will be used. All studies conducted as part of this thesis used the term *free sugars*, as defined by the World Health Organization (see section 2.2.2).

[2] *Free sugars*, as defined by the World Health Organization, include "all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates".

[3] Definitions for *added sugars* vary by jurisdiction, but have traditionally referred to sugars and syrups that have been added to foods or beverages during processing or preparation (see section 2.2.2).

contents of foods and beverages [14], its pervasiveness in the food supply, intakes, and alignment with guidelines cannot be accurately determined.

Nevertheless, a number of recommendations have been made to decrease consumer exposure to products high in extrinsic sugars in Canada through several policy interventions [15, 16]. Food policies, like nutrition labelling regulations, are an invaluable tool for shaping the food environment [17]. Nutrition labelling provides information to consumers to help them make appropriate food choices, inform their dietary priorities [18], stimulate healthier product formulations [19, 20], and populate food composition databases [21]. In Canada, sugars information can be found in several parts of the nutrition label, including the mandatory Nutrition Facts table (NFt) and Ingredient List, and in regulated voluntary nutrient content claims [18].

Recently, the Canadian government has been actively engaged in enhancing the presentation of sugars information on the nutrition label [22]. For instance, as of 2021, the Canadian NFt will have a % Daily Value (%DV), or benchmark, for total sugars, which is a combination of both intrinsic and extrinsic sugars, based on 100g/day [22]. This benchmark is intended to help inform consumers of the amount of a nutrient in a product [22]. Although *CODEX Alimentarius* [23], the global standards for foods, does not include the labelling of extrinsic sugars in their nutrition labelling guidelines at this time, the introduction of a %DV for total sugars is inconsistent with *CODEX Alimentarius* recommendations for the development of nutrient reference values [23]. A total sugars %DV does not reflect the latest dietary guidelines or scientific evidence [23], nor does it align with the nutrition labelling practices of Canada's largest trading partner, the US [18]. Additionally, concerns have emerged that labelling focused on total rather than extrinsic sugars may hinder the ability of consumers to abide by extrinsic sugars intake guidelines and may also negatively impact intakes of foods rich in intrinsic sugars that are recommended in *Canada's Food Guide* (e.g. fruits, vegetables, dairy products) [14, 24, 25]. Likewise, research has indicated that consumers can use the benchmarks for a single nutrient to assess the overall healthfulness of a product and subsequent intent to purchase [26]. However, there has been no evaluation of the %DV for total sugars, or any alternative (e.g. %DV for extrinsic sugars), in terms of its application to the prepackaged food and beverage supply and its alignment with extrinsic sugars intake guidelines and favourable nutrient profiles.

Nutrition labels are also used by manufacturers to market foods and beverages, through regulated voluntary nutrition claims (e.g. nutrient content claims, disease-risk reduction claims) [27]. It is believed that because nutrition claims can be more easily seen and interpreted by consumers than the full NFt, they are better able to help them make choices when shopping [20]. Consumers reportedly use the presence of sugar-related nutrient content claims to assess the overall healthfulness, calorie content, and sugars content of products, despite the claim referring only to the single nutrient [28, 29]. While there is evidence to suggest that products carrying nutrition claims have slightly more favourable nutrient profiles (of unknown clinical relevance) [30]; nutrition claims, including those related to sugars, have also reportedly been found on products that are high in sodium, sugars, saturated fats, and calories [31, 32]. With the growing attention on sugars, both in dietary guidelines [3, 5-8, 33] and in nutrition labelling regulatory changes [22], it is important that all the information available to consumers, including nutrition claims, support the selection of foods with nutrient profiles in line with extrinsic sugars guidelines. However, it is unknown the extent to which Canadian prepackaged foods and beverages with sugar-related nutrient content claims align with consumers' expectations of them (i.e. "healthier" or lower in calories) or have more favourable nutritional compositions than products without these claims.

To date, minimal research has examined the amounts and types of sugars in the Canadian prepackaged food supply. There is an urgent need for such information to avoid inaccurate food composition data, leading to erroneous results in research, poor policy decisions, misleading food labels, and misinformed food selection [34]. This thesis aimed to address this gap in research through three studies that had the following objectives and hypotheses:

Study 1: To determine and characterize the total and free sugars contents of foods and beverages in a large representative sample of Canadian prepackaged foods and beverages. This was a novel, non-hypothesis driven, investigation.

Study 2: To model and compare the use of total sugars vs. free sugars labelling on the Nutrition Facts table for their ability to identify products exceeding WHO free sugars intake guidelines and that have suboptimal nutritional composition.

I hypothesized that a free sugars %DV would identify a greater proportions of foods and beverages that exceed the WHO free sugars intake guidelines and have suboptimal nutritional composition as products with “a lot” of sugars than a total sugars %DV.

Study 3: To compare the nutritional composition of foods and beverages with and without sugar-related nutrient content claims and the consistency with which these claims are able to act as a marker for identifying products exceeding the WHO free sugars intake guidelines.

I hypothesized that foods and beverages with sugar-related nutrient content claims would have free sugars levels that exceed the WHO free sugars intake guidelines but compared to similar products without sugar-related nutrient content claims, they would have more favourable nutritional compositions.

All three studies were cross-sectional analyses of the University of Toronto’s Food Label Information Program (FLIP) 2013 database, a large food composition database that contains a representative sample of Canadian prepackaged foods and beverages. Overall, this thesis provides the first characterization of free sugars contents of Canadian foods and beverages and investigates the efficacy with which the sugars-related nutrition labelling policies can be used to identify foods and beverages consistent with the WHO free sugars intake guidelines. As a consequence of the novelty of this research, the results from these three investigations provide indispensable data to inform the implementation of WHO free sugars intake guidelines to food labelling, to enable research that requires detailed data on the sugars contents of prepackaged foods and offers valuable insights for future policy decisions aimed at aligning sugars-related nutrition labelling with WHO free sugars intake guidelines.

There are eight chapters in this thesis: Chapter 2 is a detailed review of the relevant literature; Chapter 3 outlines the rationale and objectives and hypotheses for each study; Chapters 4 through 6 present the published manuscripts of Study 1, 2, and 3; Chapter 7 discusses the key findings, implications, and future directions; and Chapter 8 is a summary of the conclusions.

Chapter 2

2 Background and Literature Review

2.1 Diet-related non-communicable disease

With the advent of effective vaccinations, antibiotics, and improved sanitation, fewer people around the world are dying of communicable diseases, but the proportion of people dying from non-communicable diseases (NCDs) has increased substantially [2]. Seventy percent of deaths worldwide can be attributed to NCDs, specifically, cancers, cardiovascular disease, diabetes, and chronic respiratory disease [35]; in Canada, these NCDs are estimated to account for approximately 88% of deaths [36]. The morbidity, mortality, and disability from these diseases stifle social and economic development worldwide [2]. The estimated economic burden of NCDs in Canada is considerable, with over $30 billion in healthcare costs and an additional $64 billion in indirect costs due to lost productivity per year [37].

NCDs are complex and chronic, and for this reason, addressing the modifiable lifestyle factors that increase risk of NCDs is regarded as a vital strategy for preventing their onset [37]. Unhealthy diets, broadly characterized by intakes of foods and beverages that are high in sugars, sodium, saturated fats, and trans fats [38], is one of the leading modifiable risk factors for death and disability from NCDs [1]. Thus, the WHO recommends intakes of these nutrients and total energy be limited, while maintaining a diet with adequate and balanced intakes of other nutrients [4]. In the past few years, several national and international authoritative bodies have made recommendations specifically advising that intakes of dietary sugars be limited to decrease risk of NCDs [3, 5, 6, 33].

2.2 Dietary sugars

2.2.1 Brief overview of sugars

Dietary sugars are a class of carbohydrates comprised of one and two monomer units of carbon, hydrogen, and oxygen atoms, known as monosaccharides and disaccharides, respectively [39]. Monosaccharides include glucose, fructose and galactose, and disaccharides include sucrose, lactose, maltose, and trehalose [39]. Once metabolized, sugars provide the same amount of energy as other carbohydrates (e.g. starch), and protein; approximately 4 calories per gram [39]. There is,

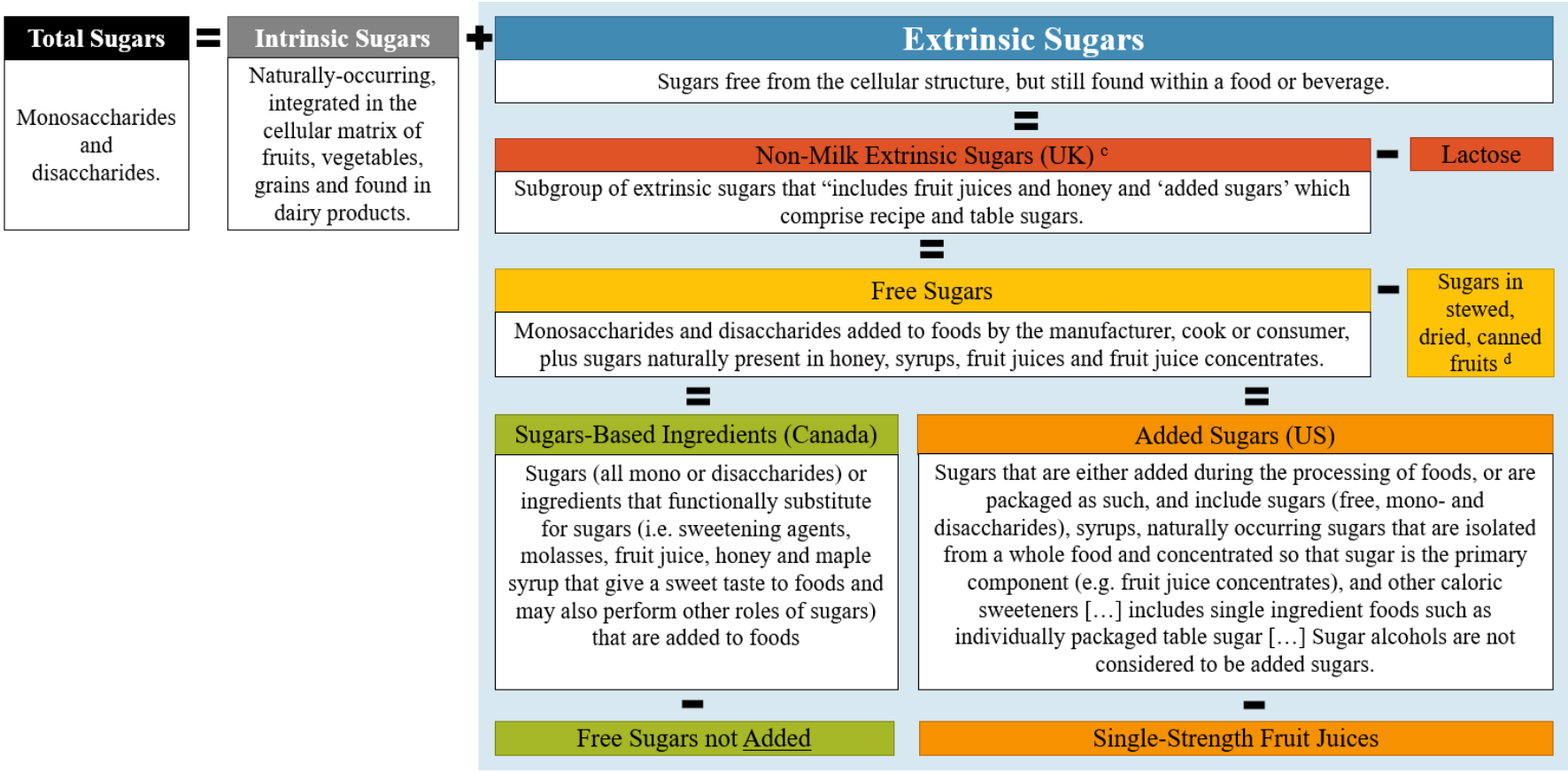
however, no dietary requirement or biological need to consume sugars in particular, only to consume 100g per day of any source of carbohydrate to meet the glucose requirements of the brain [33]. Sugars are found as integral components in foods of plant origin like fruits, vegetables, and some grains, as well as in dairy products and honey [40]. In the diet, sugars can be consumed as part of foods and beverages which naturally have sugars present, or in products which have sugars added during manufacturing or preparation [25]. Sugars are used as an ingredient in foods and beverages because they offer a wide variety of favourable functional qualities [41-43]. For instance, they can be used to enhance sweetness and flavour, balance tartness, enhance preservation by binding to water, retard spoilage, improve texture and mouth feel, contribute to bulking or volume, provide fuel for yeast growth, improve browning capabilities, control moisture, prevent crystallization and balance freezing-points [41-43].

2.2.2 Terminology for sugars

To supplement the chemical divisions of sugars, numerous terminologies have been introduced that are more reflective of the health concerns associated with sugars and are therefore more suitable for use in the context of nutritional guidance [39]. An early use of these terms, sometimes referred to as "terms of origin" to differentiate them from terminology based on chemical structure [41], dates back to 1989 when the United Kingdom Department of Health developed the terms *intrinsic sugars* (naturally-occurring) for sugars integrated into the cellular matrix of a food and *extrinsic sugars* for sugars added to a food or free from the cellular structure but still found within a food [44]. Although *intrinsic* and *extrinsic sugars* are chemically indistinguishable from one another [41], *extrinsic sugars* may be more closely related to poorer dietary quality and health, necessitating the differentiation between the two (see section 2.4.1 Institute of Medicine guidelines) [45-47]. Most sugars terminology that has subsequently emerged can be generally categorized as *extrinsic sugars* with slight variations in definitions. **Figure 2.1** presents these terms and their associated definitions. These terms are dynamic and have been evolving, entering, and leaving the public discourse over the past few decades, leading to a lack of consensus and consistency in terms of which definitions to use in practice and in research globally [41, 48-50 51]. *Free sugars* was originally defined by the WHO in 2003 and then expanded to its current form in 2015 with the further mention of "fruit juice concentrates" in addition to the originally mentioned "fruit juices" [3, 4]. The uptake of this definition has been most pronounced in

the United Kingdom, Europe, and the Americas [5, 52-54]. Although no specific definition for *added sugars* has been regulated in Canada, the components of a food that constitute *sugars-based ingredients* have been detailed as part of the compositional criteria required for "no added sugars" nutrient content claims [55]. Prior to the 2016 definition of *added sugars* introduced by the *US Food and Drug Administration* (**Figure 2.1**), the *US Department of Agriculture* defined added sugars as "sugars and syrups that are added to foods during processing or preparation." [56]. In this case, any sugars that were used as an ingredient were considered to be "added", regardless of the functional property the manufacturer was intending to achieve. The updated US *added sugars* definition is more inclusive to sugars that are not "added" into foods and more closely resembles a definition of *free sugars*, but exempts single-strength (non-concentrated) fruit juice [57]. Lastly, *non-milk extrinsic sugars* was initially coined in the United Kingdom so as not to discourage the consumption of milk products which naturally contain lactose, an *extrinsic sugars* by definition [44]. Likewise, definitions of *free sugars* and *added sugars* do not include the sugars naturally-occurring in milk [3, 55, 57]. Unlike the definitions for *free* and *added sugars* described here, *non-milk extrinsic sugars* also captures 50% of the sugars present in stewed, canned, and dried fruits [58]. Although this percentage was arbitrarily selected, it was meant to account for the partial breakdown of the cellular structure of fruits during processing [58]. In practice, the United Kingdom has since switched over to the use of a *free sugars* definition [5]; the *non-milk extrinsic sugars* definition now remains pertinent only in terms of synthesizing the available literature [44]. The numerous and inconsistent terms for *extrinsic* sugars has led to confusion in the public discourse as well as inconsistent results in research [49]. The discussion that follows uses the term *extrinsic sugars* as an over-arching word to describe both *added* and *free sugars* definitions, unless otherwise specified. However, the research conducted as part of this thesis was focused on *free sugars* as defined by the WHO, as it is used internationally and underpinned in the literature and in regulations.

Figure 2.1 Sugars terminology [a] and associated definitions [b]



[a] **(=)** used to identify the components of a "parent term" (term above or to the left of a "="); **(+)** indicated the combination of components that are captured within a "parent term"; **(-)** identifies the components of a "parent" term that are not also components of a "sub-term" (term below or to the right of a "=").

[b] Citations for each definition: total sugars [39, 59], intrinsic and extrinsic sugars [44], free sugars [3, 4], sugars-based ingredients (Canada) [55], added sugars (US) [57], non-milk extrinsic sugars (UK) [44].

[c] The UK has since switched over to the use of a free sugars definition [5]

[d] Non-milk extrinsic sugars includes 50% of the sugars naturally present in stewed, canned, and dried fruits [58].

2.3 Debates on the health effects of sugars

Study design variations and the use of many different terms for sugars are consistently cited as a major barrier to synthesizing the related body of literature and to establishing a clear relationship between dietary sugars and health outcomes [41, 48-51]. As a result, this relationship has been highly contested and debated [60]. Although an abundance of research that has emerged in recent years has helped to better elucidate this connection [58], specifically, the association between increasing intakes of free or added sugars and sugar-sweetened beverages and higher risk of developing obesity [60-67], diabetes [68-71], cardiovascular disease [70, 72-81], and dental caries [82, 83], among other adverse health outcomes [84-86], debate still exists as to the role of food form (e.g. food vs. beverage sources) and the contribution of sugars as a unique nutrient to health outcomes [51, 87]. These inconsistencies are further compounded by the limitations in food composition data available to inform research and the lack of detailed, accurate, and current food composition data to address inconsistencies (see section 2.7.1). Nevertheless, the growing body of literature has provided sufficient evidence to warrant the development of dietary guidelines by several authoritative bodies recommending intakes of extrinsic sugars be limited [88].

2.4 Evolution of dietary guidelines for sugars intakes

Dietary guidelines have been used in some manner for hundreds of years and can broadly be grouped into those that provide a quantitative standard which can be used to assess adequacy of intakes, generate educational materials, and by policymakers to develop science-based policies and regulations, or those that use a qualitative approach, describing foods in terms of overall dietary intake patterns [89]. In Canada, only qualitative recommendations exist for total sugars as part of national dietary guidance [24]. *Health Canada's* 2007 *Eating Well with Canada's Food Guide* ("*Canada's Food Guide*") includes a discretionary statement advising Canadians to limit intakes of foods and beverages high in sugars, without specifying a type or amount of sugars [24]. A moderation statement encouraging Canadians to limit their intakes of sugar, fat, salt, and alcohol was first introduced as part of *Canada's Food Guide* in 1982 when the goal of the food guide switched from preventing nutrient deficiencies to curbing rising rates of NCDs [24]. Many other countries around the world have similar qualitative recommendations for total sugars as part of their food-based dietary guidance [90]. For 10 years, between 2003 and 2013, the *Australian Dietary Guidelines* included a quantitative recommendation for total sugars of 17.5% of energy,

citing that 15 to 20% of energy from total sugars was considered to be compatible with a healthy diet [91]; however, in 2013 the quantified recommendation was removed and a qualitative statement recommending added sugars intakes be limited was introduced [92]. As a result, there are currently no widely accepted quantitative recommendations to limit total sugars intakes because of concerns that this may inadvertently discourage the consumption of foods that are part of a balanced diet, such as fruits, vegetables, and milk [25]. The following sections outline the quantitative guidelines for extrinsic sugars that have emerged from authoritative nutrition and health organizations.

2.4.1 Institute of Medicine added sugars guidelines

The establishment of quantitative guidelines for extrinsic sugars dates back to the 2002 edition of the *Institute of Medicine's* (IOM) *Dietary Reference Intakes* (DRI) [33]. Prior to this, there were only qualitative population-based guidelines from the UK recommending reductions in non-milk extrinsic sugars as part of overall caloric reductions [44]. In 2002, the IOM published recommendations for use in both the US and Canada [33]. At that time, the IOM determined there was insufficient evidence to introduce a DRI for sugars, but they recommended that consumption of added sugars not exceed 25% of energy, following a review of the literature that evaluated the diets of US subpopulations [33]. The data available to inform this recommendation suggested that intakes of added sugars above 25% of energy may dilute the number of essential micronutrients required in the diet [33], a phenomenon dubbed the "micronutrient dilution hypothesis" [45]. This phenomenon stems from the possible displacement of micronutrient-dense foods in the diet with those that are high in added sugars, hinging on the concept that added sugars provide calories but little to no other nutritional benefits [45]. This theory has been subject to criticism and debate which may be due to methodological and conceptual differences in research, such as variations in sugars terminology, presentation of sugars in absolute amounts and in amounts relative to energy intakes, differing criteria to assess micronutrient inadequacies, and discrepancies in handling of misreported dietary intakes [45]. Authors of a systematic review from 2009 noted the contribution of these discrepancies to their results, which showed inconsistent and often non-linear intakes of micronutrients with increasing reported intakes of added sugars [45]. This led the authors to conclude that it may be an overly simplistic theory to describe an inherently complex phenomenon [45].

More recently, a similar concept has emerged that focuses on the relationship between extrinsic sugars and overall dietary quality, rather than only micronutrients, and it is supported by convincing data from dietary intake studies [46, 47, 87, 93, 94]. A systematic review published in 2015 found that higher intakes of added sugars were associated with poorer dietary quality and lower intakes of micronutrients [46]. Conversely, this association was not found when examining intakes of total sugars, seemingly because of the intrinsic sugars derived from nutrient-dense food sources [46]. Evidence from Canada has likewise shown that Canadians with the highest diet quality scores had lower mean added sugars intakes [47]. Similarly, among Canadian children, higher consumption of both solid and liquid sources of added sugars was associated with higher caloric intakes, lower fruit, vegetable, and micronutrient intakes, and lower overall dietary quality, as measured with Canadian Healthy Eating Index scores [87]. Studies in Australian adults and children also found higher intakes of added sugars were associated with higher energy and lower micronutrient intakes [93, 94], but the same associations for total sugars were inconsistent and when present, were of smaller magnitude [94]. The guidelines that emerged after the IOM 2002 recommendations are for maximum intake levels considerably lower than 25% of energy and may be reflective of the growing body of scientific evidence since that time.

2.4.2 World Health Organization (WHO) free sugars guidelines

In 2003, the WHO recommended a maximum of 10% of energy come from free sugars [4]. Twelve years later, the WHO reaffirmed this 10% limit with their publication of *Guideline: Sugars intake for adults and children*, citing concern for the association between sugars and poor dietary quality, risk of non-communicable disease, dental caries, and obesity [3]. The maximum 10% of energy is considered a "strong guideline" because the beneficial effects of adhering to it are believed to outweigh any potential undesirable ones [3]. A maximum 5% of energy was also set, but as a "conditional guideline", because there was less evidence to support the feasibility and benefits of adhering to it [3]. The WHO notes that if population-level intakes fall below the strong guideline, that countries should then aim for the conditional guideline rather than discontinuing efforts [3]. Two commissioned systematic reviews and meta analyses; one on body weight [60], the other on dental caries, informed the WHO guidelines [3].

Firstly, the commissioned review by Te Morenga and colleagues demonstrated that among adults consuming an ad libitum diet, higher free sugars intakes were associated with increased body

weight and vice versa for lower intakes [60]. Obesity is a very complex condition that is influenced by over 100 variables, with increased energy intake being a major contributor [95]. Dietary sugars, namely extrinsic sugars, is one aspect of the diet thought to contribute significantly to caloric intake because of the abundance and accessibility of extrinsic sugars in the food supply [96]. It was apparent from this review that the associations between body weight and free sugars intakes was mediated via energy intake, as differences in weight were not seen under iso-caloric conditions [60]. This may be a reflection of free sugars being consumed as an addition to a diet or as a result of replacing non-calorically sweetened products with ones containing free sugars [60]. Among children, the meta-analysis of prospective cohort studies demonstrated a greater likelihood of being overweight or obese with highest compared with lowest intakes of sugar-sweetened beverages [60]. Results from the meta-analysis of randomized-controlled trials among children was less convincing, likely owing to poor compliance over time [60]. However, two trials have been published since the analyses by Te Morenga and colleagues, that clearly demonstrated the lowering effect of reducing intakes of sugar-sweetened beverages on body mass index in children and adolescents [64, 66]. Secondly, the commissioned systematic review of observational studies conducted by Moynihan and Kelly found that 5 out of the 5 studies conducted in adults and the majority (42 out of 50) of studies conducted in children reported a positive relationship between free sugars intakes and prevalence of dental caries [83]. This study was used in the quantification of the WHO guidelines because it enabled the comparison of various free sugars intake levels with the risk of dental caries and highlighted this association as a dose-response relationship [83]. Since the WHO guideline was published, similar recommendations have been developed by other authoritative and public health bodies, as well as endorsed by non-governmental health organizations in Canada (e.g. Heart and Stroke Canada, Diabetes Canada) [15, 16].

2.4.3 American Heart Association added sugars guidelines

In 2009, the American Heart Association introduced quantitative recommendations for added sugars intakes to comprise no more than half the discretionary calorie allowance (the caloric difference between calories required for energy and calories consumed to meet nutrient requirements) [7]. This is equivalent to a maximum of about a 100 calories per day for women and 150 per day for men [7]. Evidence on the increasing caloric contribution of added sugars to the US diet and its contribution to weight gain, nutrient inadequacy, biomarkers of cardiovascular

disease, and diabetes informed the guideline development [7]. However, these recommendations were not widely used, partly owing to the removal of the concept of discretionary calories from the 2010 version of the *US Dietary Guidelines for Americans* [97] citing difficulty in the translation of discretionary calories into meaningful consumer education material [97]. As a result, discretionary calorie allowances in the *US Dietary Guidelines for Americans* was replaced with a statement recommending intakes of solid fats and added sugars be limited [97]; thus, also limiting the practicality of these American Heart Association guidelines [43]. In 2016, the American Heart Association emerged with recommendations specifically for children stating that added sugars should be consumed in amounts less than 25g per day by children over 2 years of age and should be avoided by children less than 2 years of age [8]. This guideline was based on a review of current scientific evidence of the health effects of added sugars in children, specifically on blood pressure, lipids, insulin resistance, diabetes, non-alcoholic fatty liver disease, and obesity [8]. Notably, attempts to isolate the effects of sugars were not included as part of the review to better reflect the real-world effects of sugars consumption by free-living people [8].

2.4.4 Public Health England free sugars guidelines

Public Health England adopted the recommendation that intakes of free sugars should not exceed 5% of energy in 2015 [5]. This guideline was based on an extensive systematic review of carbohydrates and health conducted by the *Scientific Advisory Committee on Nutrition* [98]. The review examined both randomized controlled trials and prospective cohort studies and summarized the findings in terms of the strength of effect or association as well as the adequacy of the available evidence using the *Scientific Advisory Committee on Nutrition's* framework for the evaluation of evidence [98]. Moderate evidence from randomized controlled trials and prospective cohort studies showed an effect of sugars intake on energy consumption in adults consuming an ad libitum diet, an association between consumption of sugars and dental caries after adjustments for oral hygiene practices, and an association between sugars-sweetened beverage intakes and risk of type 2 diabetes [98]. Randomized controlled trials conducted in children and adolescents indicated that consumption of sugars-sweetened beverages resulted in greater weight gain and increase in body mass index than consumption of non-calorically sweetened beverages [98]. Only studies in the systematic review that showed a dose-response relationship were considered in the formation of the quantitative guideline [58]. As a result, a meta-analysis of 11 randomized-controlled trials demonstrating the effects of differing sugars intakes

in relation to energy intakes was used [58]. Five of the trials manipulated intakes by adjusting other sources of energy in the diet and the remaining trials replaced sugars with non-caloric sweeteners [58]. Results demonstrated a change in energy intakes of 19 calories for each unit change in percent of energy consumed as extrinsic sugars; this was evident for both increases and decreases in intakes [58]. The 5% of energy recommendation was made within the context of aiming for a reduction in intakes of 100 calories per person per day to achieve moderate weight loss in most individuals [58].

2.4.5 US 2015-2020 Dietary Guidelines for Americans added sugars guidelines

The US *2015-2020 Dietary Guidelines for Americans,* published in 2015, recommends a maximum 10% of total energy intake come from added sugars [6]. To inform these recommendations, the *Dietary Guidelines Advisory Committee* utilized food pattern modelling, combined with a review of the available evidence on extrinsic sugars and health [99]. The review of available evidence considered the link between higher consumption of added (or free) sugars and risk of type 2 diabetes, body weight, cardiovascular disease, and dental caries [6]. Overall, results from the review found strong and consistent evidence showing the association of added sugars intakes from both food sources [60] and sugar-sweetened beverages [100, 101] with excess body weight in adults and children [6]; strong evidence of the relationship between added sugars consumption from all food sources [102], but primarily from sugar-sweetened beverages [76, 103-105] with increased risk of type 2 diabetes [6]; and moderate evidence examining the relationship with coronary heart disease, hypertension, and stroke [6]. The *Dietary Guidelines Advisory Committee* also looked at the WHO's commissioned systematic review on the relationship between sugars consumption and dental caries [83], citing consistent evidence to support the association [6]. To complement the evidence review, food patterns were modelled to evaluate how much added sugars could be consumed while still meeting nutrient and food group requirements [6]. This was done through the modelling of three dietary patterns (i.e. healthy American-style diet, healthy Mediterranean-style diet, and healthy vegetarian diet) [6]. A limited amount of energy available in the diet for added sugars was left after other nutritional requirements had been met, ranging from 4% to 9% for different levels of energy intake [6]. The *Dietary Guidelines Advisory Committee* also found that dietary patterns characterized by lower intakes of sugars-sweetened foods and

beverages were strongly and consistently associated with a reduced risk of cardiovascular disease [6].

2.5 Operationalizing guidelines in the context of healthy diets

The WHO free sugars intake guidelines are intended to be used in conjunction with other dietary guidance to promote healthy dietary choices [3]. Although the exact definition of a healthy diet varies according to nutrient requirements and life stages, the WHO cites the basic tenets as including the consumption of fruits, vegetables, legumes, whole grains, and nuts, while limiting intakes of free sugars, fats (saturated fats and trans fats in particular), and salt [106]. Historically, a single-nutrient approach to dietary advice has resulted in unintended consequences. For instance, the demonization of all types of fats in the 1980s and 1990s led to the selection of and reformulation of foods that were lower in fats but higher in sugars [107]. In addition, the need to interpret specific nutrient-based information in the context of the whole diet is complicated because of numerous and often conflicting advice, and because nutrients aren't consumed in isolation. The disregard for the overall nutritional composition of foods and diets in lieu of a focus on a specific nutrient can manifest in ineffective and inefficient interventions and unintended adverse outcomes [108]. More recently, an emerging body of literature aims to consider the global nutritional quality of foods more holistically [109]. Broadly, the classification or ranking of foods based on their nutritional composition for the promotion of health, is known as nutrient profiling (NP) [109]. NP systems vary in the components used to evaluate the nutritional composition of a food or beverage, and can focus on "negative" aspects of a food, such as "nutrients to limit" or energy density as well as "positive" attributes, such as nutrients to encourage (e.g. fibre), or the presence of fruits, vegetables, nuts, legumes, or whole grains [109, 110].

2.6 Intakes and sources of total sugars in the Canadian diet

2.6.1 Total sugars intakes

To date, sex and age subgroup analyses of total sugars intakes have been conducted for the *Canadian Community Health Survey* on nutrition version 2.2 (CCHS 2.2) from 2004, but not for extrinsic sugars intakes [111]. CCHS 2.2 used self-reported dietary intakes collected from single 24-hour recalls for a nationally representative cohort of around 35,000 Canadian adults and children combined with food composition data from the *Canadian Nutrient File* [111]. The

Canadian Nutrient File is the food composition database maintained by *Health Canada* that is used to analyze national dietary surveys [112]. It provides nutrient composition data for approximately 5,800 foods [112]. Based on results from CCHS 2.2, Canadians over 1 year of age consumed an average of 110g of total sugars per day, or 21.4% of total energy intakes [111]. Children aged 1 to 3 years consumed the highest proportion (27.4%) of their energy intake from total sugars followed by children aged 4 to 8 years [111]. Overall, males in each age group consumed significantly more than females when considering absolute total sugars consumption; but as a proportion of energy, females consumed more than males [111]. Additionally, Canadians living with Type 1 or Type 2 diabetes consumed significantly less total sugars than those without diabetes [111]. It is posited that this stems from the dietary management of diabetes which includes the consumption of a balanced diet and advice to limit intakes of added sugars [16, 111]. Dividing the cohort into those with and without diabetes, intakes were 73.4g versus 111.5g per day on average, equating to 17% and 21.5% of total energy, respectively [111]. Details on intakes as a proportion of energy overall and by age and sex subgroups and for those with and without diabetes are presented in **Table 2.1**. Similar trends in total sugars intakes have been documented in other countries. Briefly, a review of sugars consumption from the results of national surveys worldwide, published between 1995 and 2012, also found children and infants were top consumers of total sugars, with an average intake of 28% of energy, which decreased to about 20% of energy in adults and older adults [113].

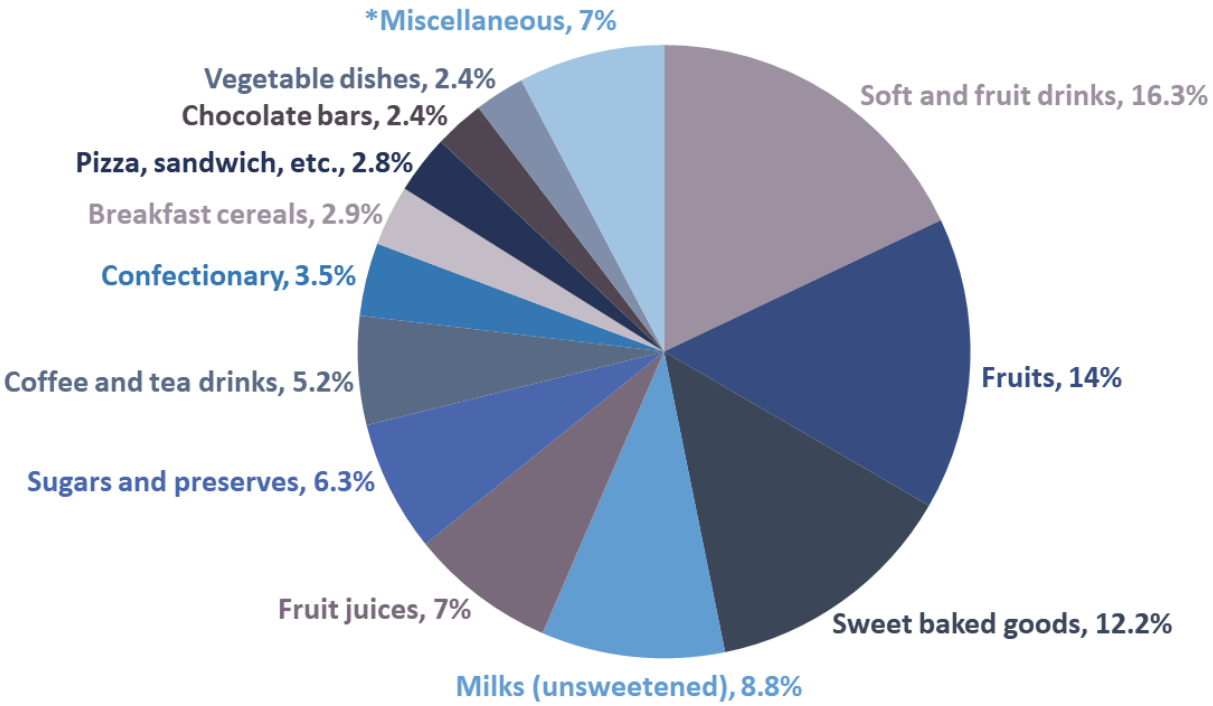
Table 2.1 Canadian intakes of total sugars as a proportion of total energy intake, by age and sex, from CCHS 2.2 [111]

Condition	Age	Sex	Total sugars intakes (% energy)
All	1 to 3	Both sexes	27.4%
	4 to 8	Both sexes	26.1%
	9 to 13	Males	25.1%
		Females	25.6%
	14 to 18	Males	24.1%
		Females	24.6%
	19 to 30	Males	20.4%
		Females	22.9%
	31 to 50	Males	18.8%
		Females	20.3%
	51 to 70	Males	18.8%
		Females	20.4%
	71 or older	Males	19.9%
		Females	21.9%
	All	Both sexes	21.4%
With Diabetes	All	Both sexes	17.0%
Without Diabetes	All	Both sexes	21.5%

2.6.2 Food sources of total sugars

Based on the results from CCHS 2.2, the majority of total sugars in the Canadian diet were derived primarily from naturally-occurring sources of sugars [111]. For instance, 31.1% of total sugars were derived from fruit and vegetables, 17.7% from milk products, 14.2% from grain products, and 1.3% from meat and alternatives [111]. Yet, more than one third (34.7%) came from "other foods", such as soft drinks, snacks, condiments, and confectionary products [111]. "Other foods" are not part of the basic food groups in *Canada's Food Guide* (i.e. fruit and vegetables, dairy and alternatives, grains, meat and alternatives); these foods are not necessary to consume as part of a healthy diet [24]. Overall top food and beverage contributors are shown in **Figure 2.2**. The proportion that each food group contributed to total sugars intakes varied by age and sex. Children aged 1 to 3 years consumed the highest proportion of their total sugars from fruits and vegetables (38%) and milk products (31%) [111]. This was followed by children aged 4 to 8 years consuming 29.9% from fruits and vegetables, and 24.5% of their total sugars from milk products, but compared to the younger age group, a greater proportion (27% vs. 16.5%, respectively) came from "other foods". For adolescent and adult males "other foods" were the top contributors to total sugars intakes (37.5%, 45.8%, 43.2%, and 39.8% of total sugars for ages 9 to 13, 14 to 18, 19 to 30, and 31 to 50, respectively) [111]. For females of the same age ranges, "other foods" also contributed the most to their intakes (34.4%, 41.8%, 37.8%, and 33.6% of total sugars, respectively) [111]. Males and females 50 years and older had intakes of total sugars coming primarily from fruits and vegetables (37.3-37.6% for males and 39.1-42.2% for females) [111]. Compared to Canadians without diabetes, those living with diabetes consumed a larger proportion of their sugars from fruits and vegetables (40% vs. 31%, respectively), milk (20% vs. 18%, respectively), and grains (16% vs. 14, respectively), and less from "other foods" (21% vs. 35%, respectively) [111]. Although the high intakes of "other foods" is suggestive of some of the contribution that extrinsic sugars make to Canadian diets, the data available to identify primary sources of extrinsic sugars in Canada are limited by the absence of extrinsic sugars information in the *Canadian Nutrient File*.

Figure 2.2 Top contributors accounting for 90.8% of total sugars intakes of Canadians based on CCHS 2004 data. Data provided by Health Canada [114].



** 'Miscellaneous' includes vegetables (1.8%), sweetened yogurts (1.7%), pasta and rice dishes (1.3%), frozen dairy desserts (1.1%), sweetened milks (1.1%).*

2.7 Intakes and sources of extrinsic sugars in the Canadian diet

2.7.1 Food composition databases with extrinsic sugars levels

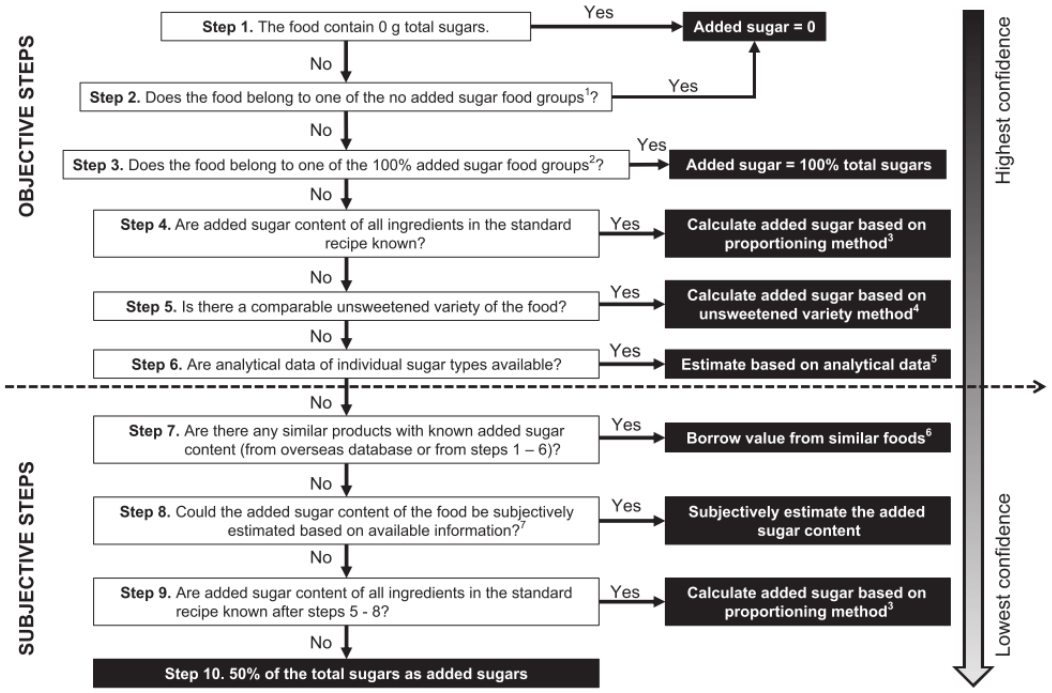
There are challenges with using the *Canadian Nutrient File* to assess intakes of extrinsic sugars and monitor changes in the food supply, including the lack of scheduled, systematic and comprehensive updating of the database and the absence of Canadian brand-specific data [112]. The majority of data in the *Canadian Nutrient File* is generic, derived from the *US Department of Agriculture* database, with adjustments for Canadian fortification levels and food regulatory standards, and with the addition of some Canadian-only foods [112]. Most relevant to this thesis, the *Canadian Nutrient File* includes information on total sugars content but not extrinsic sugars

[115]. There are no Canadian food composition databases that properly characterize the extrinsic sugars contents of foods and beverages [14]. Although there are a few databases worldwide that include added sugars contents and have been used to assess intakes [116, 117], as aggregated data, they do not provide the level of detail required to adequately define the extent to which the food supply itself is detrimental to health, to identify appropriate actions that can be taken to ameliorate these outcomes, and to monitor nutrient content changes [50, 118]. There are also no food composition databases that specifically include free sugars contents.

2.7.2 Calculating extrinsic sugars contents of foods and beverages

In the absence of extrinsic sugars declarations on the nutrition label, and in food composition databases, algorithms can be used to estimate extrinsic sugars contents [119]. Methods to estimate extrinsic sugars contents of foods and beverages have been described in the past, but generally use inconsistent methods and often require an in-depth understanding of food composition and proprietary data on ingredient proportions from food manufacturers or standardized recipe formulations, rely heavily on subjective decision-making, assumptions based on food groups, or involve dozens of steps [119-123]. Additionally, early methods to estimate non-milk extrinsic sugars have been described as inadequately detailed to facilitate replication [122]. To address these limitations, Louie and colleagues developed a systematic methodology in 2014 to estimate the added sugars content of foods in the national Australian food composition database (see **Figure 2.3**) [119]. The methodology is a 10-step decision algorithm that moves step-wise from most objective to the more subjective decisions [119]. The decision algorithm uses information on total sugars contents, standardized recipe formulations, analytical data on individual sugars types (e.g. lactose content), substitute values from other food composition databases, and subjective estimates [119]. This methodology showed high inter-researcher agreement in choice of steps and in resulting estimated added sugars contents [119]. However, there are no existing standardized methodologies to date that have been developed for use specifically in determining free sugars rather than added sugars contents (as defined by the WHO [3]), or on a branded food composition database, particularly where recipe formulations are unavailable.

Figure 2.3 Step-by step algorithm for calculating added sugars contents developed by Louie and colleagues [119]



[1] Include 100% fruit/vegetable juice and intensely sweetened juice/cordial base, non-sugar-sweetened milk, buttermilk, breast milk, non-sugar-sweetened dairy products (including intensely sweetened yoghurts), oats and porridge with no added sugars, fresh fruit, vegetables (including salads with no dressing), meat, seafood and tofu, fruits canned in juice or intensely sweetened liquid, dried fruits, eggs and egg products (except egg-based desserts), all spices and herbs, all oil and fats, all plain cereal grains, pastas, rice and flours, nuts (except sweetened varieties and nut bars), coconut (and products) and seeds, non-sweetened alcoholic beverages, legumes, non-sweetened coffees, mixed meat dishes with no sugary ingredients, plain bread (except gluten-free), English muffin, bagels, pizza bases and naan, plain pastry, intensely sweetened jam and beverage base.

[2] Include sugar and syrups, regular soft drinks, sport drinks, flavoured water and non-fruit-based energy drink, coffee and beverage base with no milk solids, dry or made up with water, breakfast cereals and cereal bars without fruits, chocolate or milk solids, processed meats, stock powder, savoury biscuits and sweet biscuits, cakes and buns, donut and batter-based products that do not contain fruits, chocolate or dairy products, all confectionery except fudge, crumbed/battered meat and seafood, soy beverages and yoghurt.

[3] Added sugar per 100 g (AS100 g) is given by the following formula: $AS_{100g} = \frac{\sum_{i=1}^{j} W_i \times AS_i}{\left(\sum_{i=1}^{j} W_i\right) \times (100\% + \%W)}$, where Wi is the weight of the *ith* ingredient in recipe, *ASi* is the added sugar content per 100 g of the *ith* ingredient and %WΔ is the percentage change in weight on cooking.

[4] Added sugar per 100 g (AS100 g) is given by the following formula: $AS_{100g} = \frac{100 \times (S_{us} - S_{total})}{S_{us} - 100}$, where Sus is the amount of sugar in the unsweetened variety of the food, and Stotal is the final listed sugar content.

[5] If analytical data for lactose are available, and the ingredients do not include dried fruits or malted cereals, added sugar content was calculated as total sugars−lactose. If the food contains malted cereals and lactose data are available, added sugar content was calculated as total sugars−lactose−maltose.

[6] Values from foods with similar nutritional compositions and, where possible, within the same food group were borrowed. The proportion of total sugars as added sugar was calculated for the borrowed food. The added sugar value of the target food will then be estimated as total sugars × proportion of sugars as added (calculated from the borrowed food).

[7] Information on the ingredients list was used to guide the decision. Foods were deemed to have no added sugar if the ingredients listed did not contain added sugar. If the ingredients contained added sugar, the proportion of sugary ingredient, for example, the percentage of sweetened raspberry in a raspberry-flavoured muesli bar, was used to inform the estimation. If information on proportion was not available, the order of appearance of sugary ingredients and common recipes were used to inform decisions. For non-packaged foods, estimation was based on common recipes [119].

2.7.3 Estimates of Canadian extrinsic sugars intakes

Despite the absence of extrinsic sugars information in food composition databases, there have been efforts to estimate intakes in Canada. The first study attempting to estimate extrinsic sugars intakes of Canadians approximated that added sugars contribute between 11% and 13% of energy intake [9]. To obtain these estimates, authors used two approaches [9]. In the first approach Canadian sugars and sweeteners availability data and soft drinks availability data from the US were examined [9]. In Canada, economic data on availability of corn syrup are considered proprietary information, thus data on soft drinks from the US were used as a proxy for corn syrup data, a common sweetener used in soft drinks [9]; the appropriateness of this measure as a proxy is unclear. Based on 5 years of availability data and accounting for wastage, the per capita average energy available from added sugars was estimated at 13% [9]. Availability data do not measure actual consumption, even though it is often presented as an amount per capita because it assumes equal distribution of sugars available for consumption across the population [42]. Additionally, this approach relied greatly on extrapolations from US rather than Canadian data [9]. In the second approach the authors used Canadian data, however, results depended heavily on assumptions about food group composition [9]. This approach used high-level findings on total sugars intakes from CCHS 2.2 to deduce added sugars intakes [9]. Ten food groups (e.g. milk, fruit, confectionery) representing the top sources of total sugars intakes were categorized as either providing added sugars or intrinsic sugars [9]. However, this assumption overlooked the potential for both types of sugars to be present within a single food group and may underestimate the contribution of added sugars to the diet. The average intake based on survey data was 11% of energy and age group estimates ranged from 9.9% of energy for adults to 14.1% of energy for adolescents; children aged 1 to 8 were estimated to consume approximately 10.4% of energy from added sugars [9]. Despite the methodological limitations of this study, as the only one of its kind, it can still be useful to signify tendencies in sugars usage and intakes in the absence of more accurate measures in Canada.

Based on these estimates, Canadian intakes of added sugars [9] are believed to be above the recommended maximum intake levels according to guidelines from the WHO and the US Dietary Guidelines for Americans, and they are double the maximum guidelines from Public Health England and the conditional maximum guideline from the WHO [3, 5-7]. International intakes of extrinsic sugars in many countries are also more than maximum recommended intake

levels. Added sugars intakes ranged from 14 to 17% of energy among US children and adults in 2011 and 2012 [124]. Australian estimates of added and free sugars intakes were lower than those in the US, contributing to 11% and 12% of energy, respectively, based on 2011/2012 data collected as part of the Australian Health Survey [125]. The proportion of the Canadian population that exceed the guidelines is currently unknown, but adherence in other countries to the maximum 10% of energy recommendations has been found to be as low as 5% among children (aged 7 to 18 years), 28% among adult females and 33% among adult males in the Netherlands [52]; less than 20% among children and adolescents, and 45.3% overall, in Australia [125]; and 42% overall, in New Zealand [126].

Other countries have documented increases in added sugars intakes after weaning, with preschool aged children consuming greater than 10% of energy from added sugars in the US, Australia, and the United Kingdom [113]. Canadian data showing the top sources of total sugars are increasingly comprised of "other foods" after age 3, may suggest a similar trend in Canada is plausible [111]. International added sugars intakes then decline over adulthood to less than 10% of energy among older adults, based on findings from four countries [113]. Like Canada, few countries have intake data for both total sugars and extrinsic sugars, with the majority of countries only having total sugars intake data [113]. The published extrinsic sugars intake levels for populations that had total sugars intakes similar to Canadian estimates (about 19% to 25% of energy), had added sugars intakes ranging from 10% to 16% of energy (excluding infants) [113, 125].

2.8 Determinants of food choices and sugars intakes

Several factors contribute to the selection of foods and consumption of diets that are high in extrinsic sugars. Dietary choices are not only a function of individual selection, but the convergence of individuals with society and their environment [127].

2.8.1 Individual determinants

Individual determinants of food choice consist of food preferences, nutritional knowledge perceptions of healthy eating, physiological and psychological factors [127]. At times, individual determinants can compete with one another, for instance, a biological desire to consume sugary foods that taste good may conflict with the nutritional knowledge that consuming these foods can be detrimental to health [128]. According to Tracking Nutrition Trends 2015, Canada's longest

running nutrition tracking study, 89% of Canadians reported that nutrition was an important factor influencing their selection of foods [129]. Since before the emergence of many of the above-mentioned dietary recommendations, Canadian consumers have been concerned about sugars in their diets [130]. Sugars was an increasing concern for Canadian consumers between 1989 and 2001, and of those who reported changing their diets during this time, 15% reported reducing their sugar intake [130] and in 2015, 78% of Canadians reported efforts to consume less sugars and 70% reported selecting products because they were low in sugars [129]. More recently, a consumer study from 2017 found one-third of the almost 2000 Canadian respondents reported sugars had a very strong influence on their food choice [131].

Concern about consuming sugars and efforts to lower intakes may be stymied by a lack of knowledge of the sugars contents in foods and beverages and ability to select lower sugar foods [132]. For instance, consumers in a Canadian study reported difficulty finding "healthy" processed foods that are lower in sugars [133]. Similar results have also been found internationally. In a study of over 300 German parents who were asked to estimate the sugars contents of six foods commonly consumed by children (i.e. orange juice, cola, frozen pizza, fruit yogurt, chocolate granola bars, and ketchup), the vast majority under or overestimated the sugars contents of these foods [134]. Most were underestimates, which ranged from 71% to 41% lower than actual values and overestimates were as high as 293% of actual values [134]. Importantly, the underestimation of sugars contents may lower the level of perceived risk, which is an important predictor of health behaviours [132].

Efforts to decrease intakes of extrinsic sugars need to be supported by other individual, environmental, and social determinants. Ninety-six percent of respondents in Tracking Nutrition Trends 2015 reported taste was an important factor when choosing foods, and 38% believed it was the most important [129]. There is also evidence to suggest that taste plays a significant role in the consumption of sugars. To elaborate, humans have demonstrated an innate preference for sweet taste [135], which increases the overall pleasure of consuming foods that have sugars or other sweeteners [135]. The consumption of products that taste sweet has also been shown to promote the desire to continue their consumption, thus perpetuating a cycle of the desire and intake of sweetened products [135]. Throughout history, sugars have been added to foods to enhance palatability and consumption [49], which has, in part, contributed to the abundance of sugars in the food supply, propagating an unsupportive food environment.

2.8.2 Environmental determinants

Determinants of food choice at the environmental level are related to the broad economic, political and social factors that work to shape the environment [127]. In general, the current food environment is typified by processed packaged foods and beverages that are characteristically high in calories, sodium, fats, and sugars [136]. Currently, the global food environment is typified by an abundance and affordability of palatable foods that are high in sugars, making the selection of foods that are in line with dietary sugars guidelines particularly difficult [10, 11]. Studies from other countries demonstrate the ubiquitousness of sugars-based ingredients in packaged foods [12, 13]. In the US, 74% of the packaged products purchased between 2005 and 2009 contained a sugars-based ingredient [12]. Likewise, in a sample of 5,744 Australian packaged foods, 61% contained a sugars-based ingredient [13]. Prior to the research published in this thesis, similar evaluations on the prevalence of extrinsic sugars in the food environment have not been conducted in Canada. Cost was also reported to be an important factor when choosing foods by 89% of respondents in Tracking Nutrition Trends 2015, and 24% reported it was the most important [129]; an increase from 19% in 2013 [137]. Sugars, however, are notoriously considered an inexpensive source of calories [108, 138]. Products high in added sugars are cheaper than other foods and prices of sugars over the past 30 years have been rising at a rate lower than the overall food price index, according to US data [138]. The cost of producing sugars is relatively low and because sugar as an ingredient (i.e. table sugar or sucrose) is also a commodity, it can be traded at less than the cost of production [108]. As a result, diets that are higher in sugars cost less, relative to diets that are more nutrient-dense and lower in sugars [139].

Individuals thus find themselves making food choices within the context of a food environment with vast amounts of sugars-laden options that appeal to both price and taste as primary determinants of food choice [129]. This puts consumers who are more sensitive to food prices in a particularly disadvantaged position. Evidence from Canada evaluating general food purchasing patterns suggest that food expenditures were lower among households with lower incomes and/or higher living expenses and fewer of the purchases made by these households were for fruits and vegetables, milk products, meat and alternatives [140], or lower sugar options [141]. Conversely, higher income households purchase more from almost all food groups, with the exceptions being higher fat milk, eggs, and sugars [142]. The affordability of foods and beverages that are high in sugars may explain, in part, the relationship between sugars intakes and some socio-economic

determinants. Much of the research examining the relationship between socio-economic factors and extrinsic sugars intake has been conducted in the US, and shows an inverse relationship between added sugars intakes and education, income [143, 144], money available for food [145], and food security status [146]. Interventions that can influence determinants of food choice become an invaluable tool to sway intakes as well as address the conflicts between individual desires to consume less sugars and a food environment that hinders, rather than enables selections in line with dietary guidance [17]. Thus, a range of policy actions exist to operationalize extrinsic sugars guidelines [108].

2.9 Canadian Nutrition Labelling Regulations

Canada has a well-established history of implementing nutrition policies to improve dietary quality dating back as far as 1874 with the Adulteration Act to ward against the deliberate adulteration of food [147]. Health concerns have shifted over the past 150 years and today one of the most important nutrition policy tools available is nutrition labelling [148]. Nutrition labelling is intended to act on a proximal cause of NCDs – food intake [149] by providing information to help Canadians make appropriate food choices that can enable them to compare and select foods and inform their dietary priorities [18]. Nutrition labelling also has the potential to stimulate product reformulations and persuade manufacturers to introduce products with more favourable nutrient compositions into the food environment [19, 20]. Labels can also be used to populate food composition databases to inform interventions aimed at numerous determinants of healthy eating [21].

Nutrition labelling falls under the responsibility of two federal departments; *Health Canada* and the *Canadian Food Inspection Agency* [27]. *Health Canada* establishes the standards and policies through the *Food and Drug Regulations* under the *Food and Drugs Act*, while the *Canadian Food Inspection Agency* is responsible for the enforcement and administration of nutrition labelling policies [27]. As of 1988, a voluntary nutrition labelling system with unstandardized formats was available in Canada [18]. This was followed by mandatory nutrition labelling, introduced through regulatory amendments to the *Food and Drug Regulations* in 2003 [18]. Mandatory nutrition labelling regulations in the US, which were initiated in 1990, acted as a model for their introduction in Canada [150]. The 2003 Canadian amendments were made with the overall goal of enabling Canadians to make informed food choices and prevent injury to health

through the provision of information [18]. More specifically, the objectives of the 2003 nutrition labelling regulations were to:

1) enable food choices that reduce risk of developing NCDs or permit the dietary management of NCDs;
2) encourage the availability of foods that can reduce the risk of NCDs;
3) develop a nutrition labelling system that improves compatibility with US nutrition labelling requirements; and
4) provide a standardized format to convey nutrient content information to allow for comparisons among foods at the point of purchase [18].

Included in the 2003 amendments were provisions for the mandatory and voluntary presentation of nutrition information, with the changes to be fully implemented by the end of 2007 [18]. Among them, the Nutrition Facts table (NFt), Ingredient Lists, and nutrition claims would provide consumers with sugars-related information [18].

2.9.1 Nutrition Facts table (NFt) and Ingredient Lists

As of 2007, the NFt can be found on almost all pre-packaged food products sold in Canada; with the exception of fresh fruits and vegetables, raw meats and seafood, individually sold single serving confections, alcoholic beverages, foods prepared in-store, and others [27]. The NFt can be used in numerous ways by consumers, including to compare the nutritional composition of two products, to learn about the nutritional composition of a food and to identify foods that have a lot or a little of a nutrient [22]. The NFt includes a declaration of serving size, calories, the amount of each of 13 core nutrients (fat, saturated fat, trans fat, cholesterol, sodium, carbohydrate, fibre, total sugars, protein, vitamin A, vitamin C, calcium, and iron), and a percentage of Daily Value (%DV) or reference standard for select nutrients [27]. The %DV depicts the amount of a nutrient as a percentage of recommended daily intakes for micronutrients, or as a percentage of a reference standard for other nutrients, based on a 2,000-calorie diet [18]. The %DV is intended to provide relative significance to the level of a nutrient in the context of daily intakes. Benchmarks of 5% or less of a DV is “a little” and 15% or more is “a lot” have been used as part of educational campaigns to assist consumers with interpretation [151]. For “nutrients to limit” (e.g. sodium, saturated fats, trans fats) the selection of products with 15% or less of a DV would contribute to lowering the risk of diet-related NCDs based on analyses of simulated diets reflective of

recommendations in *Canada's Food Guide* [151, 152]. For example, a food that contains 4 grams of saturated and trans fats per serving, has 20% of the dietary reference standard for saturated and trans fats (20g per day), and this can be interpreted as containing "a lot" [151]. Specifically, total sugars was presented on the NFt as "Sugars" with a declaration of an absolute gram value, without a %DV [27].

Without a declaration of extrinsic sugars on the NFt, the Ingredients List becomes the only way for consumers to identify the presence of extrinsic sugars in a food through the recognition of sugars-based ingredients [27, 41]. Ingredients in the Ingredients List are presented in descending order of proportion by weight according to the ingredients' common names [153]. Despite the usefulness of the Ingredients List for identifying products that contain sugars-based ingredients and their relative contribution to a product, the Ingredients List does not reveal the absolute amount of extrinsic sugars in a product needed to follow quantitative dietary guidance. Adding to the confusion, there are also dozens of often unrecognizable names for sugars-based ingredients in the Ingredients List. Although this had not been quantified with Canadian data, extrinsic sugars were dubbed a "hidden" source of calories for this reason [95, 154].

Since the nutrition labelling regulation changes of 2003, there have been changes to consumer perceptions and expectations, increases in the prevalence of NCDs, growth of the scientific literature, and adjustments to Canadian consumption patterns [114]. Yet, the nutrition labelling regulations remained largely unchanged for over a decade, until 2016, when they were amended once more, with changes to be in full force by the year 2021 [22] or 2022 if a proposed adjustment to the timeline made to coincide with other nutrition labelling regulations is accepted [155].

2.9.1.1 2016 labelling amendments regarding the presentation of sugars information

The 2016 nutrition labelling amendments reflected an update in the scientific literature, consultations and engagement with stakeholders, and addressed concerns of Canadian consumers who took part in preliminary round table discussions about nutrition labels in 2013 [156-158]. Changes to nutrition labelling, primarily to the NFt and Ingredients List, were made so Canadians could more easily make comparisons between foods [22]. The 2016 amendments regulated that serving sizes presented on the NFt would be more consistent between similar foods and more reflective of the amount that Canadians actually consume in one sitting; Daily

Values were updated and a DV for total sugars was added; a declaration for potassium was added to the NFt because of its importance in maintaining healthy blood pressure and evidence that Canadians do not consume enough; declarations for vitamin A and C were removed as these were no longer considered nutrients of public health concern and intakes were sufficient for the majority of the population; a footnote explaining how to interpret the %DV which states "5% or less is a little, 15% or more is a lot" was added to the bottom of the NFt; and the list of ingredients was formatted to enhance readability and understandability [22]. However, as mentioned above, the changes will not be fully implemented until 2021 or if revised, until 2022 [22, 155].

The Mandate letter from the Canadian Prime Minister to the Federal Minister of Health listed improving added sugars information on the nutrition label as a priority action [159]. Thus, several changes to the nutrition labelling regulations focused on the presentation of sugars information [22]. This was also identified as a priority area by Canadian consumers who wanted a clearer indication of the sugars-based ingredients in the Ingredients List [156, 157] and because the nutrition labels "do not currently provide sufficient information on sugars to help assess whether there is a little or a lot of sugar in prepackaged food" [22]. Two major amendments were made to address these concerns. First was the requirement for mandatory grouping of sugars-based ingredients to be listed in brackets after the common name "Sugars" in the Ingredient List [22]. Sugars-based ingredients would include any monosaccharide or disaccharide, other sweetening agents, or ingredients that functionally substitute for a sweetening agent [22]. The grouped sugars-based ingredients will be placed in the list according to the combined percentage contribution to the product [22]. This will provide consumers with a clearer indication of all the sugars that are added to a food and their combined relative contribution to a product - but still not the absolute amount [158].

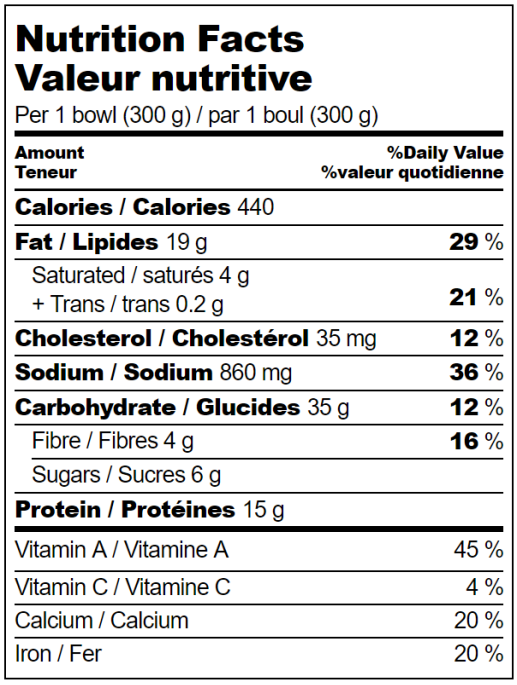
Second was the addition of a %DV for total sugars set at 100g per day or 20% of energy (see **Figure 2.4**) [22]. To determine whether a product has a lot of sugars, the %DV for total sugars can be used in conjunction with the mandatory footnote [22]. Canada would not be the first country to include a total sugars %DV on the nutrition label. The United Kingdom and Australia and New Zealand already have a %DV for total sugars on their nutrition labels, however, they are based on a lower DV of 90g per day and were implemented prior to the emergence of much of the scientific literature on health outcomes related to extrinsic sugars and the guidelines

recommending their intakes be limited [91, 160]. In Australia and New Zealand, the previous total sugars intake recommendation from 2003 was 17.5% of calories, which was derived from the DV standardized for a 2,000-calorie diet (90g is 17.5% of a 2,000 calorie diet) [91]. In the United Kingdom, the DV of 90g per day reflects the amount of total sugars intake an average female adult, with assumed energy intake of 2,000 calories, would consume if their diet was consistent with dietary recommendations for fruits, vegetables, dairy, and added sugars (maximum 10% of energy) [160]. Males in this scenario would consume 120g total sugars per day, but the lower of the two benchmarks was chosen for use on the nutrition label [160]. Likewise, the Canadian total sugars DV is reflective of Canadian total sugars intakes from 2004, but details on the derivation of the 100g DV were not published [158].

The US *Food and Drug Administration* proposed including added sugars on the US nutrition label in March 2014 [161]. In July 2015, the US proposal was amended to include a %DV based on a maximum of 10% of energy coming from added sugars (see Figure 2.4) [162] with compliance for these changes likely to be in full effect by January 1, 2021 [163]. The US *Food and Drug Administration* included an added sugars declaration to assist consumers in maintaining healthy dietary practices and to consume a healthy dietary pattern based on the diet pattern modelling conducted by the *Dietary Guidelines Advisory Committee* [57]. Traditionally, a mandatory declaration for a nutrient on the US label was based on an independent relationship between a nutrient and a health outcome, however, the need for consumers to understand added sugars' relative significance within the context of the diet was used as the paradigm for labelling added sugars [57]. The US *Food and Drug Administration* also cited a lack of an established reference value for total sugars to derive an appropriate DV [57]. Conversely, in 2014, *Health Canada* initially put forward the inclusion of a declaration for added sugars, however, the addition was not part of the regulatory amendments finalized in 2016; citing opposition from industry stakeholders as a contributing factor to its exclusion, despite high levels of support among consumers and health stakeholders [158]. Thus, the final Canadian 2016 nutrition labelling regulatory amendments that includes a total sugars DV neither reflects the latest dietary guidelines or science [90], nor does it align with the nutrition labelling practices of Canada's largest trading partner, the US [18]. Additionally, although *CODEX Alimentarius* [23] does not include the labelling of extrinsic sugars in their nutrition labelling guidelines at this time, the introduction of a DV for total sugars is contradictory to *Health Canada* and *CODEX Alimentarius* [23]

recommendations for the development of nutrient reference values, because it does not reflect the latest dietary guidelines or scientific evidence, nor enhancing international alignment with our largest trading partner [23, 158]. Requiring a disclosure of the amount of extrinsic sugars with a benchmark that reflects current dietary guidelines, is considered the most accessible and reliable way for consumers to obtain the information they need adhere to intake recommendations [14, 50]. The implications of including a total sugars DV for providing information to assist in the selection of foods that align with extrinsic sugars guidelines have not been assessed.

Figure 2.4 Current and amended Nutrition Facts tables/panels in Canada and the US

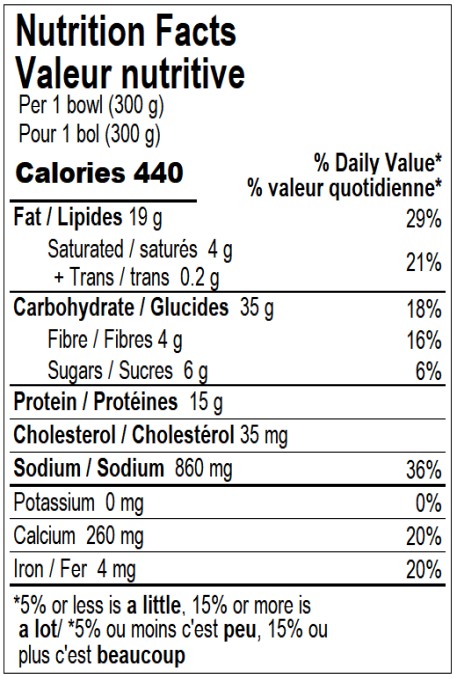


Nutrition Facts
Valeur nutritive

Per 1 bowl (300 g) / par 1 boul (300 g)

Amount Teneur	%Daily Value %valeur quotidienne
Calories / Calories 440	
Fat / Lipides 19 g	**29** %
Saturated / saturés 4 g + Trans / trans 0.2 g	**21** %
Cholesterol / Cholestérol 35 mg	**12** %
Sodium / Sodium 860 mg	**36** %
Carbohydrate / Glucides 35 g	**12** %
Fibre / Fibres 4 g	**16** %
Sugars / Sucres 6 g	
Protein / Protéines 15 g	
Vitamin A / Vitamine A	45 %
Vitamin C / Vitamine C	4 %
Calcium / Calcium	20 %
Iron / Fer	20 %

a. Current Canadian Nutrition Facts table [18]



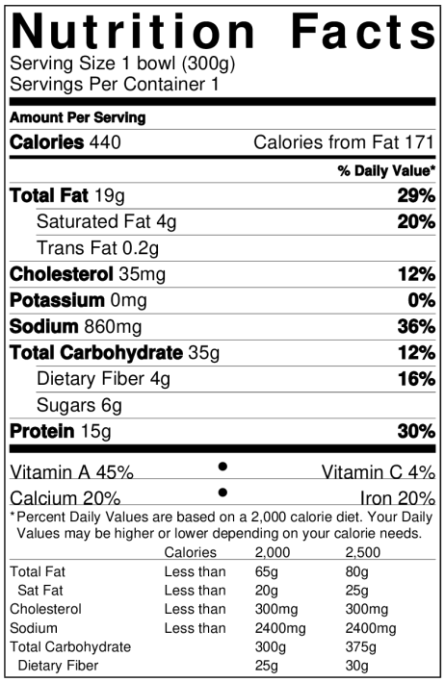
Nutrition Facts
Valeur nutritive

Per 1 bowl (300 g)
Pour 1 bol (300 g)

Calories 440	% Daily Value* % valeur quotidienne*
Fat / Lipides 19 g	29%
Saturated / saturés 4 g + Trans / trans 0.2 g	21%
Carbohydrate / Glucides 35 g	18%
Fibre / Fibres 4 g	16%
Sugars / Sucres 6 g	6%
Protein / Protéines 15 g	
Cholesterol / Cholestérol 35 mg	
Sodium / Sodium 860 mg	36%
Potassium 0 mg	0%
Calcium 260 mg	20%
Iron / Fer 4 mg	20%

*5% or less is **a little**, 15% or more is **a lot**/ *5% ou moins c'est **peu**, 15% ou plus c'est **beaucoup**

b. New Canadian Nutrition Facts table [22]



Nutrition Facts

Serving Size 1 bowl (300g)
Servings Per Container 1

Amount Per Serving

Calories 440	Calories from Fat 171
	% Daily Value*
Total Fat 19g	**29%**
Saturated Fat 4g	**20%**
Trans Fat 0.2g	
Cholesterol 35mg	**12%**
Potassium 0mg	**0%**
Sodium 860mg	**36%**
Total Carbohydrate 35g	**12%**
Dietary Fiber 4g	**16%**
Sugars 6g	
Protein 15g	**30%**

Vitamin A 45% • Vitamin C 4%
Calcium 20% • Iron 20%

*Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs.

	Calories	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2400mg	2400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

c. Current US Nutrition Facts Label [150]

Nutrition Facts

1 servings per container
Serving size **1 bowl (300g)**

Amount Per Serving
Calories **440**

	% Daily Value*
Total Fat 19g	**24%**
Saturated Fat 4g	**20%**
Trans Fat 0.2g	
Cholesterol 35mg	**12%**
Sodium 860mg	**37%**
Total Carbohydrate 35g	**13%**
Dietary Fiber 4g	**14%**
Total Sugars 6g	
Includes 5g Added Sugars	**10%**
Protein 15g	**30%**
Vitamin D 0mcg	0%
Calcium 260mg	20%
Iron 3.6mg	20%
Potassium 0mg	0%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

d. New US Nutrition Facts Label [57]

2.9.1.2 Comments on the addition of added sugars declarations

Canada did not publicize comments made during the recent consultation period for changes to the nutrition labelling regulations; however, the main issues related to labelling added sugars can be garnered from the publicly available comments on the US label changes [57]. The comment period on the US nutrition labelling amendment was open from March until August 2014 and over 35,000 submissions on added sugars were reported, which were combined into 215 unique comment areas [164]. Of the 215 unique comments, 106 supported the change to include an added sugars declaration, 89 were in opposition, and 20 remained neutral [164]. Like in Canada, most of the opposing comments came from the food industry, while there was overwhelming support from scientists and public health experts [164]. Resistance by food manufacturers to the inclusion of added sugars on the food label was anticipated given that alerting consumers to the prevalence of added sugars could threaten profitability [164]. Some of the main comments in opposition to labelling added sugars included a lack of a scientific rationale [164] and an inability to verify the amount of added sugars declared with laboratory methods [90]. Firstly, several comments from members of the food industry repeatedly cited the lack of evidence that added sugars intakes are associated with adverse health outcomes [164]. In fact, the *Sugar Association* stated that no authoritative scientific body had implemented a maximum recommended intake level for added sugars after a thorough review of the scientific literature [164]. However, since the consultation period in 2014, maximum intake guidelines have been published by a number of authoritative bodies [3, 5-7], and the *US Food and Drug Administration* concluded there was unequivocal evidence that excess added sugars consumption was a public health issue to be addressed [57]. Secondly, a declaration of added sugars would mean the onus would be on the product manufacturer to keep sufficient records (e.g. recipes, formulations, analyses of databases) for substantiation of the amount of added sugars claimed [57]. The provision of these records to enforce nutrition labelling regulations has been met with opposition because it was seen as revealing proprietary information of otherwise confidential recipe formulations [50]. However, added sugars are not unique in the sense that there are currently also no analytical methods to distinguish between dietary fibre and non-digestible carbohydrates that do not meet the definition for dietary fibre, various forms vitamin E, and folate and folic acid; all of which also rely on records kept by manufacturers to verify any declarations [57].

2.9.2 Nutrition claims

Another important function of the nutrition label is to act as a vehicle for the marketing of foods and beverages [27]. Although nutrition claims can be used voluntarily, specific regulated criteria must be met before a product is permitted to carry a claim [153]. The *Food and Drugs Act* explicitly state that nutrition claims in Canada must not be false, misleading, or likely to create an erroneous impression [165]. Admissible regulated claims include nutrient content and health claims [18]. Nutrient content claims identify the level of a specific nutrient in a food or beverage to assist consumers in making easy comparisons between products and to make informed food choices to prevent detriments to health [18]. Nutrient content claims are meant to be based on established scientific and health standards and should account for trade and economic considerations wherever possible [18]. The requirements are based on standardized reference amounts (the average quantity of food consumed in one sitting) and serving sizes, the amount of energy or other nutrients in a food, and only specific wordings for each claim are permitted for use [18]. Sugar-related nutrient content claims include "reduced in sugars", "no added sugars", "free of sugars", "unsweetened" and "lower in sugars"; the criteria for carrying a claim and permitted wording variation for which are outlined in **Table 2.2** [18]. Health claims include disease-risk reduction claims, which highlight an aspect of the product that can reduce the risk of developing a disease or condition (e.g. "a healthy diet low in saturated and trans-fat may reduce the risk of heart disease"), function claims, which highlight the beneficial effects on normal biological functions (e.g. "consuming 7 grams of fibre from coarse wheat bran promotes regularity") [153], and general health claims, which are not specifically regulated beyond the obligation to not be misleading and include claims that are implied through front-of-pack systems, like logos, symbols, or illustrations [149, 166]. The 2003 nutrition labelling regulations allowed for five disease-risk-reduction health claims, with the potential for expansion, provided that sufficient scientific evidence is available to substantiate the claim [18, 166]. A number of additional disease-risk-reduction health claims have since been approved [167], however, there are no approved health claims that specifically refer to sugars [153].

Table 2.2 Criteria and permitted wording for sugar-related nutrient content claims, adapted from the Canadian *Food and Drug Regulations* [59]

Claim	Conditions	Permitted Wording
Free of sugars	• Food contains less than 0.5 g of total sugars per reference amount and serving size; and • Food meets the conditions for "free of energy" claim (except chewing gum)	"free of sugar"; "sugar-free"; "no sugar"; "0 sugar"; "zero sugar"; "without sugar"; "contains no sugar"; "sugarless"
Reduced in sugars	• Food is modified to contain ≥25% (and ≥5 g) less total sugars than a similar food per reference amount or per 100 g if the food is a prepackaged meal	"reduced in sugar"; "reduced sugar"; "sugar-reduced"; "less sugar"; "lower sugar"; "lower in sugar"
Lower in sugars	• Food is modified to contain ≥25% (and ≥5 g) less total sugars than a food from the same food group per reference amount or per 100 g if the food is a prepackaged meal	"lower in sugar"; "lower sugar"; "less sugar"
No added sugars	• Food contains no added sugars or ingredients that functionally substitute for or contain added sugars • Total sugars content is not increased through some other means (increase for functional effects, other than sweetness, are excepted) • Similar reference food contains added sugars	"no added sugar"; "no sugar added"; "without added sugar"
"unsweetened"	• Food meets the conditions for "No added sugars" claim • Food does not contain a sweetener	

2.9.2.1 Prevalence of nutrition claims on foods

In 2013, nutrition claims (nutrient content and health claims) were found on 46% of a sample of over 15,000 foods and beverages representative of the Canadian prepackaged food supply [168]. Fruits and fruit juices (68.5%), dairy products (64.4%), snacks (62.1%), and soups (61%) were the food categories with the greatest proportion of products carrying any type of claim [168]. Nutrient content claims were found on 42.9% of products, making it the most prevalent type of nutrition claim [168]. The most common nutrient content claims were related to vitamin and

minerals (15.2%), total fat (12%), trans fat (11.2%), and fibre (8.2%) [168]. Similar trends have also been documented in the US, where 49% of products carried nutrition marketing and of these, 75.7% had nutrient content claims [31]; in the United Kingdom, nutrient content claims were also the most prevalent of the nutrition claims and were found on 29% of a random sample of 382 food products [30]; and in a study of five European countries 64% of foods carried a nutrient content claim [169].

In 2013, 5.1% of products in the Canadian prepackaged food supply carried a sugar-related nutrient content claim, a significant increase from 4% in 2010, and they were often found on sources of sugars in the diet (e.g. fruit and fruit juices, beverages, dairy products and alternatives, sugars and sweets, and desserts) [168]. This increase may be a reflection of growing consumer interest in limiting sugars intakes as dietary guidelines emerge [168]. Comparatively, a study in the US found that in 2012 "low sugar" claims were present on 2% of foods and 8% of beverages [170], and in 2013, 12% of foods in a five-country European study carried claims referring to sugars contents [169].

2.9.2.2 Nutritional quality of products carrying nutrition claims

While there is evidence to suggest that products carrying nutrition claims have slightly more favourable nutrient profiles (of unknown clinical relevance) [30], other work has demonstrated that they are high in 'nutrients to limit' (i.e. calories, saturated fats, sodium, sugars), which is counterproductive to the prevention of NCDs [31, 171]. A 2010 study of over 56,000 packaged foods and beverages in the US with nutrition claims were assessed for their nutritional quality [31]. Almost half (49%) of the products had nutrition marketing and 48% of those were high in saturated fat, sodium, or added sugars [31]. At the time of that study, no DV for added sugars had been established [31], so a benchmark of 32g per day was used which is approximately 6.5% of total energy for a 2,000-calorie diet, lower than current dietary guidance suggests. Sugars was the most commonly exceeded benchmark (31%) followed by sodium (17%), and saturated fats (11%) [31]. Further, a recent US study on "low-content" claims (i.e. low-fat, low-sodium, and low-sugar), found products carrying these claims did not necessarily have better nutritional profiles overall, or for the claimed nutrient, when compared to products without the claim [170]. There was also a greater prevalence of low-content claims in food categories that tended to be high in the same nutrient stated in the claim (e.g. low sugar claims were more prevalent on soft drinks) [170].

Minimal tracking of sugar-related nutrient content claims and the nutritional quality of products bearing these claims has been conducted in Canada.

2.10 Effects of nutrition labelling on food choice and diet

In theory, nutrition labelling can impact consumers' diets through: 1) the provision of information; 2) stimulation of product reformulation; and 3) nutrient content information can be used to populate food composition databases which are used to support policies, population health interventions and research on dietary intakes.

2.10.1 Provision of nutrition and sugars content information to consumers

2.10.1.1 Use of nutrition label information

Hypothetically, a consumer uses the nutrition label to gather information and then the informed consumer decides which foods to purchase and therefore consume; all foods consumed then collectively form a dietary pattern [19, 149]. In Canada, the food label is the most commonly used source of food and nutrition information and is viewed as a credible source by the majority of respondents surveyed in Tracking Nutrition Trends 2015 [129]. On the food label, the NFt and Ingredient List are among the most likely pieces of information to guide food selection; as are the %DV, statements about nutrient or health benefits, and healthy logos or symbols, albeit to a lesser extent [129]. Canadians reported a variety of purposes for usually or always using nutrition label information: 48% used it to determine the calorie content of a product, 43% used it to compare the nutritional quality of similar foods, 43% used it to assess if there is a little or a lot of a nutrient in a product, 39% used it to compare the nutritional quality of different foods, 36% used it to identify the presence of specific ingredients, 35% used it to find foods with health claims, 27% used it to determine how much of a product to eat, 24% used it to see if a product provides a serving from a food group in *Canada's Food Guide*, and 20% used it to identify organic foods [129]. Consumers more likely to consult the food label include females, and those of older ages, higher incomes, and higher levels of education [129, 172]. Additionally, consumers who consult the food label are more likely to consume a healthier diet but given that studies of label use tend to be cross-sectional in nature, it is unclear if label use is the predictor in this relationship [172].

Canadians also reported making food choices based on the presence of various sugars-based ingredients in the Ingredient List [129]. Canadians who reported low sugar contents influenced their food selection were more likely to avoid products with sugar, corn syrup, evaporated cane juice, or fructose [129]. Similar trends have been documented internationally: adults in Northern Ireland reported prioritizing sugars information as second only to calorie contents when selecting foods [173]; respondents from six European countries cited sugars as the third most looked for nutrient after calories and fat [174]; and in Australia and New Zealand, sugars was reported as the most sought after piece of nutrition information when purchasing a food for the first time [175]. Additionally the same Australia/ New Zealand study found that of the respondents who used the ingredient list, sugars was reported to be the most frequently searched for component [175].

2.10.1.2 Understanding information on the Nutrition Facts table

For nutrition labelling to successfully lead to changes in consumer behaviour, the information presented on the label not only needs to be used, but also understood and interpreted [19, 149]. Several studies indicate that NFt information is often misinterpreted [149] and that respondents had difficulty deciphering the %DV [176, 177]. The comprehension of the information presented on the NFt is complicated by the need for calculations, interpretation of quantitative information, and comparisons of the nutritional composition between products, especially when serving sizes are inconsistent [172]. The 2016 nutrition labelling amendments in Canada may address some of the barriers to understanding nutrition information on the NFt, particularly with the standardization of serving sizes and the introduction of a footnote to assist with the interpretation of the %DV (Figure 2.4) [22].

The US nutrition labelling regulation amendments and the initial Canadian proposal to include added sugars on the NFt, sparked a number of consumer research studies assessing consumers' understanding [162, 178, 179] . In a couple of studies, the addition of added sugars contents on the food label led to the misinterpretation of total sugars contents because respondents thought the amount of added sugars was in addition to total sugars, rather than a subcomponent of total sugars [162, 178, 179]. However, different wording for the added sugars declaration has been shown to address this misunderstanding and as a result, the final wording in the US nutrition labelling amendment was changed from "added sugars __g" to read "includes __g of added sugars" on an indented line below the total sugars declaration (Figure 2.4) [179]. Further research demonstrated

that consumers were better able to assess the levels of added sugars in a product when there was a declaration of added sugars on the label [179]; and when a label also had a %DV for added sugars, consumers were better able to identify the healthier of two products and the one higher in added sugars, compared to labels that only listed total sugars [180, 181].

The use of nutrition label information by consumers may result in trade-offs when choosing foods because seemingly competing principles about healthy eating, expert recommendations, and the nutritional properties of foods are juggled [19]. A small Canadian study found that consumers use the benchmarks for a single nutrient to determine the overall healthfulness of a product and subsequent intent to purchase [26]. Likewise, evaluations of consumers' perceptions of healthfulness were shown in a US study to be influenced by the amount of added sugars listed on a product [28]. For instance, a more nutritious product with less added sugars was more easily identified as the healthier of two items [28]. However, some work has demonstrated that consumers have difficulty identifying products that contain a little or a lot of sugars without information to provide context [181]. *Health Canada's* footnote for interpreting a %DV is intended to direct consumers to healthier products, yet, the healthfulness of products that exceed the benchmark for "a lot" of total or extrinsic sugars remains unknown.

2.10.1.3 Interpretation of nutrient content claims

It is believed that because nutrition claims can be more easily seen and interpreted by consumers than the full NFt, they are better able to help them make choices when shopping [20]. However, there is concern that some claims may be deceptive to consumers. It has been suggested that when some products display nutrition information while others do not, as would occur with the voluntary nature of nutrition claims, a consumer may infer that products without a claim are of lesser nutritional quality, or that products with relative claims are healthy in absolute terms, not just healthier in comparison to another product [149]. It has been well established that the mere presence of nutrition marketing on a product can lead to the 'halo' effect, in which consumers attribute additional nutritional benefits to a product, despite the claim only referring to a single nutrient [182-185]. This phenomenon stems primarily from research evaluating consumer use of "low fat" claims. When presented with a product carrying a "low fat" claim, consumers have been shown to underestimate the calorie content which can lead to over consumption [186].

To date, there has been limited investigation into consumers' interpretation of sugar-related nutrient content claims, however the results from existing research identify several examples of consumer misinterpretations [29, 187]. A mock-package survey (n=1525) conducted in New Zealand found that some (27%) consumers incorrectly believed that a product with a "no added sugars" claim would not contain any sugars, and 36% of participants believed products carrying this claim were definitely healthy [187]. Similar interpretations of "no added sugars" claims were shown in an online experiment in Australia and New Zealand (n=1007) with between 17% and 29% of respondents believing the product would not contain any sugars [188], although, this misinterpretation appeared to be attenuated when a disclaimer that a product contains natural sugars, was present [188]. Respondents in a study conducted to inform sugar-related nutrient content claim regulations in the European Union believed that artificial sweeteners would be added in place of sugars in products with "no added sugars" claims [29]. In addition, participants of focus groups and an online survey were unsure what level of sugars reduction there would be in products with a "reduced in sugars" claim. Respondents expected sugars to be reduced anywhere between 1% and 50%. Fifty percent was mentioned as the ideal despite regulations only requiring a minimum 25% reduction [29]. Respondents also expected calorie reductions to be meaningful and similar to any reductions in sugars [29]. Consumer perceptions of sugar-related nutrient content claims in Canada remains an understudied area. Existing knowledge suggests a need to explore the potential for products with sugar-related nutrient content claims to mislead consumers who may believe they are indicative of products that are lower in sugars, lower in calories, and 'healthier' options.

2.10.2 Food system responses to nutrition labelling: reformulation

Nutrition labelling can also improve dietary quality through responses in the food system, for instance, the reformulation of foods and beverages or the introduction of healthier products to the market [189]. As manufacturers strive for an advantage over their competition, reformulation of products to be lower in added sugars would be a positive outcome of introducing added sugars to the Nutrition Label [190]. An example of this was seen in Canada with the introduction of trans-fat declarations on the NFt, which led to voluntary removal of trans-fat from many Canadian foods by the manufacturers [191, 192]. Additionally, permitting manufacturers to display nutrition claims can act as an incentive for manufacturers to create products that meet the criteria required to carry a claim [190]. Product reformulation of foods and beverages is an approach that can have an

equitable benefit across the whole population, including those with limited income and low health literacy [95] and is considered a "best buy" approach, according to the United Nations [193]. Reformulation of existing products; especially by stealth reformulation, requires no behaviour change on the part of the consumer which means diets can be improved regardless of how the consumer interprets or uses nutrition information [194]. Furthermore, reducing intakes of sugars has been shown to alter taste preference for sweet foods, which can ultimately shift intakes towards less sweet products [195]. However, such a modification may require that sugars are not replaced with ingredients that maintain the sweet taste of a product, such as low or no-calorie sweeteners [196]. In anticipation of the inclusion of added sugars declarations in the US and the emergence of dietary guidelines for extrinsic sugars, efforts and plans to reduce added sugars contents by manufacturers have already been documented [197, 198].

2.11 Summary

Nutrition labelling is intended provide information to consumers to enable food selection and comparisons [18]. However, it is unclear how effectively sugars information on the nutrition label can be used as a marker for identifying healthier foods and beverages that are low in extrinsic sugars. Concerns have emerged that labelling of total, rather than extrinsic sugars may hinder the opportunity for consumers to abide by extrinsic sugars intake guidelines and may detrimentally impact intakes of foods composed primarily of intrinsic sugars (e.g. fruits, vegetables, dairy products) [14, 24]. Despite this, the presentation of sugars information on the NFt in Canada currently, and historically, has focused on a declaration of total sugars contents [18]. Additionally, nutrition claims, although more easily interpreted than the information on the NFt [20], are still vulnerable to misinterpretation [149 182-185]. Consumers associate the presence of sugar-related nutrient content claims with products that are healthier, lower in calories, and lower in sugars [29]. However, the criterion in the regulations required for products to carry these claims do not warrant such assumptions [28]. Although there are indications that sugars information found on nutrition labels may not be optimal indicators of products with favourable nutritional compositions or those in line with extrinsic sugars guidelines, investigations to this end have been limited, likely owing to the lack of information on the pervasiveness and types of sugars available in Canadian prepackaged foods and beverages.

Chapter 3

3 Research Rationale and Objectives

Canadian consumers are actively attempting to reduce their intakes of sugars [129, 137], however the usefulness of nutrition label information for supporting their efforts is unknown. There are two major policy changes underway in North America regarding the declaration of sugar information on the NFt. Regulatory changes in Canada will require the NFt on foods and beverages to have a % DV for total sugars, based on 100g/day by the year 2021. In contrast, nutrition labels in the US will require a declaration for added sugars, with a %DV based on 50g/day; a first for any country worldwide and a change aligned with dietary intake guidelines. Historically, sugars labelling in Canada has focused on total sugars, however, there is concern that the absence of extrinsic sugars declarations may act as a hinderance for consumer adherence to extrinsic sugars intake guidelines. Until now, there has been no evaluation of the %DV for total sugars or any alternative (e.g. free sugars) in terms of its ability to identify foods with free sugars levels exceeding the WHO free sugars intake guidelines and that have suboptimal nutritional compositions.

Furthermore, with the growing attention on sugars in labelling regulations and in dietary guidelines, it is important that all the information available to consumers, including nutrition claims, support the selection of foods that reduce the risk of NCDs, without misleading the consumer. Consumers have been shown to use the presence of nutrition claims to assess the overall healthfulness of a product and subsequent intent to purchase [129], however, the extent to which Canadian prepackaged foods and beverages with sugar-related nutrient content claims are indicative of healthier products or meet consumers expectations to be lower in calories and sugars [29, 187], have not been comprehensively examined.

Thus, examinations of the ability of sugars-related nutrition labelling information to identify foods according to their alignment with the WHO free sugars intake guidelines and overall product healthfulness is needed to better comprehend the implications for consumers. The lack of detailed data on the pervasiveness of sugars in the food environment hinders measurements of sugars intakes and related health effects, thereby stifling the development, implementation, and monitoring of policies and programs aimed at limiting sugars consumption. Consequently, there

is also an urgent need for detailed information on the types, amounts, and sources of sugars in foods and beverages in the Canadian marketplace.

Given these considerations, the following outlines the objectives and hypotheses for three studies that collectively aim to characterize sugars in the current Canadian prepackaged food and beverage supply and to evaluate sugars-related labelling, specifically sugars information on the NFt as well as sugar-related nutrient content claims, in terms of their ability to identify foods and beverages misaligned with the WHO free sugars intake guidelines and with suboptimal nutritional composition.

3.1 Study 1 (Chapter 4)

Study 1: Total and free sugar contents of Canadian prepackaged foods and beverages

Objective: to determine and characterize the total and free sugars contents of foods and beverages in a large representative sample of Canadian prepackaged foods and beverages. Study 1 is a non-hypothesis driven study.

Study Published: Bernstein J.T., Schermel A., Mills C.M., L'Abbé M.R. (2016). Total and free sugar content of Canadian prepackaged foods and beverages. *Nutrients* 8:582. doi:10.3390/nu8090582.

Author Contributions: JTB and MRL conceived and designed the overall research plan. AS coordinated data collection. CMM compiled data on free sugar ingredient use. JTB conducted the research, analyzed the data, and wrote first draft of the manuscript. All authors were responsible for final content.

3.2 Study 2 (Chapter 5)

Study 2: A free sugars daily value (DV) identifies more "less healthy" prepackaged foods and beverages than a total sugars DV

Research Question: Is a total sugars %DV or a free sugars %DV able to identify a greater proportion of products exceeding the WHO free sugars intake guidelines and with suboptimal nutritional compositions?

Hypothesis: a free sugars %DV would identify a greater proportions of foods and beverages that exceed the WHO free sugars intake guidelines and have suboptimal nutritional composition as products with "a lot" of sugars than a total sugars %DV.

Objective: to model and compare a total sugars %DV (based on 100g) and a free sugars %DV (based on 50g) for ability to identify products that exceed the WHO free sugars intake guidelines and with suboptimal nutritional composition.

Study Published: Bernstein J.T., Labonté M.E., Franco Arellano B., Schermel A., and L'Abbé M.R. (2018). A free sugars daily value (DV) identifies more "less healthy" prepackaged foods and beverages than a total sugars DV. *Preventive Medicine* 109:98-105. doi:10.1016/j.ypmed.2017.12.031.

Author Contributions: JTB and MRL conceived and designed the overall research plan. AS coordinated data collection. JTB, BFA and MEL, calculated NPSC scores. JTB conducted the research, analyzed the data, and wrote first draft of the manuscript. All authors were responsible for final content.

3.3 Study 3 (Chapter 6)

Study 3: Healthfulness and nutritional composition of Canadian prepackaged foods with and without sugar claims

Research Question: Do foods and beverages with sugars-related nutrient content claims have more favourable nutritional compositions than similar products without these claims and do they have free sugars levels consistent with the WHO free sugars intake guidelines?

Hypothesis: Foods and beverages with sugar-related nutrient content claims will have free sugars levels that exceed the WHO free sugars intake guidelines, and compared to similar products without sugar-related nutrient content claims, they will have more favourable nutritional compositions.

Objective: to compare the nutritional composition of foods and beverages with and without sugar-related nutrient content claims and evaluate the consistency with which these claims are able to act as a marker for identifying products exceeding WHO free sugars intake guidelines.

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Author Contributions: JTB and MRL conceived and designed the overall research plan. AS coordinated data collection. JTB and BFA identified presence of sugars-related nutrient content claims. JTB conducted the research, analyzed the data, and wrote the first draft of the manuscript. All authors were responsible for final content.

Chapter 4

4 Study 1: Total and free sugar contents of Canadian prepackaged foods and beverages

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4.1 Abstract

A number of recommendations for policy and program interventions to limit excess free sugar consumption have emerged, however there are a lack of data describing the amounts and types of sugar in foods. This study presents an assessment of sugar in Canadian prepackaged foods including: (a) the first systematic calculation of free sugar contents; (b) a comprehensive assessment of total sugar and free sugar levels; and (c) sweetener and free sugar ingredient use, using the University of Toronto's Food Label Information Program (FLIP) database 2013 (n = 15,342). Food groups with the highest proportion of foods containing free sugar ingredients also had the highest median total sugar and free sugar contents (per 100 g/mL): desserts (94%, 15 g, and 12 g), sugars and sweets (91%, 50 g, and 50 g), and bakery products (83%, 16 g, and 14 g, proportion with free sugar ingredients, median total sugar and free sugar content in Canadian foods, respectively). Free sugar accounted for 62% of total sugar content. Eight of 17 food groups had ≥75% of the total sugar derived from free sugar. Free sugar contributed 20% of energy overall in prepackaged foods and beverages, with the highest at 70% in beverages. These data can be used to inform interventions aimed at limiting free sugar consumption.

4.2 Introduction

Excess consumption of free sugar (see **Box 4.1** for definitions) has been associated with increased risk of obesity, cardiovascular disease, diabetes, and dental caries [60, 74, 76, 81, 82]. In fact, one study found that increased consumption of refined carbohydrates, like free sugar, are second only to trans fats in increasing risk of cardiovascular disease [199]. Thus, guidelines to limit intakes to a maximum of 5%–10% of energy/day [3, 5, 6, 15, 16] have emerged in many regions. Recommendations have also been made in Canada and other countries to decrease the affordability, availability, accessibility and exposure to products with excess free sugar [15, 33, 193]. Despite these calls to action, the lack of detailed data on the pervasiveness of sugar in the food

environment [49] hinders the development of policies and programs to reduce free sugar consumption and associated health benefits with targeted interventions [118].

Box 4.1 Definitions.

- **"Free sugars"** is the sugar no longer in its naturally-occurring state (i.e., no longer in whole fruits, vegetables, unsweetened dairy, and grains) and can be consumed as is or incorporated into other foods [3]. Examples include table sugar, syrup, honey, fruit juice and nectars.
- **"Added sugars"** is the free sugar that has been added to foods [33], however regulatory definitions vary widely under different jurisdictions, some of which are currently under review [57].
- **"Naturally-occurring sugars"** is the sugar found naturally within whole foods (i.e., within whole fruits, vegetables, dairy, and some grains) [49].
- **"Total sugars"** is a combination of free sugar and naturally-occurring sugar and is currently the only type of sugar declared on the Nutrition Facts table (NFt) in Canada [200] and in many jurisdictions [57, 201-203].
- **"Free Sugar Ingredients" (FSI)** are all mono- and disaccharides added to foods as well as those naturally-occurring in honey, fruit juices, and syrups (e.g., sugar, honey, maple syrup, molasses, fruit juice, glucose, fructose, agave, and corn syrup) [3].
- **"Sweeteners"** are food additives that are used to give products a sweet taste and can include sugar alcohols (e.g., maltitol, xylitol, and sorbitol), non-nutritive sweeteners (e.g., aspartame, sucralose, and acesulfame-potassium), cyclamate sweeteners, or saccharin sweeteners [153] and are not considered FSI.

There are very limited data available on the free sugar contents of prepackaged foods and on consumption rates in Canada and globally [49]. This may be in part because free sugar is chemically indistinguishable from naturally-occurring sugar and as a result, contents must be calculated or supplied by food manufacturers. This has contributed to free sugar ingredients (FSI) being considered a "hidden" source of energy as it is not always obvious to consumers that they are present in food [95]. This phenomenon has been noted as a worry of Canadian parents [154]. Additionally, the various definitions used to describe sugar and inconsistencies in their components, make comparisons of food composition and sugar intakes problematic, increases the potential for confusion and misinterpretation and points to the need for uniform terminology [49]. Understanding the main sources and amounts of free sugar in Canadian foods will allow for monitoring trends in product formulations, reformulation efforts by the food industry, and Canadian intakes of free sugar overtime, that would otherwise be virtually impossible to measure.

Canadians consumed an average of 110 g (21.4% of energy) of total sugar per day in 2004 [111]. Although that report did not differentiate between total sugar and free sugar, another study used these total sugar intakes to estimate the average added sugar consumption of Canadians at 11%–13% of energy [9, 111]. These authors estimated the proportion of total sugar coming from added sugar by assuming each of the top food categories contributed either naturally-occurring sugar or added sugar [9]. These total and added sugar consumption rates were based on food composition information obtained from the Canadian Nutrient File (CNF) database, the national nutrition database maintained by Health Canada [204, 205]. However, using the CNF to assess sugar in the food supply poses several challenges, including its lack of scheduled, systematic and comprehensive updating, and its lack of brand-specific data [205]. Such data are required for analyzing a rapidly changing food supply, which can vary widely in free sugar content and the use of sweeteners. In contrast with these earlier assessments, more precise estimates of total, added, and free sugar intakes are needed to inform and evaluate relevant public health initiatives.

To obtain a more accurate assessment of the types and amounts of sugar in the Canadian food supply, data need to be reconciled using comprehensive, current, and accurate food composition data [49] along with systematic calculations of free sugar content. Acknowledging this need, in 2014 the Heart and Stroke Foundation of Canada (HSFC) called upon researchers to quantify the amount of free sugar in the Canadian food supply [15]. The overall purpose of this study is to provide a detailed and systematic evaluation of free sugar contents in a large representative sample of Canadian prepackaged foods that can serve as a benchmark to support and measure public health interventions and monitor free sugar consumption. Specific objectives include: (1) determining the amount of free sugar in Canadian prepackaged foods using a step-by-step decision algorithm tailored for use on a large, systematically collected, branded food composition database; (2) assessing total sugar and free sugar contents by food group and by detailed subcategory; and (3) conducting the first comprehensive assessment of the use of free sugar ingredients (FSI) and sweeteners in prepackaged foods and beverages.

4.3 Materials and Methods

Food Label Information Program (FLIP) Database

The Food Label Information Program (FLIP) is a database of Canadian food and beverage package labels by brand name that is updated every three years at the University of Toronto (U

of T). The purpose of the FLIP is to provide detailed assessments of the nutrition information found on the labels of food products in the Canadian marketplace, and to monitor changes over time. To date, two phases of the FLIP have been completed. The first phase, with data acquired in 2010/2011 (FLIP 2010), is described elsewhere [206]. The second phase, FLIP 2013, is described in this paper. The FLIP 2013 contains nutrition information for 15,342 unique products. Data collection took a similar approach as the FLIP 2010 with regards to acquiring food information from the top selling grocery retailers, although it was fully digitalized to enhance the ease and efficiency of collection and analysis. Food composition database software (University of Toronto and Dietitians of Canada, Toronto, Canada) (web and mobile) was developed for FLIP 2013 in collaboration with the Dietitians of Canada, resulting in a shorter and more efficient food collection and data processing approach.

FLIP 2013 Data Collection

Data acquisition occurred between May and September 2013, and was carried out in the Greater Toronto Area and Ottawa, Ontario, and Calgary, Alberta. Data were collected from major outlets of the four largest grocery chains in Canada (Loblaws, Metro, Sobeys, and Safeway), representing 75.4% of the grocery retail market share [207]. A Smartphone application was developed and used to scan and store the Universal Product Code (UPC), and to photograph all sides of food and beverage packages, and capture price. By systematically scanning the grocery store shelves, every food product with a Nutrition Facts table (NFt), including all available national and private label brands were collected. Seasonal products (e.g., eggnog, Easter chocolates), Natural Health Products (e.g., supplements), baby/toddler foods, and products that did not have a Canadian NFt (e.g., unpackaged fruits, vegetables) were excluded from the data collection. Food products sold at multiple retailers (such as national brand products) were captured only once. When multiple sizes of a product were available, only one size was sampled, but all flavours and varieties of a product were collected. Information collected for each product included the UPC, company, brand, price, NFt information, ingredients, container size, nutrient content claims, disease risk reduction claims, function claims, front of pack symbols, children's marketing, other claims (e.g., organic, natural, and gluten-free), and date and location of sampling.

FLIP 2013 Data Processing

Upon scanning the UPC code, foods that had not already been collected in this phase were automatically assigned a product ID and photos uploaded onto the FLIP website for data processing. The FLIP website allowed for efficient data entry using dropdown menus (e.g., to assign foods to specific categories or to indicate the presence of different nutrition claims), and used Optical Character Recognition technology to automatically extract data from the NFt and ingredients list. The FLIP database, run on a Microsoft SQL server, also enabled users to generate data outputs and reports in Microsoft Excel for further statistical analyses.
Food products were classified under multiple categorization systems. Categorization systems used included Schedule M of the Food and Drug Regulations [B.01.001] [208], as well as Health Canada's sodium categories for guiding benchmark sodium levels [209]. These classification systems were also used to create similar systems specific to other nutrients, e.g., trans-fat and the sugar focused food categories used for the present study.

When required, data for some food products were also calculated for the "as consumed" form (e.g., cake mixes, drink powders, and condensed soups) using ESHA Food Processor software and food composition data from the Canadian Nutrient File [210] in order to be comparable to the prepared versions within that particular food category. In addition, for some products, serving grams were converted to millilitres and vice versa for consistency across all products within a food category. The database underwent extensive quality control checks including verification of inputted nutrient contents using Atwater factors and outliers to check for erroneous values, and multiple reviews for NFt, Ingredient Lists, gram to millilitre conversions, and food group categorizations. Excluded from this analysis were meal replacement beverages, which are indicated for special dietary use (n = 55), and products with missing total sugar declarations (n = 28) for a total of 15,259 products in the present study.

FLIP 2013 Sugar-Focused Food Categories

Products were classified into 17 sugar-focused major food groups, including 77 major subcategories, and 207 minor categories. Sugar-focused categories were created based on Schedule M food categories as outlined in the Canadian Food and Drug Regulations [208], as well as Health Canada's sodium-focused categories [211]. These categories were further divided or combined based on sugar and sweetener ingredients, intended use, and food type to ensure categories containing like products.

Assessment of Free and Total Sugar Content and Use of Free Sugar Ingredients and Sweeteners

Free sugar is chemically indistinguishable from naturally-occurring sugar [90]. As there is no declaration of free sugar content on the NFt, an algorithm was developed to derive free sugar contents which was guided by a published, systematic methodology for estimating added sugars [119, 212]. The U of T free sugar algorithm steps, to be conducted in sequential order, as well as the proportion of free sugar contents calculated at each step, are outlined in **Table 4.1**. For the purpose of this analysis, free sugar ingredients (FSI) refers to any free sugar ingredient that meets the WHO definition for free sugar including sugar, syrup, honey, fruit juices, and other sweetening agents [3]. "Sweeteners", as defined by the Canadian Food Inspection Agency as a food additive that is used to give products a sweet taste and can include sugar alcohols (e.g., maltitol, xylitol, and sorbitol), non-nutritive sweeteners (e.g., aspartame, sucralose, and acesulfame-potassium), cyclamate sweeteners, or saccharin sweeteners [153] were not considered FSI. Presence of FSI and sweeteners were identified by searching the Ingredient List of each product and the ingredients required in product preparation as stated on the package. The means and distributions of total sugar content, obtained from the NFt, and of the calculated free sugar content were reported as g per 100 g or g per 100 mL (the latter for beverages and desserts), by food group, subcategory, and minor category. Free sugar content was calculated as a percent of total sugar and as a percent of energy, the latter to allow for comparisons with maximum intake guidelines, which are usually presented as a percent of energy. All calculations were conducted on the sugar content of the "as consumed" version of the product.

Statistical Analysis

Mean, SD, and quartiles (min, 25th, 50th, 75th, max) were determined for total sugar and free sugar content. The percent of total sugar and of energy derived from free sugar were presented as proportions. Categorical variables (e.g., presence of FSI and sweetener ingredients) were presented as frequencies (percentages). All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Table 4.1 Step-by-step method for calculating free sugar content of foods and beverages in the University of Toronto's Food Label Information Program (FLIP) database 2013 and number of foods at each step (total *n* = 15,259).

Description	*n* (%) [1]
Step 1: Products that contain 0 g total sugar as declared on the NFt. Free sugar value = 0 g/100 g.	3586 (23.5%)
Step 2: Products that contain no FSI [2] listed in the Ingredient List. Free sugar value = 0 g/100 g.	2620 (17.2%)
Step 3: Products that contain ingredients which contribute no, or a minimal amount of naturally-occurring sugars (i.e., fruits, vegetables, dairy, grains). Free sugar value = 100% of the declared total sugar content (e.g., soft drinks, fruit drinks) [3].	1642 (10.8%)
Step 4: Products that contain both naturally-occurring sugars and FSI, were compared to similar products without FSI (from steps 1 and 2) from the same subcategory (i.e., RTE breakfast cereals with FSI vs. RTE breakfast cereals without FSI) or minor category (i.e., milk, flavoured vs. milk, plain). The following equation [119] was used to calculate free sugar contents: $\frac{100 \times (\text{Sugar per 100 g unsweetened} - \text{Sugar per 100 g sweetened})}{(\text{Sugar per 100 g unsweetened} - 100)}$ When possible, specific comparisons were made based on main ingredients, flavours, specific nutrient contents, or product formats (i.e., fat-free sweetened yogurt vs. fat-free plain yogurt). Calculations resulting in negative free sugar contents (<0 g) were rounded up to 0 g.	6876 (45.1%)
Step 5: Products that do not have unsweetened comparators in the same subcategory in FLIP, were assigned a free sugar value based on a substitute value from the USDA Database for the Added Sugars Content of Selected Foods [116]. A free sugar value that matches the proportion of total sugar from added sugar in a product from the USDA database was assigned. For example, a product was assigned a free sugar value at 80% of total sugar if the comparable USDA database product had 80% of the total sugar coming from added sugars.	402 (2.6%)
Step 6: Products with no comparator in Step 5, were assigned a value reflective of the proportion of total sugar coming from free sugar in products within the same food group (e.g., a chocolate cake is assigned a free sugar value based on the percent of total sugar derived from free sugar content of other products in bakery products). Only products that contained free sugar (steps 3–5) were included in the calculation.	133 (0.9%)

[1] Numbers presented represent the number and proportion (%) of products calculated at each step. All calculations were done for products in the "as consumed" form. For determination of free sugar contents in the "as consumed" form: total sugar content of the "as consumed" form was used in place of the total sugar content in the "as purchased" form as declared on the NFt; FSI added according to the package directions were treated the same as a FSI in the Ingredient List (Step #2–6); "as consumed" versions of substitute products were used when available (i.e., brownies instead of brownie mix) (Step #5). [2] FSI (free sugar ingredients) for this study refers to all mono- and disaccharides added to foods as well as those naturally-occurring in honey, fruit juices, and syrups (e.g., sugar, honey, maple syrup, molasses, fruit juice, glucose, fructose, agave, and corn syrup) [3]. [3] All products in the energy drinks, fruit drinks, soft drinks, and sports drinks categories that reached Step 3 were considered to contain a minimal amount of naturally-occurring sugars. Abbreviations: FLIP = Food Label Information Program; NFt = Nutrition Facts table; FSI = free sugar ingredients; RTE = Ready-to-eat; USDA = United States Department of Agriculture.

4.4 Results

Use of Free Sugar Ingredients and Sweeteners

Overall, 63.5% of prepackaged foods contained a FSI, 1.9% contained a sweetener, another 1.8% contained both a FSI and a sweetener, and the remaining 32.9% contained neither (**Figure 4.1**). There were 152 unique FSI found in this representative sample of Canadian prepackaged foods, not including variations in spelling, indicators of quality, purity, or origin (e.g., organic maple syrup, 100% pure agave, and Canadian honey) or specific flavours of fruit juice (e.g., apple juice, and grape juice concentrate) (**Table 4.2**). The most common types of FSI found in Canadian food and beverage products were sugar (dried or granulated) identified in 49.3% of products, glucose in 19.3%, and corn syrup in 10.7% (Table 4.2). Major food categories with the highest proportion of products containing FSI were desserts (93.6%), sugars and sweets (91.4%), and bakery products (83.1%) (Figure 1). These were also the most total sugar and free sugar dense food groups (Figure 2).

Median Total and Free Sugar Content

Median free sugar content overall was 1.4 g per 100 g (or 100 mL), about one-third of the median total sugar content (4.0 g per 100 g/mL) (**Figure 4.2**). Fruits had the fourth highest median total sugar content (14.0 g/100 g) but was among the lowest free sugar containing food groups with 0 g/100 g. This was followed by beverages with a median 9.2 g/100 mL total sugar and 8.8 g/100 mL free sugar. All other food groups contained about half or less than these total and free sugar levels. For free sugar, this drop was even more dramatic, with all other categories containing less than 2.5 g/100 g. When examining the food supply in detail by subcategories (**Table 4.3**), the top total sugar containing subcategories were sugar (100 g/100 g), fruit snacks (72 g/100 g), dried fruits (55 g/100 g), dessert toppings and fillings (53 g/100 mL), confectionery (51g/100 g), and sweet condiments (50 g/100 g). The top free sugar containing subcategories were also sugar (100 g/100 g), dessert toppings and fillings (53 g/100 mL), confectionery (51 g/100 g), and sweet condiments (50 g/100 g), however, dried fruits and fruit snacks were not among the top free sugar subcategories with 0 g/100 g median free sugar content.

Figure 4.1 Proportion (%) of prepackaged foods and beverages containing free sugar ingredients, sweeteners, a combination of both, or neither, by major food category and overall (*n* = 15,259). Proportions labelled on the figure only when value is >10%. "FSI" are those defined in Table 2. "Sweeteners" refers to all non- or low-caloric sweetening agents as defined by the Canadian Food Inspection Agency, including sugar alcohols (e.g., xylitol, and sorbitol), and non-caloric or artificial sweeteners (e.g., sucralose, and aspartame) [153]. Abbreviations: Alt. = Alternatives.

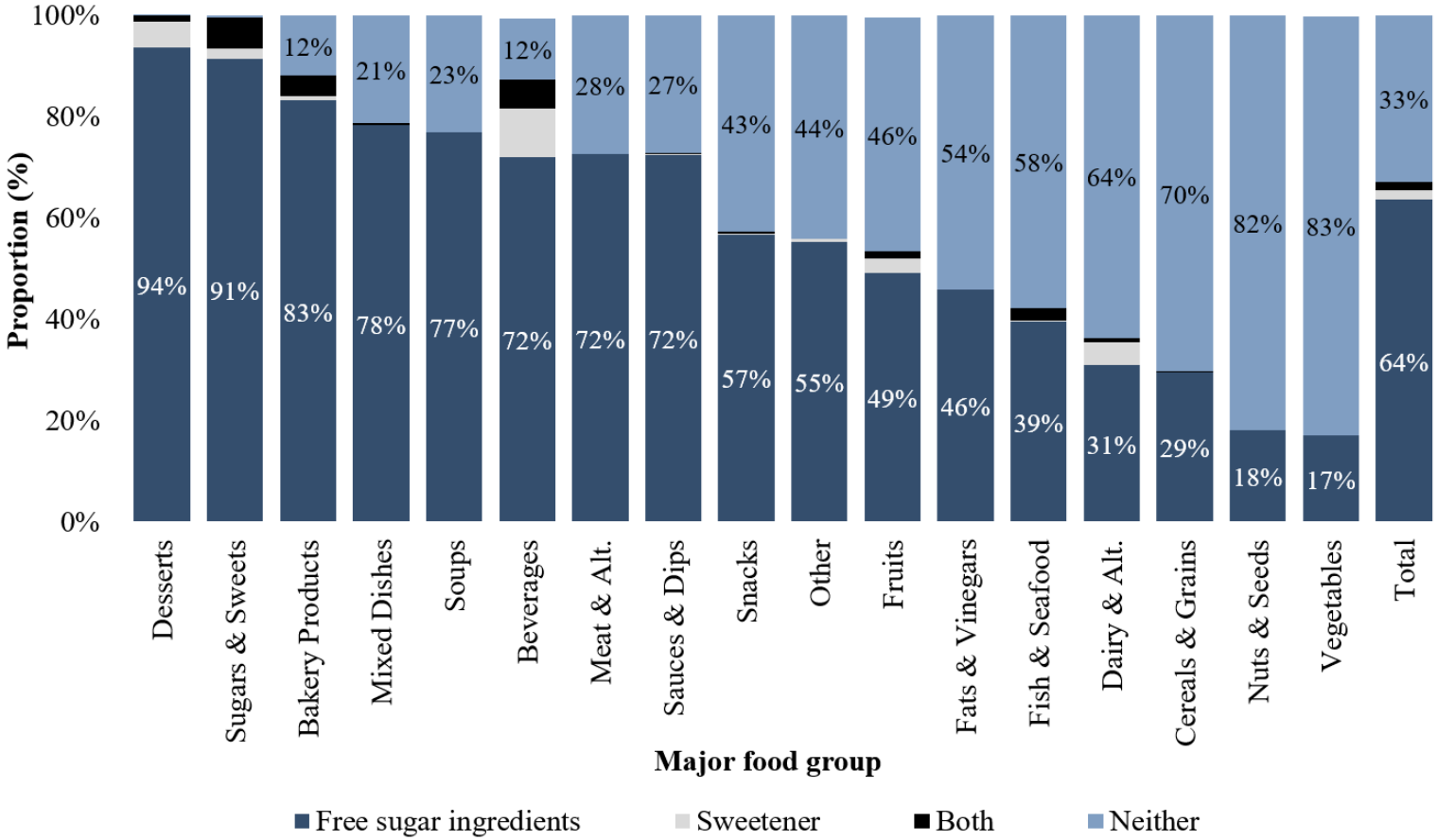


Table 4.2 Types of free sugar ingredients (FSI) identified in the FLIP 2013 database of Canadian prepackaged foods and beverages, by descending order of use (*n* = 15,259).

Type	Examples [1]	*n* (% Foods with FSI) [2]
Sugar (sucrose), dried and granulated	sugar, sucrose, brown sugar, cane sugar, pure sugar cane, pure cane sugar, raw cane sugar, powdered sugar, golden sugar, golden cane sugar, granulated cane sugar, granulated sugar cane juice, beet sugar, refined cane sugar, icing sugar, dried sugar cane juice, demerara sugar, light brown sugar, refinery syrup powder, invert sugar, evaporated cane juice, evaporated cane juice crystals, evaporated milled sugar, milled cane sugar, evaporated sugar cane juice, caster sugar, coarse sugar, turbinado sugar, natural cane sugar, turbinado cane sugar, white sugar, whole cane sugar, yellow sugar, dehydrated cane juice, dehydrated cane sugar, natural evaporated cane juice, confectioner's sugar, fondant sugar, raw sugar, evaporated cane sugar, dehydrated cane syrup, dark brown sugar	7517 (49.3%)
Glucose	glucose, glucose solids, glucose syrup, dextrose, dextrose anhydrous, dextrose syrup, anhydrous dextrose, dried glucose syrup, dextrin syrup	2939 (19.3%)
Corn syrup	corn syrup, corn syrup powder, corn syrup solids, high maltose corn syrup, dried corn syrup extract, glucose-fructose, caramelized glucose-fructose, corn malt syrup, fructose- glucose, glucose-fructose syrup, corn sweetener	1626 (10.7%)
Fruit juice	concentrated fruit juice, fruit juice, fruit juice concentrates, fruit juice from concentrate	1202 (7.9%)
High-fructose corn syrup [3]	high fructose corn syrup, sugar/glucose-fructose, sugar/fructose-glucose, sugar and/or glucose-fructose, sugar and/or fructose-glucose	873 (5.7%)
Molasses	molasses, dehydrated molasses, powdered refiner's molasses, black molasses, blackstrap molasses, dried molasses, refiner's molasses, cane juice molasses, dry blackstrap molasses, dry molasses, fancy molasses, fancy molasses powder, cooking molasses, molasses granules, molasses powder, molasses solids	706 (4.6%)
Honey	honey, liquid honey, amber honey, pasteurized honey, honey granules, honey powder, honey solids, creamed honey, dried honey, granulated honey, raw honey, buckwheat honey, dried honey powder, dry honey, white honey	625 (4.1%)

Type	Examples [1]	*n* (% Foods with FSI) [2]
Sugar (sucrose) syrups [4]	cane sugar syrup, sucrose syrup, dried cane syrup, cane syrup, cane refiner's syrup, refined sugar syrup, burnt sugar syrup, invert cane syrup, golden syrup, refiner's syrup, invert sugar syrup, caramel, caramel sugar syrup, caramel syrup, evaporated cane syrup, liquid invert sugar, liquid sugar, liquid sucrose, evaporated cane juice syrup, sugar cane syrup, treacle	514 (3.4%)
Other syrups	brown rice syrup, apple cider syrup, apple syrup, rice syrup, malt syrup, barley malt syrup, malted barley syrup, tapioca syrup, raisin syrup, sorghum syrup, wheat syrup	439 (2.9%)
Fructose	fructose, fructose solids, fructose syrup, crystalline fructose	324 (2.1%)
Other sugars	potato syrup solids, palm sugar, tapioca sugar, tapioca syrup solids, lactose, coconut sugar, oat syrup solids, maltose, isomaltose	272 (1.8%)
Maple syrup	maple syrup, dehydrated maple syrup, maple sugar	72 (0.5%)
Agave	agave, agave nectar	27 (0.2%)

[1] 152 unique FSI were identified, not including different spellings, "organic" variations of nomenclature (e.g., organic cane sugar), claims of origin (e.g., Canadian maple syrup), claims of purity (e.g., 100% pure agave) and specific flavours of fruit juice (e.g., apple juice, pear juice), are presented in descending order of use; determined from the number of products that contained each FSI. [2] Combined percentage of foods containing a FSI exceeds 100% because 4642 (30.4%) of the food supply or 46.6% of the products with a FSI contained more than 1 type of FSI. [3] Labelling terminology used in Canada for high-fructose corn syrup. [4] Caramel used for colour, when indicated within the ingredient list, was not considered a FSI. Abbreviations: FLIP = Food Label Information Program.

Figure 4.2 Median total sugar and free sugar content (g/100 g or g/100 mL) by major food group and overall (*n* = 15,259): (left) median total sugar content; and (right) median free sugar content. Categories with 0 g/100 g or 100 mL median total sugar and free sugar (i.e., other foods and beverages; fats, oils, and vinegars; meat and alternatives; and fish and seafood) are not shown. (▰) denotes a break in the x-axis between 20 and 45 g/100 g.

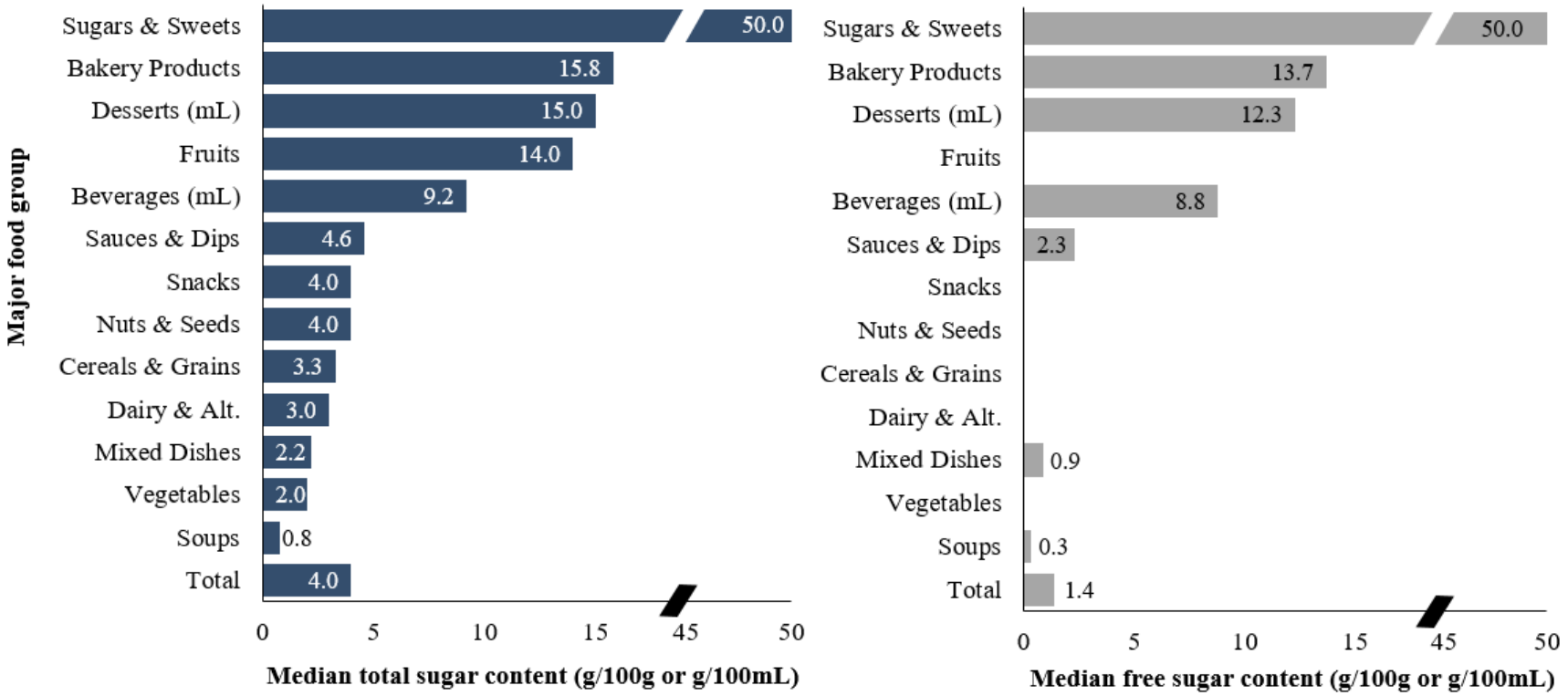


Table 4.3 Total and free sugar contents (g per 100 g or 100 mL) and average free sugar as a proportion of total sugar (%) in FLIP 2013 by food group, subcategory, and minor category (n = 15,259) [1].

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Bakery Products	2197	17 (15)	0	4	16	29	94	16 (14)	0	2	14	28	94	79%
Baked Breakfast	*123*	*10 (7)*	*1*	*5*	*7*	*10*	*38*	*5 (8)*	*0*	*0*	*2*	*5*	*34*	*29%*
Croissants	6	11 (5)	6	7	8	17	18	5 (6)	1	1	2	12	12	38%
Pancakes, Waffles, French Toast	92	7 (3)	1	5	6	9	24	2 (3)	0	0	0	3	20	18%
Tea Biscuits and Scones	14	12 (8)	4	7	11	14	28	9 (8)	0	3	7	11	25	59%
Toaster Pastries	11	26 (9)	15	17	24	36	38	22 (10)	10	12	19	32	34	80%
Baked Desserts	*88*	*30 (11)*	*8*	*22*	*28*	*39*	*50*	*27 (10)*	*6*	*18*	*24*	*36*	*46*	*88%*
Brownies/Squares	39	39 (6)	22	35	40	43	50	36 (7)	18	33	36	40	46	92%
Doughnut, Cake	12	23 (6)	12	19	23	27	30	21 (5)	11	17	20	24	29	92%
Doughnut, Yeast	5	19 (4)	15	17	17	20	24	17 (3)	14	16	16	18	23	93%
Fruit-Filled Pastries	8	24 (4)	19	20	24	28	31	17 (3)	13	14	17	19	21	69%
Other Pastries (e.g., eclairs)	14	23 (11)	8	14	21	27	50	19 (10)	6	11	18	20	41	80%
Sweet Buns (e.g., cinnamon rolls)	10	23 (6)	11	22	25	27	32	21 (6)	9	21	23	25	29	91%
Bread Products	*548*	*6 (7)*	*0*	*2*	*3*	*6*	*36*	*4 (7)*	*0*	*0*	*2*	*4*	*35*	*58%*
Bagels	37	5 (3)	2	4	5	7	16	3 (3)	0	1	3	5	15	62%
Bread w/ Additions (e.g., garlic bread)	31	2 (3)	0	0	2	3	14	1 (1)	0	0	0	1	4	27%
Bread w/ Raisins	15	16 (6)	5	9	16	18	24	12 (8)	0	4	14	17	23	72%
Diet Bread	6	4 (1)	2	2	4	5	5	2 (1)	1	1	2	3	3	52%
English Muffins	24	2 (2)	0	2	2	2	13	0 (1)	0	0	0	0	2	19%
Flatbreads (e.g., pita, naan, tortillas)	131	3 (4)	0	0	2	4	20	2 (4)	0	0	1	3	19	60%
Hearth Bread	69	2 (2)	0	0	2	2	9	1 (2)	0	0	0	1	9	39%
Muffins and Quick Breads	57	24 (7)	7	20	25	28	36	22 (7)	0	19	23	27	35	93%
Pantry Bread and Rolls	178	4 (2)	0	3	4	5	20	2 (2)	0	1	2	3	8	56%
Cake	*246*	*30 (9)*	*13*	*23*	*28*	*36*	*56*	*27 (8)*	*10*	*20*	*25*	*32*	*52*	*89%*

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Cake Mixes	52	23 (5)	16	20	22	24	36	22 (5)	15	19	20	23	36	95%
Cakes w/Icing/Filling	21	32 (7)	13	29	34	36	38	27 (6)	10	24	28	31	36	86%
Cheesecakes	35	25 (4)	18	22	25	27	32	21 (3)	15	18	21	23	27	83%
Coffee Cakes w/o Icing/Filling	42	28 (5)	19	25	27	30	43	26 (4)	18	23	26	28	41	95%
Cream, Custard, and Mousse Cake	13	22 (4)	16	18	21	23	32	18 (4)	13	15	18	19	26	83%
Cupcakes	28	43 (6)	29	40	42	46	56	37 (7)	24	33	36	41	51	85%
Ice Cream Cakes	11	26 (5)	13	23	26	28	35	21 (5)	11	19	22	23	29	83%
Sauce Cakes	4	27 (2)	25	25	26	28	29	22 (1)	20	21	22	23	24	83%
Snack Cakes	29	41 (8)	24	36	43	46	54	37 (8)	23	31	37	44	52	91%
Sponge Cakes w/o Icing/Filling	6	36 (4)	30	34	37	38	43	36 (4)	30	33	37	37	42	99%
Upside-down and Fruit Cakes	5	31 (2)	28	30	31	32	34	26 (2)	23	25	26	27	28	83%
Cereal/Granola Bars	*202*	*30 (7)*	*11*	*24*	*31*	*35*	*57*	*27 (7)*	*11*	*22*	*27*	*32*	*53*	*91%*
w/ Filling or Coating	101	33 (6)	18	29	34	37	45	29 (6)	17	24	29	34	41	88%
w/o Filling or Coating	101	27 (7)	11	23	27	32	57	26 (7)	11	21	25	30	53	94%
Cookies	*412*	*32 (10)*	*0*	*27*	*32*	*38*	*94*	*32 (10)*	*0*	*27*	*32*	*38*	*94*	*100%*
Chocolate Chip	81	32 (7)	0	30	33	36	43	32 (7)	0	30	33	36	43	100%
Chocolate Covered	39	35 (11)	0	29	37	41	56	35 (11)	0	29	37	41	56	100%
Fruit-Filled	21	33 (5)	20	31	33	34	43	33 (5)	20	31	33	34	43	100%
Other Cookies (e.g., macaroons, biscotti)	116	31 (11)	0	26	30	36	94	31 (11)	0	26	30	36	94	100%
Sandwich Cookies	64	35 (7)	0	32	35	40	53	35 (7)	0	32	35	40	53	100%
Shortbread	8	20 (10)	0	16	22	27	30	20 (10)	0	16	22	27	30	100%
Social Tea/Sugar-Type	53	24 (8)	0	19	23	29	43	24 (8)	0	19	23	29	43	100%
Sugar Wafer	30	35 (17)	0	26	40	47	58	35 (17)	0	26	40	47	58	100%
Dough and Pastry	*62*	*6 (8)*	*0*	*0*	*4*	*7*	*29*	*5 (8)*	*0*	*0*	*3*	*5*	*28*	*78%*
Pie Dough and Shells	49	6 (8)	0	0	4	8	29	6 (8)	0	0	2	6	28	79%
Pizza Crust	13	3 (1)	2	3	4	4	6	3 (1)	1	2	3	3	5	77%
Other Bakery Products	*416*	*6 (6)*	*0*	*0*	*5*	*8*	*30*	*5 (6)*	*0*	*0*	*4*	*7*	*30*	*85%*

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Pies, Tarts, Cobblers, Crisps	*100*	*20 (8)*	*2*	*16*	*20*	*26*	*42*	*17 (8)*	*0*	*11*	*16*	*22*	*40*	*75%*
Butter/Sugar	28	27 (5)	18	25	27	29	42	23 (5)	15	21	24	26	40	86%
Custard-Based	13	27 (7)	14	23	26	32	36	23 (7)	9	19	23	29	33	86%
Fruit-Filled Pies	59	16 (6)	2	14	16	18	36	12 (6)	0	10	12	14	33	67%
Beverages [3]	1407	8 (5)	0	4	9	11	17	7 (5)	0	1	9	11	17	86%
Dairy and Alternatives	*242*	*6 (4)*	*0*	*3*	*5*	*10*	*15*	*3 (3)*	*0*	*0*	*3*	*6*	*12*	*49%*
Drinkable Yogurt	35	11 (3)	3	11	12	13	14	7 (3)	0	7	8	10	11	63%
Milk, Flavoured	28	10 (2)	5	9	10	11	12	5 (2)	0	4	6	7	8	52%
Milk, Plain	52	5 (0)	3	4	4	5	6	0 (0)	0	0	0	0	0	0%
Plant-Based Milk, Flavoured	55	5 (2)	0	4	5	7	10	4 (3)	0	3	4	7	9	79%
Plant-Based Milk, Plain	59	2 (1)	0	0	2	3	5	1 (1)	0	0	1	2	5	54%
Shakes	11	12 (4)	6	6	14	14	15	9 (4)	3	3	11	11	12	70%
Smoothies	2	8 (2)	7	7	8	10	10	5 (2)	4	4	5	6	6	60%
Energy Drinks	*14*	*7 (5)*	*0*	*0*	*7*	*11*	*14*	*7 (5)*	*0*	*0*	*7*	*11*	*14*	*100%*
Energy Drinks, Diet or Light	7	2 (2)	0	0	0	4	4	2 (2)	0	0	0	4	4	100%
Energy Drinks, Regular	7	12 (1)	11	11	11	13	14	12 (1)	11	11	11	13	14	100%
Fruit Drinks	*654*	*10 (3)*	*0*	*9*	*10*	*12*	*17*	*10 (3)*	*0*	*9*	*10*	*12*	*17*	*100%*
Fruit Drink	40	9 (2)	3	10	10	10	12	9 (2)	3	10	10	10	12	100%
Fruit Juice	378	10 (3)	0	9	10	12	17	10 (3)	0	9	10	12	17	100%
Fruit Juice-Drink, Combination	236	10 (3)	0	9	11	12	17	10 (3)	0	9	11	12	17	100%
Hot Beverages	*58*	*7 (4)*	*0*	*4*	*9*	*11*	*14*	*6 (4)*	*0*	*3*	*7*	*9*	*13*	*83%*
Cocoa	27	9 (3)	2	8	10	11	14	7 (4)	0	6	9	9	12	70%
Coffee, Flavoured/Sweetened	27	5 (4)	0	1	5	9	13	5 (4)	0	1	5	9	13	100%
Tea, Sweetened	4	6 (4)	1	3	6	9	9	4 (3)	0	2	5	7	7	65%
Other Beverages	*39*	*1 (3)*	*0*	*0*	*0*	*0*	*15*	*1 (3)*	*0*	*0*	*0*	*0*	*15*	*67%*
Soft Drinks	*272*	*7 (5)*	*0*	*0*	*9*	*11*	*16*	*7 (5)*	*0*	*0*	*9*	*11*	*16*	*100%*
Iced Tea, Diet or Light	13	1 (1)	0	0	0	0	4	1 (1)	0	0	0	0	4	100%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Iced Tea, Regular	52	8 (2)	0	7	9	10	12	8 (2)	0	7	9	10	12	100%
Soft Drink, Regular	121	11 (2)	5	10	11	13	16	11 (2)	5	10	11	13	16	100%
Soft Drink, Diet or Light	86	0 (0)	0	0	0	0	0	0 (0)	0	0	0	0	0	.
Sports Drinks	*30*	*4 (2)*	*0*	*2*	*6*	*6*	*6*	*4 (2)*	*0*	*2*	*6*	*6*	*6*	*100%*
Sports Drinks, Diet or Light	11	1 (1)	0	0	2	2	3	1 (1)	0	0	2	2	3	100%
Sports Drinks, Regular	19	6 (0)	5	6	6	6	6	6 (0)	5	6	6	6	6	100%
Vegetable Drinks	*43*	*3 (1)*	*1*	*2*	*3*	*4*	*6*	*1 (1)*	*0*	*0*	*0*	*1*	*4*	*16%*
Water	*55*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	.
Cereals and Grain Products	969	8 (11)	0	0	3	14	53	6 (10)	0	0	0	10	53	33%
Hot Breakfast Cereal	*107*	*12 (13)*	*0*	*0*	*3*	*24*	*42*	*11 (13)*	*0*	*0*	*0*	*23*	*41*	*76%*
Flavoured/Sweetened	48	26 (7)	9	21	25	29	42	25 (8)	0	20	25	29	41	96%
Plain	59	1 (2)	0	0	0	0	10	0 (0)	0	0	0	0	0	0%
Other Cereals and Grains	*612*	*2 (2)*	*0*	*0*	*2*	*4*	*29*	*0 (1)*	*0*	*0*	*0*	*0*	*27*	*0%*
Ready-to-Eat Breakfast Cereal	*250*	*21 (10)*	*0*	*16*	*20*	*26*	*53*	*17 (10)*	*0*	*11*	*17*	*22*	*53*	*76%*
Flakes	36	18 (10)	7	10	13	23	43	13 (11)	1	5	8	18	40	60%
Flakes w/ Fruit and/or Nuts	30	25 (6)	16	22	24	28	42	21 (6)	11	17	19	23	38	81%
Granola/Muesli	84	21 (5)	4	18	22	25	32	16 (6)	0	13	17	21	28	72%
High-Fibre Compact	8	16 (8)	0	13	18	20	25	16 (8)	0	13	18	20	25	100%
Puffed	13	15 (17)	0	3	10	22	53	15 (17)	0	3	10	22	53	100%
Semi-Compact/Formed	59	25 (12)	3	16	20	34	53	21 (13)	0	11	15	31	51	74%
Shredded	20	16 (8)	0	15	18	22	24	16 (8)	0	15	18	22	24	100%
Dairy Products and Substitutes	1003	6 (9)	0	0	3	10	77	3 (8)	0	0	0	5	76	41%
Cottage Cheese	*26*	*5 (2)*	*3*	*4*	*5*	*5*	*12*	*1 (2)*	*0*	*0*	*0*	*0*	*8*	*12%*
Cottage Cheese, Flavoured	5	10 (2)	8	8	10	12	12	6 (2)	4	4	6	8	8	57%
Cottage Cheese, Plain	21	4 (1)	3	4	4	5	6	0 (0)	0	0	0	0	1	2%
Cream or Cream Substitute	*85*	*14 (13)*	*0*	*6*	*11*	*22*	*58*	*13 (13)*	*0*	*0*	*10*	*22*	*57*	*73%*
Cream, Aerosol or Whipped	27	16 (5)	7	11	17	22	25	15 (6)	4	11	15	20	23	90%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Cream, Liquid	50	15 (15)	0	6	7	33	58	13 (16)	0	0	3	33	57	61%
Cream, Powder	8	0 (0)	0	0	0	0	0	0 (0)	0	0	0	0	0	.
Cream Cheese	*65*	*7 (4)*	*0*	*7*	*7*	*7*	*25*	*1 (4)*	*0*	*0*	*0*	*0*	*20*	*9%*
Cream Cheese, Flavoured	37	8 (4)	0	7	7	7	25	2 (5)	0	0	0	1	20	15%
Cream Cheese, Plain	28	5 (2)	0	3	7	7	10	0 (0)	0	0	0	0	0	0%
Milk, Condensed	*36*	*18 (25)*	*0*	*2*	*6*	*37*	*77*	*15 (26)*	*0*	*0*	*0*	*30*	*76*	*29%*
Coconut Milk (canned)	18	7 (18)	0	1	2	2	77	5 (18)	0	0	0	0	76	11%
Condensed Milk	8	58 (2)	57	57	57	61	62	57 (2)	55	55	55	59	60	97%
Evaporated Milk	10	7 (2)	6	6	6	6	13	0 (0)	0	0	0	0	0	0%
Other Dairy Products and Substitutes	*468*	*1 (6)*	*0*	*0*	*0*	*0*	*60*	*0 (2)*	*0*	*0*	*0*	*0*	*9*	*42%*
Cheese, unless listed separately	327	0 (3)	0	0	0	0	50	0 (0)	0	0	0	0	0	0%
Dairy-Free Cheese and Spreads	13	1 (1)	0	0	0	0	4	0 (0)	0	0	0	0	0	0%
Feta and Feta-Style Cheese	40	0 (0)	0	0	0	0	0	0 (0)	0	0	0	0	0	.
Hard Cheese	32	7 (18)	0	0	0	0	60	0 (0)	0	0	0	0	0	0%
Processed Cheese	56	7 (3)	0	5	7	10	13	4 (4)	0	0	4	9	9	53%
Soft Cheese	*71*	*3 (5)*	*0*	*0*	*2*	*4*	*18*	*2 (4)*	*0*	*0*	*0*	*1*	*17*	*40%*
Ricotta	11	4 (1)	3	3	4	4	5	0 (0)	0	0	0	0	0	0%
Soft Cheese, Savoury/Plain	15	1 (1)	0	0	0	0	4	0 (0)	0	0	0	0	2	13%
Soft Cheese, Sweet	45	11 (4)	3	10	10	11	18	10 (4)	2	9	9	10	17	88%
Sour Cream	*17*	*5 (2)*	*3*	*3*	*6*	*6*	*7*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0%*
Yogurt	*235*	*9 (4)*	*1*	*4*	*11*	*12*	*17*	*6 (4)*	*0*	*0*	*8*	*9*	*14*	*48%*
Yogurt, Flavoured	206	10 (4)	2	7	11	12	17	6 (4)	0	3	8	9	14	55%
Yogurt, Plain	29	3 (1)	1	3	3	4	6	0 (0)	0	0	0	0	0	0%
Desserts [3, 4]	940	19 (19)	0	11	15	20	160	17 (20)	0	8	12	17	160	81%
Custard, Gelatin, Mousse, and Pudding	*195*	*13 (7)*	*0*	*10*	*15*	*18*	*26*	*12 (7)*	*0*	*9*	*14*	*16*	*26*	*86%*
Custard	8	12 (4)	9	10	11	14	19	12 (4)	8	9	11	14	19	94%
Gelatin	80	12 (8)	0	0	15	15	26	12 (8)	0	0	15	15	26	100%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Mousse	6	5 (5)	0	3	4	10	12	5 (4)	0	2	3	9	11	83%
Pudding	101	15 (6)	0	12	16	19	22	12 (6)	0	11	14	16	21	78%
Frozen Desserts	*626*	*14 (5)*	*0*	*11*	*14*	*17*	*31*	*11 (5)*	*0*	*7*	*10*	*14*	*30*	*75%*
Bars	134	19 (5)	0	16	20	23	31	17 (5)	0	14	18	21	29	89%
Cones, Filled	25	16 (4)	3	15	16	19	20	14 (4)	0	12	13	16	17	79%
Dairy-Free	14	11 (2)	10	10	11	13	14	9 (2)	7	7	10	11	12	80%
Frozen Yogurt	56	12 (2)	9	11	12	13	24	9 (2)	6	8	9	10	21	75%
Ice Cream, Ice Milk	292	12 (3)	4	10	12	14	23	8 (3)	0	6	8	10	20	65%
Ice Pops, Juice Bars, Cups	37	17 (6)	0	15	17	20	30	17 (6)	0	15	17	20	30	100%
Sandwiches	34	13 (3)	4	12	13	15	20	9 (3)	0	8	9	11	17	69%
Sherbet and Sorbet	24	16 (4)	10	13	16	19	25	14 (4)	7	11	14	17	25	85%
Sundaes	10	14 (3)	10	12	15	17	18	11 (3)	7	9	12	14	16	79%
Toppings and Fillings	*119*	*56 (33)*	*0*	*28*	*53*	*70*	*160*	*56 (33)*	*0*	*28*	*53*	*70*	*160*	*100%*
Cake Frostings and Icings	60	71 (35)	0	46	65	100	160	71 (35)	0	46	65	100	160	100%
Pie Fillings	31	26 (9)	8	21	25	28	53	26 (9)	8	21	25	28	53	100%
Toppings, Dips, Spreads	28	57 (22)	0	50	55	69	113	57 (22)	0	50	55	69	113	100%
Fats, Oils, and Vinegars	592	6 (9)	0	0	0	7	63	4 (7)	0	0	0	6	43	81%
Butter, Margarine, Oils	*242*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	.
Mayonnaise	*39*	*5 (6)*	*0*	*0*	*0*	*13*	*20*	*5 (6)*	*0*	*0*	*0*	*13*	*20*	*100%*
Salad Dressing	*311*	*10 (11)*	*0*	*0*	*7*	*19*	*63*	*7 (8)*	*0*	*0*	*5*	*12*	*43*	*79%*
Salad Dressings	253	9 (8)	0	6	7	13	43	8 (8)	0	2	6	13	43	91%
Vinegars	58	16 (17)	0	0	13	31	63	2 (7)	0	0	0	0	42	12%
Fish and Seafood	434	1 (2)	0	0	0	1	22	1 (2)	0	0	0	1	22	85%
Fruits	444	25 (23)	0	9	14	38	83	8 (15)	0	0	0	9	73	30%
Canned Fruit	*157*	*12 (4)*	*4*	*10*	*12*	*14*	*31*	*7 (4)*	*0*	*5*	*7*	*10*	*28*	*54%*
Canned in Juice	70	12 (3)	5	9	12	14	16	7 (3)	0	4	7	9	11	53%
Canned in Syrup	73	13 (3)	8	11	13	15	31	9 (3)	4	7	8	11	28	66%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Canned in Water	14	5 (1)	4	4	5	6	8	0 (0)	0	0	0	0	0	0%
Dried Fruit	*152*	*51 (20)*	*7*	*33*	*55*	*68*	*83*	*15 (23)*	*0*	*0*	*0*	*32*	*73*	*22%*
Sweetened Dried Fruit	51	65 (14)	33	65	68	76	83	44 (17)	0	32	38	65	73	66%
Unsweetened Dried Fruit	101	43 (18)	7	33	38	60	75	0 (0)	0	0	0	0	0	0%
Frozen Fruit	*61*	*8 (3)*	*4*	*6*	*7*	*9*	*15*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0%*
Fruit Sauces	*62*	*12 (3)*	*7*	*9*	*10*	*15*	*20*	*3 (3)*	*0*	*0*	*0*	*5*	*11*	*16%*
Fruit Sauce, Sweetened	27	15 (2)	13	14	15	16	20	6 (2)	0	5	5	7	11	38%
Fruit Sauce, Unsweetened	35	9 (1)	7	8	9	10	13	0 (0)	0	0	0	0	0	0%
Other Fruits	*12*	*14 (21)*	*0*	*0*	*0*	*40*	*50*	*14 (21)*	*0*	*0*	*0*	*40*	*50*	*80%*
Fruit Garnish (e.g., maraschino cherries)	4	43 (5)	40	40	40	45	50	42 (5)	40	40	40	45	50	100%
Fruit Juice Ingredients	8	0 (0)	0	0	0	0	1	0 (0)	0	0	0	0	0	0%
Meat, Eggs, and Substitutes	959	2 (3)	0	0	0	2	21	1 (3)	0	0	0	2	21	80%
Bacon	*58*	*0 (1)*	*0*	*0*	*0*	*0*	*4*	*0 (1)*	*0*	*0*	*0*	*0*	*4*	*100%*
Cooked	20	0 (1)	0	0	0	0	4	0 (1)	0	0	0	0	4	100%
Uncooked	38	0 (1)	0	0	0	0	2	0 (1)	0	0	0	0	2	100%
Deli Meats	*257*	*1 (1)*	*0*	*0*	*0*	*2*	*5*	*1 (1)*	*0*	*0*	*0*	*2*	*5*	*93%*
Dry-cured	90	1 (1)	0	0	0	1	3	1 (1)	0	0	0	0	3	90%
Fully Cooked	167	1 (1)	0	0	1	2	5	1 (1)	0	0	0	2	5	94%
Eggs and Egg Substitutes	*56*	*0 (2)*	*0*	*0*	*0*	*0*	*10*	*0 (2)*	*0*	*0*	*0*	*0*	*10*	*100%*
Meat and Poultry	*498*	*2 (3)*	*0*	*0*	*1*	*3*	*21*	*2 (3)*	*0*	*0*	*0*	*2*	*21*	*78%*
Meat Substitutes	*90*	*2 (2)*	*0*	*0*	*1*	*2*	*11*	*1 (2)*	*0*	*0*	*1*	*2*	*11*	*63%*
Meat Analogues	74	2 (2)	0	0	1	2	11	1 (2)	0	0	1	2	11	66%
Plain Tofu	10	1 (1)	0	0	0	1	2	0 (0)	0	0	0	0	0	0%
Seasoned Tofu and Tempeh	3	4 (4)	0	0	4	9	9	4 (4)	0	0	4	9	9	100%
Sweetened Tofu	3	11 (1)	10	10	11	11	11	10 (1)	10	10	10	11	11	96%
Mixed Dishes, Sides, and Entrees	1580	3 (2)	0	1	2	4	20	2 (2)	0	0	1	2	19	48%
Beans	*36*	*6 (4)*	*0*	*1*	*7*	*8*	*12*	*5 (4)*	*0*	*0*	*6*	*8*	*12*	*79%*

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Baked Beans	26	8 (2)	4	6	8	9	12	7 (2)	4	6	8	8	12	95%
Refried Beans	10	1 (0)	0	0	1	1	1	0 (0)	0	0	0	0	0	17%
Canned Chili	*21*	*2 (1)*	*1*	*2*	*2*	*3*	*4*	*1 (1)*	*0*	*0*	*1*	*1*	*2*	*22%*
Mixed Dishes, Other	*37*	*3 (2)*	*0*	*1*	*3*	*4*	*8*	*1 (1)*	*0*	*0*	*1*	*2*	*6*	*28%*
Other Mixed Dishes	17	2 (2)	0	1	1	3	8	1 (2)	0	0	0	0	6	17%
Taco Kits	20	3 (1)	2	3	4	4	6	1 (1)	0	1	2	2	4	36%
Pizza and Frozen Sandwiches	*214*	*3 (2)*	*1*	*2*	*3*	*4*	*10*	*3 (2)*	*0*	*1*	*2*	*3*	*9*	*72%*
Pizza	161	3 (2)	1	2	3	4	8	3 (2)	0	1	2	4	7	71%
Pizza Snacks and Sandwiches	53	4 (2)	1	3	3	4	10	3 (2)	0	2	2	3	9	76%
Potatoes	*126*	*1 (2)*	*0*	*0*	*1*	*2*	*9*	*0 (1)*	*0*	*0*	*0*	*0*	*8*	*20%*
Fries	49	1 (3)	0	0	0	1	8	0 (0)	0	0	0	0	1	14%
Hash Browns and Patties	19	0 (1)	0	0	0	1	2	0 (0)	0	0	0	0	1	42%
Mashed and Scalloped	58	2 (1)	0	1	1	2	9	1 (1)	0	0	0	0	8	19%
Prepared Salads	*61*	*5 (4)*	*0*	*2*	*3*	*6*	*16*	*4 (4)*	*0*	*1*	*3*	*6*	*15*	*75%*
Coleslaw	6	14 (1)	12	13	14	15	16	13 (1)	12	12	13	15	15	95%
Fish and Meat Salad	11	3 (3)	0	2	2	3	9	3 (3)	0	2	2	3	9	100%
Grain-Based Salad	6	4 (6)	1	1	2	6	15	3 (6)	0	0	1	5	14	40%
Pasta Salad	8	4 (2)	1	2	5	6	6	3 (2)	0	1	3	5	5	58%
Potato Salad	8	4 (1)	3	3	4	5	6	4 (1)	2	3	3	4	6	82%
Vegetable Salad	22	5 (4)	0	2	3	9	12	4 (4)	0	1	2	8	11	72%
Refrigerated or Frozen	*775*	*3 (2)*	*0*	*1*	*2*	*4*	*20*	*2 (2)*	*0*	*0*	*1*	*2*	*19*	*46%*
170–285 g	290	2 (2)	0	1	2	3	12	1 (2)	0	0	1	2	12	43%
Less than 170 g	381	3 (3)	0	1	2	4	20	2 (2)	0	0	1	2	19	45%
More than 285 g	104	3 (2)	0	1	2	4	16	2 (3)	0	0	2	3	15	56%
Shelf-Stable, Grain-Based Dishes	*310*	*2 (2)*	*0*	*1*	*2*	*3*	*9*	*1 (1)*	*0*	*0*	*0*	*1*	*8*	*36%*
Pasta and Noodles	177	3 (1)	0	2	3	4	7	1 (1)	0	0	1	1	5	25%
Rice and Grains	116	1 (1)	0	0	1	1	9	1 (1)	0	0	0	1	8	51%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Stuffing	17	2 (1)	0	2	2	3	5	2 (1)	0	1	2	2	4	79%
Nuts and Seeds	205	5 (4)	0	3	4	7	28	1 (4)	0	0	0	0	25	11%
Butters, Pastes, and Creams	*78*	*8 (6)*	*0*	*6*	*7*	*8*	*28*	*3 (5)*	*0*	*0*	*0*	*3*	*25*	*30%*
Other than Peanut Butter	28	4 (4)	0	0	3	7	13	2 (4)	0	0	0	2	10	28%
Peanut Butter	50	9 (5)	6	7	7	13	28	4 (6)	0	0	2	9	25	31%
Nuts and Seeds	*127*	*4 (2)*	*0*	*2*	*3*	*4*	*13*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0%*
Nut and Seed Flours	7	7 (5)	0	4	7	13	13	0 (0)	0	0	0	0	0	0%
Nuts and Seeds, Not for Snacking	120	3 (2)	0	2	3	4	8	0 (0)	0	0	0	0	0	0%
Other Foods and Beverages	274	6 (13)	0	0	0	8	100	6 (13)	0	0	0	6	100	87%
Baking Misc. (e.g., yeast, baking soda)	*15*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	.
Seasoning, Topping, Breading Mix	*259*	*8 (14)*	*0*	*0*	*0*	*13*	*100*	*7 (14)*	*0*	*0*	*0*	*9*	*100*	*86%*
Sauces, Dips, and Condiments	1204	11 (14)	0	2	5	17	70	10 (15)	0	0	2	17	70	63%
Condiments	*291*	*18 (17)*	*0*	*0*	*19*	*33*	*66*	*18 (17)*	*0*	*0*	*17*	*31*	*66*	*96%*
Barbecue and Steak Sauce	115	30 (14)	0	21	31	38	66	30 (14)	0	21	31	38	66	100%
Ketchup	24	24 (8)	7	20	27	27	33	18 (8)	0	14	21	21	29	70%
Mustard	54	9 (15)	0	0	0	20	60	9 (15)	0	0	0	20	60	100%
Other Condiments (e.g., hot sauce)	98	9 (12)	0	0	3	17	60	9 (12)	0	0	3	17	60	97%
Dips	*259*	*3 (3)*	*0*	*0*	*3*	*4*	*25*	*1 (3)*	*0*	*0*	*0*	*1*	*23*	*24%*
Dips and Salsa	210	4 (3)	0	3	3	5	25	1 (3)	0	0	0	1	23	23%
Hummus and Legume Dips	49	1 (2)	0	0	0	3	10	1 (2)	0	0	0	0	9	29%
Sauces	*654*	*11 (14)*	*0*	*2*	*5*	*13*	*70*	*10 (15)*	*0*	*0*	*3*	*13*	*70*	*65%*
Curry Paste	27	6 (4)	0	3	5	7	16	3 (4)	0	0	0	5	14	37%
Gravy and Cooking Sauce	188	8 (12)	0	0	3	9	48	8 (12)	0	0	3	8	48	79%
Marinades	60	15 (14)	0	5	11	22	50	15 (14)	0	5	11	22	50	100%
Pesto	15	3 (6)	0	0	0	5	20	0 (1)	0	0	0	0	2	29%
Soya and Oriental Sauce	61	16 (17)	0	7	12	24	70	16 (17)	0	7	12	24	70	98%
Sweet Sauce (e.g., plum sauce)	73	35 (14)	0	27	34	43	63	35 (14)	0	27	34	43	63	100%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Tomato Sauce	198	4 (2)	0	3	5	5	8	2 (2)	0	0	2	3	6	37%
White Sauce	32	3 (2)	2	2	3	4	7	1 (2)	0	0	1	1	5	26%
Snacks	854	10 (16)	0	2	4	8	83	5 (10)	0	0	0	4	65	44%
Chips, Corn, and Rice Snacks	*412*	*4 (5)*	*0*	*0*	*3*	*5*	*35*	*3 (5)*	*0*	*0*	*1*	*3*	*34*	*59%*
Extruded Snacks (e.g., cheese puffs)	90	6 (8)	0	2	5	7	35	5 (8)	0	0	1	6	34	52%
Flavoured Chips	194	4 (3)	0	2	4	4	15	3 (3)	0	1	3	3	14	68%
Plain Chips	116	2 (4)	0	0	0	2	30	1 (2)	0	0	0	0	17	32%
Savoury Snack Mixes	12	5 (2)	2	3	5	6	9	3 (2)	1	2	4	5	8	65%
Ethnic Snacks	*21*	*7 (12)*	*0*	*2*	*4*	*8*	*54*	*5 (12)*	*0*	*0*	*0*	*6*	*53*	*38%*
Fruit Snacks (e.g., apple chips, fruit leather)	*40*	*61 (24)*	*6*	*49*	*72*	*78*	*83*	*9 (14)*	*0*	*0*	*0*	*24*	*37*	*12%*
Meat Snacks	*42*	*9 (11)*	*0*	*0*	*4*	*18*	*43*	*9 (11)*	*0*	*0*	*4*	*18*	*43*	*96%*
Meat and Poultry Jerky	20	19 (9)	7	12	18	21	43	19 (9)	7	12	18	21	43	100%
Meat and Poultry Sticks	22	1 (1)	0	0	0	2	4	1 (1)	0	0	0	2	4	88%
Nuts and Seeds	*225*	*13 (13)*	*0*	*4*	*6*	*22*	*52*	*4 (9)*	*0*	*0*	*0*	*3*	*41*	*15%*
Mix w/ Fruit, Chocolate, Candy	80	28 (10)	10	20	28	33	52	12 (12)	0	0	11	17	41	34%
Mix w/o Fruit, Chocolate, Candy	145	5 (2)	0	4	4	6	14	0 (1)	0	0	0	0	8	5%
Popcorn	*80*	*9 (17)*	*0*	*0*	*0*	*6*	*65*	*9 (17)*	*0*	*0*	*0*	*4*	*65*	*63%*
Plain/Savoury	61	1 (2)	0	0	0	2	6	0 (1)	0	0	0	0	6	30%
Sweet	19	35 (17)	0	24	34	42	65	35 (17)	0	24	34	42	65	100%
Pretzels	*34*	*12 (15)*	*0*	*2*	*4*	*14*	*43*	*11 (15)*	*0*	*1*	*3*	*13*	*42*	*80%*
Coated or Filled	14	26 (14)	8	14	23	43	43	25 (14)	7	13	22	42	42	97%
Plain	20	2 (2)	0	2	2	4	5	2 (1)	0	0	1	3	4	66%
Soups	464	1 (1)	0	0	1	2	7	1 (1)	0	0	0	1	7	52%
Bouillon and Broth	*110*	*0 (0)*	*0*	*0*	*0*	*0*	*1*	*0 (0)*	*0*	*0*	*0*	*0*	*1*	*94%*
Broth	56	0 (0)	0	0	0	0	1	0 (0)	0	0	0	0	1	90%
Dry Mix	39	0 (0)	0	0	0	0	1	0 (0)	0	0	0	0	1	100%
Liquid Concentrates	15	0 (0)	0	0	0	0	0	0 (0)	0	0	0	0	0	100%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Canned Condensed Soup	*76*	*1 (1)*	*0*	*0*	*1*	*2*	*6*	*1 (1)*	*0*	*0*	*0*	*1*	*6*	*45%*
Cream or Cheese	32	1 (1)	0	0	1	2	2	0 (0)	0	0	0	0	1	12%
Non-Cream	44	2 (2)	0	0	1	2	6	1 (2)	0	0	1	2	6	69%
Dry Soup Mix	*55*	*1 (1)*	*0*	*0*	*1*	*1*	*4*	*0 (1)*	*0*	*0*	*0*	*1*	*3*	*37%*
Cream or Cheese	15	2 (1)	0	1	2	3	3	1 (1)	0	1	1	1	2	53%
Non-Cream	40	1 (1)	0	0	0	1	4	0 (1)	0	0	0	0	3	30%
Fresh and Instant Oriental Noodle	*76*	*1 (1)*	*0*	*0*	*1*	*1*	*3*	*1 (1)*	*0*	*0*	*1*	*1*	*3*	*87%*
Ready-to-Serve Soup	*147*	*2 (1)*	*0*	*1*	*2*	*3*	*7*	*1 (1)*	*0*	*0*	*0*	*2*	*7*	*30%*
Cream or Cheese	28	2 (2)	0	0	1	4	7	2 (2)	0	0	1	3	7	65%
Non-Cream Soup	119	2 (1)	0	1	2	3	6	1 (1)	0	0	0	1	5	23%
Sugars and Sweets	776	51 (17)	0	43	50	60	100	51 (17)	0	43	50	60	100	100%
Confectionery	*469*	*51 (16)*	*0*	*45*	*51*	*60*	*100*	*51 (16)*	*0*	*45*	*51*	*60*	*100*	*100%*
Baking Candies (e.g., sprinkles, chocolate chips)	33	53 (19)	0	47	53	62	100	53 (19)	0	47	53	62	100	100%
Breath Mints	6	94 (5)	88	93	93	100	100	94 (5)	88	93	93	100	100	100%
Candies (e.g., licorice, gummies, jelly beans)	151	56 (12)	6	48	55	63	100	56 (12)	6	48	55	63	100	100%
Chocolate and Candy Bars	257	46 (15)	0	42	49	54	80	46 (15)	0	42	49	54	80	100%
Hard Candies	9	70 (17)	48	61	68	80	94	70 (17)	48	61	68	80	94	100%
Marshmallows	13	56 (4)	52	52	54	57	67	56 (4)	52	52	54	57	67	100%
Sugar	*7*	*98 (4)*	*89*	*100*	*100*	*100*	*100*	*98 (4)*	*89*	*100*	*100*	*100*	*100*	*100%*
Icing Sugar	1	89 (0)	89	89	89	89	89	89 (0)	89	89	89	89	89	100%
Sugar	6	100 (0)	100	100	100	100	100	100 (0)	100	100	100	100	100	100%
Sweet Condiments	*300*	*50 (17)*	*0*	*40*	*50*	*60*	*81*	*50 (17)*	*0*	*40*	*50*	*60*	*81*	*100%*
Bread Spreads (e.g., chocolate spread)	13	52 (15)	25	47	50	58	79	52 (15)	25	47	50	58	79	100%
Fruit Preserve Spreads (e.g., jam, jelly)	187	45 (14)	0	35	45	55	75	45 (14)	0	35	45	55	75	100%
Honey and Molasses	38	76 (9)	45	76	80	80	80	76 (9)	45	76	80	80	80	100%
Syrups	62	49 (16)	3	40	50	61	81	49 (16)	3	40	50	61	81	100%

Food Group, Subcategory, and Minor Category	*n*	Total Sugar (g/100 g or 100 mL)						Free Sugar (g/100 g or 100 mL)						Free Sugar as a Percent of Total Sugar [2]
		$\bar{X}$ (SD)	Min	25th	50th	75th	Max	$\bar{X}$ (SD)	Min	25th	50th	75th	Max	
Vegetables	957	3 (6)	0	0	2	4	40	2 (5)	0	0	0	0	40	16%
Canned Vegetables and Legumes	*460*	*2 (2)*	*0*	*0*	*1*	*3*	*29*	*0 (1)*	*0*	*0*	*0*	*0*	*6*	*15%*
Canned Tomatoes	93	3 (1)	1	2	3	4	6	0 (1)	0	0	0	0	3	9%
Other Canned Vegetables	367	2 (2)	0	0	1	2	29	0 (1)	0	0	0	0	6	17%
Dried Legumes	*86*	*3 (2)*	*0*	*1*	*2*	*3*	*11*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0%*
Fresh Vegetables	*54*	*3 (6)*	*0*	*0*	*2*	*3*	*40*	*0 (2)*	*0*	*0*	*0*	*0*	*18*	*3%*
Frozen Vegetables	*155*	*3 (2)*	*0*	*2*	*2*	*4*	*14*	*0 (0)*	*0*	*0*	*0*	*0*	*4*	*2%*
Frozen Vegetables w/ Sauce	9	2 (2)	0	2	2	3	5	1 (1)	0	0	1	1	4	40%
Frozen Vegetables w/o Sauce	146	3 (2)	0	2	2	4	14	0 (0)	0	0	0	0	0	0%
Vegetable Paste	*20*	*6 (5)*	*0*	*0*	*9*	*9*	*13*	*0 (0)*	*0*	*0*	*0*	*0*	*0*	*0%*
Tomato Paste	12	10 (1)	9	9	9	9	13	0 (0)	0	0	0	0	0	0%
Vegetable and Herb Paste	8	0 (0)	0	0	0	0	0	0 (0)	0	0	0	0	0	.
Pickled Vegetables	*182*	*8 (10)*	*0*	*0*	*3*	*13*	*40*	*7 (10)*	*0*	*0*	*0*	*13*	*40*	*57%*
Sour or Spicy	126	2 (4)	0	0	0	3	29	0 (1)	0	0	0	0	9	11%
Sweet	56	21 (7)	0	14	20	27	40	21 (7)	0	14	20	27	40	100%
TOTAL	15259	11 (16)	0	1	4	13	160	9 (16)	0	0	1	11	160	62%

[1] All values presented represent products in their "as consumed" form, prepared according to package directions. [2] Free sugar as a percent of total sugar was calculated for each product (*n* = 15,259) and the average of those results is presented here. [3] Total and free sugar contents for beverages and desserts presented as g per 100 mL. [4] Maximum total sugar content exceeds 100 g per 100 mL due to rounding of total sugar declaration on products with small serving sizes in desserts food group. Abbreviations: NFt = Nutrition Facts table; $\bar{X}$ = mean; SD = standard deviation; w/ = with; w/o = without.

Free Sugar as a Percent of Total Sugar

Overall, free sugar accounted for 62% of the total sugar in prepackaged foods and beverages; the remainder was from naturally-occurring sources of sugar (**Figure 4.3**). In nearly half of the major food categories examined, free sugar contributed at least 75% of total sugar. This ranged from 100% of the total sugar in the food group sugars and sweets, to 11% of the total sugar in the nuts and seeds food group. Of the top sugar-dense food groups, free sugar as a proportion of total sugar for bakery products was 79%, for desserts 81%, and for beverages 86%. Because some food categories contain very little total sugar, the addition of small amounts of free sugar can result in the percentages appearing quite high. For example, free sugar as a proportion of total sugar in fats and vinegars (81%), other foods and beverages (87%), and fish and seafood (85%) are high, but all had a median free sugar content of 0 g/100 g. A more detailed evaluation of free sugar at the subcategory and minor category level (Table 4.3), revealed that free sugar accounted for 100% of the total sugar in cookies, energy drinks, fruit drinks, soft drinks, sports drinks, dessert toppings and fillings, mayonnaise, bacon, eggs, and all subcategories of the sugars and sweets food group. Additionally, free sugar accounted for >90% of the total sugar in many baked desserts, muffins, cakes, cereal and granola bars, ready-to-eat cereals, and several minor categories of condiments and sauces.

Contribution of Free Sugar to Total Calories

Free sugar contributed on average 20% of energy in the prepackaged foods and beverages evaluated (**Figure 4.4**), with content ≥10% of energy in seven of the 17 major food groups, including beverages (70%), sugars and sweets (62%), and desserts (41%).

Figure 4.3 Free sugar and naturally-occurring sugar as a proportion (%) of total sugar by major food group and overall (n = 15,259). Free sugar and naturally-occurring sugar as a percent of total sugar was calculated for each product and the average of those results is presented here.

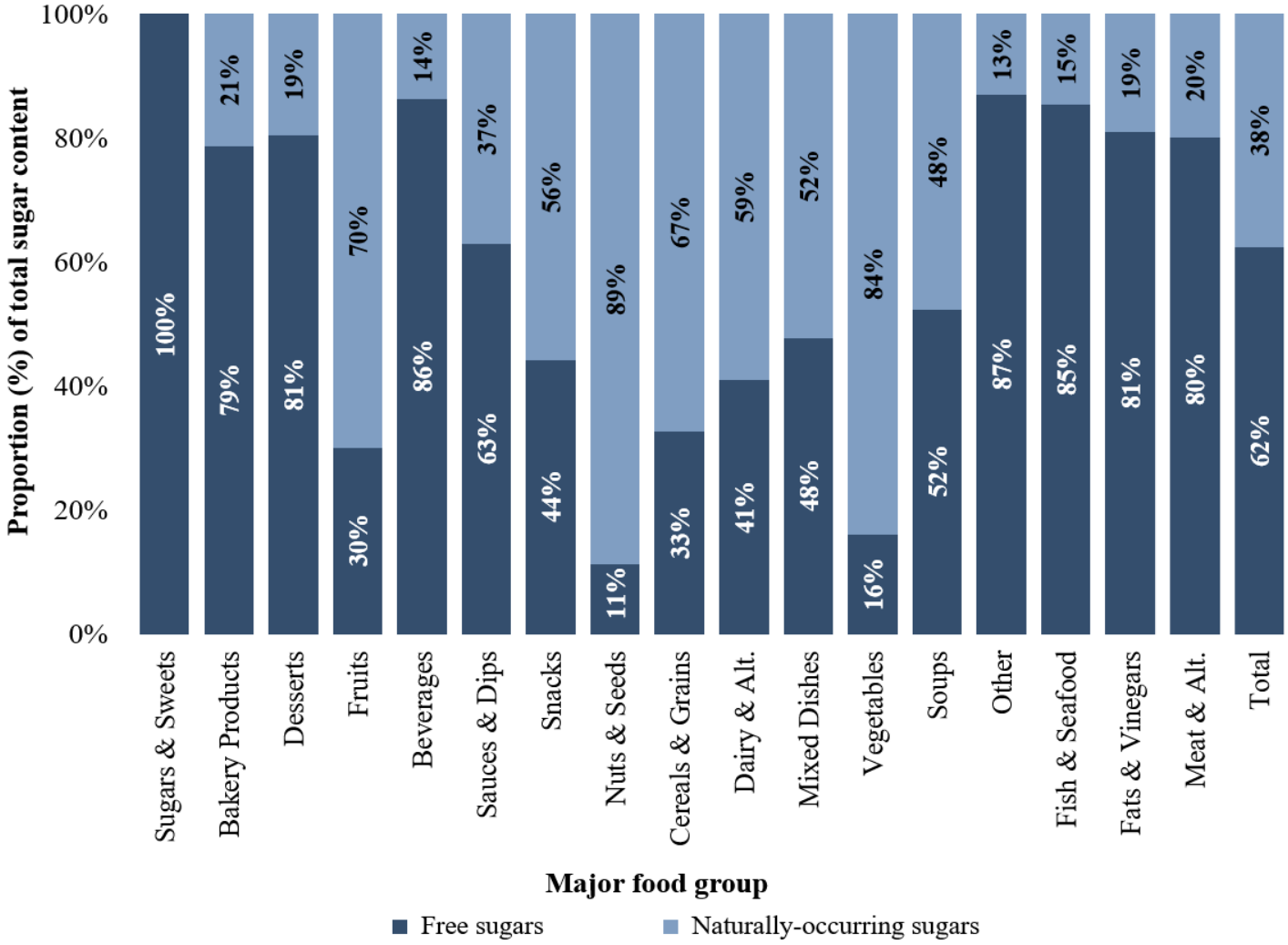
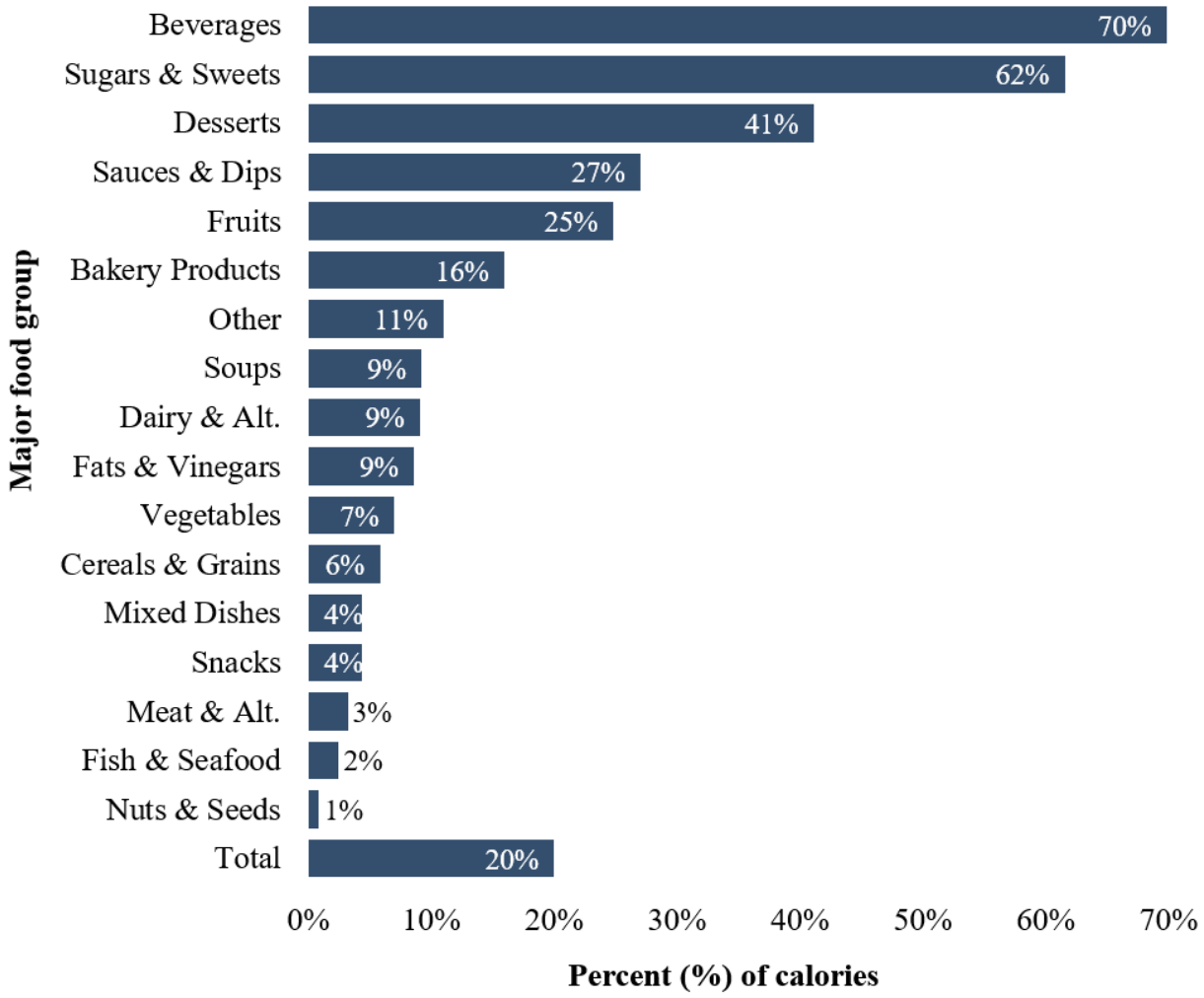


Figure 4.4 Free sugar as a percent of energy, by major food group and overall (*n* = 15,259).



4.5 Discussion

With a number of recommendations to enact policies and initiate programs that support limiting sugar intakes, it is imperative that baseline information on the types and amounts of sugar in Canadian foods and beverages be available for researchers, policy-makers, healthcare practitioners and consumers to make evidence-based decisions. This study was conducted to meet this need and is the first to systematically calculate free sugar content and to report on the total and free sugar contents and the use of FSI and sweeteners in a large representative sample of Canadian prepackaged foods and beverages.

Alarmingly, free sugar in products contributed an average of 20% of energy in prepackaged foods and beverages, which is in excess of WHO free sugar and US Dietary Guidelines added sugar intake recommendations at a maximum of 10% of energy [3, 6]. Consumption of products with excessive free sugar contents, enhances the likelihood of exceeding these recommendations [54]. Some of the more sugar-dense food groups identified in this study, foods such as sweet bakery products, frozen desserts, confectionery, and sugar-sweetened beverages, are not recommended in Eating Well with Canada's Food Guide [24]; yet these "other foods" contributed more than one-third (34.7%) of the total sugar Canadians consumed in 2004 [24, 111].

This study identified 152 different names for FSI used in Canadian Ingredient Lists, highlighting the challenge faced by consumers trying to limit their intakes of free sugar. These FSI were ubiquitously found throughout the food supply and were present in every major food group. Data on FSI use in Canadian foods (65.4%), are slightly lower than that reported in the US where 74% of packaged foods were reported to contain added sugar ingredients in 2005–2009 [12].

Results of this study also identified that sweeteners were used in less than 5% of products. Not surprisingly, they are most often used in food groups with the highest total and free sugar contents. Efforts to reduce added or free sugar intakes have raised concerns that reformulation will not result in a reduction in calories (e.g., due to an increase in refined starches, fats) [213], or will increase the use of artificial sweeteners [6, 214]. The evidence of the health effects or benefits of sweetener use in the long-term is inconclusive [99, 214]. Thus, some recommendations to reduce sugar content of prepackaged foods stipulate that this should not be met with the subsequent addition of sweeteners [15, 95].

The data presented here can be useful to support several interventions aimed at reducing intakes of free sugar. Firstly, reformulation of existing products and the development of new products to be lower in sugar have been suggested as ways to decrease the health burden associated with excess free sugar consumption [215]. This strategy, similar to the sodium reduction strategies in Canada [209] and other countries could likely be repeated for free sugar [95]. The data provided here would support such a strategy and shows that there is a wide range of free sugar content within a food category, demonstrating that products with lower free sugar contents are achievable, feasible, palatable, and sellable as shown in Table 3. This type of intra-category assessment of distributions can be used to develop the benchmarks needed for concerted efforts at free sugar reduction. Secondly, data on the free sugar content of prepackaged foods can be linked to national dietary intake surveys to provide the first evaluation of Canadian free sugar consumption. Subsequently, consumption data can be used to predict and monitor health outcomes associated with varying levels of free sugar intakes. Thirdly, the data on sweetener use and FSI use provided here can act as a baseline by which to compare future trends. Additionally, this data can be used to support consumer educational efforts to emphasize the many names for FSI, thereby helping consumers to more easily identify products that contain free sugar as well as the main food sources. One novel feature of the recently proposed Canadian nutrition labelling changes to address this concern is the proposal to group all sugar based ingredients in brackets after the word “Sugars” and be placed in the ingredient list in descending order according to the combined weight rather than scattered throughout the Ingredient List [158]

Limitations of this study include the use of declared sugar contents from the NFt, rather than laboratory analyses. NFt declarations are subject to the Canadian Food Inspection Agency’s rounding rules and can vary up to 20% from the actual analyzed value [216]. Given the vastness of the database, analysis of each product was not a feasible option. However, a study evaluating the accuracy of the declared nutrient contents of 1000 Canadian foods found only 13% of foods with unsatisfactory values (>20% difference from analyzed) for sugar contents [217]. Additionally, there are no chemical analyses available to differentiate free or added sugar from total sugar content. To account for this, the calculation of free sugar contents was based on a similar algorithm developed by Louie and colleagues [119], to estimate added sugar contents in the Australian food supply, that has been shown to have high levels of inter-researcher repeatability [212]. The most

subjective step in the U of T free sugar algorithm, Step 5, where substitute added sugar values are chosen, was done by two people and consensus was reached for any discrepancies; however, this step was only required for 2.6% of foods. Finally, the FLIP 2013 database did not include all prepackaged foods and beverages available in Canada, but rather a systematically collected and large representative subset, comprising over three-quarters of the Canadian grocery retail market share.

4.6 Conclusions

In summary, this is the first study in Canada to calculate free sugar contents and these data provide the first detailed overview of FSI and sweetener use, and of total and free sugar contents of Canadian prepackaged foods and beverages. Using the detailed free sugar algorithm and the information from the NFt and Ingredient List, free sugar content was calculated for 96.5% of the foods and only imputed for 3.5%. The method described here can be employed for use on other large branded food databases. Findings can be used to inform, monitor, and evaluate interventions to limit excess sugar consumption, and indicate areas of concern for reformulation or educational efforts. The extensive data provided in this study can be incorporated into food composition databases and can be used to measure free sugar intakes with national nutrition surveys where it is currently not available [111], and determine intakes, particularly for vulnerable groups such as children and adolescents [9, 15], compared to recommendations from the WHO [3].

The previous study (Study 1) was a comprehensive assessment of the pervasiveness, levels, and sources of total and free sugars in the Canadian prepackaged food supply. The results demonstrated the extensive availability and abundance of free sugars characterizing the Canadian food retail environment. Navigating such an environment can make the selection of foods that are in line with WHO free sugars intake guidelines particularly difficult [10, 11]. Nutrition labelling represents one of the several policy actions that can be used to operationalize the WHO free sugars intake guidelines by providing information to help Canadians make appropriate food choices, enable comparisons between foods, to inform dietary priorities, and encourage availability of foods that can reduce risk of NCDs [18 108]. The following chapters (Study 2 and Study 3) use the valuable methodological contributions and data from Study 1, which include the development of an algorithm for calculating free sugars in foods and beverages and the creation of the first food composition database in the world to contain free sugars information, to assess two approaches to presenting sugars information on the food label; a sugars DV (Study 2) and sugar-related nutrient content claims (Study 3).

Chapter 5

5 Study 2: A free sugars daily value (DV) identifies more "less healthy" prepackaged foods and beverages than a total sugars DV

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5.1 Abstract

Regulatory changes in Canada will require food labels to have a benchmark [% Daily Value, %DV] for total sugars, based on 100g/day, while US labels will require a %DV for added sugars, based on 50g/day. The objective of this study was to compare two labelling policies, a total sugars DV (100g/day) and a free sugars DV (50g/day) on food labels. This cross-sectional analysis of the Food Label Information Program database focused on top sources of total sugars intake in Canada (n=6,924 foods). Products were categorized as "less healthy" using two sets of criteria: a) free sugars levels exceeding the WHO guidelines (≥10% energy from free sugars); and b) exceeding healthfulness cut-offs of the Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (FSANZ-NPSC). The proportion of "less healthy" with ≥15%DV (defined as "a lot" of sugars i.e. high in sugars, based on Health Canada's %DV labelling footnote and educational message for dietary guidance) were compared for each sugar labelling scenario. The free sugars DV showed better alignment with both methods for assessing "healthfulness" than the total sugars DV. The free sugars DV identified a greater proportion of "less healthy" foods with ≥15%DV, based on both the FSANZ-NPSC (70% vs. 45%, $p<0.0001$) and WHO guidelines (82% vs. 55%, $p<0.0001$); particularly in sweet baked goods, sugars and preserves, chocolate bars, confectionery, and frozen desserts categories. Compared to total sugars DV labelling, using a free sugars DV identified more "less healthy" foods. Findings support the adoption of free sugars labelling.

5.2 Introduction

The World Health Organization (WHO) [3], the Dietary Guidelines for Americans [6] and several other health organizations [5, 15, 16] recommend limiting intakes of free and added sugars to a maximum 10% of energy. “Free sugars” are the sugars no longer in their naturally-occurring state (i.e., no longer in whole fruits, vegetables, unsweetened dairy, and some grains) [3]. Examples include table sugar, honey, and fruit juice. “Added sugars” are the free sugars that has been added to foods (e.g. honey added to a muffin) [55, 218]. “Total sugars”, include all free as well as the naturally-occurring sugars found in foods that tend to be part of a balanced diet, (i.e. fruits, vegetables, and milk) [6, 24, 49]. As such, limiting total sugars intakes does not align with current dietary advice and a recent systematic review found that added sugars, rather than total sugars, better explains the negative relationship between sugars and diet quality [46]. In 2016, Canada and the US changed their nutrition labelling regulations; Canadian Nutrition Facts tables will be required to include a benchmark (%Daily Value, %DV) for total sugars, based on a daily reference amount of 100g (20% of energy) [22], while American labels will include a declaration for added sugars, with a %DV based on 10% of energy [179]. The US changes align well with recent sugars intake recommendations, but to our knowledge, there has been no evaluation of the DV for total sugars or any alternative DV for sugars (i.e. for free or added sugars) in terms of its application to the prepackaged food and beverage supply and its ability to identify less healthy food choices.

The overall purpose of this study was to compare the use of a total sugars DV on food labels to a free sugars DV for correctly identifying “less healthy” foods, which exceed: a) WHO free sugars intake guidelines of <10% energy; and b) the Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion cut-offs for healthier foods. Specifically, this allowed us to assess the ability of each DV labelling scenario to identify and theoretically discourage the consumption of “less healthy” foods and beverages.

5.3 Methods

Food Label Information Program (FLIP) database

This study is a cross-sectional analysis of the University of Toronto's Food Label Information Program (FLIP) 2013 database (n=15,342), which includes information on nutrient contents, as declared on the Nutrition Facts table, UPC, company, brand, price, ingredients, container size, and sampling date for private-label and national brand prepackaged foods and beverages. Data acquisition occurred between May and September 2013, and was carried out in the Greater Toronto Area and Ottawa, Ontario, and Calgary, Alberta. Data were collected from major outlets of the four largest grocery chains in Canada (Loblaws, Metro, Sobeys, and Safeway), representing 75.4% of the grocery retail market share [207]. Specific details on FLIP 2013 have been described previously (Chapter 4). Foods that were the top sources of total sugars intakes (accounting for 91% of total sugars consumption) among Canadians, based on national nutrition survey data (CCHS 2004), were included in this study (n=6,924) [114]. Foods were categorized based on the Bureau of Nutritional Sciences food group codes and descriptions [219]. See **Table 5.1** for details on categories analyzed.

Sugars DV labelling scenarios

Two sugar labelling scenarios were examined in this study. The first involved the application of a total sugar %DV, based on 100g/day (20% of kcal), to the nutrition information available for products in FLIP 2013. Total sugar content was obtained from the Nutrition Facts table and the %DV was determined based on the manufacturer's stated serving size, the value presented to the consumer on Canadian food labels to inform their decision-making [200]. The second was for a free sugar %DV based on 50g/day (10% of kcal), the same DV the US FDA has implemented for added sugars [179]. Free sugar contents are not declared on the Nutrition Facts table and were calculated according to the WHO definition for free sugar [3] using the University of Toronto's free sugar algorithm (Chapter 4). The free sugar DV was applied to the nutrition information available for products in FLIP 2013 as described for the total sugar DV.

Use and Interpretation of %DV labelling to identify "less healthy" foods

Canadian consumers are encouraged to use the %DV as a benchmark along with Health Canada's %DV footnote which states "5% or less is a little [of a nutrient, and] 15% or more is a lot", to interpret how much is in a serving of a food and to help guide consumption [22]. The inclusion of this message as a required footnote on the Nutrition Facts table was part of the 2016 Canadian nutrition labelling regulatory changes [22]. For this study, products with ≥15% DV were deemed to have "a lot" of sugars and therefore discouraged according to Health Canada's %DV nutrition label footnote and educational messaging used in dietary guidance.

Table 5.1 Top food and beverage categories and examples of products accounting for 90.8% of total sugars intakes of Canadians based on CCHS 2004 data (n=6,924)

Food Categories[1]	% Intake[2]	n[3]	Examples from FLIP 2013
Soft drinks, fruit drinks, and others	16.3	517	Soft drinks (diet, calorie-reduced, regular), fruit drinks and combination of fruit drinks and juice, flavoured dairy and alternative beverages, cocoa, hot chocolate. Includes drink mixes.
Fruits	14.0	531	Fruit (frozen, canned, dried), fruit sauces, fruit chips (e.g. apple chips), candied fruits (e.g. maraschino cherries), canned olives, cherry pie filling.
Sweet baked goods	12.2	1165	Brownies, squares, cakes (all types), cookies, doughnuts, muffins, quick breads, pastries (including toaster pastries), sweet buns, pies, tarts, crisps (including shells), baked goods requiring preparation.
Milk, unsweetened	8.8	103	Unsweetened milk, unsweetened plant-based milk alternatives, evaporated milk.
Fruit juices	7.0	385	100% fruit juice (excludes fruit juice with added sweeteners).
Sugar and preserves	6.3	334	Sugar (e.g. white, brown, icing), honey, molasses, bread spreads (e.g. chocolate hazelnut spread), fruit preserves (e.g. jam, jelly), syrups, dessert toppings and spreads (e.g. chocolate sauce).
Coffee, tea, water	5.2	184	Coffee, tea (includes hot and iced tea), flavoured water (includes concentrated flavour enhancers).
Confectionery	3.5	571	Candies (e.g. mints, hard candies, sprinkles, gummies, marshmallow), whipped dessert toppings, custard, pudding, mousse, gelatin, sorbet, popsicles, pie filling (except cherry), cake frosting.
Breakfast cereals	2.9	145	Flakes, puffed, and semi-compact cereals, cream of wheat. Excludes high-fibre, shredded, and other hot cereals (e.g. oatmeal).
Pizza, sandwich, etc.	2.8	214	Frozen and refrigerated pizzas, hot dog dishes, sandwiches, burgers. Excludes individual components sold separately (e.g. bread, buns, burger patties).
Chocolate bars	2.4	286	Chocolate, chocolate bars, chocolate chips.
Vegetable dishes	2.4	388	Salads (e.g. coleslaw, leafy salad), fries, mashed potato, scalloped potato, hash browns, pickles, vegetable-based frozen and refrigerated dishes.
Vegetables	1.8	645	Vegetables (fresh, frozen, canned), vegetable drinks.
Yogurt, sweetened	1.7	238	Sweetened yogurt, sweetened drinkable yogurt.
Pasta, rice dishes	1.3	554	Pasta and rice dishes (shelf-stable, frozen meals, refrigerated meals, pasta salads). Includes ready-to-eat dishes as well as dishes requiring preparation.
Frozen dairy dessert	1.1	563	Ice cream, ice milk, frozen yogurt, cones, bars, sandwiches, sundaes.
Milk, sweetened	1.1	101	Sweetened milk, sweetened plant-based milk alternatives, condensed milk.

[1] Top sources of total sugars by Canadians in 2004; based on results from the Canadian Community Health Survey 2.2 (2004). Data provided by Health Canada [114]. [2] Percent contribution to Canadian total sugars intake in 2004, by food category and overall [114]. [3] n= number of unique products per food category in FLIP 2013 database.

Alignment of DV labelling scenarios with assessments of the healthfulness of foods

Products were categorized as "less healthy" by 2 sets of criteria used to define healthier foods. Details on the criteria used are outlined below. An overview of the categorization is visually depicted in **Figure 5.2a** and **Figure 5.2b**.

a) "Less healthy" based on WHO free sugars intake guidelines

Based on the WHO free sugars intake guidelines, products with ≥10% of energy coming from free sugars were considered to be "less healthy" and <10% were considered to be "healthier" [3]. Foods and beverages with ≥10% of energy coming from free sugars can contribute to a diet that has a greater proportion of energy from free sugars than recommended [54]. The proportion of "less healthy" products defined using WHO free sugars intake guidelines that had ≥15% DV using each DV labelling scenario was determined, overall and by food category (Figure 5.2a).

b) "Less healthy" based on general healthy eating guidelines

A summary score of healthfulness, developed by the *Food Standards Australia New Zealand - Nutrient Profiling Scoring Criterion* (FSANZ-NPSC) was the second method used to define "healthier" and "less healthy" foods [110]. The FSANZ-NPSC system assigns points for nutrients to limit (i.e. calories, saturated fat, sodium, and total sugars) and deducts points for nutrients and components to encourage (i.e. dietary fibre, protein, and fruit, vegetable, nut and legume content) [110]. A lower FSANZ-NPSC score is indicative of a healthier product and cut-offs are used to identify "healthier" products and "less healthy" products [110]. Specific details on the application of the FSANZ-NPSC to FLIP 2013 are described elsewhere (Chapter 6). The proportion of "less healthy" products according to the FSANZ-NPSC cut-offs that had ≥15% DV using each DV labelling scenario was determined, overall and by food category (Figure 5.2b).

Statistical analyses

Categorical variables (e.g. products with ≤5% DV and ≥15% DV) were presented as proportions (%). For variables with two levels, McNemar tests were used to compare proportions (e.g. "less healthy" products with ≥15% DV for the free sugars vs. total sugars DV labelling scenarios).

Exact binomial tests were used when there were no discordant pairs or when a variable only had one level (e.g. when a food category had no products that were categorized as ≥15% DV). Sign tests were used to compare proportions when a variable had more than two levels (e.g. proportion of ≤5% DV, >5% to <15% DV, or ≥15% DV) because assumption of symmetry required to conduct a Wilcoxon Signed-Rank test was not met. Differences were considered statistically significant at $p<0.05$. All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary NC).

5.4 Results

Proportion of foods and beverages having "a little" or "a lot" of sugars based on Health Canada's %DV footnote

About one-third (32%) of products had ≤5% DV ("a little") and another third (37%) had ≥15% DV ("a lot") under the total sugars DV labelling scenario, while 34% had ≤5% DV and 54% had ≥15% DV under the free sugars DV scenario (**Figure 5.1**). Overall, there was a significant difference in the proportions of foods in each DV category between the two DV labelling scenarios (Figure 5.2) ($M=-555.5$, $p<0.0001$). All categories except for *unsweetened milk* and *fruits* had a greater proportion of products with "a lot" of sugars using the free sugars DV compared to the total sugars DV. A cross-classification of where differences occurred, showed that 1991 (29%) products differed in the DV categorization between the two labelling scenarios (**Table 5.1**). There were two sets of misclassifications: 1) products with ≤5% DV using the free sugars DV, not identified as such with the total sugars DV (18%, n=427), e.g. *fruits* and *unsweetened milk*; and 2) products with ≥15% DV identified using the free sugars DV, but not with the total sugars DV (34%, n=1268), e.g. *sweet baked goods, sugars and preserves, breakfast cereals, pizza, sandwiches etc.,* and *sweetened yogurts*.

Figure 5.1 Proportion of prepackaged food and beverages that have ≤5% Daily Value (DV) ("a little" sugars), >5%-<15% DV, and ≥15% DV ("a lot" of sugars), based on Health Canada's %DV footnote [22], for two DV labelling scenarios: i) total sugars DV (100g/day); and ii) free sugars DV (50g/day), overall and by food category (n=6,924).(*) Denotes statistically significant differences between sugars labelling scenarios **p<0.01, ***p<0.0001 based on results from Sign test analyses.

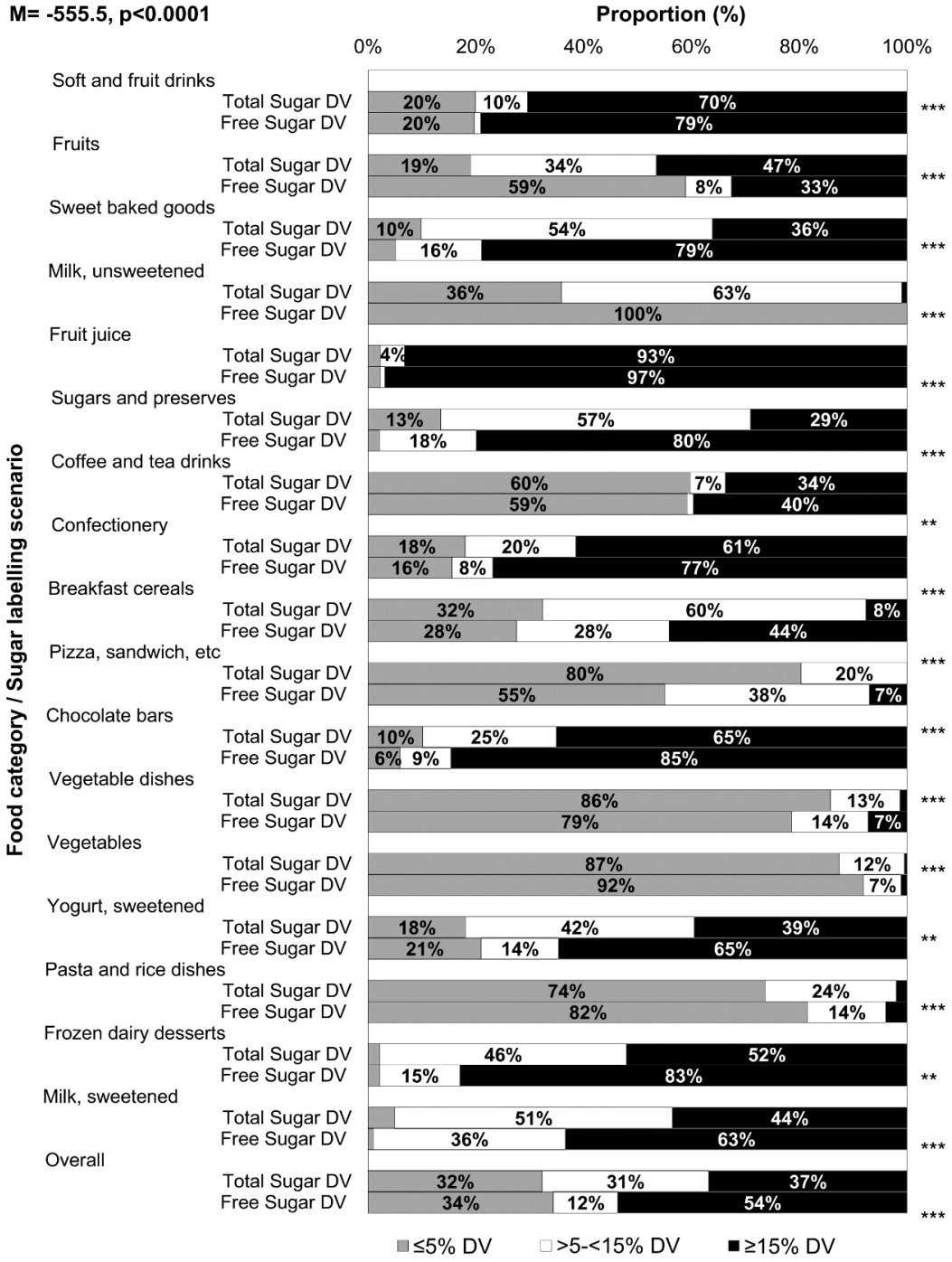


Table 5.2 Cross-classification of the number and proportion of products with ≤5% Daily Value (DV) ("a little" sugars), >5%-<15% DV, and ≥15% DV ("a lot" of sugars)[1], for two DV labelling scenarios: i) total sugars DV (100g/day); and ii) free sugars DV (50g/day), overall and by food category (n=6,924).

Free Sugars DV [2]	**≤5% DV**			**>5%-<15% DV**			**≥15% DV [3]**	
Total Sugars DV	**≤5% DV**	**>5%-<15% DV**	**≥15% DV**	**≤5% DV**	**>5%-<15% DV**	**≥15% DV**	**>5%-<15% DV**	**≥15% DV**
Soft and fruit drinks	100 (98%)	2 (2%)	.	3 (50%)	3 (50%)	.	45 (11%)	364 (89%)
Fruits	95 (30%)	136 (45%)	82 (26%)	6 (13%)	29 (64%)	10 (22%)	18 (10%)	155 (90%)
Sweet baked goods	56 (93%)	4 (7%)	.	59 (32%)	126 (68%)	.	499 (54%)	421 (46%)
Milk, unsweetened	37 (36%)	65 (63%)	1 (1%)	.	.	.	.	.
Fruit juices	9 (100%)	.	.	.	3 (100%)	.	14 (4%)	359 (96%)
Sugars and preserves	7 (100%)	.	.	38 (63%)	22 (37%)	.	170 (64%)	97 (36%)
Coffee and tea drinks	109 (100%)	.	.	1 (50%)	1 (50%)	.	11 (15%)	62 (85%)
Confectionery	74 (83%)	12 (13%)	3 (3%)	29 (67%)	13 (30%)	1 (2%)	92 (21%)	347 (79%)
Breakfast cereals	40 (100%)	.	.	7 (17%)	34 (83%)	.	53 (83%)	11 (17%)
Pizza, sandwich, etc.	118 (100%)	.	.	54 (67%)	27 (33%)	.	15 (100%)	.
Chocolate bars	17 (100%)	.	.	12 (44%)	15 (56%)	.	56 (23%)	186 (77%)
Vegetable dishes	294 (96%)	11 (4%)	.	39 (71%)	16 (29%)	.	23 (82%)	5 (18%)
Vegetables	551 (93%)	41 (7%)	1 (0%)	13 (29%)	32 (71%)	.	5 (71%)	2 (29%)
Yogurt, sweetened	43 (86%)	7 (14%)	.	.	34 (100%)	.	60 (39%)	94 (61%)
Pasta and rice dishes	392 (87%)	60 (13%)	.	16 (20%)	64 (80%)	.	11 (50%)	11 (50%)
Frozen dairy desserts	10 (83%)	2 (17%)	.	2 (2%)	82 (98%)	.	174 (37%)	293 (63%)
Milk, sweetened	1 (100%)	.	.	4 (11%)	30 (83%)	2 (6%)	22 (34%)	42 (66%)
Overall	1953 (82%)	340 (14%)	87 (4%)	283 (34%)	531 (64%)	13 (2%)	1268 (34%)	2449 (66%)

[1] DV categorization is based on Health Canada's %DV footnote of "≤5% of a DV is a little and ≥15% of a DV is a lot" [22]. [2] Free sugars DV categories are in the top row, total sugars DV categories for the products within each free sugars DV category are in the second row. [3] No products that were categorized as ≥15% DV with the free sugars DV were categorized as ≤5% DV by the total sugars DV.

Alignment of DV labelling scenarios with assessments of the healthfulness of foods

a) "Less healthy" based on WHO free sugars intake guidelines

Sixty-five percent (n=4471) of the products that are major sources of sugars in the Canadian diet, were "less healthy" with free sugars levels exceeding the WHO guidelines (≥10% of energy) (**Figure 5.2**). There were significantly more "less healthy" products with ≥15% DV using the free sugars DV scenario than the total sugars DV scenario (83% [n=3709] vs. 55% [n=2460], S= 1223.53, p<0.0001) overall (Figure 5.1) and for all categories with statistically significant differences (**Figure 5.3**). Conversely, significantly more "healthier" products (<10% energy from free sugars) had ≤5% DV using the free sugars DV scenario than the total sugars DV scenario (93% [n=2285] vs. 79% [n=1940], respectively; S=168.12, p<0.0001).

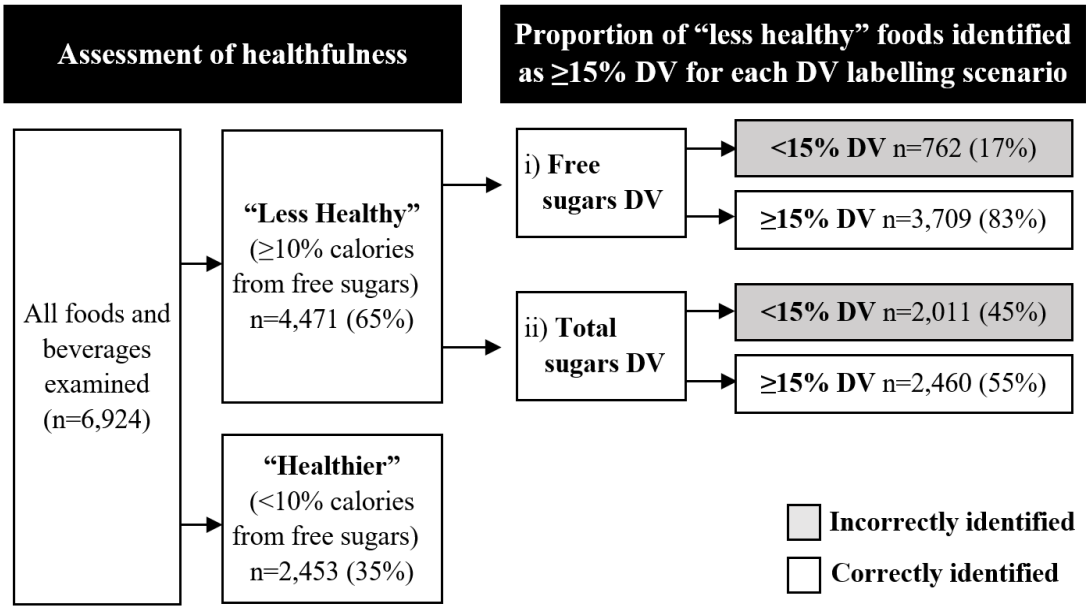
b) "Less healthy" based on the Food Standards Australia New Zealand - Nutrient Profiling Scoring Criterion

Fifty-eight percent (n=4029) of the food and beverages examined were considered "less healthy" using the FSANZ-NPSC system (**Figure 5.2**). Overall, there were significantly more "less healthy" products with ≥15% DV using the free sugars DV scenario than the total sugars DV scenario (70% [n=2809] vs. 45% [n=1809], respectively; S=968.99, p<0.0001) (Figure 5.1). This was also seen for most categories, except for *unsweetened milk* and *fruits*, where there was a greater proportion of "less healthy" foods with ≥15% DV using the total sugars DV scenario than the free sugars DV scenario, and for *vegetables* and *fruit juices*, where there was no difference in the proportions for the two DV labelling scenarios (**Figure 5.4**). Conversely, significantly more "healthier" products had ≤5% DV with the free sugars DV scenario than the total sugars DV scenario (57% [n=1642] vs. 47% [n=1363], respectively; S=168.12, p<0.0001).

The "less healthy" products according to each of the two cut-offs used to define healthfulness were not necessarily the same products. Twenty-seven percent (n=1203) of products defined as "less healthy" according to WHO free sugars intake guidelines, were not defined as "less healthy" according to the FSANZ-NPSC cut-offs and conversely, 31% (n=761) of products defined as "healthier" with the WHO free sugars guidelines were not defined as "healthier" with the FSANZ-NPSC cut-offs.

Figure 5.2 Comparison of two different sugar labelling scenarios for correctly identifying "less healthy" foods (n=6,924). "Less healthy" products were defined using two sets of cut-offs used to define healthier foods: **a)** World Health Organization (WHO) free sugars intake guidelines of <10% of energy; and **b)** Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (FSANZ-NPSC). Two DV labelling scenarios: i) a total sugars DV (100g/day); and ii) a free sugars DV (50g/day), were compared for their alignment with the cut-offs by identifying "less healthy" foods as having ≥15% DV ("a lot") of sugars, according to Health Canada's %DV footnote (Government of Canada, 2016). Grey boxes show the products in each DV labelling scenario that were not in alignment.

a. Alignment of DV labelling scenarios with WHO free sugars intake guidelines



b. Alignment of DV labelling scenarios with FSANZ-NPSC Score

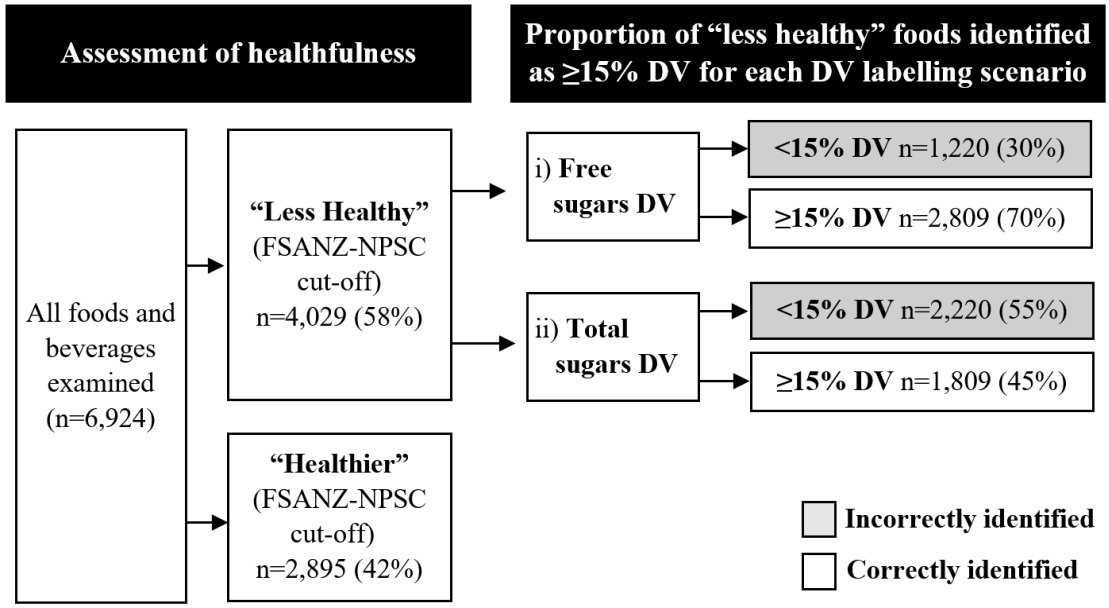


Figure 5.3 Proportion of "less healthy" prepackaged food and beverage products, defined using the World Health Organization (WHO) free sugars intake guidelines of <10% of energy (n=4471) that have ≥15% Daily Value (DV), for two DV labelling scenarios: i) a total sugars DV (100g/day); and ii) a free sugars DV (50g/day), overall and by food category. (*) Denotes statistically significant differences between DV labelling scenarios *p<0.05, **p<0.01, ***p<0.0001 based on results from McNemar tests (exact binomial test was used for *pizza, sandwich, etc.*). Test results are unavailable for *unsweetened milk* because there were no "less healthy" *unsweetened milk* products.

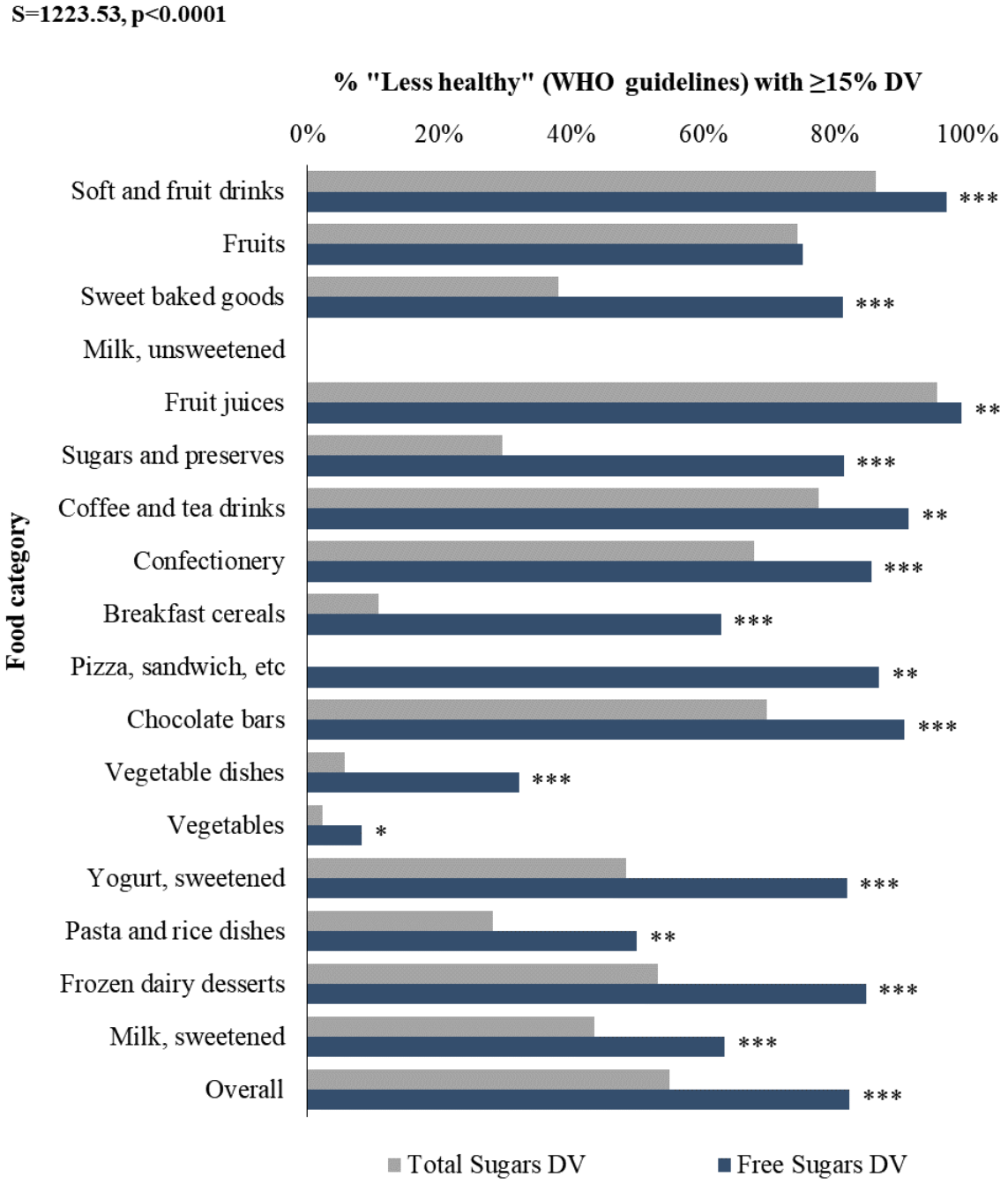
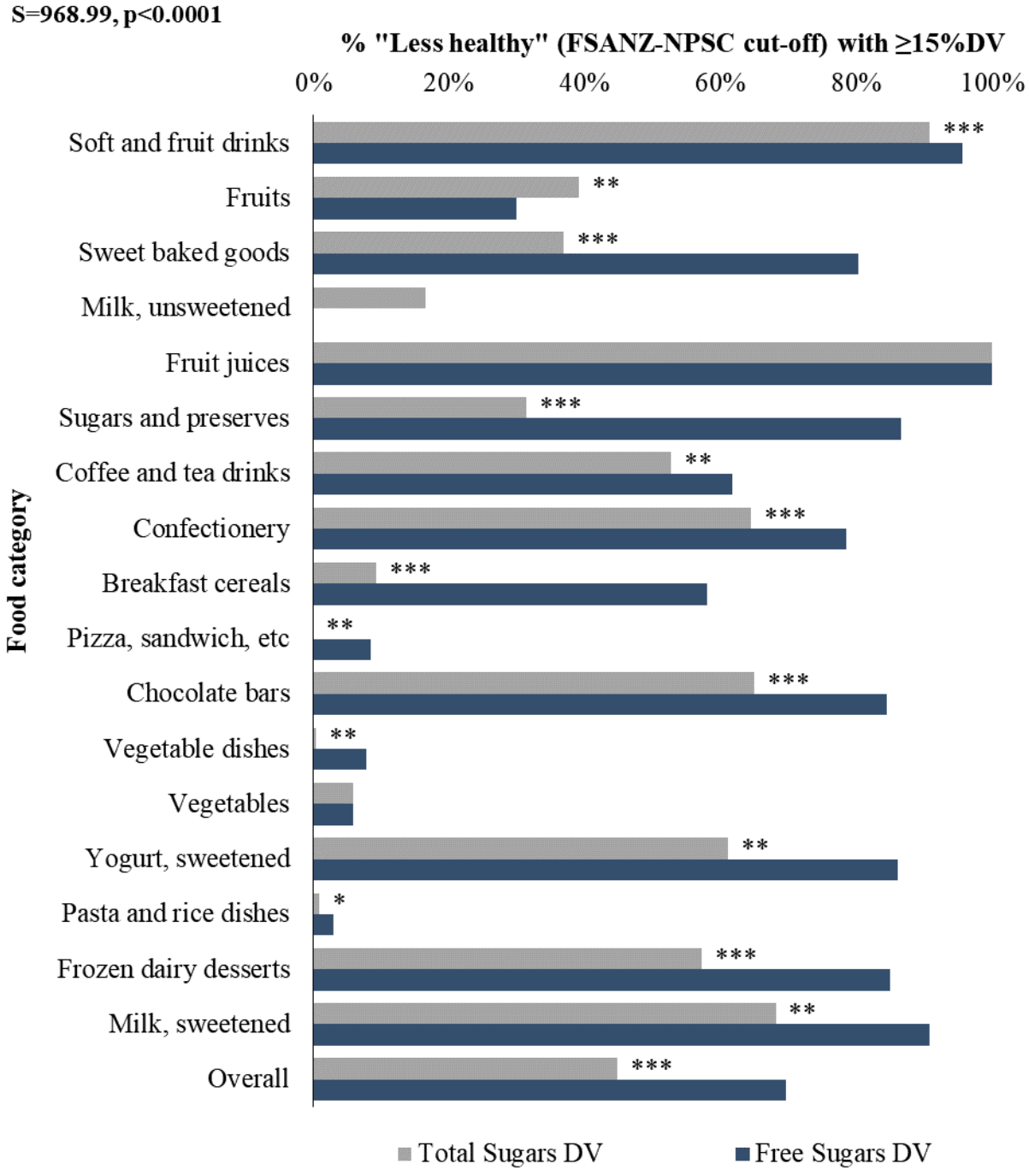


Figure 5.4 Proportion of "less healthy" prepackaged food and beverage products, defined using the Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (FSANZ-NPSC) cut-offs (n=4029) that have ≥15% Daily Value (DV), for two DV labelling scenarios: i) a total sugars DV (100g/day); and ii) a free sugars DV (50g/day), overall and by food category. (*) Denotes statistically significant differences between DV labelling scenarios *p<0.05, **p<0.01, ***p<0.0001 based on results from McNemar tests (exact binomial test was used for *unsweetened milk, fruit juice, pizza, sandwich, etc.*, and *vegetables*).



5.5 Discussion

This study was conducted to inform nutrition policies and actions related to sugars labelling on prepackaged foods and beverages. To our knowledge, this is the first study to compare a total sugars DV, based on 100g/day, to a free sugars DV, based on 50g/day, for their alignment with two different methods to define "healthier" foods; one specific to free sugars (WHO guidelines) and the other used to define "healthier" foods permitted to carry a nutrient or health claim under FSANZ regulations (FSANZ-NPSC). With recent regulatory amendments to alter the presentation of sugars information on nutrition labels, it is imperative that any change should be able to help consumers identify less healthy food choices. Findings from this study have identified limitations of the total sugars DV, compared to the free sugars DV, for identifying less healthy foods to discourage their consumption.

Of the major food sources of Canadian sugars intakes in the prepackaged food supply, an astounding 65% contained free sugars levels exceeding the WHO guidelines (≥10% of energy), which is concerning given the likelihood of exceeding this recommendation increases with the consumption of products that contain excess free sugars levels [54] and makes a healthy eating pattern harder to achieve [99]. The primary purpose of including a %DV for sugars on the Nutrition Facts table is to guide consumers to select foods and beverages lower in sugars. Considering the increased risk of obesity, diabetes, dental caries, and cardiovascular disease associated with excess free sugars consumption [74, 76, 81, 83], the need for the nutrition label to discourage the selection of products with excess free sugars levels is essential. Findings from this study demonstrate the strength of using free sugars DV labelling in this regard.

The free sugars DV also outperformed the total sugars DV, when assessing the classification of "less healthy" foods using the FSANZ-NPSC summary score for product healthfulness. This finding aligns with results from a systematic review conducted by Louie and colleagues [46] that found high levels of added sugars (similar to free sugars) was a better indicator of lower dietary quality than total sugars.

The weakness of the total sugars DV is particularly noticeable when examining the categorization of products into DV categories (i.e., ≤5%, >5% to <15% DV, and ≥15%). Many of the foods that had ≥15% DV ("a lot") with the free sugars DV, had >5% to <15% DV with the

total sugars DV. Thus, for about one-in-three foods evaluated in this study that are major sources of total sugars intakes in Canada (majority of which have high free sugars levels), consumers would be left virtually without guidance under the total sugars DV labelling scenario [137].

One improvement related to sugars information in the Canadian nutrition labelling changes, that is not included in the US regulations, is the grouping of all sugars-based ingredients in the ingredient list after the common name "sugars" [22]. Although this change would not provide consumers with a quantitative amount of free sugars needed to follow dietary intake guidelines [3, 6, 7, 15], it does highlight the presence of a number of sugars-based ingredients added to foods, that consumers may not recognize as sugars.

Strengths of this study include the use of the *Food Standards Australia/ New Zealand Nutrient Profiling Scoring Criterion* to classify the healthfulness of foods and beverages. Nutrients aren't consumed in isolation which makes the interpretation of nutrient-based information and translation into the selection of foods and beverages difficult. Using the FSANZ-NPSC approach, which defines healthfulness based on both nutrients to limit and components to encourage, accounts for this complexity.

Limitations of this study include the algorithm used to calculate free sugars, the use of nutrient information as declared on the Nutrition Facts table, as discussed elsewhere (Chapter 4), and the use of declared sugars contents from the Nutrition Facts table, rather than laboratory analyses. Nutrition Facts table declarations are subject to the Canadian Food Inspection Agency's rounding rules and can vary up to 20% from the actual analyzed value [216]. However, a study evaluating the accuracy of the declared nutrient contents of 1000 Canadian foods found only 13% declared unsatisfactory values (>20% difference from analyzed) for sugars contents [217]. As there are no chemical analyses available to differentiate free or added sugars from total sugars contents, the calculation of free sugars contents was based on an algorithm, similar to that developed by Louie and colleagues, which has shown good reliability. That algorithm has been shown to have high levels of inter-researcher repeatability based on a study in which two independent researchers calculated added sugars contents for over 5000 products and had less than 1g mean difference in the results [119].

5.6 Conclusion

In summary, these data provide the first assessment of two different labelling approaches to sugars. A %DV for total sugars, based on 100g per day, showed poorer ability to identify "less healthy" foods, defined using free sugars levels and the FSANZ-NPSC summary scores, than a %DV for free sugars, based on 50g per day. Including a %DV for free (or added) sugars based on 10% of energy aligns with recent sugars intake guidelines and is a superior labelling option for policy-makers to consider. Limiting sugars consumption, specifically free or added sugars, is an key component of overall population health, therefore labelling efforts need to provide clear and comprehensive information on the Nutrition Facts table to enable consumer decision-making related to free and added sugars.

The previous study (Study 2) compared the efficacy with which a total sugars DV and a free sugars DV could identify products that: a) did not align with the WHO free sugars intake guidelines; and b) that have suboptimal nutritional composition for the promotion of health, i.e., foods and beverages for which consumption should be limited. In light of results demonstrating the strength of the free sugars DV in this regard and considering that Canadian Nutrition Facts tables will be required to include a DV for total sugars in the near future [22], the reliability of sugar-related nutrient content claims for selecting foods in line with the WHO free sugars intake guidelines, becomes even more important. As the second approach to presenting sugars information examined as part of this thesis, the following chapter (Study 3) evaluates the nutritional composition of foods and beverages with sugars-related nutrient content claims on products with excess free sugars contents and compares their nutritional compositions to products without these claims.

Chapter 6

6 Study 3: Healthfulness and nutritional composition of Canadian prepackaged foods with and without sugar claims

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6.1 Abstract

Objective: To evaluate differences in calories, nutrient content, overall healthfulness, and use of sweetener ingredients between products with and without sugar claims. Consumers assume products with sugar claims are healthier and lower in calories. It is essential claims be found on comparatively healthier items.

Design: Cross-sectional analysis of the University of Toronto's 2013 Food Label Database. Subcategories where at least 5% of products (and n≥5) carried a sugar claim were included (n=3048). Difference in median calorie content, nutrient content, and overall healthfulness, using the Food Standards Australia/New Zealand Nutrient Profiling Scoring criterion, between products with and without sugar claims, was determined. Proportion of products with and without claims that had excess free sugar levels (≥10% of energy from free sugar) and that contained sweeteners was also determined.

Results: Almost half (48%) of products with sugar claims contained excess free sugar, and a greater proportion contained sweeteners (30%) compared with 5% of products without such claims (X^2=338.6 $p<0.0001$). Overall, products with sugar claims were 'healthier', had lower median calorie, free sugar, total sugar, and sodium contents than products without claims. At the subcategory level, reductions in free sugar contents were not always met with similar reductions in calorie contents.

Conclusion: This study highlights concerns with regards to the nutritional composition of products bearing sugar claims. Findings can support educational messaging to assist consumer interpretation of sugar claims and can inform changes in nutrition policies, for example, permitting sugar claims only on products with calorie reductions and without excess free sugar.

6.2 Introduction

In 2015, several health organizations released guidelines recommending intakes of free sugar be limited to a maximum of 10% of energy to avoid the increased risk of obesity, cardiovascular disease, diabetes, and dental caries associated with excess consumption [3, 5, 6]. In 2013, reducing sugar intakes was one of the top three improvements Canadians reported making to their diets, with 50% of *Tracking Nutrition Trends 2013* respondents making this change; up from 15% in 2008 [137, 148]. However, a nationally-representative survey of Canadians in 2010/11, found that 47% of respondents had difficulty finding 'healthy' processed foods that were lower in added sugar [133]. With the emergence of quantitative sugar guidelines from the World Health Organization (WHO) and other agencies, it is essential that information is available to enable consumers to select healthier foods that are lower in sugar.

In Canada, the most commonly consulted source of nutrition information is food product labels [137]. One aspect of food labelling is manufacturer voluntary Nutrient Content Claims (NCC), which highlight the amount of a nutrient in a food based on the information found on the Nutrition Facts table (NFt) [220, 221]. In Canada, 36% of consumers always or usually use NCC to inform their food choice [137]. In 2010, 4% of products in the Canadian food supply had sugar-related NCC ("sugar claims") [206].

It is well established that the mere presence of a NCC on a label can lead consumers to attribute nutritional benefits to the product beyond that of the nutrient stated in the claim [184, 185]. In regard to sugar claims, research has shown that many consumers assume a product is healthier when a "no added sugar" claim is present [187], and consumers also expect calorie reductions to accompany products with "reduced in sugar" and "no added sugar" claims [29]. However, Canadian regulations allow sugar claims to be present on products regardless of their calorie content [222], as do many other countries and Codex standards [221]. This is especially concerning since nutrition marketing is commonly found on foods that are high in calories and other 'nutrients to limit' (i.e. sodium, sugar, fat) [31, 171], and many Canadians rely on NCC alone and do not check the more detailed nutrition information available on the NFt [223]. Other concerns about products with sugar claims include the replacement of sugar with low- or no-calorie sweeteners [224], of which the long-term health effects remain inconclusive [99, 135, 196, 214, 225].

Sugar claims have the potential to influence food selection and it is important that they are found on products that are healthier and have comparatively better nutritional composition, particularly calories, than similar products without sugar claims, to avoid misleading the consumer [186, 226, 227]. The extent to which prepackaged foods and beverages with sugar claims are lower in calories, 'nutrients to limit', or are healthier than those without sugar claims, has not been extensively examined in Canada or elsewhere. The objectives of this study were to evaluate products with and without sugar claims for differences in terms of: 1) the proportion containing excess free sugar contents; 2) calorie and nutrient contents (i.e. free sugar, total sugar, carbohydrates, total fat, sodium, and protein); 3) overall healthfulness; and 4) the use of sweetener ingredients.

6.3 Methods

Food Label Information Program (FLIP) Database

This study is a cross-sectional analysis of the University of Toronto's Food Label Information Program (FLIP) 2013 database (n=15,342). The database includes information on nutrient contents as declared on the NFt, Ingredient list, Universal Product Code, company, brand, price, container size, and nutrition marketing for private-label and National brand foods. Data were not weighted according to market share. For this study, products were categorized into 17 sugar-focused major food groups, 77 subcategories and 207 minor subcategories to ensure comparisons of like products (Chapter 4) [228]. Specific details on the collection, categorization, and validation of FLIP 2013 have been described previously (Chapter 4). Excluded from these analyses were meal replacement beverages (n=55) which are indicated for special dietary use, items with errors in nutrient declarations determined when calorie contents calculated with Atwater values differed by >20% from declared caloric values (n=55), and products with missing sugar declarations (n=28). Only the subcategories where at least 5% of products carried a sugar claim (totalling at least 5 products) were included in this study (n=3048). These categories captured 81% of the 785 products with sugar claims in the database. See **Table 6.1** for examples of foods and beverages in each subcategory included in this study.

Table 6.1 Examples of foods and beverages included in each subcategory evaluated in this study

Food Subcategory	Food and Beverage Examples
Canned Fruit	fruit canned in juice; fruit canned in syrup; fruit canned in water
Dairy Beverages & Alt.	drinkable yogurt; milk; plant-based beverages; milkshakes; smoothies
Frozen Fruit	frozen fruit (e.g. berries, mango)
Fruit Juice & Drinks	fruit juice; fruit drink; fruit juice-drink combination beverages
Fruit Sauces	fruit sauce, sweetened; fruit sauce, unsweetened (e.g. apple sauce)
Fruit Snacks	apple chips; banana chips; fruit leather/ bars; fruit-based gummies
Nut & Seed Butter	peanut butter; almond butter/ paste; other nut and seed butter/ paste
Pies & Tarts	pie; tart; cobbler; crisp
Puddings & Gelatin	custard; gelatin; mousse; pudding
RTE Cereal	flakes; granola/ muesli; high-fibre; puffed; semi-compact/ formed; shredded cereals
Salad Dressing	salad dressing; vinegar
Soft Drinks	soft drinks, regular/diet or light; iced tea, regular/diet or light
Sweet Condiments	bread spreads (e.g. chocolate spread); fruit preserves; honey; molasses; syrups
Vegetable Drinks	vegetable juice; tomato juice; tomato-based cocktail
Water	flavoured water
Yogurt	yogurt, plain; yogurt, sweetened

Abbreviations: Alt. = Alternatives; RTE = Ready-to-Eat.

Sugar-Related Claims

A review of product labels was conducted to identify products that had sugar-related nutrient content claims ("sugar claims"). All sugar claims and variations in wording as authorized for use by Health Canada, and outlined in the Canadian Food Inspection Agency Guide to Food Labelling and Advertising [222] were considered. Sugar claims found on food packages in FLIP 2013 included: "no added sugar", "reduced in sugar", "unsweetened" and "sugar free". "Unsweetened" claims were grouped with "no added sugar" claims in this study, as both claims can only be present on products without any added sugars, but "unsweetened" claims also require the absence of other sweeteners [222].

Calorie, Nutrient Composition, and Excess Free Sugar Levels

For products with and without sugar claims, median calories (kcal/100g or 100mL), total sugar, free sugar, carbohydrate, total fat, protein (g/100g or 100mL), and sodium (mg/100g or 100mL) were determined for each subcategory. The majority of products were analyzed on a weight basis, except for Beverages and Desserts which were analyzed by volume. Calorie, total sugar, carbohydrate, total fat, protein and sodium contents as per manufacturer stated serving size (MSSS) were obtained from the NFt then converted to standardized units (per 100g or 100mL) using the MSSS. Free sugar content, as defined by the WHO, was calculated using the University of Toronto decision algorithm, described elsewhere (Chapter 4). Percent differences in medians were calculated by subtracting the median for items without a sugar claim from those with and dividing by the median of items without a sugar claim.

According to the Pan American Health Organization's Nutrient Profiling model, products with ≥ 10% of energy coming from free sugars, contain an 'excess' amount of free sugar [54]. This cut-off is also in line with dietary guidelines from the WHO that recommend intakes of free sugar should not exceed 10% of energy, as consumption of products with 'excess' nutrient contents increases the likelihood dietary intakes will be in excess of the recommendations [4, 54]. Free sugar as a percent of energy was calculated by multiplying free sugar content (g per 100g or per 100mL) by the Atwater factor for carbohydrates (4kcal/g) and dividing by the caloric content per 100g or per 100mL. This method enables the identification of foods and beverages that would

contribute a greater proportion of energy from free sugar than the recommended 10%. Moreover, free sugar contents of each product are placed within the context of the calories contributed by the same product and can therefore be applicable to diets of varying energy intakes. The difference in the proportion of products with excess free sugar contents was compared between those with and without sugar claims, overall and by subcategory.

Healthfulness

Overall healthfulness was determined using a summary score. For each unique product in FLIP 2013 (n=15,342) a score was calculated using the *Food Standards Australia New Zealand – Nutrient Profiling Scoring Criterion* (NPSC), designed to determine a foods' eligibility to carry a health claim [110]. The NPSC system assigns points for 'nutrients to limit' (calories, saturated fat, sodium, and total sugar) and deducts points for 'nutrients and components to encourage' (dietary fibre, protein, and fruit, vegetable, nut and legume (FVNL) content) [110]. To calculate NPSC scores, nutrient contents were obtained from the NFt and converted to either 100g or 100ml (food or beverage, respectively). Possible scores calculated using the NPSC system range from -18 to +81, and a lower score is indicative of a higher nutritional quality ("healthier" product) [110].

In the absence of quantitative ingredient declarations in Canada, the model was adapted to estimate points related to the % of FVNL in each product. FVNL points were assigned based on the presence and position of these ingredients within the Ingredient List which places components in descending order based on relative weight contribution (**Table 6.2**) [229].

Table 6.2 Method used to calculate fruit, vegetable, nut, and legume (FVNL) points using the Ingredients List in order to calculate the overall nutritional quality using the Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (NPSC)

Type	Points [a]	%FVNL	Method used to estimate %FVNL [b] based on Ingredient List
Concentrated [c]	0	< 25%	FVNL is not one of the first three ingredients.
	1	≥ 25%	FVNL is the third ingredient (third ingredient can account for at most 33% of the product weight).
	2	≥ 43%	FVNL is the first or second ingredient but non-FVNL ingredients (e.g. sugar, water, oil) appear to contribute *substantially* to product weight (second ingredient can account for at most 50% of the product weight).
	5	≥ 67%	FVNL is first ingredient and non-FVNL ingredients appear to contribute *minimally* to product weight.
	8	100%	FVNL are only ingredients to contribute to product weight.
Non-concentrated [d]	0	≤ 40%	FVNL is not one of the first two ingredients.
	1	> 40%	FVNL is the second ingredient (second ingredient can account for at most 50% of the product weight).
	2	> 60%	FVNL is the first ingredient but non-FVNL ingredients appear to contribute *substantially* to product weight.
	5	> 80%	FVNL is the first ingredient and non-FVNL ingredients appear to contribute *minimally* to product weight.
	8	100%	FVNL are the only ingredients contributing to product weight.

[a] Points and associated % FVNL (% FVNL contributes to weight of the product) is presented as stated in FSANZ Standard 1.2.7 [110]. [b] Criteria to estimate % FVNL was developed by a team of researchers in lieu of quantitative ingredient declarations on food labels in Canada. [c] Concentrated refers to a product that contains any FVNL in a concentrated form (dried, evaporated, paste). [d] Non-concentrated refers to a product that contains FVNL, none of which are concentrated. If an ingredient is further broken down into components within brackets, the first listed component needs to be an FVNL for the ingredient to be considered an FVNL. Abbreviations: NPSC = Food Standards Australia/ New Zealand Nutrient Profiling Scoring Criterion; %FVNL = Percent fruits, vegetables, nuts, and legumes, contribute to the weight of the product.

For Ingredient Lists that provided a breakdown of the ingredients into a second generation (provided in brackets), the first two components listed within the brackets were considered followed by the next first-generation ingredient listed (out of brackets). For example, for an Ingredient List that contains 'milk, strawberry preparation (sugar, strawberries, water), guar gum…' sugar and strawberries would be considered part of the second ingredient, and guar gum the third. For products with multiple Ingredient Lists (e.g. tuna kit with crackers), an average of FVNL points from each component was used, rounding down to the nearest whole point (e.g. (5+1)/2=3, since there is no 3-point level, it is rounded down to 2 FVNL points). Products with missing Ingredient Lists (<2%) were not assigned FVNL points unless it was evident FVNL contributed to the majority of weight based on the product name or type. Due to missing nutrient declarations on a products' NFt, five products were excluded from analyses that used the NPSC scores in this study. FVNL points were independently determined twice for each product by blinded researchers. A third researcher assessed agreement between both assignments and a group consensus was reached for any discrepancies. Final NPSC scores in the "as purchased" and "as consumed" forms were calculated. This study used the NPSC scores for products in the "as purchased" form. Median NPSC scores of products without a sugar claim were subtracted from those with a sugar claim to determine the difference in medians and direction of change, overall and by subcategory.

Sweetener Use

The Canadian Food Inspection Agency describes sweeteners as a food additive that is used to give products a sweet taste and can include sugar alcohols (e.g. maltitol, xylitol, sorbitol), non-nutritive sweeteners (e.g. aspartame, sucralose, acesulfame-potassium), cyclamate sweeteners, or saccharin sweeteners [153]. Presence of sweeteners in FLIP 2013 were identified by searching the Ingredient List of each product for permitted sweeteners as outlined by Health Canada [230]. The prevalence of sweeteners in products with and without sugar claims was determined.

Statistical Analyses

Categorical variables (e.g. presence sugar claims, proportion of products with excess sugar contents) were presented as counts and frequencies (percentages). Chi-square test was used to

compare the proportion of products with excess free sugar contents and with sweetener ingredients among products with and without sugar claims (Fishers exact test was used when cell counts were less than 5). Wilcoxon Mann Whitney U test was used to determine if calorie content, nutrient content and NPSC scores were statistically different ($p<0.05$) between items with and without sugar claims. All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc. Cary NC).

Nutritional Significance

Nutritional significance in this study refers to differences in median calorie and nutrient contents ≥25%. This is the required minimum difference for a product to carry comparative nutrient content claims such as "reduced in sugar" or "lower in sugar" claims [222]. It is also in excess of the tolerance limit for nutrient declarations on the NFt, which must be within 20% of actual analyzed values [216]. Results that are both statistically significant and nutritionally significant are presented, when examining differences in calorie and nutrient contents.

6.4 Results

Twenty-one percent (n=635) of products evaluated carried at least one sugar claim. The most prevalent type was "no added sugar" claims (n=525), followed by "sugar free" claims (n=71), and "reduced in sugar" claims (n=46) (**Table 6.3**). For the following sections on calorie and nutrient contents, "significance" refers to both statistical and nutritional significance.

Difference in calorie and sugar contents

Of the products with a sugar claim, nearly half (48%) contained excess free sugar levels (≥10% of energy), compared to 78% of comparable products without sugar claims ($X^2= 227.6$, $p<0.0001$) (**Figure 6.1**). Forty-two percent of products with "no added sugar" claims and 85% of products with "reduced in sugar" claims contained excess free sugar levels (data not shown). For nearly all subcategories, fewer products with sugar claims had excess free sugar levels compared to those without, with fruit drinks being the exception (100% of products with sugar claims had excess free sugar levels compared to 98% without, $p=0.027$, Fisher's exact test) (Figure 6.1). The proportion of products with excess free sugar levels was similar between products with and without a sugar claim in Fruit Snacks, Nut & Seed Butter, and Sweet Condiments.

Overall, median caloric density (kcal/ 100g or 100mL), free sugar and total sugar contents were significantly lower among products with a sugar claim compared to those without (-53%, -100%, and -37%, respectively, $p<0.0001$) (**Table 6.4**). At the subcategory level, products with sugar claims had lower or similar amounts of energy, free sugar and total sugar than products without sugar claims, with one exception; total sugar was 25% higher among Fruit Snacks with sugar claims compared to those without ($p=0.0124$). For Dairy Beverages and Alternatives, Pies and Tarts, Puddings and Gelatin, Ready-to-Eat Cereal, and Salad Dressing, the reduction in calories was less than the reduction seen in total sugar levels.

Table 6.3 Number and proportion (%) of products with sugar claims, by type of sugar claim and by subcategory (n=3048) [a]

Food Subcategory	"No Added Sugar" Claim [b]	"Sugar Free" Claim	"Reduced in Sugar" Claim	Any Sugar Claim
Canned Fruit [c]	14 (9%)	0 (0%)	2 (1.3%)	15 (9.7%)
Dairy Beverages & Alt. [c]	31 (12.8%)	0 (0%)	3 (1.2%)	33 (13.6%)
Frozen Fruit	37 (60.7%)	0 (0%)	0 (0%)	37 (60.7%)
Fruit Drinks	234 (36%)	0 (0%)	14 (2.2%)	248 (38%)
Fruit Sauces [c]	38 (61.3%)	0 (0%)	3 (4.8%)	38 (61.3%)
Fruit Snacks	21 (52.5%)	0 (0%)	0 (0%)	21 (52.5%)
Nut & Seed Butter	16 (20.5%)	0 (0%)	0 (0%)	16 (20.5%)
Pies & Tarts	7 (7%)	0 (0%)	0 (0%)	7 (7%)
Puddings & Gelatin	26 (13.3%)	1 (0.5%)	3 (1.5%)	30 (15.4%)
RTE Cereal [c]	10 (4%)	3 (1.2%)	3 (1.2%)	14 (5.6%)
Salad Dressing	13 (4.2%)	6 (1.9%)	0 (0%)	19 (6.2%)
Soft Drinks	4 (1.5%)	53 (19.5%)	5 (1.8%)	62 (22.8%)
Sweet Condiments	16 (5.4%)	0 (0%)	13 (4.4%)	29 (9.7%)
Vegetable Drinks	10 (23.3%)	0 (0%)	0 (0%)	10 (23.3%)
Water	0 (0%)	8 (14.6%)	0 (0%)	8 (14.6%)
Yogurt	48 (20.4%)	0 (0%)	0 (0%)	48 (20.4%)
Overall	525 (17.2%)	71 (2.3%)	46 (1.5%)	635 (20.8%)

[a] Only includes predetermined subcategories with ≥5% and ≥5 products with sugar claims (any type of sugar claim, or a combination). [b] "No Added Sugar" claims also captured products that carried "unsweetened" claims. [c] The addition of the number of products with each type of claim exceeds the number of products with any sugar claim because some products carried more than one type of claim. Abbreviations: Alt. = Alternatives; RTE = Ready-to-eat.

Figure 6.1. Proportion of products with and without sugar claims that contained an 'excess' amount of free sugar (≥10% of energy), overall and by subcategory (n=3048). Analysis only includes subcategories with ≥5% and ≥5 products with sugar claims. Only subcategories with products that contained 'excess' free sugar contents are shown; Frozen Fruit and Water not shown. (*) Denotes a statistically significant difference (* p<0.05, ** p<0.01, ***p<0.0001). (a) Denotes subcategories where a Fishers Exact test was used (cell counts <5); the remaining underwent analysis using Chi-square tests. Abbreviations: Alt. = Alternatives; RTE = Ready-to-eat.

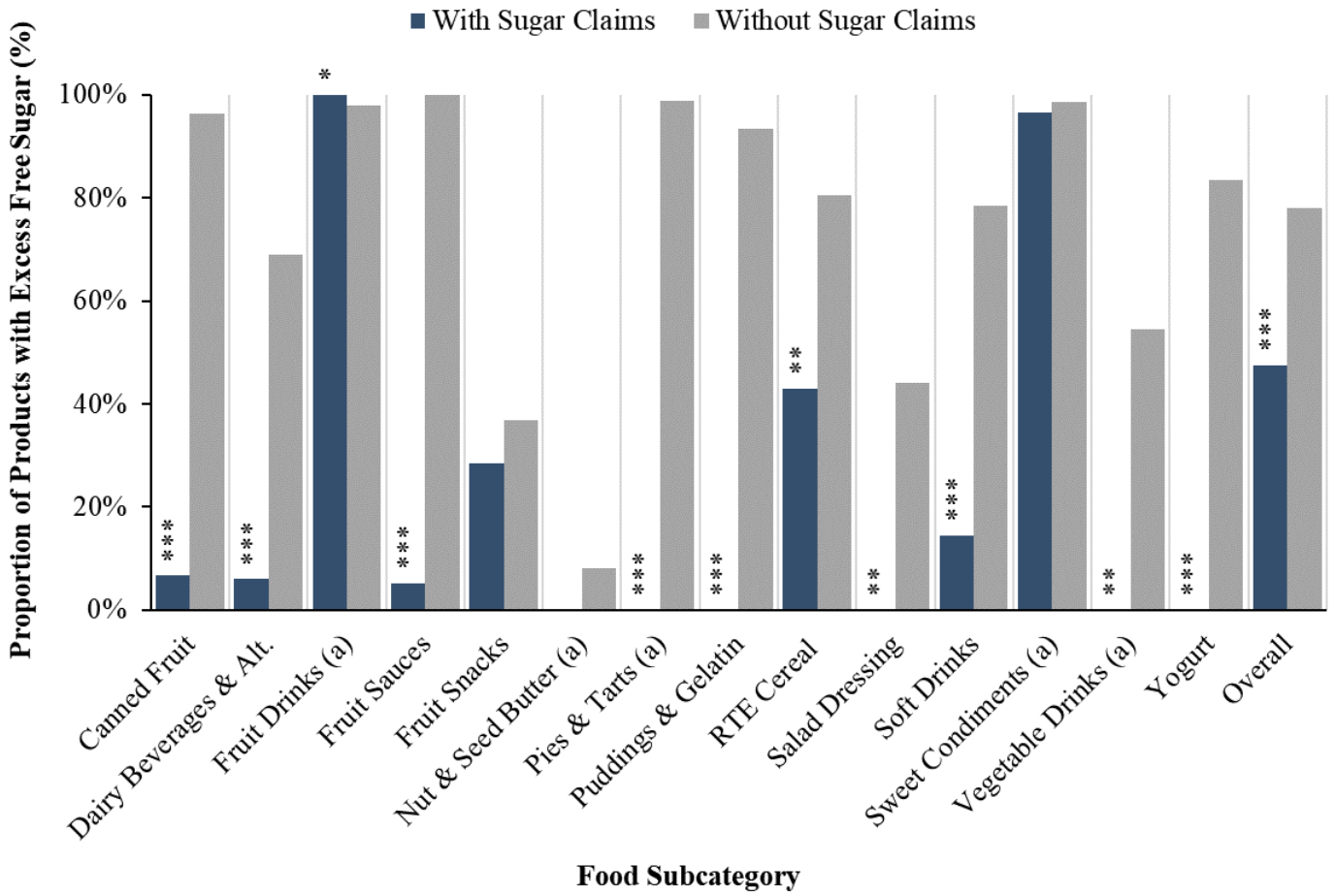


Table 6.4 Percent difference in median calorie, free sugar, total sugar, carbohydrate, total fat, sodium, and protein content per 100g or 100mL, between products without and with sugar claims, overall and by subcategory (n=3048)

Food Subcategory	Calories	Free Sugar	Total Sugar	Carbohydrates	Total Fat	Sodium	Protein
Canned Fruit	-52%***	-100%***	-56%***	-46%***	0%	-12%	-54%
Dairy Beverages & Alt.	-54%***	-100%***	-92%***	-82%***	-20%	4%	-86%***
Frozen Fruit	0%	0%	-6%	0%	0%	0%	0%
Fruit Drinks	0%	-7%	-7%	-3%	0%	25%	0%
Fruit Sauces	-38%***	-100%***	-38%***	-37%***	0%	-37%	33%
Fruit Snacks	-7%***	0%	26%*	13%**	0%	124%	-34%
Nut & Seed Butter	11%**	-100%***	0%	-20%**	7%	-100%**	4%*
Pies & Tarts	-18%**	-100%***	-77%***	-32%**	-6%	-14%	8%
Puddings & Gelatin	-73%***	-100%***	-100%***	-96%***	0%	3%	9%
RTE Cereal	-8%	-100%**	-59%**	2%	-23%	-95%***	17%
Salad Dressing	24%*	-100%***	-100%***	-50%***	72%***	-19%	198%***
Soft Drinks	-100%***	-100%***	-100%***	-100%***	0%	0%	0%***
Sweet Condiments	-44%***	-40%***	-40%***	-46%***	0%	0%**	0%***
Vegetable Drinks	-22%**	-100%**	-18%*	-17%*	0%	-4%	-19%
Water	-100%	0%	0%	0%	0%	0%	0%
Yogurt	-56%***	-100%***	-64%***	-60%***	-100%***	3%	0%*
Overall	-53%***	-100%***	-37%***	-23%***	0%***	-64%***	-37%***

[a] Negative values indicate lower levels in foods with sugar claims. [b] Only includes predetermined subcategories with ≥5% and ≥5 products with sugar claims [c] (*) Denotes a statistically significant difference (* $p<0.05$, ** $p<0.01$, ***$p<0.0001$) determined by Wilcoxon Mann Whitney U tests. Abbreviations: Alt. = Alternatives; RTE = Ready-to-eat.

Difference in other nutrients

Overall, there was no significant difference in total fat or carbohydrate content between products with and without sugar claims but sodium and protein were lower among products with sugar claims (-64%, $p<0.0001$ and -37%, $p<0.0001$, respectively) (Table 6.4). At the subcategory level, only Salad Dressing with sugar claims had a higher median fat and protein content than without claims, with a difference of 72% ($p=0.0035$) and 198% ($p<0.0001$), respectively. Nine subcategories (Canned Fruit, Dairy Beverages & Alt., Fruit Sauces, Pies & Tarts, Puddings & Gelatin, Salad Dressing, Soft Drinks, Sweet Condiments, and Yogurt) had lower median carbohydrate contents among products with sugar claims and two subcategories (RTE Cereal and Nut & Seed Butter) had lower median sodium contents than those without sugar claims.

Difference in overall healthfulness

Median NPSC scores were significantly lower ('healthier'), among products with sugar claims overall and for most subcategories except Frozen Fruit, Salad Dressing, Vegetable Drinks, and Water (**Figure 6.2**). More specifically, Vegetable Drinks was the only subcategory where the median healthfulness score was higher (less healthy) among products with sugar claims than those without (0 vs. -1, $p=0.0220$). Differences in median NPSC scores ranged from 0 in Dairy Beverages & Alt. ($p=0.0136$) to 13 in Nut & Seed Butter and in Puddings & Gelatin ($p=0.0001$ and $p<0.0001$, respectively).

Use of sweetener ingredients

Sweetener use was more prevalent among products with sugar claims (30%) compared to products without sugar claims (5%, $X^2=338.57$ $p<0.0001$) (**Figure 6.3**). This trend was also observed in six subcategories (Canned Fruit, Pies & Tarts, Puddings & Gelatin, Soft Drinks, Sweet Condiments, and Yogurt) with 100% of the products with claims in Puddings & Gelatin, and Pies & Tarts containing sweeteners (Figure 6.3). More than half of products with sugar claims contained sweeteners in seven out of the ten subcategories that contained sweeteners.

Figure 6.2 Median Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (NPSC) scores between products without and with sugar claims, by subcategory and overall (n=3043), where negative values (on the left) indicate a lower score among products with sugar claims (healthier). (*) Denotes a statistically significant difference (* p<0.05, ** p<0.01, ***p<0.0001). Analysis only includes subcategories with ≥5% and ≥5 products with sugar claims. Abbreviations: Alt. = Alternatives; NPSC = Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion; RTE = Ready-to-eat.

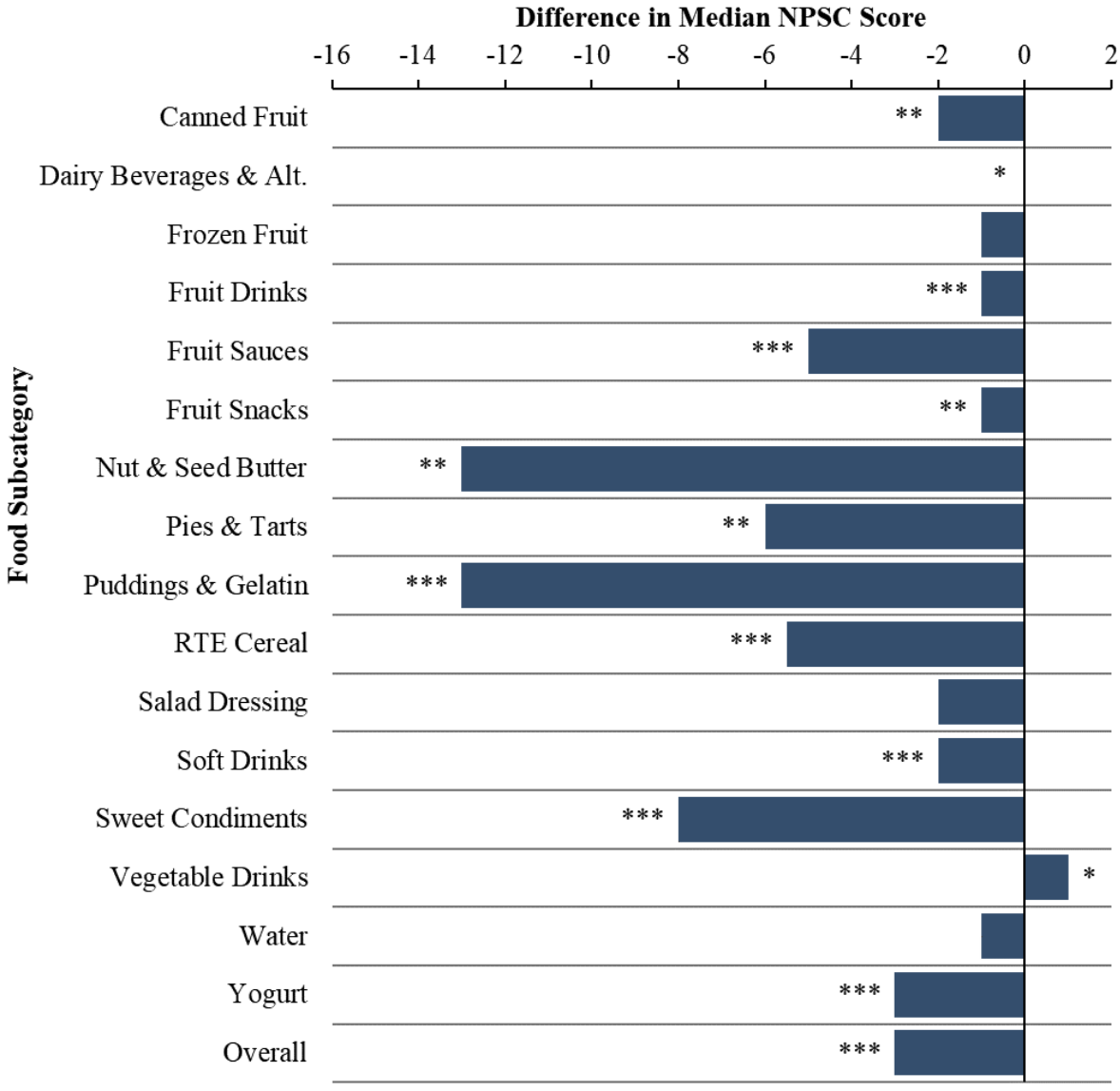
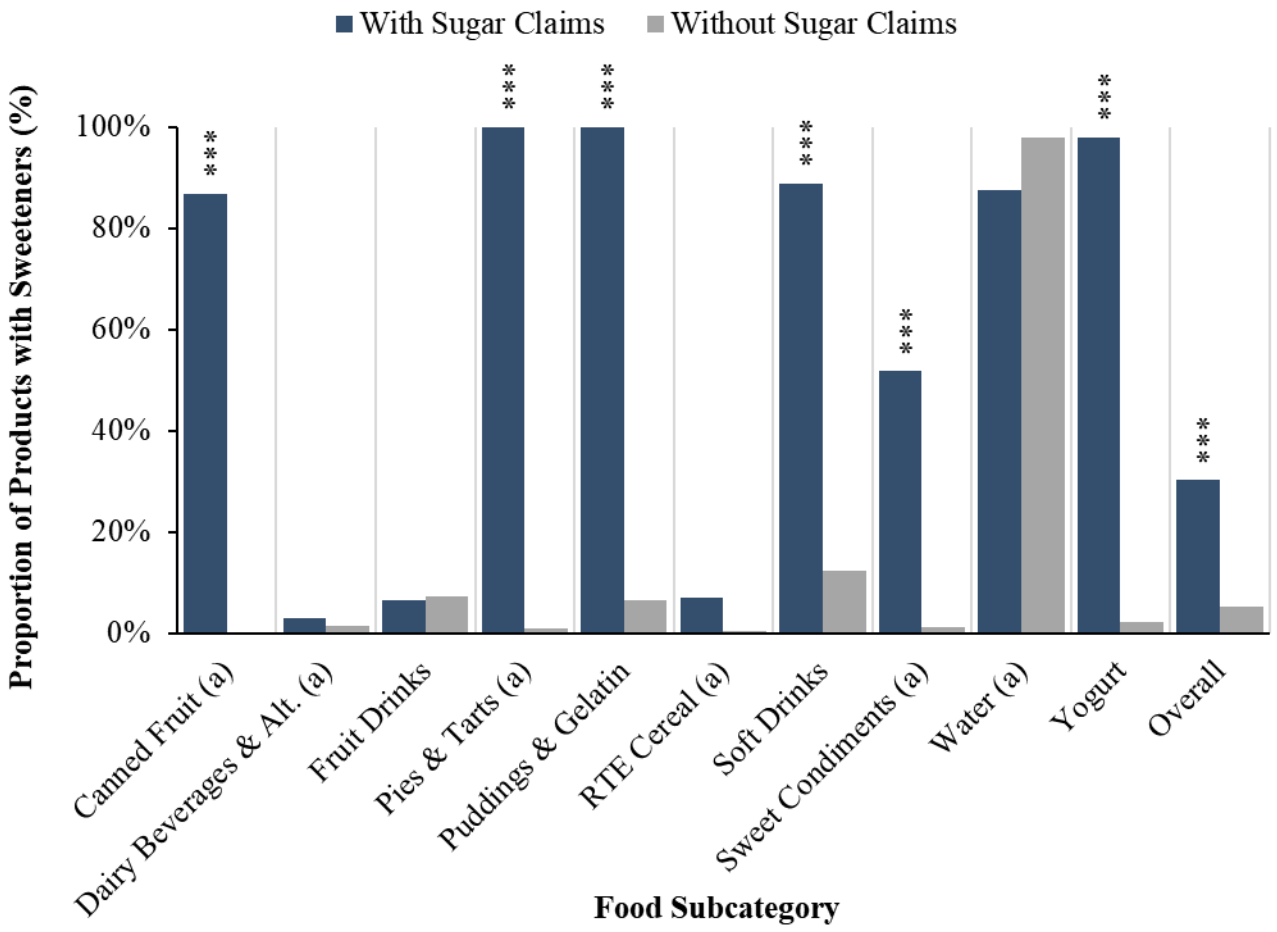


Figure 6.3 Proportion of products with and without sugar claims that contained sweeteners, by subcategory and overall (n=3048). Analysis only includes subcategories with ≥5% and ≥5 products with sugar claims. (*) Denotes a statistically significant difference (* p<0.05, ** p<0.01, ***p<0.0001). Only subcategories that contained sweeteners are shown; nut and seed butter, frozen fruit, fruit sauces, fruit snacks, salad dressing and vegetable drinks not shown. 'Sweeteners' refers to all non- or low-caloric sweetening agents as defined by the Canadian Food Inspection Agency, including sugar alcohols (e.g., xylitol, and sorbitol), and non-caloric or artificial sweeteners (e.g., sucralose, and aspartame) [153]. (a) Denotes subcategories where a Fishers Exact test was used (cell counts <5); the remaining underwent analysis using Chi-square tests. Abbreviations: Alt. = Alternatives; RTE = Ready-to-eat.



6.5 Discussion

The present study assessed the differences in calorie contents, nutrient contents, overall healthfulness, and the use of sweeteners in Canadian prepackaged foods and beverages with sugar claims compared to similar products without sugar claims. This research is particularly well-timed given the emergence of dietary guidelines suggesting the need to limit free sugar intakes [3, 5, 6] and the increased interest in reducing sugar consumption among Canadians [137, 148]. Dietary guidelines, in order to be effective, need to be supported by food labelling regulations that ensure sugar claims aid consumers in their selection of healthier food alternatives and reduce the detrimental effects associated with excess free sugar consumption [60, 74, 81, 83]. In Canada, claims used on products must abide by the specific regulation for that claim and also must not be misleading, untruthful, or create an erroneous impression of a product [166].

Contrary to consumer perceptions, many products with sugar claims had excess free sugar levels. A study by Food Standards Australia and New Zealand found 28% of respondents incorrectly thought the presence of a "no added sugar" claim meant a product would not contain any sugar [231]. In the present study, approximately half (48%) of the products with sugar claims contained excessive amounts of free sugar. For example, 36% of fruit drinks and 5.4% of sweet condiments had a "no added sugar" claim, yet over 99% of them contained excess free sugar. The Canadian regulations do not consider fruit juice a sweetener when it is not concentrated and is used as a fruit ingredient [55]. For this reason, sweet condiments (namely, fruit preserves) and fruit juice, although the latter is considered a free sugar, can still bear a "no added sugar" claim. Additionally, a "reduced in sugar" claim can only be present on products in which the sugar content is lowered by at least 25% compared to a similar reference product; yet there is no limitation based on the absolute amount of free sugar in the product and 85% of products with "reduced in sugar" claims contained excess free sugar levels. The presence of sugar claims on products with excess free sugar contents may mislead consumers, detracting from efforts to reduce free sugar intakes and risk of associated negative health outcomes. This is particularly relevant for the 70% of Canadians who consider the amount of sugar in a product at least sometimes when choosing foods [137].

Secondly, another area of concern from a public health perspective, is that most products with sugar claims were lower in free sugar contents, but the reduction was not comparable for calories. Consumer research has shown that consumers expect similar and meaningful calorie reductions in products with sugar claims [29]. This finding highlights a misalignment between consumer perceptions and regulatory requirements. Higher levels of other macronutrients used to replace sugar likely contributed to the divergence in calorie and free sugar levels. Protein and fat, for example, were higher among products with sugar claims in most subcategories that were lower in free sugar but not calories; although not always significantly higher (statistically and/or nutritionally). For low fat claims, consumer research has demonstrated that underestimating calorie contents can actually lead to increasing intake [186, 232], whether this also holds true for sugar claims is unknown.

Overall median fat content between products with and without sugar claims was not significantly different. However, many of the subcategories included in this analysis are typically already lower fat or fat-free (e.g. fruits, soft drinks, sweet condiments). These findings are in contrast to research that has shown higher sugar levels among low fat products [227] and further investigation would be required if sugar claims were to become more prevalent in the future, especially on higher fat foods. To our knowledge, this is the first study to compare the relationship between sugar claims and 'nutrients to limit' on a large scale. However, these results align with a similar, small-scale study assessing the incongruence between sugar claims and nutrient contents on cookies, crackers, and breakfast cereals [233], which found levels of 'nutrients to limit' were not significantly higher in products with sugar claims.

On a positive side, these results support earlier research that showed consumers believe products with "no added sugar" claims are healthier [187]. In this study, products with sugar claims had more favourable NPSC scores overall, and the difference was significant in most categories. Four subcategories, on the other hand, Dairy Beverages & Alt., Frozen Fruit, Salad Dressings, and Water, had healthfulness scores for claim products that were not statistically different from their counterparts without claims and may not direct consumers towards a product that is any healthier. However, median sodium levels were also lower in products with sugar claims.

Lastly, a greater proportion of products with sugar claims contained sweeteners (30%) than those without sugar claims (5%). These findings are largely in line with consumer perceptions that sweeteners would be used to replace sugar in products with sugar claims [29]. Sweetener use may also explain the lower proportion of products with sugar claims that had excess free sugar levels. The five subcategories with the greatest proportion of sweetener use among products with sugar claims were among the categories with at least 50% fewer products with excess free sugar levels (i.e. Canned Fruit, Pudding & Gelatin, Pies & Tarts, Soft Drinks, and Yogurt). The use of sweeteners may be a worthwhile method of reformulation to achieve caloric and sugar reductions in some subcategories, but the potential for sweeteners to encourage energy and sugar compensation at subsequent meals needs to be considered [135, 196, 225], along with the unknown long-term health effects of higher intakes, and acceptability of increased sweetener use by consumers. In a 2013 study, 54% of Canadian consumers reported that the use of sweeteners influenced their food choices [137].

Some of the variation in nutritional composition between products with and without sugar claims may be because the types of products with sugar claims in a subcategory differed from those without. For example, the products with sugar claims in Dairy Beverages & Alt. were mainly limited to dairy alternatives such as soy, almond, or rice milk, whereas those without sugar claims included both dairy beverages and alternatives. Similarly, sugar claims in the Fruit Juice & Drinks category, were mostly found on fruit juices, as opposed to fruit drinks or combination beverages. In Pies & Tarts, sugar claims were limited to fruit-filled pies, and not found on butter/ sugar or custard pies and tarts. Most items in Salad Dressings with sugar claims were creamy-type dressings, and lastly, 100% of the Yogurts with sugar claims were fat-free, and only one was plain, the rest flavoured. This is similar to findings from an earlier study from our group evaluating “low fat” claims on Canadian prepackaged foods, which found the claims were more often on alternatives in the same food category, rather than on the same product with less fat [171].

Limitations of this study included the use of nutrient values as declared on the NFt, rather than actual analyzed values. However, the cut-off for nutritional significance was set at 25% which exceeds the 20% variation permitted from analyzed values for labelling compliance [216]. This cut-off, although subjectively determined, also meets the minimum reduction (25%) in nutrient content required to make a “reduced” claim [222]. There are currently no direct analytical methods

available to determine free sugar contents, but calculations were based on an algorithm used to estimate added sugar levels that has been shown to have high inter-researcher repeatability [119]. Additionally, the categories analyzed are those in which ≥5% (totalling at least five products) of products carried sugar claims and therefore the overall results presented are reflective of those categories. Lastly, FLIP 2013 does not reflect the entire Canadian prepackaged food supply but is estimated to represent approximately 75% of the Canadian food retail market share [207].

6.6 Conclusion

In summary, this study found that in general, food products bearing sugar claims are 'healthier' and are lower in free sugar and calories than similar products without sugar claims. However, when comparing products within a subcategory, those with sugar claims were lower in free sugar but this was not usually accompanied by similar reductions in calorie contents. Perhaps most concerning, are the many products with sugar claims (nearly half) that also contained excessive amounts of free sugar. These results identify several short-comings in the current regulations which govern the use of sugar-related nutrient content claims, such as no requirement for calorie reductions, or reductions based on absolute levels of free sugar. Further, current regulations provide exceptions for when fruit juice is considered an added sugar and when it is considered a fruit ingredient, and to date there are no requirements that a product with a nutrient content claim needs to be any healthier than one without or meet a "healthy" criterion. The recently proposed *Healthy Eating Strategy* for Canadians suggests that "no added sugars" and "unsweetened" claims should not be used on fruit juices that meet the proposed "high in sugar" threshold of ≥15% of a DV for total sugar (based on 100g/day)[234]. This proposal may address at least some of the concerns identified in this study. Findings from this study can be used to inform needed changes in nutrient content regulations and can be used to support educational messaging to assist consumer interpretation and use of sugar claims on foods. For example, permitting sugar claims only on products with calorie reductions and without excessive free sugar content would support national healthy eating guideline objectives. Sugar claims have the potential to influence food selection, and with more Canadians trying to reduce their sugar intake, it is now even more essential that sugar claims are found on healthier products to both avoid misleading the consumer and to support free sugar intake guidelines. Unfortunately, findings from this study present

several areas of concern with regards to the nutritional composition of foods and beverages bearing sugar claims, that are not dealt with under current regulations.

Chapter 7

7 General Discussion

The three novel investigations presented in this thesis use the WHO free sugars definition and address the scarcity of evidence on the pervasiveness, levels, and sources of total and free sugars in Canadian prepackaged foods and beverages. Insofar as the information presented on the nutrition label is intended to enable the selection of foods to reduce the risk of developing NCDs or assist in the management of NCDs [18], this thesis also provides evidence of the extent to which sugars information on the NFt or in the form of nutrient content claims, can be used to identify foods consistent with the WHO free sugars intake guidelines and within the context of maintaining balanced intakes of other nutrients for the promotion of health.

In the first study, described in Chapter 4, total and free sugars contents in a large representative sample of Canadian prepackaged foods and beverages were determined and characterized. Free sugars were found to be extensively available in a wide range of foods and at levels that contribute greatly to total sugars levels and total calorie contents. In the second study, described in Chapter 5, total sugars and free sugars labelling were modelled and compared. As hypothesized, the free sugars DV was a more sensitive marker, than the total sugars DV, for identifying products misaligned with the WHO free sugars intake guidelines and with suboptimal nutritional compositions. Lastly, the third study, described in Chapter 6, compared the nutritional composition of foods and beverages with and without sugar-related nutrient content claims. Foods and beverages with sugar-related nutrient content claims were present on products that had relatively favourable nutrient profiles compared to products without sugars-related nutrient content claims, but many had excessive free sugars contents when assessed using a cut-off of 10% of calories. Taken together, results from these three studies contribute to an emerging field of research investigating the implementation of free sugars intake guidelines on food labelling and findings have important implications for recent, ongoing, and future food labelling policies and interventions, and can be used to inform the science related to sugars and health outcomes.

7.1 Key Findings

Sufficient evidence linking free sugars consumption to adverse health outcomes and unhealthy dietary patterns has led to the development of dietary guidelines recommending intakes of these sugars be limited [3, 5, 6, 33]. While there is evidence to suggest that the presence of nutrition claims and the levels of a single nutrient are directing consumer food selection [26, 129], investigations aimed at evaluating the sugars information presented on Canadian nutrition labels have been limited. Much of the research to date on the presentation of sugars information on food labels has focused on assessing consumers' knowledge, use, and understanding [29, 180, 181, 187, 235, 236], while few have focused on examinations in the context of the food supply, and even then, only briefly as part of broader investigations [170, 206]. With an increasing interest by Canadian consumers to reduce their intakes of sugars [129, 137], there is a need to better understand the amounts and types of sugars in Canadian foods and the value of sugars information on the food label for identifying products in line with free sugars intake guidelines and with favourable nutritional compositions. The paucity of research addressing these questions is likely due in part to the recentness of the free sugars intake guidelines, published in 2015, the sugars-related amendments to the Canadian Nutrition Facts table, which were finalized in 2016 [22], as well as the lack of detailed information on sugars in the food and beverage supply. As such, there is also a need to comprehensively characterize sugars in the Canadian food supply.

Study 1 presents a novel characterization and quantification of total and free sugars contents and emphasizes the extensive availability and abundance of free sugars in Canadian prepackaged foods and beverages. Results showing that 65% of products contain free sugars was replicated in a later Canadian study published in 2017 using a different data set [237]. Acton and colleagues found that 66% of foods and beverages sold at a large Canadian grocery retailer in 2015 contained added sugars [237]. The replication of the results lends credence to the data from Study 1. Although Acton and colleagues did not calculate added sugars contents, the similarities in the proportion of products with extrinsic sugars between the two studies suggests minimal progress has been made to remove extrinsic sugars from prepackaged foods between 2013 and 2015. Future iterations of FLIP collections can be used to directly examine this possibility (see discussion in section 7.5). The proportion of products with free sugars was not only replicated in Canada, but it also aligns with other published findings on free sugars prevalence from Slovenia

(53%) [238], using the same methodology for assessing free sugars contents as presented in this thesis, and added sugars prevalence from the US (74%) [12], and Australia (61%) [13]. Considering the study from Slovenia conducted by Zupanič and colleagues employed the same definition and methodology for calculating free sugars as Study 1 (Chapter 4), comparisons between these results are less likely to be plagued by methodological differences that hinder comparisons between many studies in this field [41, 48-51].

Study 1 also revealed that 62% of total sugars in prepackaged foods and beverages came from free sugars and they were almost synonymous with one another in particular food categories. This ratio may indicate that a total sugars DV based on 100g per day is inappropriate for implementing WHO free sugars intake guidelines in labelling (50g based on a 2,000-calorie diet), especially if this ratio is reflective of intakes as well as foods (62% of 100g = 62g). The implications of this conclusion are elaborated upon further in section 7.4. Zupanič and colleagues conducted a similar analysis on a Slovenian food composition database and likewise found that free sugars accounted for an average of 57.5% of total sugars [238].

Not only were free sugars found to contribute to the majority of total sugars in FLIP 2013, but they also contributed to an average of 20% of total calories. Specifically, there were seven major food groups with over 10% of calories coming from free sugars, including beverages (70%), sugars and sweets (62%), desserts (41%), sauces and dips (27%), fruits (25%), bakery products (16%), and miscellaneous products in the "other foods" category (11% of calories from free sugars). Not only did these major food groups have the highest free sugars levels as a proportion of calories, but sugars and sweets, bakery products, desserts, fruits, beverages, and sauces and dips were also found to have the highest median levels of total and/or free sugars levels when assessed per 100g or 100mL.

Building on these findings, a more nuanced evaluation of the caloric contribution of free sugars in important sources of total sugars in the Canadian diet, was conducted as part of Study 2. The analysis revealed that almost two-thirds of the types of food and beverage categories contributing to total sugars intakes in Canada, had excessive free sugars levels (≥10% of calories). Considering the WHO, US Dietary Guidelines Advisory Committee, and Public Health England all recommend a maximum of 5% or 10% of calories from extrinsic sugars [3, 5, 6, 33], it is apparent

that Canadian prepackaged foods and beverages, particularly those that are known contributors to total sugars intakes, have the potential to contribute to free sugars intakes above recommended levels [54]. Similar investigations elsewhere have yet to be conducted, however this is not unexpected, given the WHO and similar guidelines to limit extrinsic sugars intakes to less than 10% of calories have only recently been published [3, 5, 6].

Investigations carried out in Study 2 and Study 3 examined the presence of sugars information on the food label as a tool for navigating a food supply abundant in free sugars as was demonstrated in Study 1. The free sugars contents calculated in Study 1 also enabled the investigations in Study 2 and Study 3 to be conducted.

Study 2 results identified differences between the free sugars DV and total sugars DV, in terms of the categorization of products into ≤5% DV, >5% to <15%DV, and ≥15%DV groups. For instance, there were discrepancies in the products categorized as ≤5% DV with the free sugars DV, particularly in the food categories where naturally-occurring sugars are more likely to be present (e.g. fruits, unsweetened milk and alternatives). In these categories, the total sugars DV categorized more products in the middle (i.e. >5% to <15%DV) and ≥15% DV groups rather than as ≤5% DV. However, when all foods were examined together, the differences in the proportion of products with ≤5% DV are quite comparable (32% and 34% for total sugars DV and free sugars DV, respectively). Overall, the results highlight inconsistencies that primarily fall in the middle (31% vs. 12% for total sugars DV and free sugars DV, respectively) and ≥15% DV group (37% and 54% for total sugars DV and free sugars DV, respectively).

The differences in categorization of products into %DV groups are likely the result of a combination of factors. Firstly, and particularly for the products with ≤5% DV, the definition for total sugars [39, 59] fails to distinguish between the extrinsic sugars sources and the naturally-occurring sources of sugars that are considered to be integral parts of an optimal dietary pattern [24]. Secondly, the disparities were particularly marked among food categories with smaller serving sizes (data not shown) which amplifies the need for a greater proportion of the products' composition to be derived from sugars. For example, a product with a serving size of 100g would have to be composed of ≥7.5% and ≥15% free sugars or total sugars, respectively, to be ≥15% DV, however, for a product with a serving size of 30g, it would have to be composed of ≥25%

and ≥50%, respectively. Further, the total sugars %DV is based on a larger denominator (100g) than the free sugars %DV (50g) which requires that the numerator (sugars content per serving) for total sugars be double that of free sugars to have the same %DV. For instance, 10g of sugars would be 10% of the total sugars DV but 20% of the free sugars DV. This inconsistency in the calculation of the %DV would be of greater consequence in the food categories where most of the total sugars are coming from free sugars (e.g. sugars and sweets, bakery products, desserts, beverages) (see Study 1 results in section 4.4), as the difference in the %DV in these cases is largely a result of the denominators used for each type of sugars DV, rather than a difference in the total or free sugars contents.

The variable categorization of foods and beverages into %DV groups for a total sugars DV compared with a free sugars DV, suggests that the total sugars DV is a less sensitive threshold. Such disparities were additionally translated into the proportion of "less healthy" and products with excess free sugars categorized as ≥15% DV, in line with Health Canada's nutrition labelling education campaign indicating intakes should be lessened as this is "a lot" of a "nutrient to limit" [151], under each scenario. Results showed that a DV for free sugars was a more consistent marker of foods exceeding WHO free sugars intake guidelines and with suboptimal nutritional compositions ("less healthy") than a total sugars DV. The binary nature of these variables also enabled inferences to be made about the foods with more favourable nutrient compositions ("healthier"). Similarly, compared with the total sugars DV, a DV for free sugars identified a greater proportion of "healthier" foods (47% vs 57%, respectively) and products in alignment with WHO free sugars intake guidelines (<10% of calories) (79% vs 93%, respectively), as having ≤5%DV, in line with Health Canada's educational messaging indicating this is "a little" of a nutrient and that intakes need not be limited [151]. These results from Study 2 are concurrent with research showing there is a stronger relationship with added sugars and overall dietary quality than with total sugars [46]. Although this is the first study to model the implementation of a total sugars DV compared with a free sugars DV on nutrition labels, it contributes to a growing body of literature concluding the efficacy of extrinsic sugars surpasses that of total sugars for a variety of applications, such as for use within NP models and nutrition labelling [239, 240]. Once again, given the newness of both the total sugars %DV in Canada and relevant alternatives

(added sugars %DV in the US) [22, 179], other studies of the application of a sugars DV to the food supply are unavailable for comparison.

The free sugars DV, although able to identify more products that had excess free sugars levels, was not able to identify all of them, despite both the DV and the cut-off for containing excessive levels of free sugars being based on the same WHO guideline of 10% of calories [3]. This may be explained by the nature of the variable used for each application. The free sugars DV, was an *absolute value* of 50g, corresponding to 10% of calories in a 2000-calorie diet. However, the determination of an excessive level of free sugars was calculated based on the *percent contribution* of free sugars to calories [54]. As a result, both the absolute and proportionate cut-offs of 7.5g free sugars (15% of 50g) and 10% of calories from free sugars need to be met or exceeded in a single product and are thus are susceptible to variations in serving size and calorie contents. Products with small serving sizes, may meet or exceed the proportionate threshold, but to meet or exceed the absolute threshold, free sugars would need to make up an increasing proportion of a serving as the size decreases. For instance, 75% of a 10g serving would have to be comprised of free sugars for it to contain 7.5g, however, this decreases to only 5% of a 150g serving. This phenomenon was exhibited in Study 2 in several food categories (e.g. for cookies, granola bars, sweet condiments, confectionary, ready-to-eat breakfast cereals, sweetened yogurts). Similarly, for a product to have 7.5g or 30 calories worth of free sugars (7.5g * 4 calories/g = 30 calories), free sugars would need to make up an increasing proportion of calories as the total calorie content decreases (see **Table 7.1**). These limitations inherent in translating relative dietary guidelines to nutrition labelling regulations based on absolute values, contributed to 17% of products with excessive free sugars levels not being categorized as ≥15%DV when using the free sugars DV.

Table 7.1 Calorie contents and proportion of calories derived from free sugars for a food or beverage to contain 15% of the free sugars DV or 7.5g

Free sugars content per serving (g)	Calories provided by free sugars (kcals)	Total calorie content per serving (kcals)	Calories from free sugars (%)
7.5g	30 kcals	30 kcals	100%
		50 kcals	60%
		100 kcals	30%
		300 kcals	10%

Because of the lack of sensitivity of a total sugars DV on the NFt, the reliability of sugar-related nutrient content claims for guiding healthier food choices becomes even more important. Study 3 investigated the nutritional composition of products with and without sugars-related nutrient content claims as well as the alignment of products with sugars-related nutrient content claims with the WHO free sugars intake guidelines [3].

Findings from Study 3 add further precision and complement other research that has assessed the healthfulness of products with nutrition claims in comparison to products that do not carry nutrition claims and found they have relatively favourable nutrient compositions [171, 241]. Products with sugar-related nutrient content claims were "healthier", lower in calories, and lower in sugars compared with products from the same food category without these claims, as consumers have been shown to expect [29]. However, 48% of products with a sugar-related nutrient content claim had excessive free sugars contents when assessed using a cut-off of 10% of calories coming from free sugars; a finding that conflicts with consumer interpretations [29]. Thus, the results suggest the potential for these claims to be misunderstood by consumers, particularly among those who rely on nutrition claims. Consumers who have lower levels of nutritional and mathematical literacy have been shown to use the presence of claims to direct their food choices rather than the NFt information, which is recognized as difficult to interpret [20 172]. Thus, for these consumers, the presence of claims on products that align with consumers expectations becomes even more vital for informing healthy food selection, especially considering that information presented on food labels need to be correctly understood and interpreted to lead to successful changes in consumer behaviour [19, 149].

The results of Study 3 are likely a manifestation of the required criteria for a product to carry a sugar-related nutrient content claim as outlined in the Canadian *Food and Drug Regulations* [222]. For instance, for "reduced in sugars" claims, the nutrient-specific criteria required to carry this type of claim are relative (e.g. 25% less sugars than a reference product) [222] and therefore the nutritional composition of products with sugar-related nutrient content claims are *relatively* improved. Likewise, for "no added sugars" claims, the most commonly used sugars-related nutrient content claim in FLIP 2013, criteria are limited to restrictions on ingredients (e.g. sugars-based ingredients, sweeteners), rather than nutrient contents. Thus, products with "no

added sugars" claims can still be high in sugars, calories, and other "nutrients to limit" in absolute or relative terms.

By using a large representative sample of Canadian prepackaged foods and beverages, this thesis provides evidence that the 2013 Canadian prepackaged food supply is abundant in free sugars and that sugars-related nutrition labelling may not be optimal markers of foods and beverages that exceed the WHO free sugars intake guidelines or that have less favourable nutritional compositions. The results from these three investigations provide indispensable data to inform the implementation of WHO free sugars intake guidelines to food labelling, to enable research that requires detailed data on the sugars contents of prepackaged foods, and they offer valuable insights for future policy decisions aimed at aligning sugars-related nutrition labelling with WHO free sugars intake guidelines. The implications of which are discussed in the following sections.

7.2 Methodological contributions

7.2.1 Food composition database with free sugars information

Comprehensive food composition information is integral for assessing nutrition labelling regulations, however, at the outset of this thesis research in 2014, Canadian specific information characterizing the use of sugars in prepackaged foods and beverages was lacking. To avoid poor policy decisions, misinformed food selection, and erroneous results in research, there was a need to better elucidate the presence of sugars in the Canadian prepackaged food supply [34]. The creation and application of the *University of Toronto Free Sugars Algorithm* (the "U of T algorithm") and subsequent evaluations in Study 1 resulted in a food composition database with comprehensive total and free sugars contents and is the first in the world to include free sugars information. FLIP 2013 with free sugars contents addresses many of the inadequacies of the *Canadian Nutrient File* because it contains comprehensively and systematically updated Canadian data, and as a result of this thesis, also includes information on free sugars contents [205]. Such data are required for analyzing a rapidly changing food supply, which can vary widely in free sugars content and the use of sweeteners and since it is comprised of products available in the Canadian marketplace, the database is suitable for informing Canadian-specific actions. This database has innumerable applications in nutrition research and for informing policy decisions. It

can be used to garner detailed estimates of free sugars intakes in Canada, compare Canadian intakes with consumption rates worldwide, evaluate the relationship between sugars intakes and health outcomes, develop consumer education tools and mobile apps, and act as a baseline to monitor changes to the food supply over time. In fact, it has already proven to be a valuable tool with respect to many of these applications [54, 238, 242, 243].

In 2017, Moubarac and colleagues linked free sugars contents of foods in FLIP 2013 with foods reported to be consumed as part of the CCHS 2.2 from 2004, and found that Canadians consumed 13.8% of calories from free sugars, on average [242]. This represents a more accurate evaluation of extrinsic sugars intakes than previous attempts made in Canada [9] and the availability of the FLIP 2013 free sugars data was instrumental in making this possible. Based on this estimate, Canadians appears to consume extrinsic sugars within the same range (10-16% of calories) as populations in other countries with similar total sugars intakes [113, 125]. However, variations in sugars definitions and in dietary assessment techniques continue to hinder direct comparisons with intakes in other countries. Interestingly, Canadian intakes of free sugars equates to about 64.5% of total sugars in the diet (13.8% of 21.4%[111]), which is analogous to the proportion of total sugars coming from free sugars in prepackaged foods and beverages (62%) identified in Study 1. This equivalency may be indicative of a parallel between sugars intakes and the sugars contents of the foods and beverages available for consumption. The data in FLIP 2013, although not weighted for sales and limited only to prepackaged items, may be useful to gauge the intakes of Canadians, at least in terms of sugars. To that end, changes in extrinsic sugars intakes may echo changes in the relative proportion of extrinsic sugars in the food supply, however future research would be needed to verify this speculation.

The absence of reliable information on free sugars may also impede consumers' awareness of the amount free sugars in their diet, hamper the effectiveness of recommendations to limit consumption, [132] and make guidelines virtually impossible to follow. Consequently, free sugars contents in FLIP 2013 were also used to populate the free and publicly accessible, *One Sweet App* [243]. *One Sweet App* provides consumers with personalized information on the sources and amounts of free sugars in individual foods in their diet, compared with WHO guidelines [3]. This app has broad potential applications and can be used by the public, researchers, and health care professionals. *One Sweet App* was released on the iTunes Store on April 24, 2015. Dissemination

occurred through local news outlets (Metro News Canada-Toronto [244] and the University of Toronto News [245]) and via blogs and conferences. As of August 2017, *One Sweet App* had been downloaded 10,750 times [data not published].

7.2.2 Algorithm for calculating free sugars contents

In the absence of extrinsic sugars declarations on the nutrition label, the U of T algorithm was created and applied to food composition data to obtain accurate estimates of the free sugars contents of Canadian foods. The U of T algorithm can be tailored for any definition of extrinsic sugars and can be applied to any food composition database that contains total sugars contents and ingredient lists. This tool builds on an Australian algorithm created to calculate added sugars contents of aggregated products in an Australian database similar to the *Canadian Nutrient File*, which does not include ingredient information [119]. In response, the U of T algorithm adds further enhancements and allows for the calculation of free sugars contents using the nutrition label information, with the added precision attainable from branded food composition data and the ingredient list. It has already been applied to a Slovenian food composition database by researchers in 2018 [238] and used to inform the creation of other methods for estimating free sugars contents. For instance, the U of T algorithm was used in consultations with the *Pan American Health Organization* (PAHO) to guide the development of a method to approximate the free sugars contents as part of the PAHO NP model [54]. Like the U of T algorithm, the PAHO method for estimating free sugars uses the amount of total sugars declared on the nutrition label and presence of sugars-based ingredients, however, it does not require comparisons between sweetened and unsweetened products and therefore is simpler to apply. This added simplicity, however, means the PAHO method may not produce as precise calculations of free sugars contents, but it is more easily applied for ballpark estimations when exact values are not required (see **Table 7.2**).

Table 7.2 PAHO method for estimating free sugars based on the amount of total sugars declared on the product packaging [54]

If the manufacturer declares…	The estimated free sugars equals…	Examples of products
0 g of total sugars	0 g	Canned fish
added sugars	declared added sugars	Any product that declares added sugars
total sugars, and the product is part of a group of foods with no or a minimal amount of naturally occurring sugars	declared total sugars	Regular soft drinks, sport drinks, sweet biscuits, savory biscuits, breakfast cereals, and chocolate
total sugars and the product is yogurt or milk, with sugars in the list of ingredients	50% of declared total sugars	Flavored milk or yogurt
total sugars, and the product is a processed fruit item with sugars in the list of ingredients	50% of declared total sugars	Fruit in syrup
total sugars, and the product has milk or fruit in the list of ingredients	75% of declared total sugars	Cereal bar with fruit

7.3 Strengths and Limitations

There are strengths and limitations associated with the methods used and the current state of sugars research, particularly in the absence of extrinsic sugars labelling, and are detailed in the following sections.

7.3.1 Sampling of foods and beverages in FLIP 2013

To date, the FLIP database is the largest representative branded food composition database available in Canada. The data collection for FLIP 2013 took place in the four largest grocery retailers in Canada (Sobeys, Metro, Safeway, Loblaws) by market share. These retailers make up the majority (approximately 75%) of the grocery retail market share in Canada, and products in FLIP 2013 include both national brand and private label brands.

Discount banner stores operating under these retailers were not sampled and it is possible that products in discount and conventional banner stores differ in regard to their sugars contents and the presence of sugar-related nutrition claims. However, data provided by one of the largest Canadian grocery retailers by market share showed that FLIP 2013 contained about 93.8% of foods and beverages sold throughout all their banner stores (both conventional and discount)

[data not published]. Thus, it is unlikely that the collection of products from both conventional and discount banners would have significantly altered the results of the studies in this thesis.

Additionally, analysis of FLIP 2013 was not weighted to reflect the market shares of foods and beverages sold in Canada. Sales-weighted food composition databases can be a valuable tool to identify areas where interventions can achieve maximum effectiveness based on purchasing patterns [246]. Explorations using sales-weighted data in the Canadian context can be done for future collections of FLIP to emphasize the relative importance of products that are most frequently purchased, although the cost of purchasing such data is prohibitively expensive for most researchers. On the other hand, the non-sales-weighted data used in this thesis allows for robust assessments of the consumer's product package exposure as they navigate the grocery store, which is particularly important in studies of nutritional marketing [246].

Furthermore, only one size of each food product was collected in FLIP 2013, usually the mid-sized container or the container taking up the most shelf-space, although all flavours of a product were collected. This means that regardless of the number of package sizes a product was available in, only the one collected was searched for the presence of nutrition claims. If all sizes had been collected and assessed for presence of nutrition claims, this might have attenuated the findings of Study 3. However, there is no reason to believe that sugars claims present on any of the package sizes not collected would have differed in nutritional composition enough to change the conclusions of this study, especially considering the findings followed a consistent trend across many food categories. Future collections of FLIP will include information from all package sizes and can be used to further investigate the relationship between sugar-related nutrient content claims and nutritional composition among different package sizes.

7.3.2 Use of current manufacturer stated serving size

Another issue related to use of information on the NFt in this thesis research is the use of manufacturer stated serving sizes that were current as of 2013. The serving sizes used by manufacturers can vary considerably, as a result, the calculations of the %DV for total and free sugars in Study 2, may not be reflective of the serving sizes that will be declared when the amended nutrition labelling regulations come into full force in 2021 [22]. As part of the same 2016 nutrition labelling regulation amendments that introduced a total sugars DV, manufacturers will

be required to declare serving sizes that are more consistent within a food category and reflect the reference amounts outlined in the Canadian *Table of Reference Amounts* [247]. It is possible that the results found in Study 2 would be more pronounced if the same evaluation was conducted on products in which their stated serving sizes were more standardized than those in effect in 2013. However, the same issues that were raised in this thesis for products with smaller reference amounts will likely continue, there will continue to be products with small reference amounts, although results will likely be more comparable between products in the same food category [22].

7.3.3 Use of the WHO free sugars definition

Sugars terms are dynamic and have been evolving, entering, and leaving the public discourse over the past few decades, leading to a lack of consensus and consistency in terms of which definitions to use in practice and in research globally [41, 48-50 51]. The operationalized definition of free sugars employed in the foregoing studies was based on that developed by the WHO [3]. As a result, the studies described here can be comparable to other studies that use a free sugars definition, provided that other aspects of the methodology are equivalent. Comparisons with research using other sugars definitions need to be made with caution. As previously acknowledged, the use of incompatible terminologies for extrinsic sugars has complicated the existing literature and hinders inter-study comparisons [41, 48-50 51]. The next relevant alternative to using a free sugars definition, was to use an added sugars definition, however, these tend to be inconsistent between jurisdictions and overtime, whereas, the definition for free sugars is internationally consistent with that used by the WHO [3]. In addition, although Canada uses the term "added sugars" when referring to extrinsic sugars in the context of "no added sugars" nutrient content claims and sugars-based ingredients, Canada does not have a formally regulated definition for added sugars [55]. It is likely that results based on a free sugars definition would be comparable to those based on Canada's definition for what constitutes a sugars-based ingredient (Canada's added sugars definition in **Figure 2.1**) and to the *US Food and Drug Administration's* added sugars definition (**Figure 2.1**). Any differences would likely result from differences in free sugars and added sugars contents in products that are comprised of a significant proportion of single-strength (non-concentrated) fruit juices [57].

7.3.4 Accuracy of calculated free sugars contents

The potential for calculated free sugars contents to vary from actual levels must be considered, however, there are no reasons to suspect that free sugars contents were unrepresentative of actual free sugar levels or that they were systematically over- or under-estimated. Through the freely available *One Sweet App*, calculated free sugars contents were available to all manufacturers as well as Canadian consumers that wished to view them. There was no feedback received from the food industry in response to these values that would indicate the free sugars contents of FLIP 2013 products were different from their recipe formulations. Anecdotally, one large multi-national food manufacturer provided us with assurance that the calculated free sugars values for products that they manufacture, were in line with the free sugars values derived from their proprietary recipe formulations. Furthermore, any deviations from actual free sugars contents stemming from erroneous total sugars declarations by the manufacturer are likely to result in negligible effects when examining results at the food category level. Previous Canadian research has shown that less than 15% of the total sugars values declared on Canadian food labels were outside of the acceptable range outlined by the *Canadian Food Inspection Agency* [217]. Any products with obvious manufacturer errors in nutrient declarations were excluded prior to analyses and represented only a small subset of the database (55 of 15,341 products). In addition, the large nature of the FLIP 2013 database makes it less sensitive to minor errors in nutritional composition declarations.

7.3.5 Selection of nutrient profiling (NP) model

NP models use algorithms to characterize the nutritional composition of foods and beverages for the promotion of health, or the degree of "healthfulness", through classifications (e.g. healthy/ not healthy; eligible/ not eligible) or through numerical scores, and have been used by the food industry, governments, and non-governmental organizations [248, 249]. This area is still in its infancy and hundreds of NP models are in use internationally [250]. As such, no harmonized approach or standardized model is universally agreed upon or suitable for all applications [250]. One NP model that has been extensively validated is the Ofcom model for regulating the marketing of food to children ("Ofcom"), which was developed by the Food Standards Agency in the UK [251]. Research examining the relationship between diets comprised of foods and beverages in line with Ofcom criteria and health outcomes have shown a protective effect against

coronary heart disease risk [252]. Since its introduction, several NP models have been derived from the Ofcom criteria with slight modifications including the Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion (FSANZ-NPSC) used in Studies 2 and 3. FSANZ-NPSC was developed with the specific aim of regulating nutrition claims [110]. The FSANZ-NPSC, considers both nutrients to limit and components to encourage, which incorporates several of the constituents of a healthy diet according to the WHO [106]. This system produces a continuous score based on the presence of nutrients and ingredients and outlines cut-points to delineate "healthier" and "less healthy" foods that can be used to group foods accordingly [110].

For Study 3, a continuous summary score for healthfulness rather than categorical groupings enabled the comparison of products with and without sugar-related nutrient content claims on a more precise level. It is conceivable that if another NP model had been chosen, the proportions of foods classified as "healthier" and "less healthy", or the relative healthfulness scores of foods with and without sugar-related claims may have differed. For instance, if a more stringent model was used [253], such as the PAHO NP model [54], and more products in FLIP 2013 were considered "less healthy", there would be less variation in the product's healthfulness overall. Thus, it can be presumed that the difference between the proportions of "less healthy" products with the total compared with the free sugars DV in Study 2 may not have been as pronounced.

7.4 Implications and recommendations for policy and practice

The evidence available to date on the relationship between extrinsic sugars and health outcomes, although debated, has proven to be sufficient to act upon [3, 7, 8, 98, 99]. Actions are being taken and extrinsic sugars guidelines are being implemented in various policy and practice contexts [108, 254] because taking a "no action" approach and maintaining the status quo could be more harmful to population health, especially considering the extensive addition of free sugars to the food supply and the high and rising prevalence of NCDs [2]. Under such a discourse and considering the efforts and time required to implement regulatory changes to nutrition labels, it is essential that as new policies or regulations are introduced, the latest science be utilized and where evidence demonstrates policy gaps, these be acted upon so that changes will be more likely to achieve the desired health outcomes, namely reduced risks of NCDs.

7.4.1 Inconsistent extrinsic sugars definitions

The use of many different terms for sugars and inconsistencies in their components make comparisons of studies looking at food composition and sugars intakes problematic, increasing the potential for confusion and misinterpretation and points to the need for uniform terminology [41, 48-51] . The identification of free sugars-based ingredients in FLIP 2013 was an integral step to enable the calculation of free sugars contents and represents one of the broadest extrinsic sugars definitions currently in use. In the absence of a universally accepted extrinsic sugars definition, the identification of each type of sugars-based ingredient and its prevalence in the food supply, can be a valuable tool for assessing the implications of using various sugars definitions for policy and program actions. For instance, the proportion of products with fruit juices, the major distinction between free sugars and the most recent definition for added sugars in the US [3, 55], can be used to estimate how the products with added sugars may differ from those with free sugars. These approximations can then be used to assess the repercussions of comparing inconsistent definitions in the scientific literature and the significance of terminology selection for policy actions. In the meantime, having a regulated definition for extrinsic sugars in Canada may be necessary to ensure that research and nutrition labelling are consistent with one another. To allow for international comparisons, the free sugars definition according to the WHO may be an appropriate option for Canada to consider as it is used in several countries and across continents [5, 54]. Alternatively, although it is incongruent with many other jurisdictions, the most recent publication of an added sugars definition by the *US Food and Drug Association* [179] may also be considered as an option to better align with the US; a stated aim of Canadian nutrition labelling regulations [18].

7.4.2 Labelling of sugars-based ingredients

Results from Study 1, identifying 152 different names for free sugars-based ingredients, support existing sentiments that the current Ingredient List obscures the identification of free sugars sources [154] and reinforces them as a “hidden” source of calories [95]. The vast array of terms used to describe sugars-based ingredients confirms the need for the newly introduced Canadian nutrition labelling regulations that will result in sugars-based ingredients being grouped together in the ingredient list to indicate the overall contribution of sugars-based ingredients [22]. It is important to note, however, that this policy change would still neglect to provide consumers with

the amounts of sugars-based ingredients needed to enable adherence to guidelines [22]. In the absence of such information, quantitative ingredient declarations (QUID), especially those centred on sugars-based ingredients, may be a worthwhile consideration for future policy action. The potential benefits of QUID are twofold, firstly, extrinsic sugars contents can be calculated more directly using the known proportions of sugars added to a food product when extrinsic sugars are not declared on the NFt [119], and secondly, it can help consumers assess the amounts of ingredients that they may wish to increase or decrease [255]. The feasibility of such a labelling amendment, the level of demand by consumers, and its potential to contribute to health benefits, would need to be explored further.

7.4.3 Total sugars and free sugars DV

At the outset of this thesis research in 2014, the decision to present a total sugars DV on the NFt had not yet been made and there was a proposal by Health Canada to include a declaration for added sugars on the NFt [256]. Thus, there was an opportunity to inform the results of this consultation and investigate the potential application of such policy options on the food supply and in the context of existing sugars intake guidelines. The research presented in Study 2 was conducted in order to provide evidence to inform this policy decision. Although focused on Canadian data, the results have the potential to inform decisions in other countries that may be considering similar nutrition labelling changes, such as Australia [257], because it is the first study to compare the application of a total and extrinsic sugars DV to prepackaged foods and beverages.

The final regulatory decision to use a total sugars DV in Canada was made in 2016, with the government citing opposition from industry stakeholders as a contributing factor to its exclusion, as well as worries that a declaration for added sugars would be difficult to enforce and would support the misbelief that added sugars are chemically different from intrinsic sugars [158]. Around the same time, the amendments to the US nutrition labelling regulations were finalized which included a %DV for added sugars, citing support from health professional and scientists and addressing the same concerns that the Canadian government cited in response to consultation submissions [179] (see section 2.9.1.2). The results from this thesis support the use of an alternative to a total sugars DV, namely a free sugars DV based on 50g, for several reasons. Consumers

report consulting the nutrition label to obtain nutrition information, and many are particularly interested in sugars contents [129, 137]. A declaration and %DV for free sugars would better guide consumers not only away from products with excess free sugars, but also away from products with suboptimal nutrient compositions. Moreover, the analysis from Study 2 was concentrated on the top sources of sugars intakes in Canada, so the results are focused on products that are more likely to impact sugars intakes and are suitable for informing policies aimed at facilitating dietary improvements.

However, given the decision was made to use a %DV for total sugars, a total sugars DV that aligns more closely with the ratio of free sugars coming from total sugars (62%) in the food supply might have been a more useful tool to bridge the gap between the two options for sugars labelling. For example, a total sugars DV of 81g, would have been preferred when informed by the examinations in Study 1 (50g / 62% = 81g) [3]. It is worth noting, however, that this ratio is limited to prepackaged foods and beverages and therefore not necessarily reflective of the ratio of free sugars to total sugars in Canadian diets that is needed to inform the development of a total sugars DV, but merely demonstrates that a DV based on another value could be more suitable than 100g. Coincidentally, however, the ratio in the food supply (62%) is similar, and perhaps is a reflection of, the ratio of free sugars to total sugars in the Canadian diet (64.5%) (13.8% energy from free sugars [242] / 21.4% of energy from total sugars [111]= 64.5%).

While the total sugars DV of 100g per day may be a less sensitive marker of product alignment with the WHO free sugars intake guidelines and of overall nutritional composition, it still represents an improvement on the current NFt without a %DV for total sugars. The total sugars %DV identified almost half of the “less healthy” products (45%) and those that were misaligned with WHO free sugars intake guidelines (55%) in Study 2 and is still a better option than keeping the status quo.

7.4.4 Complimentary Policy Actions

A number of proposed sugars-related nutrition labelling policies have emerged since the outset of this thesis research, some of which were constrained by the desire to be consistent with the most recent nutrition labelling regulatory amendments [22]. The desire for consistency in nutrition labelling regulations may amplify the limitations of a single policy decision that is echoed in

other subsequent regulatory decisions which use the total sugars DV as a basis, for example, regulatory changes emerging from *Health Canada's Healthy Eating Strategy* [234]. However, consistency within regulations also presents an opportunity for other policies to mitigate the consequences of the limitations that have been identified with total sugars labelling and can act as alternative ways to achieve the same goals. That is, other means can be used so the food environment can better support the identification and consumption of foods and beverages that align with the WHO free sugars intake guidelines and have favourable nutrient compositions. There have already been several proposals in Canada that address some of the shortcomings in labelling sugars information that have emerged from this thesis. In 2016, Health Canada prepared the first of several consultations under the umbrella of the *Healthy Eating Strategy* [234]. The *Healthy Eating Strategy* proposals include, but are not limited to, the updating of sugar-related nutrient content claims to better align them with other regulatory proposals, along with the introduction of a standardized front-of-package system (FOPS) to indicate foods and beverages that are "high in" sodium, saturated fats, and total sugars, and restrictions on the marketing of foods that are "high in" sodium, saturated fats, and total sugars to children [234]. Many aspects of this strategy were published in Canada Gazette part I on February 10, 2018 [155].

Similarly, proposals stemming from the *Healthy Eating Strategy*, for "high in" FOPS, for example, have included adjustments for products with small reference amounts. For these products, adjustments to increase the reference amounts used to calculate the nutrient thresholds to determine which products carry a FOPS, have been proposed to capture foods that are primary sources of sodium, saturated fats, or total sugars, but consumed in small quantities [155]. This proposed adjustment may resolve the discrepancies between using the free sugars DV and total sugars DV that stems from products with small serving sizes, as demonstrated in Study 2. Also proposed, is the exemption of products that contain only naturally-occurring sugars from carrying "high in" total sugars FOPS [155]. These changes can help to address the failure of the total sugars DV to distinguish between free sugars and naturally-occurring sugars by ensuring that only products with free sugars carry a "high in" total sugars FOPS [155]. Future research can continue to evaluate the impact of these and forthcoming policy decisions on availability, food intakes, and health outcomes.

7.4.5 Criteria required to carry a sugar-related nutrient content claim

It is apparent from Study 3 that selecting products with sugar-related nutrient content claims does not provide assurance that the food itself would be low in sugars, and if lower in calories, not of a comparable expected magnitude to the difference in sugars contents [29]. The incongruence between the nutritional composition and consumer perceptions of products carrying these claims has implications for enforcement, as the information presented on food labels must be truthful and not be misleading [165].These claims may be truthful in that they accurately present information on some aspect of sugars contents or sweetener ingredients in alignment with regulatory requirements, however, contradictions between what is stated in the claim and how consumers interpret the statement because of their preconceived notions [29], may be construed as deceptive or misleading. In response, changes to the criteria required for products to carry sugar-related nutrient content claims or to the claims permitted for use, may be warranted as it is the case in other jurisdictions [258].

To ensure consumer protection, a caveat in the nutrition labelling regulations that nutrition claims are only permitted if the average consumer can correctly interpret the sentiments of the claim, could be considered. Such a qualification is already an integral component of European regulation of nutrition and health claims and evidence to show consumer understanding of claims is a required as part of regulatory evaluations [258]. This consideration would expand on the current requirement for claims to not be misleading by adding further specification as to what constitutes "understanding" and thus misinterpretation, thereby necessitating tests of consumer understanding of claims.

Additional measures such as only permitting sugar-related nutrient content claims on products with low levels of free sugars as well as introducing a definition for "healthy" foods as a standard requirement for nutrition claims could be considered. For instance, the Food Standards Australia New Zealand Nutrient Profiling Scoring Criterion cut-offs were developed with the specific aim of regulating nutrition claims in Australia and New Zealand to prevent their presence on "unhealthy" products [110]. Although Study 3 examined the healthfulness of products with sugar-related nutrient content claims compared with those without, the analysis did not extend to using these cut-offs. However, this has been recently been examined as part of a

broader analysis of nutrition marketing in FLIP 2013 by Franco-Arellano and colleagues [241]. Franco-Arellano and colleagues found products with sugars-related nutrient content claims were "healthier" than those without these claims, with 77% meeting the FSANZ-NPSC cut-offs for a "healthier" product compared to only 43% [241].

Some progress has already been made to address the concerns about sugar-related nutrient content claims emerging from Study 3. Proposed amendments to sugar-related nutrient content claims from the *Healthy Eating Strategy* include: changing the criteria for "no added sugars" and "unsweetened" claims to exclude their presence on fruit juices (included in the definition of free sugars but not sugars-based ingredients in Canada) that are high in sugars according to the proposed FOPS (15%DV or more); allowing the "free of sugars" claims to be used on products that contain high-intensity sweeteners and on products that meet the requirement for a "low in energy" rather than "free of energy" claim; introducing a "low in sugars" claim for foods with no more than 5g total sugars per reference amount or serving size; and introducing a "lightly sweetened" claim for foods that have at least a 50% less sugars-based ingredients than a similar food [155]. Considering that the categories of fruit drinks and sweet condiments had the highest proportion of products with claims that also had excess free sugars levels (100% and 97%, respectively), the proposed amendment to limit the presence of sugar-related nutrient content claims on fruit juices with ≥15%DV for total sugars will likely contribute to the attenuation of this phenomenon, especially if the amendment is expanded to also exclude sweet condiments.

7.5 Future Directions

This work provides a foundation to inform and support the development of sugar-related nutrition labelling policies in Canada. Results suggest the need for continuous evaluation of new policy developments in this area. While many findings related to sugars in prepackaged foods and beverages and the implementation of extrinsic sugars guidelines in relation to sugar-related nutrition labelling were elucidated, this field is in its relative infancy. Thus, there are several opportunities to expand on this work.

7.5.1 Evaluation and monitoring of food-system responses

There are several opportunities to evaluate the potential and demonstrated effects of the current sugars-related nutrition labelling regulations in Canada as well as future policies by monitoring the food supply. One objective of the 2003 and 2016 Canadian nutrition labelling regulatory amendments was to encourage the availability of foods that can reduce the risk of NCDs [18, 22]. Reformulation of products to be lower in free sugars is one method by which this could be achieved [22]. The abundance of foods and beverages with free sugars suggests the need to reduce its availability within the Canadian food environment. In addition, the distribution of total and free sugars contents detailed in Study 1 indicates the potential for reformulation strategies to be successful and areas where alterations may be the most feasible. The sheer existence of food categories with a wide range of free sugars contents demonstrates that foods with comparatively lower sugars contents can be sellable, acceptable, palatable, and safe. On the other hand, the viability of lowering sugars contents in food categories where the range is smaller may be limited. There may be some types of products that require sugars to provide important texture, flavour, or food safety functions, minimizing the extent of reduction that could be reasonably expected [41-43]. The reformulation of foods is considered a key option to achieve population nutrient goals [224], and although not widely used for sugars as of yet, it has been implemented in the UK as part of a systematic sugars reduction strategy [254].

Efforts to reduce extrinsic sugars intakes have raised concerns that reformulation will increase the use of low/no-calorie sweeteners [6, 214] because the evidence of the health effects or benefits of sweetener use in the long-term is inconclusive [99, 214]. In response, recommendations to reduce sugars contents from Heart and Stroke Canada and from researchers in the UK stipulate that this should not be done with the subsequent addition of sweeteners [15, 95]. In FLIP 2013, only 5% of products contained low/no-calorie sweeteners, which is consistent with literature from Australia, Mexico, New Zealand and the US in which 5% of products overall contained non-nutritive sweeteners, ranging from 4% in the US to 11% in Mexico [259]. Future efforts aimed at surveying the prepackaged food supply are required to monitor the availability of foods with lower sugars levels, but also to examine calorie levels and ingredients that are used to replace sugars (e.g. refined starches) [189]. Specifically, if reducing the sugars contents of prepackaged foods becomes a priority in Canada, the baseline data presented in Study 1 can additionally be used to monitor

the addition of low/no-calorie sweeteners to ensure amounts available do not surpass levels deemed to be safe for consumption [230].

The work presented in this thesis provides a baseline snapshot of the free sugars contents in FLIP 2013, which may be an ideal point in time for collection of baseline information on sugars contents from a population health perspective. An essential component of implementing program or policy interventions is the effective evaluation and monitoring of related outcomes [260]. Monitoring of changes over time compared with baseline data collected prior to the implementation of new regulations as a "natural experiment", becomes an invaluable tool for the evaluation of different policy options [261]. The most recent changes in the discourse surrounding free sugars and added sugars began in 2014 when the WHO opened a public consultation on draft sugar guidelines [262] and Health Canada [263] and the US *Food and Drug Administration* [161] proposed the inclusion of added sugars declarations on the nutrition label that same year. Having data on free sugars contents collected in 2013, prior to the aforementioned policy discussions, allows for a comparison between baseline free sugars levels with those at future time points [260]. However, the trajectory of changes in free sugars contents leading up to this remains unknown. In the future, free sugars contents can be calculated for the foods and beverages that were collected as part of FLIP 2010 and the changes between 2010 and 2013 can assess the earlier baseline trajectory. This assessment can enable evaluations of not only the differences over time, but also the changes in the magnitude of differences [261], as previously used for calories contents and intakes in the US [264]. Utilizing baseline trajectories is a well-established method of population intervention evaluation that attempts to adjust the variation attributable to the changing policy discourse, regulations, and practices from the underlying secular trends [261]. Baseline data can then act as a comparator for any future data collections. Additionally, such data will allow for the comparison of the two different policy approaches to providing sugars information on food labels in the US and in Canada, with the FLIP 2013 database with free sugars contents acting as the Canadian baseline to similar American branded food database counterparts released by the USDA [12, 116, 265].

7.5.2 Extrinsic sugars intakes and related health outcomes

Several aspects of the relationship between sugars and health have been debated [60]. The data emerging from this thesis, particularly the food composition database with free sugars information can be useful to define the extent to which the food supply itself is detrimental to health. Considering the aim of nutrition labelling policies is to act on one of the proximal causes of NCDs, food intake, one method of evaluating the success of a policy decision is to determine the corresponding impact on dietary intakes. Based on FLIP 2013 calculations of free sugars contents, the average free sugars intakes of Canadians based on 2004 data has been determined [266]. A crucial aspect of free sugars intake assessments that has yet to be addressed includes the differential rates by which Canadian sub-populations consume free sugars and the main food and beverage contributors to free sugars intakes and the proportion of the Canadian population that exceed the WHO free sugars intake guidelines. Certain sub-populations such as adolescents and young men, may be particularly at risk for overconsumption of free sugars due to their significantly higher total sugars intakes [111]. Additionally, the relationship between important socio-demographic factors and extrinsic sugars intake in the Canadian context has not been examined [143-145]. With the recent release of the 2015 collection of the CCHS nutrition [267], an opportunity is available to assess longitudinal changes in sugars intakes in Canadian sub-populations and the health outcomes associated with different levels of consumption.

Finally, the development of the free sugars algorithm and incorporation of free sugars data into FLIP 2013 has allowed me to help with the conceptualization of future sugar-related research as part of a recently funded *Canadian Institutes of Health Research* strategic operating grant on sugars. The underpinning concept of this grant depends heavily on the methodological contributions originating in this thesis. This work will link the more precise total and free sugars contents from FLIP with data from CCHS 2015 to estimate total sugars and free sugars intakes and model the health impacts of various levels of consumption. A thorough understanding of intakes in the population is an important first step in understanding the relationship between extrinsic sugars intakes and health outcomes and assessing the dietary impact of food policy decisions. Additionally, the limited exploration of this field and absence of complete food composition databases, has likely contributed to the disputed views of the relationship between sugars and health [41, 48-51].

8 Conclusions

The work presented in this thesis provides a novel examination of the amounts and types of sugars in the current Canadian prepackaged food supply and the efficacy with which the sugars-related nutrition labelling policies can help Canadians identify foods and beverages consistent with the WHO free sugars intake guidelines. The extensive availability and excessive levels of free sugars in foods and beverages; the inconsistency with which total sugars DV labelling identified "less healthy" products and those with excessive levels of free sugars; and the presence of sugar-related nutrient content claims on items that had excessive levels of free sugars, suggests the WHO free sugars intake guidelines are not optimized within the current Canadian food supply and within the labelling tools available to assist consumers in navigating their food environments. As such, this work highlights the challenges faced by Canadian consumers trying to limit their intakes of free sugars and ensure adherence with the WHO free sugars intake guidelines and thus, adherence with a dietary pattern aimed at reducing risk of NCDs [4, 38].

The purpose of this research was to inform current, ongoing, and future policies and interventions aimed at limiting consumption of excessive amounts of free sugars and points to the need for a food supply in which free sugars availability is limited and nutrition labels more reliably identify foods that are in line with WHO free sugars intake guidelines and have a nutritional composition that promoted healthy dietary patterns. An important contribution of this research includes the development of an algorithm for calculating free sugars in foods and beverages and the creation of the first food composition database in the world to contain free sugars information. These tools represent significant advancements in the field of sugars research and can be used to inform and enable a vast array of future studies and will be essential to evaluate current and future sugars-related nutrition labelling policies and their effects on food composition, intakes, and health outcomes.

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