

1 **Assessing nutritional value of ready-to-eat breakfast cereals in the province of**
2 **Quebec (Canada): a study from the Food Quality Observatory**

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38 **ABSTRACT**

39 **Objective.** The Food Quality Observatory was created in the province of Quebec (Canada) in 2016. In
40 this study, the Observatory aimed to generate a methodology to 1) test the use of sales data combined
41 with nutrient values to characterize the nutritional composition of RTE breakfast cereals offered and
42 purchased in the province of Quebec (Canada), and 2) verify the extent to which a FOP label based on
43 the percentage of daily value (DV) for total sugar, as a strategy to improve the food supply, would be
44 distributed in this food category.

45 **Design.** Nutritional information were obtained by purchasing each RTE breakfast cereal available in the
46 Greater Montreal area. Cereals were then classified according to their processing type.

47 **Setting.** The nutritional values of 331 RTE breakfast cereals available in Quebec were merged with sales
48 data covering the period between May 2016 and May 2017. A total of 306 products were successfully
49 cross-referenced.

50 **Results.** Granola and sweetened cereals were the most available (36.6 % and 19.6 % respectively) and
51 purchased (19.8 % and 40.9 % of sales, respectively). When compared with other types of cereals,
52 granola cereals had a higher energy, fat, saturated fat, protein content and a lower sodium content. A
53 larger proportion of chocolate (65 %) and sweetened cereals (49 %) were above 15 % of the DV for
54 sugar.

55 **Conclusions.** This study showed that the methodology developed generates important data to monitor
56 nutritional quality of the food supply and ultimately contribute to improve the nutritional quality of
57 processed foods.

58

59 **KEYWORDS:** Food supply, nutritional value, food purchases, ready-to-eat breakfast cereals.

60 INTRODUCTION

61 According to the World Health Organization, food environment is one of the key factors to promote a
62 healthy diet⁽¹⁾. Recent studies showed the influence of the food environment on food choices and food
63 consumption which revealed the importance of monitoring food outlets and food quality in stores^(2, 3).
64 Moreover, processed foods represent a third of the total volume of food purchased in supermarkets and
65 grocery stores in the province of Quebec (Canada)⁽⁴⁾. Processed foods are often high in fat, sugar and
66 sodium and studies show that chronic overconsumption can lead to an increased risk of
67 noncommunicable diseases⁽⁵⁾.

68 To better understand the food environment to which populations are exposed, many countries are
69 monitoring food's nutritional value and its evolution over time. The International Network for food and
70 obesity / Non communicable diseases Research, Monitoring and Action Support (INFORMAS)⁽⁶⁾ and
71 the Food monitoring group⁽⁷⁾ already monitor food composition in different countries in order to support
72 governmental regulation and voluntary commitments by industry in creating healthier food
73 environments. In parallel, the Observatory of food quality in France (OQALI) evaluates the nutritional
74 composition of different food categories. For instance, they observed an improvement in the nutritional
75 composition of pizzas and ready-to-eat meals (i.e., lower fat and saturated fat content) between 2009-
76 2012 and 2015-2016⁽⁸⁾. The observed differences were mainly explained by product reformulation by
77 the industry rather than changes in consumers choices towards healthier options. OQALI as well as other
78 researchers in Europe and in the USA found that there is a high variability in nutritional quality among
79 processed foods, even among products within a same food category^(6, 7, 9, 10). Although an increase use of
80 sales data has been observed over the past five years⁽¹¹⁾, access remains very difficult for researchers and
81 thus, a limited number of studies has combined such data with the nutritional composition found on food
82 labels in order to estimate what consumers actually buy and eat. This combination is highly relevant since
83 it could contribute to better target products for reformulation. Indeed, it may help to focus policy makers
84 efforts on the types of products that sell the most since a small improvement in nutrient content of great
85 sellers can have a large and significant impact on public health⁽¹²⁾. Furthermore, it may allow to monitor
86 and assess the impact of the introduction of new regulations (i.e., nutrition facts table, front-of-pack
87 [FOP] labelling) on food purchases. Except for sodium⁽¹³⁾ and sugar⁽¹⁴⁾, no study reporting overall
88 nutritional value of food products in Canada has been yet published, which supports the relevance of
89 monitoring the food environment and the nutritional quality of the food supply in provinces such as
90 Quebec.

91 In 2016, the Quebec government created the very first government health prevention policy⁽¹⁵⁾, a policy
92 of major importance aiming to improve population health and quality of life. Several actions have been
93 established within a framework to improve the nutritional quality of the food supply and further
94 encourage food companies to improve the nutritional quality of their products. Meanwhile, the
95 implementation of an observatory aiming to monitor the nutritional quality of the food supply was
96 deemed a priority for a network of researchers and knowledge users (representatives from governmental,
97 non-governmental, parapublic and private organizations). Hosted by the Institute of nutrition and
98 functional foods at *Université Laval*, the Food Quality Observatory (henceforth Observatory) was thus
99 officially launched in 2016 and is currently supported by the Quebec's Ministry of Health and Social
100 Services as well as the Quebec's Ministry of Agriculture, Fisheries and Food. By generating reliable and
101 useful information on the nutritional quality of food products available, the Observatory aims to
102 contribute to the creation of healthier food environments, which will in turn facilitate healthier food
103 choices and likely improve the overall health of the population.

104 The food category of ready-to-eat (RTE) breakfast cereals has been selected to test the methodology and
105 the feasibility of the studies to be undertaken by the Observatory. Indeed, breakfast is an important meal
106 of the day⁽¹⁶⁻²⁰⁾, and RTE breakfast cereals are part of the daily diet of a large proportion of the
107 population^(21, 22). Several studies which have analysed the impact of RTE breakfast cereals on dietary
108 intakes and human health show variations in their nutritional value. Despite many positive impacts on
109 diet quality (since they may provide whole grains, nuts, fruits, fibre, etc.) and cardiometabolic health^{(19,}
110 ^{20, 23-27)}, some RTE breakfast cereals are highly processed and high in some nutrients of public health
111 concern (e.g., added sugar, sodium, and preservatives)^(28, 29).

112 It is also known that information on processed food products such as nutrition facts table, claims and
113 other nutritional information can be difficult to understand for consumers⁽³⁰⁾. Strategies have been
114 implemented to facilitate consumers' food choices and to improve the nutritional quality of the food
115 supply. Among these strategies, United Kingdom adopted in 2006 a voluntary FOP traffic light system
116 coded for fat, saturated fat, sugar and sodium⁽³¹⁾. In 2013, the UK government published guidelines for
117 uniform FOP color coded labelling⁽³²⁾. Since then, most of the UK supermarkets and many food
118 manufacturers provide that label⁽³³⁾. Australia and New Zealand adopted in 2014 a voluntary Health Star
119 Rating FOP system⁽³⁴⁾. Two years after the adoption of the FOP system, energy density and sodium
120 content were found to be lower whereas fibre content was higher in labelled products compared with
121 their composition prior to the adoption of the FOP system⁽³⁵⁾. In 2016, Chile adopted a FOP warning
122 symbol for food products exceeding specified amounts of energy, saturated fat, sugar and sodium⁽³⁶⁾.

123 After implementation, Chile observed that food companies reformulated products to adapt to the new
124 regulation⁽³⁷⁾. All food categories combined, total sugar content showed the highest reduction after the
125 FOP implementation, suggesting that sugar content of RTE breakfast cereals would thus be of major
126 interest. The number of products with FOP “high in sugar” before (with a simulation) and after
127 implementation in Chile was significantly reduced in cereal products (e.g., cookies, crackers, cakes,
128 breads) which included breakfast cereals. Indeed, median of total sugar almost had dropped by 50 %
129 between 2013 and 2019, with 51 % of cereal products having a warning symbol in 2013 in comparison
130 to 47 % in 2019. In 2017, a voluntary FOP label using letters from A to E was adopted to characterize
131 the nutritional quality of food products in France (Nutri-Score)⁽³⁸⁾. Since then, Belgium, Switzerland and
132 Spain also adopted the Nutri-Score. In Canada, a standardized FOP warning symbol on food exceeding
133 15 % of the daily value (DV) for saturated fats, total sugar and sodium is currently under consideration
134 by the government⁽³⁹⁾. While it remains difficult at this point to confirm if nutrient-specific warning labels
135 are more successful than summary labels⁽⁴⁰⁾, such a warning symbol could potentially act as a nudge for
136 the food industry to reformulate their products while easily and rapidly informing consumers about less
137 healthy food options. Moreover, this warning symbol would target specifically nutrients of interest which
138 are known to be consumed in excess by consumers. In the case of RTE breakfast cereals, a FOP warning
139 symbol – particularly for total sugar which is a nutrient of interest in this food category – could potentially
140 affect a large number of products, including great sellers⁽⁴¹⁾.

141 Therefore, the aims of the present study were to generate a methodology to 1) test the use of sales data
142 combined with nutrient values to characterize the nutritional composition of RTE breakfast cereals
143 offered and purchased in the province of Quebec (Canada), and 2) verify the extent to which a FOP label
144 based on the percentage of DV for total sugar, as a strategy to improve the food supply, would be
145 distributed in this food category.

146

147 **METHODS**

148 Data collection

149 In order to reach the objectives described above, a database containing the nutritional value of each RTE
150 breakfast cereal was created by *Protégez-Vous* - a Quebec-based non-profit organization specializing in
151 consumer information and product testing - and was used by the Observatory following a data-sharing
152 agreement. Nutritional and labelling information were obtained by *Protégez-Vous* by purchasing every
153 RTE breakfast cereal in supermarkets, grocery stores and specialty grocery stores from the Greater
154 Montreal area (Quebec, Canada) in September 2016. Cereals that were considered in this study were only

155 cold breakfast cereals available in individual packaging (no multiple packages with several varieties of
156 cereals) and those with nutritional information available on packaging. All information present on the
157 product packaging (e. g., brand, nutrition facts table, list of ingredients, nutrition and health claims,
158 serving size, etc.) was coded in the database using double coders. The reference portion of 55 g was
159 chosen because it represented the reference amount for cereals (i. e., amount typically consumed in one
160 occasion) at the time of the study. Nutritional value variables listed for the purposes of this study were
161 as follows: energy (kJ), total fat (g), saturated fat (g), total sugar (g), fibre (g), protein (g) and sodium
162 (mg). The price per reference portion (55 g) and per unit (e. g., one box) were also documented by
163 calculating the average of the prices observed in the various stores visited.

164 This nutritional value database was merged with a sales database (provided by Nielsen company⁽⁴²⁾) of
165 RTE breakfast cereals sold in the province of Quebec for 52 weeks between May 2016 and May 2017
166 by using unique product codes (UPC). For each product, the database included the following data: sales
167 in Canadian dollars (CAD\$), sales in kilograms (kg) and sales in unit. Sales information comes from the
168 optical reading of the products purchased in the main food chains of Quebec markets.

169 Classifications

170 RTE breakfast cereals were grouped by two different coders into different classifications to facilitate
171 comparisons (e. g., muesli, sweetened, granola, etc.). The classifications were adapted from OQALI in
172 France⁽⁴¹⁾. Each classification includes products with common characteristics in terms of their type of
173 ingredients and/or technology used during processing. Definitions of these classifications are presented
174 in supplemental materials.

175 Statistical analyses

176 To provide a general description of the nutritional value and the price per serving of RTE breakfast
177 cereals found on the shelves available in Quebec (food supply), means and standard deviations
178 illustrating the distribution of each of these variables were first calculated (n=331). The descriptive
179 analyses were then repeated by weighting by sales volume in kg (food purchases; n=306)). Weighting
180 the averages for sales better represents what Quebecers buy – and eventually consume – by giving a
181 higher weight to the most popular cereals and a lower weight to the cereals which are less purchased.
182 Since the analyses weighted for sales were produced from the combined database, the number of products
183 analyzed was lower than the one for the unweighted analyzed (in which only the nutritional value data is
184 available). Kruskal Wallis tests and ANOVAs were used to compare means and weighted for sales means
185 nutrient content and prices between different cereal types. For all statistical tests, the significance

186 threshold was corrected using the Bonferroni correction method to compensate for multiple comparisons.
187 Statistical tests were conducted using SAS software version 9.4.

188

189 **RESULTS**

190 A total of 331 different RTE breakfast cereals were identified in the Quebec food supply. Nutritional
191 value and all packaging information were referenced for these cereals. Using the UPC, this dataset was
192 merged with the sales database which contains more than 700 RTE breakfast cereals sold over one year.
193 A total of 306 products with sales information were successfully cross-referenced with the 331 cereals
194 identified in the food supply representing 92% of RTE breakfast cereals identified in the Quebec food
195 supply. The sales volume of products for which nutritional and purchasing information were both
196 available amounted to CAD\$ 230 million which represents 90 % of all sales of RTE breakfast cereals in
197 Quebec. Products present in the sales database but missing in the nutritional database were mostly
198 multiple packages with several varieties, discontinued products or different sizes of the products already
199 included in the study.

200 **Table 1** shows the variety of RTE breakfast cereals according to their type and purchase percentage. The
201 most represented types of cereals were granola (36.6 %), sweetened (19.6 %), plain (15.4 %) and muesli
202 cereals (10.3 %) whereas the most purchased were the sweetened (40.9 %) and the granola type (19.8
203 %).

204 (Add Table 1)

205 **Table 2** shows the nutritional value and price per portion of all types of RTE breakfast cereals for both
206 offered (as found on the shelves; n = 331) and purchased RTE breakfast cereals (weighted by sales
207 volume; n = 306). A large variability was observed in saturated fat, total sugar and sodium content of the
208 different types of cereals. The variability was even higher in purchased than offered RTE breakfast
209 cereals, emphasizing once again on the importance of monitoring both food offered and purchased at the
210 same time. Mean saturated fat content weighted for sales varied between 0.1 g (plain) and 2.7 g (granola)
211 per 55 g of RTE breakfast cereals while mean total sugar content varied between 6 g (plain) and 18 g
212 (chocolate) and mean sodium between 117 mg (granola) and 328 mg (plain). More particularly, when
213 compared with others, granola cereals purchased had a higher energy, fat, saturated fat, protein content,
214 a lower sodium content and a similar total sugar content. Results remained similar when the unweighted
215 nutritional composition of cereals was considered. Selling price of granola cereals was higher than other
216 RTE breakfast cereals. When compared with others, sweetened cereals purchased had a higher total sugar
217 content, and lower energy, fat and protein content. In addition to the previous results, when the

218 unweighted nutritional composition was considered, sodium content was higher and saturated fat and
219 fibre contents were lower. Selling price of sweetened cereal was similar to others.

220 (Add Table 2)

221 **Figure 1** shows the large variation of total sugar content between the different types of cereal as well as
222 between products within the same category. One RTE breakfast cereal out of five exceeded 15 % of the
223 DV for total sugar (i.e., 15 g) and would get a FOP warning symbol according to Health Canada policy
224 under review. More specifically, chocolate (65 %) and sweetened cereals (49 %) were those exceeding
225 15 % DV most often. Moreover, this figure illustrates the sales for each product and shows that many
226 important sellers were sweetened cereals and most of them exceeded 15 % of the DV for total sugar.
227 Actually, 65 % of sweetened cereals' sales are above the 15 % of DV for total sugar.

228 (Add Figure 1)

229

230 **DISCUSSION**

231 The overview of RTE breakfast cereals offered and purchased in the province of Quebec generated in
232 this study confirmed that the methodology of combining nutritional and sales data in Quebec and relating
233 this data to the percentages of DV is feasible and relevant. First, 331 different RTE breakfast cereals have
234 been identified and sales data were available for 306 of them which allowed coverage of a large part of
235 the total cereals market (90 %) in the analyses. This overview also represents a wide variety of RTE
236 breakfast cereals, similar to what has been observed in other countries^(10, 43-45). Moreover, the present
237 study showed that granola and sweetened cereals are the most frequently found in the market with
238 respectively 36.6 % and 19.6 % of the RTE breakfast cereals offered, as well as 19.8 % and 40.9 % of
239 the RTE breakfast cereals purchased. These findings differ from what is observed elsewhere since, in
240 comparison, chocolate cereals and light cereals were the most frequent RTE breakfast cereals in
241 France⁽⁴¹⁾ while those two types of cereal each represented only 5% of the supply in Quebec. We also
242 found that the nutritional value differs greatly between types of RTE breakfast cereals offered in the
243 province of Quebec, as it has also been observed in other countries^(41, 46). Total sugar content of Quebec
244 RTE breakfast cereals greatly varies between types of cereals and even within same type. For example,
245 the large range observed for total sugar content among sweetened cereals (i. e., from 1.8 g to 30.6 g per
246 55 g serving) clearly demonstrate interesting opportunities for improvement. While large variations had
247 also been observed elsewhere in the world, the mean total sugar content is higher in Quebec than in
248 Australia⁽⁴⁷⁾, UK⁽⁴⁸⁾ and Belgium⁽⁴⁵⁾, which again underline the need for reformulation in this food
249 category.

250 Additionally, a great proportion of chocolate (65 %) and sweetened (49 %) cereals are above 15 % of
251 DV for total sugar (i.e., 15 g per 55 g serving). This means that most of these cereals would carry, on the
252 front of the package, the FOP warning symbol currently under consideration by Health Canada. Since
253 chocolate cereals represent only 3.5 % of total RTE breakfast cereals purchases, reformulating total sugar
254 content of these products – even if desirable – would have little impact in terms of public health.
255 However, 65 % of sweetened cereals’ sales (sweetened cereals represent 40.9 % of total RTE breakfast
256 cereals purchases) are above the 15 % of DV for total sugar. Thus, small reduction of total sugar content
257 in these products may have a major public health impact. These cereals should therefore be closely
258 monitored in the future to ensure that improvement efforts through reformulation are made by the
259 industry. Reformulated products without nutritional warnings were perceived as more healthful and had
260 higher purchase intention scores than their regular counterparts with warning while nutrient claims did
261 not have a relevant effect on consumers’ perception⁽⁴⁹⁾. Such a FOP symbol could thus be a win-win for
262 consumers and companies.

263 Monitoring the evolution of the nutritional composition of RTE breakfast cereals is of major importance.
264 No improvement has been seen between 2006 and 2010 in nutritional composition of RTE breakfast
265 cereals in Australia⁽⁴⁷⁾ nor in New-Zealand between 2013 and 2017, suggesting that industry self-
266 regulation of the nutritional composition of this food category needs reconsideration⁽⁴⁶⁾. However, in the
267 UK, a significant sodium reduction was observed in breakfast cereals between 2004 and 2015 confirming
268 the success of the UK voluntary sodium reduction program⁽⁵⁰⁾. Similarly, OQALI had observed a
269 significant sodium reduction in chocolate and sweetened RTE breakfast cereals (30 mg and 60 mg per
270 100 g respectively) between 2008 and 2011⁽⁵¹⁾. However, those changes were not significant after
271 weighting for sales, suggesting that the biggest sellers did not change the nutritional composition of their
272 products.

273 Since few studies have combined nutritional data with sales data to monitor the actual food supply, the
274 present study is the first in Canada to assess the nutritional value of RTE breakfast cereals that are both
275 offered and purchased. However, the present study has some limitations. The nutritional database is an
276 overview at a given time that may not represent the whole portrait of the food supply during the whole
277 year. Different products may not have been identified, such as the products that entered the market after
278 data collection or those sold at another moment during the year but that were discontinued before the
279 data collection. Additionally, not all RTE breakfast cereals were successfully matched to sales data
280 (n=25). In fact, the sales database available through the Nielsen company does not include some RTE
281 breakfast cereals, such as certain private labels of specific grocery stores. Moreover, even if food sales

282 data can give an overview of food intakes^(52, 53), it is not possible to ensure that RTE breakfast cereals
283 purchased are actually eaten by the consumers who bought them.

284 In terms of perspectives, the Observatory will use the methodology described in this paper to address
285 other food categories that can have a significant impact on population health with the aim of monitoring
286 the evolution of the nutritional value of the food supply in years to come. Currently, sliced breads,
287 luncheon meats, RTE soups, granola bars, frozen meals, pasta sauces, yogurts and dairy desserts,
288 sausages, cookies and crackers have also been analyzed which sums up to more than 4000 food items
289 (www.offrealimentaire.ca). These databases will give the possibility to characterize Quebec and
290 Canadian food categories from different angles: target consumers, presence of claims, artificial
291 sweeteners or food additives, etc.

292 In conclusion, the methodology used in this study provides an overview of the RTE breakfast cereals
293 offered and purchased in the province of Quebec. This also leads to the identification of general findings
294 regarding the nutritional value as well as to the information available on food packaging. Consequently,
295 with these results, it becomes possible to identify areas of improvement regarding the nutritional
296 composition of processed foods, which is of great relevance for policy makers and public health nutrition
297 advocates for healthier food choices. These findings form the basis for monitoring nutritional value of
298 RTE breakfast cereals in the future. The same methodology will also be used for other food categories
299 and will then allow the monitoring of a significant portion of the food supply in Canada.

300

301 The full report is freely available (in French only) on www.offrealimentaire.ca.

302

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304 **REFERENCES**

- 305 1. World Health Organization (2020) Healthy Diet - How to promote healthy diet.
306 <https://www.who.int/news-room/fact-sheets/detail/healthy-diet> (accessed October 2020).
- 307 2. Ni Mhurchu C, Vandevijvere S, Waterlander W *et al.* (2013) Monitoring the availability of
308 healthy and unhealthy foods and non - alcoholic beverages in community and consumer retail
309 food environments globally. *Obesity Reviews* 14, 108-119.
- 310 3. Minaker LM, Shuh A, Olstad DL *et al.* (2016) Retail food environments research in Canada: A
311 scoping review. *Canadian Journal of Public Health* 107, eS4-eS13.
- 312 4. Plamondon L DG, Paquette MC, (2019) L ' achat d ' aliments ultra-transformés en
313 supermarchés et magasins à grande surface au Québec. *Institut national de santé publique du*
314 *Québec*.
- 315 5. Srour B, Fezeu LK, Kesse-Guyot E *et al.* (2019) Ultra-processed food intake and risk of
316 cardiovascular disease: prospective cohort study (NutriNet-Santé). *bmj* 365.
- 317 6. Neal B, Sacks G, Swinburn B *et al.* (2013) Monitoring the levels of important nutrients in the
318 food supply. *obesity reviews* 14, 49-58.
- 319 7. Dunford E, Webster J, Metzler AB *et al.* (2012) International collaborative project to compare
320 and monitor the nutritional composition of processed foods. *European journal of preventive*
321 *cardiology* 19, 1326-1332.
- 322 8. Observatoire de la qualité de l'alimentation (OQALI) (2019) Contributions de l'offre et de la
323 demande à l'évolution de la qualité nutritionnelle de l'alimentation.
- 324 9. Baldrige AS, Huffman MD, Taylor F *et al.* (2019) The Healthfulness of the US Packaged Food
325 and Beverage Supply: A Cross-Sectional Study. *Nutrients* 11.
- 326 10. Observatoire de la qualité de l'alimentation (OQALI) (2008) Étude du secteur des céréales pour
327 le petit-déjeuner.
- 328 11. Bandy L, Adhikari V, Jebb S *et al.* (2019) The use of commercial food purchase data for public
329 health nutrition research: A systematic review. *PLoS One* 14, e0210192.
- 330 12. Korošec Ž & Pravst I (2014) Assessing the average sodium content of prepacked foods with
331 nutrition declarations: The importance of sales data. *Nutrients* 6, 3501-3515.
- 332 13. Arcand J, Jefferson K, Schermel A *et al.* (2016) Examination of food industry progress in
333 reducing the sodium content of packaged foods in Canada: 2010 to 2013. *Applied Physiology,*
334 *Nutrition, and Metabolism* 41, 684-690.
- 335 14. Bernstein JT, Christoforou AK, Weippert M *et al.* (2020) Reformulation of sugar contents in
336 Canadian prepackaged foods and beverages between 2013 and 2017 and resultant changes in
337 nutritional composition of products with sugar reductions. *Public Health Nutrition*, 1-9.
- 338 15. Gouvernement du Québec (2016) Politique gouvernementale de prévention en santé.
339 <https://publications.msss.gouv.qc.ca/msss/fichiers/2016/16-297-08W.pdf> (accessed June 2020).
- 340 16. Barr SI, Vatanparast H Smith J (2018) Breakfast in Canada: Prevalence of consumption,
341 contribution to nutrient and food group intakes, and variability across tertiles of daily diet quality.
342 A study from the International Breakfast Research Initiative. *Nutrients* 10, 985.
- 343 17. Barr SI, DiFrancesco L Fulgoni VL (2014) Breakfast consumption is positively associated with
344 nutrient adequacy in Canadian children and adolescents. *British Journal of Nutrition* 112, 1373-
345 1383.
- 346 18. Hopkins LC, Sattler M, Steeves EA *et al.* (2017) Breakfast consumption frequency and its
347 relationships to overall diet quality, using healthy eating index 2010, and body mass index among
348 adolescents in a low-income urban setting. *Ecology of food and nutrition* 56, 297-311.

- 349 19. Williams P (2007) Breakfast and the diets of Australian children and adolescents: an analysis of
350 data from the 1995 National Nutrition Survey. *International Journal of Food Sciences and*
351 *Nutrition* 58, 201-216.
- 352 20. Gibson S & Gunn P (2011) What's for breakfast? Nutritional implications of breakfast habits:
353 insights from the NDNS dietary records. *Nutrition Bulletin* 36, 78-86.
- 354 21. Albertson AM, Anderson GH, Crockett SJ *et al.* (2003) Ready-to-eat cereal consumption: its
355 relationship with BMI and nutrient intake of children aged 4 to 12 years. *Journal of the American*
356 *dietetic association* 103, 1613-1619.
- 357 22. Leech RM, Boushey CJ, McNaughton SA (2021) What do Australian adults eat for breakfast? A
358 latent variable mixture modelling approach for understanding combinations of foods at eating
359 occasions. *International Journal of Behavioral Nutrition and Physical Activity* 18, 1-16.
- 360 23. Albertson AM, Thompson D, Franko DL *et al.* (2008) Consumption of breakfast cereal is
361 associated with positive health outcomes: evidence from the National Heart, Lung, and Blood
362 Institute Growth and Health Study. *Nutrition Research* 28, 744-752.
- 363 24. Deshmukh-Taskar P, Nicklas TA, Radcliffe JD *et al.* (2013) The relationship of breakfast
364 skipping and type of breakfast consumed with overweight/obesity, abdominal obesity, other
365 cardiometabolic risk factors and the metabolic syndrome in young adults. The National Health
366 and Nutrition Examination Survey (NHANES): 1999-2006. *Public health nutrition* 16, 2073-
367 2082.
- 368 25. van den Boom A, Serra-Majem L, Ribas L *et al.* (2006) The contribution of ready-to-eat cereals
369 to daily nutrient intake and breakfast quality in a Mediterranean setting. *Journal of the American*
370 *college of nutrition* 25, 135-143.
- 371 26. Albertson AM, Wold AC, Joshi N (2012) Ready-to-eat cereal consumption patterns: the
372 relationship to nutrient intake, whole grain intake, and body mass index in an older American
373 population. *Journal of aging research* 2012.
- 374 27. Holmes B, Kaffa N, Campbell K *et al.* (2012) The contribution of breakfast cereals to the
375 nutritional intake of the materially deprived UK population. *European journal of clinical*
376 *nutrition* 66, 10-17.
- 377 28. Maschkowski G, Hartmann M, Hoffmann J (2014) Health-related on-pack communication and
378 nutritional value of ready-to-eat breakfast cereals evaluated against five nutrient profiling
379 schemes. *BMC Public Health* 14, 1178.
- 380 29. Cordain L, Eaton SB, Sebastian A *et al.* (2005) Origins and evolution of the Western diet: health
381 implications for the 21st century. *The American journal of clinical nutrition* 81, 341-354.
- 382 30. Campos S, Doxey J, Hammond D (2011) Nutrition labels on pre-packaged foods: a systematic
383 review. *Public health nutrition* 14, 1496-1506.
- 384 31. Sacks G, Rayner M, Swinburn B (2009) Impact of front-of-pack 'traffic-light' nutrition
385 labelling on consumer food purchases in the UK. *Health promotion international* 24, 344-352.
- 386 32. Food Standards Agency, UK. (2013) Guide to creating a front of pack (FoP) nutrition label for
387 pre-packed products sold through retail outlets.
388 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/566251/FoP_Nutrition_labelling_UK_guidance.pdf (accessed March 2021).
- 389
390 33. British Nutrition Foundation (2018) Helping you eat well - Looking at label.
391 <https://www.nutrition.org.uk/healthyliving/helpingyoueatwell/labels.html?limit=1&start=3>
392 (accessed October 2020).
- 393 34. Commonwealth of Australia (2014) Health Star Rating System.
394 <http://www.healthstarrating.gov.au/internet/healthstarrating/publishing.nsf/content/home>
395 (accessed March 2021).

- 396 35. Mhurchu CN, Eyles H Choi Y-H (2017) Effects of a voluntary front-of-pack nutrition labelling
397 system on packaged food reformulation: The health star rating system in New Zealand. *Nutrients*
398 9, 918.
- 399 36. DOF (2015) Reglamento sanitario de los alimentos. Diario Oficial de la Republica N°4193.
400 http://web.minsal.cl/sites/default/files/decreto_etiquetado_alimentos_2015.pdf (accessed
401 October 2020).
- 402 37. Quintiliano Scarpelli D, Pinheiro Fernandes AC, Rodriguez Osiac L *et al.* (2020) Changes in
403 Nutrient Declaration after the Food Labeling and Advertising Law in Chile: A Longitudinal
404 Approach. *Nutrients* 12, 2371.
- 405 38. Ducrot P, Méjean C, Julia C *et al.* (2015) Effectiveness of front-of-pack nutrition labels in French
406 adults: results from the NutriNet-Sante cohort study. *PLoS One* 10.
- 407 39. Taillie LS, Hall MG, Popkin BM *et al.* (2020) Experimental Studies of Front-of-Package Nutrient
408 Warning Labels on Sugar-Sweetened Beverages and Ultra-Processed Foods: A Scoping Review.
409 *Nutrients* 12, 569.
- 410 40. Temple NJ (2020) Front-of-package food labels: A narrative review. *Appetite* 144, 104485.
- 411 41. Goglia R, Spiteri M, Menard C *et al.* (2010) Nutritional quality and labelling of ready-to-eat
412 breakfast cereals: the contribution of the French observatory of food quality. *European journal*
413 *of clinical nutrition* 64, S20-S25.
- 414 42. Nielsen MarketTrack (2017) Ready-to-eat Cereals, Quebec All Channels, 52 weeks ended May
415 27.
- 416 43. Nieto C, Rincon-Gallardo Patiño S, Tolentino-Mayo L *et al.* (2017) Characterization of breakfast
417 cereals available in the mexican market: Sodium and sugar content. *Nutrients* 9, 884.
- 418 44. Angelino D, Rosi A, Dall' Asta M *et al.* (2019) Evaluation of the nutritional quality of breakfast
419 cereals sold on the Italian market: The Food Labelling of Italian Products (FLIP) study. *Nutrients*
420 11, 2827.
- 421 45. Vermote M, Bonnewyn S, Matthys C *et al.* (2020) Nutritional Content, Labelling and Marketing
422 of Breakfast Cereals on the Belgian Market and Their Reformulation in Anticipation of the
423 Implementation of the Nutri-Score Front-Of-Pack Labelling System. *Nutrients* 12, 884.
- 424 46. Chepulis L, Hill S Mearns G (2017) The nutritional quality of New Zealand breakfast cereals: an
425 update. *Public Health Nutrition* 20, 3234-3237.
- 426 47. Louie JC, Dunford EK, Walker KZ *et al.* (2012) Nutritional quality of Australian breakfast
427 cereals. Are they improving? *Appetite* 59, 464-470.
- 428 48. Pombo-Rodrigues S, Hashem KM, He FJ *et al.* (2017) Salt and sugars content of breakfast cereals
429 in the UK from 1992 to 2015. *Public Health Nutr* 20, 1500-1512.
- 430 49. Schnettler B, Ares G, Sepúlveda N *et al.* (2019) How do consumers perceive reformulated foods
431 after the implementation of nutritional warnings? Case study with frankfurters in Chile. *Food*
432 *quality and preference* 74, 179-188.
- 433 50. Pombo-Rodrigues S, Hashem KM, He FJ *et al.* (2017) Salt and sugars content of breakfast cereals
434 in the UK from 1992 to 2015. *Public health nutrition* 20, 1500-1512.
- 435 51. Observatoire de la qualité de l'alimentation (OQALI) (2013) Étude d'évolution du secteur des
436 céréales pour le petit-déjeuner - Données 2008 et 2011.
- 437 52. Ransley JK, Donnelly JK, Khara TN *et al.* (2001) The use of supermarket till receipts to determine
438 the fat and energy intake in a UK population. *Public health nutrition* 4, 1279-1286.
- 439 53. Martin SL, Howell T, Duan Y *et al.* (2006) The feasibility and utility of grocery receipt analyses
440 for dietary assessment. *Nutrition journal* 5, 10.

441

442 **TABLES & FIGURE**443 **Table 1. Availability and purchases of ready-to-eat breakfast cereals according to their type**

RTE breakfast cereals		n (%)	Purchases (%)
Total		331 (100.0)	100.0
Type	Granola	121 (36.6)	19.8
	Sweetened	65 (19.6)	40.9
	Plain	51 (15.4)	14.2
	Muesli	34 (10.3)	5.8
	Chocolate	17 (5.1)	3.5
	Bitesize	17 (5.1)	6.5
	Light	15 (4.5)	5.1
	Fibre	11 (3.3)	4.2

444

445

446 **Table 2. Nutritional value and price (per 55 g serving) of ready-to-eat breakfast cereals according to their type**

RTE breakfast cereals		Energy (kJ)		Fat (g)		Saturated fat (g)		Total sugar (g)		Fibre (g)		Protein (g)		Sodium (mg)		Price (CA\$)																	
		Supply	Purchases	Supply	Purchases	Supply	Purchases	Supply	Purchases	Supply	Purchases	Supply	Purchases	Supply	Purchases	Supply	Purchases																
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD														
Total (n=331)		912	96	879	84	3.9	3.6	2.6	2.6	0.9	1.3	0.8	1.6	11	6	13	6	4.7	3.1	4.4	3.8	5	2	5	2	148	117	216	125	0.75	0.35	0.60	0.15
Type	Granola (n=121)	979*	100	971*	84	6.8*	3.7	5.9*	3.3	1.6*	1.7	2.7*	2.9	11	3	12	1	4.7	1.3	4.5	1.1	6*	2	6*	2	90*	72	117*	82	0.84*	0.34	0.60	0.16
	Sweetened (n=65)	879	59	862*	42	1.9*	1.6	1.9*	1.2	0.3*	0.5	0.4	0.4	16*	6	17*	5	3.3*	1.8	3.7	1.9	4*	1	4*	1	201*	122	218	125	0.66	0.37	0.61	0.13
	Plain (n=51)	900	71	887	29	1.8*	3.0	0.7*	1.4	0.2*	0.3	0.1*	0.2	5*	4	6*	2	3.7	2.7	1.6*	2.7	5	2	4	1	199	130	328*	78	0.75	0.45	0.53	0.14
	Muesli (n=34)	866*	50	833*	67	3.4	1.9	2.5	1.6	0.9	0.8	0.4	0.5	12	4	14	3	4.6	1.3	5.1	1.2	5	1	5	1	101	87	168	75	0.66	0.23	0.58	0.12
	Chocolate (n=17)	883	84	916	42	3.2	2.2	4.0	1.5	0.9	1.6	0.5	0.5	17*	4	18*	2	2.9	1.6	3.8	1.4	4*	1	4	0	192	114	281	70	0.87	0.36	0.74*	0.13
	Bitesize (n=17)	854	54	874	42	1.5*	0.8	1.8	0.8	0.2	0.2	0.3	0.2	6*	4	7*	4	6.0*	2.3	6	1.7	5	1	6*	1	177	158	182	129	0.58	0.21	0.48*	0.10
	Light (n=15)	874	42	862	38	3.1	1.8	2.1	1.6	0.5	0.5	0.3	0.5	11	3	11	3	6.4	3.3	4.4	3.3	8	3	7*	3	196	102	265	114	0.79	0.11	0.78*	0.10
	Fibre (n=11)	757*	113	674*	105	2.2	1.4	1.8	0.5	0.7	1.2	0.2	0.3	10	4	11	4	15.0*	8.1	17.5*	6.4	5	1	6*	1	212	118	281	93	0.66	0.17	0.60	0.10

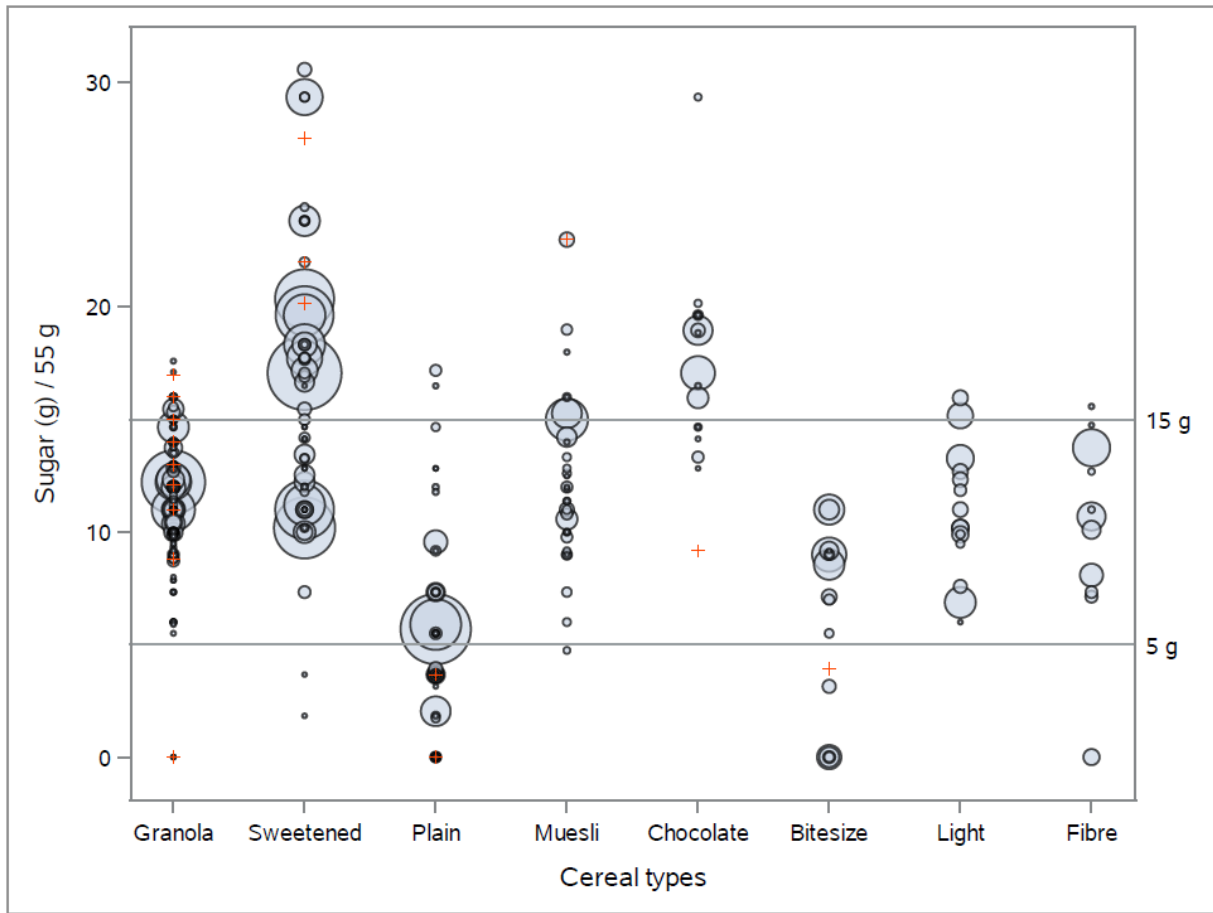
447 SD, Standard deviation

448 Supply represents the average nutritional value of the cereals found on the shelves (n = 331)

449 Purchases represents the average nutritional value of cereals weighted by sales volume (n = 306).

450 *Significantly different from other cereals (p<0.00078). This threshold equals to the Bonferroni correction for supply and purchases separately.

451 **FIGURE 1**



452
453 **Figure 1. Distribution of sugar content of different types of ready-to-eat breakfast cereals**
454 **and their sales volume**
455 The bigger the circles the higher the sales (kg)
456 Signs + represent RTE breakfast cereals for which sales data were not available