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Food and Nutrition of Indigenous Peoples

Seasonal and Community Size-Related Patterns of Population Dietary Energy, Macronutrients, and Fiber Purchased in Grocery Stores across Nunavut, Canada

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A B S T R A C T

Background: Food composition-linked grocery sales data provide time- and resource-efficient, low-bias population nutrition insights. This is particularly valuable in the Inuit-majority territory of Nunavut, Canada, where up-to-date diet-related data are lacking amid a nutrition transition.

Objectives: We aimed to investigate whether, in 21 Nunavut communities served by a market-dominant retailer: *1*) mean daily per capita sales of energy, macronutrients (protein, fat, and carbohydrate), and fiber; *2*) percentage of energy from each macronutrient; 3) mean daily energy density; and 4) food category contributions to sales of energy, macronutrients, and fiber differed across the *1*) 6 Inuit-defined seasons and *2*) 5 community size levels (with the territorial capital, Iqaluit, representing the highest level).

Methods: Each of 24,463 unique products sold between 1 February, 2013, and 31 July, 2019 was matched to its closest nutritional equivalent in the Canadian Nutrient File or the United States FoodData Central database for energy, macronutrient, and fiber values to be multiplied by product amount. Per capita standardization was performed with 2016 Census data. Analysis of variance tested for the statistical significance of differences in means.

Results: Consumer nutrition patterns were seasonally consistent. In the 4 community size levels other than Iqaluit, percentage of energy from protein was relatively low (9%–10%), percentage of energy from carbohydrate was high (63%–66%), and food energy density was high (295–319 kcal/100 edible g). Purchases were least energy-dense in Iqaluit and the largest community size quartile (276 and 295 kcal/100 edible g, respectively). Among 16 categories and across community size levels, Beverages and Juices & Drinks constituted roughly one-fifth of energy and one-third of carbohydrates sold. Sale of fiber was consistently low (6–7 g/capita/day).

Conclusions: To our knowledge, this is the first analysis of nutrient-linked grocery sales data in the Arctic. Our findings reveal energy-dense, high-carbohydrate, low-protein, low-fiber store-bought grocery sales in the context of an advanced nutrition transition in Nunavut.

Keywords: food retail, grocery sales, food composition data, nutrition transition, Inuit, Nunavut

Abbreviations: AMDR, Acceptable Macronutrient Distribution; ANOVA, analysis of variance; CNF, Canadian Nutrient File; IHS, Inuit Health Survey; NWC, North West Company; USDA, United States Department of Agriculture.

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Introduction

The majority-Inuit, Arctic territory of Nunavut, Canada has been undergoing a sustained nutrition transition for a century, with dietary patterns shifting away from traditional, harvested staples (locally called "country food") toward store-bought food [1–4]. This growing reliance on convenient, generally more energy-dense store-bought food bears major implications for community nutrition and health [1,3,5–7], with the prevalence of overweight or obesity increasing from 51.3% in 2003 to 59.5% in 2013 [7] and the prevalence of diabetes rising from 1.5% in 2004–2005 to 3.3% in 2012–2013 [6]. Such increases in chronic conditions have become common in Indigenous and other colonized populations that have undergone or are currently undergoing a nutrition transition away from their traditional diets; as a result, many of these communities face a double burden of overnutrition and undernutrition [8–10].

In Nunavut, store-bought foods and beverages are flown or sealifted from southern Canada and sold almost exclusively in 2 grocery chains [11]. These foods and beverages tend to be less nutritious than country food, yet shopping in these stores is increasingly more convenient, can be cheaper than harvesting, and is federally subsidized by the Nutrition North Canada program (to ease food retailers' shipping costs to remote northern communities)—fueling the nutrition transition [12–14].

Despite Inuit expressing food sovereignty preference for increased access to country food, climate change and other issues have made harvesting more challenging, further driving the transition to store-bought food [3,13,15]. Dietary recall data from the 2007–2008 Inuit Health Survey (IHS) revealed that country food comprised a minority of daily energy, especially among younger persons: 12.5% of nonalcohol calories among participants aged <40 y compared with 25.6% among those aged ≥40 y [16]. Territory-wide nutrient intake data have not been collected since 2007–2008, underscoring the need for more current analyses. Prior studies have pinpointed dietary fiber intakes below recommendations as a longstanding public health issue, and ongoing declines in the consumption of country foods have raised concerns about reduced protein, n–3 (ω-3) fatty acids, and several micronutrient intakes [17–21].

Investigations into the nutritional makeup of store-bought food in the contemporary diet of Nunavummiut (residents of Nunavut) are lacking and urgently needed to inform population nutrition programs and policies [22]. Epidemiologists looking for rigorous ways to study population dietary trends and health policymakers designing and evaluating diet-related interventions are paying increasing attention to retail food environments [23–29]. Although it is generally not possible to analyze store-level grocery sales data at the individual level—limiting analytic granularity to ecological (in this study, community) scale—when linked to energy and nutrient values using food composition databases, they remain a rich source of valuable information about consumer nutrition and health behavior at the population level. Such data are also free from many limitations such as recall bias and self-report error that plague other dietary assessment methods, including 24-h recall, food frequency questionnaires, and food diaries, which have been used extensively with Inuit communities in Canada [2,23,24,28–32].

Nearly all Nunavut communities have 2 grocery stores—each operated by one of the 2 retail chains: the North West Company (NWC, whose stores are often called NorthMart or the Northern) or Arctic Co-operatives Limited (the Co-op). Convenience stores, restaurants, or other food vendors are extremely rare outside of Iqaluit (the territorial capital). As a result, grocery sales by the 2 chains constitute the vast majority of store-bought contributions to the diet of Nunavummiut.

Inuit define their 6 seasons by amount of daylight, sea ice compared with open-water trail use, and temperature—factors associated with wildlife availability and subsistence practices [33]. Given the continued, partial dietary reliance on harvesting, Inuit seasonality constitutes a germane analytic stratification variable in local studies of diet and nutrition. Some studies in Nunavut communities have examined dietary patterns' seasonality (with seasons less strictly defined), but none to our knowledge have done so using the 6 Inuit-defined seasons [17,30]. The population size of a community is a second useful stratification variable because it serves as a strong proxy for country food reliance: smaller communities tend to engage more frequently in traditional subsistence (and face higher poverty and poorer health outcomes) [34–36].

In this study, using food and beverage sales data from stores owned by NWC, we investigated population dietary energy, macronutrient, and fiber patterns in 21 communities across Nunavut, stratified by Inuit-defined season and community population size. Our specific descriptive objectives were to estimate the following characteristics of food and beverage sales by each of our 2 stratification variables: *1*) mean daily per capita energy, macronutrients (protein, fat, and carbohydrate), and fiber; *2*) percentage of energy from each macronutrient; *3*) mean daily energy density; and *4*) food category contributions to sales of energy, each macronutrient, and fiber. To our knowledge, this is the first study examining purchases based on food retailer-provided, energy- and nutrient-linked grocery sales data in the Arctic. We expect our findings to inform the work of food and health policymakers, nutritionists, and researchers in a context in which current data on population nutrition are lacking.

Methods

Sales data source information and preprocessing

NWC, which has a majority market share in much of the northern retail food landscape in Canada [37], provided store-level data on daily sales in 21 grocery stores in Nunavut from 1 February, 2013, to 31 July, 2019. For each store and day, the dataset recorded the discrete number of units of each product sold (along with weight in grams or pounds or the liquid volume). NWC assigned each product to a subclass; in turn, subclasses were grouped into classes, and classes were grouped into categories. We focused our analysis on categories because subclasses and classes were too granular and numerous for ease of reporting. To draw more dietetically salient conclusions, as well as to improve statistical power, we combined a number of original categories into 12 broader categories. In addition, we included 4 of the original categories to yield a total of 16 categories: Baked Goods; Baking Ingredients, Spreads, & Syrups; Beverages; Biscuit, Cookies, & Dry Bread; Breakfast Foods; Candy & Confections; Canned Foods; Condiments, Dressings, & Sauces; Eggs &

Dairy; Fresh & Frozen Meat; Frozen Prepared Foods; Juices & Drinks; Pasta, Rice, Dried Vegetables, & Ethnic Foods; Processed Meats; Produce; and Snacks (Supplemental Table 1).

For a variety of reasons described in Supplemental Table 2, we excluded 6 of the original categories from our analysis (Fast Food, Baby Care, Ready-Made Dishes, In-Store Bakery, Cold Deli, and Hot Beverages). Furthermore, we excluded specific products if they were neither food nor beverages (e.g., cooking supplies or equipment), had too-vague descriptions (e.g., "party tray," "meat pack"), or lacked volume or mass information (for products for which such information could not reasonably be assumed based on similar products or generic versions of the food). Sales data on products returned to the store and sales listed in units equal to 0 were also excluded. Our final dataset included 24,463 products across 16 categories (Supplemental Table 1).

Linking grocery products to their nutritional content

We matched each of the 24,463 products to its closest nutritional equivalent in one of 2 food composition tables: the latest version (2015) of Health Canada's Canadian Nutrient File (CNF) or, failing to find a CNF match, the more comprehensive United States Department of Agriculture (USDA) FoodData Central database [38,39].

To perform the matching, we used a search algorithm based on the fuzzy matching command "matchit" in Stata 17.0 SE (StataCorp LLC) to query the CNF for suggested matches. To increase the specificity of matches offered by the algorithm, we implemented a food database mapping approach to the CNF similar to one previously published by a subset of our team that included a priori matching of each class in our database to its equivalent food group in the Statistics Canada Bureau of Nutritional Sciences system [40,41]. For the 29.9% of products lacking a CNF equivalent at the end of this process, we searched the USDA FoodData Central databases for a match. Because ultimately 85.6% of USDA-matched products were matched in its Branded Foods database, which does not consistently provide micronutrient data, our subsequent analyses were limited to energy, macronutrients, and fiber. See Supplemental Text 1 for details of the algorithm-aided matching process.

As CNF and USDA food composition data are reported per 100 g, we standardized products' units in grams. To obtain liquid products' gram amounts, we used density measurements in grams per milliliter from the FAO/INFOODS Density Database Version 2.0, the CNF's online food search tool (which sometimes offers mL–gram equivalents), and other sources [42,43]. Because food composition tables report energy and nutrients per 100 edible grams, for products that contained inedible portions (e.g., bone-in chicken drumstick, banana as sold with its peel), product weight was multiplied by 1 minus a refuse fraction (provided by the CNF or USDA) to arrive at the final (edible) grams. In this manuscript, grams (g) of a product correspond to the edible weight.

Defining community population size levels

Our dataset encompassed each of NWC's grocery stores in Nunavut, covering 21 of its 25 (84%) communities (Supplemental Figure 1). Excluding the territorial capital of Iqaluit, we categorized communities into quartiles (Q1–4) in increasing order of population size according to the 2016 Census: Q1—Kimmirut, Chesterfield Inlet, Qikiqtarjuaq, Sanirajak (named Hall Beach until 2020), and Arctic Bay; Q2—Sanikiluaq, Coral Harbour, Taloyoak, Clyde River, and Naujaat (Repulse Bay until 2015); Q3—Gjoa Haven, Kinngait (Cape Dorset until 2020), Pangnirtung, Kugluktuk, and Pond Inlet; and Q4—Igloolik, Cambridge Bay, Baker Lake, Arviat, and Rankin Inlet. Iqaluit was treated as the fifth and highest community size level. We examined the population, median income, employment rate, proportion female (calculated from the Census as the number of female respondents divided by community survey sample), median age, and number of food retailers across the community size levels (mean and SD for the communities included in each quartile) [44,45].

Consultation with in-territory colleagues revealed that reporting results according to these groupings would help protect the privacy of the non-Iqaluit communities. Iqaluit boasts a substantially larger population size, in addition to other characteristics that make its data interpretation unique and reporting of its community-specific results less sensitive [46–49].

Inuit season dates for each community

The 6 Inuit-defined seasons are Ukiuq, Upingaksaaq, Upingaaq, Aujaq, Ukiaqsaaq, and Ukiaq [33,50]. Seasonal dates, which vary by community, were derived from the 2016 Nunavut Land Use Plan and are summarized in Supplemental Table 3 [33]. Aujaq and Ukiaqsaaq are considered open-water seasons (late summer and fall); Ukiaq, Ukiuq, and Upingaksaaq tend to be colder with less daylight available and more reliance on ice as an extension of the land for travel and harvest (late fall, winter, and spring); and Upingaaq represents early summer with maximal daylight but is a period of transition from sea ice to open water.

Analytic plan

We calculated *1*) mean daily per capita sales of energy (kilocalorie per day), macronutrients (protein, fat, and carbohydrates; g per day), and fiber (g per day); *2*) percentage of energy from each macronutrient; and *3*) mean daily energy density (kcal per 100 g) of purchased food and, separately, beverages (the categories of Beverages and Juices & Drinks, as well as milk products [extracted from Eggs & Dairy]); by *1*) Inuit-defined season and *2*) community population size level. After confirming normality, we used analysis of variance (ANOVA) to test for statistical significance (with a threshold of $P < 0.05$) across Inuit-defined seasons or community size levels.

Because of the substantial differences between Iqaluit and the other 20 communities, we calculated differences across Inuit-defined seasons separately for the 20 non-Iqaluit communities (grouped) and Iqaluit. We used population estimates from the 2016 Canadian Census to calculate mean daily energy, macronutrient, or fiber sold per capita for each of the 6 Inuit-defined seasons [44]. For the 20 non-Iqaluit communities, for each season, we first calculated the per capita energy, macronutrient, or fiber sold on each date in each subregion and then calculated the daily mean across all dates and subregions.

To calculate differences across community population size levels, we first calculated the mean for the entire study period of energy, macronutrients, or fiber sold per day within each level

and then divided by the total population for that level—arriving at a nutritional unit per capita per day [44].

To calculate the percentage of energy from each macronutrient, we used the following macronutrient-specific multipliers before dividing by energy (kcal): fat, 9 kcal/g; carbohydrate, 4 kcal/g; and protein, 4 kcal/g [51].

We analyzed mean daily energy density separately for food and beverages as energy (kcal) per 100 g of edible product.

We calculated the proportional contribution of each food category (as %) to total energy, each macronutrient (fat, carbohydrate, and protein), and fiber by *1*) Inuit-defined season and *2*) community size level. For each season or community size level, and for each nutritional variable (energy, each macronutrient, and fiber), we calculated within each of the 16 categories (Supplemental Table 1) $\Sigma_i(w_i \times n_i \times s_i)$, where i = each individual grocery product, w_i = edible weight of a single unit of the product in g (edible g/unit), n_i = nutrient or energy amount in edible portion of i (nutritional units/edible g), and s_i = sales amount of i (units) and then divided by the total across all categories to arrive at each category's proportional contribution.

Results

Employment rate, median income, and median age did not exhibit clear trends across the community population size quartiles (Table 1). Q2 and Q3 had the lowest means of median employment rate (37.3% and 45.1%, respectively) and median income ($21,122 and $20,791 Canadian dollars, respectively), whereas Q2 had the lowest mean of median age (20.9 y). Iqaluit, which was classified separately, had an appreciably higher employment rate (73.9%), median income ($70,695), and median age (31.1 y) than any of the community size quartiles. The mean number of food retail stores was in the range of 2 for each community size quartile, with Iqaluit having 4 food retail stores. The proportion of females ranged from 0.47 in Q1 to 0.50 in Iqaluit.

Tables 2 and 3 summarize mean energy, protein, fat, carbohydrate, and dietary fiber purchased per capita per day as well as energy density of food and of beverages across the 6 Inuit seasons and 5 community population size levels, respectively. Iqaluit was separated entirely from the seasonal analysis and stood alone in the highest (fifth) community size level. Via ANOVA testing, for the 20 non-Iqaluit communities, we observed statistically significant differences among seasons for each of the 7 variables tested; for Iqaluit, we only observed statistically significant differences across seasons for protein and the 2 energy density variables (food and beverages). Nevertheless, these observed seasonal differences were small overall (Table 2). Percentage of energy from protein, fat, and carbohydrate was also very consistent across seasons.

There were some notable differences across community size levels (Table 3). First, Iqaluit had the lowest mean energy, fat, and carbohydrate sold per capita per day as well as the lowest mean energy density of food and beverage sales. Second, excluding Iqaluit, the smallest community size quartile (Q1) had the lowest mean energy, protein, fat, and carbohydrates sold per capita per day. Notably, among these non-Iqaluit community size levels, Q4—the largest non-Iqaluit community size level—had the lowest mean energy density among food and beverages sold and the highest protein sold per capita per day, even higher than Iqaluit. Finally, in Iqaluit, the percentage of energy from protein and fat was higher than in the other community size levels, and the percentage from carbohydrate was lower. Daily dietary fiber purchased per capita was very consistent across Inuit-defined seasons and community size levels at 6–7 g/cap/d (Tables 2 and 3).

Differences in food category contributions to each nutritional variable (energy, carbohydrate, total fat, protein, and fiber) across Inuit-defined seasons were small (Supplemental Tables 4 and 5). Food category contributions to each nutritional variable across community size levels exhibited many commonalities and several differences, especially between Iqaluit and the other community size levels (Table 4). Baking Ingredients, Spreads, & Syrups; Eggs & Dairy; and Juices & Drinks were among the top 5 contributors to energy sales for all community size levels (including Iqaluit). The contributions to energy sales of Eggs &

TABLE 1
Key characteristics of Iqaluit and the 4 community size-level quartiles (mean and SD of the 5 constituent communities of each of the respective quartiles).

Characteristic	Mean (SD) for Q1-4 and single estimate for Iqaluit				
	Q1 ($n = 5$)	Q2 ($n = 5$)	Q3 ($n = 5$)	Q4 ($n = 5$)	Iqaluit
Population[1]	628 (224)	987 (94)	1471 (105)	2203 (523)	7740
Employment rate[1] (%)	48.1 (7.7)	37.3 (2.9)	45.1 (2.9)	52.4 (10.6)	73.9
Median income (Canadian dollars)[1]	24,471 (3657)	21,122 (1922)	20,791 (1950)	29,435 (8764)	70,695
Proportion female[1]	0.47 (0.03)	0.49 (0.004)	0.48 (0.01)	0.49 (0.01)	0.50
Median age (y)[1]	23.1 (1.8)	20.9 (1.6)	23.8 (1.6)	24.4 (3.3)	31.1
Number of in-community food retail stores[2]	2 (0)	1.8 (0.4)	2 (0)	2.4 (0.5)	4

[1] Data from the 2016 Canadian Census. For median income, the variable used was "Median total income in 2015 among recipients aged 15 years and over in private households"; proportion of females for each community was calculated as the number of female respondents divided by community survey sample in the Census [44].

[2] This variable is mostly based on published data by Naylor in 2019 and is intended to represent a count of in-town food retail stores [45]. However, instead of using Naylor's value of 2 for the number of retailers in Clyde River, we used the value of 1 (an NWC store) because a second store (not of the other main grocery chain, Arctic Co-operatives Limited) only opened in this community in 2019, at the end of our study period. As the territorial capital, Iqaluit uniquely enjoys access to more options in addition to the 2 main grocery chains, including several small food retail and convenience stores, a soup kitchen (now called the Qajuqturvik Community Food Centre), a gas station selling snacks and beverages, and a few online retailers that can ship food to the community; this value is thus likely an underestimate of total food retail options for Iqaluit.

TABLE 2
Mean daily energy, macronutrient, and fiber sales, percentage of energy for each macronutrient, and mean energy density of sales of food and beverages, among groceries sold between 1 February, 2013, and 31 July, 2019, across Inuit-defined seasons (Iqaluit compared with the 20 other communities).

	Inuit-defined season						*P* value[1]
	Ukiuq	Upingaksaaq	Upingaaq	Aujaq	Ukiaqsaaq	Ukiaq	
	Late winter	Spring	Early summer	Late summer and fall (open water)		Late fall-winter	
IQALUIT							
Mean (SD) energy or nutrient sold per capita per day, and % of energy for each macronutrient[2]							
Energy (kcal/cap/day)	884 (236)	889 (235)	849 (217)	859 (246)	880 (263)	850 (291)	0.08
Protein (g/cap/d)	30 (8)	30 (8)	29 (7)	29 (8)	30 (10)	29 (10)	<0.01
% of energy/cap/day	*14%*	*14%*	*13%*	*14%*	*14%*	*14%*	
Fat (g/cap/d)	35 (10)	35 (9)	33 (9)	34 (9)	35 (11)	34 (12)	0.08
% of energy/cap/day	*36%*	*35%*	*35%*	*35%*	*36%*	*36%*	
Carbohydrate (g/cap/d)	116 (31)	117 (33)	113 (31)	114 (37)	114 (33)	111 (37)	0.34
% of energy/cap/day	*52%*	*53%*	*53%*	*53%*	*52%*	*52%*	
Fiber (g/cap/d)	6 (2)	6 (2)	6 (1)	6 (2)	6 (2)	6 (2)	0.59
Mean (SD) energy density (kcal/100 edible g)[3]							
Food (non-beverages)	277 (186)	277 (185)	276 (185)	276 (185)	276 (186)	277 (186)	<0.01
Beverages	75 (88)	73 (87)	72 (85)	71 (84)	71 (84)	72 (85)	<0.01
20 OTHER COMMUNITIES							
Mean (SD) energy or nutrient sold per capita per day, and % of energy for each macronutrient[2]							
Energy (kcal/cap/day)	1312 (571)	1268 (623)	1304 (648)	1246 (615)	1220 (582)	1268 (611)	<0.01
Protein (g/cap/d)	31 (14)	29 (15)	30 (15)	29 (14)	29 (14)	29 (15)	<0.01
% of energy/cap/day	*9%*	*9%*	*9%*	*9%*	*9%*	*9%*	
Fat (g/cap/d)	42 (18)	40 (19)	41 (20)	40 (19)	39 (18)	41 (19)	<0.01
% of energy/cap/day	*28%*	*28%*	*28%*	*29%*	*29%*	*29%*	
Carbohydrate (g/cap/d)	212 (96)	206 (106)	212 (112)	199 (104)	195 (97)	203 (102)	<0.01
% of energy/cap/day	*65%*	*65%*	*65%*	*64%*	*64%*	*64%*	
Fiber (g/cap/d)	7 (3)	6 (3)	7 (3)	6 (3)	6 (3)	7 (3)	<0.01
Mean (SD) energy density (kcal/100 edible g)[3]							
Food (non-beverages)	306 (183)	306 (182)	307 (182)	305 (182)	304 (183)	307 (183)	<0.01
Beverages	83 (95)	82 (95)	83 (96)	81 (93)	80 (93)	83 (96)	<0.01

[1] *P* value was calculated using an analysis of variance test.
[2] Total for carbohydrate contribution to energy is a slight overestimation due to USDA's "carbohydrate by difference"; hence, the percentages across distribution of macronutrients may not sum to exactly 100% [39].
[3] The energy density calculation of "Beverages" included the categories of Beverages and Juices & Drinks plus milk (extracted from the category of Eggs & Dairy), whereas "Food (non-beverages)" included all other groceries.

TABLE 3
Mean daily energy, macronutrient, and fiber sales, percentage of energy for each macronutrient, and mean energy density of sales of food and beverages, among groceries sold between 1 February, 2013, and 31 July, 2019, across community size levels (the 4 quartiles and Iqaluit).

	Community size level					*P* value[1]
	Q1	Q2	Q3	Q4	Iqaluit	
Mean (SD) energy or nutrient sold per capita per day, and % of energy for each macronutrient[2]						
Energy[2] (kcal/cap/day)	1,156 (521)	1,308 (645)	1,313 (575)	1,334 (514)	869 (249)	<0.01
Protein[2] (g/cap/d)	26 (11)	29 (15)	29 (13)	34 (13)	30 (9)	<0.01
% of energy/cap/day	*9%*	*9%*	*9%*	*10%*	*14%*	
Fat[2] (g/cap/d)	36 (15)	42 (20)	40 (17)	43 (16)	34 (10)	<0.01
% of energy/cap/day	*28%*	*29%*	*27%*	*29%*	*36%*	
Carbohydrate[2] (g/cap/d)	188 (91)	213 (107)	215 (98)	209 (84)	114 (34)	<0.01
% of energy/cap/day	*65%*	*65%*	*66%*	*63%*	*53%*	
Dietary fiber[2] (g/cap/d)	6 (3)	6 (3)	7 (3)	7 (3)	6 (2)	<0.01
Mean (SD) energy density (kcal/100 edible g)[3]						
Food (non-beverages)	313 (180)	319 (182)	308 (183)	295 (183)	276 (186)	<0.01
Beverages	80 (93)	84 (98)	91 (99)	77 (91)	72 (86)	<0.01

[1] *P* value was calculated using an analysis of variance test.
[2] Total for carbohydrate contribution to energy is a slight overestimation due to USDA's "carbohydrate by difference"; hence, the percentages across distribution of macronutrients may not sum to exactly 100% [39].
[3] The energy density calculation of "Beverages" included the categories of Beverages and Juices & Drinks plus milk (extracted from the category of Eggs & Dairy), whereas "Food (non-beverages)" included all other groceries.

TABLE 4
Category contributions (%) to energy, macronutrient, or fiber sales by community population size level between 1 February, 2013, and 31 July, 2019.

Energy or nutrient Category	Contribution (%) by community size level				
	Q1	Q2	Q3	Q4	Iqaluit
Energy					
Baked Goods	6.46	6.49	6.27	6.66	6.63
Baking Ingredients, Spreads, & Syrups	13.32*	16.58*	14.14*	15.61*	11.93*
Beverages	9.33*	9.38*	7.80*	6.89*	4.35
Biscuit, Cookies, & Dry Bread	2.91	2.79	2.51	2.61	2.21
Breakfast Foods	2.71	2.77	2.84	2.80	2.94
Candy & Confections	6.18	5.48	6.21	4.08	3.49
Canned Foods	3.11	3.48	3.22	2.96	2.49
Condiments, Dressings, & Sauces	1.09	0.98	1.30	1.53	1.88
Eggs & Dairy	12.39*	11.82*	11.81*	13.80*	17.99*
Fresh & Frozen Meat	5.21	5.51	5.66	7.44	12.24*
Frozen Prepared Foods	1.69	1.46	1.23	1.18	1.28
Juices & Drinks	12.21*	10.32*	15.46*	12.21*	6.90*
Pasta, Rice, Dried Veg., & Ethnic Foods	5.87	5.95	6.03	6.67	6.11
Processed Meats	3.51	3.51	3.43	3.88	4.63
Produce	4.03	3.69	3.68	4.11	8.35*
Snacks	9.96*	9.79*	8.41*	7.57*	6.58
Total carbohydrate					
Baked Goods	6.89	7.07*	6.79	7.55*	8.92*
Baking Ingredients, Spreads, & Syrups	14.65*	18.40*	14.91*	18.57*	13.84*
Beverages	14.94*	15.10*	12.27*	11.50*	9.07*
Biscuit, Cookies, & Dry Bread	2.90	2.78	2.49	2.69	2.63
Breakfast Foods	3.54	3.63	3.67	3.77	4.67
Candy & Confections	7.37*	6.56	7.82*	4.77	4.88
Canned Foods	2.45	2.74	2.61	2.50	2.61
Condiments, Dressings, & Sauces	0.75	0.63	0.76	0.99	1.54
Eggs & Dairy	5.56	4.66	4.76	5.64	7.91
Fresh & Frozen Meat	0.64	0.63	0.51	0.59	0.65
Frozen Prepared Foods	1.14	0.98	0.84	0.84	1.08
Juices & Drinks	19.83*	17.78*	24.45*	20.71*	13.53*
Pasta, Rice, Dried Veg., & Ethnic Foods	6.83	7.02*	7.21*	8.20*	8.89
Processed Meats	0.46	0.50	0.44	0.53	0.65
Produce	5.08	4.77	4.68	5.62	13.37*
Snacks	6.97*	6.75	5.78	5.52	5.77
Total dietary fat					
Baked Goods	4.15	3.69	3.56	3.45	2.89
Baking Ingredients, Spreads, & Syrups	12.84*	15.20*	14.56*	12.58*	12.33*
Beverages	0.04	0.03	0.04	0.05	0.03
Biscuit, Cookies, & Dry Bread	2.88	2.71	2.48	2.53	1.98
Breakfast Foods	0.83	0.76	0.90	0.89	0.82
Candy & Confections	4.90	4.27	3.90	3.67	2.57
Canned Foods	3.50	3.84	3.57	3.05	2.04
Condiments, Dressings, & Sauces	2.08	1.95	2.87	3.03	2.91
Eggs & Dairy	24.37*	24.59*	25.46*	28.08*	30.48*
Fresh & Frozen Meat	9.87*	10.38*	11.35*	14.02*	18.40*
Frozen Prepared Foods	2.45	2.06	1.79	1.61	1.45
Juices & Drinks	0.26	0.11	0.57	0.13	0.18
Pasta, Rice, Dried Veg., & Ethnic Foods	2.31	2.05	1.97	2.22	1.88
Processed Meats	8.84*	8.59*	8.94*	9.47*	9.40*
Produce	2.28	1.81	1.93	1.68	3.21
Snacks	18.39*	17.96*	16.09*	13.54*	9.44*
Protein					
Baked Goods	8.64*	8.93*	8.88*	8.68*	6.55*
Baking Ingredients, Spreads, & Syrups	5.15	6.30	6.96	5.96	4.11
Beverages	0.16	0.16	0.16	0.20	0.11
Biscuit, Cookies, & Dry Bread	2.35	2.28	2.09	1.86	1.06
Breakfast Foods	2.42	2.45	2.47	2.17	1.84
Candy & Confections	1.99	1.80	1.51	1.37	0.85
Canned Foods	6.36	7.03	6.29	5.33	3.19
Condiments, Dressings, & Sauces	0.48	0.45	0.55	0.61	0.60
Eggs & Dairy	22.08*	20.10*	20.02*	21.37*	22.76*
Fresh & Frozen Meat	21.27*	22.56*	23.31*	27.64*	36.83*
Frozen Prepared Foods	2.87	2.56	2.10	1.81	1.44
Juices & Drinks	1.09	0.61	2.45	0.49	0.58
Pasta, Rice, Dried Veg., & Ethnic Foods	7.89*	7.99*	7.53*	7.74*	5.17
Processed Meats	7.55*	7.52*	7.27*	7.19*	6.50*
Produce	3.53	3.18	3.21	3.43	5.47*
Snacks	6.18	6.08	5.18	4.15	2.94
Dietary fiber					
Baked Goods	15.77*	16.38*	16.50*	17.93*	14.40*
Baking Ingredients, Spreads, & Syrups	6.47	7.90*	8.46*	8.34*	7.03*
Beverages	0.07	0.07	0.08	0.14	0.04
Biscuit, Cookies, & Dry Bread	2.55	2.72	2.17	2.46	1.89
Breakfast Foods	9.11*	9.38*	9.24*	8.85*	7.82*
Candy & Confections	3.70	3.49	2.95	2.72	1.79
Canned Foods	6.15	6.47	6.05	6.05	4.54
Condiments, Dressings, & Sauces	2.43	2.25	2.57	2.89	2.93
Eggs & Dairy	1.54	0.92	0.88	1.65	1.43
Fresh & Frozen Meat	1.47	1.58	1.19	1.28	0.73
Frozen Prepared Foods	2.22	2.06	1.74	1.62	1.25
Juices & Drinks	3.47	2.44	6.63	3.42	1.98
Pasta, Rice, Dried Veg., & Ethnic Foods	6.99*	7.24	7.35	7.97	6.39
Processed Meats	0.44	0.36	0.36	0.22	0.17
Produce	20.80*	20.32*	19.89*	22.62*	38.78*
Snacks	16.81*	16.43*	13.94*	11.85*	8.82*

*The top 5 categories contributing to energy and to each nutrient by community size level are indicated by asterisks.
N.B. Due to rounding, totals may not sum to exactly 100%.

Dairy; Fresh & Frozen Meat; and Produce were higher in Iqaluit compared with the other communities, and the contributions of Beverages and Juices & Drinks were lower.

Baking Ingredients, Spreads, & Syrups; Beverages; and Juices & Drinks were among the top 5 contributors to carbohydrate sales for all community size levels, with the contributions of all 3 lowest in Iqaluit, where the contribution of Produce was high. Baking Ingredients, Spreads, & Syrups; Eggs & Dairy; Fresh & Frozen Meat; Processed Meats; and Snacks were the top 5 contributors to total fat sales for all community size levels, with gradients of increasing contribution with rising community size level for Eggs & Dairy and Fresh & Frozen Meat and decreasing contributions with rising community size level for Snacks. Baked Goods; Eggs & Dairy; Fresh & Frozen Meat; and Processed Meats were among the top 5 contributors to protein sales for all community size levels, with Fresh & Frozen Meat showing a gradient

of increasing contribution with rising community size level. Finally, Baked Goods; Breakfast Foods; Produce; and Snacks were among the top 5 contributors to fiber sales for all community size levels, with the contribution of Produce highest in Iqaluit and the contribution of Snacks showing a gradient of decreasing contribution with rising community size level.

Discussion

We investigated energy, macronutrient, and fiber patterns among food and beverage sales in Nunavut across the 6 Inuit seasons and 5 community population size levels. Our work covers 21 (of 25 total) communities with negligible spillover risk (due to no connecting roads and high shipping costs) and 6.5 y of daily sales of products by one of the territory's 2 major food retailers. The ever-growing preponderance of store-bought food in the contemporary Inuit diet calls for special attention to grocery sales patterns and their public health nutrition implications.

We documented largely consistent sales of energy, each macronutrient, and fiber across Inuit-defined seasons. However, purchases differed across community size levels in a pattern that suggested healthier, less energy-dense purchases in Iqaluit and the largest community size quartile. Overall, our results were consistent with an advanced state of nutrition transition, with energy-dense, high-carbohydrate, low-protein, low-fiber store-bought contributions to diet in Nunavut.

The consistent consumer purchasing behavior of energy, macronutrients, and fiber we observed across the Inuit-defined seasons was a departure from results in a 1987–1988 study in Qikiqtaaluk (Baffin Island) that found variation in dietary intake across the calendar year, attributed to the fluctuating availability of and access to particular country foods [30]. Deseasonalization is likely the result of several dynamics, including the globalization of food systems, Nutrition North Canada's federal subsidies for food retailers in these remote communities, consumer demand (as in other contexts) for year-round availability of products, and actual year-round product availability [52–54]. The latter is due to the summer sealift bringing a substantial proportion of shelf-stable and frozen products as well as year-round flights (weekly up to daily in a few communities) supplying refrigerated and fresh store-bought staples such as fresh meat, dairy, produce, and eggs.

Leaving aside Iqaluit, the fact that the smallest community size quartile had the lowest amounts of mean energy and macronutrients sold per capita per day may reflect that smaller communities tend to be more reliant on harvesting and may therefore be deriving less of their diet from groceries—or perhaps just from NWC (instead buying relatively more from the other major chain) [35,55]. Alternatively, given the high poverty and limited employment opportunities available in smaller communities in Nunavut, low energy and macronutrients sold may be a manifestation of overall food insecurity (i.e., eating less of both store-bought and country food) [56]. Conversely, the fact that the largest community size quartile had the highest protein sold per capita per day is consistent with the largest non-Iqaluit communities being less reliant on protein-rich country food than smaller communities and/or the largest communities being wealthier, resulting in greater food security. Limited data exist on individual community food security status; recent estimates from across Nunavut include only the 10 most populous communities [57].

The lower energy, fat, and carbohydrate sold per capita per day at the NWC grocery store in Iqaluit compared with the other 20 communities is consistent with Iqaluit having numerous food retail options in addition to the 2 major grocery chains; this includes several small food retail and convenience stores, a soup kitchen, a gas station selling snacks and beverages, and a few online retailers that can ship food from elsewhere in Canada to the community [46–49]. Iqaluit had the highest percentage of energy from protein, the lowest percentage of energy from carbohydrate, and the lowest energy density of food and beverage sales. One possible interpretation is that Iqaluit residents enjoy healthier diets than those in the other 20 communities; however, it is also possible that in Iqaluit, healthier NWC food sales are counterbalanced by unhealthy food sales from non-NWC retail sources, especially convenience stores that likely sell more energy-dense foods, resulting in a diet that is not, in fact, overall healthier than that in the other 20 communities. These alternative explanations should be explored in future research.

The top categories contributing to energy, macronutrients, and fiber were largely consistent across community size levels (moreso across the non-Iqaluit community size quartiles); their contributions echoed dietary recall studies in Nunavut of food sources of energy and nutrients. The 2007–2008 IHS conducted across the territory revealed that sweetened beverages contributed 25.2% of mean daily carbohydrate intake, with fruit juice contributing 3.1% [16]. In a 24-h dietary recall study of 2 Nunavut communities published by Sharma et al. [17] in 2010, sweetened juices/drinks and regular soda/soft drinks were 24.1% and 6.5% of carbohydrate intake, respectively, raising concerns about the risks of chronic conditions such as diabetes. Our study found that in the 20 non-Iqaluit communities, Juices & Drinks and Beverages collectively contributed about a fifth of energy and a third of carbohydrate sold. In the IHS data, "solid" vegetables and fruit were 11.2% and 5.7%, respectively, of daily dietary fiber intake in the territory [16], whereas we found that roughly a fifth of fiber sold in non-Iqaluit communities came from produce (rising to almost two-fifths in Iqaluit). The category Baking Ingredients, Spreads, & Syrups was among the top 5 contributors to energy, carbohydrate, and fat, which would be expected given that this category includes products such as sugar and oils/lard that were among the top sources of energy, carbohydrate, and fat in the IHS and the study by Sharma et al. [17].

In our work, Snacks were among the top 5 contributors to energy, fat, and fiber sold (except energy in Iqaluit). This is consistent with the results of the IHS, which found potato chips to be a robust contributor to fat and fiber, and with the study by Sharma et al. [17], which found chips to be a top contributor to energy, fat, fiber, and carbohydrates. These results touch on the complicated social and dietary role of these products in Nunavut, where convenience may be preferred because of factors including food preparation time and skills, access to cooking facilities, and household overcrowding [58]. Interestingly, Snacks showed a gradient of decreasing contribution to energy, fat, and fiber, respectively, with rising community size level (including Iqaluit). The role of convenience in the popularity of typically energy-dense snacks should be explored along with the

costs and benefits of potential community nutrition interventions.

Although some of our results align with previously published estimates of store-bought contributions to energy and nutrient intake via dietary assessment methods, others are distinct and suggest a deepening of the nutrition transition in Nunavut. Carbohydrate trends in particular serve as our strongest bellwether of this transition because country food contains very little to none of this macronutrient [59]. Carbohydrate sales (g/cap/d) in the non-Iqaluit communities in our study were comparable with carbohydrate consumption estimated by individual dietary intake recall data from 1987 to 1988 in the community of Qikiqtarjuaq [30] and more recently in the study by Sharma et al. [17] (~200 g/cap/d in our study compared with roughly 147–271 g/cap/d in the previous studies). However, in the earlier studies, participants reporting their intake had access to both main grocery chains, suggesting a possible increase over time in store-bought carbohydrates.

Changes over time in percent distributions of contributions of carbohydrate and protein to total energy among purchased store-bought foods further suggest that the nutrition transition in Nunavut has likely progressed. The best comparison is to the 1987–1988 study by Kuhnlein et al. [30], in which the researchers stratified their reporting by country compared with store-bought ("market") food. At that time, Inuit aged 3–60 y took in 53%–62% of their store-bought dietary energy from carbohydrates [30]. In our analysis, we found that non-Iqaluit communities sourced 63%–66% of their store-bought energy from carbohydrates. Meanwhile, the relative contribution of protein to energy sold in stores declined from 10%–13% in the 1987–1988 study to 9%–10% in the 20 non-Iqaluit stores in our study [30]. For fats, the percent contribution to calories was roughly the same as in our recent study timeframe: 28%–35% of energy among store-bought foods [30].

These changes suggest a modest shift in consumer purchasing behavior away from Health Canada's Acceptable Macronutrient Distribution Range (AMDR): 45%–65% of calories are recommended to come from carbohydrates, 5%–20% and 10%–35% from protein (4–18 and 19+ y olds, respectively), and 25%–35% and 30%–40% from fat (4–18 and 19+ y olds, respectively) [60]. In comparison with Nunavut, the majority of Canadian adults in a representative sample from the 10 provinces (who are generally not at all or minimally reliant on harvesting) consumed macronutrients within the recommended AMDR [59]. The higher carbohydrate-to-energy and lower protein-to-energy ratios among grocery sales in non-Iqaluit communities are particularly concerning because, as already noted, since 1987–1988, the contribution of store-bought food to total energy has risen in Nunavut in conjunction with declines in consumption of more protein-rich country food [30].

Because fiber is largely absent in country food, it has been of particular dietary concern for many years. The study by Sharma et al. [17], published in 2010, revealed mean daily dietary fiber intake in Nunavut to be 8–9 g, well below Canada's recommended adequate intake of 25 g for women and 38 g for men. We found that grocery sales at NWC stores in Nunavut provided only 6–7 g/cap/d; even if we were able to account for fiber purchased at the other major grocery chain, fiber consumption would likely still be substantially lower than Canada's recommended adequate intake. Low-fiber diets have been linked in diverse populations to constipation, diverticulosis, irritable bowel syndrome, and heart disease [61–64].

An energy-dense diet leads to increases in body mass over time [65,66]. Energy-dense foods such as cereal, grains, chips, and candy are often favored by food retailers in the Arctic because they do not require a cold chain so are less costly to ship to remote locations than refrigerated products [67]. Across community size levels, mean energy density of food sold ranged from 276 to 319 kcal/100 edible g; these values align with "medium energy dense" foods (as defined by Rolls), such as "breads, desserts, fat-free baked snacks, cheeses, and higher-fat meats" [68]. Our observed range is substantially higher than the mean dietary energy density of foods consumed by the quartile of Canadian adults with the lowest quality diet (215 kcal/100 g) [69], although it must be noted that our grocery sales data are unable to offer a complete dietary picture because they do not capture less energy-dense country food or sales from other retail sources. Although beverages are usually excluded from energy density calculations in diet and nutrition studies, beverage-specific energy density is receiving increasing attention [70,71]. Biltoft-Jensen et al. [70] found energy-dense, nutrient-poor drinks had an average energy density of 86 kcal/100 g, which is within the range of 72–91 kcal/100 g that we observed across community size levels.

Our study had limitations. First, we could not account for population dietary estimates of country food, which tends to be richer in an array of nutrients and lower in energy density compared with many store-bought foods [42]. Country food intake should continue to be supported and encouraged for its nutritional benefits, particularly in juxtaposition to the high energy density of food and beverage purchases. We also could not account for the role of key demographic and lifestyle contextual variables that are crucial for interpreting dietary patterns and food purchasing behavior such as alcohol consumption and body mass index. Based on global patterns in contexts of nutrition transition and rising rates of overweight and obesity in the 2000s in Nunavut, one might expect these trends to have continued throughout our study period [6–9].

Despite NWC's market dominance in the local retail landscape, we do not know the proportion of grocery sales that our data represent within each community, especially in relation to the other major retail chain. In addition, we only know what was purchased and not what was consumed or how it was prepared. We also were unable to include several of NWC's food categories in our analysis, resulting in a slight underestimation of our per capita outcomes; this most affected Iqaluit, whose store is by far the largest, with the most excluded products.

NWC's food categories were not designed for nutritional analyses, and some were overly broad; for instance, Canned Foods included canned fruit, vegetables, soup, and seafood, and Eggs & Dairy encompassed both high- and low-fat products. Future research would benefit from a more nutrient-driven and/or culturally adapted categorization system. Although this cross-sectional ecological study represents population-wide, per capita mean estimates in the 6.5-y period studied, future longitudinal approaches could help reveal important temporal patterns and associations with policy interventions, economic factors, or climate-related disruptions to the local food system.

An additional limitation was the exclusion of 4 communities that lack (or lacked during our study period) an NWC store: Kugaaruk (where an NWC store recently opened), Resolute, Grise Fiord, and Whale Cove. Sales data from the Arctic Co-op would therefore have represented total groceries sold within each community. On the other hand, the 4 grocery retailers in Iqaluit enumerated by Naylor [45] are likely an undercount (see Table 1 footnote for details). Ideally, future research will include nutrition information-linked grocery sales data from all food retail options; for nearly all communities in our study period apart from Iqaluit, this would have entailed the simple supplementation of our NWC data with that of the Co-op—with the exception of Clyde River, where NWC operated the only store for the majority of the study period. As online food shopping options have increasingly penetrated the food system across Nunavut in recent years beyond Iqaluit, imputation methods based on in-store compared with online retail purchasing patterns will likely become necessary.

The ascendance of store-bought food in the diet of Nunavummiut has implications for public health, nutrition, and policy. High mean energy density of groceries purchased as well as the major contributions of beverages, juices, and other typically sweetened drinks toward total sales of energy and carbohydrate are of particular concern given rising overweight, obesity, and diabetes in Inuit communities [3]. Regarding policy, many Nunavummiut feel that Nutrition North Canada prioritizes retailers within the Inuit food system, enabling continued colonialism in the name of food security [57]. Inuit organizations now frame food security and the nutrition transition as food sovereignty issues [15,58,72]. Nutrition North Canada has expanded its grant programs to support the harvest of country food in addition to its ongoing subsidies to grocery retailers [73].

Although the future of food sovereignty in Nunavut remains to be charted, the food composition–linked food and beverage sales database we have generated and analyzed offers new population dietary surveillance insights. We revealed energy, macronutrient, and fiber sales and energy density patterns among store-bought foods purchased in a major grocery chain across Nunavut. Such surveillance can help guide decision making by public health and food system stakeholders as well as future studies to probe the role of food and health policy in consumer nutrition behavior in Nunavut.

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Author contributions

The authors' responsibilities were as follows – SZG, MJ, JDF, NLH, RD: conceptualization; SZG, MJ, JDF, NLH, RP-E, RD: methodology; SZG: software and project administration and funding acquisition; SZG, RD: investigation; SZG, MJ, JDF, NLH, RD: writing—original draft preparation; and all authors: analysis and cointerpretation, writing—review and editing, read and approved the final manuscript.

Institutional review board statement

Given that the store-level data used in this work were not identifiable at the individual level, this study was deemed not to be human subjects research by the Yale University Institutional Review Board (protocol 2000028795). As such, and in lieu of a research license, this project was registered with the Nunavut Research Institute (registry no. 01 038 22).

Conflict of interest

SZG reports financial support was provided by National Institute of Environmental Health Sciences, Yale Center on Climate Change & Health, Yale International Fox Fellowship Program, Whitney & Betty MacMillan Center for International & Area Studies at Yale, Yale Institute for Biospheric Studies, Yale Global Health Initiative, Yale Sustainable Food Program, and P. E.O. International. Throughout the course of this study, LK was an employee of the North West Company (whose data were used in this work and which had no role in study funding, design, or analysis). RP-E is an Editorial Board Member for *Current Developments in Nutrition* and played no role in the journal's evaluation of the manuscript. The other authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The grocery sales data and code described in the manuscript will not be made available because they are under contract via a data use agreement between Yale University and the North West Company. Linkage of products to their food composition data was done using 2 national, publicly available databases: the Canadian Nutrient File and the USDA FoodData Central.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cdnut.2025.107558.

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