Vol. 13 No. 2, pp. 86–116 August 2026

Canadian Food Studies
La Revue canadienne des études sur l'alimentation

Research Article

New life cycle database on food consumption: A strategic tool to drive Climate-Smart Action in Québec

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Abstract

Purpose: Food consumption is a major contributor to individual carbon footprint but production conditions, supply-chain configurations, and eating habits vary significantly across regions. A regionalized overview of food consumption patterns and their potential impact on climate change is therefore essential to allowing businesses, governments, and citizens to reach more sustainable food consumption targets.
Methods: We collected and structured data to develop the first life cycle inventory database of food consumption in the province of Québec (Canada) and build a farm-to-fork model covering 58 food categories consumed in 2018. Food intakes are derived from a 24-hour recall survey of 2297 Québec adults conducted in 2015. Consumption markets (domestic and imported) based on the Québec Ministry of Agriculture, Fisheries and Food data, food production processes, food loss and waste rates based on FAO data, and transportation distances are regionalized. We analyze the main contributors to food consumption carbon footprint across the supply chain and outline the profiles of eight Québec adult archetypes.
Results: The average food consumption carbon footprint in Québec is 2377 kg CO_2eq per capita per year. Gender-and-age-based carbon footprint archetypes range from 1.7 and 2.9 metric tons CO_2eq/adult/year. Meat and dairy contribute to 48%, and food waste contributes 17% to the carbon footprint of purchased food.
Perspectives: This initial diagnostic provides a baseline for identifying the key drivers of Québec's food consumption carbon footprint. While further regionalization and greater granularity are still needed, this initiative offers a solid foundation for stakeholders to shape sustainable food systems and drive climate change mitigation.

Keywords: carbon footprint, GHG emissions, life cycle assessment, Québec, life cycle inventory database, food consumption

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DOI: 10/15353/cfs-rcea.v13i2.792
ISSN: 2292-3071

Résumé

Objectif : La consommation alimentaire est un facteur majeur de l'empreinte carbone individuelle, mais les conditions de production, les configurations des chaînes d'approvisionnement et les habitudes alimentaires varient considérablement d'une région à l'autre. Il est donc essentiel d'avoir une vue d'ensemble régionalisée des modes de consommation alimentaire et de leur impact potentiel sur le changement climatique pour permettre aux entreprises, aux pouvoirs publics et aux citoyens d'atteindre des objectifs de consommation alimentaire plus durables.
Méthodes : On a collecté et structuré des données pour développer la première base de données d'inventaire du cycle de vie de la consommation alimentaire dans la province de Québec (Canada) et construire un modèle « de la ferme à l'assiette » couvrant 58 catégories d'aliments consommés en 2018. Les apports alimentaires proviennent d'une enquête de rappel alimentaire sur 24 heures menée en 2015 auprès de 2 297 adultes québécois. Les marchés de consommation (produits locaux et importés), d'après les données du ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec, les processus de production alimentaire, les taux de pertes et de gaspillage alimentaires d'après les données de la FAO, ainsi que les distances de transport, sont régionalisés. On analyse les principaux facteurs contribuant à l'empreinte carbone de la consommation alimentaire tout au long de la chaîne d'approvisionnement et on dresse le profil de huit archétypes d'adultes québécois.
Résultats : L'empreinte carbone moyenne de la consommation alimentaire au Québec est de 2 377 kg d'équivalent CO_2 par habitant et par an. Les profils d'empreinte carbone, selon le sexe et l'âge, varient entre 1,7 et 2,9 tonnes d'équivalent CO_2 par adulte et par an. La viande et les produits laitiers représentent 48 % de l'empreinte carbone des aliments achetés, tandis que le gaspillage alimentaire en représente 17 %.
Perspectives : Ce premier diagnostic sert de référence pour identifier les principaux facteurs de l'empreinte carbone liée à la consommation alimentaire au Québec. Même s'il faut encore affiner la régionalisation et la granularité des données, cette initiative offre une base solide aux acteurs concernés pour mettre en place des systèmes alimentaires durables et lutter contre le changement climatique.

Mots-clés : empreinte carbone, émissions de GES, analyse du cycle de vie, Québec, base de données sur les inventaires du cycle de vie, consommation alimentaire

Introduction

In order to mitigate climate change, the Québec province of Canada (referred to as Québec) has committed to reaching carbon neutrality by 2050 (Government of Québec, 2024). Greenhouse gas (GHG) emissions contribute to climate change regardless of where they are released around the world. Therefore, achieving carbon neutrality requires not only reducing emissions within Québec's territory but also addressing those generated abroad, such as the production emissions of imported food commodities consumed in Québec. This calls for a consumption-based approach, which accounts for both direct and indirect emissions linked to consumed goods, whether produced locally or imported. This contrasts with the traditional territorial approach, which only accounts for direct emissions from domestic production and excludes emissions embedded in imports.

Moreover, achieving carbon neutrality requires the identification of effective mitigation actions beyond those that are perceived as effective. Indeed, evidence shows that perceived low-carbon solutions are not always efficient (Hartmann et al., 2021; Macall et al., 2021; Saulais & Espougne, 2024) and this gap between perception and actual impact is especially pronounced for food-related choices (Kause et al., 2019; Saulais & Espougne, 2024). This is also often due to the lack of quantification of GHG emissions reductions and life cycle perspective (to account for both direct and indirect impacts). There is a strong need to go beyond perceptions and to rely on robust and quantified scientific data to first identify hotspots and then efficient actionable levers to mitigate potential consumption impacts (Cap et al., 2025; Cucurachi et al., 2019; Dubois et al., 2019; ElHaffar et al., 2020; Ivanova et al., 2020).

The food sector is key to reducing the global carbon footprint (Costa et al., 2022; Hadjikakou et al., 2025; Rockström et al., 2025; Te Wierik et al., 2025). If no mitigation measure is taken, on both production and consumption ends, global food consumption alone could add nearly 1°C to global warming by 2100 (Ivanovich et al., 2023). Agrifood systems are responsible for one-third of global GHG emissions (Costa et al., 2022; Crippa et al., 2021; Rockström et al., 2025), with 70 % of GHG emissions associated with crop production and animal breeding, including 30% from land use and land use change activities (LULUC), mainly from deforestation and soil degradation. The remaining 30% is associated with food processing, packaging, distribution and end-of-life (FAO, 2024). The food sector also contributes to biodiversity loss, water stress, land use, and eutrophication (Crenna et al., 2019; Willett et al., 2019), which are exacerbated by climate change (Gosling & Arnell, 2016; Viveros Santos et al., 2023; Yang et al., 2024). Food consumption is one of the highest contributors to consumer carbon footprints in Europe (Alves et al., 2024; Castellani et al., 2019; Notarnicola et al., 2017; Sala & Castellani, 2019), Asia (Adhikari & Prapaspongsa, 2019; Zhao & Schroeder, 2010) and North America (Heller et al., 2018; Jennings et al., 2023; Jones & Kammen, 2011; Weber & Matthews, 2008a). In Canada, food consumption represents about 16% of the consumers' carbon footprint, and up to 19% in Québec, following transport and housing (Patouillard et al., n.d.). It is therefore essential to improve the representativity of LCI data in the food sector.

Life cycle inventories (LCI) in the food sector should be regionalized to better reflect domestic production conditions and consumption patterns, which are highly variable among regions (Chaplin-Kramer et al., 2017; Scarborough et al., 2023). Indeed, for the same product, the carbon footprint of food production on farms can vary up to a factor of 5 (Cao et al., 2026; Halpern et al., 2022; Wang et al., 2026) and depend on many local factors like pedo-climatic conditions (e.g., precipitation, temperature, soil conditions) and agricultural practices (e.g., intensive, organic, no tillage, greenhouse, deforestation) affecting yields, input quantities (e.g., fertilizers, pesticides, energy), or direct GHG emissions (e.g., CH_4, N_2O) (Chapman et al., 2025; Clune et al., 2017; Poore & Nemecek, 2018). In addition, food supply chains are mostly international (Li et al., 2022), especially in high income countries where consumers want to access any type of food at any time of the year (Fan et al., 2022). Therefore, LCIs of food purchased at the retail level should also be regionalized to account for market shares of consumed food produced locally and for international imports with associated transport (Nemecek et al., 2019). Finally, LCIs of ingested food should be regionalized at the diet level to account for food consumption habits (e.g., amount and type of consumed food products, waste rate at the consumer level) that vary greatly from one region to another (Aleksandrowicz et al., 2016; Fan et al., 2022; González-García et al., 2018; Ibarrola-Rivas & Nonhebel, 2022; B. F. Kim et al., 2020). These observations also apply to the food supply sector in Québec, where the context is different from the rest of North America or Canada due to its specific climate conditions and agricultural practices, defined by a high level of specialization in meat and dairy production (Chemins de Transition, 2023; ISQ & MAPAQ, 2021; Le Vallée et al., 2017).

Climate change is a recurrent hotspot of impacts on biodiversity and human health in life cycle assessments (LCA) of food systems (Crenna et al., 2019; Fresán et al., 2025). Moreover, it is a widely considered environmental indicator by decision-makers (Dietz et al., 2018). Hence, we are focussing on the carbon footprint in this study. Many studies assessing carbon footprint of diets have been conducted on various regions (Aguirre-Sánchez et al., 2023; González-García et al., 2018; Heller et al., 2013; Kustar & Patino-Echeverri, 2021; Nabipour Afrouzi et al., 2023), especially in Europe (Germani et al., 2014; Hallström et al., 2022; Mertens et al., 2019; Notarnicola et al., 2017; Rabès et al., 2020; Scarborough et al., 2023; Vieux et al., 2012) and the United States (US)

(D. Kim et al., 2020; Rose et al., 2019). The Institut de la statistique du Québec—Québec provincial institute for statistics—published an estimate of the carbon footprint of food consumption in 2017, equal to 2.2 metric tons CO_2 equivalent per capita (Institut de la Statistique du Québec, 2022). However, this does not account for imports embedded with direct methane and nitrous oxide emissions and GHG emissions from LULUC activities. To our knowledge, only four LCA-based studies have already assessed the carbon footprint of diets in Canada as a whole or in the province of Ontario. Auclair and Burgos (2021) assessed the carbon footprint of self-selected diets in Canada, without any distinction by province. Additionally, this study suffers from two main limitations: 1) GHG emissions per food product are not specific to the Canadian context, but reflect global averages; 2) The lifecycle of food consumption is truncated, mostly accounting for impacts from cradle-to-farm gate (or sometimes for cradle-to-processing gate), and excluding packaging, distribution and consumer stages (e.g., food storage, preparation, and end-of-life). Veeramani et al. (2017) and Topcu et al. (2022) assessed the carbon footprint of self-selected diets in Ontario, differentiated by dietary patterns. They used a LCI regionalized for Ontario with farm-to-fork boundaries excluding some stages like waste management or refrigeration. Topcu et al. (2025) quantified the carbon footprint of eating patterns in ten Canadian provinces, including Québec but with a normalized functional unit of 2000 kilocalories, using the Topcu et al. (2022) database, with its abovementioned limitations. Those studies mention the need for developing a Canada-specific LCI database for the food sector, and not one assesses carbon footprint of diets, considering real quantity of calories ingested and not a standard value, in Québec.

The main objectives of this article are to (i) develop a life cycle inventory database of food consumption in Québec and to (ii) assess the carbon footprint of individual food consumption in Québec. To reach those objectives, we are building a process-based LCI database to assess the carbon footprint of food consumption 1) for the average Québec consumer to identify its main hotspots; 2) for different population archetypes in Québec to explore the associated variability.

Methods

Development of the Life Cycle Inventory Database and food datasets

The life cycle inventory database for consumption in Québec, currently under development, referred to as LCI DB for consumption in Québec, aims to provide a comprehensive life cycle perspective of consumption in Quebec, including food, transport, housing, personal care, and digital services. It is built on the Québec LCI database project, developed to reflect the main production industries in Québec and integrated in ecoinvent life cycle inventory database (Lesage & Samson, 2016).

This article focusses on the food consumption axis of the LCI DB for consumption in Quebec, describing its structure and datasets developed in version 0.1.7 of the LCI DB (Patouillard et al., 2026). The LCI datasets developed (foreground LCI) are divided into seven dataset groups from "farm to fork" and are interconnected with other LCI databases to complete life cycles (background LCI). It includes food production, manufacturing and distribution, as well as impacts associated with the purchased and consumption of food (transport, storage, cooking, waste management). Data sources and links with other LCI databases are chosen to maximize geographical (Québec province or specific regions for imports when available), temporal (closest to 2018), and technological (closest available technologies) representativeness, to the extent allowed by data availability, accessibility and the time available to authors of this study. Foreground LCI datasets are mainly interconnected to background LCI datasets from the LCI DB ecoinvent v3.11 cut-off (Wernet et al., 2016). The cut-off system model was selected for the background LCI database as it is consistent with the attributional scope of this study, which aims to describe the environmental burdens associated with current food consumption patterns in Québec rather than modeling the consequences of systemic or marginal changes in production. In contrast, the consequential system model is designed to capture market-mediated responses to a change in demand, which is not the objective pursued here, while the APOS system model would be inconsistent with the modeling of food losses and waste in the foreground system, where lost or wasted food is assumed to carry its full upstream burden rather than being partly reallocated to alternative valorization pathways. Furthermore, the cut-off system model is widely used in food LCA literature, including comparable databases such as AGRIBALYSE, thereby facilitating comparability of results with existing studies. LCI datasets are built in an Excel file and then imported into the Brightway framework (Mutel, 2017). All details regarding foreground LCI datasets are available at https://doi.org/10.5281/zenodo.18938050. The following paragraphs present the LCI model developed for food consumption and the main assumptions and data sources used for foreground LCI datasets.

LCI database boundaries. "Farm-to-fork" system boundaries include all activities allowing food consumption: farm production (crops and livestock), food manufacturing and packaging, distribution including transport, consumption, and end of life (EoL). Figure 1 presents the structure of the seven dataset groups. Included and excluded activities and main data sources and modelling assumptions are described below. See Figure 1.

- *Food supply* includes all activities related to food production (from field to farm gate) and food consumption markets in Québec, i.e., shares of consumed food locally produced in Québec and imported from abroad, with their associated transport and food loss and waste (L&W) during agricultural production and postharvest handling and storage.
- *Food manufacturing* represents the transformation of raw food into processed food. It accounts for processing yields and includes the energy and other commodities for food processing, like water, and the food L&W at processing and packaging. When the processing location was not specified it was assumed to be processed in Québec. Canned and frozen goods are not modelled in this database version.
- *Packaging* includes the production, transport and EoL of food primary packaging (i.e. packaging in direct contact with food and intended for the consumer). Secondary and tertiary packaging (used during transport and distribution) are excluded due to data gaps. The primary packaging is modeled for each food category using datasets from AGRIBALYSE 3.1 (Asselin-Balençon et al., 2022). The background processes of these datasets representing the French context have been adapted for Québec, but the foreground quantities were kept unchanged. Packaging end-of-life is included and modeled as 45% going to sanitary landfill and 55% as recycled (Éco Entreprises Québec & RECYC-QUÉBEC, 2015).
- *Distribution* represents the storage of processed food at retail store. It includes the electricity consumption of retail stores (Energie Plus, 2019), the infrastructure (Petit et al., 2014) and the food L&W occurring at retail (Parfitt et al., 2010). Energy consumption, infrastructures and L&W of distribution centers are excluded due to a lack of data. In the current version of the database, the transports, storage and refrigeration between food manufacturing plants and retail store are excluded due to data gaps.
- *Preparation* includes the transport of purchased food from retail store to the consumer, as well as the cooking and storage i.e. refrigeration, water consumption and soap for washing dishes. All food consumption stages are modeled as if all meals were cooked and consumed at home. Quantities of food consumed through catering services (eat in or take out) are accounted for in the diet but are modeled as food prepared and consumed at home.
- *Food consumption* represents the average yearly diets for an adult in Québec, differentiated by gender and age archetypes. Gender was defined as biological sex (male or female), hereafter referred to as men and women. It distinguishes ingested food, food losses at consumer level, and food waste at consumer level. Purchased food is partitioned along two independent dimensions: whether a fraction is edible or non-edible, and whether the food item is consumed or discarded (Table A3 in SI 1).
  This yields three mutually exclusive categories:
  » **Ingested food**: the edible part of food items that are consumed.
  » **Food losses at consumer level**: the non-edible part of food items that are consumed (e.g., the seeds and core of an eaten apple, peels, bones). Non-edible parts are defined according to the most

common consumer behaviours, acknowledging that practices may vary. Hence, consumer have little control over the losses.

» **Food waste at consumer level**: purchased food, including both its edible and non-edible parts, that is discarded by the consumer without being consumed. The non-edible fraction of discarded food is accounted for under food waste and is therefore *not* counted as a food loss; conversely, food losses comprise only the non-edible fraction of food that is actually consumed. Excess food intake, which occurs when energy intake exceeds the body's physiological needs (Sundin et al., 2021), is not considered as food waste in this study. The three categories are thus additive and non-overlapping: Purchased food = ingested food + food losses at consumer level + food waste at consumer level.

- *End-of-Life* represents waste treatments, such as composting or landfill, used to handle food L&W all along the supply chain and at the consumer level. Direct emissions related to digestion and waste treatment of human excretion are excluded, following the recommendations of Muñoz et al. (2010).

Population archetypes. Eight archetypes are defined by dividing men and women across four age categories: 19-30 years old, 31-50 years old, 51-70 years old, 71 years old and older. Children are not considered in the current version of the database due to data gaps.

Diets. Types and quantities of ingested food and food L&W vary from one individual to another. They depend on demographic factors (gender and age), physical factors (e.g., weight, height, physical activity), and other socio-economic factors (e.g., revenue, residency region, level of education, culture). Here we differentiate individuals only on the basis of gender and age, which are two of the main factors explaining the individual variability in Québec (INSPQ, 2009). Therefore, amounts of ingested food are

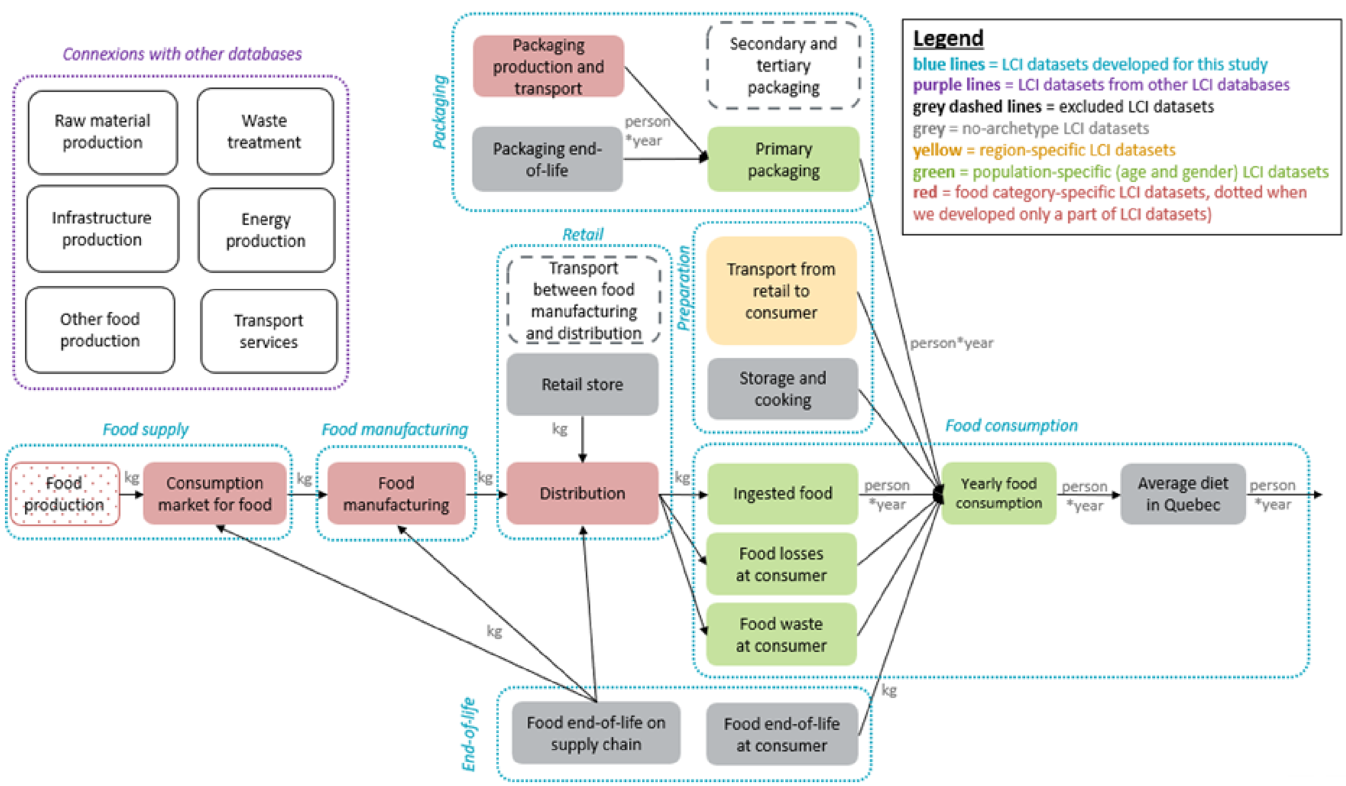

Figure 1: Boundaries of the LCI DB for food consumption in Québec. Blue lines define LCI datasets specifically developed for this project (foreground LCI), which are interconnected with other LCI databases, identified with purple lines, to complete the life cycles (background LCI). Grey dashed lines represent excluded processes. Transport and storages between food manufacturing and retail are excluded.

differentiated for 8 adult gender-and-age-based consumer archetypes (the quantity of calories associated with each archetype is available in Supplementary information file 1). Those amounts are extracted from a 2015 self-reported 24-hour recall survey used to estimate the observed annual food quantities ingested by 2297 adults in Québec (Health Statistics Division, 2023) and are differ from the recommendations of Canada's food guide (Government of Canada, 2025). We followed the 2015 Canadian Community Health Survey guidelines (Health Canada, 2018) to derive the weighted average of ingested food per age-and-sex archetype, using the sample weight attributed to each respondent of the survey, as done in previous studies (Ahmed et al., 2021). The average diet for adults in Québec, which is mainly omnivorous, is calculated based on the 2018 distribution of Québec's adult population (Government of Québec, 2019). Specific diets, such as vegetarianism, are not distinguished as a specific diet archetype in this study but are included in the survey and thus in the average diet. The amount of food produced is derived from the average diet and production yields considering food L&W rates along the supply chain from farm to fork.

Food categories. The 156 food products from the 2015 survey are grouped into 58 food categories following the INSPQ (2009) food product classification (see table A.2 of Supplementary information file 1 for the list of the 58 food categories). Each category contains one or several specific food products. A pragmatic approach was adopted to reduce the data collection time. Following Clune et al. (2017), who showed that within-category variability in climate impacts is lower than between categories, we approximated the impact of each food category using the most consumed product within it. As a result, some specific products are not modeled in detail—for example, the category "onion, garlic and leek" is represented by the LCI of onions. This choice limits analysis to categories and leaves some Québec-specific items without a representative LCI or without modeling.

Food production at farm gate. The agricultural production methods represented in the database are conventional only. Alternative methods, like organic or regenerative agriculture, are not modelled yet. It is assumed to be representative of the food market in Québec, since only about 4% of food consumed in Québec is from organic agriculture (Filière Biologique du Québec, 2025). Regional meat production LCI dataset is modeled as aggregated life cycle GHG emissions (CO_2, CH_4 and N_2O) from GLEAM model (FAO, 2017), where enteric fermentation emission factors are regionalized. GHG emissions from land use and land use change (LULUC) are regionalized and accounted for as long as they are included in the background ecoinvent 3.11 LCI datasets albeit the approach adopted by ecoinvent is not the object of an international consensus (Lehtilä et al., 2025).

Consumption market for food. Consumption market datasets are built upon imports (corrected trade data accounting for actual country of origin of production) and domestic production net of exports provided by the Québec Ministry of Agriculture, Fisheries and Food (MAPAQ, 2019). The model focuses solely on consumption markets for raw agricultural products at the farm gate (e.g., whole carrots) and does not cover consumption markets for processed food products (e.g., grated carrots). The consumption market share (MS) of a food product *f* produced in region *c* exported to region *d*, such as Québec (QC) province is calculated as per equation 1:

$$MS_{f,c,QC} = \frac{Imports_{f,c,QC}}{Production_{f,QC} - \sum_{d \in IC} Exports_{f,QC,d} + \sum_{c \in EC} Imports_{f,c,QC}} \quad (1)$$

Where *IC* is the list of all importing countries of food product produced in Québec and *EC* is the list of all countries exporting food products to Québec.

Transportation between supply chain stages. Transportation distances are calculated as the distance between the center of the exporting region to the city of Montréal (QC) arriving at a retail store using Google Maps for transport by truck and SeaRates online tool for transoceanic ship transport. Return trips are not included due to data gaps on load factor. An average transportation distance for consumption market per food category is calculated using the consumption market share of each region of imported products. Transport between distribution centers and retail store is excluded due to data gaps. Average retail-to-home transport distances are differentiated across Québec regions (Robitaille & Bergeron, 2013).

Preparation at home. We assumed that 1% of per capita water consumption is dedicated to washing dishes and that two grams of soap per liter of water was consumed. We included the carbon footprint of the production and the energy consumption of cooking appliances (Ressources Naturelles Canada, 2016).

Food L&W at consumer level. Amounts of food waste at the consumer level are calculated for each food category based on a mass balance using the following data: 1) amounts of ingested food in Québec per consumer archetype (Health Statistics Division, 2023), 2) food losses at consumer level per food product (Government of Canada, 2016), 3) food L&W at grocery level based on Food and Agriculture Organization (FAO) data for North America (Parfitt et al., 2010), 4) food L&W at grocery level and at consumer level in Canada (Statistics Canada, 2019).

Food L&W along the supply chain. Food L&W are modeled at consumption market, food manufacturing and grocery stages using food L&W rates from FAO (Parfitt et al., 2010), which provides L&W rates, differentiated by supply chain stages, food types, and world regions. Quebec L&W are approximated using North American data (Parfitt et al., 2010).

Food EoL processing pathways. Shares and processes of each food waste processing pathways, i.e., sanitary landfill and composting, are specific to Québec (RECYC-QUÉBEC, 2015).

Carbon footprint assessment method

This section describes the methodology used to assess the carbon footprint of food consumption in Québec.

Functional unit. The carbon footprint results presented in this study are quantified for the functional unit: "to provide the annual food intake of an adult in Québec province in 2018". The food intake is expressed in kg of ingested food per person per year, because our goal is to represent actual variability in food among the population rather than the intakes recommended by nutritionists for a balanced diet.

Food product classification in inventory. We adopt the food product classification by INSPQ (2009) to facilitate results comparison with a previous version of the LCI database, which used average age-and-gender specific diet compiled upon a 2004 self-reported 24-hour recall survey. This enables a thorough comparison of the carbon footprint of food consumption in Québec between 2004 and 2015, which is discussed in Supplementary information file 1.

Impact assessment. To evaluate the carbon footprint, GHG emissions are characterized using the 100-year Global Warming Potential (GWP100) from the IPCC AR6 report (Smith et al., 2021). In the IMPACT World+ footprint method (Bulle et al., 2019) version 2.1 (Agez et al., 2024), this characterization corresponds to the midpoint indicator *Climate Change, short-term*. Results are expressed in kg of CO_2 equivalent (kg CO_2eq). The results were generated through Activity Browser, the graphical user interface for Brightway (Steubing et al., 2020).

Results presentations. The carbon footprint of food consumption in Québec is explored using two complementary analyses: 1) identification of hotspots in food consumption for the average Québec consumer and 2) assessment of the carbon footprint of food consumption for different population archetypes. The carbon footprint of food consumption in Québec in 2015 was also compared with that of 2004, based on our previous study using average diet data compiled by INSPQ (2009) from a 2004 self-reported 24-hour recall survey. The results of this comparison are presented in Supplementary information file 1.

Contribution analysis. The hotspot analysis is presented for the main contributors from a consumer perspective, and the different food groups. Food groups were created by aggregating the different food categories based on the classification available in Supplementary information file 1. The carbon footprint of each food group represents the potential impact of food from farm to fork.

Results

Hotspot analysis on the carbon footprint of food consumption for the average Québec consumer

The average carbon footprint of food consumption in Québec is assessed at 2377 kg CO_2eq per capita per year. Figure 2 presents a contribution analysis of the carbon footprint of food consumption. Primary packaging contribution is presented separately from purchased food to show its total contribution. Contribution of food losses (8%) and food waste (14%) at home by consumers is also shown separately to highlight the significant leverage consumers have to reduce their carbon footprint. The contribution of transport between farm and retail store is included in each food category as we adopt a consumer perspective (consumers cannot influence the transport from farm to retail). It is not displayed due to its minor contribution to total carbon footprint.

As displayed in Figure 2, purchased food is the main contributor to the total carbon footprint of food consumption in Québec (81%). Among this 81%, 60% is due to ingested food, 8% to food losses and 14% to food waste at the consumer level. It is to be noted that food L&W at the consumer level contributes 26% of the total carbon footprint of food consumption in Québec (combining the production, transformation, transport and EoL of food lost and waste). The impacts due to waste treatments of food L&W at the consumer level alone accounts for 4% of the total carbon footprint. Finally, the primary packaging,

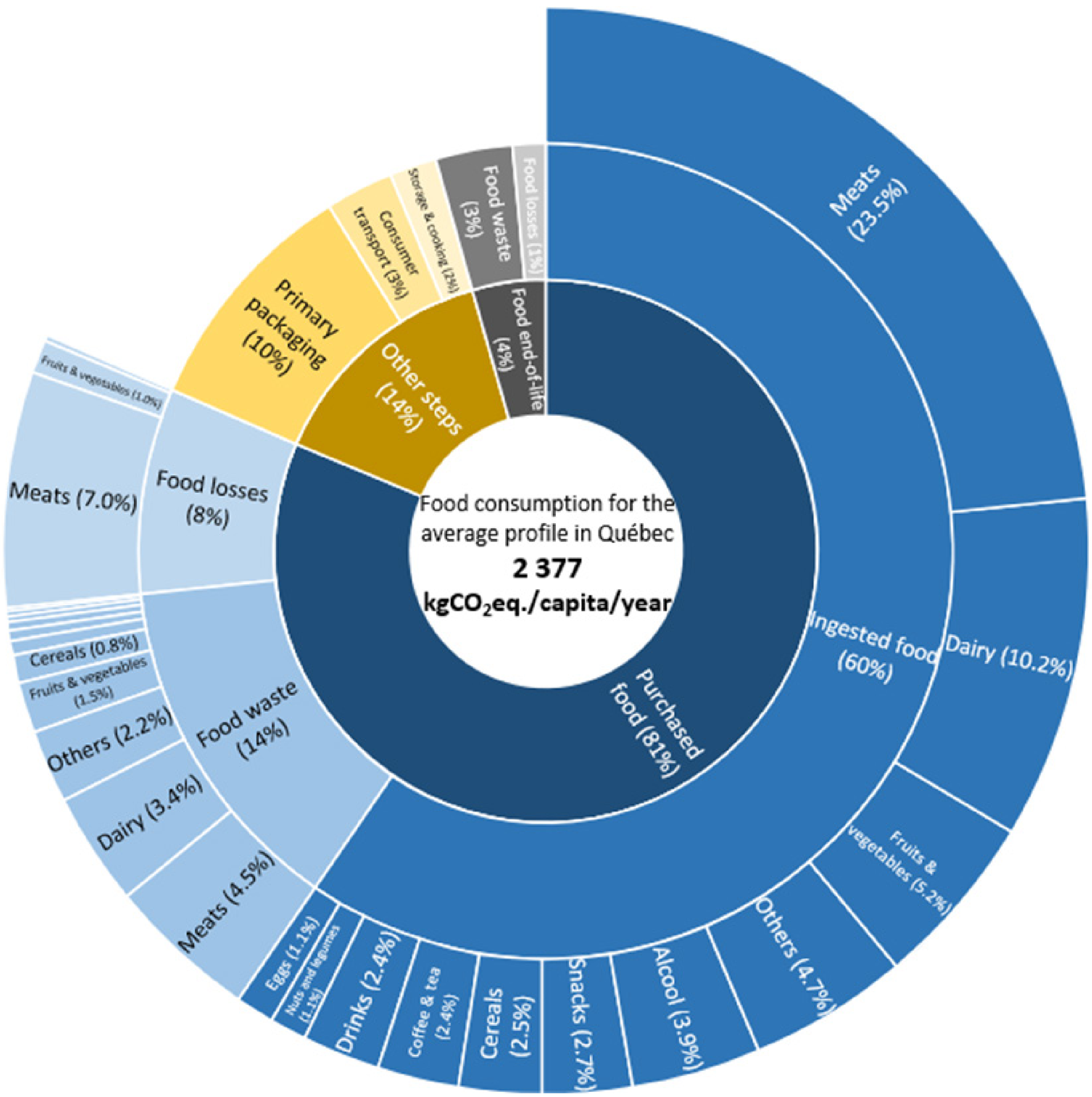

Figure 2: Contributions of life cycle stages and food groups to the average carbon footprint of food consumption in Québec. Potential impacts from distribution, food manufacturing, food supply and all food L&W except at home are embedded into purchased food carbon footprint.

consumer transport for grocery, and storage and cooking represent 10%, 3%, and 2% respectively of the total carbon footprint. This contradicts the perception, among about 20% of Québec consumers, that packaging is the most important contributor to food consumption carbon footprint (Saulais & Espougne, 2024).

In terms of food categories, meats and dairy represent more than half of the impact of ingested food (33.7%), and fruits and vegetables are the third contributor (5.2%). Meats and dairy are also the main contributors to the carbon footprint of food waste at the consumer level (7.9% of the 14%), and fruits and vegetables are the second contributor (1.5% of the 14%). Although Drinks (mainly water) represent about 40% of the total mass of purchased food (see Figure 5 in section 3.2), it is one of the food groups with the lowest carbon footprint contribution (when not accounting for primary packaging contribution). Conversely, Meats and Dairy represent 19% of food purchased but are responsible for about 50% of the carbon footprint of food consumption in Québec.

As displayed in Figure 3, the contributions of ingested food, food waste at the consumer level, and food losses at

Figure 3: Contribution analysis specific food products to purchased food, ingested food, food waste, and food losses carbon footprint from the food categories Meats (upper left), Dairy (upper right) and Fruits and vegetables (lower)

the consumer level to the carbon footprint depend on the food category. Indeed, rates of food losses and food waste as well as carbon intensities are different for each food category (and are available in supplementary information file 1). The main life cycle contributors are the following:

- The carbon footprint of **Meats** is mainly driven by beef consumption, representing 49% of the purchased meat footprint, although it only represents 26% of the amount of ingested meats. This observation can be explained by CH_4 emissions from cow enteric fermentation (49%), feed production (28%) and CH_4 and N_2O emissions from manure management (13%) (FAO, 2010).
- The carbon footprint of **Dairy** is mainly linked to processed milk and cheese representing respectively 44% and 37% of the purchased amount. Emissions from enteric fermentation, feed production and manure are the main contributors to the dairy carbon footprint (FAO, 2010).
- Regarding **Fruits and vegetables**, tomatoes, potatoes, and apples represent more than 35% of the ingested amount in our preliminary results. Tomatoes are the greatest contributor to the carbon footprint of purchased fruits and vegetables (18%) as 1) they are the most consumed food of the group in terms of purchased mass, and 2) the carbon intensity of tomato production is relatively high due to the use of fossil fuels in heated greenhouses for local production in Québec.

Figure 2 illustrates that packaging contributes globally to 10% of the total carbon footprint of food consumption. In Figure 4, we present the detailed contribution of primary packaging to the carbon footprint of the different food items. In this figure, we keep the other stages (i.e., food preparation and EoL at the consumer level) apart from the food item footprint. Primary packaging represents 33%, 21%, and 15% of the carbon footprint for Alcohol, Fruits and vegetables, and Cereals food groups, respectively (Figure 4). However, it rep-

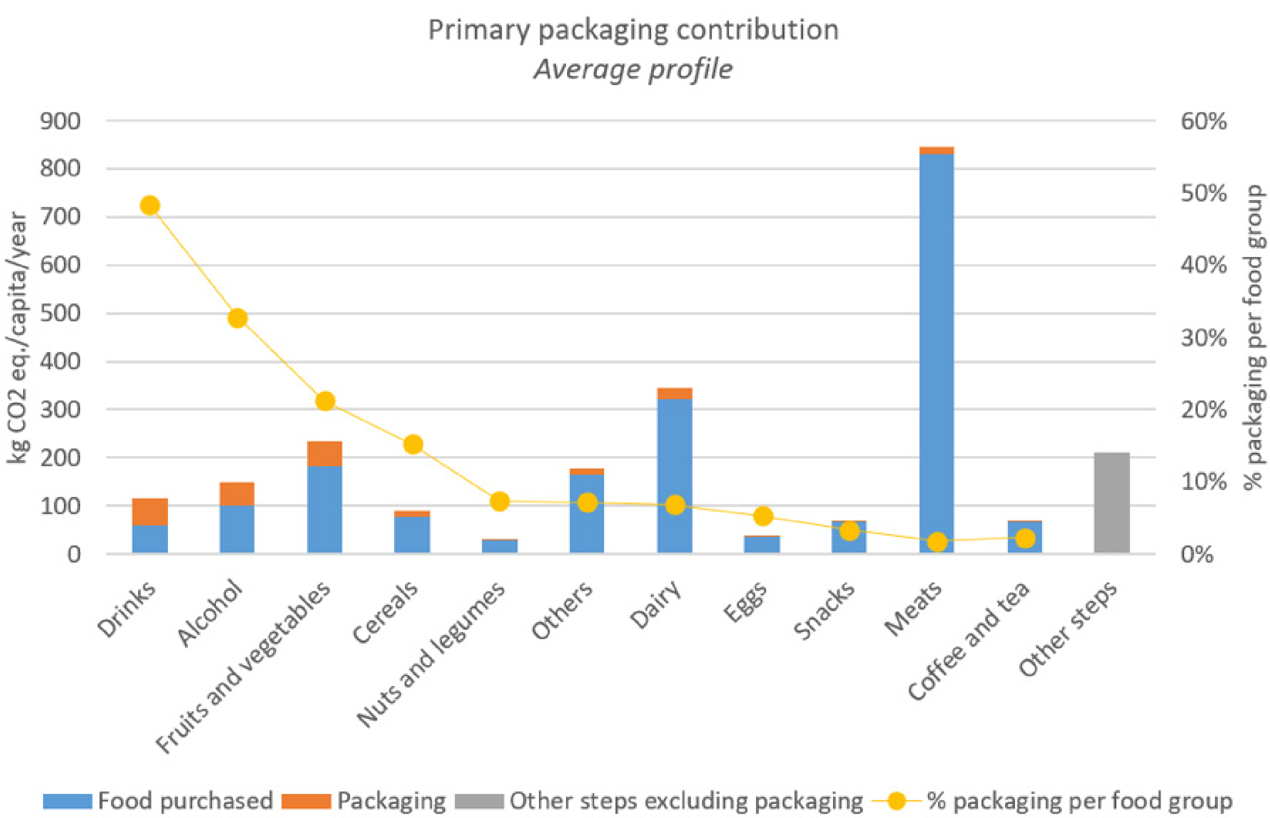

Figure 4: Contribution of primary packaging per food group to the carbon footprint of food purchased for the average Québec consumer. Other stages include food preparation and food EoL at the consumer level.

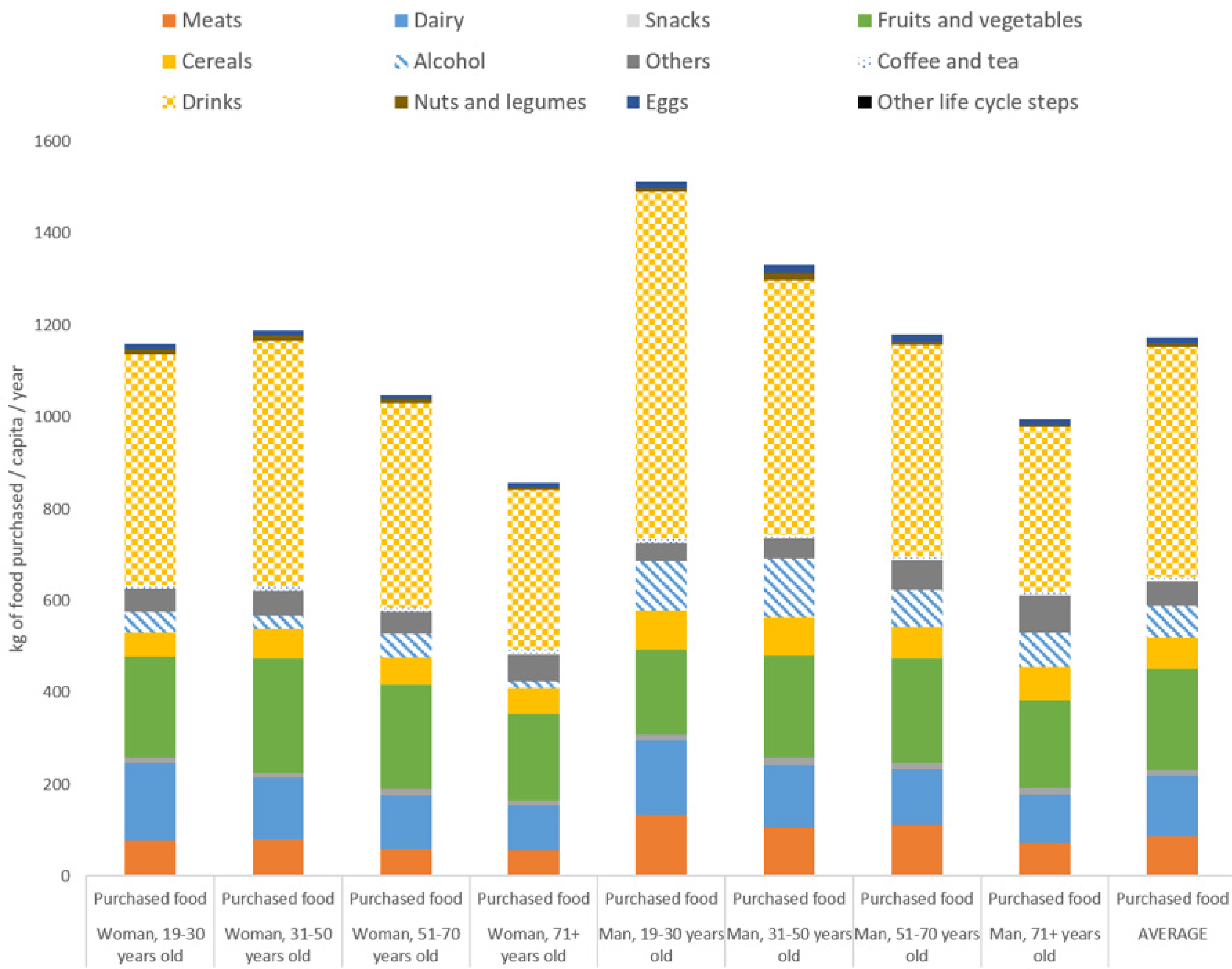

Figure 5: Quantity of purchased food (in kg per capita and per year, except for drinks in litres) for the eight gender-and-age-based archetypes in the adult population and for the average profile.

resents less than 5% of the carbon footprint of eggs, snacks, meats, and coffee and tea. Regarding the Alcohol beverages group, beer and wine are responsible for most of the packaging contribution because of glass production, which is more carbon intensive than the other packaging materials used for this food category. Regarding Fruits and vegetables, tomato, apple and banana are responsible for most of the packaging footprint because of the contribution of the polyethylene packaging film. Finally, the packaging for bread along with pasta and rice are the most important contributors to the carbon footprint of the Cereals food group due to the polyethylene packaging film.

Carbon footprints of food consumption for different population archetypes

Depending on the gender-and-age-based archetype, amounts of purchased food vary from 0.8t to 1.5t per capita per year (Figure 5) and the carbon footprint of food consumption in Québec varies from 1.7t to 2.9t CO_2eq per capita per year (Figure 6). Amounts of purchased food are lower for women compared to men and decrease with age. This is consistent with recommended calorie intakes by population archetype, which also depend on physical activity levels (INSPQ, 2009). The carbon footprint of food consumption follow the same trends as the purchased

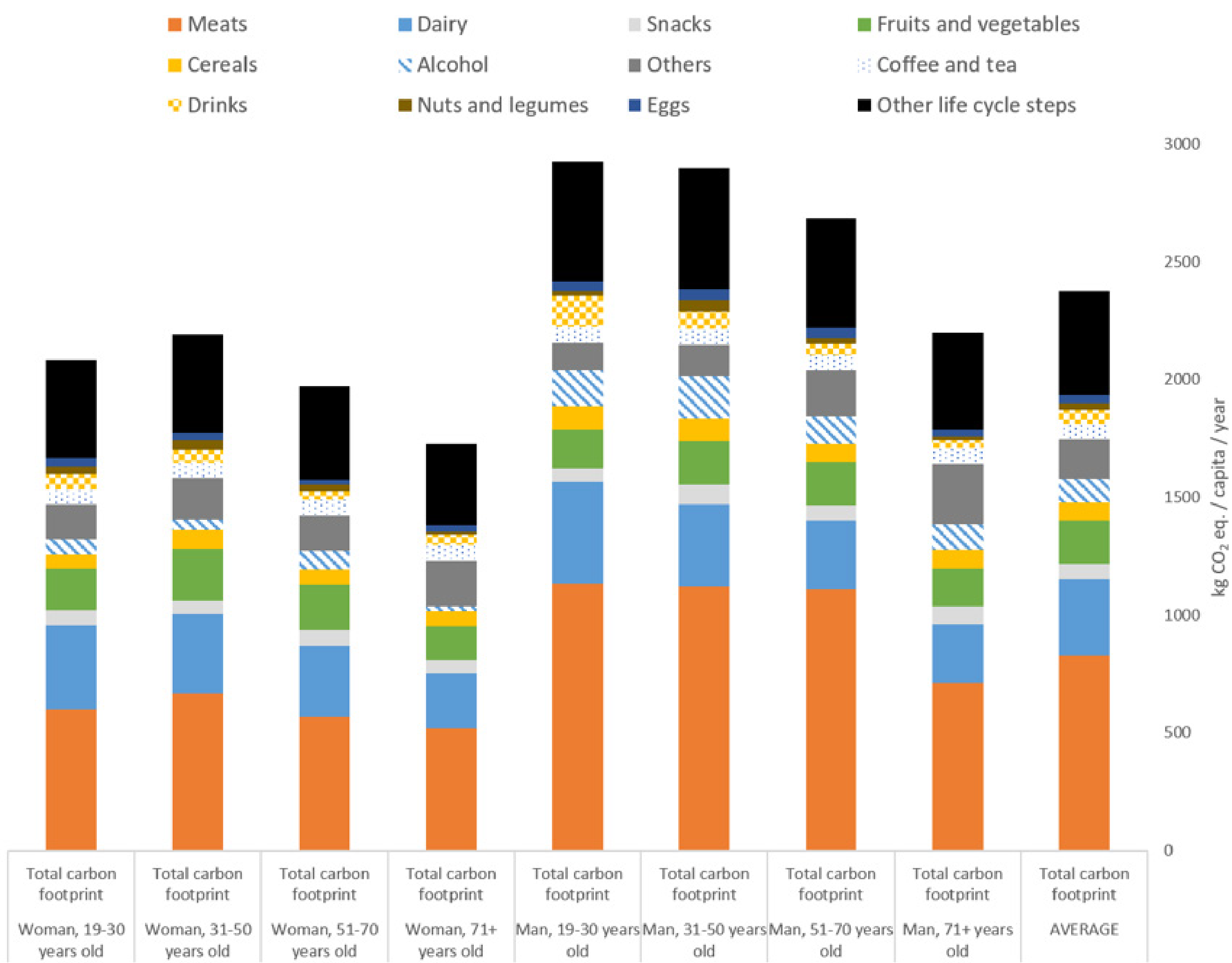

Figure 6: Total carbon footprint of food consumption in Québec (right axis in kg CO2eq per capita and per year) for the eight gender-and-age-based archetypes in the adult population and for the average profile.

amounts: they are lower for women compared to men and decrease with age from 31 to 71+ years old, which means the lowest carbon footprint is obtained for the archetype representing 71+ year-old women. For women, the Dairy contribution reduces with age, but this reduction does not compensate for the increase in Meat and Fruits and Vegetable contributions observed from 19 to 50 years old. Therefore, 31-to-50-year-olds have the highest carbon footprint of food consumption among women. For men, the reduction of Dairy and Meats contribution from 19 to 50 years old is compensated by the increased contributions of Snacks, Alcohol, and Nuts and legumes. Therefore, 19-to-30-year-olds and 31-to-50-year-olds almost have the same (and the highest) carbon footprint of food consumption among men.

Finally, considering the share of each archetype in the Québec population, men contribute 57% of the total carbon footprint of food consumption in the province, while women contribute 43% (see Supplementary information file 1). Age groups most contributing to the average profile's footprint are 31-to-50-year-olds (35%) and 51-to-70-year-olds (34%), and the less contributing is the 71+ year-old group (12%).

Discussion

Comparison with existing literature from other regions

As displayed in Figure 7, our result for the average carbon footprint of food consumption per capita per year is in the range of similar published results for various regions worldwide, even though this range is quite large, from 475 kg CO_2eq per capita per year in India to 3540 kg CO_2eq per capita per year in the US for selected studies. Our estimate is comparable to results obtained for Ontario (4% to 9% difference). However, other published results for Canada are 30% to 39% lower than ours, but main contributors (meat and dairy) are consistent. Those differences, as well as the wide range in carbon footprint estimates of food consumption in published studies, could be explained by different system boundaries. All studies cover emissions at least from cradle to farm gate, which cover more than half of carbon footprint of consumption (as per Figure 2), however no study perfectly matches our system boundary. Other sources of variability are discussed below Figure 7.

Diet composition. Food habits per region, i.e., type and amount of food products consumed, are probably one of the most influencing variables explaining the observed world variability. For instance, Indian diets are mainly lacto-ovo vegetarian whereas US or Brazilian diets include a large share of bovine meat, which explains the observable difference in terms of carbon footprint of food consumption (B. F. Kim et al., 2020).

Method for evaluating the annual food intake. First, the type of food intake reporting could influence the results. Indeed, self reported surveys may contain errors but tend to be less biased than food frequency questionnaires (Kipnis, 2003), as discussed in Heller et al. (2018), whereas food intake based on nutritional recommendations are not representative of population behaviours, due to overfeeding in high income countries or underfeeding in middle- and low-income countries. Second, the temporal representativeness of food intake data is important. Surveys based on 24-hour recall used to extrapolate annual food intake assume that selected days are representative of yearly habits, which indeed can be influenced by other factors like seasonality. Third, the quality of the sample used to represent a population when food intakes are derived from surveys might be important, particularly the inclusion of children in the population. Finally, the calorie adjustment often made to compare different diets ensuring that they fulfill the same energy function can greatly influence the results across regions, as the observed quantity of calories ingested may vary significantly.

Quality of GHG emissions and carbon footprint estimates per food item. First, the definition of the system boundaries may vary from one study to another (González-García et al., 2018; Goossens & Schmidt, 2025). Most studies account for GHG emissions from cradle-to-farm or cradle-to-processing, which means life cycle stages like packaging, distribution, final transport to consumer, storage, preparation, and EoL of food L&W are excluded (Goossens & Schmidt, 2025). In addition, food overproduction due to food L&W along the value chain and at the consumer level is not always accounted for (Sundin et al., 2021). Second, the geographical representativeness of the GHG estimates per food item is often not in line with the consumption region. In fact, most studies use world average markets or assume that all foods consumed are produced locally. Best practices would be to 1) use regional consumption markets for each food product to account for the share of imports and domestic production, and 2) regionalize the LCI datasets of food production by region. Moreover, the level of food products disaggregation can influence the results, by using either generic or more specific data. Finally, the revision of GWP100 values between the IPCC AR5 and AR6 assessments demonstrates that characterization factors are not static. Consequently, future updates may lead to changes in the calculated carbon footprint of food products.

Main limitations of this study and potential improvements

Data representativity and data gaps. Although our study provides the best available estimates for carbon footprint of food consumption in Québec along with regionalized LCI datasets, our LCA model can be improved upon at different levels.

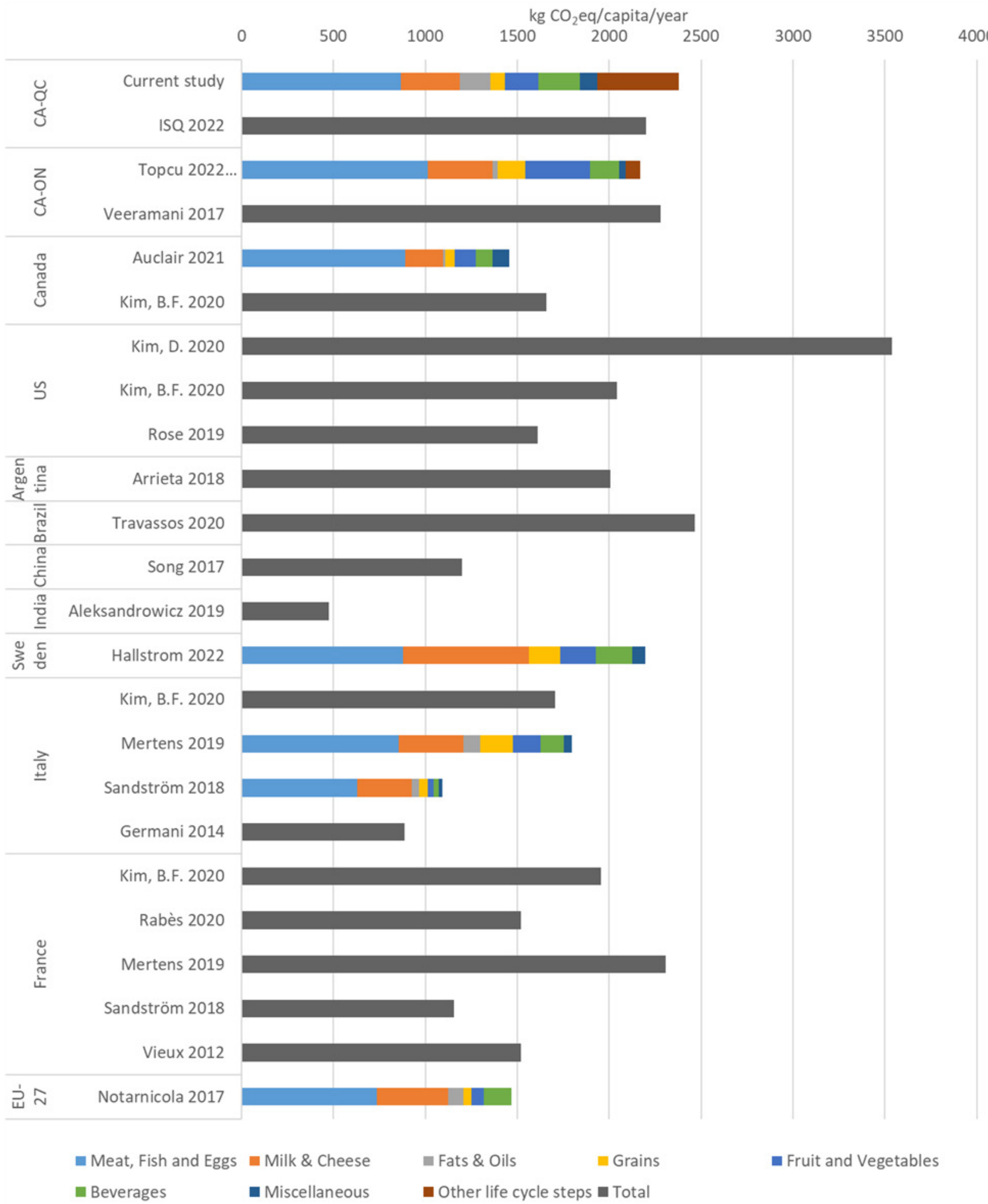

Figure 7: Carbon footprint of food consumption per capita per year for average diets in different regions from selected studies (Aleksandrowicz et al., 2019; Arrieta & González, 2018; Auclair & Burgos, 2021; Germani et al., 2014; Hallström et al., 2022; Institut de la Statistique du Québec, 2022; D. Kim et al., 2020; Mertens et al., 2019; Notarnicola et al., 2017; Rabès et al., 2020; Rose et al., 2019; Sandström et al., 2018; Song et al., 2017; Topcu et al., 2022; Travassos et al., 2020; Veeramani et al., 2017; Vieux et al., 2012). CA-QC: province of Québec, Canada; CA-ON: province of Ontario, Canada.

- **Diet composition**. We use a self-reported 24-hour recall survey from 2015 to describe food intake in Québec in 2018 (Health Canada, 2018). Diet composition may have slightly changed between 2015 and 2018, as evidenced by meat and dairy products (Agriculture Canada, 2025; Zarnovican, 2024). Between 2015 and 2025, there has been a decline in red meat and pork consumption (-9%) (Agriculture Canada, 2025; Arsenault et al., 2024) and a growing interest in plant-based proteins (Ngapo, 2022). Between 2012 and 2019, according to MAPAQ (Keable, 2021), while the population increased by 5.3%, retail sales in kilograms rose for several categories, including coffee (+10%) and chocolate (+16%), along with changes in dairy consumption patterns. Fluid milk has been increasingly replaced by cheese and cream, which experienced volume growth of +13% and +22%, respectively. However, no study currently provides a comprehensive overview of these shifts, and the 2015 survey therefore remains the most recent source available for assessing the carbon footprint of food consumption in Quebec. We analyzed that these changes in meat and dairy products consumption would not lead to a drastically different carbon footprint (between 0.8% and 1.9% increase in total). Moreover, the estimated average per capita carbon footprint of food consumption in Québec, using our LCI model with a self-reported 24-hour recall survey from 2005 (Health Canada, 2006) was only 5.7% higher than the estimate using the survey from 2015 (See Supplementary information file 1, Figure A3). This minor change in the carbon footprint of food consumption in Québec over a ten-year period is similar to the 5% to 8.5% change in Ontario between 2004 and 2015 calculated by Topcu et al. (2022). Hence, we estimate that our database slightly underestimates the current food consumption footprint.
- **Food consumption**. The current LCA model assumes that all meals are prepared and consumed at home, whereas the 2015 survey on food intake indicates that 21.8% of Canadians consumed food prepared outside the home (e.g., restaurants) (Statistics Canada, 2021). As food management could be quite different between consumers at home and restaurant services (Nabipour Afrouzi et al., 2023), there is a need to develop specific LCI datasets to model restaurant services, especially for food cooking, storage, primary packaging and L&W. In addition, cooking and storage stages might be differentiated by food categories (e.g., some products need to be cooked and refrigerated, and some do not), as they can represent a large part of the carbon footprint of some products (Frankowska et al., 2020; Long et al., 2023).
- **Food products**. Food products are aggregated into 58 food categories. Each category encompasses one or several specific food products but is often modeled using only one or two representative food products, depending on the availability of LCI data. Disaggregating these categories to better capture the variability of food products within each food category would provide a more accurate and representative picture (Clark et al., 2022). For instance, the Fish and seafood category is currently only represented by tuna production, whereas blue foods' carbon footprint can vary from 1 to more than 20 kg CO_2eq per kg of edible weight depending on species and origin (farmed or wild-caught) (Gephart et al., 2021).
- **Consumption markets**. Some consumption markets require more detailed estimations of market shares (domestic vs. imported production, open field vs. greenhouse production, etc.) and food transport characteristics (distances and modes). Consumption markets could also be defined at the food manufacturing level if data is available: in the current version, consumption markets are defined at the food product level (e.g., beef) as there is no consumption market for processed food, such as ground beef or spiced ground beef.
- **Transport between food manufacturing and retail store**. Transportation between food manufacturing plants and distribution is excluded due to a lack of data. If we assume a conservative transport distance by refrigerated truck of 1000km (500 km out and 500 km back empty) between food manufacturing plant and retail store for all food products, we estimate the contribution to total impact for the average consumer would be about 8.6%. This will be included in a future version of the database.

- **Food production**. More LCI datasets need to be developed for missing food products locally produced in Québec or to represent other agricultural practices than the conventional ones. In particular, LCI datasets for beef, chicken and pork production in Québec are now based on an average for North America from GLEAM model (Gerber et al., 2013) which do not reflect Québec specificities in terms of meat production. Instead of using global averages from LCI databases, GHG emissions from LUC can be better estimated by identifying the specific origin of products consumed in Québec associated with a risk of deforestation (e.g., soya, meat, palm oil, cocoa, coffee, chocolate), as made it possible with the TRASE platform (Lathuillière et al., 2021).
- **Food manufacturing**. LCI datasets could be improved by better regionalizing food processing, integrating frozen and canned food products, and adding more derived transformed products, such as ultra-processed foods (e.g., tomato sauce, tomato paste), which represent 46% of calorie intake by Canadian (Polsky et al., 2020).
- **Food packaging**. Material quantities and transportation distances need to be regionalized to better reflect Québec market of food products as the Agribalyse database corresponds to the French market practices in term of food packaging.
- **Food L&W and EoL**. Shares of food L&W at consumer level are extrapolated from different sources but would be improved by relying on better data from a single source distinguishing food losses and food waste based for instance on food product-specific edible and non-edible fraction (Coudard et al., 2025). Shares of food L&W along the value chain from FAO (Parfitt et al., 2010) could be improved by using more specific data per food category and per region (Xue et al., 2017). Instead of using a generic LCI dataset for all L&W EoL, more specific data per type of EoL treatment, per food category and per region could be used.

Structure of the foreground LCI database. This first version of the LCI database needs to be disaggregated and restructured for more flexibility, especially to facilitate contribution analysis at various levels: per stage from food production to food distribution; per origin of GHG emissions (domestic vs imported); per transportation stage all along the value chain to better analyze the contribution of transport, sometimes referred as food miles (Avetisyan et al., 2014; Weber & Matthews, 2008b), which accounts for nearly 20% of GHG emissions of the global food system (Li et al., 2022).

Background LCI databases. Our background LCI currently uses ecoinvent v3.11. It could be updated and diversified to better take advantage of new developments in the World Food database (Nemecek et al., 2019), AGRIBALYSE (Asselin-Balençon et al., 2022) and regioinvent (Agez & Majeau-Bettez, 2026).

Population archetypes. We analyzed the carbon footprint of food consumption for 8 population archetypes based on gender and age, as both are important sources of variability among the population and data were available. However, other sources of large variability among individuals are not captured in this study and could be explored to identify more tailored mitigation options. For instance, archetypes based on dietary patterns (e.g., veganism) (Rabès et al., 2020; Topcu et al., 2022; Veeramani et al., 2017) or based on sociodemographic variables (e.g., income levels, place of residence) could be defined. The carbon footprint of food consumption of children could also be explored in a future study.

Perspectives for future work toward sustainable food consumption in Québec

Our study provides a first estimate of the carbon footprint of individual food consumption in Québec, which can be used as a baseline for future assessments. It allows to identify the main hotspots, hence to prioritize mitigation initiatives. Next steps are to define alternative scenarios based on behavioral changes (e.g., change in dietary composition), changes in farming practices (e.g., regenerative agriculture) or other logistical or technical improvements (e.g., change in agricultural practices), to quantify their potential reduction in GHG emissions and guide consumers, businesses, and governments toward efficient mitigation solutions. Those alternative scenarios could be built from expert knowledge, but also from solutions perceived as efficient from the public (e.g., choosing local food products) to test perceptions and validate their efficiency.

Our LCI model allows us to assess the carbon footprint of average food consumption at the individual level. However, results might not be scalable to assess the total impacts for Québec due to market and physical constraints (e.g., price effects, product availability, land availability). For scenario analysis at the level of the province level (e.g., to test the effect of different mitigation measures), coupling our LCI model with techno-economic models would be required for a better systemic assessment.

Our study is limited to the assessment of climate change impacts from GHG emissions. However, the environmental assessment of food consumption should go beyond climate change by accounting for impacts related to ecosystem quality and human health due to land use, water use, use of toxic substances (e.g., pesticides), eutrophication from fertilizers, etc. As we built an LCI database instead of just extracting precalculated carbon footprints from literature, our LCI datasets can be completed with LCI data (e.g., adding intermediate and elementary flows) to allow the assessment of other relevant impact categories and identify trade-offs between scenarios. A future version of the developed LCI datasets could be fully parametrized to ensure full interoperability and flexibility (Arias et al., 2025).

Finally, to achieve truly sustainable food consumption, environmental aspects of food need to be interconnected with nutritional aspects (Gebara et al., 2025; Willett et al., 2019). This nutritional dimension in relation with environmental aspects has been explored through different angles (Aldaya et al., 2021; Jarmul et al., 2020; Macdiarmid, 2022; Stylianou et al., 2021; Willett et al., 2019). However, research work is still needed to provide robust methods to optimize food consumption from both environmental and human health perspectives (Jolliet, 2022; Scherer et al., 2024).

Conclusion

In this article, we presented the development of the first life cycle inventory database of food consumption in Québec, from food production at farm gate to fork, built upon a self-reported 24-hour recall survey conducted in 2015 by Health Canada. We evaluated the carbon footprint of food consumption for eight gender-and-age-differentiated archetypes of Québec adults, ranging from 1725 kg CO_2eq per capita per year (women aged 71 and older) to 2928 kg CO_2eq per capita per year (men aged 19 to 30). The average carbon footprint of yearly individual food consumption in Québec is estimated to be 2377 kg CO_2eq. Ingested meats and dairy are responsible for 33.7% of total impact on climate change of food consumption on average, while food loss and waste represent 17% of total potential impact. Primary packaging accounts for 10% of the total potential impact.

This LCI database for food consumption in Québec suffers from several limitations, including limited representativeness (food products, consumption markets, food processing pathways, transportation modes and distances between supply chain stages and cooking modes) and exclusions (ultra-processed food, distribution systems and catering services). Future research should tackle mentioned gaps to enhance the robustness and representativeness of this first version of a life cycle inventory database of food consumption in Québec. Adding natural resource extractions and emissions other than GHGs will be a priority. Despite those limitations, this research work remains the first open-access LCI database of food consumption in Québec, which could be used to guide decision-making for multiple stakeholders, notably involved in policy making and the transition of food systems.

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Contributions: L.P: Conceptualization, Methodology, Validation, Data Curation, Writing – Original Draft, Writing – Review & Editing, Supervision, Project Administration. T.G: Methodology, Validation, Data Curation, Writing – Original Draft, Writing – Review & Editing. E.L: Data Curation, Writing – Review & Editing. C.H: Writing – Review & Editing. C.B: Methodology, Writing – Review & Editing, Supervision, Funding Acquisition.

Acknowledgments: The authors would like to thank Elliot Muller for his support during the elaboration of the database. The authors remain solely responsible for the article.

Data statement: All data related to foreground LCI datasets are available at https://doi.org/10.5281/zenodo.18938050. Raw data of figures are available in Supporting Information files.

Conflicts of Interest: None to declare

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Appendices

See following pages for Supplementary Material.

Supplementary information file 1 for: New life cycle database on food consumption: A strategic tool to drive Climate-Smart Action in Québec

Table A.1 - Amount of calories ingested per population archetype. Source: Authors' calculation following CCHS method (Health Canada, 2018) and energy intake data from 2015 CCHS survey (Health Statistics Division, 2023)**.**

Population archetype	kCal/day (average)
Woman 19-30	1868
Woman 31-50	1845
Woman 51-70	1710
Woman 71+	1384
Man 19-30	2569
Man 31-50	2445
Man 51-70	2191
Man 71+	1820

Table A.2 - Classifications of food categories per food group

Food categories	Classification per food group used in this study	Alternative classification (for comparison with other studies)
beer	Alcool	Beverages
cider	Alcool	Beverages
spirits	Alcool	Beverages
wine	Alcool	Beverages
biscuits and cakes	Cereals	Grains
bread, white	Cereals	Grains
bread, whole	Cereals	Grains
breakfast cereals	Cereals	Grains
flour and grains	Cereals	Grains
other cereal products	Cereals	Grains
pasta and rice	Cereals	Grains
coffee and tea	Coffee and tea	Beverages

cheese	Dairy	Milk & Cheese
frozen products	Dairy	Milk & Cheese
milk, other	Dairy	Milk & Cheese
milk, partly skimmed, 1%	Dairy	Milk & Cheese
milk, partly skimmed, 2%	Dairy	Milk & Cheese
milk, skimmed	Dairy	Milk & Cheese
milk, whole	Dairy	Milk & Cheese
other dairy products	Dairy	Milk & Cheese
yogurt	Dairy	Milk & Cheese
fruit drink	Drinks	Beverages
soft drink, diet	Drinks	Beverages
soft drink, regular	Drinks	Beverages
water	Drinks	Beverages
egg	Eggs	Meat, Fish and Eggs
apple	Fruits and vegetables	Fruits and Vegetables
banana	Fruits and vegetables	Fruits and Vegetables
beans and peas	Fruits and vegetables	Fruits and Vegetables
cabbages and brocoli	Fruits and vegetables	Fruits and Vegetables
carrot	Fruits and vegetables	Fruits and Vegetables
celery, maize and mushrooms	Fruits and vegetables	Fruits and Vegetables
citrus	Fruits and vegetables	Fruits and Vegetables
fried potato	Fruits and vegetables	Fruits and Vegetables
grape	Fruits and vegetables	Fruits and Vegetables
lettuce and other leafy greens	Fruits and vegetables	Fruits and Vegetables
melon	Fruits and vegetables	Fruits and Vegetables
onion, garlic and leek	Fruits and vegetables	Fruits and Vegetables

other fruits	Fruits and vegetables	Fruits and Vegetables
other vegetables	Fruits and vegetables	Fruits and Vegetables
pepper and squash	Fruits and vegetables	Fruits and Vegetables
potato	Fruits and vegetables	Fruits and Vegetables
stone fruit	Fruits and vegetables	Fruits and Vegetables
strawberry	Fruits and vegetables	Fruits and Vegetables
tomato	Fruits and vegetables	Fruits and Vegetables
vegetable juice	Fruits and vegetables	Fruits and Vegetables
beef	Meats	Meat, Fish and Eggs
chicken	Meats	Meat, Fish and Eggs
fish and seafood	Meats	Meat, Fish and Eggs
cold meats	Meats	Meat, Fish and Eggs
other meats and bushmeat	Meats	Meat, Fish and Eggs
pork and ham	Meats	Meat, Fish and Eggs
nuts and legumes	Nuts and legumes	Miscellaneous
canola oil	Others	Fats & Oils
fat	Others	Fats & Oils
sauce and vinaigrette	Others	Fats & Oils
candy and chocolate	Snacks	Miscellaneous
snack	Snacks	Miscellaneous

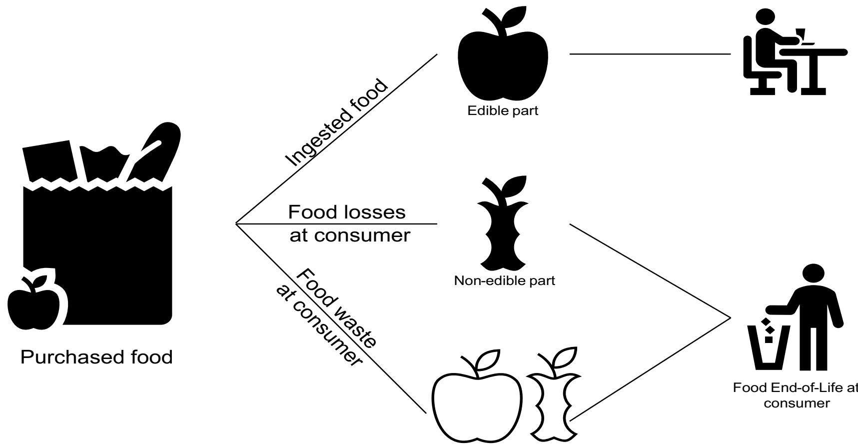

Figure A1 – Definition of purchased food divided into ingested food (edible part), food losses at consumer (non-edible part) and food waste at consumer (edible and non-edible parts).

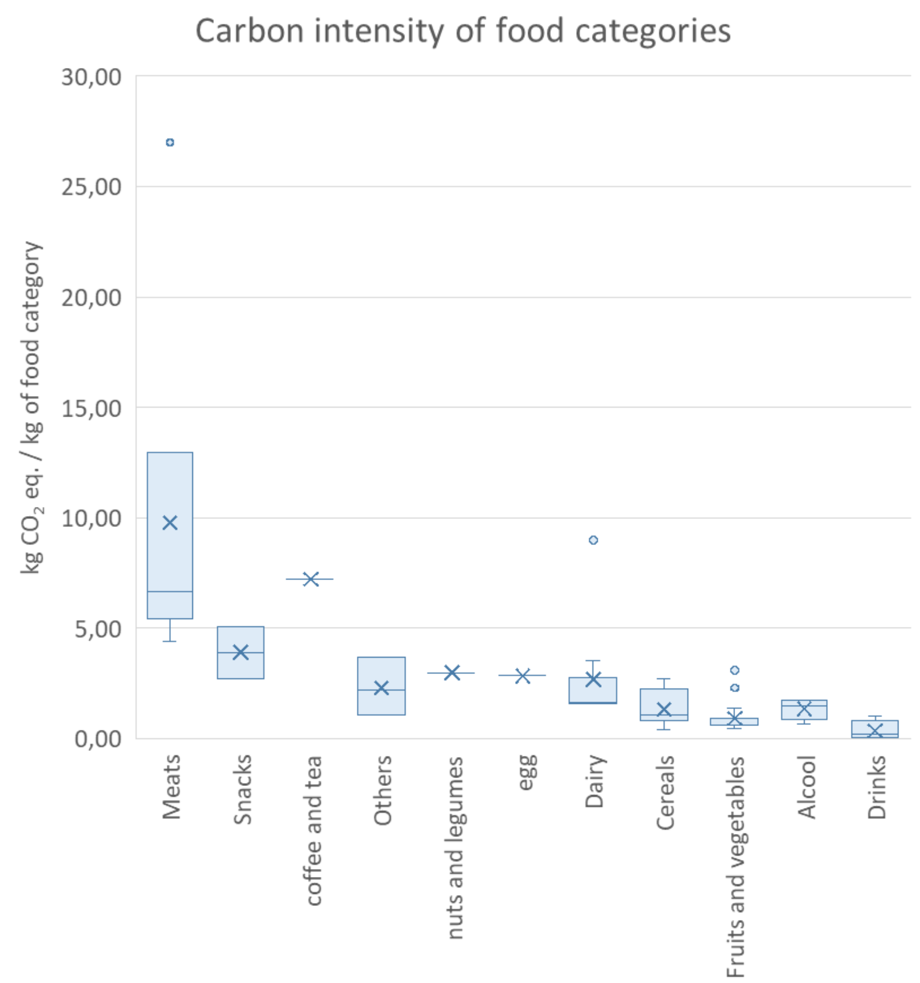

Figure A.2 - Distributions of carbon intensity of food categories per food group

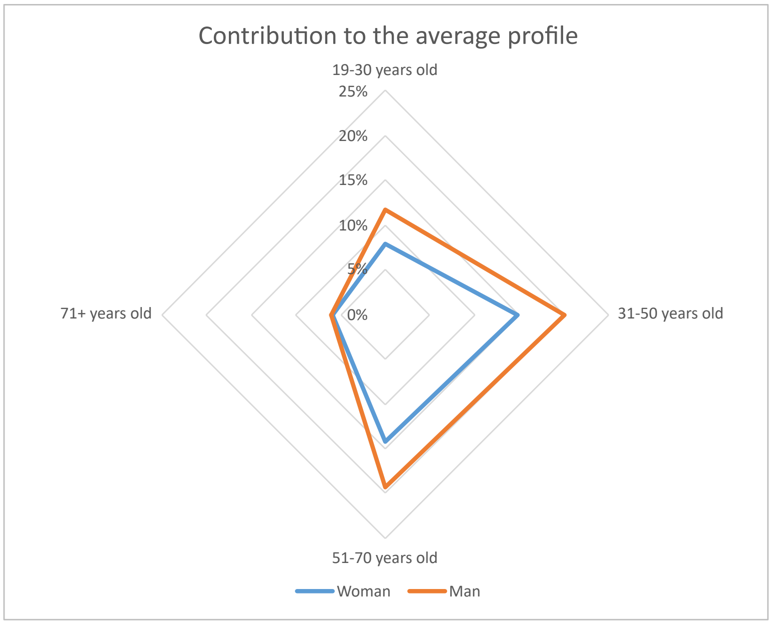

Figure A.3 - Contributions of the different population archetypes to the average profile for the carbon footprint of food consumption in Québec

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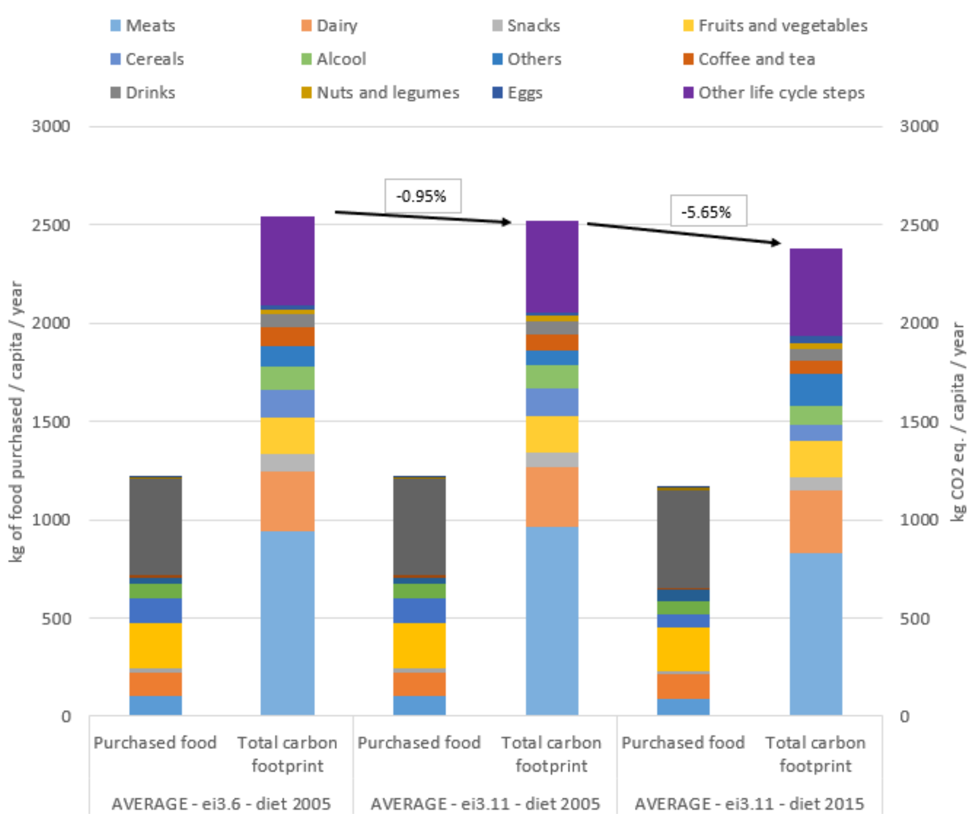

Figure A.4 – Per-capita average purchased food amount and carbon footprint based on 24h recall survey in 2005 and 2015. Left panel present results for reference year 2005 using ecoinvent 3.6 cutoff version (ei3.6). Center panel present results for reference year 2005 using ecoinvent 3.11 cutoff version (ei3.11). Right panel present results for reference year 2015 using ecoinvent 3.11 cutoff version.