Evaluating the Historic Change in Per Capita Nominal Consumption of Animal Products in Canada Over the Past 60 to 100 years

By

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Abstract

Since the early 1960s, the global anthropogenic food systems have become incredibly resource intensive and have caused a global increase in greenhouse gas emissions, freshwater scarcity, land cover conversion, and biodiversity loss. Animal agriculture, defined by the production of land-based animals for meat, milk, eggs, and other products, is a major sub-section within these global food systems that greatly contributes to the environmental degradation caused by food systems. The balance of scholarly evidence demonstrates that animal products are the most environmentally impactful products to produce and consume, and 53% of food-related emissions are derived from livestock systems. Due to the impactful environmental footprint of animal products, changing people's dietary choices and reducing meat consumption on a population level is critical to planetary health. Within the Canadian context, three quarters of food-related emissions are derived from the consumption of animal products, and reducing consumption of animal products will decrease the impact of the Canadian lifestyle on the environment.

This research investigates how historical trajectories of Canadian per capita consumption of high-impact animal products have changed over time. Per capita consumption of beef, pork, chicken, turkey, eggs, and milk is calculated using Statistics Canada production and disappearance data to examine changes in consumption over time. The results indicate that poultry currently dominates the livestock consumption in Canada, and there have been significant increases in poultry consumption over time. Beef, pork, milk, and egg consumption have decreased over time, although, the total meat consumption has remained high throughout time with no significant variation. The study adds to the evolving body of literature on agriculture and the environment by examining historic consumption trajectories of high-impact products which can be used to inform modelling scenarios of future Canadian consumption. In turn, this can help better inform decision-makers to understand the impact that potential interventions for influencing the changes in the Canadian diet could have on the Canadian environment.

Keywords: Food systems, Historical consumption, Animal-based protein, Canadian diet, Dietary patterns

List of Abbreviations

GHG	Greenhouse Gas
CO_{2eq}	Carbon Dioxide Equivalent
CH_4	Methane
N_2O	Nitrous Oxide
CO_2	Carbon Dioxide
Kcal	Kilocalories
FAO	Food and Agriculture Organization

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Chapter 1: Introduction

1.1 Motivation

Recent estimates suggest that terrestrial livestock production accounts for 56-58% of total food-related emissions (Poore & Nemecek, 2018). Livestock biomass significantly outweighs the total human biomass on earth and surpasses the biomass of wild animals by 14.3 times (Bar-On et al., 2018). The sheer scale of animal agriculture systems is increasing pressures on planetary boundaries and preventing the achievement of climate change prevention targets (Clark et al., 2020). An increase in demand for animal products will continue to amplify pressures to convert forests, wetlands, or grasslands into agricultural land (Van Zanten et al., 2018). The environmental impacts of animal agriculture production must be widely recognized in order to prevent environmental degradation and mitigate greenhouse gas (GHG) emissions.

As GHG emission intensities vary widely both within and between types of foods (e.g., protein-rich foods, vegetables, etc; Poore & Nemecek, 2018), what foods people eat has a direct impact on the amount of GHGs emitted from diet and food systems (Niles et al., 2017). Over the past decade, individual dietary habits have shifted towards more animal-based products (Niles et al., 2017). The Canadian diet is highly focused on animal-based products, and a large proportion of Canada's emissions are derived from food systems (Auclair & Burgos, 2021a).

I was personally motivated to pursue this research because of the relationship between food systems and the environment. Animal agriculture is a major contributor to global GHG emissions (Poore & Nemecek, 2018), and the environmentally impactful animal production systems are a direct result of human demand for animal products. Humans have the power to reduce the impacts of animal agriculture by changing their diet. Reducing demand for meat products can significantly reduce diet-related GHG emissions and land conversion (Hallström et al., 2015). Encouraging Canadians to reduce their meat consumption would make a significant difference in reducing the environmental impact associated with the Canadian lifestyle. It is a simple change but needs to be implemented on a national scale. I want to contribute to the body of research that explores diet and food systems to encourage a reduction in animal-product consumption in order to reduce human impact on the environment.

The goal of this project is to construct historical trajectories of Canadian per capita consumption of livestock products. Results will not only illuminate the historical change in Canadian consumption of these nutritionally important, but environmentally impactful parts of the diet, but contribute to our understanding of the sort of consumption rate reductions that might be possible in the future. In this regard, this research will help inform efforts to describe and model different future Canadian food consumption scenarios along with strategies to reduce future food-related GHG emissions in Canada.

1.2 Background

Food systems are defined as all the activities that occur along the food chain as well as the outcomes and governance of these activities (Vermeulen et al., 2012). Food systems exist on a global scale, and all humans participate in food systems by consuming food for survival (Vermeulen et al., 2012). There are numerous major components that make up the global food systems, including agricultural and seafood production, food processing, sales, and distribution (Chaudhary et al., 2018). Global food systems were established in response to the food consumption demands of the global human population. However, with the increasing human population, the demands are immense and have caused extensive degradation of Earth's ecosystems and biogeochemical cycles that sustain all life on Earth. Transformation of global food systems is required if they are to provide caloric requirements to every human on Earth while maintaining sustainable practices to prevent environmental impacts.

Agriculture is an essential production practice within the global food systems that are necessary to produce enough food to feed the world population. Due to food requirements on a global scale, agriculture requires immense amounts of land and resources to maintain production levels. The environmental requirements that are necessary to maintain agriculture production have resulted in agriculture becoming the primary driver of food-related GHG emissions (Vermeulen et al., 2012). Agriculture contributes an estimated 13.7 billion metric tons of carbon dioxide equivalent (CO_{2eq}) emissions of GHGs (Poore & Nemecek, 2018), both directly, through agricultural practices, and indirectly, through carbon loss due to land cover change and resource depletion (Vermeulen et al., 2012). Furthermore, the natural resource requirements to maintain the current agriculture systems are unsustainable and significant change in production is required in order to remain within what scholars have described as the planetary boundaries (Rockstrom et al., 2009; Steffen et al., 2015) of natural resources (Campbell et al., 2017).

All forms of animal production, including aquaculture- the farming of aquatic species and fisheries- are important, though not essential sources of protein-rich foods in human diets (Wu et al., 2014). Animal agriculture, also known as livestock production, is a major sub-sector within terrestrial agriculture systems that involves raising land-based animals for meat, milk, eggs, and other products (Wu et al., 2014). Because of the scale and the resource demands required to maintain current livestock numbers globally, livestock production is the most impact sub-sector in agriculture systems globally (Ritchie, 2019). Richie (2019) found that total emissions from animal agriculture and fisheries amount to 53% of total emissions derived from food systems. In terms of total global emissions, animal agriculture is responsible for 8-10.8% of global greenhouse gas emissions, and accounting for lifecycle assessment, the contribution of livestock is up to 18% (O'Mara, 2011). The production of livestock is also resource-intensive, and their production has caused significant resource depletion due to the necessary inputs to maintain the livestock population (Sun et al., 2020).

The capacity for animal agriculture systems to support a rising global population with increasing food demands has become a primary environmental concern (Rosegrant, 2003). With increasing global demand for animal products, livestock growth has significantly surpassed the growth of the human population (Ritchie & Roser, 2017). Since the 1960s, beef production has more than doubled, chicken production has increased by a factor of nearly 10, and milk and egg production, per animal, has increased by 30% (Thornton, 2010). Demand for meat products has been continuously growing on a global scale over time, and global meat production has increased from 71 to 341.16 million tons between 1961 and 2018 (Ritchie & Roser, 2017). The global increase in demand for livestock products has resulted in enormous production growth (Ritchie & Roser, 2017), further increasing food-related impacts on a global scale.

Dietary choices are critical determinants of planetary health and environmental impact (Auclair & Burgos, 2021b). Canada is a wealthy country, resulting in the Canadian diet being highly focused on the consumption of animal-derived products (Auclair & Burgos, 2021b). Approximately 75% of Canada's diet-related GHG emissions arise from animal-based foods (Auclair & Burgos, 2021a). This results in the Canadian lifestyle contributing to one of the highest per capita GHG emissions globally (Ritchie & Roser, 2020). Reducing meat consumption and transitioning to a vegetarian or vegan diet has the potential to reduce global GHG emissions related to food consumption and reduce per capita land demand (Hallström et al., 2015). Reducing meat consumption would decrease the environmental impact of the Canadian diet and reduce the need for high production volumes.

1.3 Study Introduction

The objective of this project is to construct historical trajectories of Canadian per capita consumption of animal-based products in order to investigate how consumption of high-impact products has changed over time in Canada. This will include estimates for beef, pork, chicken, turkey, eggs, and milk. Though my focus is on consumption, as there are no direct means to assess what is actually consumed by Canadians over long periods of time. I will be primarily relying on historical Canadian production data for certain commodity groups which have experienced limited import or exports in recent decades. I will also be referencing what is described by Agriculture and Agri-Foods Canada as 'disappearance data' to answer the following question: What, if any, changes have occurred over time in the per capita nominal mass of livestock-derived products made available for consumption in Canada over the past 60 to 100 years? Here, I use the phrase nominal consumption to represent the mass of livestock products that need to be produced. This will account for both inevitable losses before consumption and processing transformations into derived products (e.g., cheese, butter).

This work will support Nicole Arsenault's Ph.D. research modelling scenarios that explore the reductions in environmental impacts made possible by changes in Canadian consumption and production. Nicole's work will help understand the need for the adaptation of agriculture systems to a growing Canadian population. Historic consumption trajectories of high-impact products will inform the modelled scenarios by providing insight into how Canadian animal food consumption has changed during the past century. The conclusions of this research are important because limited available information suggests Canadian per capita consumption of livestock products is relatively high (Whitton et al., 2021), and targeting consumption trends would effectively decrease the impact of livestock production on the environment (Steinfeld et al., 2006).

1.4 Summary of Approach

This project aims to construct historical trajectories of Canadian per capita consumption in order to inform future projections of national food-related emissions. To do this, Canadian production and disappearance data was sourced from Statistics Canada and Agriculture and Agri-Foods Canada and organized based on available data and to standardize outputs. Production data was used to represent the consumption of chicken, turkey, eggs, and milk over time. Disappearance data was used to represent beef and pork consumption over time. Canadian population data was sourced from Statistics Canada and utilized to calculate per capita consumption. Once the data were uploaded and organized into Microsoft Excel, per capita consumption for each product was calculated using the total annual production divided by the annual Canadian national population. This determined the per capita consumption of each animal product on a yearly basis for the longest time series supported by data. Per capita consumption for each animal product was graphed using bar graphs and a trendline was added to represent the change in consumption. The results were analyzed to determine how the per capita consumption of each product changed over time.

Chapter 2: Literature Review

2.1 Overview

The purpose of this literature review is to provide an overview of the research conducted within the field of food systems. The literature is primarily focused on the rise of animal agriculture, factors driving demand for animal-based products, and the environmental impacts of meat consumption. The journals most frequently referenced in this review include: Science, The Journal of Cleaner Production, and Science of the Total Environment. This literature review also heavily relies on data derived from the Government of Canada and Our World in Data. Literature exploring the factors contributing to increased demand for animal-based products and production volumes is reviewed. The implications of meat-based diets and species-specific protein sources are explored in-depth to contextualize the environmental significance of dietary choices. The current animal agriculture production systems in place in Canada are also reviewed to distinguish the difference in data availability for the methodological approach. Knowledge gaps regarding historical consumption in Canada were identified.

2.2 Anthropogenic Challenges and the Global Food System

2.2.1 Planetary Boundaries

Though the many local to global-scale environmental changes that humans have induced are a concern, in recent years, a broad academic consensus has emerged regarding some of the most globally pressing issues that must be attended to remain within what is described as the safe operating space for humanity (Rockström et al., 2009; Steffen et al., 2015). These authors have also defined the planetary boundaries as the limitations within which human-induced change should be constrained in order to maintain conditions conducive to long-term human life and civilization on Earth into the future (Rockström et al., 2009; Steffen et al., 2015). Although, human-related activities are threatening most of the more recently defined planetary boundaries (Steffen et al., 2015). It was estimated that humanity currently is transgressing three major planetary boundaries: changes to the global nitrogen cycle, climate change, and rate of biodiversity loss (Rockström et al., 2009). Importantly, from the perspective of my thesis and focus on the impacts of food systems, Campbell et al. (2017) assessed the role that agriculture plays in terms of threatening the planetary boundaries. They found that agriculture's role in transgressing the P boundary, defined as the avert widespread eutrophication of freshwater systems, to be over 90% due to the production of fertilizer for agriculture use (Campbell et al., 2017; Steffen et al., 2015). Campbell et al. (2017) has also suggested that the role of agriculture in the status of the biosphere integrity planetary boundary to be 80%. Along with land system change and freshwater use, agriculture is the major driver of 4 out of 5 of the planetary boundaries at high risk or increasing risk zones, as well as a significant driver of many planetary boundaries that remain within the safe operating space (Campbell et al., 2017). The current food systems need to be reconstructed in an environmentally sustainable way in order to support human life (Niles et al., 2007).

2.2.2 Introduction of the Global Food System

The global food system is an interconnected set of food items or commodity-related sub-systems that is responsible for producing and delivering the food demanded by an increasing global population (Alexander et al., 2017). Food systems are fundamentally characterized by social and economic change, such as intensification of production, retailing, distribution processes, and the demand of global consumers (Ericksen, 2008). There are several production processes and delivery systems that have been developed on a global scale to supply the food necessary to feed the ever-growing demands of humanity. As wealth and population increase, the pressure for food systems to increase production capacity increases. The current global food system contributes significantly to global environmental challenges and puts at risk our ability to maintain productive food systems into the future (Niles et al., 2007).

2.3 The Growing Demand for Animal Production

Global meat consumption trends have shown a significant rise over time. Global aggregate meat consumption between 1990 and 2009 has increased by 58.7%, and per capita meat consumption has increased by 24.3% (Henchion et al., 2014). In terms of global per capita consumption of different animal products between 1990 and 2009, bovine meat decreased by 7.7%, pig meat increased by 19.7%, and poultry meat increased by 76.6% (Henchion et al., 2014). Although, total global production of beef, pork, and chicken has consistently increased over time at differing rates (Ritchie & Roser, 2017). Developed countries are high consumers of animal-based products (Thornton, 2010), and have maintained the highest consistent levels of consumption over time on a national scale (Ritchie & Roser, 2017). Historically, the primary demand for animal-based products was derived from developed countries like Canada and the United States (Ritchie & Roser, 2017). Over time, the demand for animal-based products has changed, and a major contributor to increasing demand for livestock is attributed to low-income countries. Meat consumption in developing countries was found to have increased 3 times as much as in developed countries between 1970 and mid-1990s (Delgado, 2003). Annual per capita consumption of meat in developing countries increased from 14kg in 1980 to 28kg in 2002 (Thornton, 2010). In developed countries, annual consumption of meat increased from 73kg in 1980 to 78kg in 2002 (Thornton, 2010). The consumption rates of livestock products are significantly higher in developed countries, although, the change in consumption over time is increasing at a higher rate in low-income countries (Thornton, 2010).

The growing demand for animal products is primarily driven by global income growth, population growth, and urbanization (Keyzer et al., 2002). With increasing wealth in low-income countries, low-income populations are increasing their consumption from the extremely low levels of the past (Delgado, 2003). In these regions where urbanization and income growth are rapidly rising, per capita consumption is increasing due to the new ability for people to afford variety in their diet (Delgado, 2003). This major transition in population-level dietary patterns that are associated with economic development is referred to as nutrition transition, defined as a major transformation in dietary patterns that increased the consumption of fat, sugar, processed food, and animal protein on a population level (Henchion et al., 2014). Population growth worldwide is also increasing the demand for animal products since there are more people on Earth to feed. In developed countries, like Canada, per capita consumption levels of animal-

-based products remain high and consistent (Ritchie & Roser, 2017). Although, the risein population over time has resulted in higher production values for animal-based products to accommodate larger population numbers (Ritchie & Roser, 2017). The population is a major contributor to increasing demand since more people on Earth causes an increase in production volumes to maintain sufficient nutrient needs on an individual basis.

2.4 Canadian Production Systems

Animal agriculture industries such as meat and dairy manufacturing are primary Canadian food industries (Government of Canada, 2021). In terms of total yield, Canadian meat production generates an average revenue of $29.7 billion per year (Shahbandeh, 2022). The high demand for meat products among Canadians has resulted in the development of a major Canadian industry that is heavily relied on for profit and income (Government of Canada, 2021). Not only is animal production high profiting in Canada, but Canadian beef production is highly successful in other nations due to high exportation volumes to different countries (Government of Canada, 2002). High national and international demand for beef products has resulted in beef and feedlot operations being the second most abundant agricultural operation in Canada, occupying 18.6% of operations (Government of Canada, 2017). Due to the high demand for meat products on a national and international scale, the Canadian meat industry has become a highly important industry for the Canadian economy (Government of Canada, 2021).

2.5 Supply Systems of Canadian Products

In Canada, there are two distinct livestock production governance systems in place. The first and oldest are livestock farms that are governed as a commodity free-market system where prices paid for outputs are determined by the fluctuating market conditions, farm size, and output. This traditional free-market system allows for the exportation of their products and imports of similar product. In contrast, certain livestock commodities are regulated by a secondary system governed in Canada under what is called Supply Management or Quota Management System.

2.5.1 Supply Management System

Chicken, turkey, eggs, and milk belong to the Canadian Quota Management System, also known as the Supply Management System (Barichello et al., 2006). This system was introduced in Canada in the 1970s (Barichello et al., 2006), and took several years to fully establish. Three main factors define the supply management system: 1) prices for the supply-managed products are determined by a cost of production formula; 2) the production of each product is limited to what the domestic market will consume at the cost-determined price; 3) international trade is limited to keep out less expensive foreign products (Barichello et al., 2006). These complex regulations allow Canada to restrict the supply and achieve a target price for these supply management commodities using government-administered quota (Lippert, 2001). Quota is a government-administered limit that restricts the quantity of product a farmer can produce and sell in a given period (Heminthavong, 2018). In order to produce any of the quota-managed products, farmers must hold a quota that allows them to produce a specific volume of products (Heminthavong, 2018). Consequently, it is possible to estimate nominal consumption, the amount of raw materials produced to sustain the final consumption of the product and accounting for losses, from the total volume of these commodities that were allowed to be produced in Canada for a given year.

2.5.2 Free Market System

Beef and pork production is not managed by the Canadian Supply Management System. The production of these products is significantly less regulated, resulting in few limitations on prices received, production volumes, and international trade. Beef and pork have minimal restrictions on imports and exports, resulting in high trade volumes between Canada and other countries. In 2019, Canada exported 47% of total produced cattle and beef and imported 69 million kilograms of beef products (Government of Canada, 2002). Due to high and varying levels of exports and imports, the amount of beef and pork being produced is not representative of the consumption in Canada. As a result, nominal consumption cannot be directly estimated from total domestic farm production levels. Consequently, I have relied on what are called 'disappearance' volumes that Agriculture and Agri-Foods Canada calculate annually for these commodity groups.

2.6 The Livestock Revolution

After the green revolution occurring in the 1960s, a livestock revolution began, which was primarily a result of people consuming more animal products as incomes rose (Ramankutty et al., 2018). By 2014, the world had 23.4 billion poultry birds, 1.7 billion cattle and buffaloes, and 0.9 billion pigs (Ramankutty et al., 2018). Animal production was increasing rapidly, and the production of chicken and pigs increased faster than human population growth by 5 and 2.5 times, respectively (Ramankutty et al., 2018).

Livestock production has been able to grow at such high rates due to livestock intensification (Davis & D'Odorico, 2015). Livestock intensification involves the increased production of animals in a small land area without increasing land use at the same rate (Davis & D'Odorico, 2015). This transition to higher animal densities and pursuit of greater total livestock output is a result of concentrated animal feeds, pharmaceuticals, vaccinations, improved efficiencies in feed production, and improved efficiencies in processing infrastructure (Ramankutty et al., 2018). Selective breeding has also resulted in a higher carcass mass per animal, allowing the consumable meat per animal ratio to increase (Thornton, 2010). Between the early 1960s to mid-2000s, the carcass weights for both chicken and beef increased by approximately 30%, and pig carcass weights increased by approximately 20% (Thornton, 2010). The accelerated growth rates of chicken and pig production are a result of decreasing importance of ruminants compared to monogastric species (Gilbert et al., 2015). Monogastric species are more efficient, and the production can be amplified due to the intensive production techniques and optimization of feed conversion ratios (Gilbert et al., 2015).

Figure 2.1 illustrates the increase in global meat production over time. It is important to note that beef, swine, and poultry dominate global livestock production, and total production rates have been consistently increasing over time (Ritchie & Roser, 2017). In 1961, Figure 2.1 shows that beef was the dominant meat produced in terms of total tonnage. Throughout time, the growth rate of beef production increased at a slower rate than pork and chicken (Figure 2.1). By 1996, global pork and chicken production both surpassed total beef production and have continued to increase at higher rates than beef production (Figure 2.1).

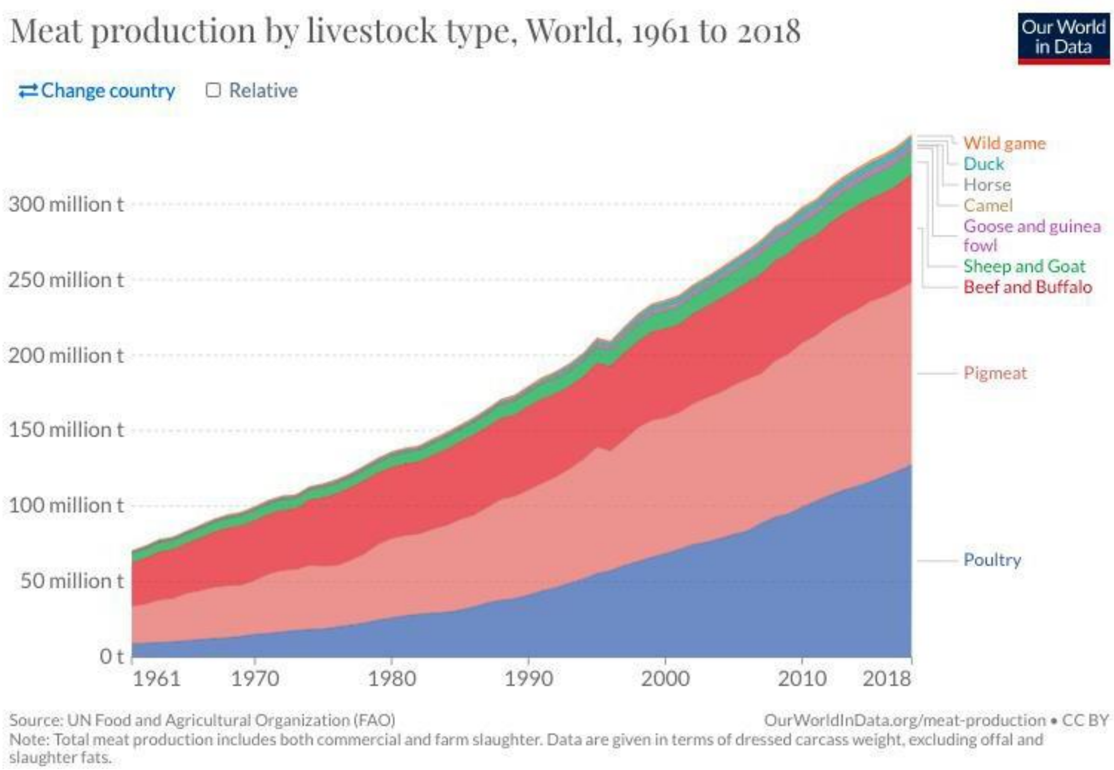

Figure 2.1 Change in global meat production tonnage by livestock type from 1961 to 2018, retrieved from Our World in Data. This figure illustrates the significant increase in meat production over time, predominantly driven by poultry and pig meat production. Graph produced by Ritchie and Roser (2017), original data derived from the Food and Agriculture Organization (FAO).

2.7 Impacts of Animal Agriculture

2.7.1 GHG Emissions

GHG emissions are defined as gases that trap heat in the atmosphere and strengthen the greenhouse effect. The FAO estimates that animal agriculture contributes 18% of total global GHG emissions (Steinfeld et al., 2006). Livestock production contributes significant GHG emissions from several processes, including enteric fermentation, use of nitrogenous fertilizers in crop and pasture production for feeds, manure management, manure deposition, and fossil fuel usage (O'Mara, 2011). Although, certain processes are primary contributors of the three major GHGs, methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2). CH_4 production from enteric fermentation is the largest source of cattle-related emissions, accounting for 71% of total livestock-related emissions (Gerber et al., 2013). The processes of spreading manure on agricultural soils, deposition of urine on pastures, and application of N fertilizers are the primary sources of N_2O emissions from livestock (O'Mara, 2011), particularly for the pig supply chain (Gerber et al., 2013). Direct emissions from livestock supply chains, animal feed production, and post-harvest activities derived from poultry and pig production account for a large proportion of emissions livestock-related emissions (Gerber et al., 2013). Based on analysis undertaken by Poore and Nemecek (2018), of the 26% of total anthropogenic GHG emissions that arise from all food system-related activities globally (Figure 2.2), 53% results directly or indirectly from the production of animal-based foods: 31% is derived directly from livestock and fisheries, 16% is derived from land use for livestock, and 6% is derived from crops for animal feed (Figure 2.2; Ritchie & Roser, 2020).

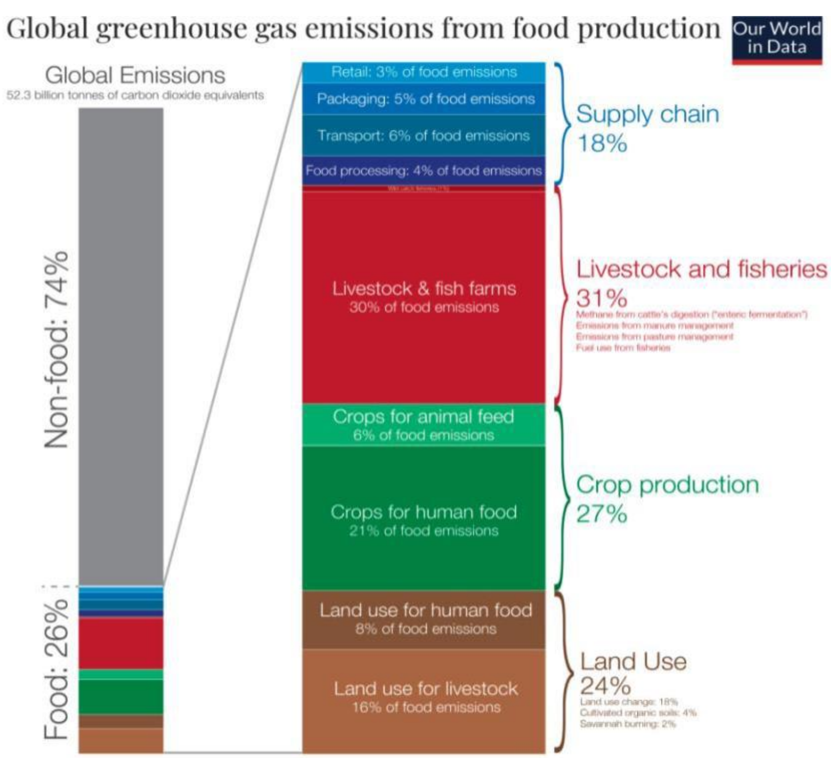

Figure 2.2 Global GHG emissions derived from food production, retrieved from Our World in Data. In terms of global emissions, food systems account for 26%. Of the food related emissions, livestock and

fish farms produce 31% of emissions, land use from livestock produces 24% of emissions, and crops for animal feed produce 6% of emissions. Graph produced by Ritchie and Roser (2020), original data derived from Poore and Nemecek (2018).

2.7.2 Resource Depletion

Despite increased resource use efficiency improvements through intensification, as noted above, livestock production remains highly resource-intensive due to substantial investments of land, water, and resources necessary to maintain the size of global herds and flocks (Sun et al., 2020). In terms of water usage, agriculture utilizes 92% of the total anthropogenic freshwater use, and 29% of the water used in agriculture is allocated for animal production (Gerbens-Leenes et al., 2013). Animal products have a large water footprint related to crop production, and the three primary factors driving the water footprint of meat are: feed conversion efficiencies, feed composition, and feed origin (Gerbens-Leenes et al., 2013). Animal feed is a major driver of freshwater use for animal agriculture, and on top of water needs for growing feed, water is also required to maintain the farm and the animal population (Gerbens-Leenes et al., 2013). The production of livestock requires substantial volumes of freshwater to sustain the feed inputs of growing livestock volumes, but also degrades other freshwater resources through pollution from livestock waste (Gerbens-Leenes et al., 2013).

Livestock systems currently occupy 30% of ice-free terrestrial land and utilize 70% of all agricultural land (Thornton, 2010; Van Zanten et al., 2018). The growth of livestock production has become a primary driver of forest and grassland conversion into agricultural land (Van Zanten et al., 2018). The need for increasing agricultural land area to accommodate growing livestock populations is necessary to sustain the growing demand for livestock products. As volumes of livestock increase, the increased requirement for animal feed subsequently contributes to driving land conversion (Thornton, 2010). In terms of total arable land, 33% is used for animal feed production (Wu et al., 2014), and the global demand for livestock products continues to drive land conversion for growing animal feed (Thornton, 2010). With increasing land conversion rates for livestock production and feed production, biodiversity vulnerability also increases due to habitat loss and fragmentation (Mantyka-Pringle et al., 2015).

2.8 Species-Specific Impacts of Livestock Production

2.8.1 Cattle

Ruminants are mammals that can obtain nutrients from lignocellulosic-rich plants through a fermentation process, called enteric fermentation, that occurs before digestion (Garnett et al., 2017). This process is advantageous due to the ability of ruminants to digest cellulosic materials, like grasses, which are generally indigestible by many other species. Unfortunately, enteric fermentation results in the production of substantial volumes of methane emissions (Garnett et al., 2017). Ruminants are the most environmentally impactful livestock animals and have the higher resource consumption volumes in the livestock system, and cattle, specifically, is the most impactful (Du et al., 2022; Ripple et al., 2013). For example, in their compilation of food item-specific life cycle assessment results, Poore and Nemecek (2018) found that dedicated beef production resulted in a mean GHG emission intensity of 50kg CO_{2eq} and the mean land use of $164m^2$ per 100 grams of protein produced (Figure 2.3). Due to the high environmental impact and large production volumes of cattle, cattle account for around 80% of total livestock-related emissions (Du et al., 2022; Garnett et al., 2017). Figure 2.4 illustrates that beef is by far the most impactful livestock species, and ruminants dominate other food products in emissions. The continued growth of beef and ruminant consumption is a major obstacle in reaching climate targets (Ripple et al., 2013).

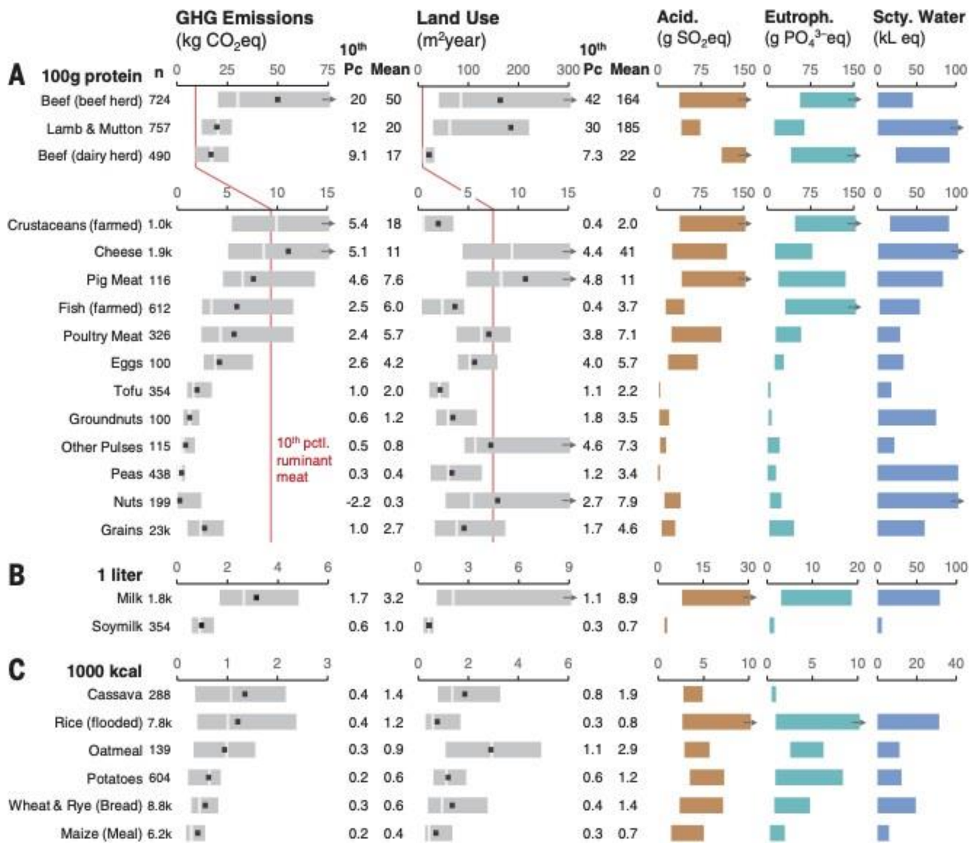

Figure 2.3 The estimated global variation in GHG emissions, land use, terrestrial acidification, eutrophication, and scarcity-weighted freshwater withdrawals for protein rich foods, milk, and starches (Poore and Nemecek, 2018). This figure shows how animal-based protein sources are more impactful than plant-based alternatives. Beef and ruminants are significantly more impactful compared to chicken, pork, eggs, and milk. (Poore and Nemecek, 2018).

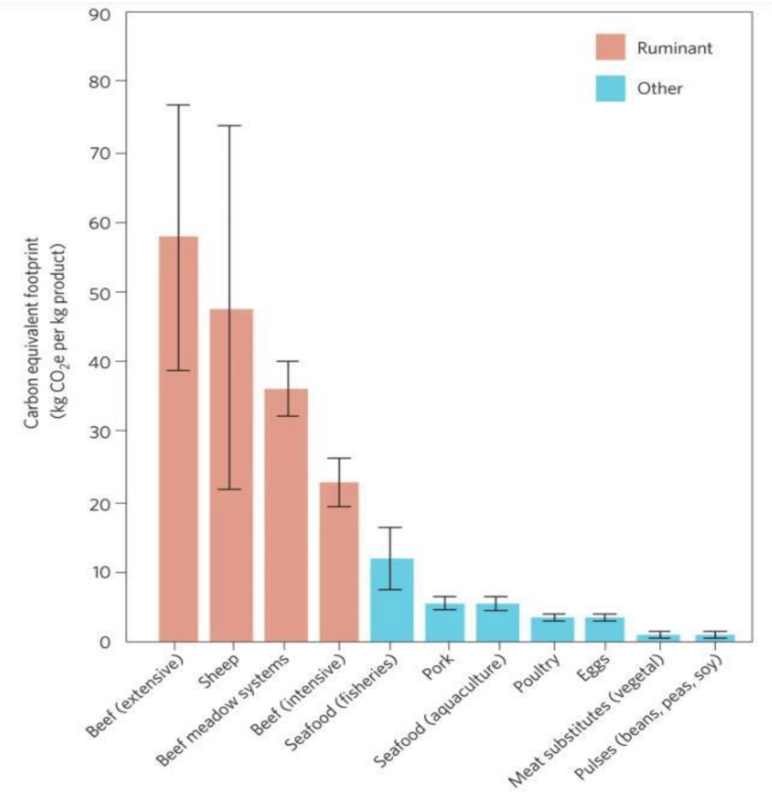

Figure 2.4 Average carbon equivalent footprint of animal-based protein sources per kilogram of product determined by a global meta-analysis of life-cycle assessment from Ripple et al. (2013). This diagram shows the relative carbon footprint of different protein foods, with ruminant animals, beef in particular, having the largest footprint. Plant-based alternatives have the smallest carbon footprint.

2.8.2 Swine

Monogastric animals, like pigs, are differentiated from ruminant animals by their single stomach (Rowan et al., 2010). Monogastric digestive systems as not capable of enteric fermentation, and therefore monogastric animals produce significantly less methane per kilogram of livestock product (Garnett et al., 2017). Figure 2.3 illustrates the significantly less environmentalimpact that pig meat produces per unit of edible meat compared to ruminant species. Despite a reduced environmental impact compared to ruminants, pig meat produces higher CO_2 equivalent emissions per kilogram of product compared to poultry and plant-based proteins (Figure 2.4). Poore and Nemecek (2018) found that dedicated pork production resulted in a mean GHG emission intensity of 7.6kg CO_{2eq} and a mean land use of 11m^2 per 100 grams of protein produced (Figure 2.3). Lower GHG emissions associated with swine production have come at the cost of higher nitrogen dependency, causing eutrophying emissions as a result of intensification (Ramankutty et al., 2018).

2.8.3 Chicken

Chicken is a monogastric animal, and it is one of the most consumed animal products on the planet. During the livestock revolution, the chicken was artificially selected to increase the efficiency of energy use for growth, resulting in less energy overall for metabolic processes (Tallentire et al., 2016). This increase in feed efficiency and decrease in growth-time to harvest weight has allowed the chicken industry to immensely increase its production volumes while limiting resource inputs and many associated impacts. Even in terms of egg production, chickens have also been artificially selected for high egg-laying frequencies, and over time have been able to produce around two times more eggs per individual (Thornton, 2010). Besides eggs, poultry meat has the lowest GHG emissions per 100g of protein of all animal-based products (Poore and Nemecek, 2018). In terms of chicken production, Poore and Nemecek (2018) found a mean GHG emission intensity of 5.7kg CO_{2eq} and the mean land use of 7.1m^2 per 100g of protein produced (Figure 2.3). Poultry emissions are lower than cattle and swine, although, poultry emissions per kilogram of the product remain higher than plant-based protein options (Figure 2.4). Despite the remarkable resource use efficiency gains and related environmental impact reductions made in poultry systems over recent decades, the high rates of poultry production for meat and eggs globally means that total emissions continue to rise (Garnett et al., 2017).

2.9 The Implications of Diet for Food System Environmental Impacts

2.9.1 Meat-Based Diets

Meat-based diets are defined as diets where animal-based proteins are the primary form of protein intake. Due to the typically higher rates of impacts of animal-based products relative to plant-based equivalents, meat-based diets are more environmentally impactful than vegetarian or vegan diets (Figure 2.4). Meat-based products have a higher environmental impact in terms of GHG emissions, water footprint, biomass use, and reactive nitrogen mobilization compared to plant-based options (Graça et al., 2015). In 2003, Pimentel and Pimentel found that the average fossil energy input for all animal-based protein sources is 25 kilocalories (kcal) of fossil energy input per 1kcal of protein produced, whereas the energy input per 1kcal of plant protein produced 2.2kcal of fossil energy input (Pimentel & Pimentel, 2003). The energy input for animal-based foods is more than 11 times greater than that of the plant-based protein alternative (Pimentel & Pimental, 2003). In the work by Poore and Nemecek (2018), as revealed in Figure 2.3, we can see that all animal-based sources of protein-rich foods have higher GHG emissions and land use per 100g of protein compared to plant-based options (Poore & Nemecek, 2018). Meat-based diets require significant fossil fuel energies and natural resource inputs to produce and is not a sustainable diet that can be maintained long-term (Pimentel & Pimentel, 2003).

2.9.2 Vegetarian and Vegan Diets

Dietary change is necessary in order to reduce the environmental impact of the global food systems (Hallström et al., 2015). A shift towards vegan and vegetarian diets has the greatest potential to reduce GHG emissions from the average animal-based diet (Hallström et al., 2015). Since diet is a primary driver of an individual's food-related carbon footprint, dietary change is extremely important to reduce global GHG emissions (Niles et al., 2017). In affluent countries, dietary change away from the average omnivorous diet and towards more plant-based diets has the potential to decrease GHG emissions and land use demand by 50% (Hallström et al., 2015). Dietary shifts that involve the decrease in meat consumption could drive the generation of sustainable agriculture systems, increasing the potential to restore natural resources, climate resilience, and human health (Niles et al., 2017).

2.10 Canadian Dietary Trends

Before 2019, the previous Canadian food guides recommended daily serving portions of a variety of food categories including fruits, vegetables, bread and cereals, fish, meat, and milk (Dyer et al., 2020). The updated food guide is recommending much larger proportions of Canadian protein intake to come from non-animal sources and generally discusses the environmental impacts of Canadian food choices (Dyer et al., 2020). Canada is a developed country, and Canadian citizens consume large amounts of animal products. In a recent analysis of apparent GHG emissions associated with self-reported food intake by Canadians, three-quarters of Canadians' total diet-related GHG emissions are derived from animal-based foods (Auclair & Burgos, 2021b). In this study, red and processed meat was the primary source of diet-related emissions and contributed approximately 47% of all dietary GHG emissions (Figure 2.5). As seen in Figure 2.5, dairy was the second contributor to diet-related emissions in Canada, contributing 14% of all dietary GHG emissions (Auclair & Burgos, 2021b). Limiting the consumption of red and processed meat and emphasis on vegetables, fruit, whole grains, nuts, and legumes is encouraged to improve overall diet quality and decrease environmental impacts of Canadians (Auclair & Burgos, 2021b).

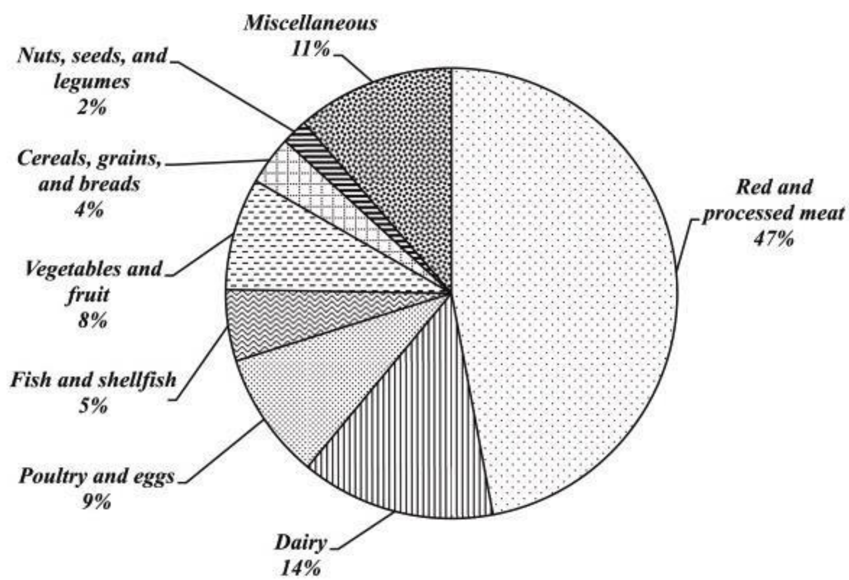

Figure 2.5 Contributions of different food groups to the total dietary GHG emissions related to food consumption in Canada, retrieved from Auclair and Burgos, (2021b). The authors calculate the GHG emissions associated with Canadian food consumption, as reported by respondents in the 2015 Canadian Community Health Survey (Auclair & Burgos, 2021b). Diagram shows that red and processed meats are the primary contributor to total dietary GHG emissions, with dairy being the secondary contributor.

2.11 Knowledge Gaps

Although there is some literature focusing on Canadian consumption of high-impact foods, the existing research is primarily focused on current Canadian consumption and the impact of self-reported diets. In 2021, Auclair and Burgos published two journal articles about the carbon footprint (i.e., GHG emission intensity) of the Canadian diet and nutrient contributions of different protein sources consumed in Canadian diets. These papers focused on a 2015 Canadian Community Health Survey to determine current consumption patterns of the Canadian diet. This survey data is not representative of the amount of consumption of animal products, and the study is more focused on the impact of consumption and nutrient intake (Auclair & Burgos, 2021b).

In 2020, Dryer and colleagues undertook an analysis of the impacts of red meat consumption in Canada using production volumes of livestock as opposed to historical consumption or production patterns in Canada (Dyer et al., 2020). Similar to my work, this study uses disappearance volumes for their analysis, though isn't focused on consumption changes over time. Sans and Combris (2015) help to fill the knowledge gap regarding historical global diets through published literature addressing the world meat consumption from 1961 to 2011. This research looks at a variety of countries and income levels to understand their general animal protein consumption (Sans & Combris, 2015). This research addresses national consumption patterns of meat protein, though, does not address species-specific consumption patterns. Little is known about how Canadian consumption of high-impact foods has historically evolved. Currently, research is highly focused on existing diet choices and their environmental impact. However, there is a gap in knowledge regarding historical consumption trends in Canada. This research will fill the gap in knowledge by mapping the historical consumption of high-impact products over time in order to determine how consumption in Canada has changed.

2.12 Conclusions

This literature has identified the factors contributing to growth in demand for animal-based products on a global scale. These factors, including income, population growth, and urbanization, have contributed to a global surge in the production of poultry, pork, and beef over time on a global scale. The challenges of increasing the production of animal-based products, however, include increased environmental implications related to dietary choices. In order to decrease diet-related environmental impacts, a shift in consumption towards plant-based options and a reduction of meat consumption would be necessary. There is very little research on historic consumption of animal-based foods over time and no research on Canadian historic consumption. This literature review has identified the need for further research surrounding the patterns of Canadian consumption over time and the requirements for future dietary changes to reduce Canada's diet-related emissions.

Chapter 3: Methodology

3.1 Data Overview

3.1.1 Defining Terms

This research sets out to estimate per capita nominal consumption of livestock products, where nominal consumption is defined as the total raw livestock commodity production necessary to satisfy domestic Canadian demand before processing transformations and losses occur. As there are no ideal datasets to understand actual Canadian consumption of final livestock derived products (e.g., cheese, steak, etc.) or accurately scale up from those values to raw commodity volumes, I am relying on two pre-existing datasets as a foundation of my research: Canadian production data of supply-managed sectors and disappearance data for beef and pork. The use of both datasets requires the assumption that the total annual production/disappearance volumes reported are the required level of production necessary to satisfy Canadian consumption demand. Though described earlier, as the supply or quota managed system effectively limits the amount of related product that is imported or exported, domestic production volumes are assumed to approximate nominal consumption well. Domestic disappearance is defined as the food available for consumption at the retail level in Canada and accounts for the production totals before losses occur (beef and pork data accounts for total carcass mass). Statistics Canada calculated disappearance values by subtracting the flows out and ending stocks from the production value and expressing this volume per capita. To expressed per capita the volumes per capita, and the population values utilized for the calculation were the Canadian populations as of July 1st of the year depicted.

Given the reliance on production data for quota-managed products, it means that non-edible portions of the animals or their products are included in the nominal consumption. For example, this includes things like blood, feathers, gastrointestinal tract, abdominal fat, and trachea for the quota managed broiler and turkey sectors, and eggshell for eggs. These are included in nominal consumption since they are necessary to produce the commodity. Although they are not consumed, they are included within production because they are by-products and will be discarded or re-directed to other uses as unavoidable food losses. In terms of eggs and milk, my use of production data means that all derived products that ultimately find their way into consumer-facing products (e.g., cheese, ice cream, ready-made baked goods) are represented not as their final form but as the nominal consumption of the original amount of commodity product that was required before it was processed or combined with other ingredients. It is the raw value of the products before they are processed for other products.

3.1.2 Sourcing Data

Statistics Canada was the primary data source used for this research. The Agriculture and Food Statistics sector within the Statistics Canada database is an open data source that synthesizes and makes available Canadian animal production data. These data are available for free download from the Statistics Canada website and consist of historical census data on many animal agriculture sectors. To source the data for the supply-managed products, eggs, milk, and poultry were searched through the database to find the most relevant production data on a yearly basis. One dataset was utilized for each of these three main supply-managed products. The three datasets were: Production, Disposition and Farm Value of Poultry Meat (Table: 32-10-0117-01,1941-2020), Milk Production and Utilization (Table: 32-10-0113-01,1946-2021), and Production and Disposition of Eggs, Annual (Table: 32-10-0119-01,1920-2020). Statistics Canada also publishes annual domestic disappearance data for a variety of protein sources every year. This dataset is called Food Available in Canada (Table: 32-10-0054-01) and will be utilized for both pork and beef consumption analysis.

3.1.3 Available Data

The Production and Disposition of Eggs, Annual (Table: 32-10-0119-01,1920-2020) dataset represents total domestic egg production in Canada over time. The total production of eggs is represented as the total amount of individual eggs in the shell that was produced for a given period. The data that were utilized for this analysis was the production of eggs in shells for Canada on a national scale, and the reference period was from 1926 to 2020. The production of eggs in shells was recorded in thousands and dozens, so these units of measure were converted to the number of individual eggs for the analysis.

The milk production and utilization (Table: 32-10-0113-01,1946-2021) dataset represents the total production of dairy milk in Canada over time. The data that was used to analyze the Canadian nominal consumption of milk comprised two related yet slightly differently described datasets: 'total milk production' and 'total milk sold off farms'. 'The total milk production' data was available for the period between 1946 and 1978. 'Total milk production' includes farm home consumed milk, milk fed to livestock, and milk sold off farms. In the late 1970s, around the time the supply management system was implemented on dairy farms in Canada, the 'total milk production' data series ends, and Statistics Canada begins reporting 'total milk sold off farms' for the period between 1976 to 2020. 'Total milk sold off farms' includes fluid purposes, industrial purposes, and milk delivered as cream. 'Milk production total' was discontinued in 1979, and in replacement, 'total milk sold off farms' was reported starting in 1976. Values for both data categories were recorded in kilolitres, and the unit was converted to liters during the analysis. The data represents the national total volumes in Canada, and the milk dataset for both categories of data was recorded per month. To find the total annual volume of milk, the monthly milk production volumes were added together. Changes over time in both data categories were expressed using one graph, but the separate nature of the datasets was retained by representing both as separate categories.

The Production, Disposition and Farm Value of Poultry Meat (Table: 32-10-0117-01,1941-2020) dataset reports the total domestic production of chicken and turkey in Canada over time. The total production of chicken and turkey is reported as eviscerated weight. The primary data that was used to analyze the consumption of chicken in Canada was the total eviscerated production mass of chicken including stewing hens, defined as egg-laying hens once they are butchered. The data that was used to analyze the consumption of turkey in Canada was the total eviscerated production mass of turkey. Both datasets are Canadian national totals, and the reference period was from 1941 to 2020. The data on both species of poultry produced were available both by weight (in kilograms) and as the number of whole birds. I have used poultry data for both weight in kilograms and number of whole birds to represent nominal per capita consumption of poultry on two different scales.

Beef and pork disappearance data were drawn from Food Available in Canada (Table: 32-10-0054-01, formerly CANSIM 002-0011). This dataset represented domestic disappearance data for a variety of food products. The beef and pork disappearance data are reported in a number of related product forms. For example, 'beef', 'beef, carcass weight', and 'beef, boneless weight', as well as parallel datasets for pork and veal are available. The middle of these three forms of products, 'species, carcass weight', is most similar to the eviscerated form that poultry data are reported in the production data described above. As veal and beef are two descriptors for edible forms of meat from cattle, data for beef and veal were combined in order to determine a total weight for beef consumption. The beef, veal, and pork values were expressed in kilograms, and both carcass and boneless weight were used to represent consumption in two separate graphs. The disappearance data for both beef, veal, and pork were available from 1960 to 2020.

In order to convert national production data for the supply-managed sectors into per capita consumption, Canadian population data was required. Two datasets were utilized to determine the Canadian population in order to cover the time series available for the various time series of product data used. Population Estimates, Quarterly (Table: 17-10-0009-01) and Archived - Population of Canada and the Provinces, Annual, 1926-1960 (Table: 36-10-0280-01 (formerly CANSIM 380-0043)) were the datasets used to determine the Canadian population and was derived from Statistics Canada. The Archived Population of Canada dataset consists of Canadian population data from 1926 to 1960, and the Populations Estimates dataset consists of Canadian population data from 1946 to 2020. The Archived Population of Canada dataset was referenced from 1926 to 1945, and the Population Estimates was the primary dataset referenced from 1946 to 2020. The population estimates dataset was recorded on a quarterly basis, whereas the Archived Population dataset was recorded on an annual basis. To ensure consistency while referencing the Population Estimates dataset, the annual value was based on the quarterly period ending in October since it was representative of the majority of the year.

3.2 Data Analysis

3.2.1 Overview of Analysis

Microsoft Excel (LTSC 2021, Microsoft corporation) was utilized to calculate per capita consumption where necessary and to represent per capita consumption over time using a bar graph. The primary calculation was to determine the per capita consumption of turkey, chicken, eggs, and milk. Since beef and pork were already expressed per capita, no calculations were necessary. Each livestock product was calculated individually to determine the per capita consumption of that product, and there was one graph produced for each product.

3.2.2 Analysis Process

The production data and population data were merged in Excel. All units of measure in the production datasets downloaded from Statistics Canada were converted before calculating per capita consumption. To make this calculation, the reported production data for the commodity was divided by the population data. This was repeated for every year the production data were available in order to determine per capita consumption over time of each commodity. Once the calculations were made for every year the commodity was available, a bar graph was created to represent per capita consumption over time. The disappearance values for beef and pork that represent per capita consumption were plotted on a bar graph as well. Bar graphs were chosen for this representation because the per capita consumption value for each year is discrete. A line of best fit and R^2 value was added using the built-in line generating function of Excel in order to show consumption trends over time for each commodity.

3.3 Limitations

3.3.1 Delimitations

This research is solely focused on the apparent nominal consumption of animal-based commodities produced nationally in Canada. This means that conclusions cannot be made on a provincial level, and changes in nominal per capita consumption trends per province are not analyzed. Including an analysis for consumption on a provincial level was considered for this research for the quota-managed sectors as provincial-level production data are available for each of the sectors. However, as interprovincial trade in Canada for each of the quota-managed products occurs, though its scale is limited, it was impossible to be confident that province-specific production was a reasonable surrogate for province-specific consumption. Free market products like beef and pork have minimal interprovincial trade limitations, making it extremely difficult to predict where the products produced in one province are ultimately consumed. Due to the uncertainty of interprovincial trade in Canada, the provincial level production data would not accurately represent the consumption of each commodity for each province.

3.3.2 Limitations of the Production Data

Poultry and egg production is managed by the quota system, although there is a limited number of chickens that Canadian residents can raise for meat and eggs without a quota. In many provinces, residents can raise up to 300 chickens without quota, but values fluctuate from province to province. These limits allow small-scale farms and backyard hens to be exempt from the quota system. These small-scale businesses or backyard farms produce eggs and poultry for consumption, but this production is not recorded in any official production statistics due to the small scale of these operations. This means that the consumption values calculated using Statistics Canada datasets are an estimate of Canadian consumption and would most likely be underestimated.

Supply management was officially introduced to Canada in 1972, and it took 10 years to establish the system and make it highly regulated. Supply management was implemented for eggs, milk, and poultry production in Canada. For each of these products, the Statistics Canada production data extends further back in time before the supply management system was established. This means that until 1972, the supply of these products was not reflective of the Canadian demand. In terms of eggs, there was significant competition between provinces to produce high volumes of eggs and decreased prices. This competition created a significant surplus of products that weren't necessary for the amount of demand. The supply management system was implemented as a necessity to reduce production since the production volumes were wasteful. This means that there might be higher volumes of supply-managed products before 1972 when the system was not implemented. Patterns of change could be reflective of the supply management system being implemented in Canada, but we cannot know to what degree this system has an impact.

3.3.3 Limitations of the Disappearance Data

Production datasets for the non-supply managed products represent total Canadian production, but due to high levels of imports and exports, these recorded production levels are not representative of total production necessary to satisfy Canadian demand. A large proportion of Canadian beef and pork production is exported, resulting in a large proportion of products being consumed in other countries. Because of this, production datasets cannot be utilized for beef and pork. Although, disappearance data can be utilized instead. Disappearance data represents the food available for Canadian consumption. This has a similar representation to production data because the disappearance values account for all food that is available for consumption in order to satisfy Canadian demand. Although the datasets differ in the name, they represent similar units of measure in terms of available products. For example, poultry is represented as eviscerated meat for both the production and disappearance data, making both datasets comparable. However, the per capita values calculated using the production data slightly differ from the disappearance values. This could be due to a difference in population values used to calculate the per capita consumption that resulted in slight inconsistencies between the two datasets.

Chapter 4: Results

4.1 Supply Managed Products

4.1.1 Eggs

Changes in per capita nominal consumption of the number of eggs produced in shells from 1926 to 2020 appear in Figure 4.1. The pattern of per capita nominal consumption of eggs from 1926 to 2020 has variation and deviation, and the line that was the best fit to the data was a cubic function (Figure 4.1). However, the more variable data early in the time series, specifically from 1926 to 1971 that occurred before the introduction of supply management to egg farming in Canada, results in an R^2 value of 0.6971. Most of the significant fluctuations observed in the per capita nominal consumption of eggs in Canada occur before the supply management system was introduced in 1972 (Figure 4.1). The periods of significant deviation in per capita consumption from the line of best fit occur from 1931 to 1938, where there is an apparent decline in per capita consumption that is not reflected in the best fit line, and from 1938 to 1948, there is an apparent spike in per capita consumption where consumption levels are at the highest of all (Figure 4.1). Before 1972, there are an abundance of inconsistencies that greatly differ from the line of best fit, but after the supply management system was introduced, per capita nominal consumption of eggs becomes less variable (Figure 4.1). The variation in per capita nominal consumption of eggs in Canada is relatively large, given the lowest value of 203 eggs per person in 1926 and the highest value of 366 eggs per person in 1945 (Figure 4.1). Some of the general patterns being observed in Figure 4.1 are an inclining slope from 1926 to 1948, a generally declining slope from 1949 to 1996, and an inclining slope from 1996 to 2020. More recently, between 1996 and 2020, there is an incline in consumption where per capita nominal consumption of eggs increases from 196 eggs per person in 1996 to 264 eggs per person in 2020.

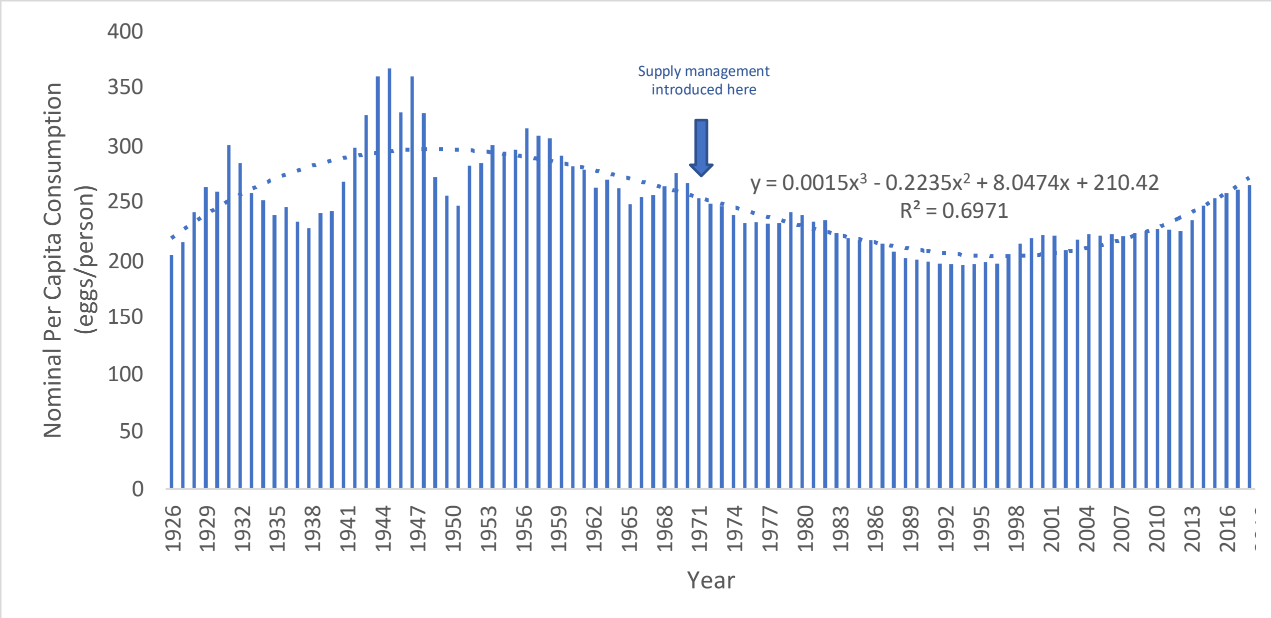

Figure 4.1 Canadian per capita nominal consumption of eggs from 1926 to 2020. Egg data represents individual number of eggs produced in shell. Data referenced for this graph was the dataset derived from Statistics Canada called The Production and Disposition of Eggs, Annual (Table: 32-10-0119-01,1920-2020).

4.1.2 Milk

Changes in per capita nominal consumption of milk in liters from 1946 to 2020 appear in Figure 4.2. There are two different types of data represented in Figure 4.2, with differing trends lines. Nominal per capita consumption of milk from 1946 to 1978 is represented by what Statistics Canada refers to as 'total milk production', while a second dataset, what Statistics Canada calls 'total milk sold off farms' is plotted for the years 1976 to 2020 (Figure 4.2). The 'milk production' data is best represented by a linear function trendline (Figure 4.2). There is a strong declining trend in per capita nominal consumption from 1946 to 1978 (Figure 4.2). The R^2 value of 0.9514 means there is a very strong correlation between the trendline and the observed data, and there is very little variance. Between 1946 and 1978, nominal per capita milk consumption decreased by approximately 6.7 liters per person on an annual basis. Milk consumption decreased from overall highs of nearly 500 liters of milk per capita in the mid-1940s to just over 300 liters of milk per capita by 1978. In terms of the 'total milk sold off farms' data that is representing nominal per capita milk consumption between 1978 and 2020, a quadratic function provided the best fit line for these data (Figure 4.2). Overall, these data display a slight decline between 1976 and 2000 (Figure 4.2). Between 2000 and 2020, there is a flattening off in per capita nominal milk consumption in Canada in the range of 220 to 240 liters per person per year. The R^2 value of 0.8714 or the best fit line to these more recent data indicates that there is a strong correlation between the trendline and observed data. Between 2014 and 2020, there is a slight increase in per capita consumption of milk. The 'total milk sold off farms' data is representative of the Canadian per capita nominal milk consumption after the supply management system was introduced. The trend observed in the period after supply management was introduced shows a slight decline, but generally consistent levels of milk consumption per person from year to year. Before the supply management system was introduced, there was a strong and consistent declining trend in milk consumption per person.

Figure 4.2 Canadian per capita nominal consumption of milk from 1946 to 2020. Milk data represents liters of milk produced before some of it was processed into products such as cheese and cream or losses occur. There are 2 sets of data representing nominal per capita milk consumption, and they are 'total milk production' in liters and 'total milk sold off farms' in liters. Both sets of data represent a similar thing but are independent from each other. Data referenced for this graph was the dataset derived from Statistics Canada called Milk Production and Utilization (Table: 32-10-0113-01,1946-2021).

4.1.3 Chicken

Changes in per capita nominal consumption of chicken in kilograms of eviscerated birds from 1941 to 2020 appear in Figure 4.3. A linear function trendline is the best fit option for the available data, and with an R^2 value of 0.953, it indicates a strong correlation with the data and very little deviation. Throughout the nearly 80 years represented, there is a very strong inclining trend in Canadian per capita nominal consumption of chicken of approximately 0.38 kilograms per person per year (Figure 4.3). There are slight deviations from the trendline, though there is a steady pattern of inclining per capita consumption consistently throughout time. When supply management was introduced in 1972, there is no clear change in the pattern of per capita nominal consumption of chicken from the years before the system was introduced (Figure 4.3). Per capita nominal consumption of chicken is increasing at a significantly large scale- from lows of less than 10 kilograms of eviscerated chicken per person per year in the 1940s to recent highs of nearly 35 kilograms of eviscerated chicken per person per year (Figure 4.3).

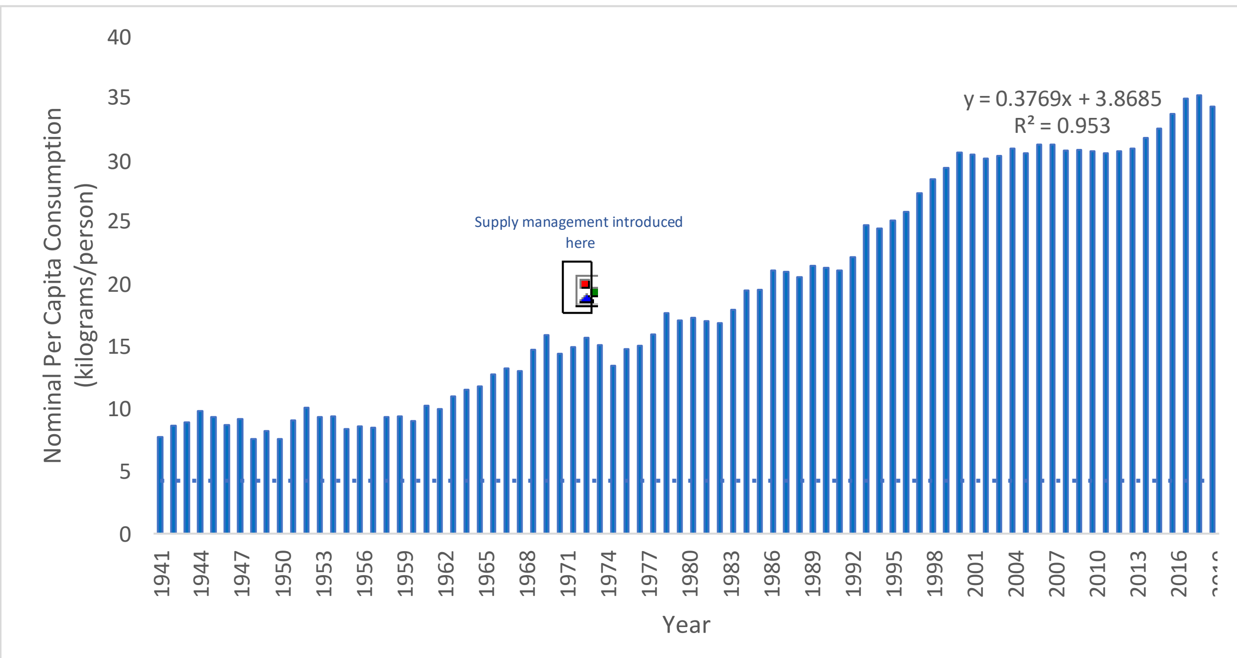

Figure 4.3 Canadian per capita nominal consumption of chicken in kilograms per person from 1941 to 2020. Chicken data represents eviscerated mass of both birds destined for direct consumption and spent laying hens and is measured in kilograms per person. Data referenced for this graph was the dataset derived from Statistics Canada called The Production, Disposition and Farm Value of Poultry Meat (Table: 32-10-0117-01,1941-2020).

Changes in per capita nominal consumption of chicken in terms of birds per person from 1941 to 2020 appear in Figure 4.4. Again, these data are best represented by a linear function trendline, and the R^2 value of 0.969 means that there is a very high correlation between the data and the trendline (Figure 4.4). There is a very clear and consistent pattern of increasing per capita chicken consumption over time. Per capita nominal chicken consumption changed from annual lows of 3.5 birds per person in the early 1940s and increased to annual highs of 19.8 birds per person in the late 2000s (Figure 4.4). There are slight deviations from the trendline, although they are very minimal. Per capita chicken consumption is increasing at high rates of approximately 0.27 birds per person per year (Figure 4.4). Supply management was introduced in 1972, and there is no evident change in chicken consumption per person from before it was introduced. It is not surprising that the inclining pattern observed in Figure 4.4 is extremely similar to the pattern observed in Figure 4.3 as there is little overall change in chicken mass per bird. There data is very consistent between Figure 4.3 and Figure 4.4, and there are only slight deviations between both figures.

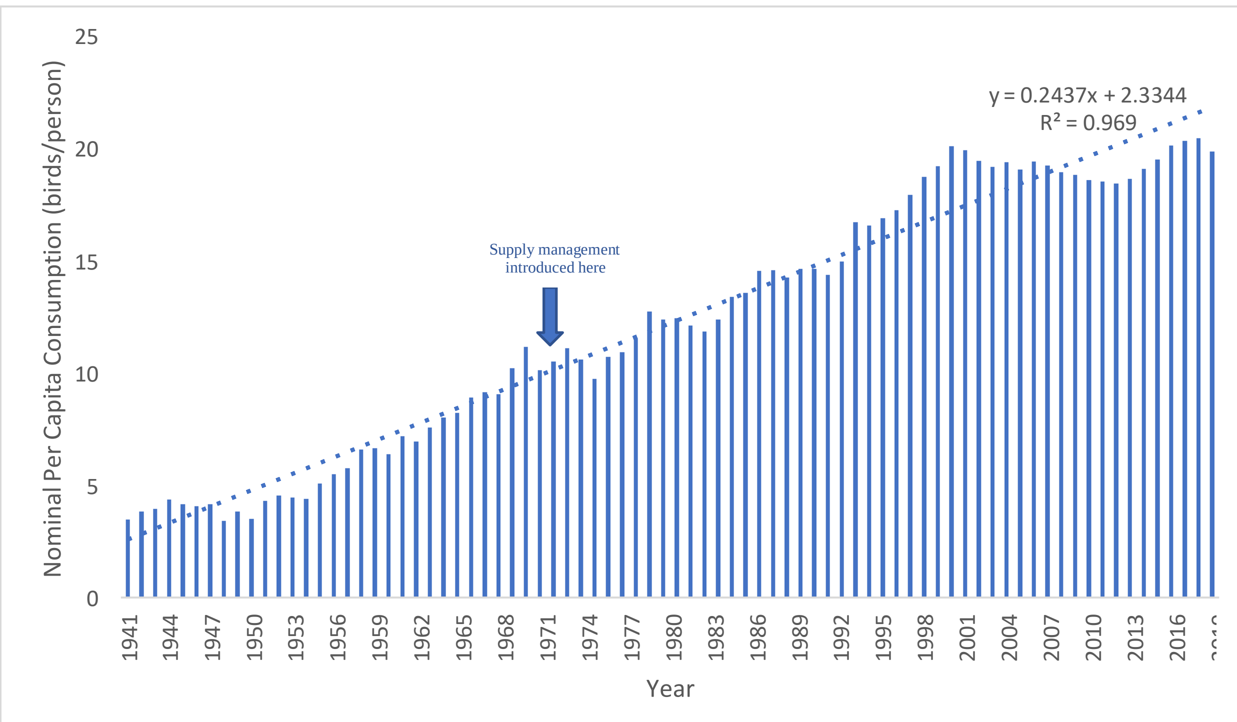

Figure 4.4 Canadian per capita nominal consumption of chicken from 1941 to 2020. Chicken data represents the number of birds destined for direct consumption and spent laying hens and is measured in eviscerated mass of whole birds per person. Data referenced for this graph was the dataset derived from Statistics Canada called The Production, Disposition and Farm Value of Poultry Meat (Table: 32-10-0117-01,1941-2020).

4.1.4 Turkey

Changes in per capita nominal consumption of turkey in kilograms of eviscerated birds from 1941 to 2020 appear in Figure 4.5. The data are best represented by a cubic function trendline, and the R^2 value of 0.8807 means that there is a high correlation between the data and the trendline with minimal deviation (Figure 4.5). Although, there are certain notable deviations from the best fit line, including higher rates of per capita consumption between 1965 and 1974. There is a significant per capita consumption incline from 1941 to 1990, and from 1990 to 2020 the per capita consumption of turkey flattens out (Figure 4.5). The lowest volumes of turkey consumption per person were in the early 1940s with average volumes of 1.2 kilograms per person (Figure 4.5). Over time, turkey consumption increased, and the highest levels of per capita consumption are characterized by spikes in the years 2007, 2018, and 2016, with values of over 5 kilograms per person per year (Figure 4.5). Late in the time series, per capita consumption abruptly declines from 2016 to 2020 (Figure 4.5). There is a decline in per capita nominal turkey consumption after the supply management system was introduced in 1972 (Figure 4.5). Supply management was introduced in 1972 during a peak in turkey consumption of around 4.3 kilograms per person between 1965 to 1974, and volumes of turkey consumption fall to 3.6 kilograms per person in 1975 (Figure 4.5).

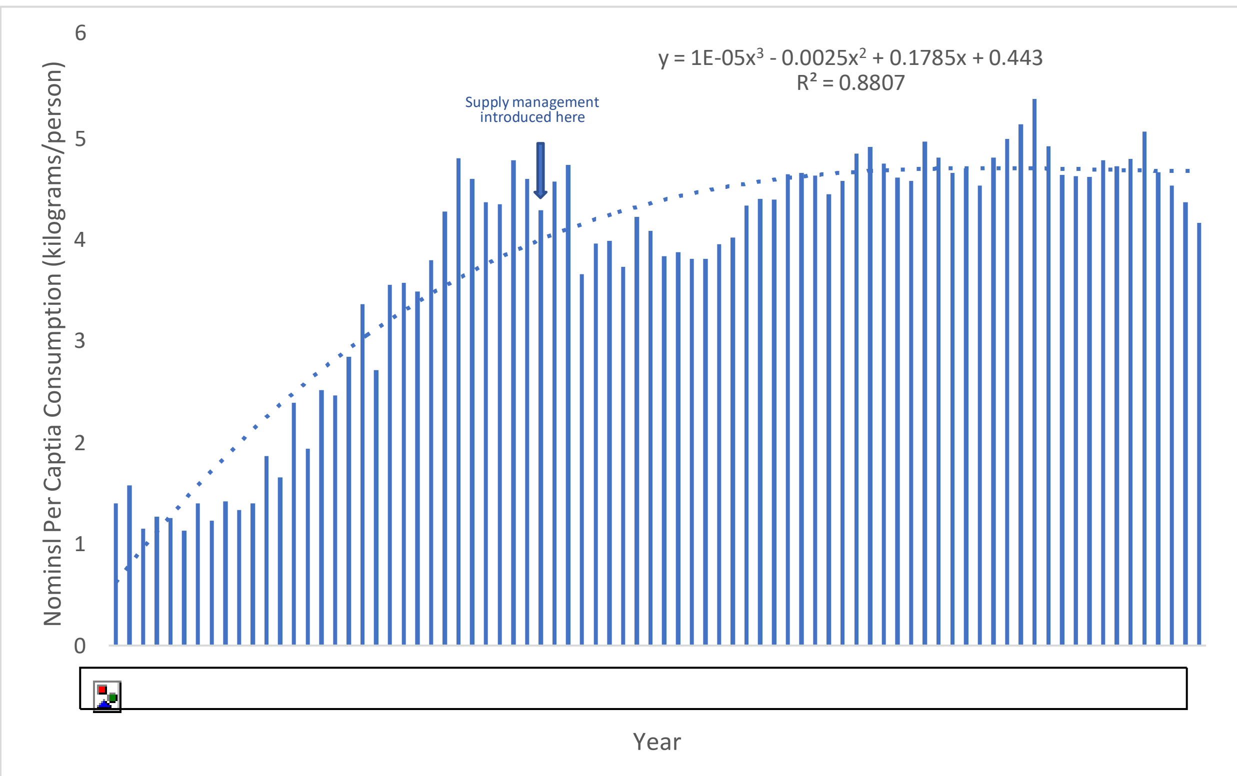

Figure 4.5 Canadian per capita nominal consumption of turkey from 1941 to 2020. Turkey data represents eviscerated mass of turkey and is measured in kilograms per person. Data referenced for this graph was the dataset derived from Statistics Canada called The Production, Disposition and Farm Value of Poultry Meat (Table: 32-10-0117-01,1941-2020).

Changes in per capita nominal consumption of turkey in the number of birds from 1941 to 2020 appear in Figure 4.6. Figure 4.6 represents per capita consumption of turkey in whole birds per person. Not surprisingly, these data are also best represented by a cubic function trendline, and some deviations and inconsistencies have resulted in an R^2 value of 0.8. There is a strong inclining pattern of per capita nominal consumption of turkeys from 1941 to 1982 when consumption increased from around 0.2 to around 0.8 birds per person (Figure 4.6). From 1983 to 2020, there is a clear decline in the number of birds consumed per capita from 0.65 to 0.49 birds per person per year (Figure 4.6). Supply management was introduced in 1972, and turkey consumption had significantly increased up to this point. Following the introduction of supply management, turkey consumption slowly began to decrease over time. Although there is a high correlation between the trendline and observed data, there are several distinct deviations including a decline in per capita consumption from 1946 to 1958 (Figure 4.6). There is also a significant incline in per capita consumption from 1965 to 1974, and this period has the highest rates of per capita consumption recorded at 0.85 birds per person (Figure 4.6). Figure 4.6 and Figure 4.5 both have high rates of per capita consumption from 1941 to the 1980s, though significant differences from the 1980s until 2020. Figure 4.6 has a declining slope from 1983 to 2020, which isn't observed in Figure 4.5.

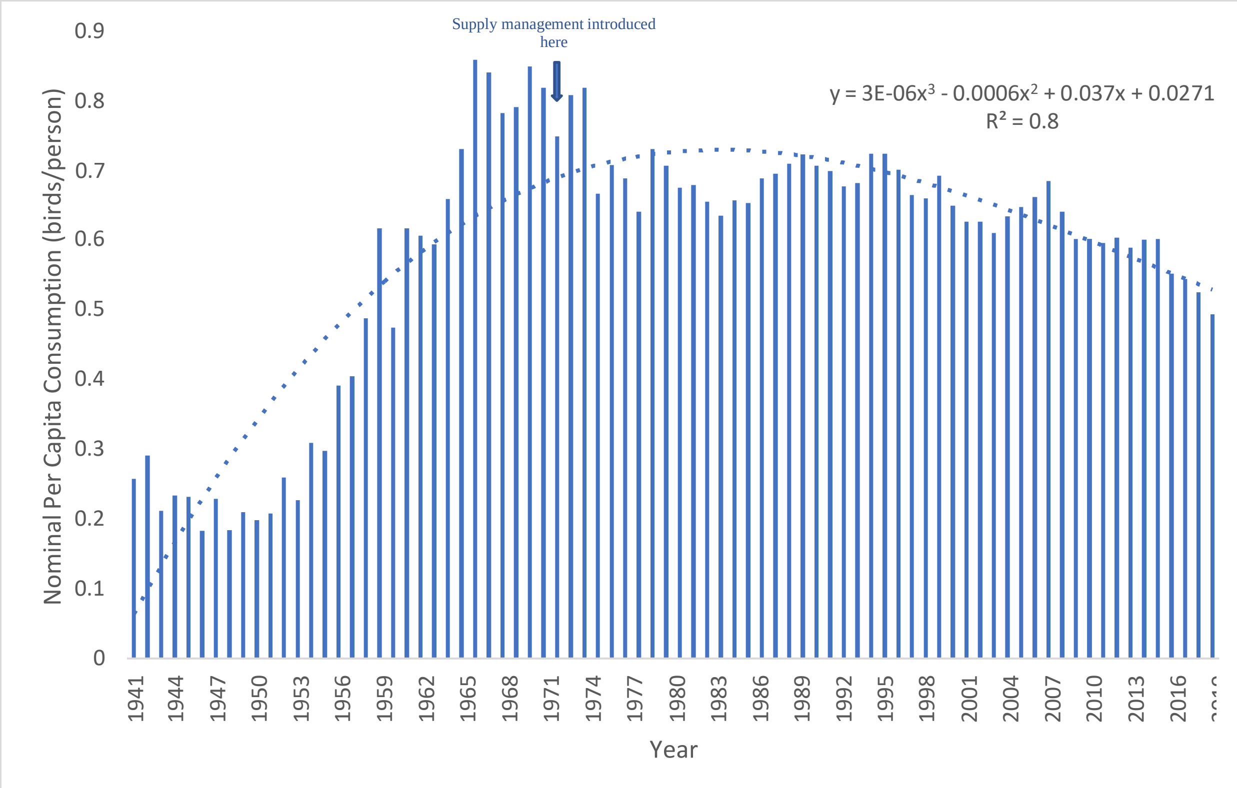

Figure 4.6 Canadian per capita nominal consumption of turkey in number of birds from 1941 to 2020. Turkey data represents eviscerated mass turkey and is measured in whole birds per person. Data referenced for this graph was the dataset derived from Statistics Canada called The Production, Disposition and Farm Value of Poultry Meat (Table: 32-10-0117-01,1941-2020).

4.2 Free Market Products

4.2.1 Beef

Changes in per capita nominal consumption of beef from 1960 to 2020 appear in Figure 4.7. Per capita consumption is expressed in kilograms of carcass weight beef and veal per person on an annual basis. A cubic function best fits the observed data, and the R^2 value of 0.8555 indicates that there is a strong correlation between the line of best fit and data with some variation. The pattern that is observed in Figure 4.7 is inclining per capita consumption from 1960 to 1976 and declining per capita consumption from 1976 to 2014 (Figure 4.7). Beef consumption increased from 34.8 kilograms per person in 1960 to 52.8 kilograms per person in 1976 (Figure 4.7). From 1976, volumes of beef consumption significantly decreased over time, and in 2020, consumption of beef was 26.5 kilograms per person. From 2015 to 2020 there is a flattening off, and this period has the lowest per capita consumption rates of all years (Figure 4.7). There are slight deviations throughout time, though the most notable deviation is an incline between 1975 and 1978. This period has the highest per capita consumption rates recorded, with the highest per capita nominal consumption volume of beef appearing in 1976 (Figure 4.7).

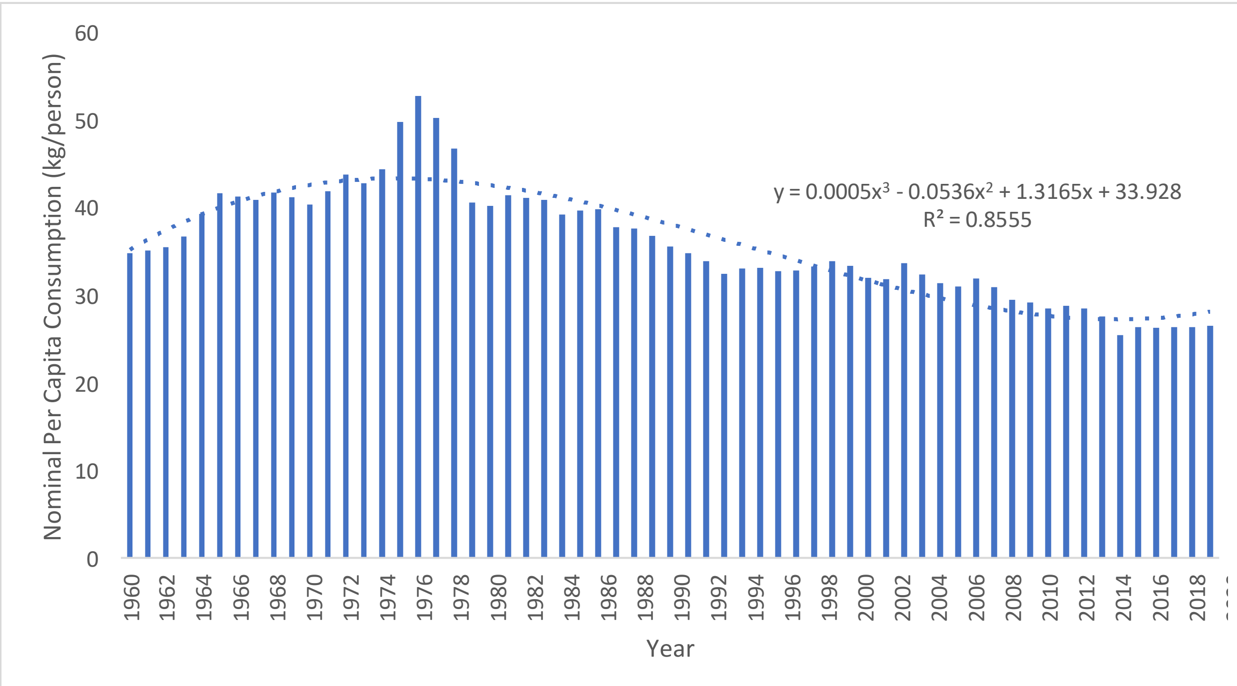

Figure 4.7 Canadian per capita nominal consumption of beef from 1960 to 2020. Beef data represents carcass weight mass of beef and veal combined and recorded in kilograms per person. Data referenced for this graph was the dataset derived from Statistics Canada, and it is referred to as disappearance data. The dataset is called Food Available in Canada (Table: 32-10-0054-01 (formerly CANSIM 002-0011)).

4.2.2 Pork

Changes in per capita nominal consumption of pork from 1960 to 2020 appear in Figure 4.8. Per capita consumption is expressed in kilograms of carcass weight pork per person on an annual basis. A cubic function best represents the observed data, and the R^2 value of 0.689 means that the line of best fit moderately fits the observed data. There is consistent deviation and variation that is occurring in Figure 4.8. There are slight inconsistent spikes and dips in per capita consumption of pork throughout time, although, no notable deviations. There is a slight increase in per capita consumption between 1960 and 1983, and a slightly steeper decrease in per capita consumption between 1983 and 2020 (Figure 4.8). Per capita consumption of pork in 1960 was

25.9 kilograms per person, and consumption decreased over time to a volume of 18.8 kilograms per person in 2020 (Figure 4.8). The highest volume of pork consumption was 32.2 kilograms per person in 1980, though this volume is not significantly higher than consumption values in the early 70s and 80s (Figure 4.8).

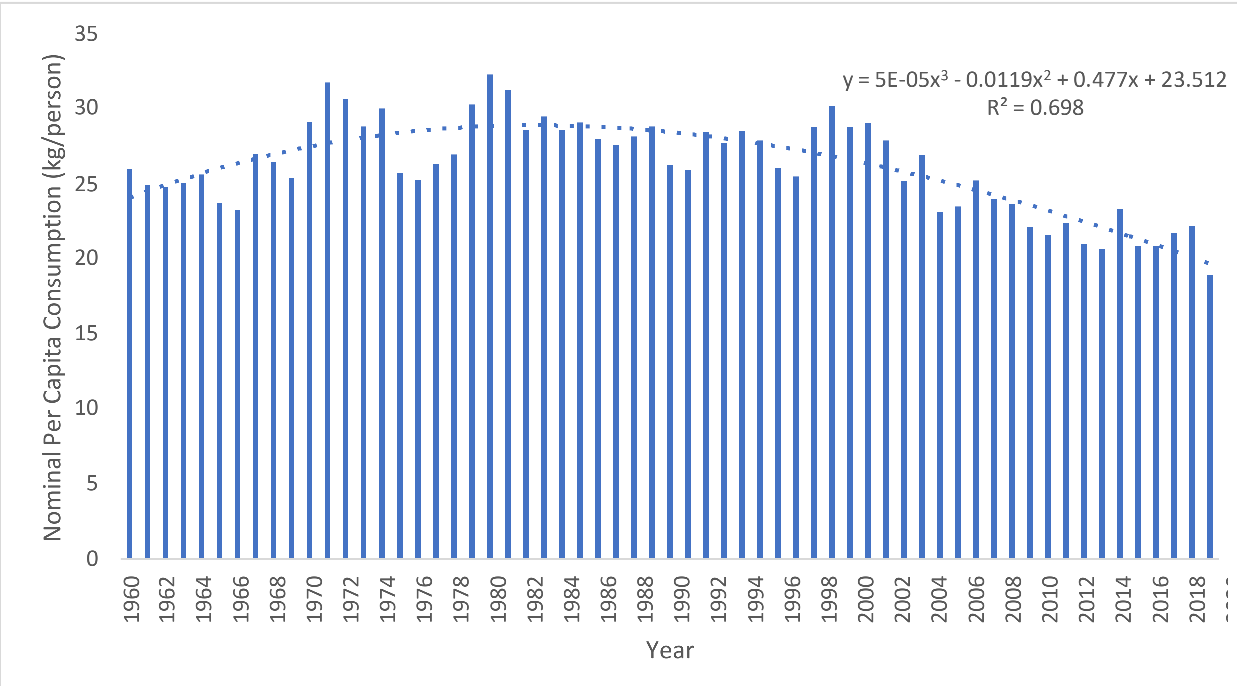

Figure 4.8 Canadian per capita nominal consumption of pork from 1960 to 2020. Pork data represents carcass weight mass and is recorded in kilograms per person. Data referenced for this graph was the dataset derived from Statistics Canada, and it is referred to as disappearance data. The dataset is called Food Available in Canada (Table: 32-10-0054-01 (formerly CANSIM 002-0011))

4.3 Total Meat Consumption

Changes in per capita nominal consumption of eviscerated livestock carcass from 1960 to 2020 appear in Figure 4.9. Beef and pork disappearance data are measured in terms of the mass of carcass weight and expressed in kilograms per person. Chicken and turkey disappearance data are measured in terms of eviscerated carcasses and expressed in kilograms per person. Chicken data wasn't available from 1960 to 1963. From the early 1960s, beef is the dominant protein source until around 1993 (Figure 4.9). In the 1960s, 70s, and 80s, beef is generally the most consumed form of meat, with pork being the second most consumed form of meat. Per capita chicken consumption initially in the 1960s is significantly lower than pork and beef consumed.

In 1963, per capita beef consumption is 36.68 kilograms per person, per capita pork consumption is 24.94 kilograms per person, and per capita chicken consumption is 10.97 kilograms per person. Per capita turkey consumption is much lower in volume compared to the other sources of protein at around 4.5 kilograms per person. As time moves on, chicken begins to dominate and per capita beef consumption decreases (Figure 4.9). By 2020, per capita beef consumption is 26.48 kilograms per person, per capita pork consumption is 18.84 kilograms per person, and per capita chicken consumption is 37.15 kilograms per person. There is a significant and consistent incline in chicken over time, and it dominates per capita pork and beef consumption in the late 1990s to 2020. Per capita pork consumption over time slowly decreases, and per capita turkey consumption over time slowly increases. There is some variation in total per capita meat consumption throughout time. The overall trend in per capita meat consumption slowly increases from 1960 to 1976 and flattens out between 1976 to 2020.

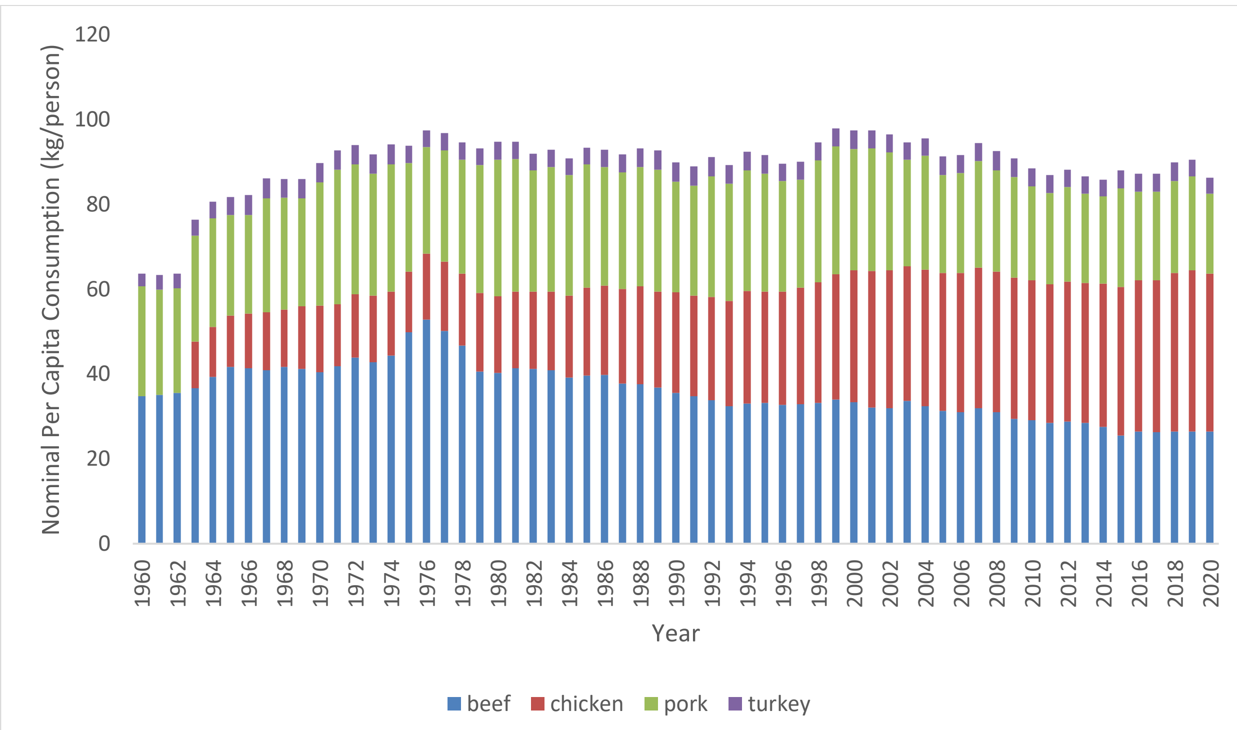

Figure 4.9 Canadian per capita nominal consumption of livestock from 1960 to 2020. Chicken data is expressed as eviscerated mass of both birds destined for direct consumption and spent laying hens. Turkey data is expressed as eviscerated mass of birds destined for direct consumption. Despite Canadians consuming chicken before 1964, disappearance data was not available for chicken products until 1964. Pork and beef dataare expressed as carcass weight. Note that all forms of livestock include inedible mass of bones, cartilageetc. Data referenced for this graph was the dataset derived from Statistics Canada, and it is referred to as disappearance data. The dataset is called Food Available in Canada (Table: 32-10-0054-01 (formerly CANSIM 002-0011)).

Chapter 5: Discussion

5.1 Consumption Trends

5.1.1 Changes in Product Consumption Over Time

Based on data that appear in Figure 4.1, apparent Canadian consumption of eggs has significantly fluctuated over time, particularly in the period from 1920 to around 1971. Some of this variation could be a result of the free-market system that was established before the supply management system was introduced in Canada to regulate egg production. Before the supply management system was introduced in 1972, a lack of government-imposed supply control allowed farmers to produce unrestricted amounts of eggs. Competition among Canadian farmers could have contributed to some of the variation seen in Figure 4.1. Another possible contributing factor to the variation in Figure 1 is the domestic consumption values that represent per capita consumption may account for exports and imports of eggs before the supply management system was implemented. Contrarily, the variation before 1972 may be reflective of varying levels of consumption from year to year despite less regulation. It is difficult to identify for certain why this variation exists.

In contrast, over the past 20 years, per capita egg consumption has been steadily increasing (Figure 4.2). A study by Hailu and Goddard (2004) found that Canadian egg consumption is affected by various media influences, cholesterol news coverage, new products, and popularization of various diet trends. This study reports that egg demand has experienced a significant change over time, similar to the results found in Figure 4.1 (Hailu & Goddard, 2004). These results show that there are a variety of factors that influence egg demand, and these unpredictable factors could contribute to the inconsistent consumption patterns observed throughout time (Figure 4.1). Although, the study by Hailu and Goddard (2004) does not include eggs that are consumed within other products such as bread, ice cream, and mayonnaise. Products that contain eggs could have different variations in demand compared to whole eggs, and product demand differences could account for significant changes in per capita consumption. Varying forms of media coverage may have influenced a portion of the nominal egg consumption reported in Figure 4.1, though the number of eggs consumed within other products is unlikely to be subject to similar influences.

Regardless of how per capita milk production is technically reported (Figure 4.2) with the results representing nominal consumptions, it is clear that per capita consumption has been declining from 1946 to 2015. In terms of the slight decreasing per capita consumption values in the early 2000s, Vatanparast et al. (2021) found similar results. This study found that consumption of milk and dairy products has decreased from 89.5% to 87.7% between 2004 to 2015, and the number of daily servings of milk consumed decreased from 1.9 cups to 1.7 cups (Vatanparast et al., 2021). In their discussion, Vatanparast et al. (2021) speculate that some of the factors underpinning the changes they observe in decreasing dairy consumption include the changing sociodemographic in Canada from increasing immigration and different cultural food preferences. In addition, milk and dairy products are also a significant contributor to total fat and saturated fat intake in the Canadian diet. Vatanparast et al. (2021) speculate that the desire to lower saturated fat in the Canadian diet may explain the observed decreases in dairy consumption. Additionally, non-dairy-derived milk substitutes have consistently risen in the past decade (St. Pierre, 2017). St. Pierre (2017) found that increases in milk substitute varieties have recently gained popularity, resulting in Canadian dairy choices moving away from traditional milk and high-fat products towards dairy alternatives. Dairy alternatives could be causing decreasing per capita milk consumption reported in Figure 4.2, although in recent years, there has been a flattening of per capita milk consumption and a slight increase in the past 5 years. The reason for this could be the variation in demand for a variety of dairy products. From 1979 to 2015, St. Pierre (2017) found that the per capita volumes of ice cream products available at the retail level have decreased by 65%, and per capita volumes of cheddar cheese available at retail have increased by 149%. Demand for differing dairy products could have a significant impact on overall per capita nominal milk consumption trends, although, it is difficult to distinguish how changes in individual milk-derived products demand have impacted overall nominal milk consumption trends.

Per capita nominal chicken consumption in Canada has substantially and consistently risen over the past 80 years (Figure 4.3). The chicken was consumed at low levels in the early 1940s, and over time, chicken consumption began to dominate the meat industry in Canada (Figure 4.3). These results are consistent with findings from Auclair and Burgos (2021), where the chicken was found to contribute 13% total dietary protein intake among Canadians. Auclair and Burgos (2021) speculate that chicken contributed the highest protein intake of all meat and plant-based protein options consumed in Canada. Canadian per capita nominal consumption of chicken has the highest consumption levels of all meat products (Figure 4.9), and these findings are consistent with high levels of protein intake found by Auclair and Burgos (2021).

In the 1940s, Figure 4.4 demonstrates how domestic Canadian per capita chicken consumption was very low, but quickly increased in popularity resulting in rising levels of per capita consumption. The green revolution occurred in the 1960s and was defined by dramatic yield improvements and improved land productivity (Ramankutty et al., 2018). Following the green revolution, the efficiency of poultry production immensely grew, and production of chicken could increase at high rates while utilizing smaller land areas (Tallentire et al., 2016). The efficiency of poultry is reflected in Figures 4.4 and 4.6 since per capita consumption of poultry birds per person is increasing at lower rates than per capita consumption of poultry in kilograms per person. The per capita consumption of turkey in birds per person has decreased from 1983 to 2020 (Figure 4.6) despite an increase in per capita consumption of turkey seen in Figure 4.5. This shows how consumption levels have been maintained despite fewer turkey birds being consumed from changes in poultry efficiency. The increased efficiencies in poultry production have allowed the poultry industry to continue to grow over time in Canada to meet Canadian demand for poultry products.

Since the late 1970s, Canadian per capita nominal consumption of pork and beef has been on a slight downwards trajectory (Figures 4.7 and 4.8). In contrast, chicken has been increasing from the early 1940s and surpassed beef and pork consumption volumes. Over time, chicken has become a popular commodity and began to dominate pork and beef consumption as of the late 1990s. The popularity and availability of chicken have increased over time and could be a reason why per capita consumption rates of red meat products have slightly declined in the past four decades. Additionally, people have become more aware of the nutritional and health aspects related to diet over time. Over the last 15 years, the media has reported research results that emphasized the negative health impacts of significant red meat consumption and have recommended decreasing consumption of red meat products (Dyer et al., 2020). Diet-related health concerns may be a contributing factor to decreasing per capita nominal consumption of red meat in the past two decades.

Despite slight decreasing trajectories of red meat consumption from the late 1970s until 2020, the consumption of red meat in Canada is still relatively high. Auclair and Burgos (2021) found that a combination of red and processed meat has the highest percent of protein contribution of all animal and plant-based food among Canadian adults. Similarly, Ranganathan et al. (2011) found that Canadian consumption of beef is extremely high, and on an international scale, Canadians consume over 3 times the global average of beef products. Compared to global averages, the volume of Canadian red meat consumption is relatively high despite slight decreases in per capita consumption over time as seen in Figures 4.7 and 4.8.

5.1.2 Global Consumption Patterns

Global meat consumption has been consistently on the rise over time. Around 292 million tons of meat are currently produced per year, and this volume of global supply has reached a historical high (Belova et al., 2013). From 1998 to 2018, global meat consumption has increased by 58% (Whitnall & Pitts, 2019). Population growth is responsible for 54% of global meat consumption increase and per capita consumption growth is responsible for 42% of the increase (Whitnall & Pitts, 2019). Canadian meat consumption in Figure 4.9 shows that total meat consumption has remained relatively consistent over the past 50 years. There have been some slight variations seen in Figure 4.9, but total meat consumption has not experienced any significant increasing or decreasing trends. Canadian total meat consumption trends are very different from total global meat consumption. Canada's per capita consumption has remained relatively constant over time, whereas global per capita meat consumption has increased in the past 20 years. As a developed country, it is logical that Canada has not experienced significant increases in meat production since dramatic increases in wealth are not occurring among the Canadian population. The majority of the global increases in meat have been a result of increasing wealth in developing countries. Figure 5.1 shows how meat production for several countries has changed between 1961 and 2018. Canada has not experienced dramatic increases in meat production over time compared to other countries (Figure 5.1). Figure 5.2 shows the per capita meat supply between 1961 and 2018 for different countries. Canada has maintained a consistently high per capita meat supply over time with very minimal change (Figure 5.2). Figures 5.1 and 5.2 show how the change in global meat consumption is driven by developing countries as opposed to developed countries like Canada.

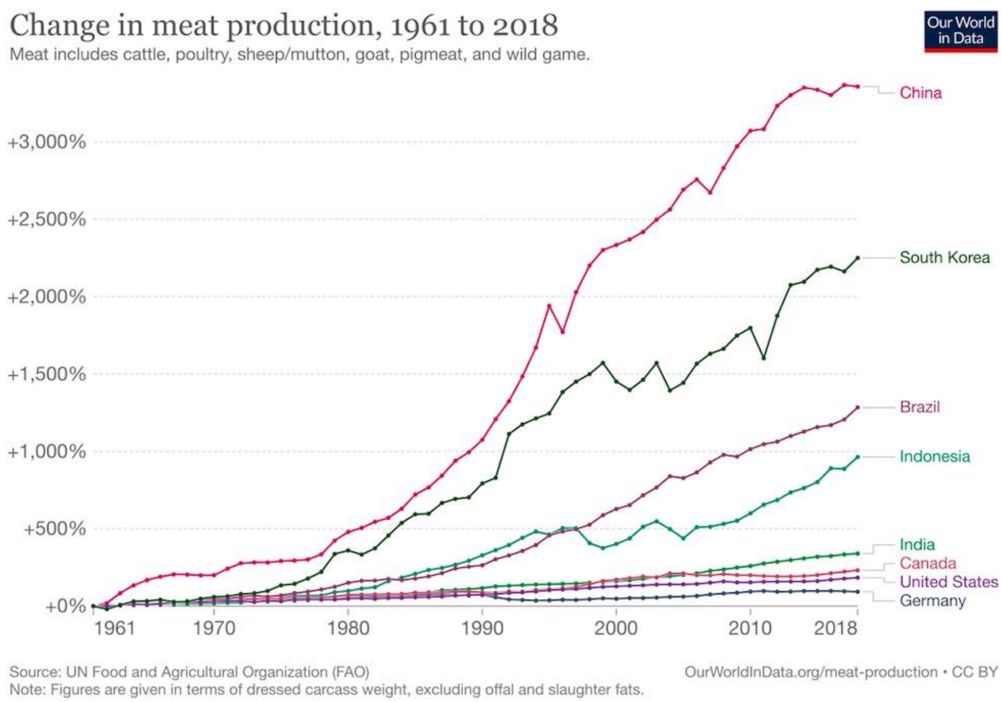

Figure 5.1 Changes in total meat production from 1961 to 2018 for several developed and developing countries. Retrieved from Our World in Data. This figure shows the significant change in meat production for different nations and how meat production differs between them. Graph created by Ritchie and Roser (2017) with data sourced from the FAO.

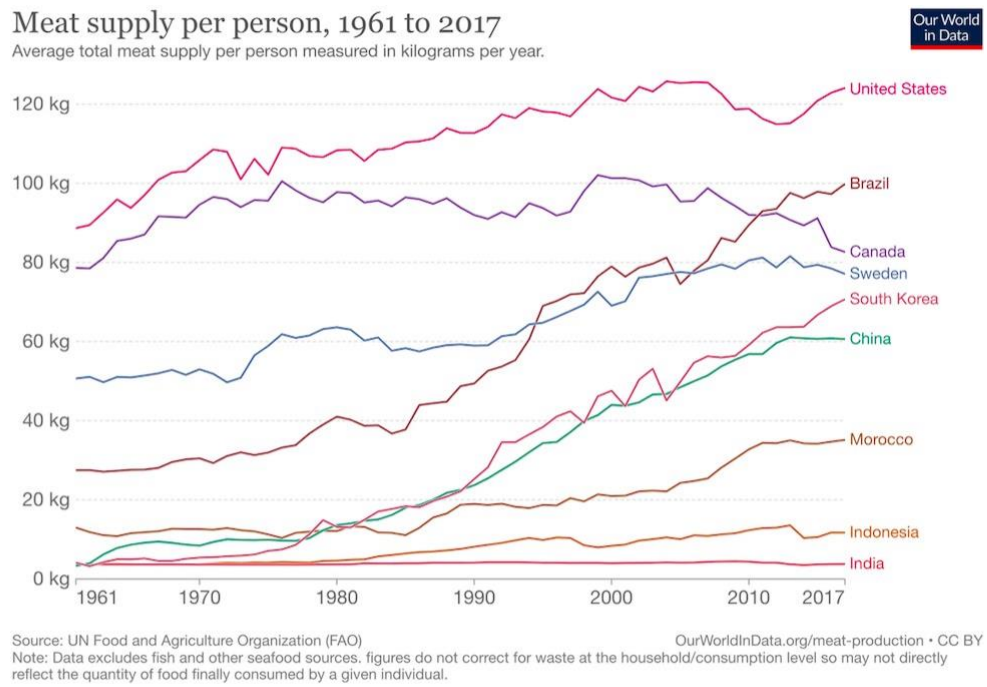

Figure 5.2 Meat supply per person from 1961 to 2017 for several developed and developing countries measured in kilograms per year. Retrieved from Our World in Data. This figure shows the significant variation in meat supply per person for different nations and how supply differs between them. Graph created by Ritchie and Roser (2017) with data sourced from the FAO.

Increasing chicken consumption in Canada is reflective of global chicken consumption patterns. From 1961 to 2010, the global production of chicken meat increased from 7.5 million tons per year to more than 86 million tons per year (Belova et al., 2013). The consistent increase in consumption rates observed in Figure 4.1 is comparable to the significant rise in global chicken consumption over time. Over the years, chickens have been artificially selected to gain more body mass, and the improvement in genetic selection has increased the average slaughter weight from 1.14kg to 1.56kg (Belova et al., 2013; Tallentire et al., 2016). The ability to produce high volumes of chicken worldwide has allowed the chicken to become a highly accessible product, and chicken has become one of the most dominant meat products on a global scale (Ritchie and Roser, 2017). Chicken is a highly consumed agricultural product and one of the primary sources of protein in Canada and on a global scale (Gafi & Javadian, 2018).

Canadian per capita nominal beef consumption (Figure 4.7) is consistent with global trends of per capita beef consumption over time. Figure 5.3 shows the change in per capita meat consumption of different products on a global scale over time. The global per capita beef consumption has increased from 1961 to 1990 and began to decrease from 1990 to 2013 (Figure 5.3). Global change of per capita beef consumption follows the same trends of increasing and decreasing consumption as seen in Figure 4.7. Global consumption per capita consumption of beef began to fall in 1990, and global per capita consumption of pork and chicken began to rise above the per capita volumes of beef consumed (Figure 5.3). Globally, chicken and pork products became more popular, and the demand for these products surpassed beef demand. These observations are very similar to Canada, but where global consumption and Canadian consumption differ is in per capita pork consumption. Global per capita pork consumption is higher than per capita chicken consumption as of 2013, whereas Canadian per capita consumption of chicken dominated pork from 2000 to 2013. Demand for pork products in Asian countries like China is extremely high, and consumption rates are increasing over time (Szucs & Vida, 2017). Economic factors, cultural influences, and accessibility to pork products differ from country to country, and a variety of these factors could contribute to differences in global pork demand in comparison to Canada.

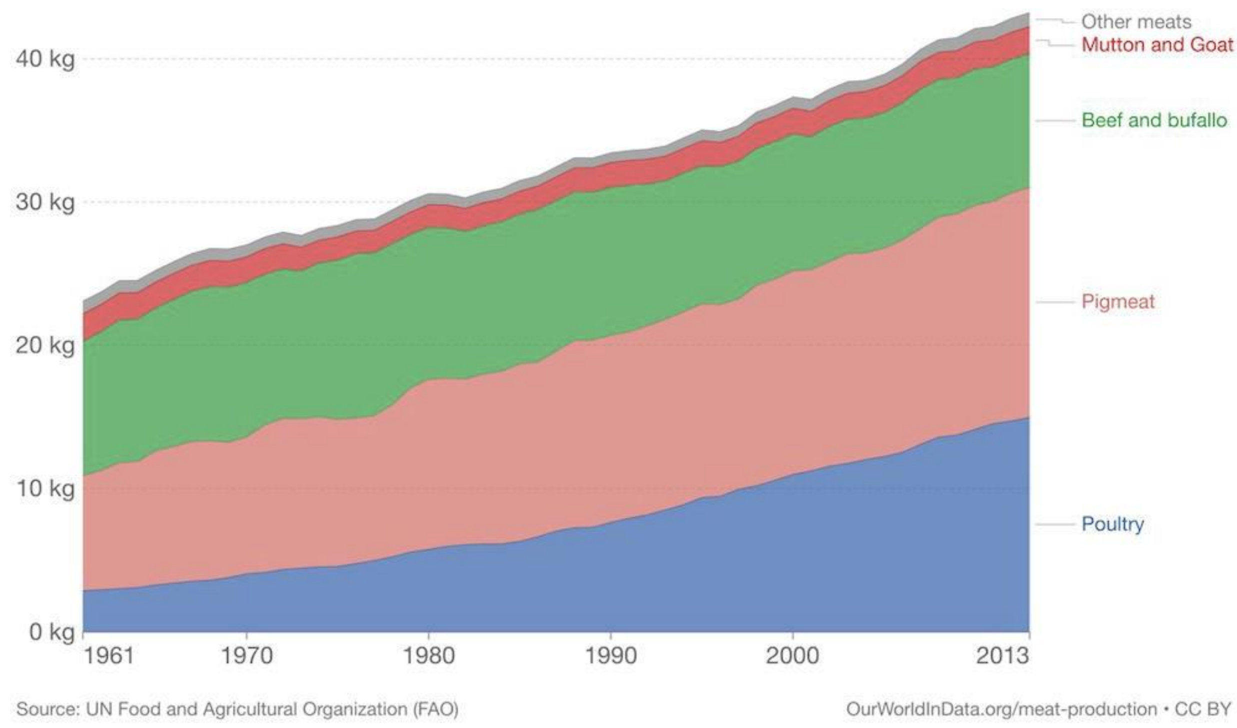

Figure 5.3 Global per capita meat consumption by species measured in kilograms per person per year from 1961 to 2013. The data is representation of per capita consumption at the consumer level and does not account for food loss and waste. This figure shows how chicken and pork consumption have

evolved in dominating meat consumption over time. Graph created by Ritchie and Roser (2017) with data sourced from the FAO.

5.2 The Canadian Diet

5.2.1 Environmental Implications

The results from this study show that consumption levels of many animal-based products in Canada are still relatively high despite certain decreasing per capita consumption trends. As mentioned previously, the primary source of protein in the Canadian diet is derived from animal products, and 75% of dietary-related GHG emissions are derived from high consumption levels of animal-based foods (Auclair & Burgos, 2021a). The results from Auclair and Burgos (2021) identifying high consumption levels are consistent with the results found in Figure 4.9. Figure 4.9 shows consistently high levels of total meat consumption over time, suggesting that animal-based products could be the primary source of protein among Canadians. These identified high consumption levels of meat-based products have resulted in a high-impact diet nationwide due to the environmental implications of meat consumption as previously discussed.

5.2.2 Reducing Impacts of the Canadian Diet

A study by Ranganathan et al. (2011) created reduction scenarios to reduce overconsumption of animal proteins in overconsuming countries like Canada in order to decrease total diet-related emissions. The primary strategy that Ranganathan et al. (2011) recommends reducing diet-related emissions is decreasing the high levels of beef consumption in countries like Canada. Shifting from beef to pork and poultry on a national scale could potentially save over 150 million hectares of land use by reducing pasture and cropland dedicated to beef production and significantly decreasing national GHG emissions (Ranganathan et al., 2011). Further, shifting from beef to legumes would save over 200 million hectares of land use from beef production (Ranganathan et al., 2011). As of 1990, Canadian consumption of dominant meat products is slowly shifting from beef to chicken (Figure 4.9), although, beef consumption levels are still significantly high (Figure 4.7). If beef consumption continues its downwards trajectory and chicken consumption continues to incline, we could see a major shift in consumption that has the potential reduce land conversion rates and GHG emissions as suggested by Ranganathan et al. (2011). Change on a national level is necessary to create significant reductions in environmental impact related to the Canadian diet.

5.3 Future Recommendations

This research was conducted to improve the understanding of Canadian consumption over time of high-impact animal products. From here, Nicole Arsenault's Ph.D. research will utilize these findings to inform the creation of future scenarios exploring the environmental implications of future animal food consumption changes in Canada. My research is an important foundation for future research in terms of understanding the environmental implications of the Canadian diet both historically and for possible future diet-related scenarios.

The findings of this research suggest that there have been changes in consumption patterns over time of some high-impact animal products. Future research is needed to assess other high-impact animal products to understand how they contribute to Canada's diet-related GHG emissions. Several other ruminant species are not as highly consumed as beef, but do contribute high GHG emissions per kilogram of product consumed. It would also be important to understand how consumption patterns of products made from eggs and milk differ from total eggs and milk production. These products have a significant influence on the historic consumption patterns of eggs and milk, so their individual analysis would be important to understand how they contribute to milk and egg consumption.

5.4 Conclusions

This research was conducted to understand how consumption of high-impact animal products has changed over time to improve our understanding of historical consumption in Canada. This research is important for understanding the development of the current high-impact Canadian diet as well as informing future projections of national food-related emissions. The results of this study suggest that there has been a lot of variation in consumption trends of different animal-based products. Over time, there has been a decrease in per capita nominal consumption of milk, beef, and pork, and there have been increases in per capita nominal consumption of chicken, turkey, and eggs. Overall, total meat consumption has remained consistently high over time. In comparison to global per capita consumption, Canada consumes high levels of animal-based food resulting in high diet-related emissions. In order to reduce diet-related emissions in Canada, it is critical to decrease the consumption of meat products on a national scale.

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