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THE CHICKEN SUPPLY CHAIN IN CANADA: MATERIAL FLOW AND SUPPLY CHAIN STRUCTURE

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THE CHICKEN SUPPLY CHAIN IN CANADA: MATERIAL FLOW AND SUPPLY CHAIN STRUCTURE

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ABSTRACT

We analyze the flow of material and identify the organizations involved in the chicken supply chain in Canada. The Canadian chicken supply chain consists of domestic producers and processors that operate at every level of the supply chain. Canada produces most of the chicken consumed in the country, but Canada is also a net importer at every level of the supply chain. Our material flow analysis identified significant unsold product quantities and material losses throughout the chicken supply chain (e.g., on the order of 61 million kilograms of chicken in 2019). This suggests that there are opportunities for improving the resource utilization of materials throughout the chicken supply chain. This study can be used as a basis for future studies to identify potential vulnerabilities and opportunities to improve the chicken supply chain in Canada, and to serve as a benchmark for studies of other supply chains. For example, an extension of this study could focus on secondary uses of by-products such as offal. These by-products could have large economic, societal, and environmental impacts that are currently overlooked and/or underutilized.

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1 INTRODUCTION

The chicken supply chain produces broiler meat which is then processed through a network of primary and secondary producers to produce finished products for retail and food service outlets. This paper provides a detailed description of the physical processes, material flow, information flow, and organizations that make decisions in the chicken supply chain in Canada. We also identify and quantify material losses along the chicken supply chain. Understanding the current structure and the flow of material through the supply chain is essential for identifying potential improvements to the chicken supply chain.

2 DATA AND METHODOLOGY

We focus on the activities of the upstream components of the chicken supply chain, namely, the producers (broiler hatching egg producers, broiler chick hatcheries, and chicken producers) and processors (abattoirs and further processors). We merged the Canadian chicken supply chain production data with import and export data, and compared the supply side with consumption data on the demand side.

2.1 Data

PRODUCER DATA. Broiler hatching egg producer data includes the statistics on the number of broiler hatching egg producers, broiler eggs set for broiler hatch, and broiler hatching eggs produced. The data was primarily obtained from Chicken Hatching Egg Producers of Canada and Agriculture and Agri-food Canada.

Hatcheries and regulated chicken producers data includes the statistics on the number of broiler hatcheries and regulated chicken producers, production of broiler chicks hatched, and broiler chicks sold. To determine the number of hatcheries and broiler hatching egg producers, we used the information available from the Canadian Hatchery Egg Producers and the Canadian Food Inspection Agency.

PROCESSOR DATA. Processor data includes data on provincially and federally licensed abattoirs, the quantity of broiler chickens slaughtered, eviscerated meat produced, and chicken available for consumption. To identify the processors and abattoirs, we used the official registry publicly available from each provincial licensing board and the Canadian Food Inspection Agency. Production quantities for eviscerated broiler meat was taken from Agriculture and Agri-Food Canada.

IMPORT AND EXPORT DATA. Import and export data includes data on imports and exports on an aggregate level for Canada. In addition, there is data on the interprovincial movement of eggs, chicks, and processed poultry. The categories of data include live chickens, whole carcasses, chicken parts (bone in breasts, bones in legs, bone in parts, bone in wings, boneless breasts, boneless parts), others (bone in others, boneless others, and mechanically separated meat), and further processed. Import and export data was taken from Agriculture and Agri-Food Canada.

SUPPLY MANAGEMENT SYSTEM. Information about the supply management system was obtained primarily from the Chicken Farmers of Canada (CFC). The CFC website provides procedures, published reports, and annual reports, which we augmented with interviews with industry experts.

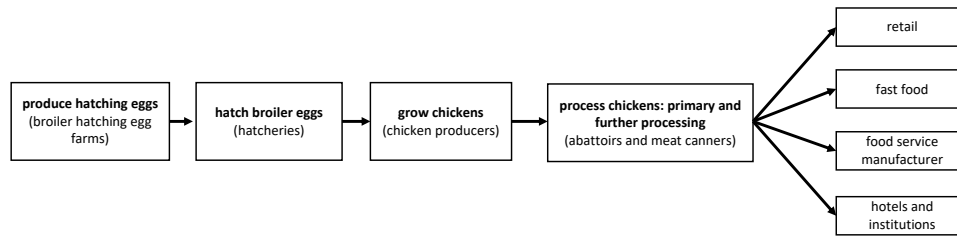


Figure 1: The chicken supply chain.

2.2 Methodology

We used the information from the annual reports of Chicken Farmers of Canada, Chicken Hatchery Egg Producers, and Chicken Farmers of Ontario to establish the overall chicken supply chain process flow. Additionally, we interviewed a number of industry experts who provided additional supply chain structure and process details.

To determine the material flow quantities, we used a combination of secondary data and mass balance calculations. Production quantities for the number of eggs laid, chicks hatched, chicks sold, broiler heads slaughtered, and total broiler meat eviscerated were obtained from Agriculture and Agri-Food Canada. Import and Export data was also obtained from Agriculture and Agri-Food Canada.

3 THE CHICKEN SUPPLY CHAIN

3.1 Supply Chain Processes and Organizations

Figure 1 shows the processes and organizations in the Canadian chicken supply chain. The following describes the main activities in the chicken supply chain.

- Produce hatching eggs:** Broiler hatching egg farms raise hens and roosters that produce broiler eggs. These eggs are sold to broiler hatcheries for incubation. Hens begin laying eggs at approximately 26 weeks of age and produce eggs up to 66 weeks of age (older hens produce large/jumbo eggs) (Let's Talk Chicken, nda). In 2020, there were 236 broiler hatching egg producers in Canada (69 in Ontario) (Canadian Hatching Egg Producers, 2020);
- Hatch broiler eggs:** Hatcheries receive broiler eggs from broiler hatching egg farms and place them in incubators for 21 days (Let's Talk Chicken, ndc). Once the broiler eggs are hatched, the broiler chicks are vaccinated to protect them from common poultry diseases (e.g., salmonella) and then transported to chicken farms. Hatcheries are registered with the Canadian Food Inspection Agency. In 2020, there were 49 licensed hatcheries in Canada (Canadian Food Inspection Agency, 2021b). See Figure 2 for the location of hatcheries in Canada.
- Grow chickens:** A chicken typically grows at a chicken farm for 35 to 55 days, depending on the desired size. Broilers that are marketed as "broilers" are 2 kilograms (35 to 36 days), "roasters" weigh 3 to 4 kilograms (45 to 55 days), and "Cornish hens" are approximately 1 kilogram (approximately 28 days) (Let's Talk Chicken, ndb).
- Process chickens:** Grown broilers are processed in poultry abattoirs. The activities in an abattoir include primary processing, poultry meat canning, poultry boning and cutting, and other/further processing. Abattoirs can be



(a) British Columbia, Alberta, Saskatchewan, Manitoba.



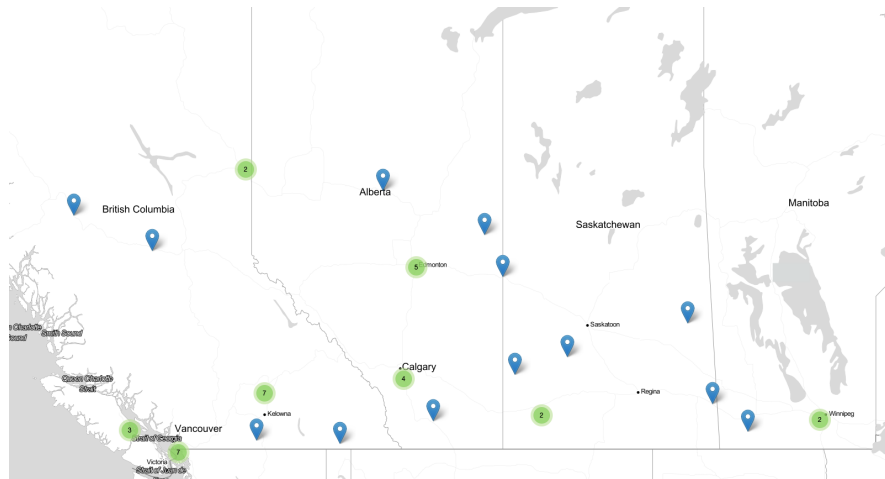
(b) Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador.

Figure 2: Registered hatcheries in Canada. Blue pins indicate a single facility, green dots indicate a medium density of facilities, and yellow dots indicate a high density of facilities (the number of facilities is displayed inside the dots).

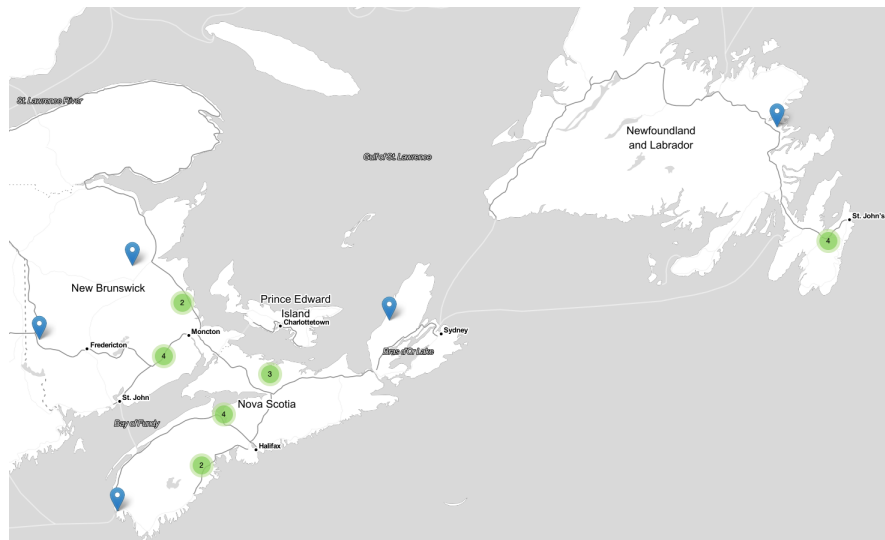
federally and/or provincially registered. Products from federally registered poultry abattoirs can be exported across provincial and international borders, whereas products from provincially registered poultry abattoirs can only be sold within the province.

In 2020, there were 409 federally registered poultry establishments ([Canadian Food Inspection Agency, 2021a](#)). They are composed of the following facilities:

- Poultry abattoir: 5 facilities
- Poultry abattoir and meat canning: 11 facilities
- Poultry abattoir, meat canning, and other processing: 40 facilities
- Poultry abattoir and other processing: 1 facility
- Meat canning: 15 facilities
- Meat canning and other processing: 130 facilities
- Other processing: 207 facilities



(a) British Columbia, Alberta, Saskatchewan, Manitoba.



(b) New Brunswick, Nova Scotia, Prince Edward Island (N/A), Newfoundland and Labrador.

Figure 3: Provincially registered abattoirs in BC, AB, SK, MB, NB, NS, PE, NL. Blue pins indicate a single facility, green dots indicate a medium density of facilities, and yellow dots indicate a high density of facilities (the number of facilities is displayed inside the dots).

The following provides information on provincially registered poultry abattoirs (see Figures 3 and 4 for their locations):

- Alberta: There were 12 provincially registered abattoirs in Alberta ([Alberta Agriculture and Forestry, 2021](#)).
- British Columbia: There were 23 provincially registered abattoirs in British Columbia. Of these, 17 establishments were Class A and able to slaughter and provide further processing services, and 6 were Class B facilities that could only provide slaughter services ([British Columbia Ministry of Agriculture, Food and Fisheries, 2021](#)).
- Manitoba: There were 3 provincially registered abattoirs in Manitoba ([Manitoba Food and Agriculture and Resource Development, 2021](#)).
- New Brunswick: There were 8 provincially registered abattoirs in New Brunswick ([Statistics Canada, 2021a](#)).
- Nova Scotia: There were 11 provincially registered abattoirs in Nova Scotia ([Nova Scotia Agriculture, 2021](#)).

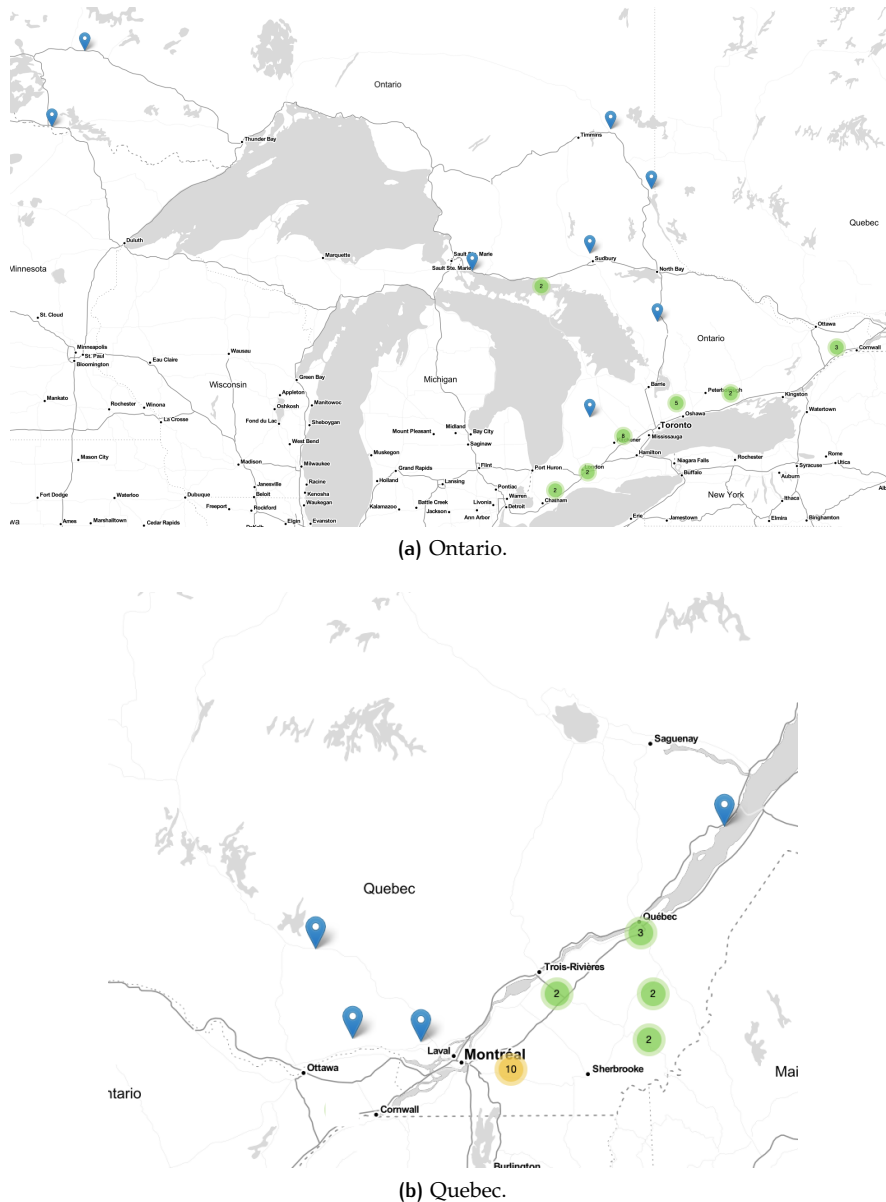


Figure 4: Provincially registered abattoirs in ON, QC. Blue pins indicate a single facility, green dots indicate a medium density of facilities, and yellow dots indicate a high density of facilities (the number of facilities is displayed inside the dots).

- Newfoundland and Labrador: There were 5 licensed abattoirs in Newfoundland and Labrador ([Government of Newfoundland and Labrador Department of Fisheries, Forestry and Agriculture, 2020](#)).
- Ontario: There were 32 provincially registered abattoirs. Of these, 26 establishments offered both abattoir and further processing services (e.g., dress carcasses, process, handle, store, package, label, sell and distribute carcasses, part of carcasses and meat products, process farm-slaughtered carcasses for owner's consumption, and perform any other regulated activities (further processing)). The other 6 establishments offered only abattoir services. Additionally, there were 364 free standing meat plants (not necessarily only poultry processing). These plants do not slaughter, but take meat from abattoirs for further processing (e.g., aging, boning, cutting, slicing, smoking, curing, fermenting, etc.) ([OMAFRA, 2021](#)).
- Prince Edward Island: No information about poultry abattoirs on Prince Edward Island could be found.

- Quebec: There were 23 provincially registered abattoirs in Quebec ([Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, 2020](#)).
- Saskatchewan: There were 7 provincially registered abattoirs in Saskatchewan ([Saskatchewan Health Authority, 2021](#)).

3.2 Material Flow

We perform material flow analysis on the Canadian chicken supply chain using data from 2019. Analysis for other years can follow the same procedure. Material flow for each process in the chicken supply chain (i.e., produce hatching eggs, hatch eggs, grow chickens, process chickens) is determined according to the following mass balance equation:

$$\begin{aligned} \text{net quantity} &= \text{domestic production quantity} + \text{quantity imported} \\ &\quad - \text{quantity exported} - \text{quantity unsold} \end{aligned} \quad (1)$$

The “quantity unsold” is a *reported* number for some of the outputs along the supply chain, but not all.

Additionally, as a mass balance calculation, we compare the “net quantity” output of an upstream supply chain activity with the “domestic production quantity” of the next downstream activity to *derive* the “quantity loss” from one supply chain stage to the next.

$$\begin{aligned} \text{quantity loss} &= \text{net quantity (upstream)} \\ &\quad - \text{domestic production quantity (downstream)} \end{aligned} \quad (2)$$

We do not have information on what accounts for the difference represented by Equation (2). Note that a negative number for “quantity loss” would imply that there was a gain in material going from upstream to downstream. None of our mass balance calculations in the chicken supply chain resulted in a gain in material going downstream, i.e., Equation (2) always resulted in a positive number. Figure 5 shows the material flow in the Canadian chicken supply chain in 2019.

NUMBER OF HATCHING EGGS PRODUCED. In 2019 in Canada, the net quantity of hatching eggs set for broiler stock was 953,831,611 eggs ([Agriculture and Agri-Food Canada, 2019d](#)). The quantity imported and exported were 130,967,266 and 2,686,545 eggs, respectively ([Agriculture and Agri-Food Canada, 2019c,e](#)). The number of unsold eggs was 35,553,439 ([Agriculture and Agri-Food Canada, 2019b](#)). Rearranging Equation (1) gives us the domestic production quantity for hatching eggs:

$$\begin{aligned} \text{domestic production quantity} &= \text{net quantity} - \text{quantity imported} \\ &\quad + \text{quantity exported} + \text{quantity unsold} \\ &= 953,831,611 - 130,967,266 \\ &\quad + 2,686,545 + 35,553,439 \\ &= 861,104,329 \text{ hatching eggs.} \end{aligned} \quad (3)$$

NUMBER OF CHICKS HATCHED. In 2019, 791,586,502 broiler chicks were hatched in Canadian hatcheries ([Agriculture and Agri-Food Canada, 2019d](#)). The number of broiler chicks imported and exported were 16,728,787 and 3,296, respectively ([Agriculture and Agri-Food Canada, 2019c,e](#)). The number of unsold chicks was 8,504,399 ([Agriculture and Agri-Food Canada, 2019b](#)). Using Equation (1) gives us the net quantity of chicks hatched:

$$\begin{aligned} \text{net quantity} &= \text{domestic production quantity} + \text{quantity imported} \\ &\quad - \text{quantity exported} - \text{quantity unsold} \\ &= 791,586,502 + 16,728,787 - 3,296 - 8,504,399 \\ &= 799,807,594 \text{ chicks hatched.} \end{aligned} \quad (4)$$

NUMBER OF CHICKENS GROWN. In 2019, Canadian chicken farms produced 748,918,732 live chickens for a total eviscerated weight of 1,292,927,467 kilograms. Of these chickens, 0.3% were < 1.0 kilogram, 90.1% were in the range of [1.0, 2.0) kilograms, and 9.6% were ≥ 2.0 kilograms (Agriculture and Agri-Food Canada, 2019a). A total of 11,122,164 kilograms of eviscerated weight were imported in the form of live chickens (20,054 kilograms) and mature chickens (11,102,109 kilograms) (Agriculture and Agri-Food Canada, 2019g). Assuming an average eviscerated weight of 1.726 kilograms per chicken, approximately 6,442,585 chickens were imported (the average eviscerated weight was derived by taking the weighted average of chickens produced in Canada in 2019 (Agriculture and Agri-Food Canada, 2019a)). No live chickens were exported and no “unsold chickens” data was reported, therefore, we assume the number of unsold chickens is zero. Using Equation (1) gives the net quantity of live chickens sent to processors:

$$\begin{aligned}
 \text{net quantity} &= \text{domestic production quantity} + \text{quantity imported} \\
 &\quad - \text{quantity exported} - \text{quantity unsold} \\
 &= 748,918,732 + 6,442,585 - 0 - 0 \\
 &= 755,361,317 \text{ live chickens.}
 \end{aligned} \tag{5}$$

NUMBER OF CHICKENS SLAUGHTERED. In 2019, the number of chickens slaughtered by abattoirs in Canada was 748,936,606. This is equivalent to 1,292,927,467 kilograms of eviscerated chicken (Agriculture and Agri-Food Canada, 2019h). Import and export quantities are not applicable for this supply chain activity.

QUANTITY OF MEAT PROCESSED. We assume that the quantity of eviscerated chicken produced by abattoirs in Canada was processed by Canadian poultry processors. Additionally, 214,096,505 kilograms and 128,839,848 kilograms of chicken meat were imported to and exported from Canada in 2019 (Agriculture and Agri-Food Canada, 2019g,f). No “unsold chicken meat” data was reported, therefore, we assume the quantity of unsold chicken meat is zero. Using Equation (1) gives the net quantity of chicken meat available for consumption in Canada in 2019:

$$\begin{aligned}
 \text{net quantity} &= \text{domestic production quantity} + \text{quantity imported} \\
 &\quad - \text{quantity exported} - \text{quantity unsold} \\
 &= 1,292,927,467 + 214,096,505 - 128,839,848 - 0 \\
 &= 1,378,184,124 \text{ kilograms of chicken meat.}
 \end{aligned} \tag{6}$$

QUANTITY LOSS. Using Equation (2), we calculate the quantity loss in the chicken supply chain as we progress from one upstream activity to the next downstream activity.

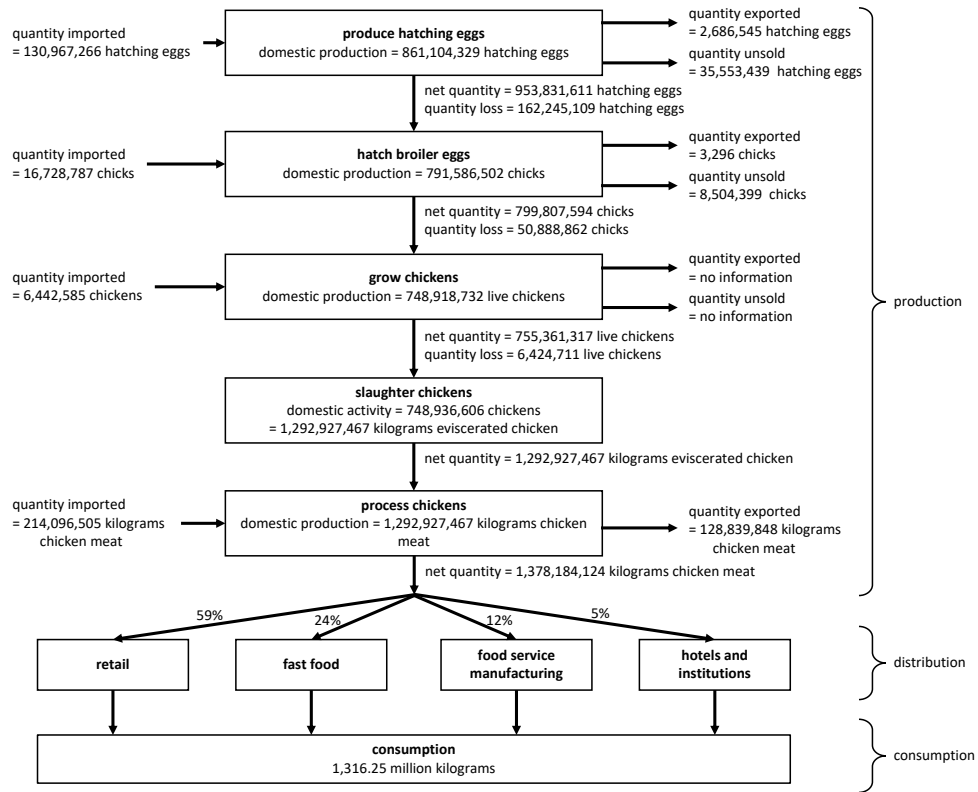


Figure 5: Material flow in the Canadian chicken supply chain, 2019.

$$\begin{aligned}
 \text{quantity loss} &= \text{net quantity (hatching eggs)} \\
 &\quad - \text{domestic production quantity (chicks)} \\
 &= 953,831,611 - 791,586,502 \\
 &= 162,245,109 \text{ (17.0\%)} \text{ lost hatching eggs or chicks,}
 \end{aligned} \tag{7}$$

$$\begin{aligned}
 \text{quantity loss} &= \text{net quantity (chicks)} \\
 &\quad - \text{domestic production quantity (live chickens)} \\
 &= 799,807,594 - 748,918,732 \\
 &= 50,888,862 \text{ (6.4\%)} \text{ lost chicks or live chickens,}
 \end{aligned} \tag{8}$$

$$\begin{aligned}
 \text{quantity loss} &= \text{net quantity (live chickens)} \\
 &\quad - \text{domestic production quantity (slaughtered chickens)} \\
 &= 755,361,317 - 748,936,606 \\
 &= 6,424,711 \text{ (8.5\%)} \text{ lost live or slaughtered chickens.}
 \end{aligned} \tag{9}$$

Because of the assumption that the quantity of eviscerated chicken from abattoirs is equal to the domestic production quantity of chicken meat by processor, the quantity loss Equation (2) gives us zero by assumption.

The quantity loss analysis shown in Equations (7)-(9) suggests that there could be significant waste in the chicken supply chain. However, the accuracy of this analysis depends on the quality of the secondary data used and the assumptions made.

3.3 Distribution Channels and Consumption

There are four main distribution channels for chicken meat: retail, fast food, food service manufacturing, and hotels and institutions. In 2019, the quantity of chicken distributed among these four channels was 59%, 24%, 12% and 5%, respectively

(Chicken Farmers of Canada, 2020). In the same year, Canadians consumed on average 35.1 kilograms of chicken per capita. The population of Canada was 37.5 million in 2019, therefore, the total amount of chicken consumed in 2019 was approximately 1,316.25 million kilograms (Statistics Canada, 2021b). The consumption through each distribution channel was thus 776.59 million kilograms to retail, 315.90 million kilograms to fast food, 157.95 million kilograms to food service manufacturing, and 65.81 million kilograms to hotels and institutions. Note that there is a difference of $1,378.18 - 1,316.25 = 61.93$ million kilograms of chicken meat between the production output of the supply chain and the quantity consumed (see Figure 5).

3.4 Regulated, Centralized Supply Management

In Canada, the supply of broiler hatching eggs and chicken is regulated with the intention to match the quantity produced to the demand, and provide farmers with a fair price for their products. Similar to dairy supply management in Canada (Wu et al., 2021), there are three pillars of the chicken supply management system: production control, pricing mechanisms, and import control.

BROILER HATCHING EGGS. The Canadian Hatching Egg Producers (CHEP) regulates the broiler hatching egg industry in its member provinces, Alberta, British Columbia, Manitoba, Ontario, Quebec, and Saskatchewan (Canadian Hatching Egg Producers, 2020). CHEP producers account for 92.3% of the broiler hatching egg producers in Canada. The remaining producers that are not part of CHEP are located in New Brunswick, Nova Scotia, and Newfoundland and Labrador (Agriculture and Agri-Food Canada, 2020).

Based on consultation with an industry/advisory committee, CHEP determines the total production of broiler hatching eggs, and allocates production across its member provinces. Production quantities are set and adjusted throughout the year to meet demand. Broiler hatching egg farmers buy quota in order to produce hatching eggs. Within each province, allocation of the provincial share of the national supply is managed by a governing body operating at the provincial level (e.g., Ontario Broiler Hatching Egg and Chick Commission). The provincial supply management organization also has price-setting authority or negotiates prices with processors on behalf of all broiler hatching egg farmers in the province (Heminthavong, 2018).

CHICKEN. The national body for administering the supply management system for chicken is the Chicken Farmers of Canada (CFC). The CFC has 15 members on its board – one from each of the ten provincial marketing boards, and representatives from the processing, further processing sectors, as well as the restaurant and food service sectors. (Chicken Farmers of Canada, 2020). The CFC receives requests from each province for the provincial chicken production volume and compares it to the national demand. The CFC allocates production volume to each provincial board, which subsequently allocates volume, based on quota, to the chicken farmers in the province.

Producers must hold quota in order to produce chicken, and quotas can be bought and sold in a provincial exchange. The provincial board also sets the minimum quota amount for a producer. For example, to be a chicken farmer in Ontario, a farmer must hold at least 14,000 units of chicken production (one unit is equal to 13 kilograms of chicken). The provincial boards negotiate prices with processors on behalf of all chicken farmers in the province (Heminthavong, 2018).

IMPORT CONTROL. Tariff Rate Quotas (TRQ) determine the quantity and tariff rate that an agricultural product can be imported into Canada. The international agreement allows imports into Canada at low or zero tariff rate. Broiler hatching eggs and chicken fall under the World Trade Organization (WTO) Agreement

on Agriculture, the Canada-United States-Mexico Agreement (CUSMA), and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) (Agriculture and Agri-Food Canada, 2021).

4 CONCLUDING REMARKS

The Canadian chicken supply chain consists of domestic producers and processors that operate at every level of the supply chain. Most of the broiler hatching eggs and chickens that are used and consumed in Canada are produced in Canada, but Canada is also a net importer at every level of the chicken supply chain. Chicken production and processing occurs in all provinces, but there is a concentration of abattoirs in Ontario and Quebec.

Our material flow analysis identified significant unsold product quantities and material losses throughout the chicken supply chain. For instance, of the 1,378.18 million kilograms of chicken produced for consumption in Canada in 2019, only 1,316.25 million kilograms were consumed – a difference (loss) of 61.93 million kilograms of chicken (or approximately 123.86 million servings). Our analysis suggests that there are opportunities for improving the resource utilization of materials throughout the chicken supply chain. However, an important extension to this study would be to determine the specific causes for why material in the chicken supply chain was unsold or lost. Additionally, this report focused on the primary use of hatching eggs, chicks, and chickens, but secondary uses of by-products such as offal would be an interesting extension of this analysis. These by-products could have large economic, societal, and environmental impacts that are currently overlooked and/or underutilized.

Note that this analysis relied on possibly inaccurate or incomplete data, or inaccurate assumptions (e.g., average eviscerated chicken weight). An extension to this study should incorporate sensitivity analysis on assumptions and build in confidence intervals around parameter estimations.

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