

Fundamentals of the **Commercial Feed Industry in Canada**



About ANAC

The Animal Nutrition Association of Canada (ANAC) is the national trade association of the Canadian livestock feed industry. The association's members include feed and ingredient manufacturers and distributors, as well as suppliers of a wide range of goods and services to the feed industry. Taken together, ANAC's membership represents 90 percent of commercial feed manufactured in Canada.

ANAC supports its members by fostering a favourable regulatory and business environment for the industry while actively participating in the evolving agri-food sector. As a world leader and international partner in sustainable animal nutrition, the association promotes and enables the highest standards of feed and food safety in Canada.

More information on the association can be found on ANAC's website: www.anacan.org.

Disclaimer

This document is intended to be used as an introduction to the commercial feed industry in Canada. The authors and the Animal Nutrition Association of Canada do not take responsibility for specific applications of the information contained in this document.

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Executive summary

The commercial feed industry serves the livestock¹ sector and is highly adaptable, unique, and diverse. As an integral partner in the food value chain, feed businesses play a critical role in ensuring the safe and continuous supply of food to consumers in Canada and around the world.

For many of the livestock operations in Canada, feed represents the highest input cost. In 2020, Canadian livestock consumed approximately 28.8 million tonnes of feed; roughly two thirds were produced in close to 470 commercial feed mills with the remaining one third produced in on-farm feed mills. Feed mills are generally located close to livestock operations and most feed is produced for domestic consumption. Commercial feed facilities vary in type and size, many of which manufacture feed for multiple species, contributing to the complexity and distinctiveness of the different operations.

The feed industry is highly regulated. These regulations include the *Feeds Act* and *Feeds Regulations*, which govern the day-to-day operations of feed mills and provides consistency amongst feed suppliers, manufacturers, and distributors.

Supported by research and scientific expertise, the primary goal of feed mills is to meet the animals' nutritional needs to optimize health and production efficiency. Least cost formulation is an important tool to ensure that finished feed products have the desired properties while making use of available ingredients and meeting the goals of the livestock producer, all while keeping costs as low as possible.

A range of ingredients, including domestic agricultural products and by-products as well as non-feed ingredients

(e.g. medications), feed additives, and specialty products are utilized to create different feed products for various livestock species. The different types of mixed feeds include complete feeds, supplements, and premixes.

Feed manufacturing can be broken down into a few key steps: diet formulation, planning and scheduling of production, ingredient receiving, particle size reduction, mixing, further processing, packaging, labelling, and shipping. The specifics, however, will depend on various factors, including the species served and the operational capabilities of the feed facility, among others. Each diet formulation and feed mill is unique depending on the needs of the customer and animals. The collaboration between different feed company staff, veterinarians, suppliers, producers, and industry stakeholders are fundamental throughout the process.

Food and feed safety are critical components of animal production. Most commercial feed mills produce feed in facilities certified under the FeedAssure® program, a customized Hazard Analysis Critical Control Point (HACCP) program, managed by ANAC, which is the gold standard for feed safety in Canada. As food and feed safety risks change, the feed industry remains at the forefront by applying preventive control measures to manage any new and emerging risks.

To continue to meet evolving consumer trends and industry challenges, being adaptable to change and focusing on customers' needs are essential. The Canadian feed industry is a leader in safeguarding a healthy food supply chain while continuing to promote a profitable and sustainable Canadian agricultural sector.



¹For the purpose of this document, the term livestock aligns with the Feeds Regulations, 2022, published in *Canada Gazette*, Part I. Livestock refers to cattle, sheep, goats, bison, water buffalo, cervids, llamas, alpacas, swine, poultry, ratites, pigeons, pheasants, partridges, quail, grouse, guinea fowl, pea fowl, horses, rabbits, bees, as well as finfish, molluscs, and crustaceans intended for human consumption.

Introduction

The Canadian feed industry encompasses the manufacturing and distribution of ingredients and mixed feed for livestock. As an integral part of the food value chain, the sector intersects with a wide range of stakeholders, from grain growers to suppliers of nutrient supplements, as well as producers of meat, eggs, and milk. The industry serves a vital role in ensuring a robust supply of quality feed and feed ingredients and consequently a safe and continuous supply of food to consumers in Canada and around the world.

This document has been developed by the Animal Nutrition Association of Canada (ANAC) to provide information and foundational knowledge to individuals unfamiliar with or looking for an overview of the Canadian feed industry. Many aspects including key ingredients, basic animal nutrition, relevant regulations governing feed production in Canada, and key issues and trends in the industry are covered in this document.

For the purpose of this text, the term livestock aligns with the definition provided in the *Feeds Regulations, 2022*. Livestock refers to cattle, sheep, goats, bison, water buffalo, cervids, llamas, alpacas, swine, poultry, ratites, pigeons, pheasants, partridges, quail, grouse, guinea fowl, pea fowl, horses, rabbits, bees, as well as finfish, molluscs, and crustaceans intended for human consumption.



Snapshot of the feed industry

The feed industry is complex, unique and adaptable, and a vital partner in the country's agriculture and agri-food supply chain.

Role in the Canadian food value chain

An important contributor to the economy

The Canadian feed industry contributes to the domestic economy in many ways. These contributions can be assessed by collectively looking at the value chain of the industry which is intricately related to the value chain of Canadian agricultural commodities. In 2020, primary agriculture in Canada was estimated to account for 2.1% of the gross domestic product and in 2018, employed nearly 270,000 people. Livestock-based operations comprised 41.6% of the sector in 2011. The steady production of animal protein in Canada ensures the stability of the feed industry which provides established employment opportunities, often in rural communities.

The majority of the livestock feed produced in Canada is consumed domestically with a small amount exported to other countries. In 2020, international exports of livestock feed and feed ingredients generated approximately \$2.4 billion dollars in revenue.

Provides nutritious feed for livestock

Commercial feed manufacturers have the important role of turning raw ingredients into safe and nutritious feed for livestock. This feed is then sold to livestock producers, which allows them to generate meat, milk, and eggs.

Feed costs account for up to 75% of the total cost of livestock production and will vary depending on the species. The feed industry is a major user of Canada's domestic grain supply with 80% of barley, 60% of corn, and 30% of wheat grown domestically being utilized in Canadian feed manufacturing. The feed industry provides grain and oilseed farmers with a consistent market for the sale of their products. It also provides a cost recovery stream for waste and by-products of other agriculture and agri-food production, or products that are below human grade that, if not fed to animals, would otherwise have minimal economic value.

Serves a range of livestock species

The Canadian feed industry manufactures feed for a variety of species as shown in Table 1. The major species served include beef and dairy cattle, swine, and poultry. They represent the largest volume of food producing animals in Canada. Minor species include sheep, goats, horses, fish/shellfish, and rabbits. (Note the volume of aquaculture is expressed as weight rather than by head and is not included in Table 1. A production volume of 187,026 tonnes was reported in 2019.) Other species represent niche markets.

Table 1. Population of Canadian livestock served by the feed industry

Source: ANAC's *Canadian Livestock Feed Consumption - 2020 Estimates*

Species	Number of Head (x1000)
Broiler Chickens	789,183
Laying Hens	34,130
Swine	27,846
Turkeys	21,851
Beef Cattle	9,847
Ducks/Geese	6,274
Dairy Cattle	1,918
Horses/Ponies ¹	964
Sheep	905
Goats ²	230
Rabbits ²	173
Bison ²	105
Elk ²	22
Llamas/Alpacas ²	21
Deer ²	15

■ Major species ■ Minor species ■ Niche species

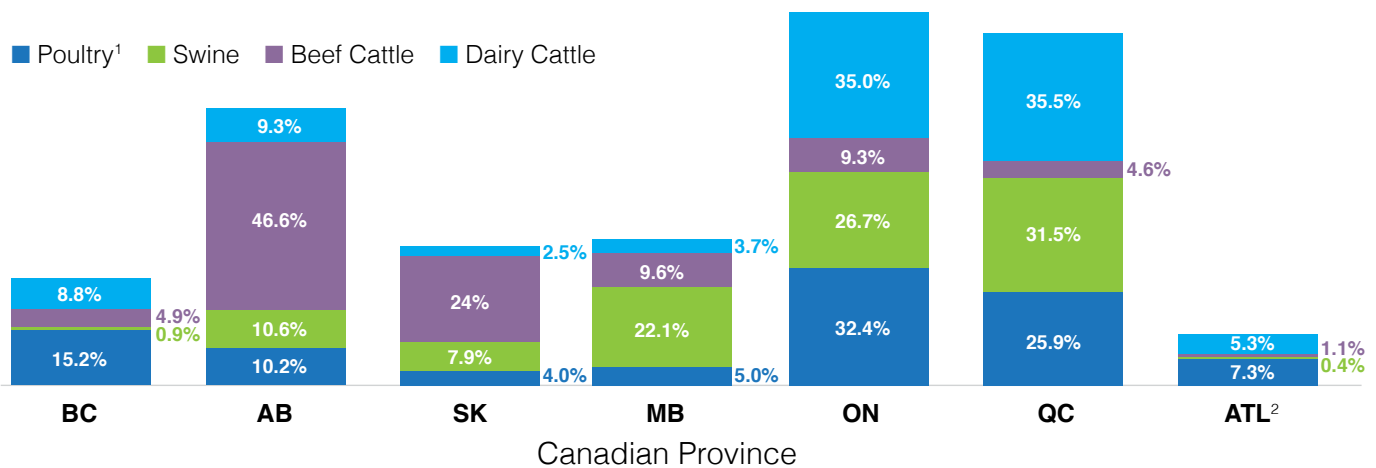
¹ Value from Equestrian Canada's *2010 Canadian Equine Industry Profile Study*

² Values from *Statistics Canada 2016 Census*

Figure 1 illustrates the distribution of poultry, dairy cattle, beef cattle, and swine across Canada as a percentage of their domestic species population. For example, Alberta is home to 10.6% of the total Canadian swine herd population, whereas Ontario has 26.7%. Most of the pork in Canada is produced in Quebec, Ontario, and Manitoba, while Saskatchewan and Alberta produce most of Canada's beef.

Figure 1. Distribution of major livestock species across Canada

Source: ANAC's *Canadian Livestock Feed Consumption - 2020 Estimates*



¹Poultry includes broilers, layers, and turkeys.

²Atlantic Canada (ATL) includes New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

Industry structure

Most feed in Canada is produced in commercial feed mills

Livestock consume roughly 28.8 million tonnes of feed each year which includes crops grown on farm as well as manufactured feed.

Approximately two thirds (19.2 million tonnes) is supplied by commercial feed mills, of which there are approximately 470 in Canada. Commercial feed mills are businesses that manufacture feed for sale and distribution in the Canadian marketplace and/or for export. The remaining one third (9.6 million tonnes) of the feed consumed by Canadian livestock is produced by the estimated 25,000 on-farm feed mills (farms that have mills that only produce feed for their own animals).

Note that feed legislation in Canada does not currently apply to feeds made by on-farm feed mills as long as the feed is not sold off the farm, does not contain medication, and does not contain any substance that may pose health risks to livestock. However, on-farm feed mills that use protein material sourced from any animal or animal byproduct (including ruminants, poultry, swine, and horses) during the feed manufacturing process are subject to feed legislation, regardless of where it is manufactured.

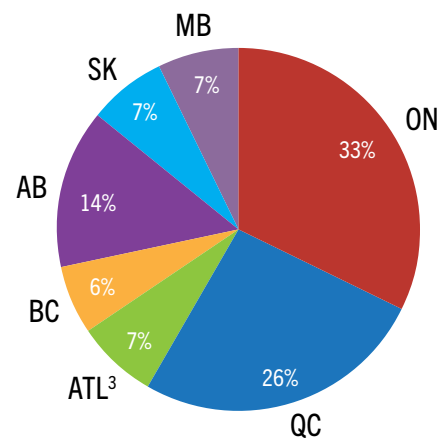
Feed mills are distributed across Canada

Commercial feed mills are usually located close to livestock operations. The proximity of feed mills to farms keeps transportation costs to a minimum. It also facilitates the close working relationship between feed companies and their customers.

The largest concentration of feed mills is in Ontario and Quebec (Figure 2), due to the high concentration of livestock within these provinces, particularly dairy, poultry, and swine.

Figure 2. Distribution of commercial feed mills across Canada by province.

Source: CFIA 2021



³Atlantic Canada (ATL) includes New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

Most commercial feed mills in Canada manufacture feed for multiple species

Many of Canada's feed mills are considered multi-species, meaning they produce a variety of feed products (premises, supplements, complete feeds) for several livestock species. As a result, a wide range of ingredients are found at feed mills and are often dependent on regional availability. Producing feed for many species also impacts production efficiencies and manufacturing procedures as special attention is needed to minimize cross-contamination of ingredients that may not be suitable for all species.

The industry is highly adaptable to meet customers' needs

The majority of feeds manufactured in Canada are custom made to meet the specific needs of the producer and their animals to optimize health and production. Animal nutritionists must work closely with producers and feed mill staff to ensure that the unique needs of each customer are met. Compared to the United States, Canada has fewer integrated operations (i.e. multi-functional operations including feed production, raising livestock, and processing).

The size and type of feed mills in Canada vary significantly as do the age of the facilities, manufacturing capabilities, and degree of automation. Feed mill operations are influenced by the livestock species they serve, seasonal and regional availability of ingredients, ingredient cost, changing consumer demands, and global trade. These external impacts make no two feed mills in Canada the same, even within the same company. The differences between feed mills can present a challenge but are also one of the most exceptional attributes of the Canadian feed industry. Feed company employees must therefore be highly adaptable to adjust to changing ingredient availability, ingredient cost and market trends.

An industry undergoing increased consolidation

The Canadian feed industry is a mature industry. The overall trend is that the number of commercial feed mills is decreasing but the amount of feed produced per mill is increasing.

This movement towards industry consolidation is similar to trends observed at the farm level with a decrease in the number of farms but an increase in production size. This allows companies to remain competitive by benefiting from economies of scale.



Regulations

The Canadian feed industry is highly regulated, which is reflected in the processes and day-to-day operations of a feed company.

The key legislation and authorities governing livestock feed in Canada are shown in Figure 3.

Feeds Act & Regulations

The *Feeds Act* and *Regulations* are the principal legislation governing the feed industry and are the responsibility of the Canadian Food Inspection Agency (CFIA). Unlike other sectors in Canada, feed is federally regulated with few province-specific requirements. These regulations include requirements related to the manufacturing, sales and imports of feed and feed ingredients. In contrast to other countries, pet food is not regulated in Canada in the same way as livestock or animal feed.

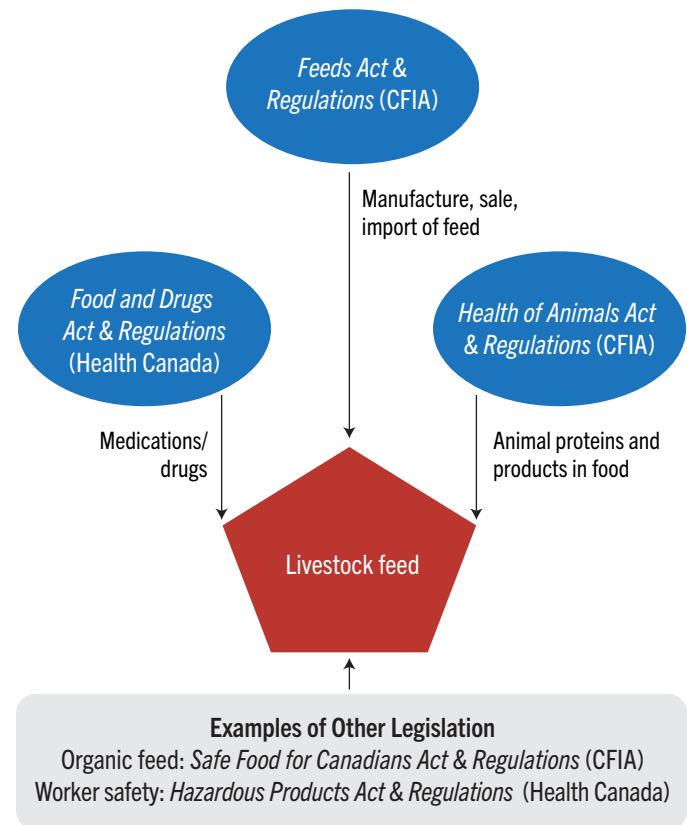
All ingredients intended to be fed to livestock in Canada must first be approved by the CFIA and requirements for approval, along with the labelling requirements for feed are included in the *Feeds Regulations*. At the time of publication of this Canadian feed industry document, the 1983 regulations are in place. However, a modernization of the regulations is underway and anticipated to be enacted in 2022.

Health of Animals Act & Regulations

The *Health of Animals Act* and *Regulations* are the responsibility of the CFIA and aim to protect animals and animal health. This legislation includes regulations for controlling diseases and toxic substances that may affect animals. These regulations also outline the requirements for animal products that are fed to livestock. In particular, they include materials that are prohibited from being fed to ruminants (ie. animals with four compartment stomachs such as cattle, sheep, and goats).

In 1997, the CFIA prohibited the inclusion of any ruminant protein and material in ruminant feed to limit the spread of bovine spongiform encephalopathy (BSE), more commonly known as mad cow disease. Ten years later, in 2007, the Government of Canada introduced the Enhanced Feed Ban which prohibited the use of specified risk material (SRM) in animal feeds, pet foods, and fertilizers to further reduce the risk of disease spread. The *Health of Animals Act* and *Regulations* work alongside the *Feeds Act* and *Regulations* to safeguard the health of animals and humans consuming animal products.

Figure 3. Key legislation and authorities governing livestock feed in Canada



Food and Drugs Act & Regulations

Drugs in Canada are regulated by Health Canada under the *Food and Drugs Act* and *Regulations*. Many veterinary drugs are administered through feed. These medications can include a wide range of products including coccidiostats, beta-agonists, and antibiotics.

The Compendium of Medicating Ingredient Brochures (CMIB) outlines medicated ingredients, called drug premixes, approved by Health Canada to be added to livestock feeds in Canada. The CMIB includes information on:

- the purpose of each medicating ingredient
- which species the medicating ingredients are approved for
- accepted levels to be included in feed
- directions for feeding
- compatibilities with other medications
- how the medications are to be incorporated into feed
- labelling requirements for products containing the medications

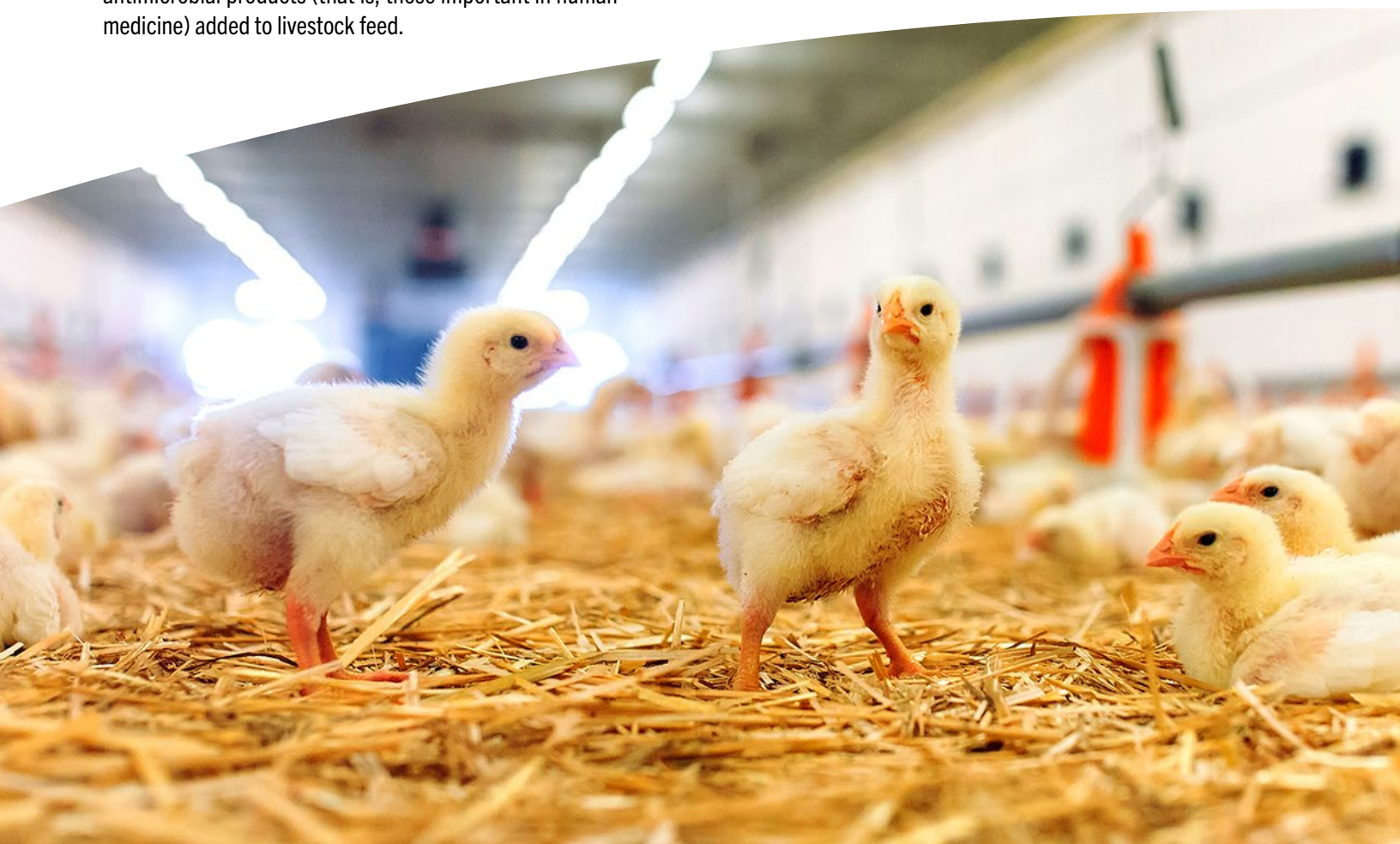
Some drug premixes require a producer to obtain a veterinary prescription before being able to purchase feeds containing those medicating ingredients. This includes all medically important antimicrobial products (that is, those important in human medicine) added to livestock feed.

Off-label drug use is also allowed to be added to feed, pursuant to a veterinary prescription. Off-label drug use is the use or intended use of a drug approved by Health Canada in an animal in a manner not in accordance with the label or package insert (i.e. outside of what is listed in the CMIB for in-feed use).

In emergency situations, through the emergency drug release (EDR) program, veterinarians may request authorization to access unapproved drugs for emergency veterinary use and these are also sometimes added to feed.

Other regulations

There are other general regulations that the feed industry must follow. These include the *Weights and Measures Act and Regulations*, the *Hazardous Products Act and Regulations*, and the *Safe Food for Canadians Act and Regulations*, among others. These regulations serve to ensure the safety of all Canadian products, including livestock feed.



Animal nutrition

The fundamental goal of the feed industry is to provide nutritionally balanced feed products that will maintain optimal animal health and enhance production efficiency.

The basic building blocks in an animal's diet include carbohydrates, proteins, fats, fibre, vitamins, and minerals, as well as water. How animals utilize these basic elements in their diet will depend on the species.

Monogastrics and ruminants

Monogastric animals (such as pigs and poultry) have a single-chambered stomach; whereas ruminants (such as cows, sheep, or goats) have a four-chambered stomach. The largest compartment of the ruminant stomach is called the rumen, which contains a diverse ecosystem of bacteria, microbes, and fungi. These rumen microbes help break down the fibre component of the diet releasing nutrients into the body that would otherwise be indigestible to a monogastric. Additionally, the rumen allows ruminants to utilize a wide range of ingredients and thrive on a variety of plants and feed ingredients.

Since monogastrics and ruminants break down and utilize feed ingredients and nutrients in a different manner, diet formulations and feed manufacturing need to be addressed differently. More information on animal nutrition and how both monogastric and ruminant animals digest and utilize dietary components such as carbohydrates, protein, fats, vitamins, and minerals can be found in [Appendix A](#).

Tailored nutritional solutions

Nutritionists work closely with their company's sales and production staff as well as livestock producers to create diets that meet the specific nutritional requirements for the animals on a given farm. Nutritionists in Canada generally hold at a minimum a Master of Science degree and play an important role in the feed industry.

Animals have different nutritional needs depending on their age and stage of production. For example, a lactating dairy cow would not be fed the same diet as a dry cow (a cow resting from milk production between lactations), heifer, or calf. Additionally, a sick cow, depending on the ailment, may require special nutrition that is different from healthy cows.

By engaging with sales staff and producers to understand the individual farm's production goals, nutritionists can align their feed formulations to optimize animal health and production efficiency. Some nutritionists are also independent consultants who work directly with producers to formulate diet specifications, which are then manufactured on-farm directly or on their behalf by a commercial feed mill.

The customization of feeds in the manufacturing process is a critical service provided by the Canadian feed industry to meet the individual needs of each producer. No two Canadian farms are the same and as a result, diet specifications change from farm to farm.

When formulating diets, on-farm ingredient availability and water mineral conditions are taken into consideration. For example, a livestock producer may only require a supplement to balance the grains and forages available on farm. Other producers may need additional nutrients incorporated into complete feeds, supplements, or premixes to target the life-stage or production phase of the herd or flock. With seasonal variation affecting the availability and nutrient content of crops, formulations may need to be adjusted as frequently as every load of feed produced.

Least cost formulation

Creating products based on nutrient requirements

Most mixed feed products are customized to the unique customer needs and based on the ingredients available both on farm and at the feed mill. For complete feeds where agricultural crops (that may vary in nutritional composition and availability) can represent 90-95% of the formulation, least cost formulation is a method to ensure that costs are minimized while using available ingredients to optimize animal performance and health. Animal nutrition companies maintain their formulation database with regular updates from quality control samples of incoming ingredients. Nutritionists use this information and their understanding of animal nutrition to formulate a final product that will meet the goals of the livestock producer for their animals. This approach differs greatly from other industries where a product is manufactured with a set formulation every time to achieve consistency in the final product.

Feed ingredients

The feed industry uses its knowledge of available and innovative ingredients to provide solutions that deliver optimum animal nutrition and meet the needs of livestock producers.

Creating a range of feed products

The CFIA has some 1,250 feed ingredients approved for use in livestock feeding in Canada. Companies specializing in feed additive/product manufacturing use some of these ingredients to make products that are then further mixed into feeds. Meanwhile, feed mills utilize other types of approved ingredients to formulate final products that will meet customer needs. These include complete feeds, supplements, and premixes.

A **complete feed** provides all the nutritional requirements necessary for the maintenance of life or for promoting production, except water. A complete feed is often used when the producer does not have the ability to mix feed on farm.

A **supplement** is a feed that is used with another feed to improve the nutritive balance of the diet.

A **premix** is a mixture of ingredients (such as trace minerals, vitamins, and in some cases, medicated ingredients) that is used to provide a critical portion of the total diet. It is intended to be mixed with other ingredients to produce a supplement or complete feed. For example, a premix is often used when a producer is mixing feed on-farm and has grain ingredients readily available such as corn and soybeans.

Many feed ingredients are used and produced domestically

Broad categories of feed ingredients produced in Canada include cereals, oilseeds, pulses, by-products of food and ethanol production, and products from the rendering industry. Cereals are primarily used as an energy source in feed formulations, and include crops such as wheat, barley, corn, and oats. Proteins are an essential component in animal diets and can be derived from both plant and animal sources. Plant-based proteins include canola meal, soybean meal, distillers' grains with solubles and pulses. Animal-based proteins include fish meal, whey and rendered meat and bone meal by-products. Fats and oils are a very concentrated source of energy.

Table 2 provides a general overview of the most commonly used feed ingredients and the livestock species that consume them. The particular selection of feed ingredients will depend on the individual animal, production stage, and/or class of livestock (i.e. monogastric versus ruminant).

Additional information regarding the use of specific feed ingredients such as canola meal, barley, and corn, among others, can be found in [Appendix B](#). More information on the national production of crops used as feed ingredients is available from the Government of Canada's [Reports and Statistics Data for Canadian Principal Field Crops](#).

Other feed ingredient categories

When we think of what an animal eats, grains, forages, vitamins, and minerals frequently come to mind. Diets, however, often also include feed additives or other non-feed and specialty products. Like all ingredients that can be fed to livestock, these other ingredients are regulated and must be approved by either CFIA or Health Canada before being allowed to be mixed in feed.

Feed additives include antioxidants, mould inhibitors, pelleting aids, anticaking agents, acidifiers, viable microbial products, and flavouring agents among others. Veterinary biologics are also being approved for mixing in feed to allow for the efficient administration of these products. Feed additives and veterinary biologics are all regulated by the CFIA.

Veterinary health products (VHPs) and medicinal ingredients (e.g. antibiotics) for mixing in feed, are regulated by Health Canada. All medicinal products used in feed must have a drug identification number (DIN) issued by Health Canada or be part of an emergency drug release (EDR). Veterinary health products are only now starting to be approved for use in feed and it is expected that these types of products will increase in availability in the future.

By-products from other manufacturing industries, including grain and animal protein by-products, are critical ingredients used in livestock feed formulations. The use of these ingredients is highly regulated. The feed industry provides a unique market for by-product ingredients such as oat hulls, soy hulls, bakery meal, and distillers' grains, that would otherwise have little economic value. Some of the most common by-products used in the feed industry are highlighted in Table 2.

Table 2. Common feed ingredients and the main livestock species that consume them

Feed Ingredients	Key Livestock Species
Cereals and Pulses	
Wheat	Cattle, poultry, swine
Barley	Cattle, poultry, swine
Corn	Cattle, poultry, swine
Grain By-Products	
Pea/Lentil screenings	Cattle, poultry, swine
Oat hulls	Cattle, poultry, swine
Soy hulls	Cattle, poultry, swine
Bakery meal	Cattle, poultry, swine
Wheat shorts	Cattle, poultry, swine
Plant-Based Proteins	
Canola meal	Cattle, poultry, swine
Soybean meal	Aquaculture, cattle, poultry, swine
Distillers' grains with solubles	Cattle, poultry, swine (dependent on lifestage)
Pulses	Aquaculture, cattle, poultry, swine
Animal-Based Proteins	
Fish meal	Aquaculture, swine (nursery diets)
Meat and bone meal	Poultry, swine
Fats/Oils	
Vegetable oil	All livestock
Grease	All livestock
Tallow	All livestock
Trace Minerals	
Iodine, iron, manganese, selenium, zinc	All livestock
Cobalt	All livestock except poultry and swine
Copper	All livestock except sheep
Macro-minerals	
Calcium, phosphorus, magnesium, sodium, potassium	All livestock
Sulfur	Cattle, goats, sheep
Vitamins	
Water soluble (Vit. B, C)	Calves, horses, poultry, swine
Fat soluble (Vit. A, D, E, K)	All livestock

Feed manufacturing

The process by which feed is manufactured in a mill involves a range of specialized processing steps and a coordinated effort by staff.

Ingredient manufacturing, in contrast to the manufacturing of complete feeds, supplements, and premixes, can vary greatly and be quite specialized. The main steps to produce finished feed are relatively consistent and include:

- diet formulation
- raw ingredient receiving
- particle size reduction
- mixing
- further processing
- packaging and labelling
- shipping

The different roles typically found in a feed mill include:

- mill managers
- administrators
- nutritionists
- production personnel, including equipment operators
- quality assurance/feed safety coordinators
- sales people

The team works together to ensure a safe and quality product is delivered to all customers.

Feed is manufactured into many textures

Feed mills produce feed in various forms. A mash is the simplest solid feed form that can be manufactured and is produced by grinding and mixing all raw ingredients into the correct proportions to meet the formulation requirements. Pellets, crumbles, flakes, liquid, or blocks can also be formed to meet the varying needs of each farm operation.

Feed in different forms provides animals the opportunity to best utilize the nutrients within the feed according to their digestive anatomy and physiology.

Different textures may be more favoured by one animal species compared to another, or a younger animal may only be able to digest a certain form/texture until it further matures and develops.

In some cases, the form of the feed may be chosen based on the operational capability of the farm. For example, a dairy farm that uses a robot feeder would be best able to handle a pellet whereas a producer manually mixing feed has more flexibility in the form of the feed that can be used. Feed industry experts and producers work collaboratively to determine the most appropriate feed texture needed for different applications.

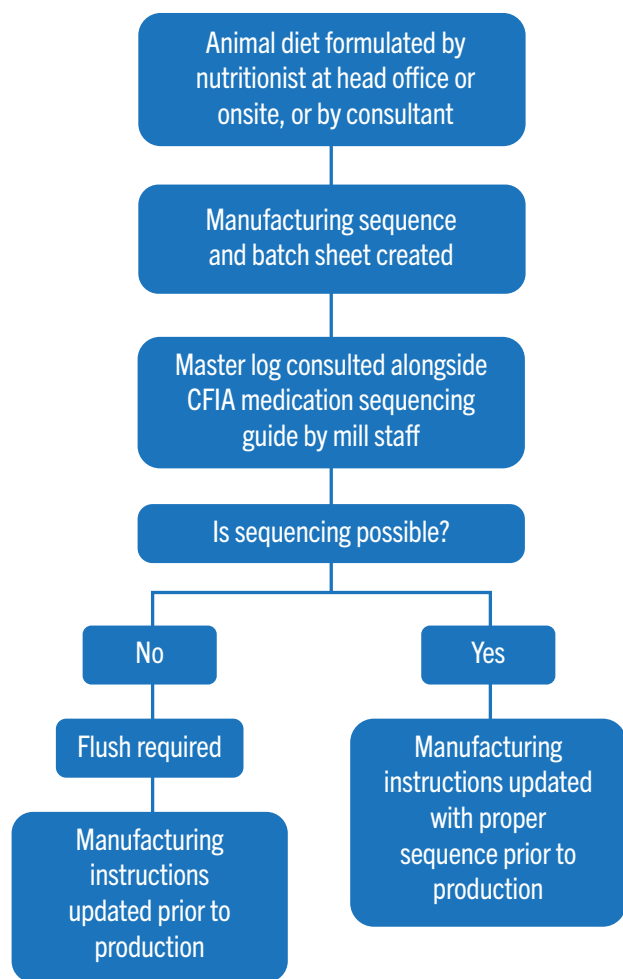
Scheduling and planning production

Figure 4 illustrates key administrative activities, when scheduling feed production, to minimize risks of cross-contamination that could present a risk to animal or human health. Before diets are manufactured, all necessary paperwork needs to be received by the mill. This includes the formula for the diet which can either be developed by nutritionists on site, nutritionists at a head office location, or a consultant. The mill then creates batch sheets, which are master logs, to ensure different batches of feed are manufactured in the correct order or sequence.

Planning the manufacturing sequence is an important consideration during processing of livestock feed.

Planning the manufacturing sequence allows feed manufacturers to prevent cross-contamination of feeds containing medications or other ingredients that could be harmful to a certain species or humans. CFIA publishes a medication sequencing guide to help facilities plan the order in which they manufacture different diets to prevent cross-contamination of feed with incompatible medications. If sequencing is not possible between batches, but there is the requirement to prevent cross-contamination, facilities will perform a flush. A flush is the process whereby a large quantity of product (e.g. grain) is run through the equipment to clean out previous batch residues as a means of preventing cross-contamination.

Figure 4. Process for planning manufacturing sequence



Receiving feed ingredients

Figure 5 shows a schematic of key steps in the manufacture of a mixed feed from ingredient receiving to shipping of finished product.

The first step in feed manufacturing is the receiving of ingredients. Feed mills generally have a variety of controls in place to ensure that ingredients are of good quality. This includes, but is not limited to, a supplier approval process, verifying certificates of analysis, and random sampling and testing.

A feed mill will receive ingredients in different forms. Dry bulk ingredients such as wheat and corn are received and stored in upright silos or underground pits. Liquid bulk ingredients are received at the mill, filtered to remove foreign material (as applicable) and then stored in tanks. Dry, bagged ingredients are received at the mill and stored in a warehouse type section of the manufacturing site.

Some bulk ingredients are processed after receiving and can be ground, flaked using a steam roller, or cracked depending on their desired end use.

Grinding to desired particle size

For some feeds, grinding is an important step in the feed manufacturing process to ensure the proper particle size of the feed is obtained. It is also critical to ensuring pellet quality. Particle size reduction increases the surface area of the feed particle and can improve nutrient availability for livestock by allowing for more uniform mixing of the finished diet. Despite some diets needing a reduced particle size, finely ground feed material is challenging to handle in the mill and excessive grinding can pose negative health consequences for the animals as well. Most often, the desired particle size is based on the requirements of the animal.

Mixing feed ingredients

Once the desired consistency of the feed ingredients is met, the ingredients are ready to be mixed. The bulk dry ingredients are added first, followed by any micro-ingredients, such as vitamins, minerals, and any medications. Lastly, any necessary liquids are added into a large feed mixer where they produce a homogeneous product that ensures the animal receives the required amount of nutrients in every bite. Dry ingredients can include products such as grains, vitamins, minerals, medications, and specialty feed additives. Wet ingredients can include products such as molasses, oils, and water.

Processing further

Once mixed, the feed product is milled into its sale form before being packaged and labelled as per CFIA regulations.

Preparing the feed in the proper form for sale is key to ensure it can be efficiently handled, transported, fed, consumed, digested, and utilized by the animal.

Once the homogeneous feed product is adequately mixed, the feed mixture is packaged or stored in its existing form or is further conditioned, pelleted, cooled, or crumbled to meet the form required by the animal.

In a conditioner, the feed mixture is heated and steamed at a high pressure and mixed, which helps to improve the nutritional value of the feed and is essential to produce good quality pellets.

Pelleting is the most energy intensive process in feed manufacturing as it involves forcing conditioned feed through holes under heat and high pressure which enables the desired pellet size to be produced. Depending on the desired pellet and the mill, heat levels will be different.

Once the feed is pelleted, the pellets travel into a machine for cooling. Cooling is critical to remove the moisture and heat generated during the conditioning and pelleting processes.

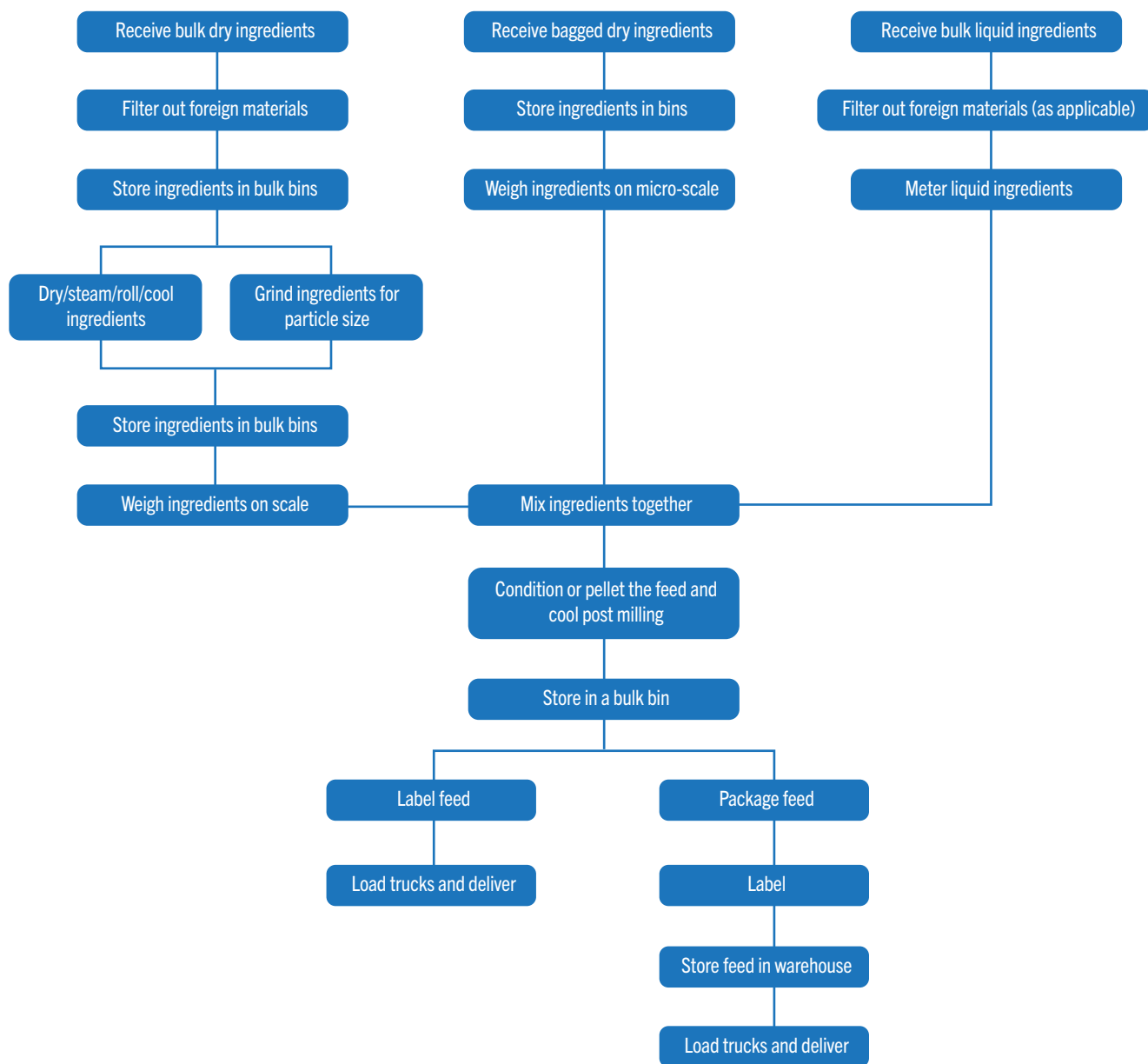
If a crumble is desired, the pellets are crushed into a consistency that is coarser than mash, yet smaller than a pellet.

Packaging, labelling, shipping

Upon cooling, the finished diet is packaged in bags, large totes or moved to bulk bins. It is labelled to meet CFIA requirements.

The feed is then stored until it is ready to leave the facility by truck or rail, (or in some cases, by ship) to be delivered to farm operations or feed distributors.

Figure 5. Typical feed manufacturing process from receiving of ingredients to final shipment.



Feed and food safety

Feed and food safety are critical elements of animal production and as a result, there is a high level of regulatory oversight on animal feed production in Canada.

Feed safety regulations ensure that animal products intended for human consumption are safe. Numerous practices, regulations, policies, and procedures are embedded in the day-to-day operations of the Canadian feed industry to ensure the safety of animal feed and consequently human food. CFIA carries out regular inspections of Canadian commercial feed facilities to verify that regulations are being followed throughout the manufacturing process.

Feed is manufactured in FeedAssure® facilities

An estimated 70% of the commercial livestock feed produced in Canada is manufactured in Hazard Analysis Critical Control Point (HACCP) certified facilities, under the FeedAssure® program.

FeedAssure® is a customized HACCP program, developed and managed by ANAC, and is the gold standard for feed safety in Canada.

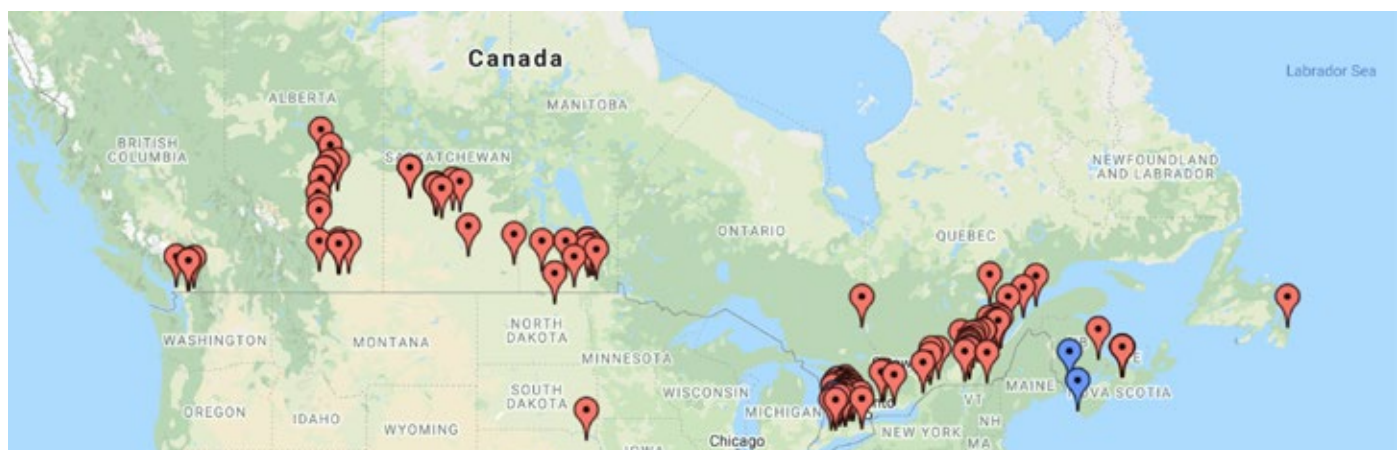
Created in 1999 and one of the first feed safety programs globally, the FeedAssure® program involves a detailed set of protocols to identify and control hazards in the feed manufacturing process. Elements of the program encompass the entire feed supply chain from supplier approvals and receiving, through to the manufacturing process as well as packaging, storage and distribution of the final product. All FeedAssure® certified facilities undergo an annual audit by a 3rd party to demonstrate their adherence to the program requirements and to maintain certification. The FeedAssure® program is recognized by CFIA as a risk mitigation tool demonstrating a high level of commitment to feed safety.

Figure 6 shows the relative distribution of FeedAssure® certified facilities in July 2021, which closely mirrors the location of livestock and commercial feed mills in Canada.

Feed and food safety are a shared responsibility between producers, feed manufacturers, processors, retailers as well as other industry stakeholders and government representatives.



Figure 6: Map showing locations of the 179 FeedAssure® certified facilities in July 2021.



Staying at the forefront of feed and food safety

Feed and food safety have long been important components of animal production systems in Canada.

In the late 1990s, bovine spongiform encephalopathy (BSE), more commonly known as “mad cow disease”, became a leading issue for the Canadian feed industry. BSE is a highly contagious and fatal disease affecting the central nervous system of cattle. It is caused by the accumulation of abnormal prion proteins and is generally transmitted when cattle consume feed contaminated with these prions (even minuscule amounts).

To curb the spread of BSE within Canadian cattle herds as well as throughout the feed supply chain, the Canadian government introduced two feed bans: one in 1997 followed by the enhanced feed ban in 2007. After the prohibition on the use of animal protein material in ruminant feeds, the feed industry adapted, sought alternatives, and implemented rigorous cleaning and

segregation practices, to ensure a consistent and safe supply of feed for ruminant animals. Although the risk of BSE in Canada is now considered negligible due to the controls in place (as recognized in May 2021 by the World Organisation for Animal Health, OIE), the industry remains vigilant and continues to apply best practices that will safeguard against emerging feed and food safety threats.

More recently, the potential viral transmission of foreign animal disease through feed has gained more attention. With limited mitigation options against African swine fever virus (ASFv) and porcine epidemic diarrhea virus (PEDv), biosecurity practices have been placed at the forefront to guard against these diseases. Strong biosecurity protocols have become widely recognized as essential to limit the spread of many animal diseases, and are among the many preventive controls being implemented by the feed industry to ensure feed and food safety.

As feed and food safety risks evolve, consumer and regulatory requirements become more stringent, and the feed industry continues to adapt.



Trends and innovations

The feed industry is continually evolving to meet the needs of its customers, contributing to the overall competitiveness of the Canadian livestock sector.

With the world population expected to reach over nine and a half billion people by 2050, global food production and distribution will need to grow exponentially to meet the demand. Overall, there has been an increase in the demand for safe, affordable, and nutritious food.

Transparency in the food production system

Consumers are more invested in how their food is produced than ever before, which has driven various consumer trends. Increasingly, consumers are concerned about how their food is made from farm to fork. Consequently, this creates new challenges as the feed industry not only balances optimal and efficient animal nutrition, but also consumer perceptions of the ingredients used to feed livestock while maintaining the profitability of their customers.

Supporting producers to meet consumer trends

New consumer trends often get communicated to the feed industry via livestock producer requirements. These trends can originate from domestic customers as well as international export markets depending on the scope of the issue and the dissemination of the overall trend.

For example, public awareness regarding antimicrobial resistance has led to the establishment of niche markets in Canada such as “raised without antibiotics (RWA)” products. Although the use of these antibiotics is highly regulated in Canada, consumer concerns place pressure on livestock producers to implement animal management practices that secure public trust and further solidify a social contract with consumers by reducing their reliance on antibiotics. Other niche markets targeting the method of production ultimately affecting animal feed include “grain/grass fed” and “organic”, among others. These pressures impact the way feed is formulated and manufactured to ensure customers’ (i.e. livestock producers’) requirements are met.

The Canadian Ractopamine-Free Pork Certification Program (CRFPCP) was created specifically for the export market, but due to the significant quantity of pork being exported, it has been widely adopted throughout the commercial feed industry. Despite

ractopamine being approved for use in Canada, the CRFPCP provides assurances that all pork produced under the program is ractopamine-free, a requirement for export markets such as China.

Improving animal health through nutrition

The use of antimicrobials, such as antibiotics, in feed for animals dates back to the 1940s. During the Second World War, there was an intensification of livestock production which was required to meet global food demands. During this time, a correlation was discovered between feeding antibiotics to animals and an increase in production efficiency. By the late 1960s, the industry began to understand the negative consequences of this type of antibiotic use which contributed to the development of antibiotic-resistant microbes.

Judicious use of antimicrobials

Globally today, antimicrobials in animal production are increasingly reserved for the treatment of sick animals and in disease prevention programs. In 2018, Canada banned the purchase of medically important antimicrobials (i.e. those important to human medicine) without a veterinary prescription. This means that when these medicating ingredients are used on farms, it is done with oversight by a veterinarian. This policy change was to help combat antimicrobial resistance and encourage more judicious use of antibiotics.

While all animal food sectors now require a veterinary prescription to use medically important antibiotics, different sectors of the animal food industry, such as poultry, have implemented voluntary limits on the use of certain classes of antibiotics to prevent disease. Much of the focus involves preventing animal disease and illness so there is overall reduced need for antibiotic use, much of which is accomplished through nutrition and management practices. Continuous research is taking place in Canada’s agriculture and agri-food industry to assess the efficacy and safety of various feed ingredients to include in animal diets that can help industry further reduce their reliance on antibiotics while maintaining healthy and productive animals. Examples of these types of products include probiotics, prebiotics, and organic acids.

Sustainability

Finding value in by-products originating from the agri-food and biofuel sectors

The Canadian feed industry has always strived to produce and manufacture products that are safe and sustainable. Recycling by-products from other production and manufacturing industries has long been a fundamental practice of the feed industry. This has created a market for products that would otherwise have limited economic value. For example, the feed industry makes use of wheat and other grains that are below human grade specifications that would otherwise go to waste if not fed to animals. Other by-products, such as fruit and vegetable waste, distillers' grains (a by-product of ethanol fuel production), and bakery waste are used in livestock feed. To the animal feed sector, they present an opportunity to provide nutritional value to animals while reducing feed costs and waste.

Improving sustainability through innovative approaches and ingredients

Nutritionists work to enhance animal productivity by ensuring that livestock have an optimum diet to stay healthy, grow, and produce

food for human consumption. Careful selection of the raw materials, considering their origin and processing methods, helps to reduce the livestock industry's carbon footprint and minimizes feed waste, while ensuring that the animals are fed a nutritious diet. Innovations related to new protein sources (e.g. insect), more bioavailable ingredients, precision nutrition, and processing of ingredients are among the areas actively being researched to improve the efficiency and utilization of resources in animal production.

Across the agriculture and agri-food industry, continued efforts have been made to produce sustainable food products for both the human and animal food chain. In recent years, consumers and government regulators have been paying more attention to the environmental impact of products and processes. While this is reflected in choices consumers make, policymakers work to ensure that environmental marketing claims are meaningful and truthful. Like in other industries, the feed industry is increasingly evaluating what further measures can be taken within their processes with environmental sustainability in mind.

As more is learned and understood about best practices, these considerations are taken into account when creating feed for customers.

Conclusion

The Canadian feed industry is a critical partner in the country's agriculture and agri-food value chain where livestock species consume approximately 28.8 million tonnes of animal feed each year. Roughly 19.2 million tonnes of feed is supplied by approximately 470 commercial mills across Canada. Feed represents one of the largest input costs for farm operations; thus a collaborative effort is required between nutritionists, feed manufacturers, distributors, suppliers, and farmers to optimize animal health and production through economical feeding practices. The manufacturing process of each mill is unique, complex, and utilizes a wide range of ingredients and inputs to formulate a customized product to meet individual animals' nutritional requirements as well as the needs of different farm operations.

To meet evolving consumer trends and industry challenges, the Canadian feed industry continues to be adaptable to change and customer-focused. This ensures that farmers can produce safe and high quality food, now and in the future.

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Appendix A – Animal nutrition

Carbohydrates

Carbohydrates are the primary energy source in livestock diets and can constitute a large proportion of the animal's diet. Carbohydrates are mostly found in plant materials, where only a modest amount is found in animal tissues. Carbohydrates can be classified into two categories: simple carbohydrates (sugars) and complex carbohydrates (starches and fibre), where both are used as an energy source for the animal. Both monogastrics and ruminants are able to effectively digest and utilize carbohydrates.

Monogastrics can readily absorb simple carbohydrates through their gastrointestinal wall and can also produce and utilize volatile fatty acids (VFAs) in their hind gut; whereas ruminants are able to break down complex carbohydrates into VFAs through the use of rumen microbes. These VFAs, or energy precursors, can be easily absorbed into the blood stream and utilized by the animal. The process in which monogastrics and ruminants produce and utilize VFAs is different, which is reflective in the way carbohydrates are incorporated into their respective diets.

Protein

Proteins are organic molecules that are composed of chains of amino acids. All animals have amino acid requirements; therefore, proteins are an essential component in livestock feed that are required for growth, reproduction, lactation, and maintenance. In monogastrics, protein digestion and absorption occurs in both the stomach and small intestine. In contrast, in ruminants, protein digestion can occur in either the rumen, or the small intestine depending on the type of protein and feed processing. Unlike monogastrics, ruminants require both dietary protein and microbial protein which supply adequate amounts of amino acids for optimal production.

Fat

Fats are a concentrated source of energy compared to carbohydrates and can be classified into saturated fats and unsaturated fats. Fats and oils are essential fatty acids that have various functions, such as increasing digestibility of feed, which make them useful in livestock diets. There are large amounts of fat found in animal products, compared to plants, making them a desired ingredient in feed formulations. In monogastrics, fat digestion primarily takes place in the small intestine whereas in ruminants, fat digestion primarily takes place in the rumen. Ruminant diets generally contain small amounts of fat as high concentrations will disrupt rumen microbes and can result in metabolic diseases; however, this is dependent on the production stage and environment. Poultry diets often contain a low level of fat depending on the phase of the diet and the type of bird being fed.

Vitamins and minerals

Vitamins and minerals are critical for proper growth and health of animals. Although vitamins and minerals are required in small quantities, they perform specific functions within the animal. Vitamins are categorized as either water-soluble (e.g. B vitamins, vitamin C) or fat-soluble vitamins (e.g. vitamin A, D, E, and K). Minerals are categorized into macro minerals and micro minerals (trace minerals) and both have important functions within the body despite being required at varying levels.

Appendix B – Feed ingredients

Cereals and pulses

Wheat

Wheat is a common grain used in Canadian feed production; roughly 30% of available wheat in Canada is used by the feed industry. Domestically, most wheat is grown in western Canada (primarily Alberta, Saskatchewan, and Manitoba). Consequently, most western Canadian livestock diets contain a high percentage of wheat. Wheat is primarily grown for human consumption, but the proportion of crop that is below human grade is destined for the feed sector. Wheat can be included in corn-soy diets (i.e. formulations consisting of corn and soybean meal to provide both energy and protein), to help reduce costs and help in the pelleting process.

Barley

Barley is a highly utilized feed grain in Canada and considered one of the oldest cultivated grains. It is used worldwide as both a human food source and feed source in livestock diets. In Canada, a large proportion of barley is grown for the beer industry. Barley that is below malt grade is utilized by the feed industry and often contains protein levels that are only suitable to be fed to livestock. Most of the barley in Canada is grown in Alberta and Saskatchewan; therefore, it makes up a large proportion of diets fed to swine, cattle, and in some instances poultry, in western Canadian provinces.

Corn

Corn, also known as maize, is the highest produced cereal crop worldwide and is a standard ingredient used in feed production. Over half of the corn produced in Canada is utilized by the Canadian feed industry. It is primarily grown in Ontario and Quebec; therefore many livestock diets in eastern Canada are corn-based. Most importantly, corn can be processed in many ways allowing it to be fed to livestock in a variety of forms. Corn can be ground, cracked, fed in whole kernels, fed at different moisture levels (i.e. high moisture corn), or turned into corn silage. Each of these processing methods allows the nutrients within the grain to be best utilized by the animal to which it is fed. Additionally, these processing methods allow corn to be fed to a variety of livestock species including poultry, swine, cattle, sheep and goats.

Proteins

Canola meal

Canola is one of Canada's most important crops and is a commonly traded protein ingredient worldwide. Roughly 20 million metric tonnes of canola are grown each year across Canada, with the majority of production found in western Canada. Canola is mostly used as a protein source in western Canada, specifically Alberta, Saskatchewan, and most of Manitoba. Canola was developed in Canada during the early 1970s by removing the anti-nutritional factors found in rapeseed. Canola seed contains 44% oil, which is extracted and utilized by the culinary industry. The leftover seed contents are processed into meal that can be utilized by dairy cattle and swine but is also included in poultry diets. Canola meal is mostly sought for its balanced amino acid profile which can make it more advantageous compared to other protein sources.

Soybean meal

Soybean products are the most commonly used plant-based protein source in animal diets worldwide. In Canada, soybean meal is commonly used as a protein source in eastern Canada (e.g., Quebec, Ontario, and many parts of the Maritimes) and has some use in Manitoba. Soybeans are characterized as an oilseed, whereas the plant itself is a legume. Soybeans are rarely fed raw but can sometimes be fed roasted to some species; however, they are most often heat-treated and processed into meal. After the hulls and oil are removed, the leftover contents of the soybean are processed into a highly-digestible meal known as soybean meal. Up to 1.5 million tonnes of soybean meal is produced annually in Canada and provides a quality source of both energy and protein for livestock. Despite its high nutritional value, soybean meal contains anti-nutritional factors which hinder nutrient utilization by the animal. Therefore, proper heat treatment is required to maximize the nutrient availability of the soybean meal.

Animal-based proteins

Animal-based proteins are a high quality, well balanced product of the rendering industry. Edible animal products that are not consumed or utilized in the human food chain are rendered and used by the feed industry. Fish meal and meat and bone meal (MBM) are two examples of animal-based proteins utilized in feed manufacturing. Fish meal is sourced from slaughter plants and consists of clean, dried ground tissues of undecomposed whole fish, fish cuttings, or both, while MBM is sourced from proteins derived from animals such as cattle, swine, and poultry. Animal-based proteins are a safe product utilized by the Canadian feed industry. The production and use of rendered materials, such as MBM, are governed by federal regulations (CFIA).

Fats and oils

There are a variety of fats and oils available for use in animal feed including vegetable oils, tallows, and greases. High quality oils included in livestock feed include soybean oil, palm oil, canola oil, rapeseed oil, and corn oil, which differ in their fatty acid profile. These oils can be sourced from the processing and extraction of various crops. Animal fats, such as tallow, lard, grease, and animal-vegetable blended fat are obtained from the tissues of livestock and are sourced from processing and rendering plants and are included in animal diets as a concentrated source of energy.

