Nutrition

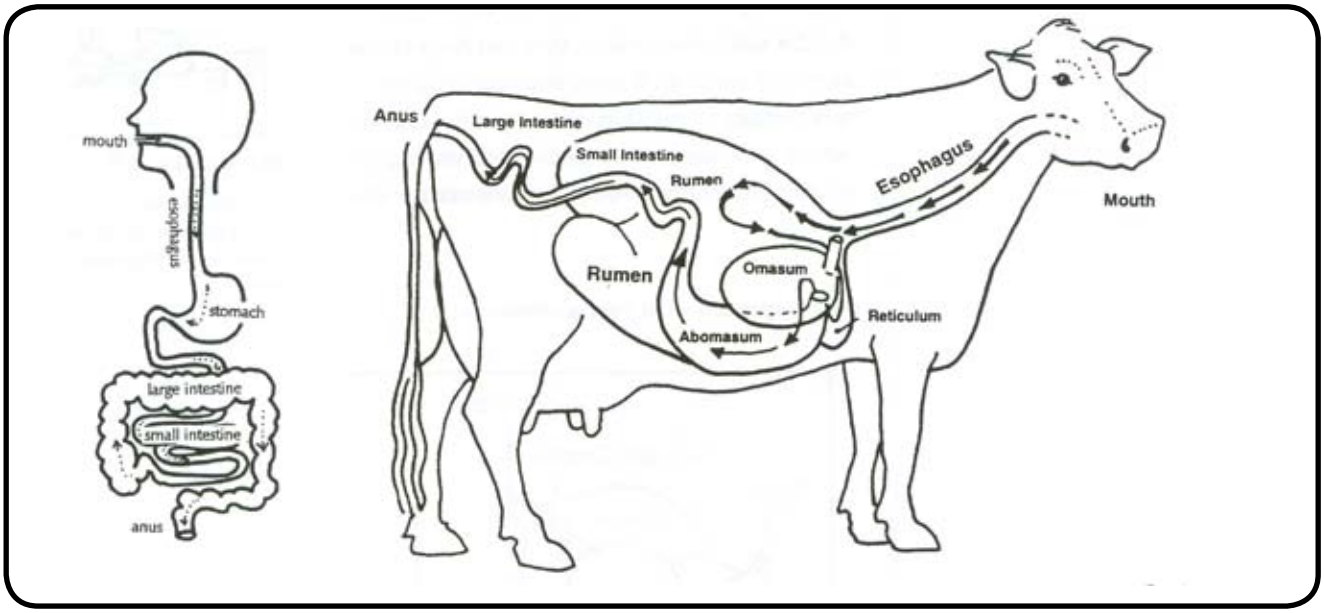
Ruminant and Monogastric Stomachs

What did you have for supper last night? A couple of handfuls of grain? Some hay? Probably not. But the cows in the barn did.

Ruminant animals have complicated digestive systems. This means they not only need a special diet to stimulate digestion, but they also have unique health problems associated with their ruminant stomachs. A ruminant stomach has four chambers, each with its own job to help break up or digest food.

Humans have a monogastric stomach - monogastric means one stomach. In monogastric animals, all of the work involved in breaking up food is done in one stomach.

To understand the ruminant stomach, it is helpful to compare it to the monogastric stomach. The diagrams below show cow and human digestive tracts:



Now, look at how ruminants compare to other animals:

	Volume of the total digestive tract				
	Ruminants		Monogastrics		
Digestive Compartment	**Cattle**	**Sheep**	**Horse**	**Pig**	**Human**
Total Stomach	70.8%	66.6%	8.6%	29.2%	18.8%
Small Intestine	18.5%	20.5%	30.2%	33.3%	62.4%
Cecum	2.8%	2.6%	15.6%	5.6%	0%
Large Intestine	7.9%	10.3%	45.3%	31.9%	18.8%
	356.0 kg	44.0 kg	211.0 kg	28.0 kg	6.0 kg

Source: Alberta 4-H Project

From the comparison table, you will notice several things:

- The ruminant stomach takes up much more space than the monogastric stomach
- The total capacity of ruminant stomachs is much larger than monogastric stomachs for animals of similar sizes
- The large intestine takes up much more room in monogastrics than in ruminants
- Did you notice any other differences?

The Digestive Trail

The digestive system is also called the alimentary tract. It consists of all the parts of the cow's body that work together to digest food. Let's travel through the parts of a cow's digestive system:

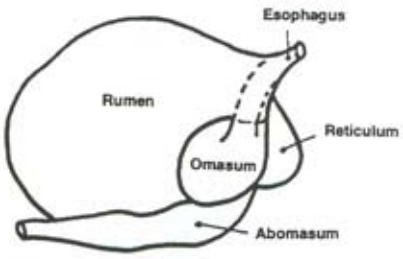
Structure	Components	Function	What happens to the food?
Mouth	• Contains lips, teeth, a tongue, and salivary glands	• Lips help bring the food into the mouth. • Teeth begin mechanical digestion. • The tongue helps mix and move the food towards esophagus. • Salivary glands provide juices containing enzymes that help in the chemical digestion of food. • The epiglottis, a muscular flap, closes off the trachea and opens up the esophagus so that food can pass smoothly to the stomach.	• The teeth crush the food. • Saliva wets it and turns it into a soft mash; saliva contains enzymes which begin digestion of starch (a complex carbohydrate). • Tongue turns the mash into a bolus.
Esophagus	• Tube connecting mouth and stomach • The cardiac sphincter, a special ring of muscles, is located where the esophagus joins the stomach	• The passage of chewed food from the mouth to the stomach. • The cardiac sphincter is normally closed preventing food and acid in the stomach from moving back up. A peristaltic contraction triggers it to open.	• No digestion occurs here.
Stomach	The stomach has 4 chambers (discussed following this chart): • Rumen • Reticulum • Omasum • Abomasum The walls of the stomachs have three layers: 1) An inner MUCUS MEMBRANE, or lining with glands that secrete important digestive juices 2) A thick middle MUSCLE LAYER that makes movement possible 3) An outer layer of CONNECTIVE TISSUE	• First major digestive organ within the gut. • The lining of the stomach secretes gastric juice, a mixture of mucus the enzyme pepsin and hydrochloric acid (HCI). • The mucus acts as a gel to provide a flexible protective coating to the stomach. • Pepsin helps in the digestion of protein. • HCI is what gives the stomach the acidic environment needed by the enzymes that work there. • Separating the stomach from the intestine is the PYLORIC SPHINCTER. Like the cardiac sphincter, it acts as a valve. It prevents food moving back into the stomach, and lets food enter the intestine when opened.	• Powerful contractions churn the food, mixing it with the gastric juice. • PROTEINS are partially digested here; fats and carbohydrates are not well digested. • No nutrients are completely digested in the stomach. Therefore, the food must be sent on to the small intestine. • By the time the stomach is finished, the food is a soft, warm, grey to brown mush called CHYME.

Structure	Components	Function	What happens to the food?

Small Intestines	• The SMALL INTESTINES are divided into three sections – the duodenum, the jejunum and the ileum.
	• The DUODENUM: This is the first part of the small intestine. It occupies roughly 5% of the total intestinal length. It is tied to the stomach, and is formed in an S-shaped curve, which holds the pancreas. Ducts from the pancreas and the liver enter here.
	• JEJUNUM: This central portion is the largest part of the small intestine, occupying 90% of its length. It is not clearly separated from either the duodenum or the ileum.
	• ILEUM: This last 5% is usually bunched up or contracted. It meets the large intestine at the ILEO-CECAL VALVE, which prevents food from moving back up into the small intestines.
		• The small intestine has two major functions.
		  • To complete the digestion of food
		  • To absorb nutrients
		• Digestion occurs primarily in the duodenum and the jejunum. This is where intestinal juice mixes with bile and pancreatic juice to provide the enzymes needed to finish the breakdown of food.
		• Intestinal juice comes from the lining of the wall of the intestine. Unlike the stomach, which is acidic, the juices in the small intestine are alkaline.
		• Absorption takes place once digestion is complete, in the final two thirds of the jejunum and in the ileum.
		• The exception to this rule is animals whose cecum is enlarged and specialized, because this is where cellulose digestion and absorption occurs.
		• The horse, rabbit and pig all have special cecums.
		• The walls of the small intestine contain two important parts: GLANDS, which secrete intestinal juices that aid in digestion; and VILLI.
		• Villi are small finger-like projections in the lining of the intestine that greatly increase its surface area.
		• Due to the villi, nutrients are more easily and more quickly absorbed. The villi move constantly. This helps them come in contact with all the digested food so that it can be completely absorbed.
			• As food leaves the stomach, it is a semi-fluid acidic mass known as CHYME. Chyme is gradually released into the duodenum thanks to periodic openings of the pyloric sphincter.
			• As soon as chyme enters the duodenum, it mixes with new secretions, and turns from an acidic to an alkaline mush.
			• Once digestion is complete, the chime becomes chyle, a milky material that contains all the nutrients from digestion.
			• The nutrients are picked up by the villi that line the intestine, and ultimately make their way into the animal's bloodstream.

Structure	Components	Function	What happens to the food?
Large Intestines (Colon)	• The large intestine differs from the small in that it is larger, lumpier and has a more fixed position. It is divided into the cecum and the colon.	• No digestion and very little absorption take place in the large intestine. Its job is: o To remove excess water from the non-absorbed foods o To concentrate non-absorbed foods into feces. 2) CECUM: this is usually an off-shoot where the small and large intestine meet. • In humans and carnivores it is a small and simple affair, not much more than a holding tank for digested food that has had all its nutrients removed. • In non-ruminant herbivores and omnivores the cecum is more important. For example In the horse, it is a huge pocket 1.3 meters long. Its capacity is greater than that of the stomach and its lining contains villi, glands and a mucus membrane. 1) COLON: the colon is a reservoir for excrement. • It empties into the RECTUM, which opens to the outside at the ANUS. • The anus is controlled by two sphincters. • In animals that have been trained, the external, voluntary sphincter allows feces to be held until it is convenient for voiding.	• Specialized cecums act like rumens. They have billions of micro-organisms that ferment and digest cellulose. Unlike rumens, little gas is produced.

A Closer Look at the Four Stomach Chambers



Rumen (paunch)

- The largest stomach in an adult cow, taking up 80% of the total stomach capacity, and holding up to 110kg of food
- All the food goes here first. The food is mixed.
- The muscles in the rumen break down the food.
- Bugs (called microorganisms) are present in the rumen to break down the food and rebuild it into protein. The cow digests the bugs later and uses the protein made by the bugs for herself. When you feed a cow, you are really feeding the rumen bugs!

Reticulum (honeycomb)

- The second stop for partially digested food is the reticulum.
- It has honeycomb shaped compartments all over it. The honeycomb catches wire, nails and other foreign materials.
- Food is mixed, soaked in acidic juices and broken down further
- Food that's too large is regurgitated back to the mouth to be rechewed as cud, or bolus.

Omasum (books)

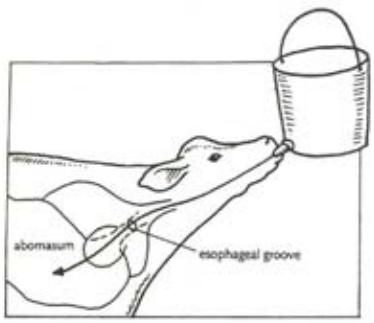
- The third stop on the digestive trail is the omasum.
- Food is broken down further.
- Many 'leaves' like the pages in a book make up the omasum.
- The omasum squeezes the food between the leaves to get rid of water and move the material to the last compartment

Abomasum (true stomach)

- Finally, the food stops in the last chamber of the stomach – the abomasum.
- The abomasum is similar to a human stomach.
- This is the only stomach that works in a young calf and the milk she drinks goes directly here.
- Secretes stomach juices and acids that break down food materials into simple nutrients (proteins, carbohydrates, fats, etc.)
- The cow's body will absorb these nutrients to give her energy and help her grow. Most absorption takes place later, in the intestines.

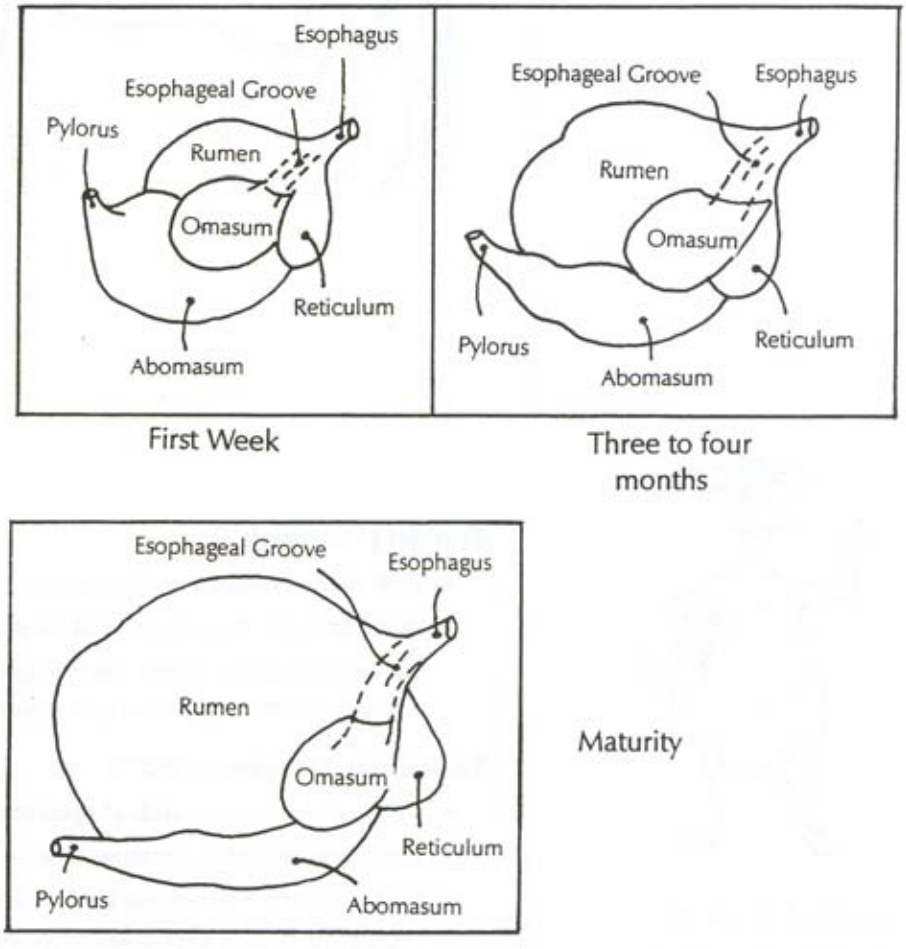
Newborn Calves Compared to Adult Cows

In newborn calves, the abomasum is the only compartment that functions, so calves are called 'pre-ruminants'. A calf's abomasum takes up much more space inside her stomach than the abomasum of an adult cow does. See the table below for a comparison of the stomach of a cow and a calf:



	% of Total Stomach	
	Newborn Calf	**Adult Cow**
Rumen	25%	80%
Reticulum	25%	6%
Omasum	10%	3%
Abomasum	40%	11%

Development of a cow's stomach



In newborn calves, the liquid she drinks passes through the **esophageal groove** straight into the abomasum, bypassing the other three compartments. The act of suckling, along with the smell and taste of milk, triggers the esophageal groove, which is a tunnel created in the digestive system when the muscular folds of the rumen and reticulum meet. The fluid she drinks flows through the tunnel, bypassing the other stomachs en route to the abomasum.

The other stomachs are bypassed at first because the calf needs to eat dry feed to develop the size of her rumen and the bugs contained within it. You can help stimulate the growth of the rest of her stomach through a good feeding program. You should offer a calf a dry grain mix within a few days of her birth. Grain stimulates rumen development, which increases the number and variety of rumen microbes. The microbes grow quickly and produce nutrients for the calf from the grain she eats.

Off to a Great Start – Keys to Feeding Calves

Designing a feeding program for your calves is one of the keys to raising healthy replacement heifers. Well fed calves grow faster, can be bred at a younger age, and enter the milking herd sooner.

Well fed calves can gain up to 1 kg a day without getting fat! Farmers should aim to have their calves gain 0.6 kg (small breeds) to 0.75 kg (large breeds) per day. Calves need to gain weight so they're big enough to have a calf by the time they're two years old. If it takes longer than that, the farmer begins to lose money because the heifer takes too long to become a milking cow and bring new calves into the herd.

There are several factors that are important to feeding calves, in addition to what's in the food they are getting. Here are some tips to make your calves "clear their plates":

Regular feeding – calves must have regular mealtimes, eating at the same times each day, spread out evenly throughout the day. That helps keep calves from getting too hungry. Calves that are too hungry eat too fast and can get upset stomachs.

Uniform food – calves grow better when they eat pretty boring diets. They need to eat the same quality and quantity of food every day, given to them at the same temperature.

Clean Equipment – always wash the feeding equipment between feedings to kill germs that could make calves sick. The wash water should be 80°C and after washing in soap and water the nipples should be rinsed in a 10% bleach solution to disinfect them. Just like people, calves do not like to eat from dirty dishes!

Not too much, not too little – avoid underfeeding and overfeeding. Underfeeding leaves calves hungry so they eat too fast at the next meal and also prevents them from growing quickly. Overfeeding calves can cause scours or make them get too fat.

What Should I Feed My Calf?

Liquid Feeds

All calves should be fed colostrum for the first three days of their lives. After the first three days, you can feed sour colostrum, whole milk (fresh or acidified) or milk replacer. As calves get older, they can start eating dry feed.

Colostrum

Colostrum is the first milk that a cow gives after she has given birth to a calf. It is very important to feed the calf four litres (large breeds) or three litres (small breeds) within 30 minutes of birth, and another two litres within eight hours of birth.

Colostrum is very important for the calf in many ways:

- Immunity to diseases – calves are born without disease protection. Feeding a calf colostrum right away gives her immunity to diseases that will last until she is about 14 days old, when her own immune system starts to function. *(For more information on immunity provided by colostrum, see Health section of 4-H Dairy Resource Guide)*
- Cleans out the digestive tract
- Has three times more Vitamin D than normal milk
- Has 100 times more Vitamin A than normal milk
- Has a higher protein content to help calves start growing

The table below compares the contents of colostrum to normal milk:

Nutrient	Colostrum	Normal Milk
Protein (builds muscles)	14%	3%
Milk fat (energy)	6%	4%
Lactose (milk sugar)	3%	5%
Minerals	1%	.7%
Total Solids (% not water)	24%	13%

Make sure you feed good colostrum!

- Colostrum should look and have the consistency of melted vanilla ice cream.
- Runny, thin colostrum or those mixed with blood are bad.
- Quality can be tested using a colostrometer to test the immunoglobin levels.
- Bacterial counts can also be tested and should be less than 100,000cfu/mL (cfu refers to coliform forming units). Calves cannot absorb colostrum with high bacteria counts very well.
- Colostrum should not be pooled from several cows within the herd, because it increases the risk of spreading diseases.
- Storing colostrum
    - Colostrum can be refrigerated (1°C-2°C) without harm for up to seven days
    - It can be frozen in 2-litre double bagged freezer bags or plastic containers. It can be kept this way for up to one year. It is good to keep a supply of frozen colostrum so that if a cow gives birth and for some medical reason is unable to provide colostrum for her calf, frozen colostrum is available for it.
    - Colostrum should be thawed in a warm water bath (50°C). It may be microwaved on low for short time periods as well if it is closely watched and mixed.

Sour Colostrum

Sour colostrum is a healthy meal for your calves and saves a lot in feeding costs. Sour colostrum is colostrum that's been allowed to ferment (sour); but, that doesn't mean it's bad! Fermenting colostrum produces acid that keeps the milk from spoiling. Colostrum is fermented in a large garbage pail lined with a garbage bag and covered by a tight lid.

Making sour colostrum:

1. Clean a garbage pail thoroughly and line it with a clean garbage bag.
2. Obtain colostrum from the first six milkings of a cow. Do not use colostrum from cows with mastitis or those taking medicine. Especially on smaller farms, the simplest feeding system involves keeping a separate pail of sour colostrum for each cow.
3. Pour colostrum into the garbage pail and close the lid. Stir the colostrum each time you add more milk or remove milk to feed the calf.

4. To speed up souring, add one cup of fermented buttermilk to the colostrum. You can also store the garbage pail in a warm room, such as the milk house, for the first four days.

5. After five days, put the garbage pail in a cool place (5°C to 20°C). It takes 5 to 10 days for colostrum to sour. You can keep it for 30 days. After that, its nutrients start to break down and mold starts to grow…and it really smells!

Calves can be fed this sour colostrum for the first four to five weeks of life, and can then be weaned onto dry feed. Calves are fed diluted sour colostrum (three parts sour colostrum and two parts warm water).

Whole Milk

Whole milk is a great food source for growing calves; but, it is also the most expensive liquid to feed because it means that you will be unable to ship as much milk to the dairy and therefore will receive less money from milk sales on your milk cheque.

If you overfeed or suddenly change the amount or quality of whole milk that the calf is drinking, you can make it sick - so it is important to stick to a regular diet.

The temperature of the milk is also important. Feed calves at their body temperature (approximately 38.5°C) to reduce the stress on their bodies.

Milk Replacer

Milk replacer is a substitute for milk. It is often fed because it is cheaper than feeding milk as it does not require milk to be kept out of the bulk tank. When purchasing milk replacer, it is important to read the label, just like when you are grocery shopping. Buying cheaper products might save money in the short term, but weak, small, unhealthy calves will cost you money in the future. Remember that high-quality milk replacers contain:

- minimum of 20% crude protein (build's and repairs the calf's body)
- minimum of 15% crude fat (provides energy for growth and muscle movement)
- 0.3% crude fibre
- high quality milk products (buttermilk powder casein, dried whey, skim milk powder, milk albumin)
- the ability to mix easily with warm water and stay mixed until the calf drinks it

Poor quality milk replacers often contain the following:

- lower protein levels
- soybean flour (soy fed to young calves may cause allergic reactions in the digestive tract or diarrhea in young calves)
- cereal flour
- meat solubles

Calves have trouble digesting protein from plants until they are at least three weeks old.

It is also important to follow the instructions on the label.

Mixing milk replacer:

1. Read the instructions on the milk replacer container.
2. Measure the room temperature water and milk replacer powder you'll need for one feeding.
3. Sprinkle the powder on top of water.
4. Stir the mixture well with a wire whisk.
5. Make sure you keep the water at body temperature.

Methods of Feeding Milk to Calves

The following chart compares conventional feeding to nature's way of feeding calves:

	Nature's Way	Conventional Feeding
Percent of Body Weight Fed (%)	20-25	8-15
Litres (L)	8-10	4-6
Gain (kg/day)	1.0	0.2-0.5
Number of meals per day	7	2-3
Nursing minutes per day (min)	48	6-8
Interval between feedings per day (hours)	4	10-14

Source: OMAFRA Factsheet "Mimicking Nature's Way for Milk-Fed Dairy Calves" by Neil Anderson, 2007

Conventional Feeding

- These are some common ways of feeding calves on the dairy farm:
    - Feeding calves with a nipple and bottle or pail (this is the most common feeding method)
    - May involve a computerized calf feeder that allows calves to drink certain amounts of milk
    - Mob feeding limited amounts of milk to many calves at once
- Calves are fed on a regular schedule, usually two (sometimes three) times per day.
- Calves are fed a specific, measured amount. It is obvious from the above table that calves are not usually given as much to drink as they would drink naturally.
- Grain intake is higher in conventional feeding than in nature because of the limited milk intake.
- Feeding a calf from a nipple at a young age causes it to suck, which allows milk to pass into the abomasum through the esophageal groove. If milk goes into the wrong stomach, the calf gets gas and becomes bloated.
- Feeding a calf from a bottle is like feeding a human baby from a bottle.
- If you use a pail to feed the calf, remember that she probably is not getting as much milk into her abomasum where more of the nutrients can be absorbed by her body.
- If you use a pail, make sure the calf doesn't gulp the milk. To teach the calf to drink from a pail, let her suck your fingers on top of the milk in the pail until she learns to drink properly

Nature's Way of Feeding

- In nature, calves will drink until they are full, suckling several times throughout the day
- On modern dairy farms, natural feeding is not practical, as it reduces milk produced for human consumption, and suckling can cause the calf to injure the cow's teats or infect her with germs

Imitating Nature's Way of Feeding

- Free access systems allow calves to drink freely in a similar manner to nursing

Acidified Milk

- Acidified milk has been fed in Finland since 1996, with farmers there reporting that it is inexpensive, enables them to use excess colostrum, requires minimal labour, and results in healthy calves with few bouts of diarrhea who do not often suck on other calves. Since 2005, some farms in Ontario have been feeding acidified milk to calves, and the number of farmers utilizing this method continues to increase.

What is it?

- Acidified milk is whole milk that has diluted acid added to it.
- Formic acid is the most common acid used for acidification. 1 part 85% formic acid is added to 9 parts water to dilute the acid. For example, use 1 litre of formic acid to mix with 9 litres of water. Some retail outlets sell formic acid that is already diluted.
- The diluted acid is then mixed with cold colostrum (5 °C or less), whole milk or milk replacer. It takes 40-45mL of diluted acid for every 1litre of colostrum or 30mL of acid for every 1 litre of milk or milk replacer. The pH of the mixture should be 4.0-4.5.
- The mixture should be stirred when combining the liquids, again within an hour of mixing and three times per day after that. The mixer can be a simple as a paint stir stick attached to a cordless drill.
- The low pH preserves the milk, inhibiting the growth of mold and bacteria, and allows the milk to be stored at room temperature for several days.

Feeding Acidified Milk

- Milk should be fed at ambient temperature in the summer, and 20°C in the winter. In Canada, it is challenging in cold calf housing environments to keep the acidified milk warm enough. Some farmers have experimented with using fish aquarium heaters or other methods to keep the milk warm.
- Store the milk in closed containers for one to three days before feeding to allow the acid contact time to kill bacteria; do not let flies or cats into the milk
- Clean nipples, valve lines and containers with warm water and dish detergent.
- Provide free choice water and calf starter as well.
- Mount nipples 24-28 inches above the floor level for calves.

Penning

- Calves can be housed individually, allowing them to suckle without interference from other calves; individual housing helps to prevent the spread of diseases.
- When housed in groups, it is important to have several nipples available so that all calves can drink adequately throughout the day.
- Group sizes should be limited to not more than eight calves.

Costs

- Free choice acidified milk has higher costs compared to conventionally feeding milk or milk replacer because more is fed.
- Cost of the acid
- The cost may be offset by better health and lowered veterinary and medicinal costs as well as less time spent caring for sick calves

Weaning

- Gradual weaning can be done by diluting the milk with more and more water over a one week period

Dry Feeds

You can give calves dry grain a few days after they're born. They won't eat much of it for about a week, but it's still important to start calves on dry feed early. Why? Calves are ruminant animals without a working rumen! To get the rumen working, you must feed a calf dry feed so that her body "learns" to digest it.

Calves eating dry feed grow faster and have fewer health problems related to liquid feeding, such as scours.

Calf Starter

Calf starter is dry grain formulated to meet the energy needs of calves.

Calf starter should be:
- palatable (tastes good and is easy to eat)
- coarse (cracked, rolled, pelleted, not finely ground)
- 18% to 20% crude protein (CP)
- 72% to 74% total digestible nutrients (TDN). TDN is another word for the energy in feed.

Hay

Hay is also important to a calf's diet, once she is 2-3 months old. She should be fed long, soft, dry hay starting about one week before she is weaned. Hay helps the calf's stomach grow and gives her extra energy.

Weaning

Weaning is when you stop giving your calf milk and switch her entirely over to water and dry feeds.

Your calf should be eating 1.0 kg per day of dry calf starter for several days before she is weaned, and should already be eating hay.

Calves should be weaned before they are eight weeks old to save money. Most savings result from reduced labour, as it takes less time to feed calf starter than it does liquid feed and it takes less time to clean out calf housing. Calves eating a liquid (milk-based) diet have looser manure and are more likely to suffer from calf scours.

Calves left on milk a long time (i.e. more than three months) can also get very fat. This can result in health problems and decreased milk production later in life.

Feeding Heifers and Dry Cows

These groups of animals need healthy, nutritious diets made especially for them. Heifers need to grow, but not get too fat. Older heifers also need feed to help support the fetuses growing inside their bodies.

Heifers must gain 0.6kg (small breeds) to 0.75kg (large breeds) a day to ensure that they are large enough and ready to breed at 14 to 15 months of age in order to calve at 23 to 24 months of age.

Heifers move through four feeding stages:

Post-Weaning Stage (2 to 6 months old)
- Feed a palatable calf starter and good quality hay
- At three or four months of age, heifers can be switched from calf starter to grains

Heifer Stage (6 to 12 months old)
- 6-9 months
  - At least half of the total roughage dry matter (DM) should be from dry hay. The rest can be from haylage, corn silage, total mixed ration or pasture.
- 9-12 months
  - Balance the ration by varying the amount and type of grain according to the nutrients supplied by the forage being fed
- Balance the ration for minerals and vitamins using a pre-mix that is top-dressed on forages or added to grains. This is a lot like eating sugar on your cereal – it tastes good and gives you more energy!

Breeding Stage (12 to 18 months)
- This is a key feeding time because heifers must be healthy and have proper diets to improve their reproductive success
- Feed a balanced ration, with mineral and vitamin pre-mixes, just like younger heifers
- Breeding weights, achieved partly by proper nutrition, range from 366kg for large breeds

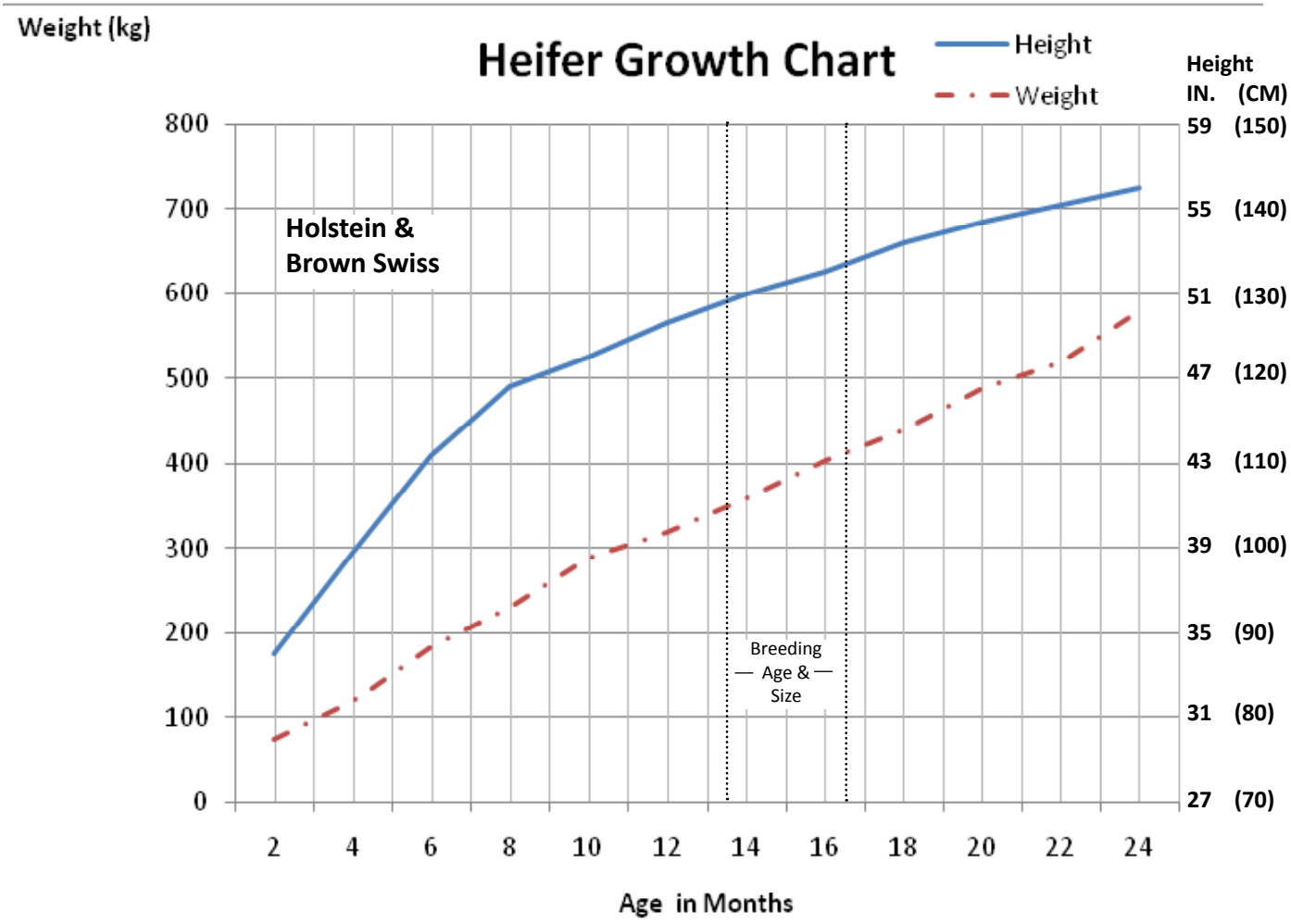
to 268kg for small breeds. If heifers aren't large enough to breed at 14 to 15 months of age, you need to figure out what is going wrong with your feeding program or other heifer raising conditions

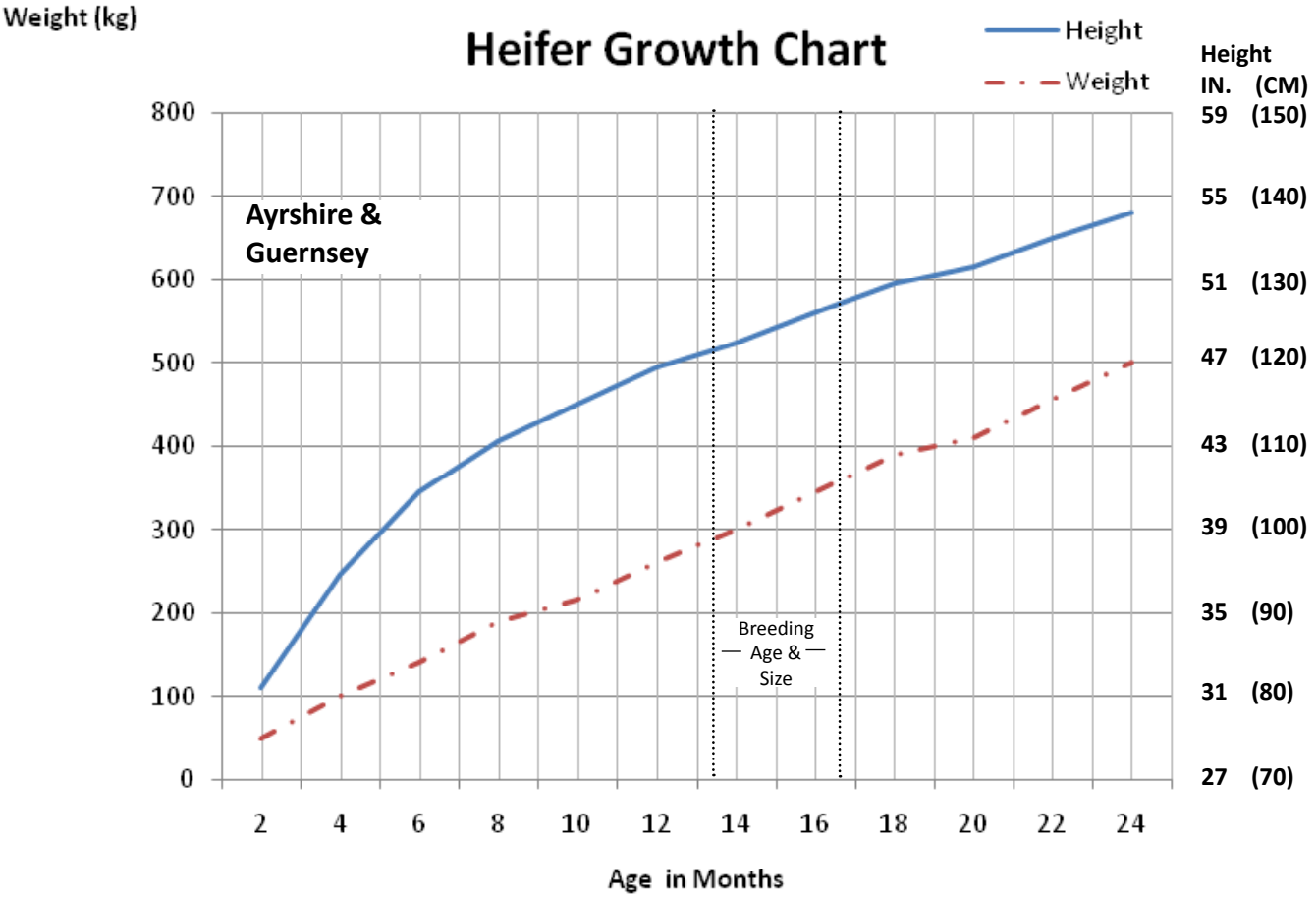
Bred Heifer Stage (18 to 24 months or until close to calving)

- Feed to prevent cows from getting fat but still keep them growing. Fat cows have problems calving and will milk less.
- Don't feed too much high energy forage such as corn silage (as it will make them fat).
- Maintain a balanced ration of roughages, grains and minerals
- Two to three weeks before calving, switch to a close up dry cow diet

Charting Heifer Growth

One of the best ways to tell if your feeding program is working is to measure your heifers' heights and weights. The following growth charts plot good, typical growth patterns for heifers of different breeds. Use these charts to measure heifers in your herd to see how they compare to this pattern. If your heifers aren't on track, evaluate your feeding and management program.




Weight (kg)
Heifer Growth Chart
Height
Weight
Height
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59 (150)
55 (140)
51 (130)
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43 (110)
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Ayrshire &
Guernsey
Breeding
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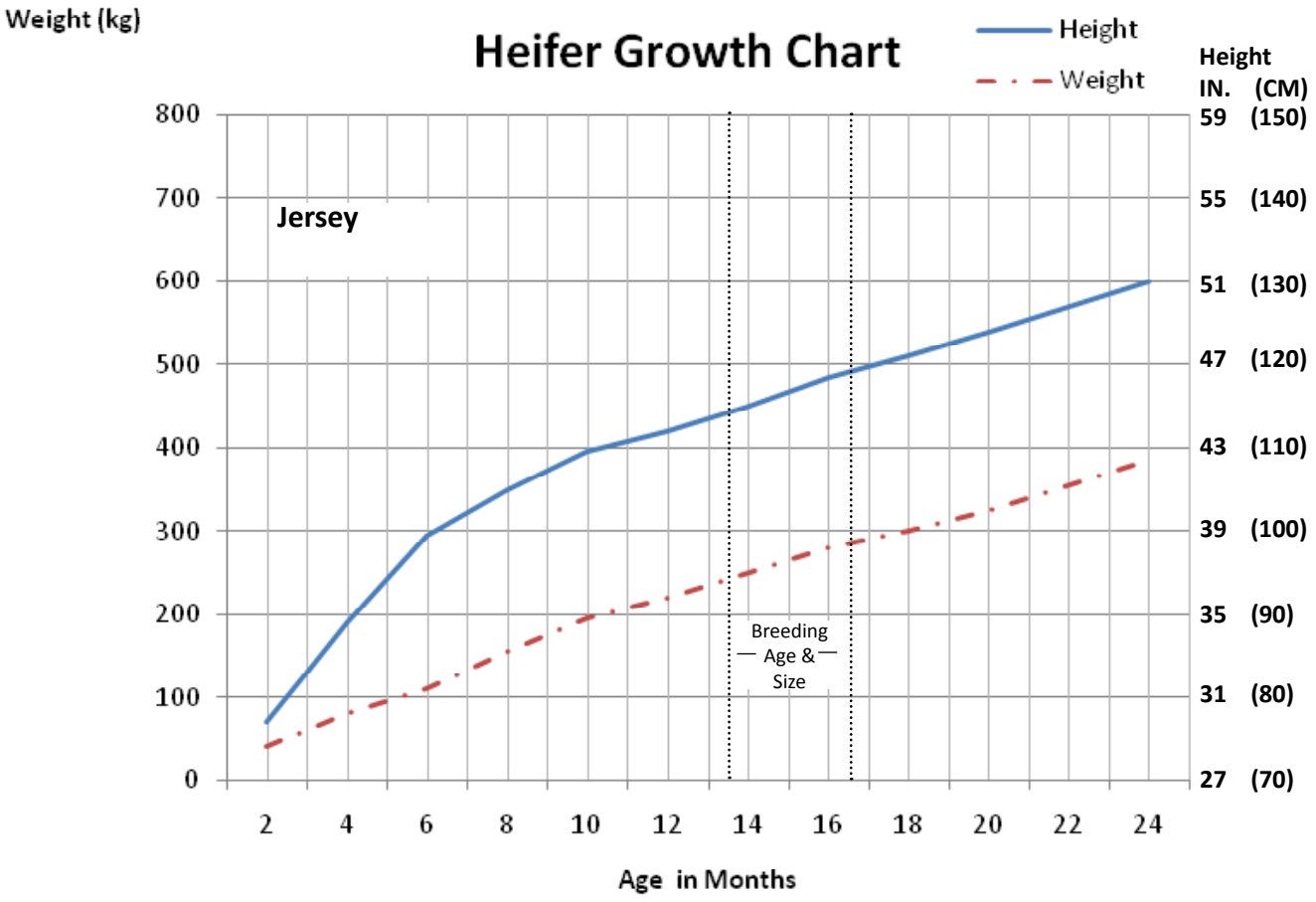
2 4 6 8 10 12 14 16 18 20 22 24
Age in Months


Weight (kg)
Heifer Growth Chart
Height
Weight
Height
IN. (CM)
59 (150)
55 (140)
51 (130)
47 (120)
43 (110)
39 (100)
35 (90)
31 (80)
27 (70)
800
700
600
500
400
300
200
100
0
Jersey
Breeding
Age &
Size
2 4 6 8 10 12 14 16 18 20 22 24
Age in Months

Feeding Dry Cows

Dry cows need to be fed in stages, just like heifers do! As a dry cow gets closer to calving, her diet changes because her body is getting ready to give birth. Dry cows are usually split into two groups, far-off dry cows and close-up dry cows. Diets for dry cows were traditionally based on a 60-day dry period, but today, many farmers are increasing productive life by managing cows with the 45 day dry periods. The feeding schedule below is based on a 60-day dry period. Cows within a short 45 day dry period are fed slightly less forages and more grain.

Far-off Dry Period – Dry cows who are still several weeks away from calving

> You need to keep these cows on a diet that is very high in forages. In fact, 85% to 100% of her feed intake should be forages. Each day, dry cows eat about 2% of their body weight in dry matter feed.

Close-up Dry Period – Dry cows who are two to four weeks from calving

> Close-up dry cows eat less than far-off dry cows, so they need to be fed differently. You need to put more nutrients in the ration because they eat less volume of feed. You also need to start lead feeding dry cows.
>
> *Lead-feeding* refers to gradually increasing the amount of grain a dry cow eats during the two weeks prior to calving. After calving, cows need more energy to produce milk, which means that she needs to eat more grains. Lead-feeding prepares the cow's stomach for a high grain diet.

Pre-Calving Cows

Cows that are near calving require special attention. What they eat will directly affect their health, their calving and the amount of milk they'll give during their lactation. A poor diet can result in milk fever, ketosis or other disorders.

To help prevent milk fever, the standard practice for feeding pre-calving cows is to LIMIT the amount of calcium in their diets. Limiting calcium may sound strange, but by reducing the calcium level in a cow's feed, her body learns to absorb calcium from her bones and digestive tract when there is a shortage in her bloodstream. That way, her body will know how to deal with the sudden need for calcium at calving.

More and more, dairy farmers are trying to balance dietary cation-anion difference (DCAD) in pre-calving rations to prevent milk fever.

Digging Deeper: Dietary Cation-Anion Difference (DCAD)

DCAD is a complicated term referring to how different molecules in the cow's body and her feed react together. A ration with a negative DCAD can create the same effect as reducing dietary calcium.

Feeding a negative DCAD ration is like giving a cow heartburn on purpose. The cow's body doesn't like heartburn, so she needs to take an antacid, kind of like you taking a Tums or Rolaids. Since there is no pill for the cow to take, she uses the calcium from her own bones. Therefore, the cow's body learns to absorb calcium from her internal resources when it has a shortage.

> The principles behind DCAD involve a little bit of chemistry:
>
> - Cations, such as sodium (Na^+) and potassium (K^+), carry positive charges and increase blood pH.
> - Anions, such as chlorine (Cl^-) and Sulfur(S^{2-}), carry negative charges and lower blood pH. A low blood pH means that the cow's blood is more acidic.

- When the difference between cations and anions is negative (i.e. more anions than cations), the blood pH is lowered and it becomes acidic. To neutralize the lower pH, the cow uses calcium from her bones.

Feeding a ration with negative DCAD must be done carefully. The following tips are useful when feeding these rations:

- Test your ration often to make sure the right amount of anionic salts is added.
- Use combinations of two to four anionic salts to reduce taste problems.
- Feed anionic salts in a total-mixed-ration so cows won't avoid eating the salts.
- Feed negative DCAD rations at least 14 days before calving.
- Don't give DCAD rations to milking cows.
- Most importantly - consult a nutritionist before feeding a DCAD ration. He or she can give you the exact ration requirements for this feeding program.

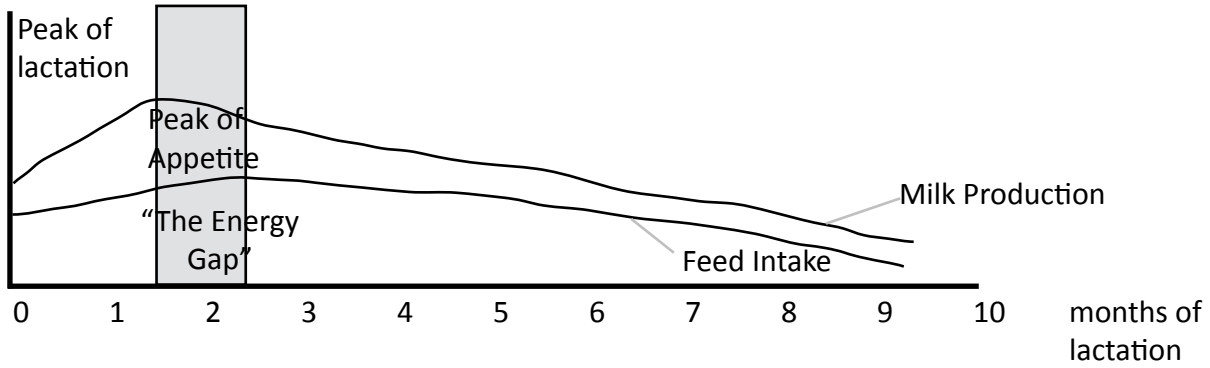
Feeding Milk Cows

The most important thing about feeding milk cows is to make sure each cow is fed a *balanced ration*. A balanced ration contains all the nutrients a cow needs for her health and helps her meet her milking potential. Great cows can be so-so milkers if they are not fed properly.

A balanced ration needs:

- Energy
- Protein
- Vitamins
- Minerals
- Water

The trick when feeding a balanced ration is to feed the cows the right amount of the different feeds to get the proper amounts of the required nutrients. This balancing act is very important to the cow's health and milk production.



The energy required for milk production often exceeds a cow's feed intake throughout her lactation, as seen in the diagram. Balanced rations are required to reduce or eliminate this potential energy gap. The amount that a cow wants to and is able to eat is limiting factors that affect feed intake. This could result in less milk production than the cow is genetically capable of and/or weight loss as the cow utilizes her body's fat reserves as energy for milk production. Proper diets limit the amount of weight loss, since thin cows are more difficult to breed and milk production is compromised. At the end of a cow's lactation, when she is not giving as much milk, her feed intake energy may often surpass the energy required for milk production. But by that time, her body is usually using energy to prepare itself for calving again.

Components of a Balanced Ration

Energy = Total Digestible Nutrients (TDN)

A cow's diet needs 75% TDN

Energy

Cows need energy for:

- Growth
- Milk production
- Reproduction
- Muscle movement

Cows get energy from two sources: **carbohydrates and fats.**

Carbohydrates are found in grains and forages such as corn and hay. The carbohydrates found in grain are sugars and starches, which are easy to digest. Easy digestion means they have a high feeding value. Carbohydrates found in forages are harder to digest. In forages, carbohydrates are part of the plant's fibre, called cellulose. Cows need this 'hard to digest' fibre to keep their stomachs working. Think of plant fibre as 'weights' that a cow uses to keep her stomach in shape. Feeds containing cellulose have a lower digestibility, but cows are able to digest them with the help of their rumen microorganisms.

Fats give cows lots of energy in a small bite. The energy is much more concentrated than in carbohydrates, so fats are found in small doses in many feeds, including grain. Fat can be added to a cow's ration as well. The most common way to add fat is by feeding soybeans.

Protein

Protein is important for a cow's growth. Protein is broken down into amino acids during digestion. The amino acids are absorbed in the intestine and are carried through the bloodstream to build and repair several body parts:

- Organs
- Hair
- Bones
- Milk protein
- Skin
- Hooves
- Blood

Protein in a balanced diet is called Crude Protein (CP). Milk cows need 15-19% CP.

Protein can be found in all feeds, including grain and forages. Alfalfa, hay and haylage are high in protein. So are oil seeds such as soybeans and canola. Some cows also get added protein, called supplements. These supplements are usually by-products from the processing of oil seeds. For example, soybean meal, a protein supplement, is left over after soybeans are crushed to make margarine for people.

Bypass proteins can also be fed as an additional protein source. Such proteins are called "bypass" proteins because they are resistant to rumen bacterial breakdown so they are digested in the intestines, not the rumen. Production benefits are seen by feeding bypass proteins to high producing animals. The greatest benefits are seen when cows are on a high silage diet because fermentation transfers protein to more soluble forms which will be used by rumen bacteria rather than the cow directly. Bypass proteins make more protein readily available to the cow. Excellent sources of bypass proteins include:

- dried corn gluten feed
- dried distillers grains
- dried brewers grains
- corn gluten meal
- fish meal

Feeding too much protein causes the nitrogen component to be excreted in the urine. It is important to balance the animal's ration to prevent wasting money on excess protein -it is also more environmentally friendly.

Vitamins

Vitamins are nutrients that are only needed in small amounts, but they are still very important. They can either be fat or water soluble.

Vitamin	What it does	Where it's found in feed
Fat Soluble		
Vitamin A	Helps with normal night vision, cell and bone growth	Carotene
Vitamin D	Strong bones and teeth	Cow can make her own when exposed to sunlight
Vitamin E	Muscle tone and development	Vitamins are usually added to feed in a vitamin and mineral premix (commercial supplement)
Vitamin K	Helps with blood clotting	
Water Soluble		
Vitamin B	Needed to change feed into energy, important for blood	
Vitamin C	Strengthens bones and teeth	

Minerals

Minerals are a very small part of a cow's diet - but without them, cattle can get sick. Minerals are divided into two groups: major and trace. Cows need major (macro) minerals in larger amounts than trace (micro) minerals.

Mineral	Needed for…
Major (Macro)	
Calcium	Bones, milk production, muscles
Phosphorus	Bones, milk production, digestion
Potassium	Nerves
Sodium	Digestion, use of nutrients
Chlorine	Digestion, use of nutrients
Sulphur	Digestion
Trace (Micro)	
Selenium	Tissue repair, healthy calves
Cobalt	Digestion, use of Vitamin B_{12}
Iron	Red blood cells
Copper	Blood, body tissue
Zinc	Hooves, skin, growth
Molybdenum	Energy use, growth, iron use
Manganese	Growth, bones, reproduction, nervous system
Iodine	Metabolism (rate food is used in the body as energy)

Did you know?

Salt is made up of sodium and chlorine, two major minerals needed by cows.

A milking cow needs 30-100g of salt each day, depending on how much milk she produces.

Did you know?

For a milking cow, the ratio of calcium to phosphorus should be 1.8-2.1:1. For a dry cow, this ratio should be 1:1.

Water

Cows need lots of water! In fact, this is the most important nutrient that her body needs. A cow's body is 70% water. A cow needs to drink five litres of water to produce one litre of milk. Cows need water to:

- cool their bodies
- digest food
- get rid of body wastes
- maintain body fluids

A cow should have free access to water. That way, she'll get enough to drink each day.

There are several factors that influence the amount of water a cow drinks each day:

- Air temperature
- Humidity
- Wind speed
- Feed temperature
- Growth rate
- Amount of water in feed
- Salt in feed
- Size of animal
- Feed intake
- Milk production

Ingredients of a Balanced Ration

The nutrients that are required by a cow can be found in the following feeds:

Forages (roughages)– cows eat forages because their four-chambered stomachs can break down the hard to digest fibre in forages. Cows get energy from this fibre. The feed value of roughages depends on:

- the plant
- how good the soil is
- how well the crop is fertilized
- how long it grows before harvesting (younger, more immature plants yield higher feed values and are more palatable)
- how it's harvested
- how it's stored

You can find out the feed value of roughages by taking samples and sending them away for a feed analysis, performed in a laboratory.

There are a few types of forages, including hay, haylage, and corn silage:

Hay –a very common forage, made from legumes such as alfalfa, and grasses such as timothy. Hay is cut in the summer and dried in the sun, then stored after it is baled. It is best to store dry hay inside to prevent it from getting wet and moldy.

Haylage –made from hay cut early in the season and then wrapped, bagged or stored in a silo. Haylage should be green and smell like clean, sharp vinegar. Haylage has about the same energy as hay, but it is wet. This means that the leaves stay on the stem of the plant. Because most of the nutrients found in hay are in the leaves, haylage has more nutrients than hay.

Corn silage –made by chopping the cob, leaves and stalks of corn plants. The chopped corn is put in a silo or a bag to ferment, resulting in corn silage. Corn silage has high energy and low protein.

Concentrates – provide a "concentrated" source of energy. Concentrates are the sweet tasting part of a cow's diet, so you have to make sure you don't let cows 'pig out' on concentrates. Concentrates are a mix of grains and other products. Examples of concentrates are:

- grains such as corn, oats and barley
- distillery and brewing by-products
- oilseed meals, such as soybean, linseed and canola meal
- whole seeds, such as soybean and cotton seed
- Non-protein nitrogen (NPN), such as feed-grade urea and anhydrous ammonia

Farmers can buy concentrates that are already mixed with vitamins and minerals or can make their own concentrates and purchase a mineral mix to add.

Grains are rolled, ground or cracked to make them easier to digest. Whole grains are harder for the cows to digest.

Protein supplements – high protein oil seeds such as soybeans and canola or by-products like soybean meal, distiller's grain and brewer's grains. These add a concentrated source of protein to the ration.

Mineral and vitamin supplements –add extra salt minerals and vitamins to the ration. Most of these nutrients come from other feeds in the ration, but the supplements boost the level a bit higher.

Ration Recipe

To create a balanced ration, you need a recipe. To get the right recipe, you need to:

- know the weights of your cows
- know the stage of lactation and current production levels of your cows
- know the percentage of two year olds in your milking herd
- weigh the feeds that the cows eat already
- aim for a ration with lots of forage
- feed the cow's stomach – microorganisms in the cow's rumen need to be fed for healthy digestion
- use concentrated sources of protein, such as roasted beans, soymeal, and corn gluten meal
- ask a nutrition expert to help you create the right ration recipe for your cows

Digging Deeper Recipe Testing

Feeding the right ration is impossible if you don't know what kind of nutrients are in a cow's feeds. To find out, you must have the feed tested. Feed tests let you turn hay, soybeans, grain, and other feeds into a great ration.

Listed below are the actual ingredients of a sample balanced ration. The ration is balanced for a cow that milks 40kg a day. The amount of energy, protein and vitamins in the example ration are listed below the actual ingredients.

Alfalfa hay	6.1kg
Corn silage	9.1kg
High-moisture corn	8.2kg
Soybean meal	2.5kg
Soy mill feed	2.3kg
Distiller's grain	1.4kg
Dry fat	0.2kg
Minerals, vitamins, additives	0.2kg

Balanced ration for those ingredients:

Protein

Crude protein (CP)	17%
Degradable Intake Protein	60% of CP
Undegradable Intake Protein	40% of CP

Energy

Net Energy	1.72Mcal/kg
Total Digestible Nutrients	75%
Fibre	
Crude fibre	15%
Acid detergent fibre	19%
Neutral detergent fibre	25%

Minerals

All major and trace minerals

Vitamins

Vitamin A	3200 IU/kg
Vitamin D	1000 IU/kg
Vitamin E	15 IU/kg

Methods of Feeding

Total Mixed Rations (TMR) vs. Traditional Feeding Programs

Traditionally, farmers have fed forages and concentrates separately, usually adding top dress for energy, protein, and vitamins. But, TMRs are rations that include all feeds mixed together. Think of it as a stir-fry for cows. All the ingredients are mixed together and contain all the minerals, carbohydrates, fat, protein and vitamins a cow needs to stay healthy and milk well.

The chart below compares the two methods of feeding.

	Traditional Feeding	TMR
Description	• Feed forage, concentrates and top dress separately	• Blend all of the ration ingredients and feed one mixture
Equipment Requirements	• Feed storage facilities (i.e. silos, hay mow, grain bins) • Way to get feed to cattle (i.e. feed carts, computer system, pickup trucks, etc.) • Scales	• Feed storage facilities (i.e. silos, hay mow, grain bins) • Room for mixing TMR that is attached to feed storage facilities • Storage for bags of minerals, vitamins, etc. • Mixer and scales • Feed delivery system
Labour Requirements	• Getting feed from storage facility to cattle	• Weighing and mixing feed daily • Moisture-testing ingredients weekly • Getting the TMR from the mixer to the cattle
Feed Program Benefits	• Easier to implement • Fewer expenses • Can give individual attention to cows • Feed mistakes affect few cows • Expensive feeds aren't wasted on cows that don't need them	• Cows can't pick over what they don't like • Can increase production 10%-20% • Less labour • Reduced feed waste • Know average amount and costs of feed for each cow
Feed Program Disadvantages	• Cows can avoid what they don't like (i.e. minerals) and therefore not get a balanced ration • Labour intensive (delivering each foodstuff separately)	• Expensive to start due to equipment costs • Continually changing ration to account for moisture changes • Mistakes are serious because they affect all cows • May have to redesign facilities to accommodate a TMR system

Feeding to Alter Milk Composition

What you feed a cow not only changes how much milk she gives, but also its composition! It's important to know how feeding changes milk composition because of the way dairy farmers are paid for their milk. Multiple component pricing pays producers according to the components in their milk, such as butterfat and protein. Improving components within defined solids-not fat ratio caps can add money to your milk cheque each month.

In order to change the cow's milk composition by feeding a proper ration, it must be balanced to do so. Otherwise, you could end up with a sick cow instead of a bigger milk cheque. The table below shows how feeding affects production:

+=positive effect;
-=negative effect;
0=neutral;
?=unclear

	Milk Yield (kg)	Percent Protein	Percent Fat
Greater dry matter intake	++	0?	0?
More forages, less grain	-	-	+
Less forage, more grain	+	+	-
More corn silage, less haylage	+	+	-?
More fermentable NSC	+	+	-
More ADF/NDF	-	-	+
More added fat	+	-	+?
Higher crude protein	+	+	0
More undegradable protein	+	+	0
More limiting amino acids	+	+	0
Feed TMR	+	0	+
Feed grain more often	+	+	+
Use high-moisture corn	+	+	-?
Grind/roll corn finer	+	+	-?
Steam-flake grain	+	+	-?

Source: Adapted from Hutjens and Shanks, 1993

Tips for Getting the Cows to 'Clear their Plates'!

Increasing how much dry feed cows eat is a major goal of dairy feeding programs. This leads to better milk production. To get your cows to 'clear their plates' follow these tips:

- Let cows have access to food 24 hours a day and have fresh feed in bunks or mangers after milking. Cows are hungry and thirsty after they are milked. As well, feed several meals a day instead of just one or two big meals.
- Make sure they have fresh, clean water all the time. Cows that drink more eat more dry matter.
- Adapt your feeding times to the likes of your cows. Feed them when they want to eat, not when you want to feed them.
- Clean mangers and bunks daily - cows are picky eaters! The leftovers are probably there because the cows don't want to eat them. The smell of rotting, stale feed in a manger spoils a cow's appetite for the fresh feed on top.
- Sweep feed up to tied cows frequently or create activity around a feed bunk. Curious cows will take a bite.
- Keep cows healthy and comfortable - then they'll eat more.
- Feed a TMR (total mixed ration). It includes all the parts of a balanced ration blended together instead of fed separately.
- Design feed bunks with cows in mind
    - Cows eat less at head-to-head feeders because of social interactions. Keep head-to-head feeders at least 3 m apart.
    - Give each cow at least 60 cm of bunk space to eat from
    - Eating in the heads down, grazing position increases saliva and the amount eaten. Mangers should be 10 cm above hoof level.
    - Smooth mangers are better because stale feed gets caught in rough surfaces.
    - Cows fear light and dark patterns because they have trouble perceiving depth. Try using light coloured tile or liners in feeders.
- Make it easy for cows to get to and from feed. Have wide passages and non-slip floors for them to walk on.

VO-COW-BULARY – A Glossary of Ration Recipe Terms

Acid Detergent Fibre (ADF)	ADF is the least digestible part of the plant fibre and is one type of carbohydrate. Forages contain a lot of ADF. ADF predicts the amount of energy in feed – the more ADF, the less energy. Cows need a ration of at least 19% ADF for proper digestion.
Amino Acids	The building blocks or smaller pieces that make up feed protein. The protein in different types of feed is made up of different amino acids. Having the right balance of these acids benefits both the rumen bugs and the cow. This balance makes the protein provided by the feed more useful.
Bypass Proteins	Proteins that resist breakdown by rumen bacteria and are digested in the intestines.
Crude Protein (CP)	Repairs and builds organs, skin, hair, hooves, bones, blood and milk protein. Milking cows need 15-19% CP in their diets.
Degradable Intake Protein (DIP) (also called Soluble Protein)	Comes from legumes and some protein supplements. Rumen bugs eat this type of protein very quickly.
Digestible Neutral Detergent Fibre (DNDF)	The portion of NDF digested at specific levels of feed intake. It is a percentage of the NDF.
Dry Matter Intake (DMI)	The amount of dry matter (DM) in the ration if the water was removed from it. The first 6kg of DM a cow eats keeps her alive. For every extra kg after that, the cow produces an extra 2.5kg of milk.
Effective Fibre	You can feed the proper amount of ADF and NDF, but if the forage is ground too finely, the cow won't take in the proper amount. Cows don't chew finely chopped forages enough for proper digestion. That results in sick cows. For the best fibre intake, forages must be coarse.
Neutral Detergent Fibre (NDF)	NDF is most of the plant fibre and represents the bulkiness of the feed. Cows need about 28% NDF for proper rumen function.
Non-fibre Carbohydrate	Nonfibre carbohydrates, such as sugars and starches, are easy to digest. This means they're a good source of energy. Grains are high in non-fibre carbohydrates.
Total Digestible Nutrients (TDN)	Refers to the amount of energy available for the cow in her feed.
Undegradable Intake Protein (UIP) (also called bypass protein)	Comes from foods such as roasted soybeans. Rumen bugs cannot eat this type of protein. It bypasses the rumen and is digested in the other parts of the cow's stomach or her small intestine.
Vitamins and Minerals	Cows need vitamins and minerals in small amounts. That's why some of them are measured in parts per million. But, these small amounts of vitamins and minerals keep cows healthy.

References and Resources - Nutrition

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Anderson, N. “When they get enough feed they’re healthier and need fewer drugs” OMAFRA Facts. www.omafra.gov.on.ca/english/livestock/dairy/facts/headstart.htm. July 2001. Accessed January 19, 2008.

Ontario Veal Association. “ Colostrum Management – Off to a healthy start naturally!” www.calfcare.ca, 2007.

Related Activities (See Activity Guide)

Ruminant vs. Monogastric Animals	Nutrition	All ages
Digestion Game	Nutrition	All ages
Showcase on Stomachs	Nutrition	All ages
Build a Ruminant Digestive System	Nutrition	All ages
Digestion - a Chemical Reaction	Nutrition	Junior members
Ruminant Diseases	Nutrition	All ages
Feeding the Calves	Nutrition	All ages
Reading the Label	Nutrition	All ages
Decisions, Decisions	Nutrition	Senior members
Ingredient Classification Game	Nutrition	All ages
Snatch the Feed	Nutrition	All ages
Name the Feed Relay	Nutrition	All ages
Matching Feeds Game	Nutrition	All ages
Bringing Home Dinner	Nutrition	All ages
Match the Nutrients Game	Nutrition	All ages
Different Rations	Nutrition	All ages
Feeding Program Pros & Cons	Nutrition	All ages
Designing a Feeding Program	Nutrition	All ages / Senior members
Feeding a TMR	Nutrition	All ages
Judging a Balanced Ration	Nutrition	All ages
The Judge’s Seat - Feedstuffs	Nutrition	All ages
Nutrition Crossword	Nutrition	All ages