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Rumen

This is the first and biggest stomach. There are 5,000 trillion microbes in the rumen of a mature cattle beast.

In an healthy rumen, its' bugs transform much of the non-protein nitrogen (like nitrate, urea, etc) into their own real proteins, which are then digested by the cow in the lower tract as if those proteins had been consumed intact as real protein. It's a very nice system, and it allows us to use many forms of nitrogen in feeds, not just true protein.

If the rumen pH goes below 6.5 or above 7 problems can occur.

Cows fed on grain can have a rumen pH between 5 and 6 but should it fall below 5 there are serious consequences.

They should chew each cud about 30 times and then swallow it and there should be two cuds (regurgitations of rumenal contents) each minute.

The rumen pH with good pasture is 7 which is optimum. Cows fed on grain can have a rumen pH below 6.

Bad hooves can be from digestion problems.

Ruminants can use many forms of nitrogen quite effectively, they do not require just pure protein. In an healthy rumen, the rumen bugs transform much of the non-protein nitrogen (like nitrate, urea, etc) into their own real proteins, which are then digested by the cow in the lower tract as if those proteins had been consumed intact as real protein. It's a very nice system, and it allows us to use many forms of nitrogen in feeds, not just true protein.

The rumen is what differentiates ruminants (cattle, sheep, deer and goats) from single stomached animals like humans, horses and pigs. It is the first compartment of a ruminantÕs stomach. It develops after calves are given solid feeds such as pasture, hay, silage and grain, although grain has the lowest effect.

Billions of microorganisms, principally bacteria, fungi and protozoa grow and multiply, producing enzymes for digestion of feed particles and for synthesis of by-products which become nutrients for the ruminant.

Rumen capacity is up to 200 litres and its wall has finger-like projections which increase the surface area for absorption of nutrients into the blood stream.

In a well balanced rumen the contents move and mix every half minute and you can see the rumen (top left side of a ruminant) flex as this happens. The average cow ruminates for 12 hours a day. The eating system of a ruminant is to graze quickly and to

swallow the food with a certain amount of saliva, drink some water, and then regurgitate a cud, chew (grind) it between powerful molars, and in incorporate more saliva. After grazing at least half the cows in a herd should be chewing their cuds.

Rumen microbes need food in the form of pasture, silage, hay, crops, grain, etc., to provide energy (soluble carbohydrates) and degradable protein. They turn fibre into energy. They also benefit from certain balanced minerals to multiply and perform. A good soluble mineral mix which is best provided in the drinking water. The better the rumen and its microbes perform, the more protein that will pass into the gut for absorption. If the microbes donÕt obtain enough energy, then they canÕt use the soluble and degradable protein to perform. The rumen microbes derive most of their energy from carbohydrates, which come in two main forms, of fibre and sugars. The microbes are unable to derive energy from f

at or from the volatile fatty acids in silage.

More carbohydrates are needed than protein, but cows milk well on very high protein pastures. In the Northern Hemisphere where confined feeding allows controlled levels of all items, recommended crude protein percentages have crept up from 14% in the 1950s to 16 in the 1980s to 18% in the 1990s. Good clover-rich fast growing spring and autumn pastures in New Zealand have about 25%. Protein in the

Northern Hemisphere is expensive so the percentage aimed for in mixes will possibly be lower than if it were cheap. In New Zealand when the protein is too high and carbohydrates too low, the microbes use the extra protein and the animalÕs body reserves to digest the excessive amounts of protein. Also ammonia is given off which turns into urea and is excreted in the urine sometimes burning the grass. Excess potassium in pastures or feeds can do the s

ame.

Once the food has been thoroughly regurgitated, chewed and reduced to a smaller size, it moves on to the next stomach.

BF and silage which has been cut too fine, can move on to the second stomach before being thoroughly chewed and mixed with saliva. To prevent this, many farmers in the northern hemisphere, where substantial amounts of BF are fed, mix everything together, to ensure that it is all regurgitated and masticated thoroughly. Feeding too much BF, and silage which had been cut too finely, caused digestive problems in dairy cows, and it was many years before they discovered the cause which was silage cut too short (10 to 30 mm rather than 70 mm and longer), and too much BF fed at one time.

In North America and countries where silage was chopped very fine to allow easy blowing into silos and to give better compaction, cow digestion problems occurred to the extent of displaced abomassums and even d

eaths within a day or so. Mixing the offending short chopped silage with hay as in total mixed rations (TMR) helps reduce these problems and gives better digestion and increased production. However, if the silage had been longer and the BF fed several times a day, the increased production obtained in TMR trials may have not occured.

It has been found that rumen bacteria vary between animals in the same herd and it is known that young stock need to be alternated with older ones to pick up rumen bacteria, but this is not always done (in calf hutches it canÕt occur) resulting in slow growth on pasture, casuing farmers to keep feeding milk and/or BF for months and months instead of weaning successfully onto good legume pastures at seven to nine weeks. Weaning at these ages canÕt be done onto grass only pastures.

Unfortunately there is very little understanding of the total operation of the rumen simply because it is seldom written about.

One trial years ago

showed that taking the rumen bacteria from goats and inserting it in cattle improved their digestion of fibre. IÕve not read more about it. It is known that all grazing stock do better when mixed. One reason could be the natural transfer of rumen bacteria between them. One reason is certainly reduced internal parasite infestation.

Rumination

Re-chewing or cud-chewing of the feedstuffs is characteristic of ruminants. Rumination involves regurgitation of ingesta from the reticulo-rumen, swallowing of the regurgitated liquids, remastication of the solids accompanied by salivation and swallowing of the newly formed bolus.

Fermentation

A large population of bacteria (16 to 40 billion per ml.) and protozoa (200,000 per ml.) produce enzymes to degrade the carbohydrate, protein and lipid of the feedstuffs consumed by the ruminant animal. These populations are mixed species of bacteria which respond to the changing diets offered to the animal. The microorganisms

multiply and grow, and as they do they produce protein and by-products such as volatile fatty acids and vitamins which can be used by the host animal. The environment of the rumen is almost ideal for microorganisms; pH between 5.5 and 7.0, temperatures between 38 and 40 degrees Celsius which is ideal for most enzymes, food is supplied in a somewhat continuous manner, rumen contractions mix the ingesta exposing new sources of nutrients, and the rumen wall removes the end-products of fermentation to prevent feed-back inhibition of growth. The number of microorganisms is dependent on the amount and nature of the diet, the frequency of feeding, rumination, physical distribution and quantity of protozoa and bacteria, and the species of the host animal.

Ruminant animals (dairy and beef cattle, sheep, goats, deer, etc.) have a unique four-compartment stomach. Ruminants have the ability to utilize complex carbohydrates such as cellulose o

r fibre (a major constituent of plants) and non-protein nitrogen compounds (ie. urea), therefore, have the ability to utilize feeds which have limited or no nutritive value for humans. The primary function of the digestive tract is to convert feedstuffs into chemical compounds which can be absorbed into the bloodstream for use as nutrients for a variety of needs such as body maintenance, growth, fattening, milk production, and reproduction.

Salivary Glands

Located in the cheeks and rear of the mouth, the salivary glands produce sodium bicarbonate to buffer the acidity of the rumen and mucins to lubricate the feed particles prior to swallowing. The salivary glands also secrete urea, phosphorus, potassium, magnesium, and other minerals, and some vitamins.

Esophagus

The esophagus is a muscular tube leading from the mouth to the reticulum and rumen. Contraction of muscle causes feed boluses to be moved down to the reticulum or up during the process of

regurgitation and rumination.

Reticulum

The reticulum is the second compartment of the ruminant stomach and functions in conjunction with the rumen. The reticulum is much smaller than the rumen, is separated from the rumen by a low pillar, and aids in the movement of fibrous feeds up the esophagus for rumination. The opening from the reticulum to the omasum is small and limits the passage of particles. For young calves, a groove, called the esophageal groove, in the reticulum between the esophagus and omasum extends upward to form a tube which allows milk to pass directly to the abomasum. The esophageal groove functions only until calves are weaned to solid food.

Omasum

The omasum consists of many layers of muscular leaves which greatly increase the absorptive capacity. The exact function of the omasum is not known, but water and probably VFA's are absorbed from the omasum.

Abomasum

The abomasum, or true stomach, functions essentially the same as the non-ruminant stomach. The abomasum secretes enzymes and hydrochloric acid which begin the degradation of protein to peptides and amino acids. There are many folds in the walls of the abomasum which increase it's secretory capacity.

Small Intestine

The small intestine is lined with small, finger-like projections called villi which also secrete enzymes which aid in digestion.The major role of the villi is to increase the absorptive capacity of the intestine. Muscles in the intestinal wall contract in alternate waves to move the digesta down the intestinal tract. The duodenum, or first part of the small intestine, secretes enzymes for digestion but also serves to accept secretions from the pancreas and bile glands for the digestion of protein, carbohydrate and lipid. Bile salts aid in the preparation of fatty acids for absorption. Amino acids, fats, vitamins, and minerals are absorbed mainly from the duodenum and other areas of the small intestine, jejunum and ileum.

Large Intestine and Cecum

The cecum is a blind sac at the junction of the small intestine and large intestine which serves as an additional fermentation vat, although the importance in the dairy cow is limited. The large intestine serves to absorb water and perhaps some VFA's and vitamins.

The following figure demonstrates the relative size of the rumen in newborn calves and mature ruminants. The most striking change is the vastly increased size of the reticulo-rumen.

Mastication

Initial chewing or mastication mixes saliva with feed and forms a bolus for swallowing. Complete mastication occurs via regurgitation while the cow is resting or after eating. Mastication rate varies with the level of hunger and the nature of the feed, but averages at 40,000 to 45,000 chews per day.

Salivation

Salivation functions to aid in mastication and swallowing, to provide a buffering source (sodium and potassium salts) for the acids produced during fermentation in the rumen, to provide a source of nutrients such as urea, mucin, phosphorus, magnesium, and chlorine for the rumen microorganisms, and to provide anti-frothing agents such as mucin to limit bloat.

Intestinal Digestion

Undigested feedstuffs and microbial biomass pass into the abomasum and are subjected to acid (pH less than 2) conditions and enzymatic attack. The enzymatic attack continues in the small intestine such that protein is degraded to peptides and amino acids, starches are broken down to glucose, and triglycerides are broken down to free fatty acids. The amino acids, peptides, glucose, and free fatty acids are then absorbed from the lumen of the digestive tract into the bloodstream for circulation and use by body tissues.

Simple sugars and water soluble carbohydrates usually are fermented rapidly (digestion rates of 4 to 8% per min) and completely. Although rapid fermentation can lead to ruminal acidosis and off-feed disorders, soluble carbohydrates typically do not cause problems in most diets because they comprise less than 10% of diet DM.

High temperature drying of grains can decrease extent and rate of starch digestion by 10 to 20%. Compared to medium grinding, coarse grinding or rolling decreases rates by 5 to 10%, whereas fine grinding increases them by 5 to 10%. Coarsely rolled high moisture grains also have rates of fermentation that are 10 to 20% higher than medium-ground dry grains, and rates can be increased further if high moisture grains are finely ground. Moist cooking (steaming) of starches can increase rates of fermentation by 10 to 20% and when combined with thin flaking can increase rates of fermentation of starches by 20 to 30% above those obtained when grains are ground to medium fineness. Although increased rates of passage associated with high MY and feed intakes will not change rates of starch digestion, they can decrease extent of digestion in the rumen by 10 to 30% because less time is allowed for digestion before passage occurs.

Digestion

One reason for a very acid rumen is because of the high percentage of silage (acid preserved) fed in some cases.

USA trials have shown that hay, mag oxide (Causmag is the best form) and Bicarbonate of Soda fed to freshly calved cows increases the rumen pH and increased feed intake, especially when on lush feed.

Propionic acid is formed during fermentation, which is important for the formation of milk, sugar (energy) and protein. However, if propionic acid rises above about 20% of the total acid in the rumen, fibre digestion reduces, which in turn reduces production. Rumen and liver functions can be adversely affected. In these cases, bicarbonate of soda can help

In New Zealand many farmers have found that bicarb stops the fat percentage fluctuating, and usually keeps it at the higher level.

I suggest that you try some bicarb at 40 grams per cow per day through the dispenser, on and off at fortnightly periods to see. To avoid interactions with other things going into the dispenser dissolve it, and put it into the dispenser at midday.

If a response is obtained then keep using it until the pasture firms up and cow appetites are up as happens in November.

After November you should not need bicarb.

Ruakura did trials and their figures showed an economic return when supplied through water troughs in September/October at 50 grams/cow/day. The recommended rate is 40 grams/cow/day.

Less or no response was found when drenched, so donÕt drench it.

Results vary from herd to herd, season to season and between pasture types. Your feeding maize silage may mean you'll get a response.

Thin cows produce less milk fat and are harder to get and hold in calf.

New pastures have a higher digestibi

wlty than old ones, however if they have high K, which is common where high rates of K are applied to a preceding crop and when establishing the new pasture, palatability can decrease.

Salt and balanced minerals aid digestion.

Low selenium will cause scouring, so reducing the digestion of pasture. After supplementing dairy cows with selenium their milk has increased in by 4 litres/cow/day within a week, and milk protein tests have gone up.

The digestibility or a food is influenced not only by its composition, but also by the composition of other foods consumed with it. For example an excess of soluble carbohydrates which is an energy producing organic compound of carbon, oxygen an hydrogen (starch, sugar, glucose), can depress the digestion of cellulose.

Cellulose is the main constituent of plant cell walls. Roughages such as cereal straws have a high lignin content to bind the cellulose.

Short, or short chopped forages (particularly pasture and silage), travel through the rumen more quickly, so are not as well digested. Feeding hay with short and or sappy feeds stimulates the rumen, increases rumen rotation and cudding, so improves digestion and pasture utilisation.

The better the quality of the pasture, hay and silage, the less BF required to produce the same amount of milk or meat, so the lower the cost.

When molybdenum is deficient, nitrate (undigestible toxic protein) levels are higher. Molybdenum is necessary for the conversion of nitrates into amino acids and helps animals convert surplus nitrates into uric acid so it can be expelled.

Where Mo levels are high (3 ppm or higher) copper may have to be supplemented directly to the animals through the drinking water over a day. Even at 7 ppm of Mo in pasture, Mo toxicity may not occur if copper is supplemented. Avoid supplementing with

high amounts of dry copper (as opposed to the same amount in a dayÕs drinking water). Dry copper can be toxic and kill.

Sheep grazing pastures with a very low Mo content (less than 0.1 ppm) had copper rapidly accumulate in their livers, which led to chronic copper poisoning, and subsequent death.

Heat lowers the digestibility of protein, so avoid allowing hay or silage to heat. Hay should be dry enough to avoid heating, and silage compacted enough to avoid heating. Use white plastic covers to prevent heating of the silage just below the cover.

Poor quality hay, straw and corn stubble can have their digestibility improved by feeding molasses or a molasses-based product at the same time. Where possible it is best poured over or somehow mixed with the low quality roughage.

Molasses is highly soluble carbohydrates derived from sugar cane or sugar beet. It provides instant energy and stimulates rumen micro-organisms.

Change Diets Slowly

The digestion of food is a

complex operation, involving saliva, gastric and other digestive fluids, and millions of bacteria, micro-organisms and flora in the various parts of the stomach and digestive tract.

They change to suit the food being eaten. The change is a gradual process, taking up to ten days.

If a diet change is made suddenly, much of the new food will pass through the digestive system without being fully utilised. The result will be scouring in the animal, and a decrease in production or growth.

Sudden changes in diet are not good for animals (or people) and whilst those subjected to sudden dietary changes when visiting foreign countries remember the consequences, they don't always appreciate that animals suffer from the same disturbances.

Unless they are done gradually or only partially, sudden changes between any of the following will cause problems - pasture, hay, silage, crops, meal, maize stubble, or any similar variation in feeding.

A partial change, say from 100% pasture to 75% pasturen and 25% any other feed, doesn't cause problems.

A sudden change from dry pasture to short lush pasture should also be avoided, because scouring can occur, with animals losing weight and production dropping.

Old dry pasture and poor quality conserved feeds, as well as low in feed value, are unpalatable causing low intake and low digestibilty, resulting in slow passage through the stomachs and low animal production.

Short lush pasture is highly palatable and rapidly digested, but lowers the rumen pH to below 6, partly because there is less cud chewing so less saliva absorption and can bring on acidosis. Its high moisture content (90%) means that more has to be eaten to give adequate nutrition. Dairy cows fed solely on short 1,700 kg DM/ha (100 mm - 4 inches tall) lush spring and especially new autumn pasture can be so severely affected that their milk and milkfat percentage drop and they lose condition, until the microflora in the stomach and intestines adapt to the new diet.

After autmun rains following dry spells this can be so severe that despite getting more feed and more protein than when on the old dry summer pasture, they scour and suffer. The autumn flush of young lush pasture has a greater effect than the spring one because fertilizing elements such as nitrogen and potassium increase in the soil during the dry conditions when they are not being used by plants through a lack of moisture.

Feeding a little good quality hay or silage with the lush pasture reduces the problems.

Despite the almost annual change from dry summer pasture to lush over a few weeks after autumn rains fall, usually about mid March, almost all New Zealand dairy cows get through the period without much trouble, but some donÕt, so milk production crashes.

Avoid sudden changes of hay to silage to grass, etc., and avoid sudden changes of minerals. Milk fever can be brought on by supplementing with calcium and/or magnesium prior to calving and then stopping at calving, because digestive system

s adapt to get either as much as possible out of the feed, or as much as they need out of the feed.

If you have difficulty drying your cows off, just suddenly take them off grass and put them on to hay. This upsets their rumen so much that milk production drops. If this doesn't work, reduce the hay and reduce their water. Usually such drastic action is not necessary, but there is a lesson to be learned from the sudden change, and that is not to change diets quickly when you want them to put on condition, or produce milk.

Change feeds slowly because different microbes digest different feeds, so it is important to make all feed changes gradual, increasing the new feed over about ten days, to allow the necessary microbes to multiply. If this is not done, scouring can occur through poor digestion, so milk or meat production losses are suffered.

Diet change problems can occur when changing from -

¥ Winter feed to spring pasture.
¥ Summer pasture to summer forage crop.
¥ Summer crop to silage or hay.
¥ Silage or hay to autumn pasture.
¥ Dry summer pasture to autumn lush pasture.
¥ Autumn pasture to winter hay, silage or crop.
¥ Pasture only to feeding grain or other feed when the pasture supply is insufficient.
¥

Although changing from one form of grass to another is not as severe on the animal's digestion, it nevertheless should still be done gradually.

Almost every autumn, one sees examples of animals (dairy cows in particular) scouring on fresh autumn grass which sprouts up within days of warm rain after a dry spell, especially if the new feed is short.

With dairy cows, which are excellent barometers of management systems because the daily milk yields can be measured, production frequently drops, the animals scour, and become thin, all within a week or two, because of the sudden change from a dry, fairly wholesome pasture, to a high moisture, low energy diet.

During this period continue with the crop, or feed hay or silage until the g
rass firms up.

Low pH kills protozoa, however some ruminants do well with few protozoa.

The ill effects of rapid changes, are aggravated by the fact that most humans react to problems rather than forecast and counter them ahead of time, so diet changes usually occur after animals are already suffering hunger and nutritional stress from under feeding. Under theses conditions diet change effects are worse and can be drastic.

A sudden increase in the quantity of food eaten by an animal generally causes a faster rate of passage, giving digestive enzymes a shorter period in which to work, so reducing the digestibility of the food and aggravating diet change problems.

New Crops & Feeds

The way to avoid problems is to make the change very slowly, by giving the animals about ten minutes on the new crop on the first day, 15 on the second, 20 on the third, and so on. Watch the droppings and make feed adjustments as necessary.

Even changes from grass to hay or silage should be made gradually,

+ although these changes, and ones to sorghums (millets, sorghums, maize, etc.) can be made more quickly than to brassica crops. Examples of the latter are turnips, kale and chou moellier.

There have been many incidents of animals dying following sudden changes to chou moellier. In one case, just south of Auckland, New Zealand, a farmer started grazing his chou moellier, and didn't know why some of the animals died within days of making the sudden change.

He became terrified of the crop, and sold it to a neighbour at a bargain price. The neighbour started grazing the chou moellier immediately, but broke his animals in to it very gradually, with no deaths, no sickness, and no dietary disturbances.

Toxic Crops

Some plants are toxic to some animals however little is eaten, like ragwort to cattle, and s
ome only if large amounts are consumed, like onions and some brassicas.

Problems can occur when large amounts of any one feed or crop are fed, for example hay on its own can constipate some cattle.

While even a little ragwort is toxic to cattle, it takes a lot to affect sheep. With copper it is the opposite. Cattle need a lot, while the amount in lucerne is enough to cause excess toxicity in sheep.

In the US on average one lb of grain produces 2.4 lb of milk, and on some farms grain constitutes half the total ration. Feeding so much makes an acid stomach, so de-acidifiers are used, which help improve digestion and production per lb of grain.

Low pH kills protozoa, however some ruminants do well with few protozoa.

Variations Between Animals

There is a difference in digestive ability of ruminants of a similar type, and between different ruminants such as sheep, goats and cattle. Sheep are able to digest whole cereal grains much better than cattle, mainly because the sheep chew the grains better. Cattle, however, digest low quality roughages better than do sheep. Goats can digest woody material and when goat rumen material was transferred to cattle, their digestion improved.

Grains should be more thoroughly rolled or soaked for cattle, but not ground into a flour-like meal. Coarsely ground grains can be soaked in SMM or salt flavoured water for 24 hours before feeding to cattle to improve digestibility.