Composition and Function of Feedstuffs

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Important factors

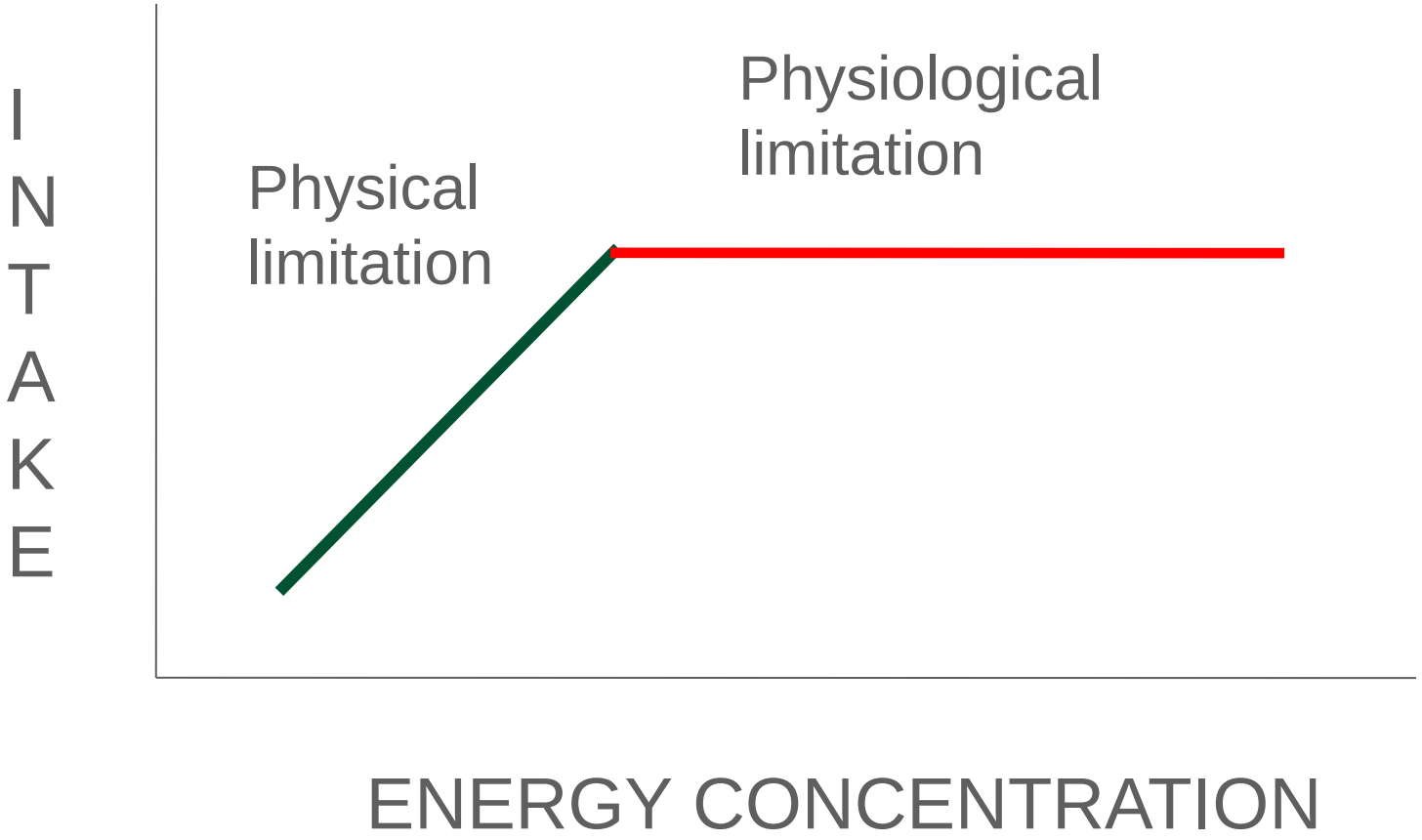
- Intake
- Energy
- Protein
- Fat
- Carbohydrate composition
- Minerals
- Vitamins
- Toxins and anti-nutritional factors
- Structure

Intake

One of the most important aspects of ruminant nutrition:

- The amount of feed the animal can consume (poor or high quality) determines productivity.
- The amount of feed that can be used to produce animal products (milk and meat) over and above maintanance.

Intake


INTAKE
Physical limitation
Physiological limitation
ENERGY CONCENTRATION

Typical values for a productive dairy cow

Feed		
Maize silage	21 kg	7 kg DM
Grass silage	12 kg	4 kg DM
Barley	4 kg	4 kg DM
Sugar beet pulp	1 kg	1 kg DM
Rapeseed cake	3 kg	3 kg DM
Total	41 kg	19 kg DM

Rumen content

60-100 kg
10 kg DM
3 kg microbes
10^{16} bacteria
10^{10} protozoa
10^{8} fungi

Daily rumen production

1400 l CO_2
500 l methane (CH_4)
6 kg short chain fatty acids
3.5 kg microbial matter

Concentrates

Factors regulating ruminants fed mainly on cereals:

- The animal itself
- The animals capacity to metabolise nutrients.
  - Age, weight, stage of growth, breed, sex.

- The size of the rumen is no limiting factor for cereal intake
- Ruminants ferment strach in the rumen and absorb volatile fatty acids, in contrast to single-stomached animals (digest starch and absorg glucose)

Roughages

- The stomach volume normally resticts the intake of fibrous material.
- Animal eats less than its capacity to utilize nutriens.
- Physical restriction due to slow fermentation, longer time to leave the rumen.

Four factors that determine the amount of roughages that can be consumed:

- Solubility
- Insouluble but digestible parts
- Speed of digestion of insouluble parts
- Palatability

Solubility

- Roughages contains a sizeable faction which is soluble, e.g. sugars.
- Highly digestible, but inside the plant cell walls.
- Straw 10 to 15%, hay 20 to 35%
- Preservation is important as large effect on feed intake.

Insoluble but digestible

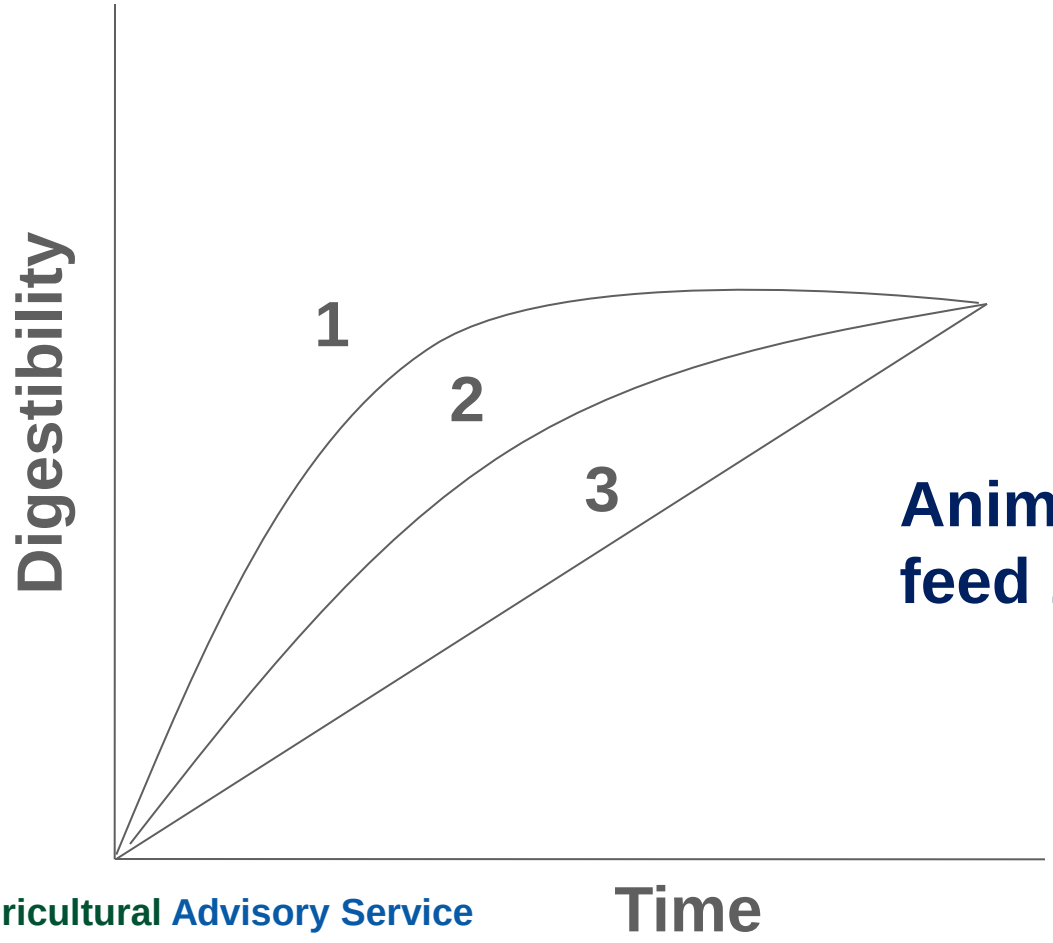
- The largest proportion of roughages
- 20 to 50%
- Slow digestion og insoluble parts may increase the time in the rumen = insufficient digestion

Speed of digestion, insoluble parts

In general:

- The speed of digestion normally increases with increasing quality or digestibility
- Many expections..e.g. clover and grass same digestibility but clover ferments faster = ruminants eat more clover

Same digestibility but different speed of digestion



Animals will eat more of feed 1 and least of 3

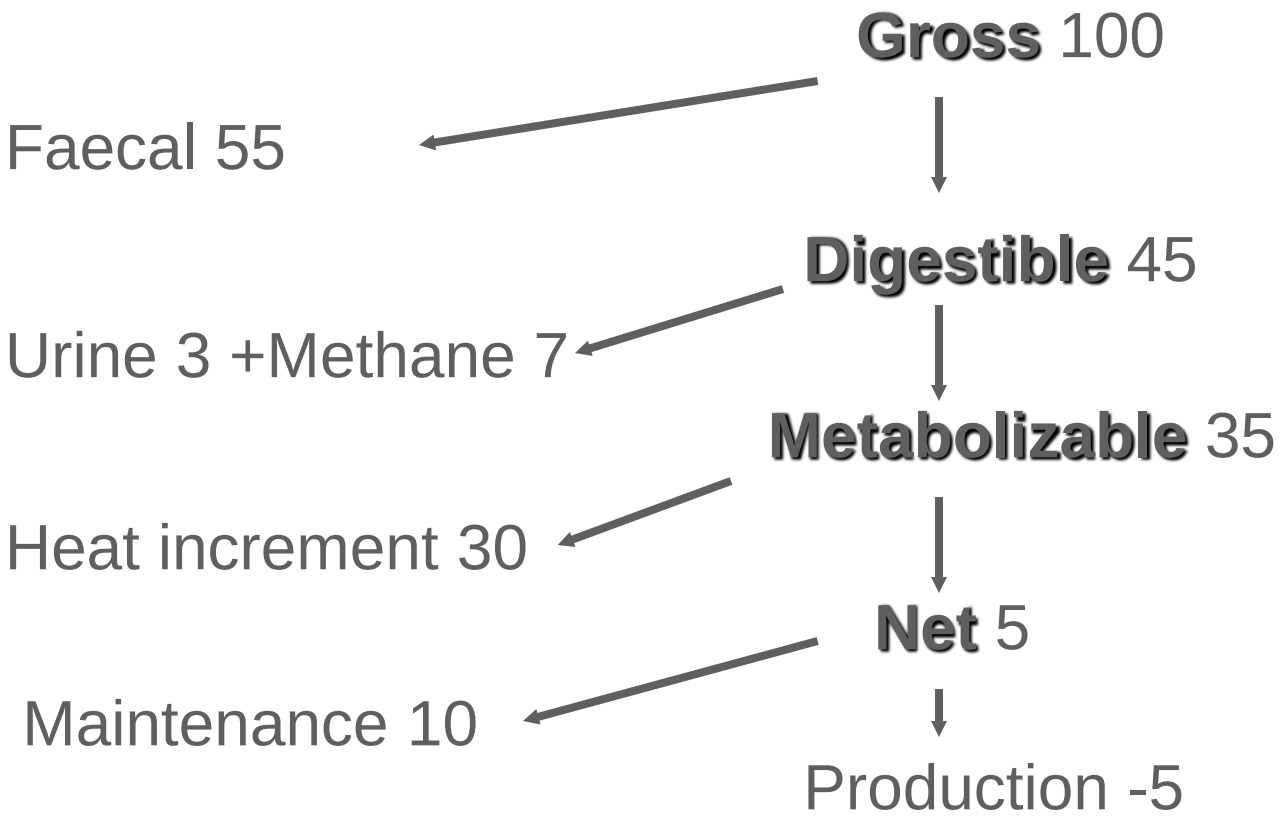
Palatability

- Some plants and feeds are more liked by animalsa than other.
- Cows, sheep and goats may not have the same preferances in feeds.
- Palatability can sometimes be confused with problems of sped of digestion, digestibility and reduction of particles.

Animal factors

- Speed at which insouluble large particles are broken down.
- Chewing, ruminanting and bacteria
- The ruman reach mature proportions at 10 to 12 weeks.
- Dry cows can consume less roughage than lactating cows
- Cattle in Northern Europe not the same capacity as cattle in South East Asia (rice straw)

Energy, - example of distribution



Energy (Composition of feeds)

True digestibility,%

NDS

Soluble carbohydrates	100
Starch	90+
Organic acids	100
Pectin	90+
Protein	85+
Fat	80+

NDF

Cellulose	0 - 100
Hemicellulose	0 - 100
Lignin, cutin, silica, tannins, phenolics	0

Protein , - ruminants

(N, CP, DCP, AAT+ PBV, RDN+UDN)

Kjeldahl

Sheep digestibility

In sacco (rumen degradability)

Mobile bag (intestinal digestibility)

ADF-N

In vivo

Duodenal and ileal fistulated cows

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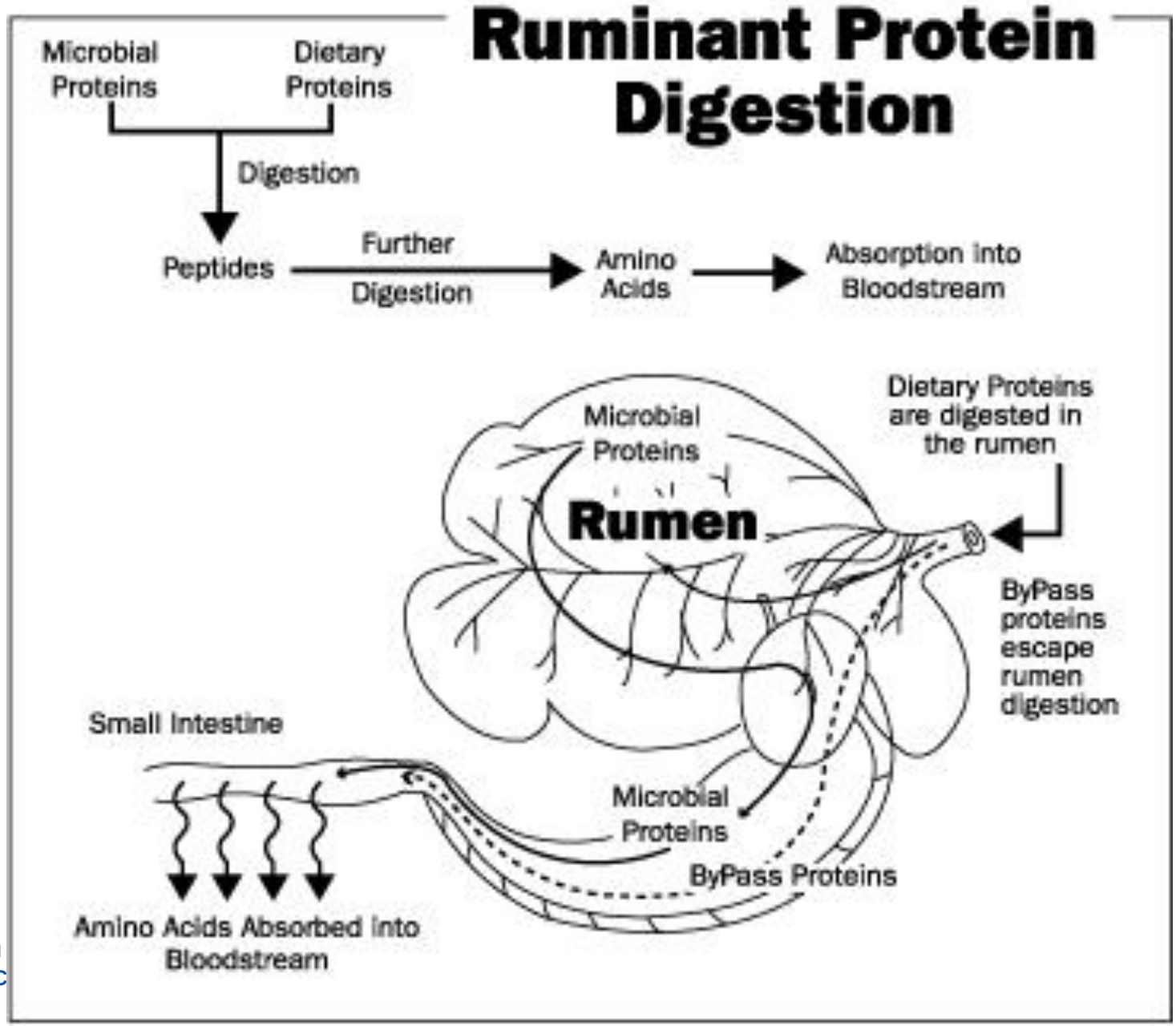

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Rumen Bypass Protein.

- The ruminant animal depends on two sources of protein for its proper growth and development,
- 1) microbial protein,
- 2) rumen bypass protein.
- The rumen bypass protein is protein found in the diet that escapes digestion by the ruminal bugs.

- Bypass proteins provide an important part of the total protein needed by young, rapidly growing ruminants.
- Animals don’t have a specific “protein” requirement.
- Instead, they depend on the small components that make up protein, called amino acids.
- Every protein is a result of several connecting units of these amino acids.

- In the small intestine protein is broken down into individual amino acids, which are then absorbed into the animal's body to support growth and development.
- For ruminant animals, the exact proportion of required amino acids is currently unknown; therefore, it is important to supply a variety of bypass protein sources to ensure a steady flow of amino acids into the small intestine.

Important parameters determining true protein supply to the ruminant

- Protein in feed
- Rumen degradability of protein
- Rumen (net) microbial protein synthesis
- Supply to microbes with rumen degradable protein
- Intestinal digestibility of rumen undegraded feed protein
- Intestinal digestibility of microbial protein

FATS

"What you eat is what you get" ?

- NO - clearly incorrect in the case of dietary lipids and ruminant animals.

- Following absorption, a major fate of fatty acids is their oxidation for energy.
- Recognition that specific fatty acids produced in the rumen also play a critical role as signaling molecules involved in the expression of specific genes and the regulation of metabolic processes.

Fat

Example of forage leaves:

	% of dry matter	% of ether extract	
Utilisation			
Ether extracts	5,3	100	High
Fatty acids	2,3	43	High
Non-fatty acids			
Wax	0,9	17	Low
Chlorophyll	0,2	4	Low
Galactose	0,4	8	(Not fat)
Other unsapronifiable	1,0	19	Low

Fats in Dietary Ingredients

- “Lipid” refers to a broad class of substances that are insoluble in water or other aqueous solvents, but are soluble in organic solvents such as ether, chloroform, hexane, acetone, and certain alcohols.
- Most normal forages, grains, and byproducts contain some amount of lipid.

The major lipid constituents in dairy cow nutrition are:

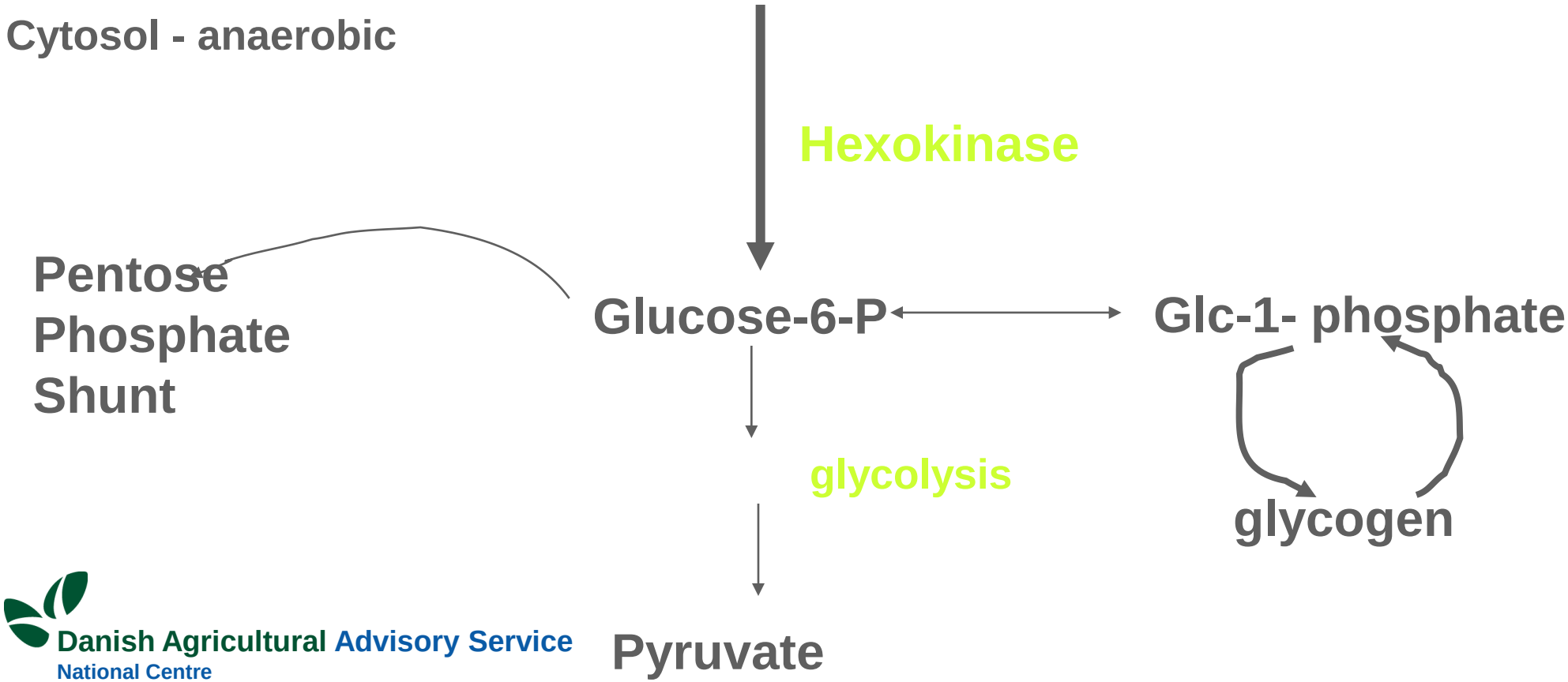
- Triglycerides: Major lipid type found in cereal grains, oilseeds, animal fats, and byproduct feeds. Also the type of lipid making up milk fat.
- Glycolipids: Major lipid type found in forages.
- Phospholipids: Minor component of most feeds. Form the cell membrane of all animal cells, and the surface of milk fat globules. Also important in fat digestion in the small intestine of cows.

Carbohydrates

- Carbohydrates are called carbohydrates because they are essentially hydrates of carbon (i.e. they are composed of carbon and water and have a composition of $(CH_2O)_{n.}$
- The major nutritional role of carbohydrates is to provide energy and digestible carbohydrates provide **4 kilocalories per gram**. **No single carbohydrate is essential**, but carbohydrates do participate in many required functions in the body.

Carbohydrates

- Serve as primary source of energy in the cell
- Central to all metabolic processes



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Minerals

- The major minerals in cattle nutrition are calcium, phosphorus, sodium, chlorine, magnesium, and potassium.
- They are required at comparatively high levels described as **percent of diet** or **grams per day**.
- An essential mineral performs specific functions in the body and **must** be supplied in the diet, but too much of any may be harmful or even dangerous.

Calcium (Ca) and phosphorus (P)

- The most abundant minerals present in the animal.
- They are also the ones most often added to ruminant diets.
- Both are found in the teeth and bones, but calcium is also found in milk and eggs.
- In addition, Ca is necessary for the clotting of blood, the contraction of muscles, and the functioning of numerous biochemical reactions in the body.

- All biochemical reactions which allow the energy in food to be utilized by animals require phosphorus.
- Animals usually require 1.5 parts of Ca for every part of P.
- Diets high in legume hay usually require supplemental P only, while diets high in grain often require supplemental Ca.
- Young animals, including humans, which do not receive adequate amounts of Ca or P may develop rickets, which in cattle show up as **arched backs**.

Deficiency of vitamin D

- May contribute to the problem.
- Older animals fed inadequate amounts of vitamin D develop osteomalacia, the symptoms of which are weak and easily fractured bones.
- Animals having diets low in Ca and P will show a drop in milk production.
- A low level of P in the diet may also cause poor reproductive performance in females, and lower the availability of vitamin A.

Calcium:phosphorus ratio

- Should be more than 1:1 but less than 7:1.
- If possible add the proper amounts of Ca and P to cattle diets, or feed it free choice.
- Mineral supplements formulated for **free choice** feeding usually have Ca and P present in a 1:1 or 2:1 ratio.

- Research has shown that **animals on range need supplemental P**. Any mineral supplement used should contain at least 14 per cent P.

Sodium (Na) and chlorine (Cl)

- Found together as sodium chloride (NaCl or common salt), and serve to maintain proper acidity levels in body fluid and pressure in body cells.
- The hydrochloric acid found in the stomach contains chlorine.

- Even though many of our feeds contain enough sodium and chlorine to meet the requirements of cattle, supplemental cobalt iodized (blue) salt or trace mineral salt **should be available at all times**.

Potassium (K)

- Like sodium, serves to maintain proper acidity levels in body fluids and pressure in body cells.
- It is also required in a number of enzyme reactions in carbohydrate metabolism and protein synthesis.
- Forages normally contain more than adequate amounts of potassium. Supplemental potassium may be necessary for high-grain feedlot diets.

Magnesium (Mg)

- Necessary for the utilization of energy in the body and for bone growth.
- Cattle fed on lush, immature pasture may have a low level of Mg in the blood, which can result in **grass tetany**, a disease characterized by convulsions, twitching of muscles, staggering gait and falling.

Sulphur (S)

- A component of body protein, some vitamins, and several hormones.
- It is involved in protein, fat and carbohydrate metabolism as well as blood clotting and the maintenance of proper body fluid acidity.
- Most feeds contain adequate amounts of S for cattle. Supplemental S may be necessary when non-protein nitrogen sources are being utilised in high grain feedlot diets.

Trace Minerals

- **Feeding trace minerals is not a simple matter**.
- They are required only in very small amounts.
- Some minerals fed in excess amounts may cause a deficiency in others; a slight deficiency or excess may cause a decrease in performance which is hard to pinpoint.
- Even though the level in the diet appears adequate, an animal may occasionally respond to an increased supply of a particular mineral because other dietary factors may have decreased its availability.

Iron (Fe)

- An essential part of hemoglobin, a compound which carries oxygen in the blood.
- A deficiency of Fe may cause anemia and reduce growth. Generally there is no need to supply extra iron.

Zinc (Zn)

- Affects growth rate, skin conditions, reproduction, skeletal development, and the utilization of protein, carbohydrates and fats in the body.
- While Zn deficiency is not common in ruminants, it can cause a mange-like skin condition called paraketerosis.

- Recommended dietary allowance (RDA) is 50 parts per million (ppm) zinc. If a supplement is required, it could be supplied in trace mineralized salt, mineral or protein supplement.

Copper (Cu)

- Deficiency can result in anemia, depigmentation in hair, infertility, scouring, and cardiac failure.
- Feed testing laboratories find that many samples contain less than the estimated RDA of 10 ppm. Although the symptoms of copper deficiency are rarely evident, improved growth and performance is often seen after Cu supplementation.

Manganese (Mn)

- Essential for the utilization of carbohydrates.
- Symptoms include retarded bone growth and reproductive failure.
- The RDA for Mn is 50 ppm.

Cobalt (Co) is necessary for the microorganisms in the rumen to synthesize vitamin B12.

Iodine (I)

- Needed in trace amounts by the thyroid gland, which influences the rate of metabolism in the body. A deficiency causes goitre. As the prairie provinces are deficient in both cobalt and iodine, a salt containing both of these elements must be used.

Molybdenum (Mo)

- Forms an essential part of some enzymes. It may also have a stimulating effect on fibre digesting microorganisms in the rumen.
- Excessive quantities of Mo interfere with the utilization of Cu and may cause a Cu deficiency, symptoms of which include severe scours and loss of body weight. If the diet is high in sulphur the problem is more severe.

Selenium (Se)

- "Alkali disease" or "blind staggers" occurs when cattle eat feed containing toxic or excess amounts of Se (10 ppm) over a long period of time.
- Chronic toxicity results in loss of weight, dullness, sloughing of hooves, and lameness.

- Toxicity is rare but occasionally found where cattle on overgrazed pasture are forced to eat a milk-vetch that accumulates selenium.
- The best cure is to remove the animal from the pasture.
- Selenium deficiency may result in "white muscle disease" in calves, lambs, and foals.
- A vitamin E deficiency increases the amount of selenium required to prevent this form of nutritional muscular dystrophy.

- Cows on Se deficient diets may have lower fertility and an increased incidence of retained placentas.
- The RDA for Se is 200 parts per billion. Se can be added to salt or mineral mixes, or injected.

Fluorine (F)

- Essential for proper bone development but will cause toxicity if fed at too high a rate.
- It is used on domestic water supplies to reduce the incidence of tooth decay.
- Too much FI causes abnormal bone growth, mottling and degeneration of teeth, and delayed growth and reproduction.
- To avoid excessive consumption of FI be sure any rock phosphate fed is defluorinated.

- Trace minerals can be effectively supplemented in the diets of cattle by using the **proper trace mineralised salt**.

Minerals

Micro mineral requirement and toxic level

	Mineral mg / feed dry matter	
	Requirement	Toxic level
Fe	100	High
Cu	10	100
Zn	50	1000
Co	0.1	20
Se	0.1	4
I	0.1 - 2	High
Mo	0.2	6

Minerals

Mineral contents of cattle, net requirements and utilisation of minerals

g / kg

Mineral	Carcass	Weight gain	Milk	Maintenance	Utilisation,%
Calcium	13-17	16 -> 10	1.2	0.016	45 - 50 (68)
Phosphorus	7 - 9	10 -> 1.5	1.0	0.014 -> 0.028	55 (58)
Potasium	1.9	1.6	1.4	0.05	100
Sodium	1.5	1.4	0.63	0.017	100
Cloride	0.9	0.9	1.1	0.026	100
Sulphor	1.5				
Magnesium	0.5	0.4	0.13	0.003	20

Vitamins

These organic compounds are required in minute amounts by the body. They are essential to metabolism and some must be supplied in the feed of ruminants.

Vitamin A

- Most important vitamin in cattle nutrition.
- It is the only one which normally must be added to cattle diets.
- It is necessary for bone development, sight, and maintenance of healthy epithelial tissues (i.e. lining of digestive and reproductive tracts).
- A deficiency can cause an increased susceptibility to disease, night blindness and reproductive failure.

- Vitamin A may be supplied by green forages which contain carotenoids.
- Carotenoids are broken down in the body to vitamin A. Thus forages are not analysed for vitamin A but carotenoids, which are measured in milligrams per kilogram or pound: mg/kg or mg/lb.
- Cattle can convert 1 mg of carotene to 400 international units (IU) of vitamin A, while chickens can convert 1 mg to 1667 IU of vitamin A.

- Animals on green grass can store vitamin A in the liver and draw on it for 2-3 months.
- Animals may also be injected with a 2-3 month supply. It should be injected twice during the winter.
- Water soluble vitamin A is sometimes added to the water, however, it is difficult to tell whether the animal is getting its daily or monthly quota this way.
- Mineral supplements should not be relied upon to supply vitamin A as they only contain very small amounts.

Vitamin D

- “Sunshine vitamin” because ultraviolet light acting on a compound on animal skin changes that compound into vitamin D.
- Vitamin D is found in sun-cured forages.
- Animals kept outdoors or fed sun-cured hay do not usually suffer a deficiency, whereas animals kept indoors and fed silage may do so.

- Vitamin D is involved in the uptake to Ca and P, so that a vitamin D deficiency resembles a Ca and P deficiency: rickets in the young animals, weak bones in older animals, and a decreased growth rate.

Vitamin E and selenium

- Have similar and interrelated functions in the body.
- Use supplements containing vitamins D and E in addition to vitamin A.
- They may not always be necessary but cost little to add.

Water requirements, Cattle

- On average, cows drink 80 litres of water every 24 hours
- A cow producing 40 litres of milk every 24 hours needs about 120 – 150 litres of water every 24 hours
- Water requirements increases by 3 litres for every degree the temperature rises

  above 20^{o} C

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Water requirements, Sheep

- ~3.8 L of water/day for ewes on dry feed in winter,
- 5.7 L/day for ewes nursing lambs,
- 1.9 L/day for finishing lambs.
- Water can be a limiting nutrient; due to unpotable because of filth or high mineral content.

Goats

- Goats among the most efficient of domestic animals in water usage, approaching the camel in their low rate of water turnover per unit of body weight.
- Goats less subject to high temperature stress than other species of domestic livestock.

- Lesser need for body water evaporation for maintaining comfort in hot climates, conserve body losses of water by decreasing losses in urine and feces.
- Factors affecting water intake in goats include lactation, environmental temperature, water content of forage consumed, amount of exercise, and salt and mineral content of the diet.