Nutrition of ruminants

János Schmidt
Eszter Zsédely

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by János Schmidt and Eszter Zsédely

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Lecture notes for students of MSc courses of Animal Science and Nutrition and Feed Safety

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Authors:

Schmidt, János MHAS professor emeritus (University of West-Hungary)

Zsédely, Eszter PhD institutional engineer (University of West-Hungary)

Supervisor:

Dr. Várhegyi, Józsefné Research Institute for Animal Breeding and Nutrition

Manuscript enclosed: 25 July 2011

Responsible for content: TÁMOP-4.1.2-08/1/A-2009-0059 project consortium

Responsible for digitalization: Agricultural and Food Science Non-profit Ltd. of Kaposvár University

Chapter 1. The role of the rumen in the ruminants feeding

The ruminants have a particular place among the herbivorous animals. One reason is that their large pre-stomachs help them to utilise a lot of fibre from forages, on the other hand they can utilise by the intermediate metabolism the volatile fatty acids formed in the rumen. Due to the high rumen volume (150-200 l in cattle and 20-25 l in sheep) they can consume a lot of forages. During feed intake they chew the feed only superficially, its thorough mechanical shredding takes places, after it is sufficiently softened in the rumen, during the rumination.

1. The rumen microbial population.

A part of the nutrients getting into the rumen by the feeds breaks down and transform as a result of the operation of microbes, living in the rumen. The most profound changes undergo the feed carbohydrates and the N containing compounds.

The rumen microbial ecosystem is divided into two groups: the bacteria including micro-flora and the protozoa (infusoria) including microfauna. A large number of microbes are living in the rumen, their number is as high as 10^9-10^{11} cell count in 1 ml rumen fluid. The most of them are the bacteria. In the new borne calf the pre-stomachs, stomach and intestinal tract are sterile. The microbes get in to the digestive tract by the milk and feed consumed and multiply the extent mentioned. The rumen microbial population, in parallel with the anatomical and functional development of the rumen, develops by the age of 3-4 months of the young cattle.

1.1. Microflora

The rumen micro-flora consists of a large number of bacteria. We know of 30 families of about 200 species of bacteria living in the rumen. According to what nutrients are broken down and what materials are formed as a result of their operation, they can be classified into the following groups: bacteria breaking down cellulose, hemi- cellulose, starch, sugar, organic acids or protein and bacteria producing lactic acid or methane. The number of bacterial species listed, as well as their cellnumber in the rumen is determined primarily by the composition and nutrient content of the diet. This close relationship explains that why a sudden and significant change in feed causes the fall over of the balance among the bacterial groups and why the bacteria can be reduced several orders of magnitude. (Figure 1.). It draws the attention that feed changes shall be completed for ruminants only gradually, with due transition.

1.2. Microfauna

The protozoa are present in the rumen in a significantly lower number, than bacteria (10^5/ml rumen liquid). Their number is only a thousandth of the number of bacteria. The protozoa, however, because of the larger size (their diameter is between 20-200 μm), could account of up to half of the weight of rumen microbes. The majority of the protozoa belong to the order of the ciliated protozoa, but some of them are Flagellata. Two groups are distinguished within the Ciliates: the Holotrich and Entodiniomorf (Oligotrich) protozoa. The ciliata are very sensitive to the acid pH, if the rumen fluid pH decreases to pH 6, they no longer reproduce. The protozoa in the rumen are not essential. This indicates that calves, having destroyed infusoria in the rumen, stay healthy. Bacteria compensate for the loss of infusoria. In the absence of protozoa the bacterial starch-degrading activity is poorer. It is noted that the results of experiments with calves destroyed fauna are contradictory.

The protozoa utilize the nutrient dissolved in the rumen liquid, but they are able to digest with their enzymes also feed particles and died rumen bacteria. Some Holotrich infusoria have sugar, maltobiose and cellobiose degrading enzymes, as well as α-amilase. The oligotrich infusoria well break down the starch of various sorts. They are able to absorb a significant amount of starch and it is passed to the lower digestive tract, protecting starch from the bacterial degradation in the rumen, which is important in the glucose supply of the animal. The oligotrich infusoria can break down cellulose, in smaller amount, too.

The protozoa also posses proteolytic activity, so they are able to utilise protein as an energy source.

2. Rumen fermentation

2.1. Degradation of carbohydrates in the rumen

The bacteria obtain the energy needed to the reproduction by the degradation of feed carbohydrates. Organic acids (mainly acetic, propionic, butyric, valerian and lactic acid) are produced, while energy released by the bacteria is recovered in the form of ATP. (Figure 2.). 3-5 kg organic acids are produced in the rumen of a 600 kg cow, which, depending on the feed composition is of 50-70% acetic acid, 15-30% propionic acid, 10-15% butyric acid and 2-5% valerianic and capric acids.

The volatile acids produced in the rumen have a significant role in the intermediary metabolism of the ruminants. Their importance demonstrates that about 70-80% of the ruminants energy supply is based on the volatile fatty acids, generated in the rumen. Among them the propionic acid is converted with the best energetic efficiency to ATP. In addition to energy supply, fatty acids participate in the production of the milk nutrients. Later on we shall speak more about this role of the organic acids.

When the feed contains a lot of fibre, the cellulose, the main component of the fibre, will ferment slowly and steadily, resulting of a lot of acetic acid. It is beneficial from the view of milk fat production, because about 65% of the milk fat is synthesized from the acetic acid, formed in the rumen.

When feeding feeds rich in water soluble carbohydrates (molasses, beet), a rapid fermentation takes place in the rumen, and the amount of butyric acid increases to the expense of acetic acid. Due to the rapid fermentation, the pH may decrease under pH 5, which will cause the destruction of protozoa. By the intensive fermentation the substrate quickly decreases, as a consequence the pH of rumen fluid varies among wide limits between two feedings, which is unfavourable for rumen fermentation. Feeding a lot of starchy feed, the amount of propionic acid increases in the rumen fluid, but a lot of starch favours the operation of lactic acid producing bacteria, as well. If animals are gradually accustomed to the higher quantity of concentrate, there is enough time to the proliferation of the lactic acid depleting bacteria. However, when a large portion of concentrate is fed to the animals without proper transition, than, in the absence of sufficient number of lactic acid depleting bacteria the rumen pH drops below pH 4.5, in this environment only the acid tolerant lactobacilluses and streptococcus bacteria can multiply and ferment. The formation of large amount of lactic acid results in the development of lactic acidosis.

If the ration contains sufficient amount of roughages, and there is a proper roughage: concentrate ratio the acetic acid:propionic acid ratio in the rumen fluid is of 3:1, which is ideal for milk production, because there is enough acetic acid for milk fat production. Increasing the quantity of the concentrate and reduction of roughages in the ration changes the nature of the rumen fermentation, resulting in more propionic acid and a reduced share of acetic acid in the rumen. The narrowing acetic acid: propionic acid ratio is favourable to the protein synthesis (meat production), but it reduces the fat content in the milk of dairy cows. The increase in the volume of propionic acid is advantageous in terms of the lactose production, because it is an important precursor of the glucose synthesis in the gluconeogenesis process.

In addition to volatile fatty acids, methane is also produced by the methane producing bacteria in the rumen. The methane is a high calorie product (39.57 kJ/l) of the rumen fermentation, resulting in significant energy loss for the animal, since by the methane production wasted energy reaches 8% of the feed gross energy content. Additionally, methane is the gas charged to environment that increases the amount of greenhouse gases, although their impact is often overstated. There are efforts to decrease the energy losses due to the methane production by using methane inhibitors.

The water-soluble mono- and disaccharides are completely fermented in the rumen. Their breakdown occurs quickly. The starch is not water-soluble, but it can absorb water, causing it to swell, and so the bacteria can adhere to in the surface. Starch degradation in the rumen is different for feeds, due to the different starch structure. For example: among the cereals the starch of barley, wheat and rye is practically entirety fermented in the rumen, while 15-20% of corn starch and 25-30% of the millet and sorghum starch escape the ruminal degradation. This fact is important in supplying animals, especially cattle, of glucose.

More than ten species of bacteria participate in the breakdown of cellulose, as well as some species of protozoa.

The degradation of cellulose occurs in more steps. This process starts with the activity of 1,4-β-glucosidase enzyme, which extracellular enzyme cuts into smaller parts the cellulose chain. In the next step other enzymes form cellobiose of these chain fragments that the cellobiase enzyme breaks down to glucose in the next process. The microbial decomposition of cellulose is significantly influenced by the lignin content of the fibre. The lignin forms lignocellulose bonds with the cellulose and rumen microbes can break down fiber with these bonds only in a smaller extent.

Approximately 40-60 % of the fibre degrades in the rumen. The high variation is in connection with the different fibre composition, primarily with the lignin content, but the rumen degradability of the fibre depends also on the energy and N-supply of the microbes, and the retention time of the feed in the rumen, which is influenced by several factors (the intensity of feeding, the size of the feed particles). Regarding energy supply of bacteria it is noted that the presence of easily degradable carbohydrates above a certain level, competing as energy source, and reduce the fibre degradation.

The other component of the fibre, the hemicellulose, is decomposed in part by the hemicellulose degrading bacteria, but some cellulose bacteria and protozoa (oligotrich) breaks down hemicellulose, as well. The hemicellulose has not got any bond with the lignin, therefore its rumen degradability is higher (50-70%) than that of the cellulose.

Pectin is found in the fibre of certain plants. The pectin swells due to water and this helps that the pectinase enzyme of the bacteria and certain infusoria break it down into galacturonic acid monomers.

2.2. The fat decomposition in the rumen

Simple lipids and complex glycerides get to the rumen by the feed, as the roughages contain complex lipids (galactolipids, phospholipids), while the grains involve simple lipids. The dry matter of the fresh immature feeds has 10% fat due to the fat-rich chloroplasts, which are found in the leaves of fresh feeds and perform the photosynthesis. This fat consists of 60-70% galactolipids and 20-30% phospholipids and the major part of their fatty acids is linolenic acid and the smaller part is linoleic acid.

The lipid content of the feed is hydrolysed than saturated by the rumen microbes. The fresh feeds stay a shorter time in the rumen, so more unsaturated fatty acids reach the lower tract than in case of hay, therefore it can explain the difference between the fatty acid composition of the milk produced in summer and in winter, under traditional feeding circumstances.

The rumen microbes can synthesise not only protein but also fat, therefore the bacterial biomass contains 9-10% fat. There is any unsaturated fatty acid in it. However 10-20% linoleic acid was found in the protozoa fat, which is probably derived from the eaten chloroplasts.

2.3. The N-metabolism of the rumen

As a result of microbial activity, there is an intensive N-metabolism in the pre-stomach system of ruminants. Proteolytic and protein synthesis processes occurring simultaneously in the pre-stomachs. The animals protein supply depends on the balance of these processes. On average 70% of the feed protein is degraded in the rumen and the resulting amino acids and ammonia is transformed more or less efficiently to microbial protein, depending on the rumen conditions, especially the energy supply of microbes. The microbial protein is an important protein source for the host animal.

2.3.1. Proteolysis in the rumen

Approximately 25-30% of the rumen micro-organisms have proteolytic activity that is capable of protein degradation. As it was already mentioned, the protozoa are also capable of protein degradation. The bacteria have both extra- and intracellular proteases and polypeptidase enzymes. The bacteria bind the peptides to the cell surface and split them off to amino acids. Than the released amino acids and the rest of peptides get into the bacterial cell, where the enzymatic break down of peptides is continued. The protozoa have just intracellular enzymes. The pH optimum of protein degradation is of pH 6 and 7, i.e. a range that is generally characteristic of the rumen. The rumen microbes can break down the different feed proteins to varying degrees. The protein degradation in the rumen is influenced by several factors. Thus, for example the degradability depends on the structure and the amino acid composition of the protein. The degradability of fibrillar type protein is lower than that of the globular types. Proteins containing disulphide bonds or cyclic amino acid are also less degradable. However, proteins contain more lysine, aspartic acid, arginine and proline are broken down to a greater extent in the rumen. The importance of rumen degradability of protein has increased in the dairy cows nutrition in connection with the increasing lactation performance. More information about this can be found in chapter 7.1.

The resulting amino acids of protein degradation are used for microbial protein synthesis. Otherwise, amino acids will be desaminated. During desamination amino acids are transformed into NH_3 and α-kethoglutaric acid, the released ammonia is added to the rumen fluid. The pH optimum of this process is of pH 6-7, that is the same as of the proteolysis, but desamination is a slower process, than the proteolysis.

The rate of the degradation of certain amino acids is different. In case of certain amino acids (aspartic acid, glutamic acid, arginine, proline and alanine) it is rapid, while the degradation of other amino acids (methionine, cystine and glycine) is slower.

The NH_3-concentration of the rumen fluid varies widely (2-20 mmol/litres), depending on several factors (the rumen degradability and the quantity of the feed protein, retention time of feed in the rumen). The rumen fluid ammonia is absorbed by diffusion and gets into the liver, where it is converted to urea in the ornithine (urea) cycle. Depending on the N-supply of the animals, a part of the urea formed in the liver will be excreted in the urine, while the other part is recycled to the rumen via of the rumino-hepatic cycle. (Figure 3.). The urea recirculation has two ways: the urea can get into the rumen by the saliva or through the rumen wall. By the saliva only a small part of the urea is returned to the rumen but the urea N excreted through the rumen wall may give 20-40% of the N of the microbial protein depending on the animal's protein supply. Therefore, the rumino-hepatic circulation is an important physiological process for ruminants, because it provides nitrogen in the rumen, when the insufficient nitrogen supply limits the microbial protein synthesis.

2.3.2. Microbial protein synthesis

The microbial protein synthesis is essential for the protein supply in ruminants. For example, depending on the milk production 55-75% of the cow protein requirement is covered by the microbial protein, synthesised in the rumen. Rumen bacteria, depending on what kind of N source used for their reproduction, are divided into 3 groups. About a third of them are obligate NH_3 utilizer, only NH_3 can be used to build protein. Most of the cellulose bacteria included in this group. Another group of bacteria in the rumen - approx. half of the bacteria - is able to synthesize protein from both NH_3 and amino acids. These are the so called facultative (optional) NH_3 utilizing bacteria. The remaining, approximately20% of the rumen microflora, in addition to ammonia also need amino acids, because they can only produce some branched, long chain fatty acids, essential for life operation, just from certain amino acids.

The rumen bacteria require for protein synthesis in addition to N, energy, minerals (especially phosphorus and sulphur) and organic compounds, providing carbon chain for the amino acid synthesis. In the synthesis of amino acids the glutamic acid plays an important role. It is an alfa amino acid formed from α-kethoglutaric acid by picking with the assistance of glutamic acid dehydrogenase, an NH_3 molecule. The glutamic acid plays a central role in uptake, storage and transfer of the amino groups, because NH_3 groups are transmitted from it by transaminases to the other compounds (keto- acids) to produce additional amino acids.

The protein synthesis is an energy consuming process. However, the energy released during anaerobe fermentation of carbohydrates in the rumen is much smaller, than that of glucose degradation in the presence of oxygen. As long as at the complete break down of glucose during the aerobic glycolysis with the associated citrate circle, 38 mol ATP is formed, the energy gain of anaerobic glycolysis by the fermentation of 1 mol glucose is only 2 mol ATP. This explains why the microbial protein synthesis is primarily limited by the available amount of energy.

English and French in vitro experiments have shown that decomposition of 1000 g digestible organic matterials (DOM) provides energy for 187 g microbial protein synthesis. This value is consistent with the opinion of the domestic metabolizable protein system, that 1000 g fermentable organic matterials (FOM) can cover the energy demand for the synthesis of 160 g microbial protein. The FOM energy content is lower, than of the DOM, because FOM does not include the energy of the undegradable protein (UDP), fat, bypass starch and of the fermentation products (the organic acids in the silages fed).

The protein content of the bacterial biomass is of 53-55%. The amino acid content of the microbial protein is 80%, while the amount of the nucleic acids and other N-containing materials, (murmon acid, glucoseamin) not utilized as protein is about 20%. The digestibility of the microbial proteins is good - it is about 80%. The digestibility of the protozoa proteins is slightly higher than that of the microbial proteins.

The microbial proteins, based on the amino acid composition, are considered to be nearly complete, which covers most of the amino acids required for milk and meat production. (Table 1.). The microbial protein is complementary to the amino acid composition of vegetable proteins. By comparing the amino acid composition of the arterial and venous blood it was concluded, that methionine may limit the milk production of dairy cows. This is also confirmed by the results of experiments with high yielding dairy cows, fed bypass methionine supplement. The wool production of sheep is also limited by the sulphur containing amino acids (Table 1.).

So far is clear, that one of the most important raw material of the microbial protein synthesis is the ammonia in the rumen. As to this ammonia is deriving in part from the urea got into the rumen by the rumen-hepatic circulation, the possibility is given, that a part of the NH_3 requirement of the microbial protein synthesis can be covered by supplying urea or other NP N-components (ammonium-sulphate, ammonium-lactate, etc.). The use of NPN (non protein N) as N source for microbial protein production is possible only if the microbial protein synthesis is limited by the lack of rumen degradable protein. In practice urea is the most used for this purpose due to its high N-content (46.5%). A number of conditions must be met, in order to make use the larger part of urea N for microbial protein synthesis. Such are the adequate energy supply of the rumen bacteria, ensuring even hydrolysis of urea in the rumen, adequate sulphur supply of microbes. When the ratio of quick, middle and slowly fermentable carbohydrates is adequate of the ration, the N:S ratio is not wider than 10:1, than you can calculate with an urea N utilisation of 80 %. An important condition for the safe use of the urea is the correct dosage of it in the ration. Even when fed two times a day, the dose of the retard urea should not exceed 30 g/100 kg body weight. When you determine the daily urea portion, you should not only consider the risk of the urea poisoning but also the efficient utilization of its nitrogen. Important is the habituating of animals to the urea by an 8-10 days transition period.

Chapter 2. Feed intake of ruminants

The feed intake of the ruminants is controlled by the central nervous system through the hunger – satiety feeling centre (ganglion) located in the hypothalamus. The stimulus, effecting the operation of the above mentioned centre, is given either by the organism of the animal (internal stimulus) or by the environment (external stimulus). An internal stimulus is for example the change of concentration certain metabolites in the body water-spaces, or the physical effect of the feedstuffs on the gastrointestinal tract. These signals are transmitted by intro-receptors into the hypothalamus. Impulses, which the external factors, influence the feed intake by acting on the appetite through the exterior-receptors found in organs of eyesight, smelling, tasting and touch.

1. Factors influencing the feed intake of ruminants

Similar to the monogastric animals chemical and physical regulation of feed intake can be differentiated, depending on whether the stimulus for the operation of the regulatory nervous system is due to the change of the metabolite concentration in the body's water space or by the physical effect of the feedstuffs (Figure 4.). However, while the feed intake is regulated primarily by the chemical ways in monogastric animals, the physical regulation dominates in ruminants. It can be explained by the different energy concentration of the feedstuffs consumed by the two animal groups. As long the feeding of monogastric animals is based on cereal based concentrates of farm or/and feed industry origin, high in energy, ruminants consume in large quantity forages of lower energy content than the concentrates.

1.1. Chemical regulation

As long the glucose content of the blood plays the primary role in the chemical control of food intake in monogastric animals, it is the volatile fatty acid content of the rumen fluid in the case of ruminants. This is due to the fact that the major part of the carbohydrates is transformed into volatile fatty acids by the rumen microbes. Receptors, located in the rumen wall detect the increase of the volatile fatty acid concentration in the rumen. Acetic acid sensitive receptors are located in the wall of dorsal sack of the rumen, and the propionic acid ones are scattered both in the wall of rumen sack and in that of veins. However, butyric acid does not influence the feed intake.

The effect of body temperature on feed consumption, the thermoregulation, is also classified as a chemical control factor, because heat is generated in the body during the degradation of nutrients. The thermoregulation plays a greater role in the control of feed intake in ruminants than in monogastric animals. It is due

- to the heat production of microbial fermentation in the rumen
- to the heat production of muscle work during the chewing and rumination of roughage
- and to the lower energetic efficiency of conversion of volatile fatty acids into ATP than that of glucose

Heat-sensitive receptors are located in the skin and in the internal surface of the rumen wall.

1.2. Physical regulation

The rumen fermentation will be only steady, if the daily ratio contains sufficient amount of roughage. In this case the volatile fatty acids can be continuously absorbed from the rumen, consequently their concentration remains below a threshold, where the chemical regulation would stop feed intake.

An important factor in physical control of feed intake is the passage, which means the outflow rate of the feed through the gastrointestinal tract. The passage is determined primarily by the time the feed spends in the rumen. It is because the feed leaves the rumen only, when it is so shredded, that the particles can pass through the opening hole of the reticulum - omasum.

The passage rate is determined by several factors. One of them is the particle size of the feed. The short chopped forage reaches sooner during rumination and rumen fermentation the required size that can get through the opening hole of the reticulum – omasum, then the long chopped or non-chopped forage.

Roughages ground to meal and grains (concentrates) stay in the rumen only for a short time. It should be noted, that although a higher passage rate increases feed intake, the digestibility of fibre - in particular for roughages - decreases.

The passage rate depends also on the chemical composition of the feed. First of all its fibre content – and the amount of lignin in the fibre - affects the passage. Rate of passage is influenced by the rate of fiber degradation, too. The slowly degraded fiber stays longer in the rumen and limits the feed intake. In spite of that cell-wall of legumes contain more lignin but rate of fiber degradation is high the feed intake is higher from legumes than from grasses. More fibre is associated with a slower passage. On the other hand an appropriate protein and easily digestible carbohydrate content of the feed decrease the retention time of the feed in the rumen because of establishing favourable conditions for active rumen fermentation.

The passage rate and the feed intake depend on the feeding frequency, too. This effect is in connection with rumen pH. When there is a long time lag between feedings, the pH of the rumen fluid varies widely, which reduces the number of the microbes in the rumen and thus the intensity of rumen fermentation. Decreasing fibre digestibility and lower microbial protein synthesis in the rumen are the consequences.

More frequent feeding results a more balanced rumen pH, improving the conditions for microbial fermentation and increasing feed intake. However more than 3-4 feeding/day does not improve the feed consumption of dairy cows.

The factors influencing the passage rate turn positive from the point of view of feed intake, when the concentrate: roughage ratio is optimal in the daily ration. In this case the dry matter digestibility varies between 60-70%. When animals consume less roughage or more concentrate than the optimal, the digestibility of dry matter increases above 70% and consequently the chemical factors will dominate in the regulation of the feed intake instead of the physical control.

Chapter 3. Determination of the feedstuffs energy and protein value in the ruminant nutrition

1. The energy value of feeds in ruminants nutrition

When calculating the daily ration, the starting point should be to cover the energy requirement of animals. For this purpose the net energy content of feeds shall be used for ruminants. It is because, in contrast to the monogastric animals, there is only a weak correlation between the digestible (DE), or metabolizable (ME) energy and the net (NE) energy content of the feeds in ruminants. This follows from the heterogeneous feed ration of ruminants, namely, in contrast to monogastric animals, they consume significant amount of roughages besides concentrates. The roughages have very different chemical composition, varying heat production (thermic energy) and the amount of methane produced in the rumen. For these reasons the energy requirement can only be met with sufficient accuracy in ruminants if the net energy of the feed is taken into account instead of digestible (DE) or metabolizable (ME) energy.

Instead of the nearly 100 years used starch equivalent value, due of its flaws and inaccuracies, the partial net energy system was introduced in the nutrition of ruminants in Hungary - similarly to the other countries in the world - in 1986. Several research results in USA and in Western-Europe justified the development and implementation of the new partial net energy system. These are the followings:

The efficiency of the utilization of feed metabolizable energy (‘k factor’) is significantly influenced by the functions (maintenance, milk, meat, or fat production). Feeding natural feeds, it is the most efficient (70-75%) when the ME is used for maintenance. Lower efficiency is found in the case of weight gain, however the efficiency of utilization also depends on its composition (protein and fat content). It is worse in the synthesis of protein (35-50 %) and is improved in the synthesis of fat (60-70 %).The mean efficiency of utilization of ME for milk production is 63%.

The efficiency of utilization of ME is also influenced by the metabolizability of feed energy, it is the metabolizable energy divided by the gross energy (q factor). This factor has the largest impact on the energy utilization (‘k’ factor) in case of growing and fattening, while this effect is similar and smaller in case of maintenance and milk production than that of fattening (Figure 5.).

The feeding level (I = the ratio between the metabolizable energy intake and the amount of metabolizable energy used for maintenance ($ME/ME_{maintenance}$) affect the rate of passage and the digestibility of the nutrients and thereby the ME content of the feeds.

The ME of feed is utilised with similar efficiency for both milk production and weight gain in lactating dairy cows, which allows the expression of the energy requirement in net energy lactation ($NE_{lactation}$) for both type of production.

1.1. The net energy for milk production (NEl)

The net energy system of milk production, developed by Moe et al., and introduced in the USA in 1969, was adopted in Hungary. The decision was motivated that the system has been developed on the basis of a large number of experimental results (hundreds of respiration experiment data). In addition, the system takes into account the results which were summarized earlier.

When we adopted the equation determining the net energy for milk production of feeds, we were having regard to the finding of Van Soest at al.(1979), that the impact of the feeding level on nutrient digestibility may not be the same for all feed, because it depends on the fibre content and the fibre composition. Moe at al. (1976) calculated initially 4% decrease in the digestibility when the feeding level increased with one unit. In contrast, Van Soest at al. proposed to take into account the effect of feeding level with different discount factor, depending on the feedstuffs. On this basis the net energy for milk production at three times maintenance level is calculated with the next formula:

NEl (MJ/kg DM) = 0,6032 • DE• (1-2•df)-0,502

(DE = digestible energy (MJ/kg DM), df = discount factor)

Respiratory experiments have shown that the cows recovered 63 % efficiency the metabolisable energy of feed for milk production. This is considered a good efficiency of the transformation, if we also regard that a significant proportion of the cow energy requirement is covered with roughages having less energy concentration than concentrates.

The utilization of ME for milk production also depends on the condition of cows. In a feeding period of energy shortages, which often occurs in the first trimester of lactation, the cows utilize fat reserves to compensate the missing energy. In such a case the energy utilization is very high, reaching 84 %. 1 kg body weight loss is equivalent to 20.61 MJ NEl, which cover the energy requirement of 6.6 litre FCM milk.

When the cows condition improves (in the last trimester of lactation), the energy used for weight gain reduces the amount of energy available for milk production. Since the metabolizable energy utilisation efficiency for weight gain is only 60%, 1 kg weight gain reduces the amount of energy available for milk production by 26.77 MJ NEl.

1.2. The energy value of feed in the nutrition of growing and beef cattle

The energy requirements for maintenance and weight gain can not be expressed in the same energy unit (maintenance or net energy for growth) in the nutrition of growing and beef cattle. One reason for this is that the varying metabolizability of feeds has very different impact on the efficiency of utilization of the metabolizable energy (‘k’ factor), and among the reasons it should be also mentioned that the ‘k’ factor is significantly different for maintenance or weight gain. Similarly to the dairy cows, the net energy system, developed in the USA by Lofgreen and Garett (1963) for beef cattle has been introduced to replace starch equivalent value. It must be noted, that the system is based on a large number of experiments using comparative slaughter technique and carcass composition.

1.2.1. The net energy for maintenance (NEm)

The maintenance net energy requirement of animals is equal to the amount of energy required for maintaining energy balance. When the maintenance net energy content of a feed is evaluated, essentially the quantity of feed necessary for maintaining the energy balance of a metabolic weight unit ($W^{0.75}$) is determined. Knowing this value, as well as the maintenance energy requirement of a unit metabolic weight ($W^{0.75}$), the maintenance net energy content of feeds (NEm) can be calculated. On this basis, the NEm content of a feed is equal to the heat loss, that the amount of feed per unit is able to compensate in the body. Based on the results of a large number of feeding experiments of significantly different forage:concentrate ratio, Lofgreen and Garrett found the next correlation between the net energy for maintenance and metabolizable energy content of feeds:

NEm (MJ/kg dry matter)=1.37•ME-0.033•ME^2+0.0006•ME^3-4.684

ME (MJ/kg dry matter)= 0.82•DE

1.2.2. The net energy for weight gain (NEg)

From the concept of net energy follows, that the net energy for gain (NEg) content of a feed is equivalent to the energy content of weight gain, which results in the feeding of one unit feed. NEg is determined by the so called ‘differential experiment’. The feed in question is fed in two different amounts and the energy of the induced growth is measured.

Lofgreen and Garrett conducted a lot of differential trials and found the next relationship between the net energy for gain and the metabolizable energy content of feeds:

NEg (MJ/ kg dry matter) = 1.42•ME-0.0416•ME^2+0.0007•ME^3-6.904

2. The protein value of feeds in ruminants nutrition

Over the past two decades many new results became available on the factors influencing feed protein degradation in the rumen, on conditions effect the extent of microbial protein synthesis, and on utilization of absorbed amino acids for milk production, weight gain or gestation, which made it possible to develop new protein evaluation systems for ruminants. This took place in Hungary in 1999, when the new Hungarian protein evaluating system, the metabolizable protein system, has been introduced. The Hungarian system is similar to the other European and the USA evaluation methods.

Metabolizable protein includes the amino acids absorbed in the small intestine, deriving on the one hand from in the rumen undegraded feed protein (UDP) and on the other hand the microbial crude protein (MCP) synthesized from rumen-degradable feed protein (RDP). The amount of protein entering the small intestine is depending on the rumen-degradability of feed protein and the amount of microbial protein synthesized from rumen degraded feed protein. 'In sacco' technique is used for the estimation of protein degradability in the rumen. It refers to high feeding level, when the rumen outflow rate 8% per hour.

The rumen microbial protein synthesis depends on several factors, of which the energy and N-supply of microbes are primarily. The new national system expresses the energy available to microbes in fermentable organic matter (FOM) that can be calculated by the following formula:

FOM (g/kg dry matter) = DOM – (UDP + digestible fat + fermentation products + bypass starch)

where

FOM = fermentable organic matter, g/kg feed-dry matter
DOM= digestible organic matter, g/kg feed-dry matter
products of fermentation: organic acids, alcohol, g/kg feed-dry matter

According to the national system 1 kg FOM provides energy for 160 g microbial protein (MCP). The N needed to the reproduction of microbes is covered generally by the RDP fraction of feed protein but, if necessary the urea, recycling through the ruminate-hepatic circulation into the rumen, also contributes to the supply of N. The national system assumes that the RDP N in 90 %, while the NPN N in 80 % utilized for microbial protein synthesis.

Concerning the protein supply of ruminants, the digestibility of protein is also important. The domestic system assumes the digestibility of microbial protein and its amino acid content 80%, it means that 640 g is the digestible protein content of 1 kg microbial protein.

The digestibility of the rumen undegradable protein (UDP) is partly depends on the protein content of acid detergent fibre in the feed. The system assumes that the acid detergent fibre protein certainly can not be digested. The digestibility of UDP reduced with the acid detergent protein is 90% in the domestic system. The digestibility of UDP of the feed protein is calculated in the following manner:

UDP digestibility (%) =((UDP-ADIN)•0,9) / UDP

ADIN= acid detergent nitrogen • 6.25, g/kg feed dry matter

As the amount of microbial protein synthesized in the rumen is dependent on two factors the energy and protein content of the feed. Therefore it seems to be appropriate that all feed should be given two metabolizable protein values, depending on energy and protein content of the feed.

The nitrogen-dependent metabolizable protein (MPN) means the quantity of protein, originated from the true digestible protein proportion of UDP and the digestible true microbial protein potentially synthesized from RDP. The method for its calculation is as follows:

MPN (g/kg dry matter) = 0,9•(UDP-ADIN•6,25)+0,9•0,8•0,8•RDP

The energy dependent metabolizable protein (MPE) means that protein amount, which is originated from digestible protein of UDP and the potentially synthesized digestible true microbial protein from the fermentable organic matter (FOM) content of the feed. The formula is:

MPE (g/kg dry matter) = 0,9•(UDP-ADIN•6,25)+160•FOM•0,8•0,8

Both metabolizable protein values should be calculated for rations. The production of animals is always limited by the lower value.

When a ration is formulated a protein balance in the rumen should be also calculated. This tells us, how is the protein supply of microbes in relation to energy of a particular ration fed. The balance is calculated as follows:

protein balance of the rumen (g) = MPN-MPE

The positive balance indicates that more protein (nitrogen) is available for the micro-organisms to protein synthesis than energy. In such a case, the energy supply limits the microbial protein synthesis. Practical experiences suggest that a slightly positive protein balance (100-150 g in the dairy cow ration) is beneficial to dry matter consumption. But an excessive protein supply (long term surplus over 250 g for dairy cows) has a negative effect on reproductive performance.

The negative protein balance, if the protein requirement is met not harmful. The lack of N for the microbial protein synthesis, can be supplied partly or completely by urea getting into the rumen through the ruminate-hepatic circulation. A larg deficit can be compensated by the feeding of NPN substances.

Chapter 4. Nutrient requirements of cattle

The inherited performance of livestock animals can only be realized if all their nutrient requirements are completely satisfied (energy, protein, amino acids, minerals and vitamins). Failing that, sustained production and a long productive lifetime can not be achieved.

1. The energy requirement of cattle

Energy requirements of cattle are expressed by net energy, maintenance requirement is equal the heat production of fasting animal, and net energy requirement for production is the same as the energy content of the product.

1.1. The maintenance energy requirement of cows

Whereas the change in feed metabolizability has similar effect on ME utilization for maintenance and milk production, the maintenance energy requirement can be expressed in net energy for lactation.

The energy used for maintenance leaves the body by heat radiation or conduction. This heat can be measured in order to determine the energy requirement of the animals for maintenance. The fasting heat production of dairy cows is 0.305 MJ NEl/$W^{0.75}$, which covers the basal energy needs. However, further energy is needed for the digestion of maintenance feed, absorption of nutrients as well as for a minimum movement necessary to maintain health. These items are about a 15 % increase in the basal energy requirements. This means that the maintenance energy for dairy cows is altogether 0.351 MJ NEl/$W^{0.75}$.

Grazing and the concomitant move (going out to the pasture and back and grazing) will further increase the energy demand for maintenance. For example: a 600 kg cow uses 1.26 MJ energy to walk 1 kilometre on a flat road, and a further 10-16 kJ of energy per minute is required during the grazing. This explains why the grazing on good, medium and low quality pasture raises the maintenance energy demand by 10, 15 or 20%, respectively.

Recent studies have shown that the net maintenance energy requirement of certain dairy breeds is higher than previously indicated (0.368 MJ/$W^{0.75}$).

1.2. The energy needs for milk production

The NE required for milk production depends on the quantity and composition of the milk produced. Since we know the energy content of the milk components (fat 38.12 kJ/kg, protein 24.52 kJ/kg, lactose 16.54 kJ/kg), we are able to calculate the energy content of milk of known composition. Many regression equations are available to calculate the energy content of milk. There is equation, which only takes into account the fat content in the calculation. This is the basis that the energy content of milk fat makes up 50 % of the milk energy. The equation in question is described by the following formula:

energy value of milk (MJ/kg milk) = 0.403•milk fat % + 1.4731

1.3. The energy requirement of pregnancy

There are a lot of data on the amount of nutrients built into the foetus and on the dynamics of nutrient retention. It is known that the retention of nutrients is increasing exponentially during the pregnancy, which results that the development of the foetus from the 7th month onwards is accelerating. Building the foetus increases the cow maintenance energy requirement by 18% in the 7th, by 30% in the 8th and by 50% in the 9th month of the pregnancy. The animals utilize the metabolizable energy of the feedstuffs with a very low efficiency during the pregnancy. The efficiency of utilisation varied in the experiments between 10-25%. This is because nutrients get through the placenta only by using a significant amount of ATP. The energy requirement of the pregnancy can be calculated by the next formula:

daily energy requirement = $184.1 \cdot e^{0.0174t}$

t=days of the pregnancy

e=natural logarithm

1.4. The energy requirements of growing and beef cattle

The heat production per metabolic weight unit of 0.322 MJ has been found by Lofgreen and Garrett. However, recent studies suggest, that the maintenance net energy requirement of different breeds and types differ widely, namely it is greater for large frame growing cattle than that of the medium frame cattle. Naturally, the above values should be increased by 15% in the case of growing animals similarly to cows. Its reasons are detailed in the chapter 4.1.1.

The weight gain and its composition of growing cattle is influenced by several factors (breed, weight, frame size, sex), which factors should be taken into consideration, when we want to determine the energy requirement of growing cattle exactly. Lofgreen and Garrett based on the analysis of the hundreds of bodies found that there is a strong correlation (r=0.97-0.98) between the rate and the energy content of weight gain, which allows to calculate the energy content on the basis weight and weight gain. This facilitates to determine the energy requirement of growing cattle on a differentiated way, taking into account the factors mentioned.

Knowing the weight and the daily weigh gain level, the net energy requirement for weight gain of growing cattle can be calculated by the follow formulas:

Medium frame size (Hereford, Jersey cross-breeds):

Bull: NEg (MJ) = $0.20627 \cdot W^{0.75} \cdot Wg^{1.097}$

Heifer: NEg (MJ) = $0.28702 \cdot W^{0.75} \cdot Wg^{1.119}$

Large frame size (Hungarian-Simmental, Holstein Frisian, Charolais, Limousin):

Bull: NEg (MJ) = $0.18284 \cdot W^{0.75} \cdot Wg^{1.097}$

Heifer: NEg (MJ) = $0.25439 \cdot W^{0.75} \cdot Wg^{1.119}$

W= body weight, kg

Wg=daily weight gain, kg

2. The metabolizable protein (MP) requirement of cattle

Protein requirements of cattle is expressed by metabolizable protein which is the net protein requirement divided by the efficiency of utilization of protein.

When determining the animal protein requirements, the net protein requirement shall be assumed, that it represent the amount of protein that animals use for maintenance and incorporate into animal products (milk, weight gain, foetus and wool).

It is known that the nitrogen used for maintenance is excreted from the body as the endogenous fraction of the urine and faeces. The N- loss originating of the wear and tear of the skin and hair is also part of the maintenance requirement. The endogenous urine N proportion on the metabolic body weight basis (2.75 x $W^{0.75}$ g/day), while the endogenous faecal N content on the indigestible dry matter basis of the feed fed (90 g/kg indigestible dry matter) is calculated. It is well known, that the body can replace the amino acids excreted by the endogenous N fraction of the urine and the wear and tear of the skin and hair with 67% efficiency, and those excreted by the endogenous proportion of the faeces N with 90% effectiveness.

Knowing the factors determining the maintenance needs, as well as the efficiency of amino acids used for maintenance, the metabolisable protein requirement of cattle can be calculated:

maintenance MP requirement (g/day)=$3.41 \cdot W^{0.75}$

To determine the metabolisable protein requirement of the production (milk production, weight gain and foetus development), you should know the quantity of the protein secreted (in the milk) or retained (in the weight gain and the foetus) in the product, as well as the protein utilization efficiency. The amount of protein excreted in the milk is easy to see, in contrast the calculation of the protein retained in the body by the weight gain and in the foetus is a more difficult task. Nevertheless, there are a large number of experimental results on the N-turnover, performed in growing and fattening, cattle of different variety (age, weight, breed), furthermore results of whole body and foetus analysis are available. On the basis of these data the amount of retained protein in the weight gain and in the foetus can be estimated with sufficient accuracy.

The following amino acid efficiencies are accepted in the domestic metabolizable protein system, when the amount of the required metabolizable protein of different productions is calculated:

milk production65%

weight gain (mean)50%

foetus development50%

These data suggest that for the production of 1kg FCM milk (protein content 3.3 %) 51 g metabolisable protein is required. (33/0.65)

Based on the results of whole body and foetus analysis, regression equations were developed, which allows the calculation of the protein in the weight gain or in the foetus, depending on breed, body weight, sex and rate of the weight gain, as well as in the case of pregnant animals on the stage of pregnancy (NRC 1985, ARC 1980, AFRC 1992). For example: a cow incorporate 105 g protein into the foetus on the week 36th of the pregnancy, so it requires 210 g metabolizable protein, because of the 50 % efficiency of amino acid utilisation.

3. The mineral requirement of cattle

The exact determination of the mineral demand is not a simple exercise. Sufficient data are available on the net requirement of most minerals. However, our knowledge is incomplete in utilisation of more minerals. It is because the absorption of minerals can not be tested in the same way that is in use when determining the digestibility of organic matter. Minerals are absorbed in one section of the digestive tract, while in another section later excreted, so you can not infer the rate of mineral absorption from the quantity of excreted minerals in the faeces. Based on the amount of minerals consumed in the feed and excreted with the faeces, only the mineral balance can be identified. The absorption of minerals can be analysed by using isotope marked mineral or chimus samples, which are collected from the different part of the intestine with channul.

It complicates the determination of minerals efficiency, that it is influenced by several factors. For example: the Ca and P absorption rate is lower in older than in younger animals or the narrower supply increases the absorption efficiency of both elements.

Surveys using isotope minerals have shown that in the case of Ca and P, the endogenous excretion is less and are better absorbed, than that was found in previous studies. The latest recommendation is 44 g Ca and 34 g P for 1000 kg body weight.

The requirement for maintenance and production is given together in relation of the other macroelements.

The values depend on the age, sex and production level of the animals. They are as follows:

Mg 0.7 - 2.5 g/kg DM

Na 1.0 - 1.9 g/kg DM

Cl 2.0 - 2.5 g/kg DM

K 6.5 - 10.0 g/kg DM

The demand of maintenance and production is given also together concerning the microelements. The cow microelement requirement in 1 kg dry matter is as follows:

Fe 50 mg

Cu 10 mg

Mn 60 mg

Zn 50-60 mg (depending on the milk production)

I 0,6 mg

Se 0,3 mg

Co 0,1 mg

The microelement needs of heifers and beef cattle differ (lower) from those values only in respect of Mn, Zn and I and to a lesser extent.

The average composition of cow milk contains 1.28 g Ca, 0.95 g P, 0.5 g Na and 1.1 g Cl. Producing of 1 kg milk requires, taking into account the absorption efficiency, of 2.8 g Ca and 1.7 g P. The Mg demand of 1 kg milk is 0.6 g. In spite of its low absorption efficiency (20%), a Mg supplement is usually not required. The most mineral premixes produced for dairy cows contain Mg supplement. Herbages contain only a small amount of Na and Cl, so they need to make up by salt supplement. The Na and Cl requirement of maintenance and milk production can be met by feeding of 1.5-2 g salt per kg milk.

The mineral supply of young and pregnant animals requires also particular attention, whereas a significant proportion - about 8-10% - of juvenile weight gain is made up of the minerals, and foetus development demands also a good mineral supply, especially in the last trimester of the pregnancy, when the calf skeletal system develops intensively. The growing cattle require 20 g Ca and 10 g P for each kg weight gain, and these requirements are of little change with the progress of age. Although the mineral content of weight gain decreases with age, but at the same time the utilization of Ca and P is declining, this is why that continues to provide the above mentioned amount of minerals for the weight gain of growing cattle.

The Ca and P requirement of the foetus development can be met, if you provide 15 g Ca and 10 g P above the maintenance demand. In the case of heifers you should give 20 g Ca and 10 g P supplements for every kg weight gain above the maintenance and pregnancy requirement, because they do not reach the mature body weight in the time of the first pregnancy.

It is very important, that the Ca:P ratio should be narrowed to in the last two weeks of the dry period in order to prevent the milk fever (parturient paralysis).

The narrow ratio will stimulate the cow’s body, that allowing the hormonal system (by increasing the parathormone production of the parathyroid) to mobilize calcium and phosphorus reserves to cover the Ca and P-requirement of the foetus development and the milk production after the calving.

4. The vitamin requirement of the cattle

You should only pay attention to the vitamin A, D and E supply of the ruminants except the calves. The cow’s demand of these fat-soluble vitamins is the next:

vitamin A 3200-4000 IU/kg DM

vitamin D 1000-1200 IU/kg DM

vitamin E 15-20 IU/kg DM

The higher values are considered to the dry cows. The carotene is important not only as the pro-vitamin of vitamin A, but also it has own functions, the progesterone production of the corpus luteum (yellow body) is inhibited, if the β-carotene supply is insufficient. Its consequences are the silent heat and the cyclus abnormalitas. Therefore the cow diet should include 5-10 mg β-carotene/kg milk above the vitamin A supplement.

The ruminants are self-sufficient from vitamin B-groups and vitamin K except the niacin (vitamin B_3), as the rumen microbes can not wholly cover the niacin demand, the quantity of niacin, which can prevent the excessive fat mobilization of high yielding cows. Therefore the niacin supplementation in the first trimester of the lactation can improve the milk yield and also the fat content in the milk.

Chapter 5. Nutrition of calves

A newborn calf is a monogastric animal in view of nutrition, since its first stomach system are less developed then the true stomach (abomasum). The capacity of the first stomach of a few days old calf is of 0.75 litres and that of the abomasum is of 2 litres. Followed by the rapid development of the first stomach system, on the week 8th its capacity is of 6 litres and it will increase to 14 litres on the 12th week. It is of 30 litres of the one year old calf, while the abomasum volumes are 6, 7 and 10 litres, respectively. The development of the first stomach is largely influenced by the nutrition of the calf, namely, it develops rapidly if the calves consume concentrate and hay, compared to the calves consuming only milk-replacer. In the age of 12 weeks, the first stomach of calves consuming milk replacer, concentrate and hay was twice as big as that of the calves consuming only milk or milk replacer. Among the solid feeds hay has the greatest influence on rumen muscularization and volume, while in the view of rumen papillae development concentrate is important. The rumen papillae development is stimulated by volatile fatty acids in the following order: butyrate, propionate, acetate. The effect of the latest is small.

The first stomach and the intestinal tract of a newborn calf is still sterile. Calves, consuming the milk but above all the concentrate and hay will have access to the bacteria and protozoa that later in the rumen have decisive importance for functioning of first stomach system and supplying nutrients to the host animal. Although there are already some cellulose-degrading bacteria in the undeveloped rumen of the one week old calf, the characteristic micro-flora and -fauna of the adult cattle develops in parallel with the anatomical and functional development of the first stomach system only by the 3-4 months of age. Consequently, this is the age at which the rumen volatile fatty acids and microbial proteins are determining in the energy and protein supply of the calves.

The calves digestive enzyme production develops only gradually- like the first stomach system. The calves in their first 4 weeks are only able to break down the milk protein as the digestive system is primarily adapted to that source of protein. At this age the digestion of proteins is going in the abomasum, where the milk first curdles rapidly to the effect of rennin produced of pro-rennin, and then the rennin hydrolyses curd milk protein. Hydrolysis efficiency depends on the pH of abomasum. The lactic acid formed by bacterial fermentation of the lactose in the abomasum provides the slightly acidic pH for the optimal functioning of the rennin. During the first weeks of the calves life only a minimal amount of pepsin and the hydrochloric acid is produced in the abomasum, which explains, why the calf at most 5 weeks of age can break down plant proteins.

Calves, younger than 4-5 weeks, can digest from the di- and polysaccharides only the milk sugar (lactose). Other polysaccharides (saccharine, maltose, starch, cellulose) in the absence of digestive enzymes (saccharase, maltase, amylase, cellulase), reach the colon without degradation, where as a result of microbial operation, will be fermented. In so doing, the resulting products (lactic acid, volatile fatty acids) may cause in larger quantities sever digestive problems (diarrhoea).

The fat digestion in young calves can be evaluated as good, which can be attributed to the fact, that they also have two lipolytic enzymes. One of them is the lipase in the saliva that starts to break down the milk fat already in the abomasum. This associated with lipase produced by the pancreas, which is already in the first two weeks after birth is available in sufficient quantities.

Artificial rearing of calves by drinking is a common calf rearing method of milk producing units. Therefore it is enough only to list the benefits of this rearing method against natural breast feeding. These are as follows:

- More milk and butter comes for human consumption.
- The calf sucking does not harm the cow udder.
- The growth and development of the calves can be controlled by the formulation of the composition of milk replacer and by changing the amount of milk offered to drink.
- Artificial calf rearing is cheaper than nursing.
- The calf drinking is also advantageous from the veterinary point of view (for example: the risk of infection by inflammatory bacteria is lower).

Calves fed first colostrum, which composition is significantly different from the normal milk. The main difference is that the colostrum contains immunoglobulins, which are essential for the development of calf resistance. However, these proteins are effective only, if pass through the intestinal wall, which is only possible in the first few hours of life (24-36 hours after birth). This time the villi by pynocithosis ingest the non degraded immunoglobulins. Immune proteins can remain non degraded in the abomasum and the small intestine, because the rennin does not hydrolyse the immunoglobulins, pepsin during this period has not yet produced and the trypsin inhibitors in the colostrum does not allow the effect of the small amount of trypsin to prevail. As the calves in the first 8-10 days of life, does not produce antibodies, and 6-8 weeks of age only in small quantities, it is very important that calves receive colostrum as soon as possible. The composition of colostrum is constantly changing hour by hour. The initial 5-7% immunoglobulin content of the colostrum is halved 6-8 hourly, and the 7th day after birth it contains only 0.2 %.

The colostrum contains not only more of the immunoglobulins, but also of some vitamins, compared to the normal milk. Thus e.g. the vitamin A content of the colostrum may reach 700-900 IU in 100 ml milk, when pregnant animals received a good supply of carotene, which is normally 6-7 times of vitamin A content of the normal milk. The vitamin E content of colostrum can reach 10 times to normal milk and more the amount of vitamin B-group in the colostrum as well.

The colostrum contains more the minerals than the normal milk, especially the magnesium content is significant. This gives the mild laxative effect of colostrum that helps that the bowel pitch (meconicum) is removed from the colon.

As described, efforts should be made that the calves receiving the colostrum as soon as possible. Therefore, when the calf stands up, should drink 1-2 litres of colostrum and repeat this later. There is no uniform opinion on the question, whether the calves shall receive the colostrum by drinking or nursing. There are arguments for both methods. Nowadays suckling of colostrums is advised, and suckling should always be supervised and assisted. For the adequate passive immunity, colostrum intake levels of 2.5 l within the first 6 hours of life and 4 l within the first 12 hours of life can be achieved. If the calf not able to drink or suckle successfully colostrum can be administrated by stomach tube.

As the volume of the calf's abomasum is still small at this time, they should drink or suck 4-5 times a day. You should give to the calf 8-10 litres of milk in the first two days and approximately 35 litres in the first week. The milk offered to drink shall be always udders warm (37-38 ^{0}C). If the cow produces more milk than the need of the calf, the surplus milk shall be added to the milk replacer of the older calves. The milk may be poured to the consumer milk the earliest from the 8th day after calving.

The 5th-6th day after the calving, let drink calves 3 times a day and to ensure a proper transition, start to mix skimmed milk or milk replacer to the colostrum.

Whole milk, for economic reasons is no longer given to calves. To replace the milk, the following options are available:

- drinking a mixture of whole milk and skimmed milk
- drinking skimmed milk complemented with fat supplement
- drinking milk replacer

Several studies confirmed that the 1.8-2.0 % fat milk can be effectively used in calf rearing. Such milk fat content can be produced either by a partial skimming of the whole milk or by mixing the whole milk and skimmed milk in a proper proportion. Let drink calves 6-7 litres of milk mixture a day in two equal instalments between the 2nd and 7th weeks of rearing. On the 8th week the daily ration of mixed milk may be reduced to 4 litres. For drinking the calves you can use bucket or nipple drinker. The calves learn easier the use of the later, but it is much more difficult to clean.

The milk can be offered in sweet and sour form, as well. This latter has several advantages. A digestion physiological advantage is, that the sour milk curdles faster in the abomasum and additionally, such milk is harder to deteriorate, consequently will be less diarrhoea. The sour milk may be used without any risk within 48 hours. The acidification can be made by lactic acid producing bacteria or by some acids. The milk curdling using lactic acid bacteria is more complicated (acidifying bacterial culture shall be produced), than the use of an acid. Even though the milk may be acidified with hydrochloric acid, the use of organic acids (acetic and formic acid) is more effective in respect of the preservation effect. 0.3-0.4 litres of 8 % formic or acetic acid shall be added to 10 litres of milk.

The use of skimmed milk supplemented with a fat product has been a common method on the domestic cattle farms in the last 2-3 decades.

More recently in Europe, such as in Hungary, the milk replacer products, including all the energy, proteins, vitamins and minerals, necessary to grow up calves are widespread. The most important component of the milk replacers is the milk powder made from skimmed milk. Of economic reasons the skimmed milk powder is replaced in increasing proportion by whey powder, produced in different ways (partially sugar-free, sugar-free, neutralized or demineralized whey powder). The proportion of the whey powder in the milk replacer is determined by its lactose content. The partially sugar-free whey powder, containing of 25-30% sugar can substitute a larger part of the milk powder than the whey powder of whole lactose content (68-76% lactose). It is, because the calf lactase production capacity is sufficient to break down of 4.7-5.0% lactose in the milk. The non degraded lactose will be fermented by microbes in the colon (large intestine) and the resulting organic acids, in larger quantities may cause digestive disorders.

There are also of economic reasons efforts, to substitute the milk powder with various plant protein concentrates, primarily with soy isolates. Whereas the stomach of calves 4-5 weeks after birth does not produce either pepsin or hydrochloric acid, so this time they can digest only milk proteins, therefore only a small proportion of these preparations may be used in the milk replacers. Beyond poor digestibility, an additional disadvantage of these preparations is to dissolve worse, than milk powder, so they settle in the milk replacer.

Different fat products were also important components in the milk replacers, in which both animal and vegetable fats (palm fat, cocoa-fat, soybean- or sunflower oil) were represented. Lately, in the EU animal fat sources were replaced by the mixture of coconut, palm and soya oils or the mix of palm and soya oils. Only high quality fat (not rancid) may be used in milk replacers. The use of some antioxidant in milk replacers is obligatory to prevent of becoming rancid. In all milk replacer there are emulsifiers as well.

Considering, that fat-soluble vitamins are also removed with the milk fat, when skimming, milk replacers, based on skimmed milk or whey powder should be complemented with these vitamins (vitamin A, D and E). Composition and utilization of several milk replacer used in Hungary, are summarized in Table 2.

Having finished the drinking of colostrum, it is enough to drink calves twice a day, because the abomasum of a 7-10 days old calf has a 3-4 litres capacity. The milk or milk replacer should have a temperature of 38-39 ºC, except the cold drinking milk replacer. The cold milk may cause digestive disorder. When the calves receive only 3-4 litres of milk a day and eat regularly concentrate and hay, you should change to drink calves only once a day.

Concentrate and hay should be offered the calves from the 2nd week of their life, that they consume solid feed as soon as possible, which is important for the development and early operation of the rumen. 3-4 weeks of age calves consume daily 150-200 g concentrate and 100-200 g of good quality hay. There are favourable feeding experiences with the so called ‘calf muesli’. At this period, calves should be fed starter diet of 18-19% crude protein, which contains high quality proteins (for example: extracted soybean meal) the required mineral and vitamin supplements as well. Calves should be fed with good quality hay, alfalfa harvested in green bud stage or grass hay harvested in early bloom stage (calf hay).

Young calves are very sensitive to outside temperature. Maintenance energy requirement increases by 0.09 MJ/kg $W^{0.75}$ NEm, for calves younger than 21 days, if the temperature decreases by 1 ºC, below 15 ºC. If the temperature decreases below the critical temperature (this is 15 ºC for calves younger than 21 days and 5 ºC after 21 days) energy supply can be increased by giving more milk replacer or increase the quantity of replacer in the liquid feed.

The date of weaning depends on the milk replacer used, the solid feed consumption, and on the variety and type of the calves. Calves of dairy herds may be weaned earlier than those of other types. You may wean the calf, if it consumes daily at least 0.8-1.2 kg concentrate and 0.5-0.6 kg hay. The expectable concentrate and hay consumption are detailed in Table 3.

After weaning calves should keep on consuming starter concentrate for 1-2 weeks, so as not to expose them to more than one change. Then calf-rearing concentrate can be fed.

The post-growing period after the weaning lasts up to the age of 6 months. This time the calves are still having large growth potential, which should be utilized during in rearing period. By the end of this period calves must have of 180-200 kg live weight. To achieve this, a daily weight gain of 800g is necessary after the weaning. It requires that the daily concentrate portion of the calves is increased gradually to 2.0-2.5 kg by the end of the post weaning period. Calf rearing concentrate of 16-17% crude protein shell be fed, which is complemented with good-quality hay and silage. If the farm has a good-quality pasture in the vicinity, the calves may be grazed or fed with fresh forage.

Chapter 6. Nutrition of replacement heifers

The heifer rearing aims to by the end of the rearing period to obtain healthy, trained breeding cattle, with a long useful lifetime and high production capacity. In addition to the animals' inherited abilities, the feeding has a fundamental role. The wrong heifer nutrition reduces the production not only of the first but the further lactations.

The heifers should be fed in a manner that they should be well developed by the time starting the breeding that is to attain the body weight, when they can be taken for breeding without damage. The age of heifers, when starting the breeding, depends on the variety and type. It is, in case of Holstein Frisian heifers of 15-16 months and a weight of 350-380 kg, and that of the Hungarian-Simmental is 18 months and 380-400 kg. The Limousin beef cattle is ready for breeding at the age of 13-16 months and of 360 kg live-weight. In general, heifers should reach 85-90% of mature weight by calving, and they can be served with a target body weight of 55-60% mature weight. On the basis of mature weight of breeds and even in dairy units the weight and weight gain can be calculated to the optimal development.

The heifer rearing period (from 6 months of age till to the first calving), in terms of nutrition should be divided into 3 parts, based on the growing rate and nutrient requirement of the animals. These are as follows:

- from the weaning to 1 year of age
- from 1 year of age to the 6th month of the pregnancy
- from the 6th month of the pregnancy to the calving

If the calf rearing was appropriate till to the weaning, the half year old heifers should weigh 180-200 kg and still have a large growth potential, which should be utilized during the heifer rearing. The heifers development is considered satisfactory, if they reach by 1 year of age 50 % of the mature weight.

For heifers of the above age and weight, the best feed is the good quality grass, therefore heifers should be kept on the pasture from early spring to late autumn. Otherwise, it justifies not only the supply of nutrient, but also the beneficial effects of the pasture on the health, hardiness and strength of the animals. The pasture can cover the heifer nutrient demand, if they can consume 15-20 kg grass daily at the age of half year and 20-25 kg grass at the age of 1 year. Some concentrate supplement is needed, if the grass yield is lower. If there is no pasture, we can cover the nutrient demand of the animals with fresh forage or silages or hay. The pasture or the fresh forage can not always cover the dry matter requirement of heifers. The lack can be replaced by feeding of good quality straw or hay. Even in the case of good-quality pasture, appropriate supply of minerals must be provided.

Hay and silage are the main forage sources in winter. You must not agree with the false conception that of poor quality silage for heifers do well. This also relates to the hay. Heifers, younger than 1 year shall receive concentrate, which may contain urea as well, in compliance with the rules of urea feeding. The amount and the composition of the concentrate depend on the quality and quantity of forages, but the daily portion should not exceed the 2.0-2.5 kg maximum.

After 1 year of age reduces the growth potential of the heifers, therefore the feeding level of the heifers may also reduce. The daily weight gain of the animals is decreasing. Between 12-18 months of age a daily weight gain of 750 g is sufficient, and it should not be higher than 850 g/day in the first 6 months of the pregnancy, including foetus development. Regarding mammary development the critical period is between 3 months to 10 months of age (to puberty). During this prepubertal period feeding level and daily gain above 750-800 g/day should be avoided.

The feeding of heifers older than 1 year shall be based on forages. At this time, the digestible system of heifers - especially the rumen - shall be accustomed to the consumption of large amount forage. Heifers older than 1 year, should graze, if it possible. The good-quality pasture can cover their energy and protein demand, but a mineral supplement shall be provided to them. In the lack of the pasture, their nutrient demand can be covered with fresh forage or conserved forages, as well.

Due to their moderate energy requirement, occasional pastures may be well utilised by the heifers in this period. Among these maize residue is the most important, where the heifers can consume even 6-7 kg of dry matter per day. The protein and mineral demand of the heifers can be met with a small amount of concentrate (1.0-1.5 kg) including some protein feed (for example: extracted rapeseed or sunflower meal) and mineral supplement.

It is the silage the most important feed in winter, which can be produced of whatever good-quality roughage (silage maize, sorghum, other cereals, sudangrass, grass, legumes, etc.). Depending on the silage quantity, 1-3 kg of hay should be included in the daily ration. Concentrate feeding is not necessary until the 6th month of the pregnancy. It may be only the case, if the pasture is poor quality, or if the daily ration, consisting of hay and silage does not cover the needs of the animals, or if mineral supplementation can be fed only with some concentrates.

The foetus development increases the nutrient requirement in a great extent from the 6th month of pregnancy, which makes it necessary to feed some concentrate or to increase its previous dose. It is also the reason of the concentrate feeding at that time, that not only the products of conception (foetus, amnion and amniotic fluid), not just the uterus retention, but also the maternal retention (maternal energy and protein reserves, developing of mammary gland) require nutrients. However, the quantity of concentrate should not be increased by such an extent that results in obesity of the heifers or calving difficulty. The daily concentrate dose between 8-4 weeks before calving shall be 1.5-2.0 kg, which may be increased to 3.0 kg in the last 4 weeks of the pregnancy. The latest increase of the concentrate dose is intended not only to meet the increased nutrient requirements, but also that the rumen habituating the larger amount of concentrate, than for cows as well. 10-14 days prior to the expected calving let us move to the feed ration which will be consumed by heifers after calving. This helps us prevent post calving feed change and the decline of food consumption.

Chapter 7. Nutrition of dairy cows

The cows milk production has increased significantly by the introduction of modern selection procedures, enrichment on knowledge of nutrition and the resulting improvement in housing in the past two decades in our country. This is also demonstrated by the date of the Table 4.

The milk production is a high burden on the organism of cows especially, having high yield. A cow producing 9000 litres of milk during the 305 days of lactation, outputs about 1100 kg dry matter, which is of a 650 kg cow body dry matter to 7.5 times. The load is even more pronounced in the first trimester of the lactation, when a cow producing 40-45 kg milk per day, gives off in the milk 4.9-5.5 kg dry matter. The significant production of this cow meets very good energy efficiency, as the efficiency of utilization of metabolisable energy in milk production is in average of 63% (k_l=0.63). In favour of the cows it should be also noted that this high energy efficiency is achieved by feeding partly roughages of less energy content than concentrates.

1. Nutrition of cows during the lactation

The cow milk production is changing during the lactation. The difference between the daily milk production on the peak and the last period of the lactation may be 25-30 kg, even for cows of good persistent. After calving the cows milk production is increasing rapidly. Cows, calved several times reach peak milk production in the 5-6th week of lactation, while the heifers in the 6-8th week of lactation. Subsequently, the milk production remains at about the same level a few weeks and than declines gradually, depending on the persistence of the cow. After the 7th month of the pregnancy cows shall be dried up.

The lactation should be divided into three periods in terms of nutrition. *The first period lasts till to the 11-13th week of the lactation*. This is the most critical period of the feeding, not only because in this period there is the highest milk production, but also because the dry matter intake of cows is not keeping pace with the milk production increase, which makes to meet the nutrient requirement of the cows difficult. As a result, in the first 6-8 weeks of the lactation, the feed consumed does not cover the energy needs of the cow. The resulting energy deficiency may reach 25-30 MJ/day, which is equivalent to the energy requirement for the production of 8-10 litres of milk.

The feed consumption of cows depends on several factors. One of them is the feeding of the cows during the dry period. There is detailed information about the feeding during the dry period in the chapter 7.2.

Another important factor can be the fatty acid composition, above all, the acetic acid content of the silage. A consumption of larger quantities of silage can only be expected if the acetic acid content does not exceed 30 % of the total fatty acid content. The amount of the butyric acid does not affect the silage intake, however, the ammonia and certain amines from protein decomposition reduce it. The moulding reduces the intake of hay. Increased fibre and lignin content of hays due to late harvest also decline the intake. Cows consume less the leaf-poor legume hays than, too.

The cows make up the missing amount of energy by the mobilization of the body reserves, especially of the fat reserves. Cows lost some of their weight. In this context it should be noted, that the weight of the cows in the period after calving would also decrease, when their energy needs could be covered. This is explained by the fact, that while during the pregnancy the anabolic processes dominate due to the maternal (extra-uterine) retention, after calving the catabolic (depleting) processes start. The feeding must maintain weight loss within limits, prevent excessive weight loss. If the weight loss is not higher than 0.8-0.9 kg/day in the first 50-60 days after calving, than the total weight loss of about 40-55 kg is not associated with animal health risks, does not impair the reproductive performance. However, if the daily fat mobilization is higher than 1 kg, large amounts of ketone bodies are formed (beta-hydroxybutyric acid, acetone, acetic-acid), that the body in the absence of sufficient amount of oxalic acid can not break down, leading to ketosis.

Moreover, it is also important that the period of mobilization body reserves shall be as short as possible. According to the experiences the chance of successful insemination is small during the weigh loss period. Its consequence is the longer parturition interval, which reduces the profitability of this sector.

One possibility for reducing the weight loss is that a ration of high energy concentration should be fed (at least 6.8-7.0 MJ/kg dry matter NEl), at this period of lactation. However, this high energy concentration should not be achieved by feeding high quantities of concentrate, because it deteriorates the structural efficiency of the ration. This can be avoided if at least 45% of the ration dry matter derives from roughages (silage, hay) of appropriate structural efficiency (supporting adequate chewing and rumination). Otherwise saliva production reduces, the pH of rumen fluid decreases, rumen fermentation conditions deteriorate, resulting in less fibre degradation in the rumen and a decrease in the microbial protein production. This implies that there is no adequate milk production increase during in that decisive period of lactation production.

A correct supply of fibre is also important in regard with the milk fat content. The C_4-C_{10} chain length fatty acids of milk fat are synthesized in the mammary gland epithelial cells from volatile fatty acids, first of all from acetic acid, generated during the microbial fermentation of carbohydrates, including fibre. The longer chain fatty acids ($>C_{10}$) in the milk fat are formed only in a small proportion of rumen fatty acids, most of them is created from the feed as well as by "de novo" fat synthesis. Overall, about 65% of milk fatty acids originate from the volatile fatty acids generated during the rumen fermentation. As acetic acid arises in the largest quantity in the microbial degradation of fibre, the supply of fibre for the cows is essential in the view of the milk fat content. Therefore, the characteristic fat content of milk only than can be expected, when the feed dry matter consists of 16% crude fibre in this period of lactation, as well.

The importance of crude fibre is also supported by the fact, that volatile fatty acids formed of crude fibres are of fundamental importance, next to milk fat synthesis, in ruminants energy supply. More information about this issue can be found in the chapter 1.2.1. .

In the conditions, that the feed dry matter consists of at least 45 % forages, the ensilaged forages, primarily corn silage play an important role in the diet. High quality silage of favourable fatty acid composition (corresponding lactic acid:acetic acid ratio), of which the cows consume from 7 to 10 kg dry matter, can be made only of maize of a dry matter content of 35-38 %, with high grain content, in dough stage. Good quality silage can be produced from sorghum or sweet sorghum. There are positive experiences of the so called mixed silage, made from a mixture of maize and silage sorghum. The good quality grass and alfalfa silages or haylage are also suitable for covering the roughage demand of the ruminants.

The hays of good quality and rich in leaves have an important role in the ration structural efficiency. In this respect, the grass hay harvested in due time is equivalent to alfalfa hay.

To increase the ration energy concentration, bypass fats can also be used. They eliminate the unfavourable impact of fats and oils, coating on the feed particles like the film and decrease the microbial degradation of feed in the rumen, primarily to the fibre degradability. The fat sources contain the more unsaturated fatty acids the more pronounced this effect is. Moreover, the polyunsaturated fatty acids are also harmful, because they reduce the milk fat synthesis in the udder. Two types of bypass fat products are marketed: hydrogenated fats and Ca-soaps. The former has higher rumen stability but the adverse effect of it is that increases the proportion of saturated fatty acids in the milk, changes the consistency of butter, as well. The Ca-soaps stability in the rumen is slightly weaker than that of hydrogenated fats, but they have no adverse effect on the fatty acid profile of the milk. Additionally, by a good choice of fat source Ca-soaps can improve – approaching fatty acids to the human demands - the nutritional value of milk fat.

It should, in principle be accepted, that the fat content of the cows daily ration shall not be higher, or not much more than 1000 g. Since the average daily ration of a cow, weighing 600-650 kg, contains from 400 to 450 gram of fat, so the amount of fat intake with the bypass fat should not exceed 600-700 grams. A good quality (good rumen stability) bypass fat substantially improves the energy supply of cows, which helps to decrease the extent and the duration of weight loss of cows.

It is not an easy task to satisfy the protein requirement of dairy cows in the first period of lactation, since the cows protein requirement can not be met by increasing the protein content of the ration, because it will decrease, beyond a certain amount the breeding results. Indeed, increasing the protein content of feed increases the NH_3-content of rumen fluid and thus the plasma urea content, which reduces the fertility results (Table 5.). The possible solution is, that while increasing the ration protein content in a smaller extent, the feed protein degradation in the rumen shall be reduced. In this case the increasing protein content of the feed does not increase, or only slightly increases the NH_3-concentration of rumen fluid.

It is about 70 % of crude protein of a daily ration that is degraded by the rumen microbes. When the daily milk production is more than 30 kg, the rumen degradability of the feed protein shall be reduced to 58-65%. This can be achieved by feeding protected (bypass) protein, or a feed with significant bypass protein content of the protein in the rumen (e.g. corn gluten). The rumen degradation of the protein can be changed by heat-treatment, by using some chemicals or with the combination of the two procedures (applying heat in the presence of chemicals). The feeding value of a bypass protein depends not only on its rumen degradability, but its post-ruminal digestibility and amino acid profile, too. The feeding of a high quality bypass protein product has a positive impact, in addition to increasing the milk yield and in a less extent the milk protein content, on herd reproductive status by providing the metabolizable protein for the cows, that the rumen ammonia content and the plasma urea content is not increasing at the same time. The data of Table 6. demonstrate the beneficial effect of feeding bypass proteins on the reproductive results. If the diet involves bypass protein, more than 17-18% protein of DM is not necessary in the daily ration.

The limiting amino acid of microbial protein is the methionine. Since the cattle have a lot of feeds, containing low methionine level, it is not uncommon that a shortage of methionine supply limits the milk production. However, the methionine supplementation can only bring positive results if it escapes rumen fermentation.

Chemically treated, as well as rumen-insoluble products in form of coated tablets are equally suitable to improve the methionine supply for cows and thereby to increase the milk production (Table 7.).

As far as the rumen protein balance is concerned, efforts should be made at this period of the lactation that the balance is slightly positive (+100-150 g/day). As already mentioned earlier, this is favourable in terms of dry matter intake, which is essential in this period of lactation. However, a larger excess of protein should be avoided to prevent deterioration of the reproductive performances.

The 2nd period of the lactation lasts from 11-13th week to 24-28th week after calving. The milk production is decreasing during this period, only a small extent in the high yielding herds. The majority of cows of high yielding herds spend this period of lactation on ‘high yielding ration’, in the high yielding group. Whereas, the feed consumption relative to milk production is good, it is possible that cows compensate the weight loss during the 1st period of lactation. It is available in 3-4 months, a daily weight gain of 250-300 g is acceptable. However, cows over conditioning should be avoided. For high yielding cows the feeding of less-than-average degradable protein in the ration can be justified, which may require the use of bypass protein, as well. Cows may need bypass fat supplementation, too.

In the case of low yielding cows the milk production is decreasing gradually in this period, so it is possible to decrease the feeding level in accordance with the milk production. This reduction should be realized by reducing the concentrate and increasing the roughage proportion in the daily ration. However special attention should be paid to provide nutrients for replacing the weight loss of previous period.

The milk production is substantially declining in *the third period of the lactation, which lasts from the 24-28th week of lactation to the dry off*. At the same time, the feed consumption of the cows allows the intake of more nutrients than their requirement based on milk production. This offers cows the opportunity to build up their body reserves for the next lactation. Experiences have shown, that energy utilized better, if these reserves are replaced during the third period of lactation than in the dry period. Indeed, when cows get the excess nutrients during the dry period, it integrated into the foetus, whereas the foetus takes priority of the mother body. This entails a risk of increased calf weight, which may increase the number of difficult parturition.

An other reason is for replacing the reserves in the last period of the lactation, that the cows utilize the nutrients with better efficiency for gain, if milk is also produced. This has also the advantage, that reserves can be cheaper incorporated (fewer nutrients are required).

Whereas we are going to provide nutrients to reserve for the next lactation, the energy and protein supply shall be moderate in this period. This can be achieved by reducing the amount of concentrates in the daily ration. The proportion of the concentrates dry matter in the total daily DM intake should not be higher than 15-25 %. This is met, when the ration dry matter contains about 6.0 MJ NEl/kg. The decreasing milk production allows that the combined protein requirements of the milk production, the building of the foetus and the reserve can be covered by the amount of crude protein of 12-14% of the dry matter.

The rumen protein balance is ideal if it is 0, so the MPN and the MPE values are equal. This balance might be negative in the case of cows with lower milk yield, even though the cow metabolizable protein requirement is met. If this deficiency is not larger than 30-40 g, the urea nitrogen getting by the rumen-hepatic circulation into the rumen can cover it. A decrease in feed consumption can be prevented by adding urea or some extracted sunflower meal with high rumen degradable protein content to the concentrate.

Nowadays the loose housing, group feeding system is quite widespread in dairy units, cows are grouped according to milk yield, days on lactation, condition etc. One cow group consume the same ration, feed mixture, which is formulated to cover the nutrient requirements of cow group. Cows are fed with total mixed rations (TMR), concentrates, forages and roughages are mixed together and distributed by mixer. The number of groups depends on several factors (production level, number of cows, housing conditions). If there are more groups, it becomes possible to form more homogenous groups. The place of cows should be changed based on the results of check milking. Cows, whose production is lower than the lower limit of the group, should go into lower yielding group. However, the cows' condition is taken into consideration in the decision process beside the production level.

2. Nutrition of the cows during the dry period

The dairy cows have to be dried off in the 7th month of pregnancy. If the milk production is only 5-10 kg/day at this time, it can be terminated within a few days by a gradual reducing of the milked milk, omitting milking and reducing the daily feed ration. A complete withdrawal of the feed and of the drinking water may be necessary, next to the above mentioned measures in the case of high yielding cows (15-17 kg/day).

The 60 days dry period shall be divided into two phases, regarding to nutrition. The first period lasts from the start of the drying off until two weeks prior to calving. This period is considered for recovering. This time, cows should be provided only with the nutrients necessary for maintenance and the developing foetus. Excess nutrients will fatten the cows, increase the birth weigh of calf and the number of calving difficulties. The over condition of cows during the lactation or dry period results in a metabolic disease called 'fat cow syndrome'. One consequence is that cows tend to consume less feed, which increases the energy deficiency that is otherwise characteristic for the post calving period. Furthermore, the fat cow syndrome is inherent to reduce the resistance of cows becoming more susceptible to diseases.

For the purpose of building up the foetus cows require as much energy as for the production of 3-4 kg milk. Accordingly, a pregnant cow, weighing 600-650 kg needs 55-58 MJ NEl/day (40-43 MJ for maintenance and 12 MJ for developing foetus), which can be covered only by forages. The majority of the cows do not require concentrate in this period. The previously high producing cows may receive some concentrate (maximum 1.0-1.5 kg/day), which had a lot of milk when drying them off and thus they are in a poor condition.

The protein requirement is covered by the crude protein of 12% of the dry matter. The rumen protein balance is often negative during the dry period, because of the protein requirement of the rumen microbes is larger than that of the cow. The missing N is mostly covered through the rumen-hepatic circulation. A high feed intake is not a goal in dry period, thus a smaller rumen deficit is not a problem, if the protein (MP) requirement of the cows is met.

The rumen should be got used gradually to the concentrate in the last two weeks of the dry period. Indeed, the energy requirement of high producing cows can be covered only by feeding large amounts of concentrate (often 10-12 kg/day), in the first period of lactation. Feeding of such a large amount of concentrate a different composition of microbial population develops in the rumen in comparison with feeding a ration of high fibre and low starch and protein content. To changes in microbial population there are at least 10-14 days necessary. So, feeding of concentrates in the last 2 weeks of the dry period is not necessary for the building up of the foetus but partly because of the adaptation of rumen microbes. Otherwise the feed intake of cows decreases dramatically one week before parturition from 1.8 % of body weight to 1.2 %. This means for a 650 kg cow, that dry matter intake falls from 11.7 kg to 7.8 kg. Some cow consume even less than it. Feeding concentrates increases the energy concentration and compensate some of the energy deficiency due to feed intake depression.

In a lot of dairy units close up group (2 weeks before calving) is fed 30% of the ration (TMR) of high yielding cows and grass hay available ad libitum. Dry cows consume 6 kg TMR dry matter including 3 kg concentrates, in this way.

3. The effect of feeding on the quality of milk and milk products

Feeding affects in many ways the quality of milk and dairy products and consequently, its nutritional value. The feeding has effect on milk composition, taste and colour, butter fatty acid profile, colour and consistency, as well as the quality of hard cheeses.

Out of the milk nutrients it is the fat content the most effected by feeding. It is due to the previously mentioned fact (chapter 7.1.) that during the ongoing fat synthesis in the mammary gland epithelial cells, about 65% of the constituent fatty acids in the milk fat, derives from volatile fatty acids, generated during microbial degradation of carbohydrates - mainly fibre - in the rumen. Therefore it was emphasized in the already mentioned chapter that the ration dry matter should also contain about 16% crude fibre in the first trimester of lactation, - when cows frequently fed more than 10 kg concentrate. It is also important, that at least 75% of crude fibre should be the so called structural fibre, resulting in sufficient chewing and rumination. This is an important condition for satisfactory salivation, for optimal rumen pH, without which there is no active rumen fermentation, and thus not adequate fibre degradation.

A large portion of concentrate can reduce the fat content of milk by narrowing the acetic:propionic acid ratio in the rumen. This effect can be prevented by feeding rumen buffers, because the buffers of alkaline components ($NaHCO_3$, MgO) increase the acetic acid production in the rumen.

The milk fat content is also influenced by the fats of the feed. If you feed more than 4% fat in the diet, rich in unsaturated fatty acids, the fat content of the milk decreases. This is the consequence that such fat impairs the microbial activity, and thus reduces the cellulose degradation in the rumen. By feeding good quality bypass fats, this effect can be avoided.

In addition, nutrition can influence the fatty acid composition of milk fat and butter as well. This is, because after the absorption of fatty acids the intestinal epithelial cells start the formation of triglycerides (triglyceride resynthesis), which triglycerides get via the lymphatic vessels and thoracic cord into the general circulation. Consequently, they have the possibility of reaching the mammary gland epithelial cells circumventing the liver and hereby affecting the milk fatty acid composition. It is well known, that certain feedstuffs (maize, sunflower- and rapeseed cake) soften, while others (hay, wheat and rye) harden the consistency of the butter, and it is related to the different fatty acid composition of the feedstuffs. The high unsaturated fatty acid concentration in dietary fat softens the fat in the milk and the texture of butter. In contrast, the predominance of the saturated fatty acids results in a harder consistency of the butter.

By feeding of bypass fat, the fatty acid composition of milk fat can be consciously converted, approached to the human needs. The dietary Ca-soap of favourable fatty acid composition and rumen stability can reduce the saturated fatty acid content of the milk fat (Table 8.). This possible change is important, because of the high saturated fatty acid fraction of the milk fat (often above 70 %) is repeatedly criticized.

Several experiments were carried out to increase the n-3 fatty acid content of milk. These experiments brought far more modest results than those, aiming to alter the fatty acid composition of the fat in products 8meat, eggs) of the monogastric animals. This is partly explained by the microbial hydrogenation processes in the rumen and on the other hand by the impact of some PUFA fatty acids on the fat synthesis in the mammary gland epithelial cells.

The feeding is influencing to a lesser extent the milk protein than the fat content. As it was mentioned in the chapter 1.2.3.2., the major part of the cows' protein requirement is covered by the microbial protein, synthesized in the rumen. Therefore the protein content of the milk can be raised by covering the energy demand of microbial protein synthesis that is to increase energy supply for dairy cows. With regard the feeding of fat supplements and bypass fat it should be noted, that rumen microbes can not utilize the energy of bypass fat, they only represent a source of energy for the cow.

The milk lactose content can not be changed by feeding following from its function in the regulation of milk osmolalrity. If there is not enough glucose available for the synthesis of lactose in the mammary gland epithelial cells, the quantity of milk will be less, because the milk sugar content should not be reduced.

The Ca and P content of the diet do not affect the Ca and P content of the milk. However, the Mn, Zn, Co and I content of the milk depends on, what quantities of these elements occur in the feed.

The vitamin A and carotene content of the milk is highly dependent on the state of carotene supply of the cow. This clearly demonstrates the carotene content of the milk produced in summer or winter on the farms that fed fresh feeds in spring and summer. In such cases the difference between the vitamin A content of the milk produced in the summer or winter months may excess of 1000 IU per litre.

The vitamin D content of the milk is determined not by the feeding but by the housing. Where the animals go to pasture or staying in a sunny paddock, the ultraviolet rays of sunlight causes the formation of vitamin D3 from

7-dehydro-cholesterol, which covers the requirement of the animals, resulting in higher vitamin D content of the milk, too.

Although vitamin E content of the milk may be increased by feeding, but the conversion is inefficient.

Vitamin B group is supplied by the rumen microorganisms in quantities necessary for the host animal, so the feeding has not got any effect on it.

Certain feeds, fed in larger quantities, give the milk a bad taste. For example: alfalfa, red clover, vetch, rye, oat, French rye-grass, (Arrhenatherum elatius), Thimothy-Meadow (Phleum pratensis) give bitter taste in the milk. Sugar beet leaves of daily 35-40 kg, give fish taste due to the betaine content of the head of beet. Certain weeds: e.g. wild garlic (Allium ursinum) wild chicory (Cichorium intybus) horsetail and marsh-horsetail (Equisetum arvense and palustre), shepherd's bag (Capsella bursa-pastoris), may also cause unpleasant taste. However, the listed weeds can only cause a bad taste in the event of grazing weedy pasture or forest edge. Therefore, in well managed operations, the taste impairing effect of these plants is not expected.

Feeding silage, in case of unsatisfactory milk production hygiene, may deteriorate the microbiological status of the milk, that hamper the high quality hard cheese production. The silages - mainly produced from legumes - depending on the quality, contain more or less butyric-acid producing bacteria. Their number in the poor quality silage can rich a value of 10^7/g. Under substandard milking hygiene, part of these bacteria can get into the milk. Because they are spore-forming bacteria, thus they were not killed by milk pasteurization. The spores, incorporated into the cheese material, cause by their production of gas, bloating of the cheeses during maturation. This problem has caused more damage to the dairy industry, when milking was performed in the barn and the milk was also staying there for a while. Nowadays, becoming common place the modern milking, this error occurs considerably less frequently.

Chapter 8. Cattle fattening

The basic goals of cattle breeding are to produce, in addition to milk, another valuable animal food product: the beef. The beef, containing 20.5% protein and only 5.7% fat is a popular food, from which the annual per capita consumption is 3.5 kg in our country. It means, that the beef, after the pork and poultry meat the third most requested meat. The red light, tender, marbled beef is on the demanding foreign markets also a searched, marketable product. The production of such goods requires not only suitable raw material for fattening, but a feeding satisfying the nutrient requirement of animals in all respects. Beef can be produced on diverse manner, like: fattening of calves, heifers unsuitable for breeding and young bulls, as well as upgrading (conditioning) of culled cows.

1. Calf fattening

Veal is searched on the markets of developed countries. The traditional way of fattening the calves is the so called ***milk-fed calf*** . The fattening was performed earlier with whole milk, later on with a mixture of skimmed milk and whole milk, and today, where farmers fatten calves, milk replacer is used. Skimmed milk itself would only be suitable for fattening calves, if there was on the market fat product, supplemented with fat soluble vitamins. When fattening the calves with milk replacer, compared to normal calf rearing, a 10-15 % increase of the milk and a 1-2 % increase in the quantity of replacer added to the liquid, is necessary, so as to achieve a daily weight gain of 1000-1200 g. The desired final weight of 120-140 kg can only be achieved by that daily weight gain at an age of 8-12 weeks.

To reduce the cost of fattening, it is possible to feed hay and concentrate with the calves beside the milk replacer. However, this extends the duration of fattening by 3-4 months. The volume of milk replacer can be reduced proportionally with increasing concentrate consumption by the 10th week. Calves may consume hay of good quality, too, but let the quantity of this not be over 0.2-0.3 kg/day, so not to decrease the energy concentration of the ration. The calves fattened on milk are marketed in 140-180 kg of live weight.

2. Fattening of growing finishing bulls

The largest share of beef is produced by fattening of growing bulls in our country. These animals have high growth potential, and therefore a large proportion of their weight gain is muscle. The live weight, at which bulls start to deposit larger amounts of fat, is determined by the breed and the type of the animals, feeding has less effect on it. It follows, that the carcass quality and the nutrient utilisation of the animals is greatly affected by the appropriate slaughter weight.

The majority of the Hungarian cattle stock is *Holstein Frisian*, which reaches in juvenile growth vigour and weight gain, in some cases even exceeds the beef breeds. However, in terms of carcass characteristics, as well as tenderness and marbling of the meat, beef breeds precede the Holstein Frisian. The maximum slaughter weight of Holstein Frisian growing bulls should be 500-520 kg, because of the start of a strong tallow formation.

The *Hungarian-Simmental* growing bulls continue to maintain longer the high growth vigour than the Holstein Frisian, the tallow production increases only later. Therefore, it is possible to fatten these animals to the live weight of 550-600 kg with good results. The Hungarian-Simmental breed precedes in meat quality the Holstein Frisian, too.

There are in small number beef cattle breeds in Hungary, as well. There are among them early (Aberdeen Angus, Hereford) and late maturing (Charolais, Limousin) types. All are typical of excellent carcass quality, meat:bone ratio and good meat quality.

Two methods have been developed for fattening growing bulls, which differ in the level of feeding. One of them is the ***traditional method*** , when the energy concentration of the daily ration is about of 4.2-4.4 MJ NEg/kg dry matter. This energy concentration allows a daily weight gain of 900-1000 g, if it also contains the required amount of protein, minerals and vitamins.

During the ***intensive fattening*** bulls consume a diet containing of 4.8-5.0 MJ NEg/kg dry matter. In this case the daily weight gain reaches 1200-1400 g.

The energy concentration of the diet depends on the forage:concentrate ratio in the ration and the quality of the feedstuffs. A lot of concentrate can be saved by feeding of good quality forages.

The most common of them are the silages. Corn silage is the most important in Hungary. From the maize, ensiled with a dry matter content of 35-38 % in dough stage, a good quality silage of favourable lactic acid:acetic acid ratio, and 4.2-4.4 MJ NEg/dry matter kg can be produced, from which the bulls of 400-450 kg are willing to consume 5.7-6.8 kg dry matter. This implies that the acetic acid content in the silage should not exceed 20-25% of the total organic acid content. Furthermore, silage of good quality can be produced from sorghum or sweet sorghum, and from the mixed grown maize and sorghum. In the case of sorghum, it has to be taken into consideration, that if its DM content is higher than 30-32%, its fibre content increases rapidly, which decreases the digestibility of nutrients and thus the energy concentration, too. The mixed silage (maize and sorghum) ensiled with 31-32% dry matter, has about 3.3-3.5 MJ NEg/kg dry matter. The whole plant cereal silages harvested in dough stage contain about 2.6-3.0 MJ NEg/kg dry matter. The NEg concentration of grass silages and pre-wilted silages is of 2.8-3.0 and 2.9-3.2 MJ, respectively. Among the roughages the wet sugar beet pulp should also be mentioned, which has a higher energy concentration (5.0-5.1 MJ/kg DM) than the maize silage and thus good fattening results can be achieved with it.

Several studies and practical experience show that feeding of good quality silage alone is also good for fattening, namely that the weight gain corresponds to that of conventional method for fattening. According to the energy concentration of the mentioned silages, the highest weight gain can be achieved by feeding maize silage or beet pulp. In the case of other silages due to their lower energy level, the weight gain of growing bulls is smaller by 5-39% (Table 9.).

Naturally, silage feeding alone does not cover the protein, mineral and vitamin demand of animals. Therefore some protein feed, mineral and vitamin supplements shall be also fed with silage.

In principle there is no obstacle to feed fresh forage with the bulls. However, the fresh feed should not be often changed, because of the at least 10-14 days adaptation time of the rumen microbes to the new feed. The young bulls may receive all fresh feeds that are fed to cows or heifers, if the available amount of silage is insufficient, but when determining the amount of the ration some special effects of the fresh forages shall be considered (bloating effect of the legumes, durrin content of sorghum, glukozinolate content of cruciferae).

When feeding green grass the protein requirement, when feeding legumes the energy requirement can not be met. The deficit shall be replaced with concentrates. Its composition should be adjusted to the green forage fed.

To increase the daily weight gain and the better utilisation of the genetic potential of the animals, in the knowledge of the performance of the animals, increase the energy concentration in the ration can be increased by feeding concentrates. Both experimental results and the practical experience have shown that the concentrate feeding increases the weight gain (Table 10.). According to some experimental results it is enough to supplement the roughages with concentrate in the second half of the fattening. The weight gain of these animals is only slightly lower than that of the animals fed with concentrate during the whole fattening period. This is so, because concentrate supplementation in the second half of the fattening results in a better weight gain, than a diet containing concentrate during the whole fattening period. The physiological reason of this is that animals after a nutrient supply lower than that is suitable for their genetic potential try to compensate by an above-average growth the consequences of inadequate nutrition in the normal period (compensatory growth).

Corn cob mix silage and husk-corn-cob mix silage can be used with good results for fattening growing bulls. Using these silages, feeding cost can be saved because of lower preservation cost.

Similar to the dairy cows nutrition, the diet of growing bulls may be supplemented with fat. Natural fat can be fed only to a limited extent, bypass fat can be used in higher quantity in the ration. For more information on fat supplement see the chapter on feeding dairy cows. (chapter 7.1.). Fattening bulls require less bypass fat supplement than that of the dairy cows due to they lower energy demand.

The metabolizable protein (MP) requirement should be met, because deficient protein supply reduces feed intake, and thus energy supply. The MPE requirement of animals of high growth potential is covered easier than that of the MPN. Urea as protein supplement can be used with good results. Using of retarded urea is not only safer but results in better N-utilization.

The rumen protein balance shall always be calculated. The deficit must not exceed 30-50 g, because of higher deficits can not be compensated by the rumen urea-N of rumino-hepatic circulation.

The fibre supply of growing bulls does not cause any problem in contrast to dairy cows in the first third of lactation. The bulls require fibre only for adequate rumen activity, saliva production and the active rumen movements. 13-14% crude fibre in the DM meets these requirements.

Good fattening performance can only be expected, if the vitamin and mineral requirements of the animals are also met. Concerning minerals, not only the Ca and P but also the Mg, Na, Cl and the microelement requirements should be respected. The data for requirement are given in the Codex Pabularis Hungaricus. The feed industry produces a wide range of mineral and microelement premixes.

The supply of vitamins A and D should be controlled, first of all in the winter months.

3. Heifer fattening

The heifers for some reasons unsuitable for breeding are fattened. It should be anticipated, that heifer fattening performance is poorer, the daily weight gain is 20% lower than that of bulls. It is, because heifers deposit tallow earlier and produce of it more than the bulls.

If a heifer calf turns out to be unsuitable for breeding, it is advisable to start fattening in a weight of 180-200 kg. Heifers fattening differs from that of bulls, because heifers receive more forage and less concentrate in the ration. Concentrate feeding of more than 2-3 kg is not recommended to avoid excessive tallow production, because it reduces weight gain, impairs feed conversion as well as carcass quality. The slaughter weight of fattened heifers is less than that of the bulls, due to the earlier tallow production. The fattening of dairy heifers to 350-400 kg weight and the Hungarian Simmental heifers to 450-550 kg weight is still profitable.

If a heifer turns out only at the time of breeding maturity, weighing 420-450 kg, that for breeding is excluded, it should be only pursued to improve its condition and thus the carcass quality. The condition improvement can be done by feeding a lot of forages and less concentrates. Grazing is also suitable for condition improving, just as in heifer fattening.

To increase the number of calves for fattening, heifers, suitable for inseminating but unsuitable for production, having once calved will be upgraded and sold for slaughtering. The daily ration shall consist of forage ad libitum and maximum 2-3 kg of concentrate.

4. Fattening of cull cows

Dairy cows are disposed because of poor production or of animal health reasons. The culling usually takes place at the end of lactation, and thus they are in general in poor condition. These animals can be sold for slaughtering only after proper conditioning. This shall be started as early as the last trimester of the lactation, until the animals are producing milk, so the efficiency of building reserves is better, and the conditioning is cheaper. Some cows which are open for a long time show extremely good condition, and there is no need for fattening.

When upgrading, the energy requirement for maintenance and the actual milk production is increased by up to 20%. Higher energy supply will only increase the amount of abdominal tallow. The cows should get the surplus energy by consuming more forage. The concentrate quantity should be 1-2 kg more, than that the animals milk production would justify.

When the upgrade fattening begins after lactation, it more forages should be fed, and the amount of concentrate should not exceed 2.5 -3.0 kg per day.

The result of the upgrading is that fat deposits among the muscles fibres, while the animals weight increases by 100-130 kg. Accordingly, animals may be sold on a higher price.

Chapter 9. Nutrition of beef cattle

1. Beef cow nutrition

A beef cow is expected to get a calf every year and enough milk to grow up the calf. As a beef cow annual production is a calf weighing 180-220 kg, low cost feeding is an important condition of economic viability. It can be achieved, when the cows graze as long as possible and the grass not grazed, used as winter feed in the form of hay or silage. The economy is also subject to feeding a lot of by-products.

A cow and its calf feeding in the pasture require, depending on its quality, about 1.0 ha. In case of a 7 months pasture and 5 months winter feeding, about 60 % of the grass yield is utilised by grazing and 40% preserved as hay and silage.

When spring calving, cows are on the pasture in the period of suckling and mating. This is advantageous, because this time grassland completely or mostly covers the nutrient needs of suckling cows. But in months July-August, the majority of non irrigated home pastures burn out or have a very low yield, that the cows require additional feed. This can be prepared in advance by temporary pastures (such as corn silage, Sudan grass). In case of sufficient grass yield that crops may be preserved by ensiling.

The beef cows grazing shall be extended to cover autumn months and depending on the weather even the first weeks of the winter. Feeding of the maize pasture or of the maize residue provides good opportunities. In lucky case (when little snow falls), cows may spend the major part of the winter on the maize residues. Várhegyi et al (1984) reported that the cows could intake 9 kg dry matter on the maize residue-pasture right after the grain harvest, which supplied 700 g crude protein and 50 MJ NEm for the animals, and thus their energy and protein requirement was covered. It should be noted, that the nutritive value of corn stover over time is reduced.

If the unit does not have corn residue-pasture or the winter weather does not permit the use of it, grass silage, haylage or grass hay derived from the pasture, as well as other forages (maize, sorghum, alfalfa silage or haylage or straw) may be the main components of winter feeding.

Farmers should pay special attention to the cow winter feeding, if the calving period is in late winter or in early spring. In this case the last period of gestation falls to the winter feeding period, in addition to corn residue grazing additional feed can be fed. An excellent feed is the fermented wet sugar beet pulp (if there is available), but cow can be fed a well made leafy sugar beet head silage, too (where sugar beet is grown). The by-products of starch or alcohol production, where available, can also be used.

It should be emphasized that even a good pasture does not meet the animals requirement concerning all the necessary minerals. This is even more valid, regarding the feeding of by-products. If the cows are also fed concentrate, the mineral supplement can be solved with the concentrate feeding. However, when the cows are only grazing, other ways should be find to solve mineral supply. Such a method may be the use of salt lick including minerals. An other one is the use of pasture premix, which contains next to minerals as a carrier grain meal or bran and may be fed ad libitum. Lick blocks are also available for fattening animals. They are different from salt lick containing some kind of cereal meal and milling industry by product.

The cows A and D vitamin demand can only be satisfied in winter by feeding supplement, e.g. mineral and vitamin premix.

2. Calves nutrition

The rearing of calves should be managed in a way, that utilising their growth vigour they reach 180-220 kg weaning weight, depending on the breed. Cows' milk production covers the calves' nutrient requirement in the first 3-4 weeks after calving. But later on additional feeding shall be provided that the calves growth and development is to be unbroken.

The milk yield of beef cows is influenced by the breed to a large extent. The milk production of the Hungarian-Simmental and the dairy cross-breed herds is adequate or even substantial, for the growth of calves. Cows of beef breeds do not produce enough milk for the calves in some cases.

One month old calf should be made possible to eat concentrate and hay. These feeds should be placed in the calf nursery, so that the cows do not eat them. As long as the cows milk production is satisfactory the concentrate may consist of a mixture of cereals. However, a little protein supplements (extracted sunflower or rapeseed meal) is necessary if the milk production declines steadily. Calves 3-4 months of age shall consume significant amount of fresh forage.

3. Feeding of beef heifers

The feeding of beef heifers is determined to a large extent by that the calves are taken for breeding aged around one year or two years of age. Using either methods, there are arguments for and against. The advantages to start breeding in two years of age (23-25 months) are the increased weaning weight, less calving difficulties, and the higher proportion of heifers pregnant again. In contrast, the lifetime production is higher of heifers served around one year of age, expressed in calf weaning weight.

Earlier, it was the general practice in the beef production to start breeding in an age of two years (first calving in 3 years of age). To this age heifers certainly reached necessary maturity and weight for breeding. This method is less demanding on feeding as well. When breeding late maturing, large beef cattle, even today it is widely used.

Starting the breeding at around 1 year of age is more often applied for early maturing beef Hungarian-Simmental and cross-breeds due to the expected larger lifetime production, expressed in weaned calf weight. When starting breeding in an age of about 1 year (13-15 months), than this should be considered already in the pre-weaning period of feeding.

It is essential, that the calves can consume supplementary feeds (concentrate and hay) next to milk and grazing and that the cows milk production level is hold or the decrease is moderated with the supply of adequate energy and protein. All these measures will increase the weight of calves at weaning. Efforts should be made that the calves reach 300-350 kg body weight by time they are 13-15 months old (to reach the 55-60% of their mature weight). It is largely dependent on the heifers winter feeding that what proportion of calves born in late winter or spring reaches by autumn the required weight. It can only be achieved by more intensive feeding, than the average. Aiming this, the daily ration of heifers in winter should consist of 10-14 kg good quality maize silage (ensilaged with 35-38% DM), or the same amount of wilted grass silage, 2-4 kg grass hay and 1-2 kg concentrate. It is only an example, which can be altered according to the feeding possibilities in the unit. Our only aim was to present the favourable ratio of the different feedstuffs in the daily ration.

The heifers did not reach the mature weight during pregnancy, so they require additional nutrients for 400-500 g daily weight gain as well, besides maintenance and the foetus development. However, it should be noted that the foetus development increases slightly the nutrient requirement of heifers until the 7th month of pregnancy. Heifers, consuming high quality forages, can reach the desired weight gain and the 400-500 kg live weight before calving without additional concentrate. Two months before the expected calving heifers ration may be slightly increased, because of increasing requirement of foetus development, however the fattening of animals because of its disadvantages (calving difficulties, reduced milk production) should be avoided.

Great attention shall be given to heifers feeding after calving, because it influences not only the development of the calf but also the reproduction of the cow. If the quality of the pasture does not allow to meet the nutrient reuirement of maintenance, milk production and the weight gain, than the diet should be supplemented (feeding concentrate if necessary), to prevent the decrease of heifers condition.

Chapter 10. Feeding the sheep

Sheep are ruminants, therefore the role and importance of the rumen in the nutrition, as described for cattle in chapter 1. is valid for the sheep. Feeding the sheep, similarly to the cattle, attention is warranted in the rumen microbial processes, since the major part of the nutrients is available as a result of microbial degradation and synthesis in the rumen.

The sheep digest the different feedstuffs the same extent as the cattle. This explains that calculating the total digestible nutrient content of a feed (TDN) for cattle, the digestibility coefficients have been determined in sheep experiments.

The two species not only digest the same amount of feed nutrients but the effectiveness of utilization of absorbed nutrients for maintenance, milk production and weight gain are the same. Therefore to calculate the energy value of sheep feed, the partial regression equations of net energy value set out in cattle experiments are used. As the rumen degradation of feed protein and the microbial protein synthesis is determined for both cattle and sheep by the same factors, and additionally the N-metabolism is very similar for them, the metabolizable protein system, in our country introduced in 1999, is applicable for feeding the sheep.

1. The role of pasture in sheep feeding

The pasture has a fundamental role in sheep farming. The economy of sheep farming largely depends on how long the grazing season, and occasional pastures can supply the flock, and how much other feed grown in the farm or purchased should be used.

Although, pasture has been decreasing for decades in our country, now we have slightly more than 1 million ha grassland area. In this area, more than 200 000 hectares are of national park, landscape-protection area or nature conservation area. They are partly grazed by animals. The average quality of the remaining approximately 800 000 hectares grassland is poor, with a yield of decades, not more than 1.5 tonnes of hay per hectare. It should be emphasized however, that there are significant variations in the quality of grasslands depending on the soil properties, the rainfall conditions, the irrigation possibility and the pasture management.

Farms held about 1.1 millions sheep in Hungary. For this stock and its progeny 420-430 000 hectares pasture of a bit higher yield could provide the feed, thus it is not the lack of area but the quality of pastures, and the profitability of sheep breeding that complicates the further development of sheep farming.

Among farm animals, sheep is to the best utilise grassland, while not as demanding to the quality of pasture as cattle or horses. They do not pick in an extent in the pasture as the two above mentioned species. Sheep having fine, motile lips are able to graze small grass as well, therefore able to utilise the sparse pasture. For lambs of 6 cm tall grass, while for adult sheep of 8-12 cm grass height is the best.

The sheep are not so picky on the pasture as cattle, but if it is possible they prefer the leaves to the stem. The sheep, grazing freely on not surrounded pasture, do not graze of about 20-30 % of the grass, which is a considerable loss in case of good quality pasture. These losses can be reduced to about 5%, using rotational grazing system. The sheep has to be accustomed to using electric fence. When using electric fence, you should not use shepherd dog.

Sheep graze 1-1.5 hours continuously, than they have a rest, while they drink and ruminate. So, it is important that water is made available on the pasture.

A sheep can consume grass of 15-16% of its own body weight on a good pasture. It means that a 60 kg ewe can consume daily 9-10 kg grass.

If the unit does not have enough pasture to provide grass for the stock or the pasture quality does not allow a continuous grazing, than the farmer should create temporary pasture and/or may also benefit from occasional pasturing. Winter crops and forage mixtures sawn in autumn may be grazed from the middle April. The August sown rye-rape mixture provides good grazing for sheep till to the early autumn frost. The rye-vetch mixture or the sweet lupine are similar good autumn-winter pasture. It is only to mention, that when grazing legumes their bloating effect should be taken into account, especially when they are wet.

The sheep well benefit the occasional pasture, too. Their fine lips allow the grazing of grain stubble. Corn is also good for pasturing. However, there is a risk of overconsumption on the above mentioned stubbles, so the grazing time should be limited. The sheep graze peas, potatoes and beet stubble, as well. The autumn growth of legumes after the last mowing and the legumes stubble before breaking are also good pastures.

2. The nutrient requirement of sheep

Respiratory experiments with sheep showed that the sheep as efficiently utilised the metabolizable energy content of feeds for maintenance, milk production and weight gain, as cattle. It follows, that the partial energy content of feed for sheep can be calculated with the same regression equations, as for cattle. However, there is one difference in the expression of energy requirement between the two species in the feeding practice: Unlike dairy cows similarly to beef cattle, the energy requirement of the ewes is expressed in net energy for maintenance and not in net energy for milk production. This can be justified with the following:

- The major part of the energy requirement of ewes – unlike the dairy cows - is devoted to maintenance and not for milk production. The lactation period and the peak milk production of sheep is shorter than that of the cows.
- The sheep milk production does not require or requires only for a short time a three times maintenance feeding level. It is more practical to express the ewes energy requirement in net energy for maintenance, in order to avoid the use of two net energy values for milk production (one for the cows and one for the ewes). This is possible, because the change in metabolisability, equally affect the utilization efficiency of the metabolizable energy for maintenance and for milk production. See more details in chapter 4.1.1.

When determining the sheep energy requirement, like the cattle, the fasting heat production should be assumed. Its value is 0.245 MJ/$W^{0.75}$ It is 15 % lower, than the needs of other farm animals, which is due to the insulating fur of the sheep. As the sheep maintenance energy requirement is 15% higher than the fasting heat production and the grazing increases further by 10% the demand, the maintenance energy requirement of housed sheep, depending on the sex, is 0.28-0.31 MJ/$W^{0.75}$, and that of the grazing sheep is 0.31-0.34 MJ NEm/$W^{0.75}$.

The sheep utilize the metabolizable energy content of feedstuffs for milk production, equally to cows, with 63% efficiency. The fat and protein content of the sheep milk is continuously increasing during the lactation. It contains in average of the lactation 7% fat and 6% protein. A milk of such composition contains 5.5 MJ/kg energy. Knowing the fat content, the energy content of sheep milk can be calculated by the following simplified regression equation:

Energy content of the milk, MJ/kg = 0.5 • milk fat% + 2.0

Changes in the ewe condition during the lactation, like the cows, influence the available energy for milk production. The reduction of ewe weight by 0.1 kg, gets 2.04 MJ NEm more energy for milk production, but the weight gain decreases the amount of energy available for milk production by 2.55 MJ NEm.

Due to gestation the maintenance energy demand of a ewe is increasing in the last 4-6. week of pregnancy by 2.89-3.17 MJ NEm, in case of one and by 4.96-5.24 MJ NEm in case of twin embryos. The energy utilization efficiency during pregnancy is poor due to the high energy demand of placental transport.

It is not possible to determine accurately the energy need of wool production, because wool growth, just like maintenance related biochemical reactions, is continuous. Another problem is that the energy efficiency for wool production was found very different (20-50%), in the related studies. Having regard to all these, the nutrient requirement standard gives the energy requirement of wool production not separately, but combined with the maintenance energy requirement. Assuming a shear weight of 4 kg, a rendement of 55% and the energy efficiency of 35%, the energy requirement of the wool production is 10% of the total requirement.

The energy requirement of growing sheep is expressed in net energy for maintenance (NEm) and weight gain (NEg), based on similar reasons detailed in the chapter 3.1.2. When calculating the NEg, besides the weight gain, the weight, the effect of sex and type shall be also respected. The regression equations for calculating the energy demand of growth can be found in the relevant books.

The protein requirement of sheep is expressed, like in cattle metabolizable protein. The most important relationships to determine MF needs are as follows:

Maintenance MP demand: 2.6 • $W^{0,75}$

MP demand of wool production, g/day: daily wool protein, g / 0.4

MP demand of milk production, g/kg milk: protein in the daily milk, g / 0.65

MP demand of pregnancy, g/day: protein built in the foetus, g / 0.5

The above euations suggest that the protein utilization efficiency is the lowest (40%) in wool production. This is related to the microbial proteins comprising the largest share of protein requirement, contain relatively little amount of cystine, compared to ceratine making up wool protein. The protein utilization efficiency for milk production and pregnancy are similar to that of cattle (65% and 50%, respectively).

Concerning protein requirement of growing sheep we refer to the regression equations published in the relevant literature.

3. Feeding ewes

3.1. Feeding of non pregnant ewes

The ewe nutrients requirement and according their feeding depends on whether the mothers are empty, pregnant or suckling. The length of time the ewes are open is influenced by whether ewes having yeaned once a year or concentrated in 7-8 months in the unit.

After weaning the mothers nutrients requirement decreases significantly. In the post-weaning period the nutrient demand involves requirement for maintenance and wool production supplemented with the nutrient demand for replacing of weight loss occurred during the suckling. It may be significant for mothers suckling twins.

The nutrient demand of non-pregnant ewes can be covered with the grass on good-quality pasture. On medium-quality pasture may be a need for a little supplementary feeding for those ewes, having poorer condition than average, after suckling twins or triplets. Although, the pasture can cover the energy and protein demand of the ewes, mineral needs should be provided separately.

The ewes must be prepared for mating. Ancient, primitive breeds (racka, cigaja) only short periods (August-October), while the proliferous breeds mate throughout the year.

Merino, the most widely bred in our country, also belongs to this latter group, though in hot summer or under poor-feeding conditions they have silent heat. In the high oestrus season all sheep breeds are in heat. This period falls to autumn months in our climate. Outside this period it is possible to mate in the pre-season (May-July) and low season (December-January). The February-April period counts as off- season period, when some of the breeds (first of all the primitive breeds) are not in heat.

In the main season, even ewes in poor condition will come on heat, while the condition in the pre- and post season play an important role in triggering to heat and the result of mating. However, the condition of the ewes influences the follicular development and the conception also in the main oestrus season.

As stated above, efforts should be made to improve ewes condition by the time of mating. In particular, the energy supply of the ewes shall be improved. As a result, picking up to heat, ovulation increases and more ovum conceives. Consequently, fewer ewes are left empty and more twin lambs are borne. (Table 11.). Preparing ewes and female lambs for heat, it is the flashing. The duration of the flashing (increased energy supply period), and the rate of energy increase, depends on the condition of the animals and lasts 2-4 weeks. It should be emphasized, that improving energy supply could be realized not only with concentrate feeding but grazing ewes on good-quality pasture or feeding good-quality hay. If concentrate is used for flashing, the daily portion is of 300-400 g. The flashing fails with ewes in good-condition and even can be harmful, because the conception rate of over conditioned ewes is inferior. After 1-2 weeks of the mating flashing must be completed, because the excess energy increases the death of foetus during early pregnancy.

3.2. Feeding of pregnant ewes

The pregnancy increases only marginally the nutrient needs of ewes in the first three months, that is the nutrient needs of open and pregnant ewes is practically not different. A medium quality pasture can cover the nutrient requirement of ewes.

In the 4-5th months of pregnancy embryonic development has accelerated. In the 5th month of pregnancy the foetus is growing as much as the previous 4 months of pregnancy, to all. Especially, the twin pregnancy increases significantly (up to 70% that of the non-pregnant ewes) the ewe's nutrient demand at the end of the pregnancy. Despite the high requirement, a good-quality pasture - producing 8-10 tons of grass - can cover the energy and protein demand of the pregnant ewes. It is appropriate, this time to prolong the duration of grazing. Animals may be kept for the night out in the pasture, because it can increase the grass consumption of ewes. In winter the daily ration of pregnant ewes should involve 3-4 kg silage, 0.5-1.0 kg hay and 0.5-1.0 kg concentrate. The silage should be of good-quality grass-silage or haylage, because the risk of listeriosis'occurrence is lower, than feeding corn silage. These pathogenic bacteria get by the consumption of poor-quality soil-contaminated silage into the animal organism. The diseases may be prevented by improving the hygiene of the ensiling process, the best avoiding soil-contamination. By the soil contamination not only Listeria, but also Clostridium bacteria may get into the silage, causing butyric acid fermentation. Therefore, the presence of butyric acid in the silage is an evidence of soil contamination. If a disease is due to feeding silage, the incidence of the disease can be moderated by reducing or total suspending of the silage feeding.

When the daily ration does not cover the ewes nutrient requirement, ewes body reserves to ensure the development of the foetus. A longer, increased energy deficit may result in the development of pregnancy ketosis, due to the accumulation of ketone bodies, the by-products of fat decomposition. The risk of the development of ketosis is high, when the daily weight loss of ewes attains 50 g.

The insufficient energy and protein supply of the pregnant ewes reduces the birth weight of lambs and their resistance will be also weaker. Furthermore the under nutrition of ewes in the last trimester of the pregnancy may decrease the expected wool production of the offspring to be born, because the secunder follicles start to develop around the 75-85. days of the pregnancy in the skin.

Special attention shall be paid to the mineral supply of the pregnant ewes. Forages cover the requirement of Ca, but the P requirement may be covered only by using some kind of P-supplement. Among the microelements the importance of the selenium shall be mentioned, because its deficiency can cause muscle degeneration of lambs and impairs the reproductive performance. The mineral supplement can be easily solved if the ewes consume some concentrate by mixing the mineral supplement or premix to the concentrate. The supplementation of minerals and sometimes vitamins can be solved by methods described in beef cow nutrition. It happens that farmers feed a small amount concentrate to perform the mineral supplement.

Concerning B vitamins, sheep, like cattle, are self sufficient. However, the sufficient carotene supply of pregnant ewes is very important, for ensuring that adequate vitamin A reserves in lambs are taken. The carotene supply of ewes is ensured on the pasture. In winter, the feeding of wilted alfalfa or grass silage, carrot or vitamin premix may be the solution of carotene supply.

3.3. Feeding of lactating ewes

There is a diverse composition of sheep breeds in Hungary. Accordingly, there are significant differences in milk production among the individual stocks. Next to the extensive stocks, kept only for wool and lamb production, there are proliferous herds of high milk production, too (600-800 kg/lactation). In addition to the breed, the milk production is also influenced by whether the ewe is suckling one or two lambs. The ewes yeaning twins or triplets have by 50-70% higher milk production than the ewes with one lamb. Consequently, ewes suckling more lambs should be separated and separately fed.

The milk production increases for 2-3 weeks after yeaning, and this production is maintained for 60-70 days, when feeding is appropriate. The feed consumption of the ewes increases by 15-20% after yaening, compared to the highest pre-yeaning consumption. Nevertheless, like the cows, the increase in feed consumption is legging behind the increase of milk production. Ewes try to compensate the resulting lack of energy by mobilising reserves. The rate of weight loss depends on the milk yield and the condition of the ewes. The better is their condition, the higher is the weight loss. During the feeding it should be directed to this weight loss should not exceed 5 % of the mother body weight, in the first six weak of lactation, which means maximum 3 kg weight loss of a sheep weighing 60 kg. If the weight loss exceeds 6-7 kg during the 60-70 days suckling period, it may hamper the reproduction of ewes, when applying the concentrated lambing method.

The insufficient energy and protein supply may adversely affect not only the ewes milk production and the growth of lambs, but also the wool production. This is explained, that the ewe milk production, such as race related maintenance process, is in favour of wool production. The quality of wool is also deteriorating, because during the inadequate nutrition wool fibres become thinner, and therefore easily broken, when processing.

The pasture has an essential role in the nutrition of suckling ewes. A pasture of 9-10 tons of grass yield can itself cover the ewes' nutrient requirement. Some hay (about 0,5 kg) should also be fed to attain better rumen functioning. A daily portion in winter, involving 3-4 kg silage, 0.5-1.0 kg hay and 0.5-1.0 kg concentrate, covers the nutrient requirement of ewes even in the peak lactation period. In case of nursing ewes, special attention should be paid to the quality of silage and haylage, and that they are not soil contaminated. Silages, produced from by-products (maize stover, sugar top with leaves) would rather be fed by non-pregnant ewes or ewes in the early pregnancy.

If there are some good-quality by-products of the food industry (sugar beet pulp, brewer's grains etc.) cheaply available near the sheep farm, then they can favourably be used for feeding the lactating ewes. The brewer's grains have beneficial effect on the milk production. The protein needs of lactating ewes, just like the pregnant ones, could not be met by feeding only roughages and cereals, for this the feeding of a little (0.15-0.20 kg) protein feed (extracted sunflower meal or rape seed meal) is required. The concentrate may contain some urea, too, but its quantity should not exceed 2%.

It is important, that mothers have access to the necessary minerals. The easiest way to supply them is, to add a vitamin and microelement premix with a P-supplement or a vitamin+ micro- and macroelements premix to the concentrate. If the first option is selected, efforts should be made when determining the amount of P supplement, that the Ca:P ratio moves close to the 1.5-1.6:1 value in the ration. In winter you should take care also on the carotene supply of the ewes.

4. Nutrition of suckling lambs

Efforts should be made that lambs start to suck as soon as possible and thus obtain colostrum, because after 12 hours of the birth the immune material content of the colostrum is reducing and the absorption of antibodies are impaired. In the first week following the birth lambs should be together with their mother, so they could suck the more times (up to 20-30 times) a day, because their abomasum is small. After the first week the number of sucking decreases, and the third weeks on even the possibility of sucking shall be restricted to encourage lambs for the consumption of solid feeds.

The 2nd week on lambs shall be offered, on a separated place in the so called 'lamb-school, granulated starter concentrate and good quality, fine-stranded, leafy meadow hay. Having limited the suckling possibilities for the lambs, the solid feed consumption increases gradually from the 3rd week on. Primarily hay consumption increases.

Lambs have an excellent growth potential in the first weeks. They double their birth weight within 14-15 days. For this, foals require 60 days while the calves 45 days. Only the young rabbit is growing faster (6 days), than the lambs.

To produce a lamb starter of good quality, you should have good-quality protein feed (extracted soy bean meal or fractionated, low-fibre sunflower meal) and the use of mineral and vitamin premix is indispensable.

Only on extensive operations are lambs allowed to suck for 3-4 months. Today, rather the early weaning (35-45. days old) is common. Lambs at this age can only be weaned without any problem, if they consume lamb starter of 0.35-0.45 kg and hay of 0.2-0.3 kg daily (so their total solid feed intake is 0.55-0.70 kg) and their weight reaches 12-15 kg.

5. Artificial lamb rearing

Lambs are reared artificially only in milking sheep farms or when due to twin birth mothers' milk production is insufficient to bring up their lambs. The artificial raising of the lambs is more difficult task than that of the calves, because of the little stomach of lambs they need to consume milk-replacer more often, than the calves. The milk-replacer, dissolved in water should not be left for a long time before the lambs without the risk of deteriorating, so lambs should be offered to drink several times per day. There are two ways to offer milk replacer for lambs several times daily:

- Using automatic drinking device, this produces by mixing the 37-380C water and the milk-replacer powder the drink several times a day, which lambs consume through rubber mouth piece. The automatic drinking equipment is expensive, so this method is only economic if a large number of lambs.
- The milk-replacer can be treated with an organic acid (formic acid, fumaric acid), so it may be several hours in front of the lambs without deterioration. Such milk-replacer has been also used in artificial calf raising since long ago, the so called "Pingvintej".

So that the lambs can easily get used to the use of rubber mouth piece, they should be allowed to suckle of at least 48 hours after birth.

The 2. week animals shall be available starter concentrate and hay. The dry matter content of the milk- replacer should be decreased gradually from the 3rd week, in order to increase the solid feed consumption. Concerning the weaning requirements, there are the same conditions to meet as in the case of natural bringing up.

6. Lamb fattening

The fattened lamb is a searched export product of the domestic sheep breeding, so it has an important role in the economy of this sector. The high growth potential allows lambs, weaned 35-45 days old and weighing 12-15 kg, to reach 26-28 kg and 29-30 kg live weight the ewe lambs and the ram lambs, respectively at 90-100 days of age. To achieve this ewe lambs and ram lambs should have a daily weight gain of 250-260 g and 290-300 g, respectively. Such performance can only be achieved by feeding of high energy concentration diet. So, in the ration of fattening lambs, shall be, next to the concentrate only the minimum amount of hay necessary to maintain rumen activity. The short fattening period does not justify the use of two different concentrates. Following the weaning, the starter shall be changed to growing concentrate, containing next to cereals 8-10% of protein feed (extracted soybean- or sunflower meal) in a week transition period. The lambs feed mixture may contain also urea, but its amount should not exceed 1.5-2.0%. When feeding urea, it is beneficial, if the mixture contains 2-3% alfalfa meal, too. The vitamin and mineral premixes are also essential components in the lamb feed mixture.

7. Nutrition of breeding ewes lambs

Previously, ewe lambs were taken into breeding in an age of one and a half years. Recently, to reduce the cost of rearing, there is a trend to mate lambs born in winter-early spring in the next autumn, in the age of 8-9 months. It is a pre-condition the ewe lambs should reach of 40-45 kg by this age. To attain this, utilising the high growth potential of lambs having weaned, an intensive feeding system should be followed. The ewes lambs for breeding are selected from the fattening lambs, not later, than their age of 10-12 weeks. The lambs reared intensively, should weigh by that time of 20-22 kg. Animals at such level of development even reach the 40-45 kg of weight in 8-9 months of age, if the daily weight gain is not more than 90-100 g. This allows the reduction of energy supply for ewe lambs selected, thus avoiding fattening them, because it has been shown to reduce the subsequent breeding performance.

That objective can be achieved by the simplest, if the animals are grazed. The good-quality pasture can cover completely the nutrient demand of 90-100 g daily weight gain. A small amount of concentrate (0.2-0.3 kg) is needed only during acclimatisation to the pasture. In the absence of pasture, 1-2 kg silage, 0.5 kg hay and 0.2-0.3 kg concentrate can cover the nutrient requirement of the ewe lambs. It is good if a grower concentrate used for lambs, to ensure the mineral and vitamin supply, too. When feeding farm cereals, the concentrate should also contain vitamin and microelement premixes.

The only difference in the feeding of ewe and ram lambs for breeding is that the daily ration of ram lambs, considering their higher growth potential, should be 25-30% more, than that of the ewes.

8. Nutrition of breeding rams

In terms of feeding breeding rams two periods can be distinguished: the mating period and the non mating period.

The nutrient requirement in the non mating period is equal to the need for maintenance. During this period animals can be kept only on forages and up to the energy needs of rumen microbes may they get some concentrate (0.3-0.4 kg), which is some grain or a mixture of cereals.

The nutrient demand of rams increases in the mating period. Rams should be prepared 2-3 weeks before to this period. This means the feeding of better-quality forages and of 1.0-1.5 kg concentrate per day. The concentrate should include preferably oat or rye. The inclusion of mineral and vitamin supplements (especially carotene or vitamin A) are also important, by mixing vitamin and mineral premix for sheep in the concentrate. The nutrition of teaser rams should be the same as that of the tupping rams.

Appendix A. Appendix 1

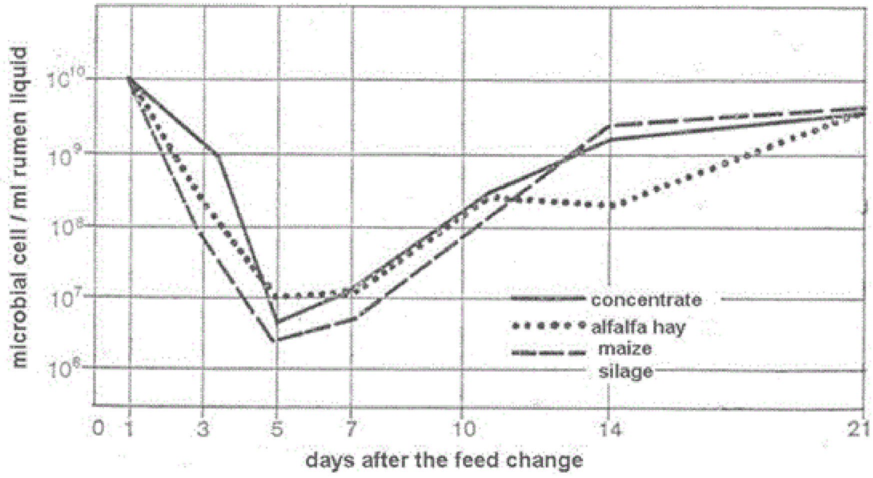

Figure 1.: **The effect of sudden change in feed on the microbial cell count of rumen liquid**
(Zintzen, 1976)

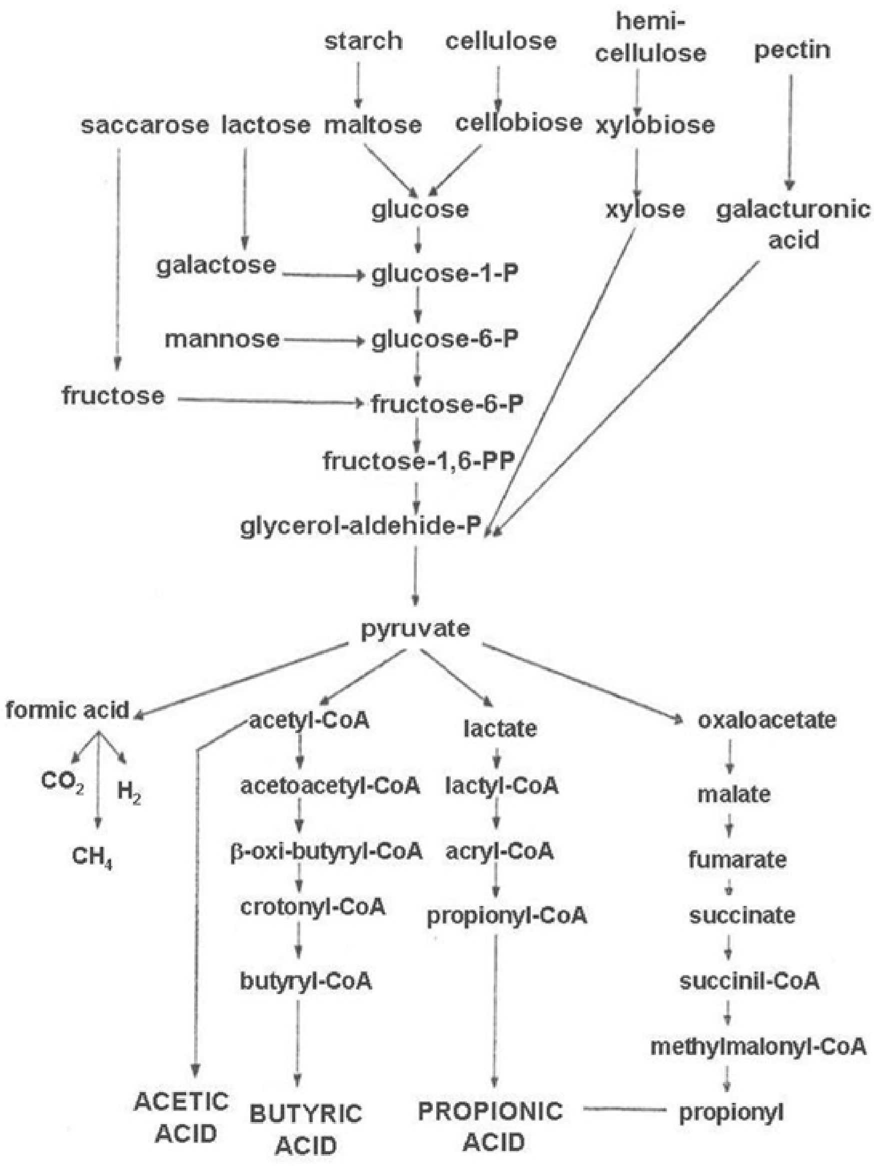

Figure 2.: **Decomposition of carbohydrates in the rumen fermentation**

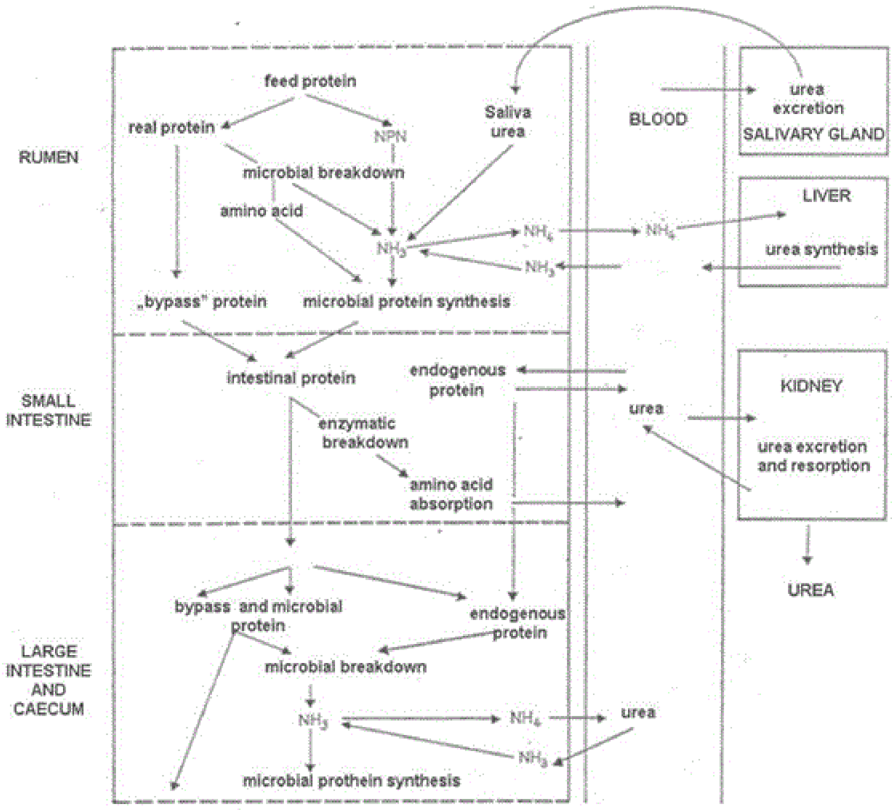

Figure 3.: **Microbial protein synthesis and the rumino-hepatic N-circulation**
(Kakuk and Schmidt, 1988)

Table 1.

The amino acid composition of the microbial rumen protein, the cow milk, the beef, the mutton and the wool
(Orskov, 1982)

	Microbial rumen protein *	Cow milk	Beef	Mutton	Wool
	%				
Arginine	5.3±1.0	4.0	6.7	6.1	10.1
Phenylalanine	5.3±0.7	5.4	4.5	3.8	4.0
Histidine	2.1±0.5	3.0	3.7	3.2	0.8
Isoleucine	5.8±0.7	5.6	5.7	4.6	3.3
Leucine	8.0±0.8	10.2	8.0	7.2	9.4
Lysine	9.2±1.8	8.2	9.1	9.8	3.0
Methionine	2.5±0.6	2.9	2.7	2.6	0.7
Cysteine	1.4±0.9	1.0	1.3	1.3	10.9
Tyrosine	4.9±0.6	4.5	3.8	3.5	6.1
Threonine	5.7±0.8	5.0	4.6	4.6	6.5
Tryptophan	1.5±0.8	1.4	1.3	1.3	1.7
Valine	5.8±0.9	7.4	5.3	4.8	5.1

* (6.25 · N content) · 0.8

Appendix B. Appendix 2

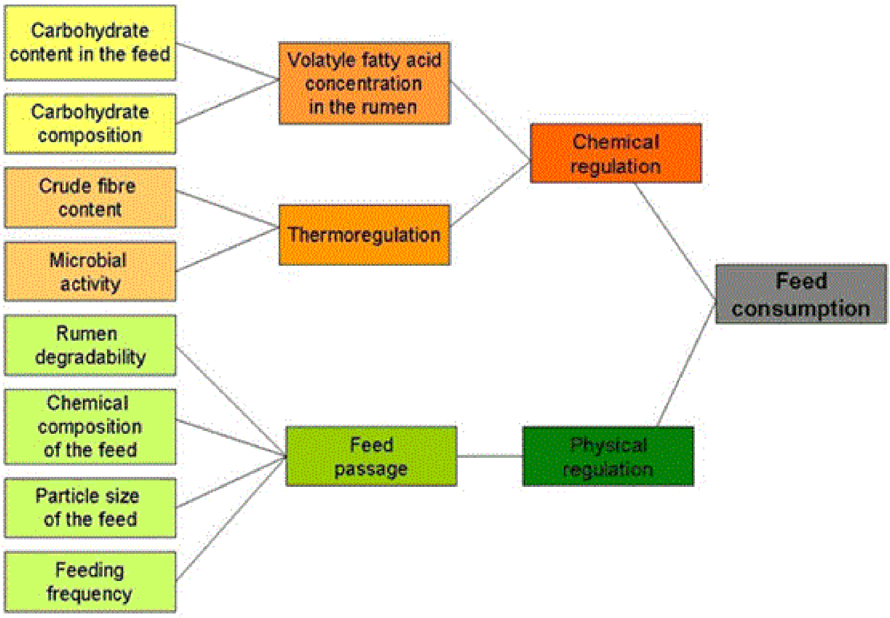

Figure 4.: **The factors influencing the feed intake of ruminants**

Appendix C. Appendix 3

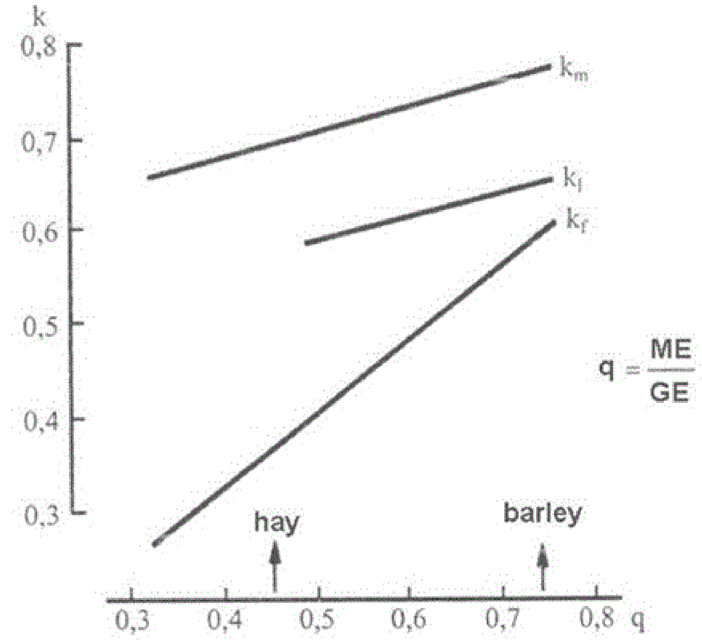

Figure 5.: **The effect of metabolizability of feed on the transformation efficiency of ME**

k_m = transformation efficiency of ME for maintenance
k_l = transformation efficiency of ME for milk production
k_f = transformation efficiency of ME for growth and fattening
ME = metabolizable energy
GE = gross energy
q = metabolizability

Appendix D. Appendix 5

Table 2.

Nutrient content of some milk replacer for calves

		Cremo Baby	Sanolac Rot	Pingvintej	Vitatej plus
Dry matter	%	95.0	-	95.0	96.0
NEm	MJ/kg	10.5	-	-	-
NEg	MJ/kg	7.5	-	-	-
ME	MJ/kg	-	14.0	-	-
Crude protein	%	22.0	20.0	22.0	21.0
Crude fat	%	15.5	18.0	22.0	17.0
Ca	%	0.7	1.2	-	0.95
P	%	0.5	0.7	-	0.90
vitamin A	IU/kg	50000	50000	70000	55000
vitamin D	IU/kg	5000	5000	7000	4500
vitamin E	IU/kg	100	100	70	300
The long of the drinking period	day	60	56	56	56
The requires quantity of one calf rearing	kg	30	43.8	30	57.4

Table 3.

The concentrate and hay consumption of the calves
(Bedő et al., 2008)

The age of the calf (day)	Daily concentrate (calf starter) intake (kg)	Daily hay intake (kg)
10-20	0.05-0.06	0.06-0.10
21-30	0.15-0.20	0.10-0.15
31-40	0.30-0.40	0.20-0.30
41-50	0.60-0.70	0.30-0.40
51-60	0.80-0.90	0.40-0.50
61-70	1.00-1.20	0.50-0.60
71-80	1.20-1.50	0.60-0.80
81-90	1.50-1.80	0.80-1.00

Appendix E. Appendix 7

Table 4.

The production of the registered Holstein Frisian cows from 1999 to 2010 in Hungary
(Source: ÁT Kft. Gödöllő)

Year	Milk production (kg/lactation)	Average lactation	Milk fat (%)	Milk protein (%)	Parturition interval (day)
1999	6716	2.5	3.74	3.32	419
2000	6979	2.4	3.75	3.27	425
2001	7376	2.4	3.73	3.26	426
2002	7604	2.4	3.74	3.28	426
2003	7756	2.3	3.81	3.26	430
2004	7880	2.3	3.73	3.20	435
2005	8103	2.3	3.57	3.18	438
2006	8243	2.3	3.51	3.16	436
2010	8783	2.3	3.55	3.26	441

Table 5.

The effect of protein content of the feed on the services per conception and on the number of the days from the parturition to the conception
(Röver, 1983)

Crude protein in the dry matter (%)	The number of unit/farm/	Number of cows	Services per conception	The number of the days from the parturition to the conception
13.0	7	18500	1.64	87.80
14.6	7	15100	1.72	88.20
17.50	8	21100	1.93	97.30

Table 6.

The effect of bypass protein on the fertility of cows
(on the basis of Hagemeister and Kaufmann)

Parameters	The effect of		
	16% crude protein	16% crude protein (its 30% is bypass protein)	19% crude protein
	protein content of ration		
Number of animals	19	20	20
NH_3 in the rumen (mg%)	8.8	7.8	16.8
Blood plasma-urea (mg%)	7.9	7.1	16.8
Pregnancy rate (%)	56	69*	44*
Services/conception	1.79	1.45*	2.25*

* $P<0.05$

Table 7.

Milk production

		Control	Experimental
		group	
Milk production	kg	33.69	34.90*
Milk composition			
Dry matter	%	11.15	11.23
Fat	%	3.10	3.19
Protein	%	2.96	2.96
Daily produced nutrients in the milk			
Dry matter	kg/day	3.78	3.94
Fat	kg/day	1.05	1.12*
Protein	kg/day	1.00	1.04

* P<0.05

Table 8.

The effect of Ca-soap on the fatty acid profile of the milk fat
(Ribács and Schmidt, 2006)

Fatty acid (%)	Control	Experimental	
	group		
Capric acid ($C_{10:0}$)	2.80 ± 0.25	1.81 ± 0.01	*
Lauric acid ($C_{12:0}$)	5.11 ± 0.71	2.60 ± 0.46	***
Myristic acid ($C_{14:0}$)	13.67 ± 1.53	10.10 ± 1.15	***
Myristoleic acid ($C_{14:1}$)	1.85 ± 0.37	1.48 ± 0.40	NS
Pentadecanoic acid ($C_{15:0}$)	1.34 ± 0.12	1.28 ± 0.05	NS
Palmitic acid ($C_{16:0}$)	35.57 ± 2.80	23.13 ± 2.56	***
Palmitoleic acid ($C_{16:1}$)	1.97 ± 0.32	2.04 ± 0.42	NS
Heptadecanoic acid ($C_{17:0}$)	0.85 ± 0.02	0.70 ± 0.02	***
Stearic acid ($C_{18:0}$)	8.32 ± 1.34	8.42 2.06	NS
Elaidic acid $C_{18:1}$	0.43 ± 0.11	1.13 ± 0.25	***
Oleic acid ($C_{18:1}$)	17.08 ± 3.07	22.57 ± 3.20	***
Linoleic acid ($C_{18:2}$)	3.78 ± 1.14	4.76 ± 1.70	NS
CLA ($C_{18:2}$ – c9,t11)	0.23 ± 0.03	1.02 ± 0.19	***
Linolenic acid ($C_{18:3}$)	0.37 ± 0.14	0.83 ± 0.34	***
Eicosenoic acid ($C_{20:1}$)	0.26 ± 0.01	0.84 ± 0.05	**
Arachidonic acid ($C_{20:4}$)	0.18 ± 0.03	0.26 ± 0.4	NS
Not analysed	*6.19 ± 2.13*	*17.03 ± 5.52*	***

NS = not significant, *P < 0.05, **P < 0.01, ***P < 0.001

Appendix F. Appendix 8

Table 9.

The comparison of different forages' results in the fattening
(Várhegyiné, 1998)

Weigh gain by feeding maize silage	Forages	Weight gain kg/day	Deviation from the maize silage	Authors
0.99 0.85	sorghum-silage sorghum-silage sudangrass silage	0.68 0.81 0.74	-31% -5% -13%	Stoneberg et al., 1974
1.24	barley silage oat silage	0.78 0.76	-37% -39%	Goodrich et al., 1981
0.99	grass silage	0.77	-28%	Flipot et al., 1992
1.76*	alfalfa silage	1.32*	-25%	Comerford et al., 1992
1.12	wheat silage	0.83	-26%	Bolsen et al., 1976
1.14	beet pulp	1.39	+22%	Fiems et al., 1983
1.10	beet pulp	1.16	+5%	Várhegyiné et al., 1996

* 40% forage - 60% concentrate

Table 10.

The comparison of the fattening performance based on forages and forages+concentrate
(Várhegyiné, 1998)

Breed (variety)	Daily concentrate portion kg		Weight gain kg/day		Deviation %	Authors
	forage	forage +conc.*	forage	forage +conc.		
A x He	0.5	5.7	1.18	1.34	+14%	Hoffman, 1977
A	0.4	2.9	0.71	0.86	+21%	Meiske et al., 1978
Hf	0.8	4.3	0.92	1.03	+12%	Várhegyiné et al., 1982
He x Hs	1.2	3.2	1.15	1.45	+26%	Várhegyiné et al., 1988
He x Hs x Ch	0.9	3.3	1.15	1.45	+6%	Várhegyiné et al., 1988
F	1.0	3.4	1.03	1.19	+16%	Giardini et al., 1976
Hf	1.0	2.5	1.09	1.18	+8%	Regiussné et al., 1984
Hf	0.8	3.4	0.93	1.18	+27%	Lányiné, 1986

* conc = concenrate

Fajta:
A = Angus
He = Hereforde
Hs = Hungarian Simmental
Ch = Charolais
Hf = Holstein-Frisian
F = Frisian

Appendix G. Appendix 10

Table 11.

The effect of feeding of the previous period before the mating season on the ovulation of ewes
(Cassida, 1963)

	Experiment		
	1.	**2.**	**3.**
	% of twin ovulation		
hay for 6 month long	18	30	3
hay for 6 month long + concentrate for 2 weeks before the parturition	29	29	20
hay + concentrate for 6 month long	46	70	38