Reprint from
milchrind
Journal für Zucht und Management
02/2020

'Protected' fat: Opportunities and limits

Dietary fats is an often heard keyword whenever 'negative energy balance' is discussed, because they are claimed to have a positive effect on fertility and heat stress in cows. Our article explains dietary fats, their benefits and drawbacks in animal feeds as well as their limitations.

High-yielding dairy cows often need more energy for milk production than what is supplied in the regular ration. The factors that limit the intake of more feed, especially in the first third of the lactation period, are above all the rumen volume and the energy level of the feed. Yet, if the cow doesn't receive supplementary nutrients, she gets into a negative energy balance and starts drawing on her internal energy stores – with concomitant negative effects on health and fertility. The consequence is that the body has too little energy firstly to become pregnant and secondly to successfully complete a pregnancy.

Another negative effect is that fat-soluble toxins are released into the blood when body fat melts down, which may cause metabolic and even claw problems.

A good solution to this problem is to offer an energy enriched feed. This adds more energy to the same volume of feed. Yet, this can only be achieved by fats, because fats supply more than two and a half times more energy per weight unit than cereals or other carbohydrate components that are typically used as energy resources.

What exactly are fats?

The basic building blocks of nutrition are fats, proteins and carbohydrates. They supply energy as well as performing other important functions. Fats are made up of one glycerol molecule to which up to three fatty acids are attached. This makes a triglyceride or a so-called neutral fat. Fatty acids that are broken off the glycerol molecules are referred to as free fatty acids. Both triglycerides and fatty acids are commonly referred to as fat and are also used in animal nutrition.

The physical properties of fats such as flowability and melting point depend on the structure of the fatty acids. Saturated fatty acids are more solid as chain length increases and as a result they have a higher melting point. At the same time, their energy value is higher whereas their digestibility is lower. As a rule of thumb, with increasing numbers of unsaturated bonds unsaturated fatty acids have a lower melting point and are therefore more liquid. With each additional unsaturated bond, the energy value decreases while digestibility increases.

Rumen-stable fats

When feeding fats, we must always take into account that not every fat is suitable for feeding to ruminants. This is because the unsaturated fatty acids have a major impact on the microorganisms in the rumen which defend themselves from unsaturated fatty acids by hydrogenating, i.e. saturating them. Most of the unsaturated fatty acids in oils are chains made

Which dietary fats are available?

Fats that are suitable for feeding animals are generally oils and fatty acids from oil plants that grow in temperate zones – soy, rapeseed and sunflower – or in the tropics such as palm oil and its fatty acids. All oils are readily available in large quantities. Other oils such as flax and also oils from algae are used because of their special fatty acids. Fish oils, which were popular in the past, are no longer fed to ruminants.

The main reason for adding fats to animal feeds is to enrich them with additional energy. The most suitable saturated fatty acids are the long-chain palmitic acid (16 carbon atoms in the chain; C16:0) and stearic acid (18 carbon atoms in the chain; C18:0) as well as the mono unsaturated oleic acid (18 carbon atoms with an unsaturated bond in the chain; C18:1).

Many oils also contain the double unsaturated linoleic acid (C18:2) and the triple unsaturated linolenic acid (C18:3). They too are often only used as an energy resource. However, these two fatty acids actually have completely different metabolic functions, because they are the only essential fatty acids in animal nutrition. They form the preliminary stage for even longer, more highly unsaturated and metabolically active fatty acids and are not produced in the animal, so they must always be supplied in the diet.

Apart from these, there are also the shorter saturated fatty acids – shorter chains with 14 or fewer carbon atoms. These are usually referred to as medium-chain or short-chain fatty acids. These free fatty acids are not suitable for feeding to ruminants, because they have a negative impact on the rumen microbes. Farmers who wish to feed unsaturated or short-/medium-chain fatty acids to ruminants must use processed fats that will pass through the rumen without harming the microbes.

Feeding cows with rumen-stable fats may be particularly helpful at high temperatures. This prevents cows from reducing their intake to avoid additional heat production by the rumen bacteria.

Photo: Topf

up of 18 carbon atoms, which means that they are converted to stearic acid and only stearic acid during the saturation. Unsaturated fatty acids that exceed the saturation capacity of approximately 5% fat in the feed disrupt the microbial activity in the rumen. This has a particularly harmful effect on the fibre-digesting bacteria which are damaged by unsaturated fatty acids – to the effect that all rumen activity breaks down.

These reactions illustrate very clearly that fats that are chosen as an extra energy source must not be permitted to affect the microbial population in the rumen. This is where those fats come in that are commonly referred to as 'protected fats' – although the term 'protected' is actually used incorrectly in this context, because it is not the fats that are protected from the microbes but rather the other way round. Consequently, the term of choice here should be 'rumen-stable' fats. These do not harm the microbes. In normal conditions, these types of fat will go through the system without affecting the microorganisms. This scenario is referred to as 'by-passing'.

These rumen-stable fats are also good for the environment, because they circumvent the microbes in the rumen without leading to the production of methane by the microbes. The greenhouse gas is the reason why ruminants have come under attack.

There are three different types of rumen-stable fats and each has different properties:

- Calcium-saponified fats
- Hydrogenated fats
- Fractionated fats

Calcium soaps made from fatty acids

Calcium soaps are made by saponification, a process that turns fatty acids and calcium into soap. This reduces the harmful effect of unsaturated fatty acids on the rumen bacteria.

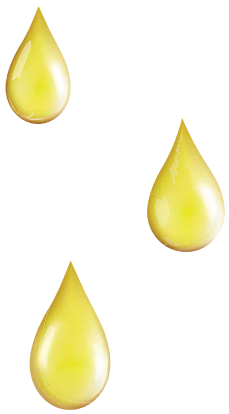
Fats improve fertility

Fertility in dairy cows depends on many factors, and the transition from calving to early lactation requires special attention. After calving, insulinogenic (i.e. starchy) feeds are helpful to restart ovarian activity (Garnsworthy et al., 2008). Feeding fats at this time may increase milk yields, yet it will not prevent the cow from drawing on her fat stores. In this transitory period, it is more effective to feed a fat product that contains Conjugated Linoleic Acid (CLA) which reduces the synthesis of fat. Energy that is supplied by a CLA-containing product plays a smaller role in metabolising fat and is therefore virtually insulinogenic, i.e. it acts more like a starch-containing component. Adding fat to the diet should only be resumed after ovarian activity has restarted (Useni et al., 2018). Finally, a fat supplement is beneficial for a good egg cell quality and high progesterone levels. As early as in 2005, Engelhard and Groenewold, using fractionated palm fat, proved that fats were good for fertility. At this point, the essential fatty acids linoleic acid (Omega 6) and linolenic acid (Omega 3) or the higher unsaturated fatty acids derived from them could also be an option. These, too, would have to be offered in a rumen-stable form however.

Fat feeding should best start when ovarian activity is resumed, i.e. about five to six weeks after calving, and at a dose of 1.5% of the dry mass or about 250g per animal per day. If the animals are in a good condition, palmitic acid-rich fat is ideal. To improve general health, de Souza suggests a fat with approx. 30% oleic acid (de Souza et al., 2018), which can be obtained by mixing fractionated fat and Ca-soap, for example. From lactation day 100, the daily dose can increase to up to 450g. As for feeding, the best approach proved to be mixing the fat to the DMR rather than to concentrate feed, which can be a problem especially with soaps.

Fats reduce heat stress

The fact that fats have a higher energy value than grain explains why it is helpful to feed fats in high temperatures. The heat that is produced by the microorganisms during fermentation in the rumen must be dissipated by the animal to the environment. In summer, especially during hot periods, this heat is released into an environment that is also hot. As a result, the animals take in less feed, so less heat is produced and needs to be released. Yet a reduced feed intake translates into reduced milk yields. Since no heat is released during the digestion of fat, cows that are fed supplementary fats do not reduce their feed intake (or only very little) to regulate their body temperature.



Author

Dr Roland Adelmann
Berg + Schmidt GmbH & Co KG
An der Alster 81
20099 Hamburg
Germany
www.berg-schmidt.com

The bibliography is available from the author.

As a rule, Ca-soaps are produced from inexpensive by-products from the refining of soy, olive and rapeseed oil or from their fatty acids and also from palmitic acids. As the composition of these fatty acids is very similar to their base products, we can infer that the soaps are of vegetable origin, provided no mixes were saponified. Typically, Ca-soaps have a fat content 85% of that of other fatty products, which explains its 15% lower energy level. These missing 15% are made up of about 10% calcium and 5% water. This composition supplies considerable amounts of calcium yet at levels that may exceed the needs of a dairy cow. Another stand-out property of Ca-soaps is their high melting point of approx. 150 °C. Ca-soaps are produced by drum flaking. The rough 'flakes' are then ground and sieved into common sizes. Ca-soaps are easily identified by their coarse structure, characteristic smell and usually grey or brown colour.

Hydrogenated fats

Oils such as soy or rapeseed oils typically contain only small amounts of saturated fatty acids. The percentage is 15% and 8% respectively. The percentage of unsaturated fatty acids is higher: oleic acid (C18:1), linoleic acid (C18:2) and linolenic acid (C18:3). In order to protect the rumen microbes from these fatty acids, the latter are hydrogenated in a chemical process in which hydrogen atoms are added to the chains. In the process, unsaturated fatty acids are converted into the saturated fatty acid stearic acid (C18:0). Hydrogenated soy oils and rapeseed oils are mainly composed of stearic acid. Hydrogenated fats have a high melting point and are marketed as granules. If they are made from refined raw materials, the colouring of the granules will be pure white and they will be practically odourless.

In principle, palm fats can also be hydrogenated. Yet hydrogenated palm fat is composed of stearic acid to a percentage of only about 40%. By comparison, saturated rapeseed oil is composed of 100% stearic acid. 60% of the hydrogenated palm fat is palmitic acid, which is present in the palm fat as a saturated fatty acid.

Fractionated fats

Fractionating fats means that the oil is physically broken down at a defined temperature. It is broken down into a part that is liquid at room temperature and has a low melting point for use in human foods and another solid part that is also used in animal feed. This is a complex process that only pays off when the oil is rich in saturated fatty acids. This is the case with palm oil which is composed of approx. 60% saturated fatty acids, a fact that makes it the most suitable product for fractionating. This high percentage of saturated fatty acids is not the only difference between palm oil and other oils; another is the specific type of fatty acids. The saturated fatty acids in palm oil are mostly palmitic acid (C16:0).

The fractionated product is used in animal feed. The solid part with a high melting point consists either of triglycerides or, after an extra hydrolysis, of free fatty acids. The largest fraction has fats that contain saturated fatty acids including small amounts of oleic acid. These fats do not interact with the rumen microbes and facilitate good digestibility in the small intestine so that they can be passed on into the milk.

These fractionated fats are processed to odourless white powder.

Benefits and drawbacks of various dietary fats

Ca-soaps can be produced from practically any fat or oil, and the process is not too complex so they are relatively inexpensive products. This may explain the longstanding popularity of Ca-soaps as supplementary fats in dairy cow rations. In some countries they are so ubiquitous that some farmers expect to smell the typical Ca-soap odour when adding fats to the feed.

Ca-soaps are composed of fatty acids that are similar to the base material. This means that they can also bring unsaturated fatty acids into the small intestine. Provided they are absorbed here, they can have a positive effect on fertility (Staples et al., 1998). The drawback of using soaps is the fact that this 'pass-through' effect will only be successful if the pH value in the rumen is within the normal range. As soon as it drops – and this happens very easily in all high-performance cows no matter the ration – the soaps start to break down and release the unsaturated fatty acids. And the more unsaturated the fatty acids, the more readily are they released – with the effect of harming the rumen bacteria and reducing the feed intake. But the advantage of breaking down quite easily is good digestibility. The unsaturated fatty acids are one reason why Ca-soaps are usually easier to digest than the hydrogenated or fractionated fats that are based on saturated fatty acids.

Another drawback of Ca-soaps is their susceptibility to oxidation. After all, oxidation requires the presence of water and unsaturated fatty acids. The smell that develops in the process of oxidation and that is typical for fatty acids may have a negative impact on animal feed intake.

Unlike Ca-soaps, hydrogenated fats are anhydrous and usually consist chiefly of pure stearic acid. This makes them practically resistant to oxidation. Since the chain length of fatty acids has also an effect on the melting point, stearic acid has a higher melting point of 69°C than the shorter-chain palmitic acid at 62°C. This is because the digestibility of fatty acids decreases as the chain length increases (Lock et al., 2006). Moreover, the digestibility of stearic acid decreases as the dosage increases (Boerman et al., 2017).

Fractionated fats are almost exclusively produced from palm fat because of its high level of saturated fatty acids. They are also anhydrous and consist mainly of palmitic acid, with small amounts of stearic acid and oleic acid. The levels of palmitic acid and oleic acid suggest a better digestibility than pure stearic acid. This could also be the cause of increased milk fat levels and improved feed conversion when feeding palmitic acid (Lock et al., 2013). Another study shows that, regardless of yield levels, palmitic acid leads to higher feed conversion rates and milk fat levels than pure stearic acid (Rico et al., 2014).

A feed variant that is used more recently draws on the composition of fractionated palm fat. For example, the combination of palmitic acid and oleic acid achieved a better digestibility than pure stearic acid or pure palmitic acid (de Souza et al., 2018) and led to increased milk yields and an improved health condition. Consequently, the combination of palmitic acid and oleic acid could be one road towards better fertility by improving the overall health condition of the cow.

Rapeseed oil or palm oil?

Neither rapeseed oil nor palm oil are suitable for feeding to ruminants as long as the oils are liquid and not processed. Both must be modified in such a way that their unsaturated fatty acid levels don't affect the rumen microbes. In addition to saponification, which is rarely applied, rapeseed also undergoes hydrogenating, during which the unsaturated fatty acids are converted into saturated fatty acids. With reference to palm oil, the standard method of producing palm fat for ruminants is fractionation. The main difference between hydrogenated rapeseed oil and fractionated palm fat is their fatty acid levels. The significantly higher level of stearic acid in rapeseed means that it is less easily digested than fractionated palm fat (Lock et al., 2006).

These digestibility values suggest that some undigested fat residues are found in the faeces. However, it should always be borne in mind that digestibility depends very much on the dose. The higher the dose of stearic acid, the more fat would be found in the faeces: This would particularly be the case with hydrogenated rapeseed.

Farmers focus on performance parameters such as milk yields or milk fat yield and also on animal fertility. With this in mind, Engelhard & Groenewold (2005) reported an improved fertility by feeding fractionated palm fat at a dose of 2.5% of the dry matter mass, while Rico maximumised milk fat yields with a dose of 1.5% fractionated palm fatty acids (Rico et al., 2013).

Fatty acids in the diet also influence the composition of milk fat. The stearic acid levels in milk increase slightly after 'rapeseed feeding' whereas palm fat tends to increase the palmitic acid level in milk (Rico et al., 2014). The dairy industry is trying to avoid an increase in saturated fatty acids in milk, because these are believed to be harmful to human health. However, such a connection is not proven by scientific facts (de Souza et al., 2015).

Neither can scientific methods prove the presence of genetically modified substances or the absence of these, both in the fat added to the feed and in its residues in the faeces. This is because genetically modified substances are detected by means of PCR (polymerase chain reaction) analysis, a method that uses DNA sections of the protein. However, after oil or fat is extracted from a plant, it no longer contains protein under normal circumstances.

Home game for rapeseed

One advantage of rapeseed is the fact that it is grown locally in Europe. Palm is grown in the tropics and soybeans are mainly grown in North and South America. This said, palm fat offers one overriding advantage. Palm oil yields 3.3 tonnes per hectare, which compares with 0.7 tonnes of rapeseed oil per hectare (WWF 2016). Soy oil yields are even lower – 0.4 tonnes per hectare. This suggests that five to eight times more land would be required for producing the same amount of rapeseed and soy oil than is used for producing palm oil. Even in view of consumer trends to locally grown food, expanding the acreage for rapeseed or especially soy in South America in substitution for palm oil would displace other crops. ■

Summary

The two rumen-stable types of fat – Ca-soaps and fractionated palm fats – have their place in the nutrition of high yielding dairy cows, albeit with some limitations. Their positive qualities lie in the aspects of energy supply, cow fertility and heat tolerance. Yet hydrogenated fat is suitable only to a limited extent due to the poor digestibility of stearic acid. After many years of adding only one type of fat to animal feeds, the trend now seems to be towards feeding combinations of palmitic acid and oleic acid. However, all these fats or fat combinations have one thing in common: They cannot make up for a poor ration or poor management.