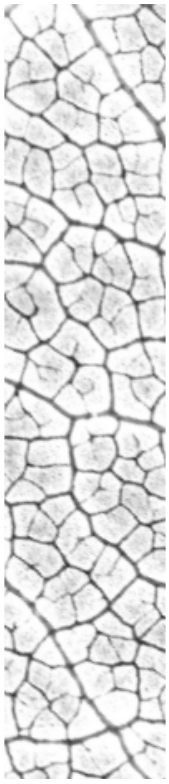

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Prospects for the use of "protected fats" in cattle feed additives

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Abstract
The article reviews the use and physiological effects of fats protected from decay in the rumen of ruminants, as well as types of feed additives containing "protected fats", presents their comparative characteristics of fatty acid composition, indicators of exchange and pure lactation energy. Summarized data indicate the prospects of the technology of "protected fats" and their use in animal husbandry.

Keywords: feed additives, "protected fat", energy additive, cattle, energy, energy ratio

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INTRODUCTION

Increasing milk yields, increasing the fat content in milk, and improving the quality of other livestock products have been and remain important tasks for feeding cattle. It is known that fats are a necessary component for the full maintenance of the energy state of a cow, the energy value of fats is 2.25 times more carbohydrates and proteins. The recommended fat content in the diet of ruminants is 4% of the total mass of the feed, and its increase leads to disruption of metabolic processes in cattle foreguttle.

Free higher fatty acids and constituent di- and triglycerides affect microbial metabolism: an increase in the concentration of high fatty acids inhibits the growth of scar microflora, and a decrease, on the contrary, contributes to the development of microorganisms. The rumen of animals contains Isotricha intestinalis, Isotricha prostoma and others, which have special organelles - hydrogenomes, in which ATP is synthesized with release of molecular hydrogen (Agarwal et al. 2015, Toral et al. 2017, Tzirita et al. 2018, Wu et al. 2012). These bacteria contain hydrogenomes (**Fig. 1**).

The released hydrogen reacts with unsaturated fatty acids in food - the process of biohydrogenation is underway, as a result of which the formation of trans-isomers of fatty acids is possible. The most common of these is the C18: 1 trans-isomer of oleic acid — vaccenic acid (Barletta et al. 2016, Doreau et al. 2016, Ferlay et al. 2017, Schmidely et al. 2017). A part of unsaturated fatty acids is not subjected to biohydrogenation, but accumulates in the rumen, where it is intensively oxidized to form acetoacetic, β-hydroxybutyric acids and acetone (Abdela 2016, Amachawadi and Nagaraja 2016).

These circumstances prompted the creation of feed additives "protected fats", which replenish the energy balance of the animal without harm to the scar, as well as reduce the risk of acidosis. The term "protected fats" is understood as a mixture of C12-C18 high fatty acids. The peculiarity of "protected fats" is that they pass through the rumen, the mesh, the book unchanged, and in the strongly acidic medium of the abomasum, their decomposition begins. During the interaction of salts of bile acids, micelles are formed in the small intestine, which are transported to the intestinal walls and absorbed diffusely in them, triglycerides from free fatty acids and glycerol-3-phosphate (formed in glucose from the liver) are resyntsed, then they are encapsulated in low-density lipoproteins, are transported to the lymphatic system and delivered to the organs and tissues through blood vessels (**Fig. 2**) (Toral et al. 2012).

Feed additives containing "protected fats" differ in the type of treatment: hydrogenated, fractionated, saponified (calcium salts of high fatty acids). The type of processing depends on the fatty acid composition of feed additives. So, for example, stearic and palmitic fatty acids predominate in hydrogenated fats, palmitic acid in fractionated fats, and a high percentage of oleic and linoleic fatty acids in calcium salts (**Table 1**).

To date, the effectiveness of feed additives "protected fats" was confirmed by various studies (Gamko and Svirid 2015, Martinez et al. 2016, Morozova 2011, Raikhman 2016, Radchikova et al. 2009), in which there was an increase in milk yields by an average of 3 l / day, as well as milk fat content by 0.5-1 % (Esaulova

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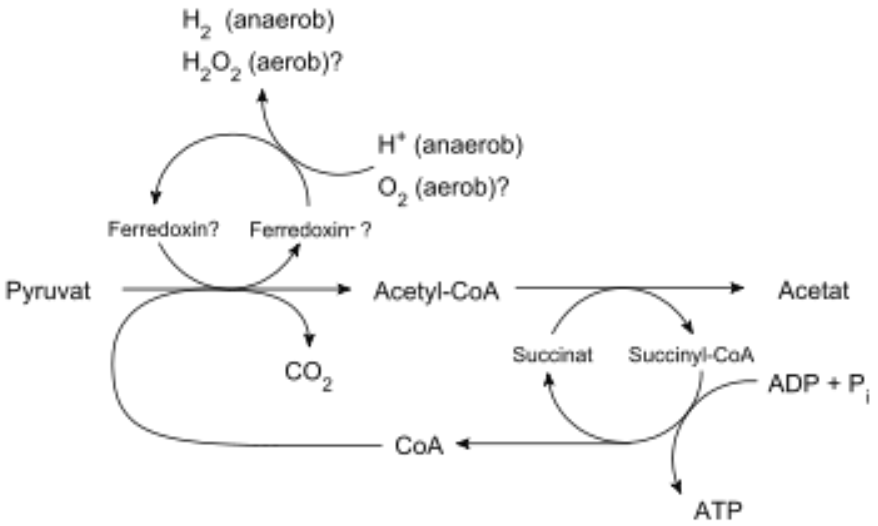

Fig. 1. The process of the formation of ATP and the release of hydrogen by hydrogenomes (Choudhury et al. 2015)

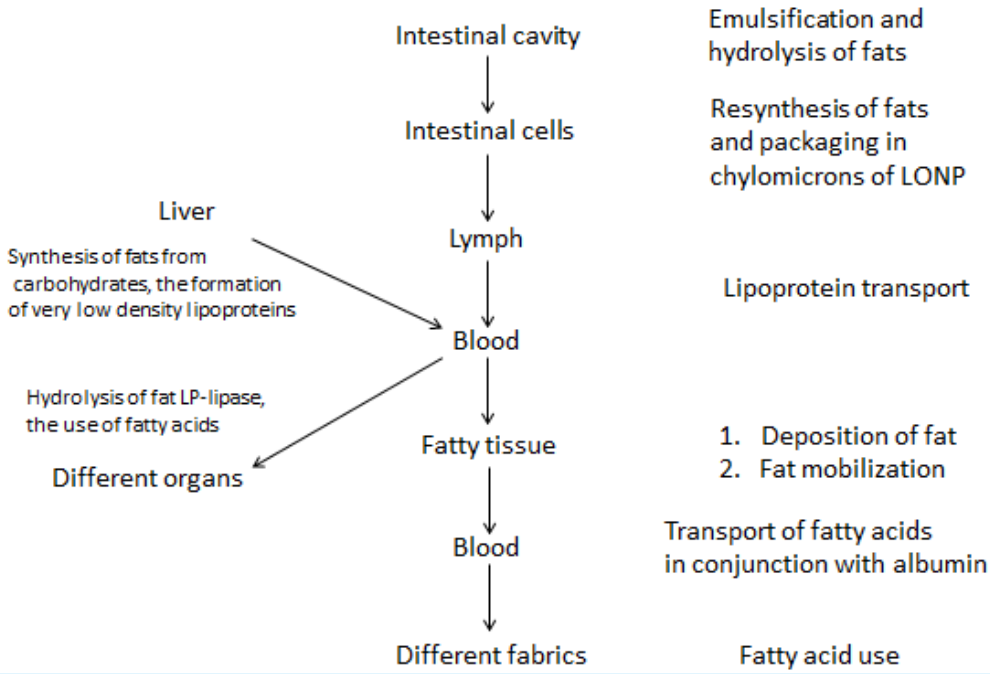

Fig. 2. Scheme of lipid metabolism (Hoffman 1971)

Table 1. Fatty acid composition of protected fats, depending on the method of production

Fatty Acid Name	Hydrogenation, %	Fractionation, %	Calcium salts of fatty acids, %
Palmitic	45-50	75-85	30-50
Stearic	45-50	3-5	0-5
Oleic	2-6	10-15	40-70
Lauric	0-1	0	0-1
Myristic	0-2	0-5	0-2
Linoleic	0	1-3	8-10

and Elizarova 2016, Golovin 2016, Morozova et al. 2013). However, there are a number of drawbacks and difficulties associated with the bioavailability and technologization of the process of obtaining protected fats:

a) Hydrogenated lower digestibility (Golovin 2016), form trans-isomers of free fatty acids (Gamayurova 2010, Medvedev and Medvedeva 2015, Voigt et al. 2006), their production is associated with high temperatures (180-220 °C) and rather toxic catalysts.

b) When receiving fractionated fats, a multistage technology is used (Kellenc et al. 2007, Kuznetsova et al. 2012, 2013, Prokopenko 2012), as well as imported raw materials, mainly palm oil.

c) In the saponified fats, a strong alkaline odor (Mba et al. 2015), moreover, calcium salts of high fatty acids are insoluble, which significantly reduces their absorption into the ruminant intestinal cells (Levakhin et al. 2012, Patent us 4826694 1989).

These circumstances determine the prospects of finding new technologies for obtaining “protected” fats, as well as ways to reduce the negative impact on the digestion of cattle, with the additional inclusion in the diet of fats. To assess the quality of feed additives “protected” fats, there are evaluation criteria: the digestibility coefficient, the exchange energy, the net energy of lactation.

The digestibility coefficient is the ratio of the digested nutrient to the feed consumed. A number of studies have shown that the digestibility of “protected” fats improves as the concentration of palmitic acid increases and stearic acid decreases (Palmquist and Jenkins 2017, RF patent number 2008131286/13 2010, Ylioja et al. 2018). This is due to the limiting factor of enzyme activity during digestion.

Exchange energy - the amount of energy absorbed by the body nutrients feed. This indicator is significantly affected by the bioavailability of “protected” fats: to participate in metabolic processes, all nutrients must be soluble; Extraction of energy from an IVH occurs in the mitochondrial matrix, the transport to which is restricted. Many manufacturers add to feed additives L-carnitine (Chamberlain and DePeters 2016, Murali et al. 2015, Pirestani and Aghakhani 2017), which is one of the carriers of high fatty acids.

The pure energy of lactation is the energy consumed for the secretion of milk (Olagaray et al. 2016).

The above criteria are universal, but not the only indicators of feed quality. There are domestic and foreign studies on the comparative characteristics of the digestibility of various types of “protected” fats (Bainbridge and Kraft 2016, Rico et al. 2017). Evidence suggests that the digestibility of hydrogenated fat - 43-79%; calcium salts of high fatty acids: 9.7–78.3%; fractioned - 39-40.6% (Boerman et al. 2015, Weld and Armentano 2017, Yeasmin et al. 2017).

Today, the consumer market is represented by a wide range of different “protected” fats. The overwhelming majority of feed additives circulating on the Russian market are produced abroad: Malaysia, Indonesia, China, Germany, etc. In the proposed assortment, there is a general trend in the values of the exchange and pure energy of lactation (**Table 2**).

Table 2. The values of the exchange energy and the net energy of lactation

Name	Exchange energy, MJ / kg	Pure lactation energy, MJ / kg
Quality Fat	35.89	24.50
Bewi Spray 95D	34.05	22.00
Fatrix CLA 100	33.50	24.00
LactoPlus MB Protect	30.00	20.50
Del-Agro (fraction.)	33.46	24.73
NutrakorFB60L (fraction)	38.85	28.00
Del-Agro (Calc.)	30.00	23.30
Nutrakor FB60L (Calc.)	33.25	26.60
Aktifat	38.00	30.00
Megalac	33.25	25.00

According to GOST for cattle feeds, the content of raw fat for highly productive cows with a capacity of 6000 kg of milk is at least 5% of the total mass of feed. With a daily feed weight of 20 kg, a metabolic energy ratio of 214 MJ and a fat percentage of 5%, the rate of fat input will be 1 kg. If the exchange energy of “protected fat” is 38.00 MJ / kg (see **Table 2**), 18% of the exchange energy of the feed is obtained. This ratio of input rate and the percentage of added exchange energy is effective.

Today, “protected fats” are produced from palm oil fractions and hydrogenated fatty acids by foreign companies from Malaysia, Germany, China, etc. The production of “protected” fat in Russia is possible only by hydrogenating unsaturated high fatty acids, but the formation of large amounts of trans isomers of high fatty acids is a significant disadvantage of this technology. Imported “protected” fats also have several disadvantages, such as low digestibility and bioavailability. But despite this, the exchange energy of “protected” fats is 1/3 of the exchange energy of the entire diet. In connection with the above factors, it can be concluded that it is necessary to develop new technologies for the production of “protected” fats based on unsaturated fatty acids in the territory of the Russian Federation, which will have high digestibility and bioavailability.

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