Energy carriers of the past and future in dairy cows' nutrition

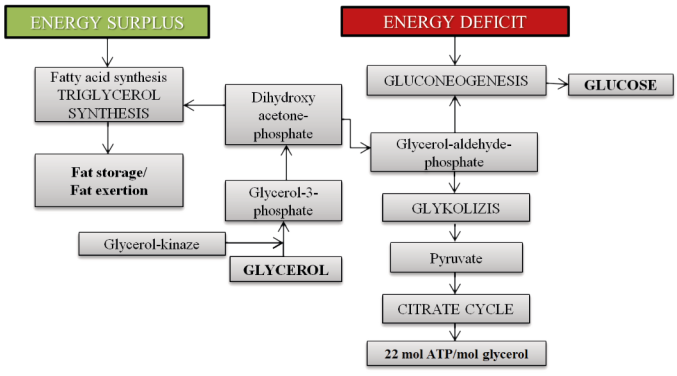
High-energy materials such as glycerol or propylene glycol have been used in feeding dairy cattle since long ago. The cow utilizes these energy carriers nicely, since the rumen fermentation produces volatile fatty acids that the animal can use for energy production. These substances become an integral part of fresh cows' and high groups' ration as kind of matrials that can prevent metabolic disorders and nearly all feeding software can calculate with them.

It is very interesting that programs usually evaluate them as substances with high sugar content. In our article, we would like to show, through the glycerol as an example, why this is problematic. We compare glycerol with a rumen protected sugar source, which according to feed software, is far below the positive effect of glycerol on milk production.

The glycerol

Glycerol as the base of lipids is a trivalent alcohol. The three hydroxyl groups in it can combine with fatty acids in ester bonds to create true lipids. Although glycerol is sweet in terms of the taste, but unlike sugars, does not raise blood glucose level, so it cannot provide direct energy to animals, even ruminants. Glycerin enters into glycolysis and the citrate cycle to generate energy (through ATP generation) or delivers energy to the animal through the gluconeogenesis, which results in significant energy loss and significant exertion of liver functions (Figure 1). This latter process is mainly disadvantageous during the transition period when the increased concentration of NEFA (non-esterified fatty acids) of blood is still challenging the liver.

Figure 1: The route of glycerol in the body. (Vida, 2014)



The Glüko-GO-60

Glüko-GO-60 is a rumen stable sugar developed by Adexgo Kft. A large part of the glucose content of the product is absorbed from the small intestine and supplies the cow with direct energy, while the small fraction that dissolves in the rumen slowly and gradually supports the rumen microbiome, resulting in an increase in the digestion of dry matter, protein and fiber. Accordingly, the molar concentration of ketogenic substances (butyric acid, valeric acid, etc.) decreases in the rumen, and acetic acid production increases, which has a positive effect on the amount of milk fat.

Comparison with Feeding Software

If glycerol and rumen stable glucose product (Glüko-GO-60) are compared with a simple sugar in a nutrition software (NDS Professional CNCPS 6.55), it is clearly apparent that glycerol is treated as a material with high (93.9%) sugar content that has rumen degradation of ca. 58%. This means that the ratio that passes to the liver is approx. 42% (absorption in the rumen and small intestine). The energy content of glycerol is similar to the simple sugars (9.57 MJ / kg). Table 1.

Table 1: Composition of sugar, glycerol, bypass sugar (NDS Professional software)

		SIMPLE SUGAR	GLYCEROL	GLÜKO-GO-60
Moisture	%	2.000	2.700	1.600
Dry matter	%	98.000	97.300	98.400
Sugar (water soluble carbs.) (WSC)	%	98.000	93.962	58.800
RD CHO 3x Level 1	%	74.809	58.001	21.217
ME NRC	MJ/kg	15.166	14.460	21.273
NE_l 3x NRC	MJ/kg	9.883	9.577	15.668
NE_m NRC	MJ/kg	10.502	10.012	16.040
NE_g NRC	MJ/kg	7.443	7.050	11.161

The rumen protected glucose product contains 60% sugar and 40% of protected fat. Its rumen degradation is lower than that of glycerol (22%), thus, it is directly absorbed in the small intestine to help satisfy the glucose needs of the animals. Due to its 40% protected fat content, its energy content is much higher than that of glycerol (15.66 MJ / kg).

The test substances (glycerol and rumen stable glucose product) were formulated with the aforementioned feeding software into the feed mix of a fresh milking group fed for 38 kg milk production. The doses are based on corn silage and consisted of the feeds used in the Hungarian practice. 0.7 kg of glycerol, 0.3 kg of by-pass glucose was added to the recipes based on the dosage recommendations of the products. Table 2.

Table 2: The composition of the feed according to the base recipe, glycerol and by-pass sugar supplementation

RECIPE	1	2	3
	BASE DIET	+ 0.7 KG GLYCEROL	+0.3 KG GLÜKO-GO-60
Feed components	A.F. kg	A.F. kg	A.F. kg
Corn silage	18.0000	18.0000	18.0000
Rye haylage	5.0000	5.0000	5.0000
Alfalfa haylage	5.0000	5.0000	5.0000
Grass hay	1.0000	1.0000	1.0000
Wet beat slices	3.0000	3.0000	3.0000
Wet corn	3.0000	3.0000	3.0000
Extr. sunflower middling 34%	2.5000	2.5000	2.5000
Corn	2.0000	2.0000	2.0000
Extr. soy middling 47%	1.5000	1.5000	1.5000
Wheat	1.5000	1.5000	1.5000
Molasses	0.5000	0.5000	0.5000
By-pass soy	0.5000	0.5000	0.5000
By-pass fat	0.2000	0.2000	0.2000
Glycerol 84%	0.0000	0.700	0.0000
Glüko-GO-60	0.0000	0.0000	0.3000
Milking premix	0.2000	0.2000	0.2000
Totals	43.9000	44.6000	44.200
DMI (kg)	21.46	22.13	21.75
	48.88% DM	49.60% DM	49.20% DM

With the addition of 0.7 kg of glycerol, daily intake of dry matter increased to 22.1 kg, while it increased to only 21.7 kg with by-pass sugar. The dry matter content of the feed mixes were similar (49.2% to 49.6%).

By examining the nutritional parameters of feed rations, it appears that protein content of feeds with both glycerol and by-pass sugar decreased relative to the basic formula due to the dilution effect of these substances. In contrast, the energy concentration increased in both cases. Table 3.

Sugar and starch concentrations have also changed in the opposite direction. The program makes a substantial difference between glycerol and by-pass glucose as a sugar source. According to the program, glycerol increases the dose of sugar to 7.43%, while by-pass glucose to 5.39% only, which is a significant difference. After analyzing the sugar balance, it can be seen that the 1000 grams sugar intake of the base recipe increases to almost 1200 g for by-pass glucose and 1650 g for glycerol. Sugar absorbed in the small intestine increases from 315 g to 430 and 574 g in the case of by-pass glycose and glycerol supplementation respectively.

Table 3: Nutrients of the feed according to the base recipe, or glycerol and by-pass sugar supplementation

	BASE DIET	GLYCEROL	GLÜKO-GO-60
		BASE+0.7 KG	BASE+0.3 KG
	in DM	in DM	in DM
CP %	16.526	16.025	16.370
NE_l 3x NRC MJ/kg	6.915	7.004	7.037
Sugar (WSC) %	4.645	7.436	5.395
Starch %	27.529	26.693	27.269
Soluble fiber %	5.552	5.383	5.499
ME MJ/day	230.13	239.9	236.2
MP g/day	2430.1	2494.5	2440.2
Milk kg ME	34.29	36.44	35.62
Milk kg MP	35.63	36.85	35.71
NE_l MJ/kg	6.91	6.98	6.99
Total sugar	996.8	1654.52	1173.2
Fermentable sugar	681.9	1080.55	743.7
Digestable sugar	314.9	574.04	429.5
Fermentable sugar %	68.41	65.76	64.83
Digestable sugar %	31.59	34.24	35.17

The data calculated by the program are interesting because glycerin is not fermented as simple sugar, but as sugar alcohol in the rumen and induces propionic acid or butyric acid production and decreases the production of acetic acid. Propionic acid produced from glycerol in the rumen promotes energy production in the citrate cycle, while glycerol absorbed from the rumen wall and the small intestine enters the liver gluconeogenesis as a triosephosphate. Accordingly, it is important to note that the 574 g of digestible sugar that the glycerol supplementation provides is not absorbed directly from the small intestine – like the 430 grams of by-pass sugar does –, but is generated by gluconeogenesis in the liver.

The basic recipe was formulated from the view of expected milk production to be somewhat energy-deficient, compensated by both supplements (glycerol and Glüko-GO-60) for recipes 2 and 3. Recipe 1 is enough for 34.29 kg milk production based on the metabolisable energy, while for 35.63 kg milk production based on the metabolisable protein. By adding 0.7 kg of glycerol (recipe 2), milk production based on energy and protein supply is 36.44 and 36.85 kg. According to the program, therefore, the addition of glycerol increases production by more than 2 kg compared to the basic recipe. However, the 0.3 kg rumen stable sugar enhances only 1.3 kg of milk yield according to NDS Professional (recipe 3).

Comparison of the two materials in production

The effect of Glüko-GO-60 on milk production was tested against glycerol in a large-scale paired cows feeding experiment. The experiment was carried out in Komárom at the dairy farm of Solum Zrt. in 2017. The stock consists of 730 Holstein-Friesian dairy cows and progenies. Feeding is based on forages (maize silage, rye haylage, alfalfa haylage, etc.). The farm's 305 days milk production in 2016 was 12156 liters.

The experiment was performed using a classical paired cows method (treated vs. control) with 17 pairs of cows. During the experiment, all the animals produced in the high production group, so housing and feeding conditions were considered the same. Only cows with multiple lactations were involved.

Cows of the experimental group received 0.3 kg of Glüko-GO-60 per day, while 0.7 kg of glycerol was administered to the control group. Before the start of the experiment, a 9-day so-called pre-feeding was introduced when the animals received 0.2 kg of Glüko-GO daily. After the pre-feeding stage, the dose was raised to 0.3 kg and then the data collection started. The data collection lasted for 53 days. The experimental feed (Glüko-GO) was allocated in addition to the feed into the mixer dispenser.

The lactating cow-pairs were selected by four aspects:
- milk production
- days in milk (DIM) (87-91 days lactations)
- numbers of lactations (lactation 2-3)
- monthly milking parameters (milk protein, milk fat)

Rations were designed to match their nutritional parameters and have the same energy content. Table 4 and Table 5.

Table 4: Nutirents of rations

	CONTROL	EXPREIMENTAL
NE_l (MJ/kg DM)	6.80	6.77
Crude protein g/DM	18.50	18.80
Crude fat, g/DM	3.90	4.30
Starch, g/DM	24.20	24.60
ADF, g/DM	16.80	17.00
NDF, g/DM	28.00	28.00
Ca, g/DM	11.00	11.00
P, g/DM	4.60	4.50

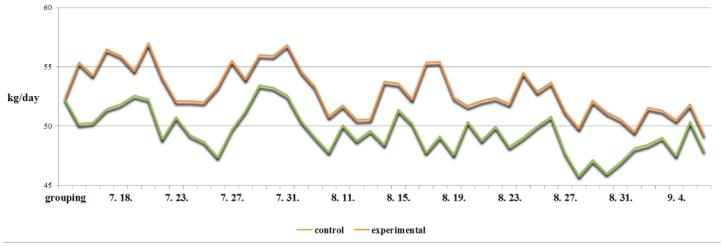
Table 5: Composition of TMR

	CONTROL (KG/D)	EXPERIMENTAL (KG/D)
Milking compound feed	12.5	12.5
Corn silage	10	10
Rye haylage	14	14
Alfalfa haylage	5	5
Wet brewer's grain	6	6
Molasses	1	1
Glycerol	0.7	-
Alfalfa hay	0.6	0.6
Glüko-GO-60	-	0.3
Total	49.8	49.4

The daily milk production, the composition of the milk (protein, fat - monthly test-milking data) and the somatic cell count (monthly test-milking data) were recorded during the experiment. The TMR of the two groups was checked regularly.

After 53 days of sample collection, daily milk production data were evaluated and graph 1 shows the milk production performance of the two groups.

Graph 1: Milk production during the experiment



There was no significant difference between the milk protein and milk fat of the experimental and the control group. There were neihter significant differences in somatic cell count (SCC) data.

As the conclusion of the experiment, Glüko-GO-60 administered in a dose of 0.3 kg/animal/day resulted in 3.4 liters higher milk production than the addition of 0.7 kg of glycerol. The reason for this is that Glüko-GO-60 is a rumen stable sugar that directly and gradually releases and utilizes energy, thus directly affecting milk production and at the same time does not burden the liver. Glycerol, however, is utilized as a gluconeogenetic agent in the body of the animals, which latter is a process that is slower and has greater energy loss, while on the other hand it charges the liver at the time when its capacity is still limited due to the body fat breakdown in the period of negative energy balance.

Summary

In the article it was tend to show that, in addition to traditional ingredients (e.g. glycerol), "modern" substances are now available for supporting energy balance of dairy cows. These novel energy supplement products may better serve the needs and health of dairy cows, but the spreading of their usage is greatly limited because of the faulty feeding software settings. Practical experience has shown that it is time to think about the role of some energy sources (e.g. glycerol, propylene glycol) in the recipes and to evaluate their use compared to such innovative products like Glüko-GO-60 containing glucose in a rumen stable by-pass form.

The basic recipe was formulated from the view of expected milk production to be somewhat energy-deficient, compensated by both supplements (glycerol and Glüko-GO-60) for recipes 2 and 3. Recipe 1 is enough for 34.29 kg milk production based on the metabolisable energy, while for 35.63 kg milk production based on the metabolisable protein. By adding 0.7 kg of glycerol (recipe 2), milk production based on energy and protein supply is 36.44 and 36.85 kg. According to the program, therefore, the addition of glycerol increases production by more than 2 kg compared to the basic recipe. However, the 0.3 kg rumen stable sugar enhances only 1.3 kg of milk yield according to NDS Professional (recipe 3).

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