Energy carriers of the future in dairy cows' feeding II

The performance of dairy cattle farms is heavily influenced by the metabolic problems of the energy-deficient period after calving, such as ketosis or fatty liver syndrome. The lower the risk of occurrence of these diseases, the higher the performance during lactation and the lower the rate of early culling in the herd.

Reproductive performance is a key factor in dairy farms. The earlier we can make our animals pregnant, the shorter the length of lactation and the more milk produced per unit of time. In Hungary, calving interval is between 430-440 days, which is the result of successful fertilization beyond the 145th day after calving. Improving the post-calving negative energy balance, speeding up the cow's oestrus cycle, and reducing early embryo loss may be an advantage in reduction of calving interval, which means „serious reserve" in dairy production.

Reproduction biology in focus

Milk production and reproductive performance are closely related, since both of them are energy-dependent. Despite the fact that close up period has great importance for the survival of post-calving energy deficient phase, it is crucial that the animals receive sufficient and digestible, energy-dense feed after calving (*Otto et al*, 2014). This is beneficial in several ways. First, we can reduce the catabolic processes of the animals by improving the negative energy balance, i.e. minimizing the mobilisation of the body's own energy reserves. This can prevent fattening of liver and ketosis, which may reduce the rate of culling caused by metabolic disorders and improve milk production. On the other hand, since reproduction is an energy-dependent process, we can reduce the time required for involution, advance the date of first insemination, and improve the pregnancy rate (*Stockdale*, 2000). As a consequence, the rate of culling due to reproductive causes may also be reduced (*Roche et al.,* 2000).

The relationship between negative energy status and reduced reproductive performance can be read in many places in the literature (*Table 1*). Cows with severe negative energy status need more time to restart their oestrus cycle (*Wathes et al.*, 2007). In parallel, earlier oestrus lead to improved fertility rates (*Opsomer et al.*, 2000).

Table 1: Effect of condition on conception (based on *Yasothai*, 2014)

Degree of condition point decrease after calving	Conception rate%
less than 1 point	50
1 to 2 points	34
more than 2 points	21

Canfield and Butler (1990) and *Beam and Butler* (1997) found that negative energy balance results in lower luteinizing hormone (LH) production, which adversely affects follicles' hormone production and hence their development. This leads to a prolonged cycle and cysticization. *Vanholder* et al. (2005) have demonstrated that non-esterified fatty acids (NEFA) in vitro significantly influence the hormone production of follicular granulosa cells and hence follicle development.

Nevertheless negative energy balance does not only affect the reproductive processes only through influencing hormone production. In subclinical and clinical ketosis high blood levels of non-esterified fatty acids (NEFA) or β-hydroxyvinic acid (BHBA) have a negative effect on the development and maturation of the dominant follicle as they alter the composition of the follicle fluid (*Jorritsma et al.*, 2003; *Leroy et al.*, 2004).

Conception is not enough, survival is also necessary...

However, reproduction biology processes occurring in the cow do not end with ovulation and fertilization of the egg. In the case of cattle, the developing embryo starts implantation between days 8 and 12 post fertilization. Before implantation, it is "floating" in the so-called uterine milk, the composition of which affects the embryo. In the case of low energy supply (especially when coupled with protein overfeeding), increased urea and ammonia in the mother's body can damage the embryo to death before nidation (*Hammon et al.*, 2005).

After ovulation, progesterone production of the corpus luteum (CL) maintains gestation until the placental hormone production becomes significant (*Ball and Peters*, 2004). Increasing progesterone levels have a positive effect on early embryonic development. It triggers the production of the nourishing and stimulating substances necessary for the development of the embryo (*Geisert et al.*, 1992). The amount of progesterone produced is therefore crucial for the survival of the embryo.

The level of progesterone in the blood is closely related to the amount of energy absorbed (*Table 2*) (*Escherich and Lotthammer*, 1987).

Table 2: Effect of energy supplementation on blood progesterone levels

Energy supplementation	Energy Concentration	Progesterone level in the blood
high	37.7 MJ IU/day	5.7 ng/ml
low	16.7 MJ IU/day	3.7 ng/ml

The growing embryo uses an interferon-tau (bIFN-τ) molecule to sign that it exists (*Campbell JR, et al.* 2003). The strength of the signal depends on the size of the embryo. A strong signal suppresses prostaglandin (PGf2α) production, to ensure the survival of the fetus. Early embryo death is due in large part to the fact that small embryos are unable to produce a sufficiently large signal to prevent the lysis of corpora lutea supporting them by prostaglandin (PGf2α) produced in the endometrium (*Thatcher et al.*, 1984).

In order for the embryo to survive the first and most critical stages of pregnancy the following must be fulfilled:

1. After calving, an appropriate energy concentration should be provided to the cow to develop large-sized ova which, due to their size, will be able to produce large signals to maintain pregnancy.

2. After insemination, progesterone production of the CL should be kept high to ensure survival of the developing embryo.

3. At the same time, the PGf2α level should be kept low during pregnancy, to stabilize progesterone production of the corpora lutea. This can be ensured by a large interferon-tau signal of the embryo.

Glüko-Rep is the newest member of the Glüko-GO range

The aboved discussed inspired ADEXGO Kft. to develop a new energy supplement as the latest member of the Glüko-GO product family, which has already been tested and proven in practice.

A significant part of the glucose content of Glüko-GO-60 is absorbed from the small intestine and provides direct energy to the cows, while a smaller proportion is dissolved in the rumen slowly and gradually supporting rumen flora, resulting in improved dry matter, protein and fiber digestion. In a digestion-physiological model study performed with rumen cannulated sheep, it was found that the molar concentration of ketogenic substances (butyric acid, valeric acid, etc.) was reduced in the rumen fluid and acetic acid production increased, which has a positive effect on the amount of milk fat and ultimately on milk production.

Since feeding the product is already recommended from the close up period and reaches its peak dose in the fresh and high dairy groups, it provides easily and gradually utilised energy to the animals when they need it the most. Its positive effect on reproduction can be attributed to its support for the maturing of gametes and the start of oestrus cycle, when animals, due to genetic selection, tend to use the consumed energy rather for milk production.

According to practical experiences Glüko-GO's easy-to-use energy is at least partly used to help maturing follicles, and thus large ova released from larger follicles can become larger embryos that are able to sign clearly their existence to the maternal body and therefore ensure their survival.

The mode of action of Glüko-Rep is based on the described mechanisms. The purpose of the development was to reinforce the reproduction biology effects and to support not only follicle maturation, but also the survival and development of the conceived embryo. For this reason, polyunsaturated fatty acids (PUFAs) have been introduced in the new product, which have long been the focus point of interest in reproduction biology (*Dewhurst et al.*, 2006).

From polyunsaturated fatty acids, n-3 (omega-3) fatty acids have a proven positive reproductive effect. The n-3 fatty acids are unsaturated fatty acids in which the last unsaturated carbon-carbon double bond is 3 bonds away from the chain-end methyl group of the fatty acid. Essential n-3 fatty acids include polyunsaturated alpha-linolenic acid (C18: 3, ALA), eicosapentaenoic acid (C20: 5-EPA), and a docosahexaenoic acid (C22: 6 DHA). The animal body is not capable of de novo synthesis of n-3 fatty acids, but EPA and DHA can be created from alpha-linolenic acid, with relatively poor conversion.

The effects of polyunsaturated fatty acids in dairy herds have been investigated by several researchers. *Robinson et al.* (2002), and *Ponter et al.* (2006) found that as a result of feeding PUFA, the developing follicles became larger compared to controls. Larger follicles lead to the formation of larger corpora lutea that can help fertilization by higher progesterone production and are able to maintain pregnancy (*Funston*, 2004). Several authors have confirmed the effect of feeding n-3 fatty acid sources (e.g. linseed oil, fish oil) on follicle development and size of corpora lutea (*Petit et al.*, 2002; *Zeron et al.*, 2002; *Ambrose et al.*, 2006; *Fouladi-Nashta et al.*, 2009; *Mendoza et al.*, 2011).

The ratio of n-3 to n-6 fatty acids has a significant effect on ovarian function (*Gulliver et al.*, 2012). The availability of n-3 fatty acids affects progesterone production and thus the chance of survival of the embryo. In contrast, the high concentration of n-6 fatty acids in the follicle fluid, through the support of PGF2α synthesis, promotes regression of the corpora lutea (via the process of luteolysis), which may lead to early embryo death (*Abayasekara et al.*, 1999; *Mattos et al.*, 2002; *Malau-Aduli et al.*, 2004).

The interferon tau signal of the large embryo supported by n-3 fatty acids reduces the production of PGF2α in the endometrium, so the corpora lutea are less likely destroyed by the luteolytic effect of PGF2α and can maintain pregnancy (*Wathes et al.*, 1995; *Inskeep*, 2004; *Childs et al.*, 2008). The research of *Petit and Twagiramungu* (2006) showed an obvious correlation between feeding of alpha-linolenic acid (C18: 3, n-3) and embryo survival.

Due to the reproductive effects of the n-3 fatty acids described above, ADEXGO Kft. decided to use one of the best n-3 fatty acid sources available for animal nutrition in the development of Glüko-Rep: fish oil. More than one third of fish oil is made up of unsaturated fatty acids and the proportion of each EPA and DHA is 30% in unsaturated fatty acids. This makes fish oil to be far the best source of omega-3 fatty acids in animal feeding.

Testing Glüko-Rep in production

The effect of Glüko-Rep on milk production and reproductive processes was tested in a large-scale feeding experiment. The experiment was carried out at the cattle farm of Solum Zrt. in Komárom in 2018. The herd consists of 730 Holstein-Friesian dairy cows and their offspring. Feeding is based on forages (corn silage, rye haylage, alfalfa haylage, etc.) In 2017, the average milk production of 305 days lactation was 12,835 kg.

The effect on milk production was tested with classical cow pairs (experimental - control), with 18 cow pairs, while reproductive effects were assessed by comparing two high production groups of the farm. During the experiment, all the animals were producing in the high yielding group, so that the housing and feeding conditions were considered to be the same. Only multiparous cows were involved in the experiment.

Animals in the experimental group received 0.4 kg of Glüko-Rep daily during the experiment, while the control group received no supplement. 14 days before the start a pre-feeding phase was introduced. After the pre-feeding phase, dose was raised to 0.4 kg and then collection of data started. Experimental feeding lasted for 85 days. Milk production was examined for 34 days, while reproduction biology data were examined for 3 months. The distribution of the experimental feed was carried out in addition to mixed into the TMR serving, in the feed mixer.

The most important parameters of the TMR are shown in *Tables 3 and 4*.

Table 3: Nutritional values of TMR

	Control	Experimental
NEl (MJ/kg dry matter)	7.16	7.25
Crude protein, % dry matter	18.53	18.24
Crude fat, % dry matter	4.13	4.77
Starch, % dry matter	26.07	26.07
Sugar, % dry matter	3.52	4.16
ADF, % dry matter	19.03	19.03
NDF, % dry matter	32.37	32.37
Ca, g/dry matter kg	9.68	9.68
P, g/dry matter kg	4.04	4.04

Table 4: Composition of TMR

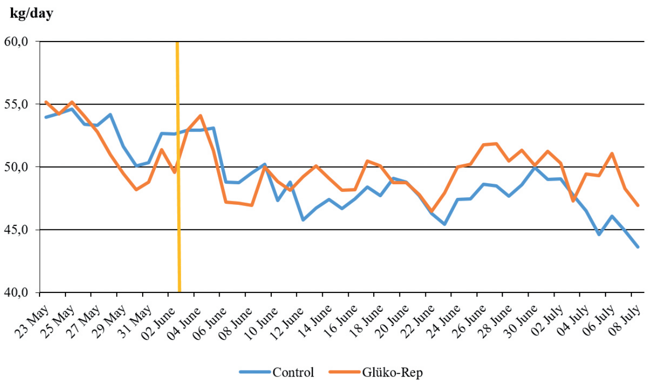
	Control (kg/d)	Experimental (kg/d)
Concentrate	13	13
Maize silage	11	11
Rye haylage	10	10
Lucerne haylage	5	5
Sugar beet pulp	7	7
Glycerol	0.7	0.7
Alfalfa hay	1	1
Glüko-Rep	-	**0.4**
Total	*47.7*	*48.1*

During the experiment, milk production was evaluated on the basis of daily milk production data. TMR analysis were performed in all the two groups.

Results

Daily milk production data were evaluated and displayed on graph. The average daily milk production of the experimental group was 49.29 kg during the experimental period, which was significantly higher (p> 0.05) compared to the control group (47.82 kg) (*Figure 1*).

Figure 1: Development of milk production during the experiment



In terms of reproductive results, we examined pregnancy rates, insemination indexes, and the rate of early embryo death (*Table 5*).

Table 5: Reproduction biological results of the experiment

	Control	Experimental
Number of involved animals	57	38
Number of pregnant animals	19	16
Pregnancy Rate (%)	33.3	42.1
Insemination Index	2.74	2.32
Number of early embryo deaths	57/10	38/0
Rate of early embryo death (%)	17.5	0

Based on the results, it can be seen that the experimental group performed better than the control on all three parameters tested. The mechanisms discussed in the first half of this article may have been in the background of conception ratio improvement of almost 10% and the dramatic reduction in early embryo deaths.

Summary

As a conclusion of the experiment, Glüko-Rep provided in a dose of 0.4 kg/animal/day increased milk production with an average of approximately 1.5 liters and significantly improved the reproduction parameters of the farm. The reason for this is that the combination of rumen-stable sugar and rumen-protected fish oil in Glüko-Rep gives the animals easily absorbed energy and nutrients (eg. n-3 fatty acids) that, through their direct positive effects, greatly contribute to follicle development and embryo survival as well as support milk production through better energy supply.

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