Omega-3 fatty acids to improve reproductive performance in dairy cows

Omega-3 (n3) fatty acids (FAs) have beneficial effects on both human and animal health. People can obtain these benefits in two ways: by taking n3 supplements or, more naturally, by consuming food with a high content of these acids, such as milk, eggs or meat.

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Some milk products available on the market have a high n3 FA content. The n3 FAs are normally added during processing with these products; only rarely do they occur naturally in the milk due to better cow nutrition.

Supplementation of cows with different sources of n3 FAs has increased in recent decades. This supplementation is done for two main reasons: first, to increase the amount of n3 FAs in milk; second, to improve reproductive performance.

With regard to the first objective, there is extensive literature showing the effective transfer of these FAs from feed to milk.

However, the improved quality of the milk fat does not always translate to increased revenue for the farmer. In contrast, the investment in improved reproductive efficiency yields significant returns.

Several authors have reported increased reproductive efficiency in dairy cows that consumed diets high in n3.

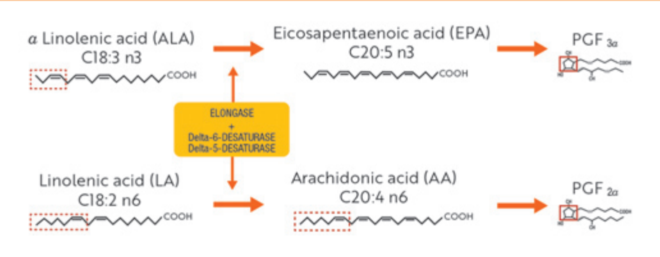

Fig. 1. Metabolic routes of omega-6 and omega-3 fatty acids (adapted from Gulliver et al, 2012).

This improvement is attributed to the reduction in the ratio of omega-6 (n6) FAs, such as linoleic acid, to n3 FAs, such as alpha-linolenic acid.

Despite using some of the same enzyme complexes, these two classes of polyunsaturated FAs (PUFAs) are precursors of different series of eicosanoids (including prostaglandins, Fig. 1).

Whilst linoleic acid (LA, n6) is a precursor of arachidonic acid (AA), which is then transformed into prostaglandin (PG) F2α (PGF2α, series 2), alpha-linolenic acid (ALA) is a precursor of eicosapentaenoic acid (EPA), which is then transformed into PGF3α (series 3).

Eicosanoids are signalling molecules associated with numerous processes in the body, including inflammation. Series 3 PGs are less inflammatory than series 2 PGs. As will be described below, PGF2α plays a key role in several aspects of reproduction.

Because both types of FAs (n6 and n3) use the same enzyme complex for their metabolism, they compete for it. Therefore, the increase in n3 FAs (ALA) in the Total Mixed Ration (TMR) causes lower production of PGF2α.

As noted, the decrease in the production of PGF2α is one of the most important effects of n3 supplementation. However, another effect that needs to be taken into account is that the membranes' increased PUFA content increases their fluidity. Omega-3 (ALA) supplementation in dairy cows has numerous beneficial effects on reproductive parameters, such as:

- **Prevention of regression of the corpus luteum (CL):**
At a hormonal level, McCracken (1972) reported that the decrease or inhibition of the synthesis of PGF2α, which has a luteolytic effect, prevents the regression of the CL, resulting in the maintenance of progesterone (P4) secretion.

- **Promotion of follicle and CL development:**
The mean diameters of the ovulatory follicle and CL were larger when cows were fed diets high in n3.

- **Assurance of oocyte maturation:**
It does this in two ways: directly, by changing the lipid composition of oocytes, and indirectly, by influencing the PG concentration in the oocytes' surrounding fluid.

Zeron et al. (2002) have reported that the number, quality, and resistance to freezing of merino sheep oocytes increases after supplementation with n3 FAs. This was also confirmed through evaluation of the oocytes' lipid composition, whose PUFA content increased.

- **Improved embryo survival:**
Successful pregnancy recognition and subsequent embryo survival involve the release of trophoblast interferons by the embryo, which inhibits endometrial expression of oxytocin receptors and secretion of PGF2α, thereby preventing CL regression and P4 secretion. Several authors have observed an increase in embryo survival and a reduction in PGF2α levels in cows supplemented with n3 FAs.

- **The aforementioned effects directly influence pregnancy rate:**
As fewer embryos are lost, the number of pregnant cows thus increases.

Santos et al. (2008) reported a higher pregnancy rate and lower embryonic losses in dairy cows supplemented with n3 FAs after insemination compared to cows

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Fig. 2. Number of viable oocytes collected from the cows in each treatment group.

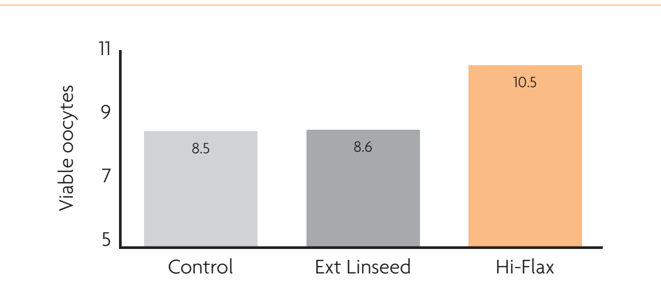
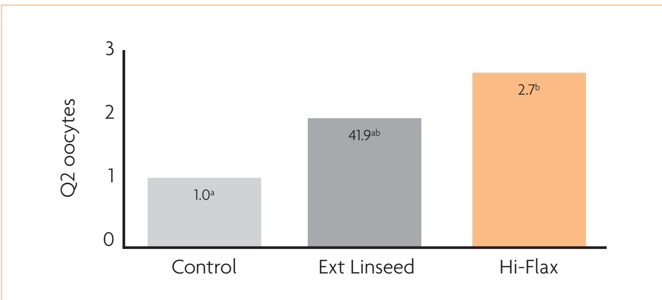


Fig. 3. Number of oocytes with a quality assessed as Q2 from cows in each treatment group.



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supplemented with n6 FAs; other authors have observed similar results.

Effect of protected n3 FAs on oocyte quality

The following study (presented at the 2019 American Dairy Science Association Annual Meeting) aimed to evaluate the effects of supplementation with different sources of n3 FAs on oocyte quality in dairy cows. As noted, several sources of n3 FAs are used in dairy nutrition.

Two of the most common are extruded linseed and free linseed oil. Norel has developed Hi-Flax a product made of linseed oil protected against ruminal biohydrogenation with hydrogenated palm stearin.

63 Holstein cows were divided into three groups (n = 21) for 84 days. The treatments consisted of supplementation with 500g/d of hydrogenated fat in the control cows (CTR), 350g/d of extruded linseed + 390g/d of hydrogenated fat (EXT) in the second group, and 500g/d of Hi-Flax (HFL) in the third group. The HFL and EXT provided the same amount of C18:3 (ALA). The cows were fed a ration (15.5% CP, 33.7% NDF, 1.65 Mcal of NEl/kg; DM basis) twice a day. At the end of 84 days, an oocyte (COC = oocyte complex + cumulus oophorus) collection was performed. The COCs were counted and a quality evaluation based on their morphological characteristics was carried out (Q1-Q4). Cows that received Hi-Flax tended (P=0.1) to present a higher number of viable oocytes (10.5) than the control cows (8.5) and those that consumed extruded linseed (8.6, Fig. 2).

As for the oocyte quality, the HFL cows tended (P=0.1) to have a larger number of oocytes with a quality assessed as 1 or 2 (Q1+Q2, 4.8) than the EXT (3.8) and CTR (3.4) cows. However, analysis of the Q2 oocyte quality revealed a significant (P=0.05) difference amongst treatments, with the HFL cows producing 2.7 Q2 oocytes, the EXT cows 1.9, and the CTR cows 1.0 (Fig. 3).

These findings agree with those reported by Zeron et al. in 2002 on the improved oocyte quality in sheep supplemented with n3 FAs. Based on this trial, it was concluded that supplementation of dairy cows with Hi-Flax (protected linseed oil) increases both the quantity and quality of viable oocytes.

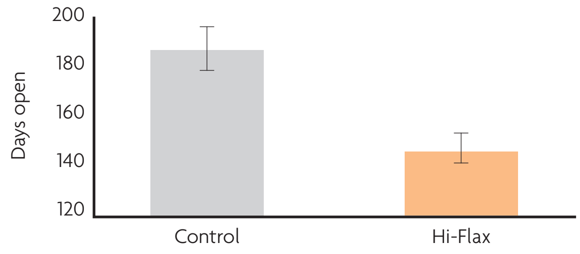

Fig. 4. Number of days open for dairy cows supplemented with calcium soap (CTRL) and protected omega-3 fatty acids (HFLX).

Effect of protected n3 FAs on productive parameters and days open

A total of 150 dairy cows were enrolled in this 'in vivo' trial with the aim of evaluating the effect of an oil rich in protected omega-3 (Hi-Flax) on both milk production and composition and reproductive performance.

The animals were separated into two groups, which were homogeneous in terms of production, number of calvings, and days in milk (n=75). Both groups received the same TMR, with the sole difference that in the control group (CTRL) each cow received 400g/d of calcium soap (ME=2822kcal/d), whereas in the Hi-Flax group (HFLX) each animal received 446g/d (ME=2824kcal/d) of Hi-Flax. Both diets were thus isoenergetic. The trial lasted four months (November-February). The results are shown in Table 1.

Table 1. Productive performance of the cows in the control (CTRL) and Hi-Flax (HFLX) groups.

Parameter	HFLX	CTRL	SE	P-value
Milk yield (l)	45.35	41.79	1.40	0.1319
Milk fat (%)	4.15	4.29	0.13	0.5092
Milk protein (%)	3.29	3.30	0.03	0.8834
Fat yield (kg)	1.88	1.79	0.07	0.5955
Protein yield (kg)	1.49	1.37	0.04	0.1390
SCC	119	145	22	0.4417
Urea	19.5	19.6	0.80	0.8627

No significant effect was observed from the use of a protected source of n3 FAs on milk production or composition.

Milk production was numerically higher (45.3kg/d) in HFLX cows compared to CTRL cows (41.7kg/d). In contrast to previous findings, the use of PUFAs did not affect the percentage of fat and protein in the milk.

This may have been due to the protection (saturated palm serine matrix) included in Hi-Flax, which makes it virtually inert in the rumen, unlike the free linseed oil used in the trial by Castro et al. (2020).

The milk's n3 content tended (P=0.08) to be higher (0.35%) for the HFLX cows than the CTRL cows (0.22%).

The effects of n3 FAs on days open (DOs) is shown in Fig. 4. Cows that received n3 FAs (HFLX) had a significantly lower number of DOs (P=0.05, HFLX 144 d, CTRL 184 d). This is equivalent to a reduction of more than 20% in DOs for the HFLX cows versus the CTRL cows.

It was concluded that supplementation with n3 FAs significantly reduced the number of DOs, with cows becoming pregnant earlier due to a higher pregnancy rate. The reduction in DOs meant fewer cows had repeated heats, with the ensuing significant money savings for the farmer. This improvement in reproduction was furthermore achieved without interfering with milk production or composition.

Conclusion

Supplementing dairy cows with a protected source of omega-3 FAs has beneficial effects on both their general health and their reproductive performance.

Significant reductions in days open can be achieved without altering the composition of the milk. This allows farmers to improve farm production and cow health. ■

References are available from the author on request