ß-carotene and cow reproductive performance // 11 Nov 2009

Fertility and reproductive performance are crucial to the profitability of dairy herds. One key factor that substantially improves fertility and reproductive performance is the dietary intake of ß-carotene. By Irmgard Immig.

Dairy herd size has seen a steady growth over the past 30 years which coincided with an increase in average milk yields. This increased productivity has brought with it the negative trend of higher culling rates caused to a great extent by reproductive problems. USDA results from 2007 (*Figure 1*) show that 26% of cows leaving herds too early in their life are culled for this reason, in particular due to a failure to rebreed after conception. Longer calving intervals and high herd replacement rates are major economic threats that negatively affect the dairy farmer's monthly bottom line. Normally, a cow should calve once per year and the herd replacement rate should not exceed 30%. Yet calving intervals of more than 420 days and replacement rates as high as 45% are reported in modern dairy herds. Calving interval and parity are major profitability factors in milk production. Cows with long calving intervals spend more time in late lactation when daily milk yield can be below 18 kg. Where calving intervals are shorter, a larger proportion of the lactation is in early lactation where daily milk yield is above 30 kg.

As for the importance of parity, older cows give up to 20% more milk than first lactation milkers (*Figure 2*). *Table 1* shows that reducing calving interval in a herd of 100 cows from 420 to 365 days can increase annual milk sales by more than €11,000 and that rearing fewer heifers as herd replacements can further increase total revenue: simple calculations emphasising the importance of getting cows back into calf as early as possible and optimising cow/heifer ratio. Both factors are prerequisites for optimum herd structure to generate the highest revenues and this in turn means that improving pregnancy rates early-on in lactation is always worthwhile – even under the situation of a tight budget and cash flow.

FIGURE 1 - REASONS WHY DAIRY COWS ARE CULLED TOO EARLY

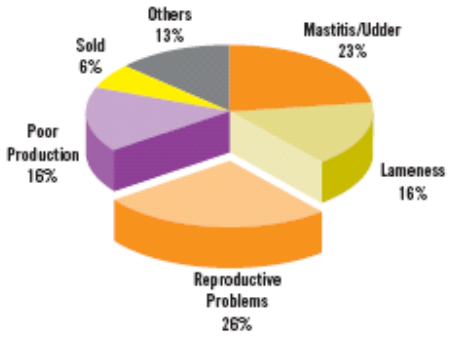


FIGURE 2 - CALVING INTERVAL (CI) AND PARITY – KEY DRIVERS OF PROFITABILITY IN MILK PRODUCTION (IN A HERD OVER 2 CALENDAR YEARS)

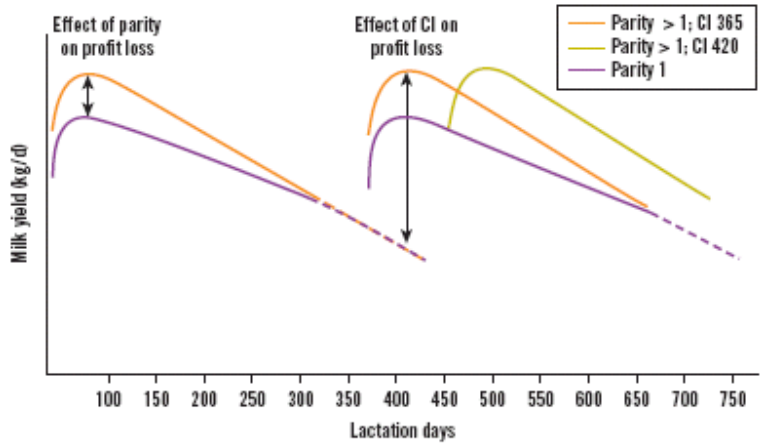


TABLE 1 - POTENTIAL VALUE TO CAPTURE THROUGH IMPROVING REPRODUCTIVE PERFORMANCE (HERD STRUCTURE OF 100 COWS OVER 2 CALENDAR YEARS)

Reproductive performance	Optimum	Low	Difference
Calving interval (d)	365	420	+55
Replacement rate (%)	30	45	+15
Days in milk	305	360	+55
Total milk production kg/cow	8,500	9,518	+1,018
Milk production kg/lactation day	27.9	26.4	+1.44
Milk yield kg/lactation day	2,787	2,643	+144
Turnover @ €0.22/kg milk/365d	223,796	212,233	+11,563
Cows culled due to reproductive problems	4	12	+8
Heifer raising costs @ €1,500/heifer	6,000	18,000	+12,000
Total value to capture €/year			+ 23,563

Symptoms of deficiency

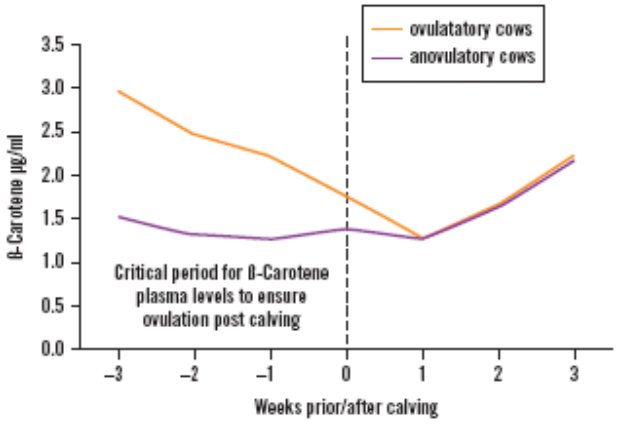
It's well documented that cows deficient in ß-carotene have impaired reproductive performance (Meyer *et al*. (1975) and Lotthammer *et al.* (1975, 1978), Arechiga, 1998). Symptoms may include weak or silent oestrus, delayed ovulation, ovarian cysts, abnormally high embryonic mortality or retained placenta. This means there's inevitably sub-optimal fertility in herds with low ß-carotene status. The knowledge of a cow's ß-carotene status for her subsequent reproductive performance is therefore key. Nowadays the ß-carotene status of a herd can be easily quantified using a rapid ß-carotene extraction method from whole blood and a hand-held spectrophotometer. This cow side technology which is now widely used by the global dairy industry provides immediate results of ß-carotene levels so that a targeted ß-carotene supplementation can be put in to place the same day. However, not only the dosage but also the source of ß-carotene plays a crucial role as ß-carotene sources are not the same. Besides stability in the feed supplement a high bioavailablity is of prime importance for optimum ß-carotene levels in the ovaries and in the colostrum.

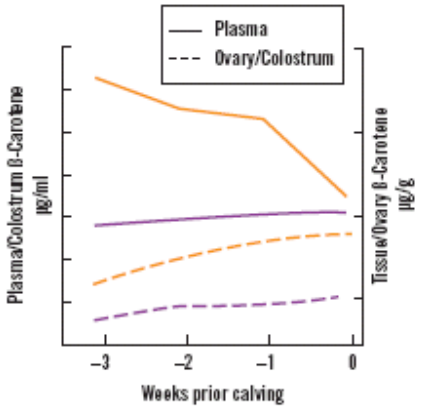
Follicle production

In a recently conducted trial at Obihiro University in Japan ß-carotene plasma levels were profiled with 22 multiparous cows from three weeks prepartum until three weeks postpartum (Kawashima *et al.* 2008).

Ovulating cows were confirmed by blood progesterone levels and ultrasonic scans. The researchers demonstrated that ß-carotene plasma levels before calving determine when cows produce the first dominant follicle after calving. Irrespective of post-calving plasma levels cows with a higher concentration of plasma ß-carotene in the last three weeks of the dry period were ovulatory whilst those with a lower status were an-ovulatory (*Figure 3*). ß-carotene status before calving is also a key factor for enrichment of colostrum thus influencing the vitality of the newborn calf (*Figure 4*). It can therefore be concluded that cows with higher ß-carotene status resume ovulation faster than cows with low ß-carotene levels. This demonstrates clearly the importance of high ß-carotene levels prior to the onset of the reproductive cycle after calving.

FIGURES 3 AND 4 - ß-CAROTENE PLASMA LEVELS BEFORE CALVING ARE KEY FACTORS FOR SUBSEQUENT REPRODUCTIVE PERFORMANCE AND COLOSTRUM QUALITY





Confirmation trials

In a survey recently conducted of intensively-managed dairy herds in countries including the US, France, Italy, Germany, Israel, Japan, Korea and Mexico it was found that the majority of cows did not exceed ß-carotene

levels of 2.5 µg/ml plasma. In most countries 75% of cows had marginal plasma ß-carotene levels and as much as 30% of cows were deficient. All herds tested were also reporting reproductive problems with long calving intervals of up to 450 days and high replacement rates of up to 45% (*Figure 5*). A trial conducted in

such a ß-carotene deficient herd showed that targeted supplementation with a ß-carotene supplement* alleviated the drop in plasma ß-carotene status before calving (*Figure 6*) (Bian et al., 2007). Abortions decreased from 10% to zero and cows resumed cyclic activity 3-8 days faster than those without being supplemented. All effects were more pronounced in those cows on the higher plane of supplementation. These results confirm once again the findings of the University of Florida from 1998 and of Lotthammer *et al*. (1975 and 1978 data not shown) that cows supplemented with ß-carotene had less reproductive disorders. The pregnancy rate after 120 post partum was nearly doubled compared to the control group (*Table 2*). Another field trial was conducted in a well-managed commercial dairy herd in the US to determine the effect of a ß-carotene supplement* in the diets of high-production cows with marginal plasma ß-carotene status. The influence on milk production, milk components, feed intake and reproduction were recorded. Half the cows received the supplement and half did not. The basic ration consisted of maize silage, lucerne/grass haylage, high-moisture shelled maize and a commercial feed mix. The results of the trial are summarised in *Table 3*.

TABLE 2 - EFFECT OF ß-CAROTENE SUPPLEMENTATION* ON PREGNANCY RATE IN DAIRY COWS (ARÉCHIGA ET AL., 1998)

		Pregnancy rate		
Treatment	Calving to 1st insemination (d)	At 1st AI	90 d pp	120 d pp
Control	77	9.3	9.4	21.1
ß-Carotene 400 mg/cow/d for ≥ 90 d	79	14.6	12.9	35.4*)

**) p< 0.05*

TABLE 3 - EFFECT OF FEEDING ROVIMIX® ß-CAROTENE TO IMPROVE FERTILITY IN A ß-CAROTENE DEFICIENT COMMERCIAL DAIRY HERD IN NORTH AMERICA (DE ONDARZA ET AL. 2009)

	ß-carotene plasma µg/ml	3.5% FCM (kg/d)	Pregnancy rate (%)	Calving interval d	Abortions (%)
Control	2.02	42.2	11	420	5
ß-Carotene 425 mg/cow/d	3.30	43.2	22	390	2.6

FIGURE 5 - RESULTS OF A SURVEY IN MODERN DAIRY HERDS: MOST OF THE COWS HAVE ONLY MARGINAL ß-CAROTENE STATUS

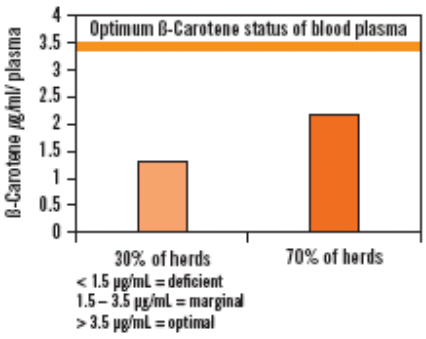
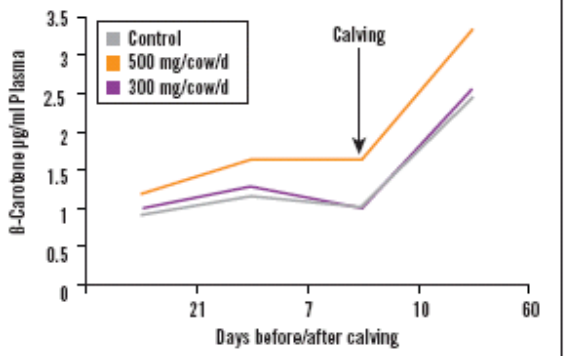


FIGURE 6 - EFFECT OF TARGETED ß-CAROTENE SUPPLEMENTATION* ON PLASMA ß-CAROTENE STATUS BEFORE CALVING IN A ß-CAROTENE DEFICIENT HERD (BIAN ET AL, 2007)



Return on investment

It was shown that the cows fed diets with the supplement increased their plasma ß-carotene levels from deficient to optimum. This increased milk fat percentage resulting in more 3.5% fat corrected milk (FCM). Pregnancy rate was doubled, calving interval reduced by 30 days and abortions were almost halved. The value of an additional 1% increase in pregnancy rate is estimated at €16/cow, the costs of abortions are estimated at €363 per case and milk price is taken as €0.22/kg per kg of 3.5% FCM. Considering the price of the supplement used in this trail at about €2,000 per 100 cows, the revenue increase exceeded €20,000 which is a return on investment of 10:1. Even a further reduction of 50% in milk price would still generate a good return on investment.

Conclusion

In conclusion, ß-carotene supplementation improves reproductive performance in ß-carotene deficient cows. Cows with plasma ß-carotene levels below 1.5 µg/ml require ß-carotene supplementation of at least 500 mg per head per day. Cows with plasma ß-carotene levels between 1.5 and 3.5 µg/ml need 300 mg ß-carotene per head per day**. Supplementation should start with the beginning of the dry period through to confirmation of the next pregnancy. <-

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