

Rapid assessment of β -carotene status

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An essential dietary nutrient necessary for optimum bovine fertility is β -carotene. Evidence from numerous scientific studies show that the role of β -carotene in bovine fertility is based on the local conversion of β -carotene into vitamin A.

Through a highly regulated local conversion in the ovary, the development and hormonal activity of the follicle and the corpus luteum are positively modulated. The pathway by which β -carotene regulates the follicular environment influencing follicle and oocyte development is schematically depicted in Fig. 1.

Low β -carotene status is frequently associated with impaired reproductive performance. Symptoms may include weak or silent oestrus, delayed ovulation, ovarian cysts, abnormally high embryonic mortality or retained placenta.

As a consequence, herds with low β -carotene status inevitably have sub-optimal fertility.

Reproductive disorders result in losses of up to €150 per cow per year. Furthermore, this accounts for between a quarter and a half of all herd culling.

β -carotene benefits

Recent studies at the University of Florida confirmed the findings of Meyer et al. (1975) and Lotthammer et al. (1975, 1978) that cows supplemented with β -carotene had a better reproductive performance. The pregnancy rate after 120 days post partum was nearly doubled compared to the unsupplemented control group.

It has also been demonstrated that β -carotene can enhance the immune response by potentiating lymphocyte and phagocyte function. These data show that β -carotene can reduce the losses associated with reproductive disorders.

Herbivores are dependant on a range of carotenes in feedstuffs to provide their vitamin A requirements.

β -carotene is the most abundant vitamin A precursor and is found in the highest concentration in fresh grass.

The relative conversion value of β -carotene into vitamin A varies from 4:1 to 10:1

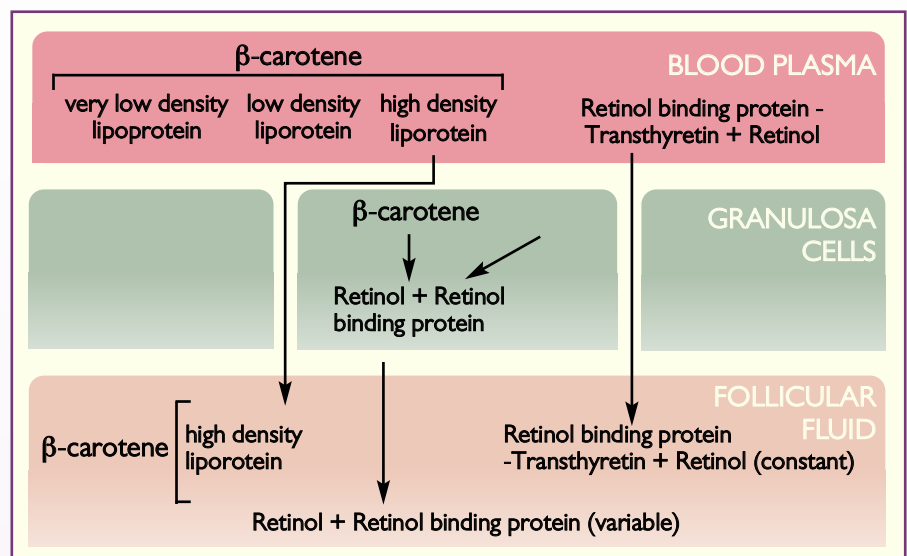


Fig. 1. Possible mechanism for a local regulation of retinol levels in follicular fluid.

depending on the criteria used and experimental circumstances. It is now accepted that 1mg β -carotene is equivalent to 400 IU vitamin A in normal dairy cow rations.

Although considerable biosynthesis of vitamin A from β -carotene occurs in the intestinal mucosa, cattle still normally circulate a large amount of β -carotene in blood.

β -carotene analysis

To ensure an optimal supply of β -carotene to the target tissues such as the ovary, adequate plasma levels are necessary.

Measuring the β -carotene status of the cow determines the appropriate requirement for supplementary β -carotene.

In the past this was done by comparing the blood plasma colour with a specific colour chart (DSM Nutritional Products).

However, colour deviations due to haemolysis or increased bilirubin levels often result in an overestimation of the true β -carotene concentration of the plasma especially in the diagnostically critical marginal range (1.5-3.5 mg/L).

These problems could be only overcome by using a spectrophotometer or HPLC in a specialist analytical laboratory.

Normally the process of sample prepara-

tion to enable extraction of β -carotene from blood is a complex, time consuming and costly procedure.

iCheck innovation

Recently, BioAnalyt GmbH in cooperation with DSM Nutritional Products have introduced the first portable hand held spectrophotometer – iCheck – for rapid β -carotene assessment at cow side.

In combination with the innovative extraction procedure iEx (patent pending), β -carotene is now extracted in a single step directly from whole blood without centrifugation.

Furthermore, the commonly encountered problem of haemolysis does not compromise the result.

Because the sample is effectively preserved, this increases the flexibility between sampling and testing. Therefore, this simple and inexpensive on-farm diagnostic tool is ideal for widespread use.

In a comparative study, this novel technique was validated using bovine serum and blood from Germany, Spain, France, Northern Ireland and Israel.

Some 176 blood samples were prepared

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iCheck and iEx for rapid assessment of β -carotene status at cow side.

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Furthermore, the results show that the novel cow side test for β -carotene were highly correlated (Pearson correlation coefficient) with HPLC analysis ($r_2 = 0.98$ and 0.99 , serum and blood respectively, $P < 0.001$).

In a subset of samples taken from Israeli animals, plasma levels were mostly in the deficient range ($< 1.5\text{mg/L}$, 29 out of 32 animals).

When the samples were assessed by the plasma colour method 24 out of 32 animals were assessed wrongly into the marginal (1.5-3.5mg/L) or even optimal ($> 3.5\text{mg/L}$) range, while with the cow side assay all animals were classified properly.

These results show that blood levels of β -carotene can now easily be assessed within a few minutes at cow side achieving the same quality as with highly sophisticated, time consuming and expensive laboratory methods such as HPLC.

Conclusion

The new iEx and iCheck technology provides a rapid, inexpensive method of determining whether a cow is receiving an adequate supply of β -carotene. If the blood levels are less than 1.5mg/L the β -carotene status of the cow is deficient and supplementation of 500mg β -carotene/cow/day is recommended.

Blood levels between 1.5-3.5mg/L require supplementation of at least 300mg β -carotene/cow/day.

When the blood level is over 3.5mg/L the cow has optimal status. This systematic approach enables the targeted supplementation of β -carotene for the improvement of fertility and calf vitality – both providing a significant benefit to the farmer's bottom line. ■