Vitamins in Ruminant Nutrition -

OVN®概念

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Content

- DSM and its vitamin history
- OVN™ what does it stand for
- Visible and not so visible vitamin deficiencies
- Effect of OVN® on animal performance
- Ruminal stability of vitamins
The Century of the Vitamins

1929-1967: 12 Nobel Prices awarded to 20 Scientists for Synthesis, Characterization and Elucidation of Function of the Vitamins

1912: Term “Vitamins” coined by Casimir Funk (B1)

1916: First large-scale, industrial Synthesis of Vitamin A by Roche

1934-87: Development of industrial Production Processes for Vitamins by Roche, starting with Vitamin C

1906-41: 13 Vitamins identified and characterized


Vitamins: Definitions and functions

**Vitamins**

- Are essential micronutrients, required for optimum health and normal physiological functions such as growth, development, maintenance and reproduction.
- Cannot be synthesized by the animals and must be fed (exception vit C)
- Have catalytic functions; they facilitate synthesis & degradation of the nutrients & control the metabolism.
- Are classified into two groups:
  - Fat-soluble (4): A (retinol), D (calciferols), E (tocopherols), K (phylloquinone)
  - Water soluble (9): B1 (thiamin), B2 (riboflavin), B6 (pyridoxine), B12 (cobalamin), niacin (vitamin PP), pantothenic acid (vitamin B5), folic acid (vitamin M), biotin (vitamin H), vitamin C (ascorbic acid).
Consequences of insufficient dietary supply of vitamins

Temporary or chronic undersupply
- Animals suffer from subclinical deficiency, impacting on performance, health and welfare.

Clinical vitamin deficiency
- Growth depression, deterioration of feed conversion, irreversible serious disorders of various origin
- Can lead to death of the affected animal
Factors influencing vitamin requirements

- Vitamin Demand

- Genetics/Breed
- Life Stage
- Feed Composition
- Housing Conditions
- Performance
- Stress
- Infectious Pressure
- Temperature/Humidity

Vitamin Demand
Optimum Vitamin Nutrition (OVN®) is about feeding animals high quality vitamins in the right amounts and ratios appropriate to their life stage and growing conditions.

Optimum Vitamin Nutrition is cost-effective optimizing

- Animal Health and Welfare
- Performance
- Quality and Nutritional Value of Animal-origin Foods
Visible vitamin deficiencies

Fat soluble Vitamins - Vitamins E & D

Vitamin E deficiency
Muscle dystrophy

Vitamin D deficiency
Rickets

Fig 1. Rickets with flared growth plates
Flared osteochondral junction, rachitic rosary, with irregular and elongated growth cartilage (arrows)
Vitamin deficiencies?
Fat soluble Vitamins - Vitamin D and Ca - metabolism,

Leaking udder
Subclinical milk fever?

Ca - deficiency
Clinical Milk fever
Vitamin deficiencies
Water soluble vitamins: Thiamin (B1)

Thiamin - deficiency - Thiaminases
brain degeneration
Opisthotonos in sheep
Polioencephalomalacia in cattle

Photo on Polioencephalomalacia: Courtesy of Gustavo Carneiro do Amaral, 2016
Vitamin and mineral deficiency
A, E, D3, ß-Carotene, Biotin, Mn, Se, Cu, Zn

Wavy hairs
Anovulation, cystic ovarian degeneration
Not so obvious vitamin deficiencies
Water soluble Vitamins - Biotin

Biotin - deficiency
Hoof disorders

Avidin induced Biotin deficiency
Dermatitis
Not so obvious vitamin deficiencies
Water soluble vitamins: Biotin

Average yield (kg/hd/d)

Weeks

1 2 3 4 1 2 3 4 1 2 3 4

No biotin added to ration
Biotin included in ration
No biotin added to ration

Control 20 mg/hd/d biotin

De Brabander and Wouters, 2005

Biotin - deficiency
Suboptimal milk yield
Reduced prevalence of sandcracks in Hereford cattle after receiving 10 mg Biotin/hd/d

Control: 29.4%
Biotin: 14.3%

*p<0.05

(Campbell et al., 1996)
Growth pattern of cattle on natural pasture

Seasonal live weight changes in Australian cattle supplemented only with minerals during the dry season.
Effect of ROVIMIX® Biotin on monthly incidence of lameness in pasture fed cows

Source: Fitzgerald et al., 2000

Period of heavy rains and high number of wet days per month
Effect of ROVIMIX® Biotin supplementation of pasture fed cows on hoof disorders

Source: Fitzgerald et al., 2000

*p<0.05
ROVIMIX® Biotin = better hoof health and more milk too

- RUMEN: Propionate produced
- Gluconeogenesis
- Lactose synthesis in the udder: Higher lactose yield increases milk yield
- Biotin: Lipogenesis, Protein synthesis, Hormone-like activation of protein metabolism, Synthesis of keratin proteins
- Prosthetic group in fatty acid synthesis
- Synthesis of intercellular cementing substance

DSM
International Symposium on Vitamins and Technologies 2017
Improving hoof horn quality with ROVIMIX® Biotin

Low quality of intercellular mortar leads to a fractured cell structure - increased risk of lameness

ROVIMIX® Biotin helps improve horn quality because of its involvement in the production of the intercellular cementing substance (mortar) which binds the horn cells together

Source: Mülling et al., 1999
Biotin increases milk production in a dose dependant manner

**DESIGN**
- 45 Holstein cows
- 0, 10 or 20 mg/day biotin
- Days -14 to 100 of lactation
- 50% forage:concentrate diet

**RESULTS**
- Significant linear effect of biotin on milk production ($P < 0.05$).
- Almost 3 extra litres for 20 mg biotin group, with no change in feed intake

**BENEFIT**
- Significant cost benefit ratio advantage

(Zimmerly and Weiss, 2001)
Ruminal biotin synthesis - in vitro
A new concept in 2001

- Historically it was assumed that adequate biotin is provided by rumen synthesis
- Studies challenged this hypothesis
- Increasing the concentrate ratio of the diet reduces rumen synthesis by about half
- Additionally, high yielding cows may have an increased biotin requirement, particularly during early lactation
- Results from studies during the last 10 years consistently show health and production benefits to supplementary biotin

(Abel et al., 2001)
ROVIMIX® Biotin increases milk production

Results from a series of research trials in Europe and the USA show that ROVIMIX® Biotin increases milk production in high yielding dairy cows by > 2 kg/cow/d

Level of significance at least p<0.05
Not so obvious vitamin deficiencies - The close up period

The close-up period is one of the most critical periods in the life of dairy cows, vitamin deficiencies are not visible but have a strong effect on the next lactation and fertility.
Cows with low vitamin E concentration have a pronounced mastitis risk

Serum levels of vitamin E in cows 30 days prepartum should exceed 5.4 mg/l, to have a 90% chance of staying above marginal levels at calving (Meglia et al., 2004)
Mastitis decreases the profitability of dairy farms

<table>
<thead>
<tr>
<th></th>
<th>Primiparous cows</th>
<th>Multiparous cows</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical mastitis (€)</td>
<td>275</td>
<td>275</td>
</tr>
<tr>
<td>Subclinical mastitis (€)</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Milk yield loss (kg in 305 d)</td>
<td>150</td>
<td>450</td>
</tr>
<tr>
<td>Profit loss @ 0.35 €/kg milk</td>
<td>52.50</td>
<td>175.50</td>
</tr>
</tbody>
</table>

Source: Nielsen, (2009)
Vitamin E - Nature’s most potent Chain-Breaking Antioxidant improves immune response

- Improves immune response time
- Improves bacteria killing
- Protects neutrophils and prolongs their lifespan

Better immune response = lower risk of mastitis
Cows respond to high ROVIMIX® E supplementation before & after calving

(Weiss et al., 1997)
ROVIMIX® E supplementation reduces the prevalence of clinical mastitis of dairy cows at parturition

<table>
<thead>
<tr>
<th>Treatment: Vitamin E</th>
<th>Dry period</th>
<th>Lactation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>100 mg/d</td>
<td>100 mg/d</td>
</tr>
<tr>
<td>Medium</td>
<td>1000 mg/d</td>
<td>500 mg/d</td>
</tr>
<tr>
<td>High</td>
<td>1000 mg/d for 46 d</td>
<td>2000 mg/d</td>
</tr>
<tr>
<td></td>
<td>4000 mg/d for 14 d</td>
<td></td>
</tr>
</tbody>
</table>

a, b, c differ: p < 0.05; A, B differ: p < 0.05

(Weiss et al., 1997)
ROVIMIX® E and Se reduce the duration of clinical mastitis symptoms

Duration of clinical symptoms was reduced by 46% for the selenium group, 44% for the vitamin E group, and 62% for the vitamin E-selenium group compared with the control.

Treatments:

- **Vitamin E**: 1000 mg Vitamin E/animal/day during dry period
- **Selenium**: Injection of 0.1 mg Se/kg BW on d 21 pre-calving

(Smith et al., 1984)
Management
Growth pattern of cattle in intensive fattening

Typical growth pattern in intensive beef fattening over 500 days, final live weight about 750 kg, DWG 1500 g/d, receiving vitamin/mineral supplement.
From pasture to feedlot

Issues
- Shipping
- Crowding
- Environmental stress
- Social stress
- Feed stress

Need
- Get them quickly on feed
- Reduce feed and social stress
- Insure nutritive value of the ration is fully exploited
- Optimum weight gain
Stress: Transport and others

Stress of transport of cattle to feedlot or to the slaughterhouse:
- Can decrease immune function
- Can decrease feed intake
- Can reduce the quality of the end product
- Is recognized as welfare issue.

High levels of vitamin E:
- Can reduce the negative impact of stress.
- Work as antioxidant and scavenging free radicals that are produced during stress and infections.
- Improve important sensory properties of the meat (field observation).
Vitamin E and Meat Quality
Lipid oxidation and meat quality

Lipid Oxidation = Deterioration of Meat Quality

- Hydroperoxides, Cholesterol oxides
- Aldehydes, Ketones
- Formation of Metmyoglobin
- Destruction of membranes

- Potentially harmful substances
- Oxidative rancidity causing adverse odour and flavour
- Colour changes
- Drip loss
Consumers discriminate at 20% metmyoglobin concentration

Vitamin E helps to preserve red colour during display, and can delay browning by up to 5 days.

About 4.0-5.0 µg vitamin E/g fresh muscle extended the time the beef was of acceptable quality.
Cows with high β-Carotene levels before calving resume ovulation faster. β-Carotene levels before calving are key for β-Carotene enrichment of the ovary and the colostrum.
Oxidative stress negatively impacts the quality of the oocyte

40% of the embryos die before 14 days after fertilization!!

The quality of the oocyte, the embryo and the corpus luteum is crucial!!

Oxidative stress

NEB

NEFA ↑

Oocyte

EMBRYO

NEFA ↑

Oxidative stress
Effect of β-Carotene supplementation on oestrogen and progesterone synthesis

<table>
<thead>
<tr>
<th></th>
<th>PEB - β</th>
<th>PEB + β</th>
<th>NEB - β</th>
<th>NEB + β</th>
</tr>
</thead>
<tbody>
<tr>
<td>β-Carotene (µg/ml)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plasma</td>
<td>1.02</td>
<td>3.04</td>
<td>0.44</td>
<td>3.28</td>
</tr>
<tr>
<td>Follicular fluid</td>
<td>0.21</td>
<td>0.48</td>
<td>0.05</td>
<td>0.51</td>
</tr>
<tr>
<td>Oestrogen (ng/ml)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum</td>
<td>0.07</td>
<td>0.09</td>
<td>0.02</td>
<td>0.06</td>
</tr>
<tr>
<td>Follicular fluid</td>
<td>1266</td>
<td>1286</td>
<td>969</td>
<td>1094</td>
</tr>
<tr>
<td>Progesterone (ng/ml)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum</td>
<td>0.26</td>
<td>0.19</td>
<td>0.20</td>
<td>0.21</td>
</tr>
<tr>
<td>Follicular fluid</td>
<td>87.9</td>
<td>152.0</td>
<td>44.5</td>
<td>90.6</td>
</tr>
</tbody>
</table>

Supplementation of β-Carotene through the feed
- Reaches the follicular fluid
- Is capable of decreasing oxidative stress during period of NEB
- Increases progesterone levels in follicular fluid
- Can it improve the quality of the oocyte and thus lower the early embryonic mortality?
The average number of services decreased by 29% from 2.0 to 1.42. The positive effect of β-Carotene on reproductive performance in cows is independent from the supplementation of Vitamin A.
Effect of supplemental ROVIMIX® β-Carotene colostrum quality
Effect of ROVIMIX® β-Carotene on colostrum quality and calf health

**Results**

- **Blood β-Carotene µg/ml**
  - Mothers: T1, T2
- **Colostrum β-Carotene µg/ml**
  - Mothers: T1, T2
- **IgG (g/L) - Colostrum**
  - Mothers: T1, T2
- **Blood β-Carotene (µg/ml) - Calves**
  - Mothers: T1, T2

**Conclusions & Benefits**

Supplementing 1000 mg β-carotene/cow/day

- Increased blood β-Carotene of the cows prepartum by 50%
- Increased colostrum β-Carotene by 73% & colostrum IgG status by 17%
- Increased blood IgG status of the calves by 22%
- Increased the β-Carotene levels in the blood of the calves by 74%
- Reduced the diarrhea in calves by 40%

Eisen, Msc Thesis TU Munich, 2015
Colostrum rich in β-Carotene reduces diarrhoea and mortality in new born calves

<table>
<thead>
<tr>
<th></th>
<th>Diarrhoea within</th>
<th>Losses due to diarrhea</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 days of life</td>
<td>12 days of life</td>
</tr>
<tr>
<td>Calves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>17</td>
<td>6</td>
</tr>
<tr>
<td>β-Carotene cows</td>
<td>16</td>
<td>2</td>
</tr>
</tbody>
</table>

Source: Lotthammer et al., 1979, Dtsch Tierärztl Wochenschr 83: 353
**β-Carotene and vitamin E content in forage samples from Brazil**

<table>
<thead>
<tr>
<th>Feed</th>
<th>β-Carotene (mg/kg DM)</th>
<th>Vitamin E (mg/kg DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanzania</td>
<td>104</td>
<td>103</td>
</tr>
<tr>
<td>Decumbens</td>
<td>106</td>
<td>84</td>
</tr>
<tr>
<td>Jiggs</td>
<td>95</td>
<td>64</td>
</tr>
<tr>
<td>Bracharia</td>
<td>56</td>
<td>77</td>
</tr>
<tr>
<td>Tifton 85</td>
<td>92</td>
<td>73</td>
</tr>
<tr>
<td>Brizanth 1</td>
<td>43</td>
<td>30</td>
</tr>
<tr>
<td>Temperate Grass</td>
<td>285</td>
<td>95</td>
</tr>
</tbody>
</table>
β-Carotene levels in plasma of cows before calving
Grass based diets in New Zealand

Lactating

Dry cows
And what about β-Carotene levels in beef cows?
Degradability & bioavailability of 2 different vitamin A forms

Species: Dairy cows
Country: France

Objective
Evaluation of the degradation and bioavailability of ROVIMIX A 1000 and a competitor A 1000 product in dairy cows

Trial details
- Dairy herd at the INRA in St. Gilles France 2003
- 4 HF cows, fistulated, milk yield: 35 kg/hd/d
- In vitro incubations were done at the University of Göttingen, Germany
- Ration: Corn silage and concentrate
- Treatment of 1 single dose of:
  - 1 000 000 IU ROVIMIX A 1000
  - 1 000 000 IU competitor vitamin A 1000
- Parameters measured
  - Retinol plasma levels
  - Retinol recovery in vitro after 6 h incubation

Results
- Competitor A 1000 bypasses the rumen
- Plasma vitamin A levels do not respond to higher bypass vitamin A

Conclusion & Benefits
- Considering the flow of vitamin A from the rumen ROVIMIX A 1000 has a 50% higher duodenal absorption
- ROVIMIX A 1000 is the perfect vitamin A product in ruminants
- The product form is the optimum combination of rumen stability and bioavailability in the animal
Stability of ROVIMIX® E 50 in Rumen Fluid

<table>
<thead>
<tr>
<th>Incubation time (h)</th>
<th>0</th>
<th>2</th>
<th>8</th>
<th>24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery (%)</td>
<td>100</td>
<td>97</td>
<td>97</td>
<td>97</td>
</tr>
</tbody>
</table>

Source: Kluenter and Rettenmaier, 1991

Conclusion: Vitamin E is rumen stable
ROVIMIX® Biotin is stable in the rumen

Biotin concentration in plasma and milk shows a linear response when increasing amounts of biotin were fed to dairy cows, proving that ROVIMIX® Biotin is stable in the rumen
And what about Niacin?

<table>
<thead>
<tr>
<th>Niacin (mg/hd/d)</th>
<th>Difference in milk production compared to control (kg/hd/d)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0</td>
<td>Schwab et al (2005)</td>
</tr>
<tr>
<td>12</td>
<td>+ 0.4</td>
<td>Schwab et al (2005)</td>
</tr>
<tr>
<td>24</td>
<td>- 0.2</td>
<td>Koopermans et al (2014)</td>
</tr>
<tr>
<td>48</td>
<td>- 0.4</td>
<td>Erickson et al (2014)</td>
</tr>
</tbody>
</table>

References:
- Schwab et al (2005)
- Koopermans et al (2014)
- Erickson et al (2014)
Challenges on dairy cows under intensive production conditions

Influences
- Dry cow management
- Disease, infections
- Feeding management
- Nutrition
- Cow environment
- Cow comfort
- Herd health programme
- Breeding strategy

Consequences
- Metabolic diseases
- Immune system
- Disease susceptibility
- Fertility
- Uterine health
- Hoof health
- Dry matter intake
- Milk yield and components

Vitamin Deficiencies?
More than 80% of the dairy cows are removed because feeding does not match their nutrient requirements.
OVN® Solutions
Our Package for Optimum Lifetime Performance in Dairy Cows

![Graph showing milk yield and reproductive health over lactation stages]

- **Reproduction**
  - Fertility/Udder Health
  - Ca-Metabolism
- **Lactation**
  - Yield/Composition/FCR
  - Persistancy/Body Stores

- Dry period
- Early lactation
- Middle-late lactation

- ROVIMIX® β-Carotene
- ROVIMIX® Hy-D
- ROVIMIX® Biotin + ROVIMIX® AD₃ E + CRINA® Ruminants + Tortuga Minerals
- RONOZYME® RumiStar®
- ROVIMIX® Niacin
OVN® Solutions
Our package for optimum growth and meat quality in beef cattle
Recent research on vitamin requirement of modern farm animals is limited and may underestimate the actual needs of ruminants.

Clinical/subclinical vitamin deficiency still occur:
  - optimum vitamin supplementation prevents from deficiency and helps to exploit the genetic potential of the animals.

Superior dietary supplementation levels of certain vitamins do provide additional value, such as improved stress and disease resistance, adequate welfare and/or better end product quality.
Before & after OVN vitamin and mineral supplementation

What the farmer said: “You changed the personality of my cow”!
Thank you!/Obrigada!

Dr. Irmgard Immig
Vitamin E Guidelines

1000 mg/d for 100-120 days pre-slaughter
2000 mg for >14 day aged carcasses

300-500 mg/d during finishing period
How Vitamin E facilitates immune function

References: Politis et al. (1995, 1996); Ndiweni and Finch (1996); Miller et al. (1993)
Cows in NEB showed strong signs of heat after β-Carotene supplementation
Before and after supplementation
Meat colour and the consumer

“The colour of fresh beef is an important criterion which the consumer uses to judge the freshness of the product.

Retailers manage their meat displays so that only those beef cuts with the preferred colour -- bright cherry red -- are displayed.”

Dan Schaefer (University of Wisconsin)
Improving retail shelf-life

A research project at the University of Bristol indicated that supplementary vitamin E fed at 1000 mg/head for 100 days delivers a benefit in terms of shelf life. In ground beef this could increase the shelf life by 4 days.
The future in vitamin research is Hy·D®

- **Heifer growth**
- **Transition**
- **Lactation**

Growth/Milk production

- 24 months from calf to heifer
- 21 d before to 21 d after calving
- 284 d in lactation
End Product Quality

- **Meat** is an important component of the daily nutrition:
  - It represents a reliable source of vitamins, particularly of the B-group
  - Higher levels of vitamins in the animal diet improve the nutritional value of the end product.
  - When elevated levels of vitamin E are supplemented to beef, lipid oxidation in fresh and processed meat is reduced. This reduces quality deterioration through oxidative rancidity, drip loss and maintains meat colour.

*Source: Roche Symposium on Animal Nutrition - Campinas/Chapecó (Brazil), June 26/28, 2001*
Disappearance of α-Tocopherol from the rumen in vivo

<table>
<thead>
<tr>
<th>Animal</th>
<th>Diet</th>
<th>Disappearance (%)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steer</td>
<td>20% concentrate</td>
<td>8</td>
<td>Alderson et al. (1971)</td>
</tr>
<tr>
<td></td>
<td>40% concentrate</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60% concentrate</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>80% concentrate</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Adult Steer</td>
<td>High-concentrate</td>
<td>39-52</td>
<td>Shin &amp; Owens (1990)</td>
</tr>
<tr>
<td>Dairy cows</td>
<td>20% concentrate</td>
<td>0</td>
<td>Weiss et al., (1995)</td>
</tr>
<tr>
<td></td>
<td>50% concentrate</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Dairy cow</td>
<td>High-silage</td>
<td>18</td>
<td>Robert (1995)</td>
</tr>
</tbody>
</table>

Conclusion: Ruminal metabolism of vitamin E is very low