Vitamin Nutrition of Dairy Cows: NRC vs. Today’s Reality

Bill Weiss
Dept of Animal Sciences
OARDC/The Ohio State University
Vitamins can:

1. Improve cow health
2. Improve reproductive efficiency
3. Increase milk yields
4. Improve the nutritional value of milk
5. Be very profitable additions to diets
Vitamins can:

1. Be detrimental to cow health
2. Reduce milk yields
3. Inflate feed costs
4. Reduce profitability
Hypothetical response function to nutrient supply

“Requirement”  Max. tolerable level (MDL)
Hypothetical response function to vitamin intake

Response

Supply

“Requirement”

Max. tolerable level (MDL)
Vitamin Requirements: What do we measure?

- Classical deficiency disease?
- Production?
- Reproduction?
- General health?
- Immune function?
If you thought measuring response was hard ....

But Wait...

THERE'S MORE!
Vitamin Supply
Vitamin Flow to Duodenum (Estimated DMI = 23 kg)

Santschi et al., 2005; Schwab et al., 2006
Rumen Disappearance of supplemental vitamins

Santschi et al., 2005

\[ \text{Rumen Disappearance, } \% \]

- Niacin
- Folic
- B-12
- Biotin

\[ \text{\( I = SE \)} \]
Change in Intestinal Supply (@ common supplementation rates)

- Niacin (6g): +7%
- Niacin (12g): +14%
- Biotin (20mg): +6%
- Biotin (20mg): +212%
Fat Soluble Vitamins: Rumen Metabolism

Vitamin A

IV Rumen Loss, %

BC 70%
Forage
50%
Forage

Feed grade Vit E:
Stable in vitro

Feed grade Vit D:
Some degradation in vitro
How much vitamin is absorbed?

- Dietary concentration: Usually Don’t know
- Amount destroyed in rumen: Don’t know
- Amount made in rumen: 0 or Don’t know
- Absorption coefficient: Don’t know
Underfeeding
Potentially reduced production and repro, increased health problems

Recommendation

Overfeeding
Potential toxicity, antagonism, higher feed costs
Fat soluble vitamin status related to health measures

LeBlanc et al., JDS 2004


**Vitamin A**

Requirement: 110 IU supplemental/kg BW

Safety Factor: 1.1 to 1.5X

Potential responses:
- ↓ RP
- ↓ Abortions
- ↓ Mastitis
- ↑ Milk

Potential Risks:
- ↓ Activity during storage
- ↑ Rumen breakdown
- ↓ Vit E absorption
- Toxici
Vitamin A (retinyl acetate) is destroyed in the rumen

Vitamin A is labile
- pelleting
- heat
- humidity
- etc.
Fat Soluble Vitamin Activity During Storage

Shurson et al., 2011
How much vit A do cows need?

1. Current NRC

2. Effect of increased milk yield (1 kg of milk has ~1000 IU of retinol)?
Vitamin A Toxicity

- Historically set at about 10X req’t
  - Reduce vitamin E status
  - Liver/vision problems
  - Birth defects

- Newer data with humans
  - Abnormal gene expression at 2X req’t

Retinoic acid is a very bioactive molecule: it does lots of things
Vitamin D: NRC, 2001

30 **supplemental** IU/kg BW
Safety Factor: 1.1 to 2X

18,000 to 25,000 IU/day
(outside cattle probably less)

Classical signs of deficiency:

- ↑Rickets
- ↑Milk fever

No recent data evaluating requirements

What about other effects?
Vitamin D and Immune Function

Humans:
Low plasma 25-OH D = ↓ macrophage kill

Mice:
In vitro +vit D; ↑ neutrophil kill

Cattle:
• With infection PMN:
  Vit D receptor up-regulated
  1-a-OH-ase up-regulated
• Mastitis cure increased with IMa 25-OH vit D
Vitamin D and Immune Response in Dairy Cows

LPS May Reduce Vit D Status

Several effects of D on immunity in humans and lab animals have been shown

Waldron et al 2003
NRC does not maximize plasma D in dairy cows

30-75 = ‘desirable’ range for humans?

For Normal plasma Ca

Hymoller et al., 2009
Vitamin D and Dairy Cows

1. Current recommendations clearly adequate with respect to Ca

2. Probably affects immune response

3. Some old data show milk yield response (~2X current NRC)

4. Time for some new research
Vitamin E
Low-Med. Risk, Med-High Reward

Lactating: ~500 IU/day (SF: 1 - 1.2 X)
Dry: ~1000 IU/day (SF: 1 to 1.2X)
Pre-fresh: ~1000 IU/day (SF: 2 to 4X)

Substantial pasture: much less, may be none

Main risk: Cost
Main benefit: Less disease
Vitamin E Periparturient Cows

Weiss et al., 1990

Kehrli, 2002

Colostrum DMI Utilization
Natural vs. “Really Natural”

Grazing Cows

Tocopherol, mg/L

Day Relative to Calving

Sanchez, 2005

+2500 IU/d Supplement

Day

Weiss et al., 2009
Vitamin E and Periparturient Cows

Weiss et al., 1997

Baldi et al., 2000
Vitamin E and Mastitis: Clinical Data

5 Studies: Improved mammary gland health
2 Studies: No effect
1 Study: Negative

Various studies (all confined cattle)
None vs. ~1000/500
None vs high at transition
~500 vs extra at transition
High during dry period

Both all-rac and RRR tocopherol
Clinical Mastitis and Vit E
Fed during dry period: Mastitis first 100 d

Bouwstra et al., 2010
Vitamin E and Milk Fat Depression

- Cows fed diet high in PUFA (1% linseed oil)
- Forage: Corn silage
- Diets were 27% NDF
- 0 or 12,000 IU of E/d

Pottier et al., 2006
Vitamin E and Milk Fat Depression

- Cows fed diet with tallow (2.3%)
- Alfalfa and corn silage
- Diets were 33% NDF
- 500 or 5,000 IU of E/d

Weiss and Wyatt, 2003
Water Soluble Vitamins

Health and Production, Sometimes
Water soluble vitamins

- Biotin
- Choline (?)
- Folic acid
- Niacin
- Vitamin B-12
- Vitamin C
- Riboflavin
- Thiamin
- Vitamin B6
- Pantothenic acid
Feeding about 20 mg of biotin/d for several months reduces hoof lesions and lameness

- White line separation
- Heel warts
- Sole hemorrhage
- “Lameness”
Biotin: Milk
Response (meta-analysis) = 1.3 kg/d
(Lean and Rabiee, 2011)
RP-Choline and Milk Yield
Response (Meta-analysis) = 2 kg/d
(Sales et al., 2010)

Exp 1-3 from Donkin (2002), Exp 4 (Janivick et al., 2006); Exp 5 (Piepenbrink and Overton, 2003), Exp 6 (Pinotti et al., 2002)
RPC reduced liver fat build up in cows with -NEB

In 2nd expt, RPC increase export of liver fat in cows in +NEB

Cooke et al., 2007
Niacin and Ketosis
(3-12 g/d)

NEFA, 11 studies
Ketones, 10 studies*

No effect  Reduced  Increased

No effect  Reduced
High Dose Niacin (abstract only)

- Jersey cows
- 0 or 48 g nicotinic acid/day
- 30 d pre until calving

In 2006, expt repeated with Holsteins and did NOT work

French, 2004
Niacin and Milk Production

Schwab et al., 2005 Meta-analysis

6 g/d: No effect on production

12 g/d: + 0.5 kg/d milk
       + 26 g/d fat
       + 17 g/d protein

Profitability depends on milk price
Fat Soluble Vitamin Summary

Vitamin A
• Stability risk: 1.2 X NRC

Vitamin D
• NRC adequate for Ca metabolism
• Other responses? : 1.0 to 2.0 X NRC

Vitamin E
• NRC adequate for dry/lactating
• 2000 to 5000 IU for transition cows
Water Soluble Vitamins

Biotin: Low Risk/High Reward  
Feed 20 mg/d

Niacin: Low Risk/Low Reward

RP-Choline: High Risk-High Reward
Risk: High cost
Reward: More milk (~4 lbs)  
Maybe less ketosis

No
Bottom Line
Feed enough minerals and vitamins (usually a little extra) but not too much

Goldilocks Strategy