

## The Effects of Supplemental Beta-carotene for Dairy Cows

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### Introduction

Dietary beta-carotene (BC) is recognized as the major precursor of vitamin A with an activity of 400 IU per milligram. The activity of vitamin A is measured in retinol equivalents (1 IU of vitamin A equals 0.3 µg of all-*trans* retinol). The NRC (2001) recommends 110 IU of vitamin A per kg of body weight for mature dairy cows. Signs of vitamin A deficiency include: abortion, retained placenta, reduced immune function, and calf morbidity and mortality (NRC, 2001). Dietary BC is absorbed and stored directly, and can be converted to retinol by intestinal enzymes.

BC can directly function as an antioxidant, which can enhance immunity with possible reproductive and mammary benefits (Chew, 1993). Although the National Research Council (NRC, 2001) concluded that the data was insufficient to establish a BC requirement for dairy cattle, they recommended additional dietary vitamin A with low forage diets, high corn silage diets, diets with low quality forages, high pathogen loads, or reduced immunocompetence.

Because of the wide variation in serum BC status, responses to BC supplementation can be inconsistent (Weiss, 1998). Dietary sources include vegetative plants and concentrations decrease with plant maturity. Most grains and fermented feeds contain minimal levels of BC because of heat damage and breakdown during storage. Although serum BC levels of 3.0 µg/ml have been suggested as the level in which supplementation is beneficial (Frye et al. 1991), a large proportion of serum samples from the 1996 NAHMS study of U.S. dairy herds (NAHMS, 1996) contained less than 3.0 µg/ml BC (Herdt and Seymour, 2006). LeBlanc et al. (2004) found mean serum BC concentration of 1828 samples from peripartum (+/- 1 wk) Holstein cows from 20 Canadian herds to be 1.12 µg/ml (SD=0.78).

### Immunity

Because BC is an antioxidant in addition to being a vitamin A precursor, it may enhance immune response in dairy cattle. Chew et al. (1982) reported low plasma vitamin A and/or BC had higher California Mastitis Test Scores. Chew (1983) supplemented 300 mg BC and 53 K.I.U. vitamin A, or 80 K.I.U. vitamin A, or 53 K.I.U. vitamin A, or no supplemental A or BC from 30 days before calving to 70 DIM. The percentages of cows with a SCC > 500,000 were 13, 27, 54, and 67%, respectively, indicating that BC had a positive effect on immune response. Wang et al. (1988) required fewer clinical mastitis treatments in cows supplemented with 300 mg BC.

Other researchers have not found indications that BC improved immune function. Oldham et al. (1991) did not reduce the incidence of mastitis with supplemental BC. Bindas et al. (1984) found that supplementing 600 mg of BC per day had no effect on SCC. Although LeBlanc et al. (2004) found no relationship between serum BC and retained placenta or mastitis, but found that when serum retinol concentrations increased 100 ng/ml or more during the last week prior to calving, there was a 60% reduction in clinical mastitis in early lactation.

## **Production Responses**

Supplemental BC has improved milk and butterfat yield in some studies (Arechiga et al, 1998; Oldham et al. 1991; deOndarza et al 2009), but not in all (Bindas et al., 1984, Rakes et al., 1985, Wang et al., 1988). This may be due to observed wide variations in BC status in dairy herds and also stage of lactation, but more research is needed to characterize production responses.

## **Reproduction**

Dietary BC levels may be linked to fertility as evidenced by higher concentrations of BC in the ovary and corpus luteum (Chew et al., 1984). Benefits of supplemental BC for the dairy cow may be related to the conversion of circulating BC to vitamin A in the uterus and ovaries (Schweigert, 2003). Graves-Hoagland et al. (1988) found plasma BC to be positively related to progesterone production by corpus luteum cells. Cows that ovulated during the first follicular wave postpartum had a higher mean plasma BC concentration than anovulatory cows (2.97 +/- 0.24 µg/ml vs. 1.53 +/- 0.14 µg/ml) three weeks prepartum (Kawashima et al., 2009a). This same research group supplemented BC during the close-up dry period (500 mg/d or 2000 mg/d in two different experiments) and increased the number of ovulating cows at the first follicular wave postpartum (Kawashima et al., 2009b). Pregnancy rate at 120 d postpartum in heat-stressed cows supplemented with 400 mg BC/d for  $\geq 90$  d was increased (35.4% vs. 21.1%) (Arechiga et al., 1998). Rakes et al. (1985) found that supplementing 300 mg of BC for the first 100 DIM reduced days to first estrus ( $P < 0.05$ ). Lotthammer (1978, 1979) found that supplemental BC improved conception rates, uterine involution, and ovulation and reduced incidence of cystic ovaries and early embryonic death.

Inaba et al. (1986) reported that cows with ovarian cysts had significantly lower plasma concentrations of BC (11 +/- 2 µg/dl) than cows without ovarian cysts (33 +/- 4 µg/dl) ( $P < 0.001$ ). In superovulated Japanese Black cattle, plasma BC concentration was related to embryo quality (Goto et al., 1989). Plasma BC concentrations above 200 µg/dl tended to improve numbers of corpus lutea and total recovered embryos and significantly improved the numbers of normal transferable embryos. In a Quebec study, low serum BC was associated with lower conception rates and longer days open (Chorfi, 2010).

In a recent study, deOndarza and others (2009) observed increases in 3.5% FCM and milk fat yield in early lactation and mature cows, improvements in reproduction (21d pregnancy rates) after 110 d, and reduced early embryonic mortality. The test herd used pedometers for heat detection, and heat signs were stronger in the BC pens.

There are reports of improved reproduction with supplemental BC in other species. Schweigert (2001) found that supplemental vitamin A (4000 IU) and BC (100 ppm) increased BC levels in the adrenals and corpus lutea of gilts. Besenfelder et al. (1996) supplemented 40 mg BC to rabbits that were assumed to have sufficient vitamin A status (20,000 IU vitamin A per kg of feed).

## **On-farm Auditing**

Because BC status varies by region, forage supply, breed, production stage, and many other factors, a cow-side colorimetric assay for serum/blood BC (iCheck®) was developed. iCheck®

has been used to evaluate BC status in hundreds of North American dairy herds, and has value in developing and evaluating targeted supplementation programs.

### **Conclusions**

Because of positive responses in colostrum quality, milk production, immunity, and reproduction, current BC supplementation has centered on 300-400 mg BC/hd/d for 100 days, starting during the early dry period or 500-800 mg/hd/d for several weeks around calving. Feeding BC to the lactating herd at 100-200 mg/hd/d can be used to help maintain year round BC status. Variation in responses may be due to individual or herd BC status, diet sources, wide variation in breeding protocols and objectives, and other factors, and status monitoring is encouraged.

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## **Vitamin Product Forms and Stability Considerations**

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### **Introduction**

Vitamin producers strive to provide a product that undergoes minimal losses during storage and feed processing, and thereafter. Bioavailability and physical characteristics are part of the equation. And lest we forget, the cost must be low.

None of the product forms can claim complete and unlimited stability across all types of stress. Still - and especially for most vitamins - the product formulations designed for commercial premixes and feed offer stability far superior to the raw unfinished vitamin (Kurnick et al., 1978).

Formulations improve over time. For example, vitamins A and D, menadione, thiamin and vitamin C were primary concerns for stability in the late 1980s (Gadiant, 1986). Today, with the exception of menadione, we can remove these from the 'risk list' because of improved product formulations under most conditions.

Yet, vitamin manufacturers can vary considerably in the quality and durability of the final product form - just as manufacturers of automobiles, electronics and other consumables vary in quality of their products.

The development of new formulations is a complicated process because many different movable parts are being considered, and these may not work in concert. For example, while we can manufacture a vitamin to be stable in virtually every possible feed processing scenario, we may relinquish bioavailability. Or perhaps the cost becomes prohibitive.

So in the end, many different aspects are involved, not unlike juggling balls, since many important issues must be addressed (Frye, 1994). And of course, the end application is important - is it nonpelleted, pelleted, extruded?

### **Vitamin Chemistry is the Starting Point**

The various chemical characteristics and weaknesses of vitamins in their natural form help direct subsequent formulations. It is the limitations and anticipated stresses for which formulations act as a buffer. The protection of that vitamin is of utmost importance.

The primary considerations for vitamin formulations include heat, moisture, light and pH (Table 1). Each vitamin is a unique chemical structure, and because of this, each bears flaws to be addressed to conform to its application. For example, heat can be especially destructive to vitamin A, folic acid, or vitamin B12, yet is of less consequence on niacin or riboflavin. Therefore, the primary focus on the heat-labile vitamins is provide protection from heat through some modification of the molecule or formulated product.

Vitamin K (ie, menadione) is one of the more unstable vitamins due to its structure, and while chemical modifications improve stability characteristics, the process of pelleting remains a concern. Thiamin and folic acid are prone to bind with the carbonyl group of reducing sugars through the Maillard reaction (Baker, 1995), and higher pelleting temperatures will increase this occurrence. In such cases, compensating for unavoidable losses with increased addition rates may be necessary until a more secure formulation is developed.

In crystalline form, some vitamins require no special protection. Ca-pantothenate, niacin and niacinamide (nicotinamide) exhibit very good stability characteristics for pelleting, thus changes in these vitamins are directed toward handling characteristics such as flowability, dustiness, or simple aesthetic purposes. In the end, the inherent chemical characteristics, along with the intended commercial application, direct vitamin final formulations.

Table 1. Stability Characteristics Inherent in Nonformulated Vitamins

Vitamin	Heat	Oxygen	Water	Light	Acid	Alkali
<b>A</b>	XX	XX	X	XX	X	O
<b>D3</b>	X	XX	X	X	X	O
<b>E</b>	X	O	X	X	O	X
<b>K (menadione)</b>	X	X	XX	O	XX	O
<b>Thiamin</b>	X	X	XX	O	O	XX
<b>Riboflavin</b>	O	O	X	XX	O	O
<b>Pyridoxine</b>	XX	O	X	X	X	O
<b>Vitamin B12</b>	XX	X	X	X	O	O
<b>Ca Pantothenate</b>	X	O	X	O	X	O
<b>Niacin</b>	O	O	O	O	O	O
<b>Niacinamide</b>	O	O	O	O	O	O
<b>Folic acid</b>	XX	O	XX	XX	XX	O
<b>Biotin</b>	X	O	O	X	O	O
<b>Vitamin C</b>	O	XX	XX	O	O	X

O = stable, X = sensitive, XX = very sensitive

## Chemical and Physical Modification

For those vitamins that need a little extra help, two basic approaches are utilized, depending on the need.

- *Chemical modification.* Chemically, our aim is to reduce the reactivity of some vitamins, thereby improving stability. For vitamins A, E and C, the reactive hydroxyl groups can be addressed by esterification (Adams, 1978), a process in which two reactants (typically an alcohol and an acid) form an ester. The use of acetic acid to form an acetate ester is common for vitamin A and E in the feed industry (ie, vitamin A acetate, vitamin E acetate). Therefore, esterification becomes routine in the processing and manufacturing of most commercial forms of vitamin A and E.

Crystalline vitamin C (ascorbic acid) is notoriously unstable to pelleting. Phosphorylation to become Rovimix®<sup>1</sup> Stay C35 dramatically improves stability, yet remains bioavailable for the animal.

- *Physical modification.* Physical formulations are intended as a barrier to protect against oxygen, moisture, light, etc., and can comprise 80% or more of the final product (Moreau and Rosenberg, 1996) Encapsulation is widely used to also control the release of enzymes, aromas, flavors, drugs, fertilizers, etc. (Gibbs et al., 1999). The barrier can be a composite of a number of components - sugars, gums, proteins, polysaccharides - designed to separate interior from exterior components. The release of the internalized components, such as enzymes and vitamins, is site-directed based on changes in pH, temperature, moisture and such.

Antioxidants, deodorants and other specialized additives might be included in the encapsulation composite. Not surprisingly, the formulation will differ across manufacturers and formulation technologies due to patents and proprietary techniques, hence not all equally protect against vitamin degradation or release. Make no mistake, the science of encapsulation is highly specific.

The commercial form of vitamin A is a good example of both technologies being utilized in concert. Once chemically stabilized through esterification, further improvements are made by cross-linking gelatin in beadlet form. Fructose and glycerine enhance the process to protect against moisture and heat during feed manufacture. An antioxidant is included to protect against oxidation, such that

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<sup>1</sup> Rovimix is a registered trademark for DSM Nutritional Products



might exist with rancid fats. The protein-based coating is hydrolyzed by intestinal pH, proteases and moisture, thus releasing the vitamin A for absorption. Beadlets can be further stabilized by specific cross linking of proteins and amino acids in the composite. A 20% improvement existed for the cross linked Rovimix®<sup>2</sup> form across four different sources of vitamin A beadlet pelleted at 194°F (DSM Internal VFP9964).

*dl-a*-tocopheryl acetate oil is sprayed onto a carrier as an adsorbate adhering to the outer portion of the carrier. As such, the carrier becomes an important consideration. Some less expensive and less advanced carriers can bind to the vitamin E molecule such that bioavailability is an issue (Lauzon et al., 2008). Sufficient stability exists in vitamin E such that a beadlet or physical barrier is unnecessary, whereas the silica assists in handling characteristics.

Table 2. Formulated Changes for Vitamins

Vitamin	Formulation	Function
Vitamin A	Ester in a cross-linked beadlet, SD	Stability, solubility
Vitamin D3	Spray dry (SD), beadlet	Stability, uniform distribution
Vitamin E	Acetate ester, SD or granular	Flow, reduced dustiness
Vitamin K/menadi	Crystalline powder	Flow, handling
Thiamin	Coarse granular	Stability
Riboflavin	SD granular	Flow, handling
Pyridoxine	Fine granular crystals	Stability, mixing
Vitamin B12	Crystalline w/carrier	Distribution
Niacin	Crystalline	Flow, reduced dustiness
Niacinamide	Crystalline	Flow, reduced dustiness
Ca-Pantothenate	SD	Flow, reduced dustiness
Biotin	SD	Distribution, handling
Folic Acid	SD	Flow, stability, mixing
Vitamin C	P, ethyl cellulose coat	Stability

### Feed Processing

*Pelleting.* Conditioning/pelleting temperature is the most obvious contributor to vitamin losses for poultry and swine feed. Van't Hoff's Rule says that an increase in temperature by 10°C will increase the rate of chemical reactions by 2- to 3-fold. Thus, during conditioning of feeds, the integrity of the vitamin is threatened with exposure to oxygen and trace minerals when the beadlet coatings or spray dry forms are softened and disintegrate - an obvious indication for the importance of properly manufactured beadlets.

<sup>2</sup> Rovimix is a registered trademark for DSM Nutritional Products

And once the beadlet or some aspect associated with stability is damaged during the conditioning process, this vitamin becomes exposed and more prone to damage in the pelleted feed before being consumed. Thus, loss in activity in pelleted feed can continue after the feed exits the pellet die.

Conditioning time affects vitamin degradation - the longer the conditioning time, the greater the threat. The goal of conditioning feed is to uniformly penetrate each feed particle with moisture and heat. Under pressure and with rigorous mixing in the feed conditioner, this creates an environment that could devastate ill-prepared vitamins and other feed additives.

Often, moisture content in conditioned feed is limited to 17-18%, and provides a solvent for destructive agents since moisture aids chemical reactions. The type of feed, mineral and fat content are factors. Each brings characteristics that influence the degree of friction experienced by the feed passing through the die. We expect lower vitamin degradation in finisher type diets (ie higher fat, lower mineral content). High meat & bone meal, along with increased corn DDGS and SBM in feeds, increases the friction through the die.

In the end, vitamin survival during pelleting is a multi-factorial process. Changes in conditioning time, fat level, old versus new corn, etc., conceivably change survival. Factors other than pelleting temperature must be considered.

Expanders. Annular gap feed expanders encompass a rapid pressure build-up with increased temperature to approximately 220-230°F for 3-5 seconds. At the outlet, temperature and pressure decline precipitously, and moisture quickly flashes off. Conditioning temperature and time are factors. Although the high temperature and pressure threaten vitamin stability, the time period is but a few seconds. Expander results from stability studies for vitamins tend to be mixed, and not always as punitive as expected.

Extrusion. The extrusion process can be rigorous with high heat and steam pressure over a considerably longer time period than for pelleting or expanders. Thus, compared to pelleted feeds, vitamins in extruded feeds generally have a significantly lower survivability. Moisture can be as high as 35-40% with much longer conditioning times. Longer conditioning times, higher moisture and higher temperatures threaten the survival of most feed additives.

Texas A & M researchers (Riaz et al., 2009) note that barrel temperature, screw rpm, moisture, and die diameter impact vitamin survival in the final feed. Generally, across a number of trials and conditions, vitamins A, E and C, along with folic acid and thiamin, were most sensitive to extrusion.

### **Vitamin Stability**

The expected survival of the various commercial vitamins in feeds pelleted at 170 to 200°F is noted in Table 3. Above 200°F, or with extended conditioning times or double pass conditioners, estimates should be revised downward. An analysis of the feed might be warranted.

We conducted a pelleting vitamin stability trial at Kansas State University to test Rovimix® vitamins at a low pelleting conditions (160°F/30 sec) versus one designed to be more harsh (190°F/60 sec; Table 4). Difference in losses was low between the two sets of conditions. With the exception of vitamin A, at the higher temperature and conditioning time, recovery was close to 90% or greater.

Vitamins need this type of buffer. Pelleting temperature can be low at initial start-up in the day, and then rise to higher temperatures at a high production rate, or as ambient temperatures rise. Summer versus winter, old corn versus new corn, as well as other factors, can change pelleting temperatures within a given time. Proper vitamin manufacture provide a buffer over a range of moderate conditions to avoid variability in vitamin survival.

In a recent field study, the stability of vitamin A, vitamin E adsorbate, riboflavin, thiamin and folic acid was determined when the feed was conditioned for 3 minutes at 205 to 210°F, and in a cooker for 5 seconds at 240°F. Losses were minimal, being 10% for vitamin A, riboflavin and folic acid (Table 5). While no loss occurred with thiamin, 25% of the vitamin E was lost. Under harsh conditions, stabilities were generally good overall.

#### **Post-processing Vitamin Losses**

Mentioned earlier, during feed processing the protective coatings can be damaged, which could allow intimate contact with solubilized trace elements and moisture. While the majority of poultry and swine feeds is consumed within days after pelleting, bagged pelleted feeds might be stored for several weeks or months.

In such cases, considerations must be made for the time lag between pelleting and feeding, since a potency loss increases with prolonged storage. Additional levels in the feed can offset higher anticipated losses.

Altemueller and Gadiant (2008) provide anticipated losses of vitamins in feeds pelleted, expanded or extruded, and then stored for 3 months at 77°F (Table 6). The extruded feed is expected to suffer the greatest loss over the ensuing 3-month period.

In a recent study to compare commercial sources of vitamin A for a 3-month period in a premix, and then another 3 months after adding to animal feed (Altemueller and Gadiant, 2008). The biggest loss (30%) occurred early during the 'premix phase' with two of the three commercial vitamins. The Rovimix Vitamin A 1000 suffered marginal losses.

Storage conditions impact vitamin survival (Kurnick et al., 1978; Anonymous, 1991; Albers, 1996). Gadiant and Fenster (1992) reported a 20-30% loss for most vitamins stored three months at 95°F after being pelleted at 194°F. At room temperature for 8 weeks after pelleting, thiamin, menadione, pantothenic acid, folic acid and vitamin B12 were most prone to losses (Albers, 1996). Granted, these data deal largely with older product forms, but still, the threats remain the same.

Little information exists in the literature regarding the effect that other additives might have on vitamin stability during pelleting. Hooge et al. (2000) reported that the stability of vitamin A, vitamin E and riboflavin improved in the presence of tribasic copper chloride in a broiler starter feed. As the industry moves toward organic trace minerals, we would expect these become less of a menace on vitamin integrity.

### **Vitamin Losses in Premixes**

Studies find vitamins to lose activity in the presence of inorganic trace minerals, especially when choline chloride is present. University of Minnesota's Shurson et al. (1996) completed a trial that compared stabilities in 4 treatments:

1. Pure vitamin alone
2. Premix with only vitamins
3. Premix with inorganic trace minerals
4. Premix with amino acid mineral complexes

After 120 days at 87°F, the most resistant vitamins were Ca pantothenate, vitamin E, riboflavin, biotin and niacin. Vitamins A and K, pyridoxine and thiamine experienced the greatest losses. The inorganic trace mineral premix induced the highest losses across all treatments. Based on the results, vitamin A was deemed the best indicator of overall premix stability, followed by thiamin, vitamin K and vitamin B12 (Shurson et al., 1996).

Ultimately, losses can be reduced 40-50% by storing vitamins and trace minerals separately until added to feeds (Shurson et al., 1996). Amino acid-trace mineral complexes were less intrusive - as opposed to inorganic trace minerals - on vitamin survival.

Tavacr-Kalcher and Vengust (2007) found choline chloride to increase vitamin destruction in premixes even if without trace minerals. After 12 months without choline chloride, the concentration of vitamins A, D and K decreased to 53, 59 and 80% of the original content. With choline chloride in the premix, these values declined to 39, 50 and 9% of their initial levels. No other vitamins were analyzed.

### **Other Feed Additives**

**25-OH vitamin D3.** For pelleting, 25-OH vitamin D3 shows good stability, in spite of the presence of a free hydroxyl. The commercial form of this product

(25-OH vitamin D3, HyD®) is prepared in beadlet form using proprietary technology. In one trial, survival at 158 and 194°F was 95 and 85%, resp., of the amount added in the mash feed. In another study, survival through pelleting was 90% or better at pelleting temperatures of 158 to 185°F, but was 78% at 194°F. Thus, it appears that a loss of about 15% occurs at about 194°F, and possibly more at higher pelleting temperatures.

### **Conclusions**

Vitamin stability for feed processing continues to improve. Most vitamins exhibit good stability (90 to 100% at 180°F for 30 seconds), although other factors influence survivability. Product formulations differ by manufacturer, thus differences exist in survivability across commercial formulations. Additional supplementation rates are often employed to compensate for unavoidable pelleting losses. Vitamins can be destabilized in premixes with inorganic trace minerals, and the losses will increase when choline chloride is present. Along with survival determinations for vitamins at the pellet die, losses can occur from the time of manufacture and consumption of that feed.

**Table 3. Range in Estimated Stability of Vitamin Products at Different Pelleting Temperatures**

<b>Vitamin</b>	<b>170 F</b>	<b>180 F</b>	<b>190 F</b>	<b>200 F</b>
<b>A beadlet</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>D3 beadlet</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>E acetate</b>	90 - 100	90 - 100	90 - 95	80 - 90
<b>E spray dry</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>K (menadione sodium bisulphite)</b>	50 - 60	40 - 50	40 - 50	35 - 40
<b>K (menadione nicotinamide bisulphate)</b>	80 - 90	70 - 80	65 - 75	65 - 75
<b>Thiamin monohydrate</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>Thiamin HCl</b>	90 - 100	85 - 95	85 - 95	70 - 80
<b>Riboflavin</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>Pyridoxine</b>	90 - 100	90 - 100	90 - 95	80 - 90
<b>Vitamin B12</b>	90 - 100	80 - 90	70 - 85	60 - 80
<b>Ca Pantothenate</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>Niacin</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>Niacinamide</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>Folic acid</b>	90 - 100	85 - 90	80 - 90	70 - 80
<b>Biotin</b>	90 - 100	90 - 100	90 - 95	85 - 90
<b>Vitamin C ethylcellulose</b>	50 - 80	40 - 70	30 - 60	20 - 40
<b>Vitamin C phosphorylated</b>	90 - 100	90 - 100	90 - 95	90 - 95

Based on 30 to 45 second conditioning time

**Table 4. Summary of Vitamin Retention (%) at Two Pelleting Temperatures and Conditioning Times**

Temperature, °F	160	190
Conditioning time, sec	30	60
Vitamin A (A/D3)	85	84
Vitamin D3 (A/D3)	98	90
Vitamin D-500	91	81
Vitamin E Adsorbate	88	89
Vitamin E spray dry	85	87
Riboflavin-80	100	100
Rovimix Pyridoxine	98	102
Rovimix Ca Pantothenate	90	95
Rovimix Biotin	100	100

**Table 5. Vitamin Stability in High Pressure Feed Processor**

Feed	Vitamin A, IU/lb	Vitamin E, IU/lb	Riboflavin, mg/lb	Thiamin, g/lb	Folic Acid, mg/lb
Mash	3768	12.85	3.39	2.46	400
Feed	3367	9.58	3.10	2.53	370
% Recovery	89	75	91	103	92

**Table 6. Retention of Vitamins in Feed Processed and Stored at 77°F for 3 Months**

	<b>Pelleting</b>	<b>Expander</b>	<b>Extrusion</b>
	<b>% Retention</b>		
<b>Vitamin A</b>	85-95	70-90	70-90
<b>Vitamin D3</b>	90-100	80-100	75-100
<b>Vitamin E</b>	90-100	90-100	90-100
<b>Vitamin K (menadione)</b>	70-90	30-50	20-50
<b>Thiamin</b>	70-90	50-70	60-80
<b>Riboflavin</b>	90-100	90-100	90-100
<b>Pyridoxine</b>	90-100	80-90	80-90
<b>Vitamin B12</b>	90-100	50-80	4-80
<b>Ca-patohenate</b>	95-100	90-100	90-100
<b>Niacin</b>	90-100	90-100	90-100
<b>Folic</b>	70-90	50-70	50-65
<b>Biotin</b>	90-100	90-100	90-100
<b>Vitamin C</b>	80-100	80-100	80-100

Altemueller and Gadiant, 2008



## Effects of Evaporative Cooling Prepartum and Vitamin E Supplementation on Performance of Holstein Cows During Summer

C.R. Staples, G.C. Gomes, J.E. Zuniga, L.F. Greco, L.D.P. Sinedino, E. Karadaya, E.S. Riberio, N. Martinez, R.S. Bisinotto, F.S. Lina, M.A. Engstrom<sup>1</sup>, and J.E.P. Santos  
University of Florida, Gainesville and <sup>1</sup>DSM, Parsippany, NJ

**Background.** A specific requirement by periparturient cows for vitamin E has not been defined yet because titration studies are lacking. The recommended rate of supplemental vitamin E is 0.73 and 0.36 IU/pound of body weight for nonlactating, pregnant cows and lactating cows, respectively (NRC, 2001). A 1450 lb cow supplemented at the recommended vitamin E guideline would consume daily ~1000 IU prepartum and ~ 500 IU postpartum of supplemental vitamin E. Cows fed fresh green forages will likely require less supplemental vitamin E. Life changes that increase metabolic demands, such as parturition and copious production of milk, increase oxygen requirements substantially. As a result, the production of reactive oxygen species (ROS) such as O<sub>2</sub><sup>-</sup>, OH<sup>-</sup>, H<sub>2</sub>O<sub>2</sub>, and lipid peroxy radical (LOO<sup>-</sup>) increases. Oxidative stress results when ROS are produced faster than they can be neutralized by antioxidants (Sies, 1991). Oxidative stress usually occurs during the periparturient period (Ronchi et al., 2000) and may contribute to periparturient disorders (Brezczynska-Slebodzinska et al., 1994) and be associated with metabolic diseases (Ronchi et al., 2000). The predominant antioxidant in biological membranes is  $\alpha$ -tocopherol. Thermal stress may aggravate oxidative stress (Bernanucci et al., 2002). Feeding additional vitamin E as an antioxidant in the summer during the periparturient period may be needed due to the greater oxidative stress caused by elevated temperature and humidity.

**Experimental Design.** Objective was to evaluate vitamin E (VitE) supplementation above NRC recommendations to periparturient Holstein cows (36 primiparous and 34 multiparous) managed in evaporatively cooled (CL) free-stall barns or shaded outdoor lots (noncooled, NCL) during the prepartum period. All-rac-alpha-tocopherol (DSM, Parsippany, NJ) was mixed with ground corn and dried molasses and top-dressed daily (0.22 lb/cow) on the first feeding of TMR. VitE treatments were 1000 IU prepartum and 500 IU postpartum (moderate VitE, M) or 3000 IU prepartum and 2000 IU postpartum (high VitE, H). The 4 treatments, CL-M, CL-H, NCL-M, and NCL-H, started at 4 weeks prepartum. After calving, cows were housed together in a free-stall facility equipped with fans and sprinklers but continued to receive their assigned supplemental VitE amounts for 15 more weeks. Blood was collected on days -30, -14, 3, 7, 14, 21, 28, 35, and 42 relative to calving for analyses of NEFA and vitamin E concentrations. Cows were subjected to timed AI at 46 and 64  $\pm$  3 days in milk. Conceptuses were collected by uterine flushing 16 days after each AI and their length measured. Dependent measures included heat stress responses prepartum, intake of DM, body weight, yields of milk and milk components, and conceptus length. Data were normalized when needed and analyzed by ANOVA for repeated measures with PROC GLIMMIX of SAS. Pretreatment covariates were used in analysis for measures of plasma vitamin E and NEFA and milk.

**Results and Discussion. Prepartum responses.** During the prepartum period, the environmental temperature and humidity index (THI) averaged 74.8  $\pm$  4.9 and cows were exposed to THI > 70 during 85% of the day. Prepartum evaporative cooling in free-stalls reduced vaginal temperature

from 103.2 to 102.4°F and respiration rates from 69 to 43 breaths per minute in the afternoon period, reduced plasma concentrations of NEFA from 0.28 to 0.14 mM, and increased intake of DM by 15%, from 19.7 to 22.6 lb/day across parities ( $P < 0.05$ ). Vaginal temperatures, plasma NEFA concentrations, and DM intake (21.3 and 21.1 lb/day; M and H groups, respectively) were not affected by amount of vitamin E top-dressed. However feeding more VitE increased respiration rates if primiparous cows were not cooled (76 vs. 68 per minute) and if multiparous cows were cooled (48 vs. 38 per minute; H vs. M, respectively; VitE by cooling by parity interaction,  $P = 0.05$ ).

Plasma vitamin E. Plasma concentrations of vitamin E were lowest at 3 days in milk. All treatment means at this time were at or below the minimum acceptable concentration for the periparturient dairy cow (3.0 to 3.5 ug/mL) as suggested by Weiss (1998) based upon improved neutrophil function and reduced clinical mastitis. Greater prepartum heat stress did not affect vitamin E concentrations at this early time postpartum but greater vitamin E supplementation increased plasma concentrations from 2.8 to 3.4 ug/mL ( $P < 0.001$ ) at 3 days in milk. This difference was even greater at 7 days in milk being 3.1 vs. 4.0 ug/mL for M vs. H, respectively. By 14 days in milk, all treatment groups surpassed 4.0 ug/mL with the exception of the multiparous cows in the CL-M group which only averaged 3.2 ug/mL. If using minimum plasma vitamin E concentrations as a guideline, multiparous cows may benefit from supplementation of vitamin E above NRC recommendations during the first 2 weeks postpartum.

Injecting 3000 IU of vitamin E within 1 to 2 weeks of calving reduced the incidence of retained fetal membranes (RFM) of heifers (LeBlanc et al., 2002) and of all parities (Erskine et al., 1997). In the current study, incidence of RFM ( $> 24$  hours) was 8.6%, metritis (fetid, watery, uterine discharge during the first 12 days postpartum) was 18.6%, and clinical mastitis (first 6 weeks postpartum) was 14.3%. Although the incidence of these maladies were not affected by amount of vitamin E top-dressed in the study, the mean plasma concentrations of vitamin E were lower in cows afflicted with these maladies. Mean plasma concentration of vitamin E at -14, 3, and 7 days relative to calving was 3.6 and 2.5 ug/mL ( $P < 0.001$ ) for healthy and RFM cows, 3.7 vs. 3.2 ug/mL ( $P = 0.03$ ) for healthy and metritic cows, and 3.7 vs. 3.2 ug/mL ( $P = 0.03$ ) for healthy and mastitic cows, respectively. Dry matter intake during the last 14 days before calving did not differ between healthy and sick cows, being 21.9 and 21.6 lb/day for healthy and RFM cows for example.

Milk, Intake, and Plasma NEFA. Feeding more vitamin E to primiparous cows reduced uncorrected mean milk yield from 60.0 to 51.6 lb/day whereas feeding more vitamin E to multiparous cows did not affect mean milk yield (82.1 vs. 84.1 lb/day for M and H, respectively; VitE by parity interaction,  $P = 0.03$ ). When milk yield was plotted over 15 weeks of lactation, the decrease in milk yield due to feeding more vitamin E was greater for cows evaporatively cooled prepartum starting at 8 weeks postpartum compared with the decrease experienced by cows housed outside with shade in the late prepartum period (VitE by cooling by week interaction,  $P = 0.01$ ). Mean concentration of milk fat was 3.61%. Neither prepartum cooling nor increased vitamin E supplementation affected milk fat concentration of primiparous cows (mean of 3.58%). However milk fat concentration of multiparous cows tended to increase when additional vitamin E was supplied in the diet under conditions of greater prepartum heat stress (3.56 to 3.71%) but not when multiparous cows were cooled prepartum (3.71 vs. 3.62%, M vs.

H; VitE by cooling by parity interaction,  $P = 0.08$ ). Treatments did not affect the concentration of milk true protein (mean of 2.92%). Feeding more vitamin E to primiparous cows tended to reduce mean yield of 3.5% FCM from 60.5 to 52.4 lb/day (M and H, respectively) regardless of the prepartum environment whereas feeding more vitamin E to multiparous cows had no effect on mean yield of 3.5% FCM (87.7 and 85.1 lb/day for CL-M and CL-H, respectively) unless the cows were exposed to heat-stress conditions prepartum in which case cows tended to increase production from 79.8 to 86.9 lb/day (NCL-M and NCL-H, respectively; VitE by cooling by parity interaction,  $P = 0.10$ ). Increased feeding of vitamin E affected postpartum intake of DM differently depending on the prepartum environment. If cows were evaporatively cooled prepartum, mean intake of DM was not affected by amount of vitamin E fed (47.1 vs. 47.3 lb/day) whereas if prepartum cows were housed outdoors with only shade provided, mean intake of DM by multiparous cows increased (49.4 vs. 54.2 lb/day) but that of primiparous cows decreased (47.2 vs. 42.3 lb/day) when top-dressed with more vitamin E (VitE by cooling by parity interaction,  $P < 0.01$ ). Efficiency of converting feed DM to 3.5% FCM by multiparous cows was not affected by prepartum cooling or increased vitamin E supplementation (mean of 1.74 lb of FCM per lb of DM intake). However increased supplementation of vitamin E to primiparous cows tended to reduce efficiency of milk production from 1.46 to 1.27 lb of FCM per lb of DM intake (VitE by parity interaction,  $P < 0.10$ ). Based upon mean plasma concentrations of NEFA, primiparous cows were under less metabolic stress compared to multiparous cows (0.21 vs. 0.36 mM,  $P = 0.01$ ). Prepartum environment and amount of vitamin E supplemented did not affect NEFA concentrations.

Conceptus Length. Thirty-two day 15 conceptuses were collected and measured for length. The current thinking is that conceptus length may be a good indicator of development and that longer conceptuses are more likely to survive very early in life. Providing more vitamin E to cows that had been exposed to greater heat stress prepartum resulted in longer conceptus length (28 vs. 63 mm, M vs. H) whereas conceptus length was shorter if cows were evaporatively cooled prepartum and fed more vitamin E (38 vs. 8 mm, M vs. H; VitE by cooling interaction,  $P < 0.01$ ). The impact of feeding more vitamin E was dependent upon the prepartum environmental conditions.

Summary and Conclusions. Top-dressing daily with 3000 IU of vitamin E prepartum and with 2000 IU of vitamin E postpartum increased milk production and milk fat concentration of multiparous cows housed under greater heat-stress conditions in the prepartum period but no benefit was detected if multiparous cows were evaporatively cooled prepartum. Performance of primiparous cows was reduced if fed vitamin E above NRC recommendations regardless of prepartum exposure to heat stress. Based upon plasma concentrations of NEFA, primiparous cows were under less metabolic stress postpartum than multiparous cows. Feeding four times the recommended amount of the antioxidant vitamin E postpartum to these lower-stressed cows may have caused greater radical formation (and/or over quenching) and hurt performance. The combination of increased thermal stress prepartum and metabolic stress due to greater milk production postpartum may have created a scenario in which the requirement for an antioxidant, vitamin E, was increased for multiparous cows.

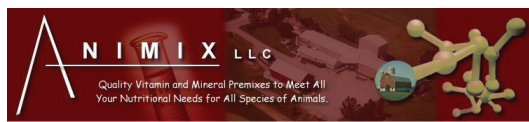
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# Vitamins & Trace Minerals *for the milk fed calf*

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A gallon of whole milk fails to meet the calf's trace mineral requirements . . .

- **Manganese** – NRC requirement 21.2 mg. Provides 0.14 mg, <sup>^</sup> 0.7% of NRC
- **Zinc** – NRC is 21.2 mg. Provides 12.5 mg, <sup>^</sup> 59%.
- **Copper** – NRC is 5.3 mg. Provides 0.28 mg, <sup>^</sup> 5%
- **Iron** – NRC 53 mg. Provides 1.4 mg, <sup>^</sup> 2.6%
- **Cobalt** – NRC 0.058 mg. Provides 0.003 mg, <sup>^</sup> 5%
- **Selenium** – NRC 0.16 mg. Provides 0.14 mg, \* 88%
- **Iodine** – NRC 0.27 mg. Provides 0.07 mg, <sup>^</sup> 26%

<sup>^</sup> = NRC 2001. NRC reports no b-vitamin levels for whole milk  
\* = USDA SR-21 for 3.25% fat milk (vitamin D used whole milk)



A gallon of whole milk fails to meet the calf's vitamin requirements . . .

- Vitamin **A** – NRC requirement 5,218 IU. Provides 5216 IU,<sup>^</sup> **100% of NRC**
- Vitamin **E** – NRC is 23 IU. Provides 3.6 IU,<sup>^\*</sup> **16% of NRC**
- Vitamin **D3** – NRC is 272 IU. Provides 139 IU<sup>^</sup> or zero,<sup>\*</sup> **0% to 51%**
- B1, **Thiamin** – NRC is 2.95 mg. Provides 1.6 mg,<sup>\*</sup> **54%**
- B3, **Niacin** – NRC 4.54 mg. Provides 4 mg,<sup>\*</sup> **88%**
- B6, **Pyridoxine** – NRC 2.95 mg. Provides 1.6 mg,<sup>\*</sup> **54%**
- **B12** – NRC 31.8 mcg. Provides 17.2 mcg,<sup>\*</sup> **54%**
- B9, **Folic Acid** – NRC 0.23 mg. Provides 0.2 mg,<sup>\*</sup> **87%**

<sup>^</sup> = NRC 2001. NRC reports no b-vitamin levels for whole milk

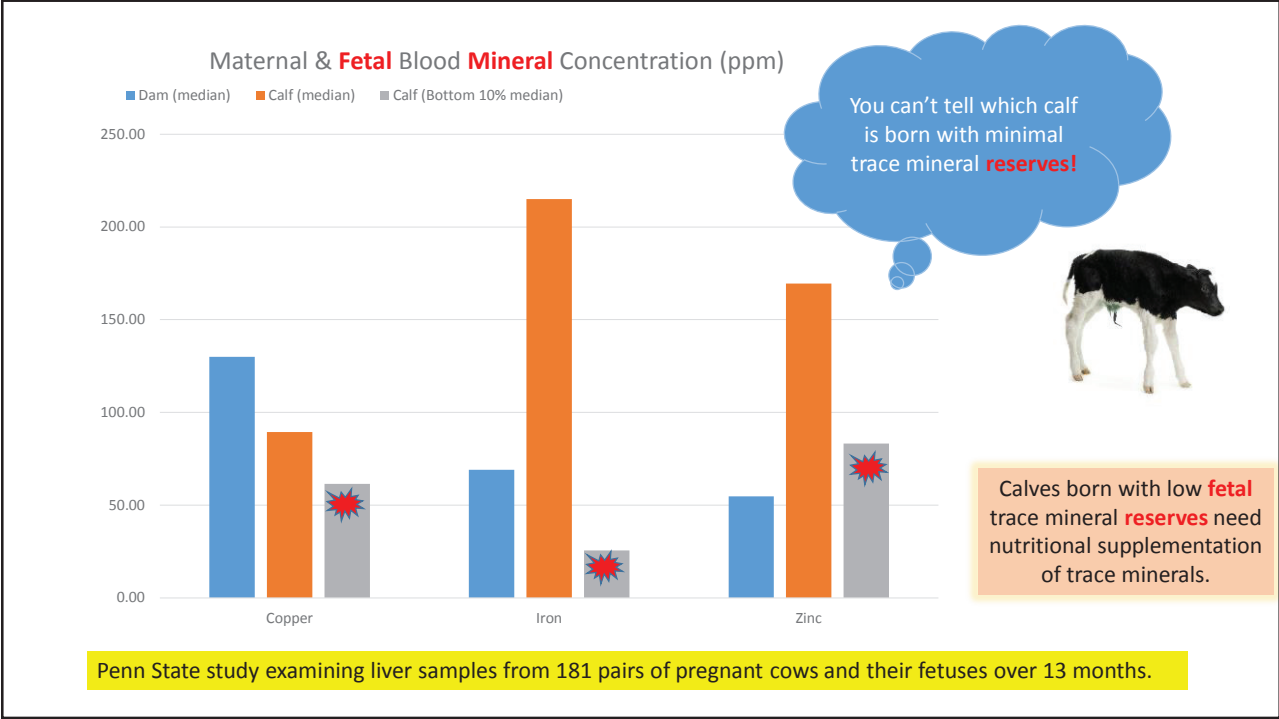
<sup>\*</sup> = USDA SR-21 for 3.25% fat milk (vitamin D used whole milk)



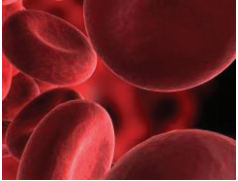
Ways to bridge this micro-nutrient gap

- **Fetal reserves**
- **Colostrum**
- **Early starter grain intake**
  - **Sunshine & grass**
  - **Supplementation**





## Fetal Reserves: Iron Concentration



**Anemic:** blood hemoglobin **less than 7.0** g/100 ml of blood

**Marginally Anemic:** blood hemoglobin **between 7.0 and 7.9** g/100 ml

- Beltsville, Maryland research center, 1953. Whole milk, grain (no TM) and alfalfa hay. Hemoglobin measured every 14 days. Nadir.
- Penn State, 1999. Veal field analysis. Blood hemoglobin at arrival.
- UC-Davis, 1994. Veal field analysis. Blood hemoglobin upon arrival

Likely 5 – 8% of calves are born anemic. Another 20% are borderline anemic.

	Hemoglobin grams/100 ml of blood			
	n	5.0 - 6.0	6.0 - 7.0	7.0 - 8.9
Beltsville, 1947	57	10.4%	8.6%	-
Beltsville, 1952	49	6.1%	20.4%	-
Beltsville, 1946	31	15.2%	21.2%	-
PSU, Veal, 1999	757	-	4.8%	23.0%
UC-Davis, Veal, 1994	290	-	-	8.0%

## Fetal Tissue Vitamin Reserves?



- Plasma vitamin D concentrations (Nonnecke, Reinhardt; USDA-ARS)
  - Newborn: 20 – 25 ng / ml
  - Target range: 30 – 60 ng / ml
- Calves are born Vitamin A deficient (Puvogel; Swiss & Penn State)
- Calf has two to seven days reserve of Vitamin C (Toutain; J of Physiology / Hidiroglou)

## Colostrum VTM Concentration

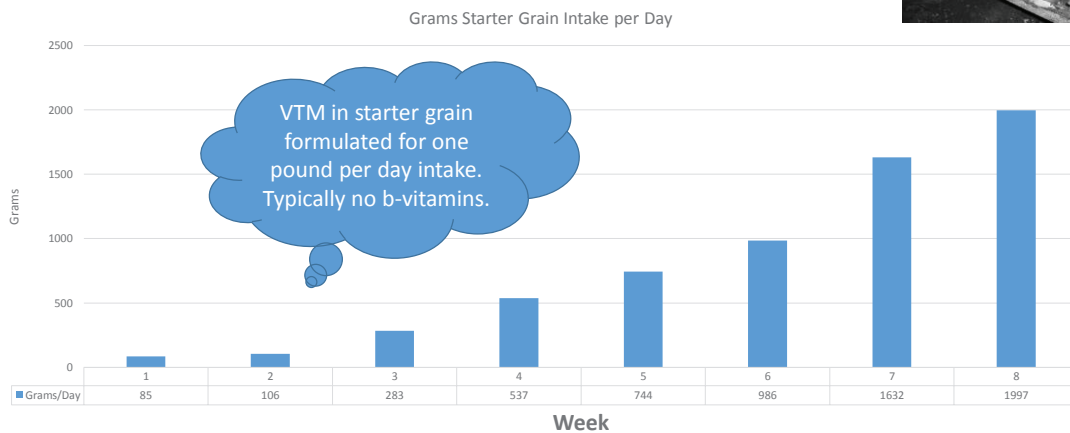
One gallon of **colostrum** is . . . (Kehoe; Penn State 55 samples / Foley, older JDS)

- Deficient in two essential B-vitamins
- Deficient in four essential trace minerals, including iron
- Barely adequate to meet one day's NRC requirement of vitamins D, E, thiamine, panthothenic acid and biotin
- Highly variable in E (low of 9 IU, high of 67 IU)
- Highly variable in Fe (deficient to 1.5x NRC)
- Rich in Vitamin A, but highly variable (3x to 46x NRC)



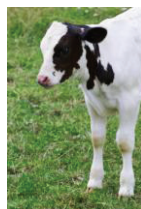


## VTM from **grain**? Intake inadequate



## Sunshine? Pasture?

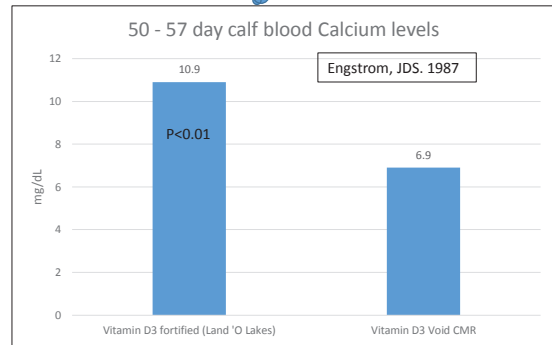
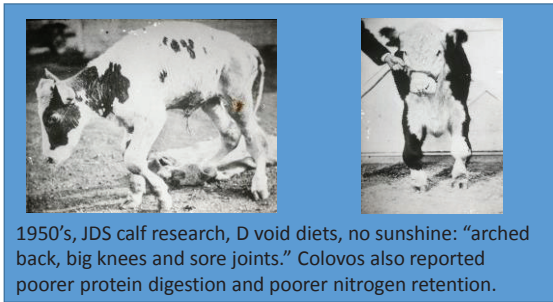
- Danish study in adult dairy cattle showed exposure to sunshine increased vitamin D synthesis. Plasma levels increased from 2.8 ng/ml to 28.6 ng/ml in four weeks. *The calf can't wait weeks!*
- Study using Angus cow/calf pairs showed no appreciable forage intake for 35 days, and the young calf would need to consume 4 – 12 lbs. of forage (depending on trace mineral) to meet daily NRC requirement.



# Supplementing Vitamin D

Vitamin D is almost inconsequential in cost per calf (1 cent?). Research shows even low levels (27 ng/ml) in blood maintain calcium homeostasis. Higher levels may improve health.

- Regulates calcium homeostasis:



- Improved immune function from vitamin D supplementation (Sacco, USDA/ARS. 2012)

# B-Vitamins are Critical

Jump Start Immune Function



Foundation for Growth, Muscle Accretion & Immunity



## Supplementing Vitamin E



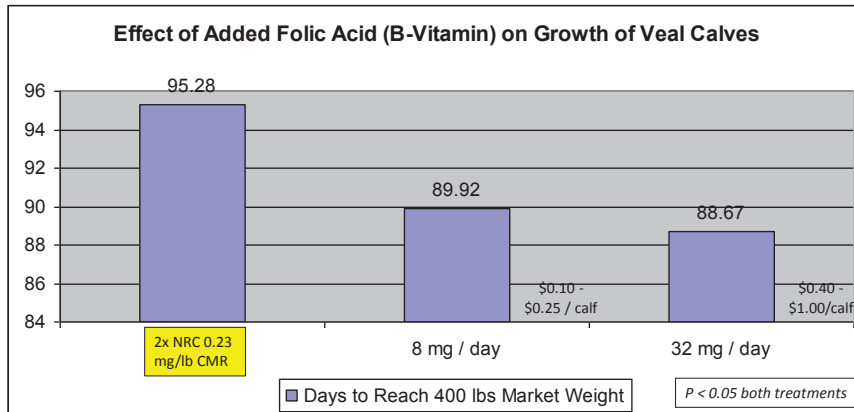
- **Calf** research shows, **supplementing E** causes:
  - ↑ white blood cell production, ↓ eye and nasal discharge (Eicher, JDS. 1994. 25 – 40 IU per day for eight weeks)
  - ↑ feed conversion (Eicher, JDS. 1992)
  - ↑ white blood cell & IgM production (2800 IU injection, weekly. Reddy, JDS, 1986)
  - ↑ weight gain, ↓ scours (Luhman. J. Dairy Science 76:220; Also BASF unpublished)
  - ↑ growth rate (2.5 lbs./day, 7 weeks) linked with ↑ E depletion (Nonnecke, USDA/ARS)
  - ↑ growth rate linked with ↑ E depletion rate (Krueger, ISU. 2013)
- ↓ vitamin E status at birth linked with ↑ mortality (Torsein, 2011)

## Supplementing Vitamin A

Be careful with excessive vitamin A feeding! Ties up E. Ideally, stay around 20,000 – 40,000 IU

- **Calf** research shows, **supplementing A** causes:
  - ↑ stool consistency (Swanson JDS. ~20,000 IU), ↓ early scours (Eicher JDS. ~20,000 IU)
  - Too little (zero) or too much (68,000 IU) vitamin A ↓ innate immune function (Rajaraman, JDS)
  - No health effect from vitamin A addition (15,000 or 30,000 IU), also less E absorbed with addition of A. If electrolyte with A was fed too (+30,000 IU more A), *more* scours (Franklin, JDS).
  - Serum retinol (Vit A) levels not effected by enhanced growth (Nonnecke, USDA/ARS)

## Supplementing B vitamins: Muscle Accretion



Girard et. al., 1993. *Livestock Production Sciences* 34: 71-82.

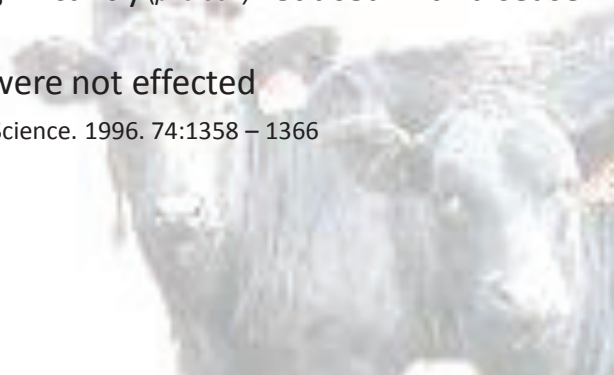
**Added Folic Acid saved 20kg (44 lbs) powder per calf!**



## B-Vitamins: Support Immunity

- Incoming Feedlot Cattle infected with bovine herpesvirus type 1 (BHV-1, i.e. **shipping fever complex**)
- Plasma concentrations of Pantothenic acid, B6 (pyridoxine) and B12 were significantly ( $p < 0.001$ ) reduced with disease challenge
- Folic acid levels were not effected

Dubeski et. al., *J. Animal Science*. 1996. 74:1358 – 1366



## Injection of B-Vitamins: Supports Immunity

- Incoming Feedlot Cattle infected with bovine herpesvirus type 1 (BHV-1, **shipping fever complex**)
- If Thiamine, Riboflavin, Niacin, Folic Acid, Pantothenic Acid, B6, B12 and ascorbic acid were injected:
  - Tended to increase IgG titer to BHV-1
  - IgG titers day 14 & 28 post challenge also tended higher ( $p < 0.09$ )

Dubeski et. al., J. Animal Science. 1996. 74:1367 – 1374

## B-Vitamins in Swine Diets

Nursery Feeds (Tokach, K-State, J.Anim. Sci 78, 2000)

- **Pyridoxine** – Quadratic ( $p < 0.05$ ) effect on **gain**
- 2<sup>nd</sup> study with **Pyridoxine**, Same effect
- No effect from added Thiamine
- No effect from added Niacin

Finisher Feeds (Tim Stahly, Iowa State University)

- 70%, 170%, 270%, 370% or 470% NRC of riboflavin, niacin, pant acid, B12 and folic acid. All are critical for muscle synthesis
- **High lean growth pigs had maximum gain at 470%**
- **Moderate lean growth maximum 370%**



## Enhanced B-Vitamin Supplementation – Veal

- 112 Calf Study – every-other-calf in barn study design
- Fed from day 11 to finish
- Control diet had typical industry levels of B-vitamins
- Test Diets had:
  - 9X thiamine, 9X riboflavin, 9X pyridoxine, 8X pant. acid, 6X B12, 7X biotin, 3X folic acid, 2X choline, 4X niacin
- Measured Individual treatments, 11 day weight, 62 day weight, hanging carcass weight & carcass quality

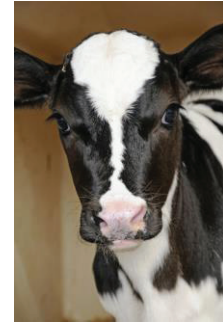
## Animix B-Vitamin Veal calf study: Results

- Increasing **B-vitamin** supplementation –  
Day 11 through day 62:
  - ↓calf treatment \$ ( $p<0.12$ , \$2.01 vs. \$0.85 / calf)
  - **↓incidence of re-treatments ( $p<0.035$ )** 29% vs. 12.7%
  - ↓antibiotic injections ( $p<0.10$ ) 1.52 / calf vs. 0.63 / calf)
  - ↓feed refusals (28% reduction, NSD  $p<0.35$ )
  - + 1.48 lbs at 62 days (NSD,  $p<0.50$ )
  - Economics through 9 weeks - \$0.93 / calf
  - Economics to 143 days - \$7.50 / calf

Very Significant  
respiratory disease  
outbreak in this  
room. Mycoplasma  
pneumonia.

## Vitamin C: Requirement

- Est. Daily Requirement for the calf –
  - 200 mg (Toutain, American Journal of Physiology 273)
- Calf is born with 1,000 mg (Toutain, American Journal of Physiology 273)
  - A gallon of colostrum contains 45 mg
  - 50% depletion of body reserves within 6 hours (Toutain)
  - but complete depletion of reserves in 6 days
  - Mega-doses are not stored
- Calf does not generate C until 2 – 3 weeks age (Lundquist, JDS 25:386)
  - Adult levels not produced until 4 months age (Wegger, Danish proceedings)



## Supplementing Vitamin C for calves

- Published calf research proves Vitamin C –
  - ↓ ocular and nasal discharge (Eicher, Morrill, JDS 75:1635)
  - ↑ IgG production in stressed calves (Cummins, JDS 74:5)
  - ↓ scours (Sahinduran, ACTA Vet Brno 73; Seife, J Vet ed B43; Nockels, Agri-Pract 9:10)
  - ↓ naval infections (Nockels, Agri-Pract 9:10)
  - Assists in respiratory challenge (Nockels, Agri-Pract 9:10)
  - Has vitamin E sparing effect (Eicher, Morrill, JDS 75:1635)

8 published calf studies reported ↑ health. One had no effect.

Very Economical – 200 mg for 4 weeks, ~10 cents / calf



## Importance of Iron Supplementation

Negative effects of iron deficiency –

- Rough haircoat, poor health, excessive licking
- Reduced feed intake, poor feed conversion
- Pale nose and/or gums
- Chalky colored manure with thick consistency
- Higher incidence of sudden death
- No reliable correlation between iron status of the cow and it's offspring
- Hemoglobin is transferred from dam to calf via cord blood transfer



Source: Dr. Drew Vermeire, Nouriche. The Producer's Connection

## Selenium Supplementation

Dairy calf trials:

- Selenium yeast improved thermo-regulation in cold weather (Ebrahimi, 2009)
- Selenium can improve immune function (Reffett, 1988)

Beef cow/calf pair trials:

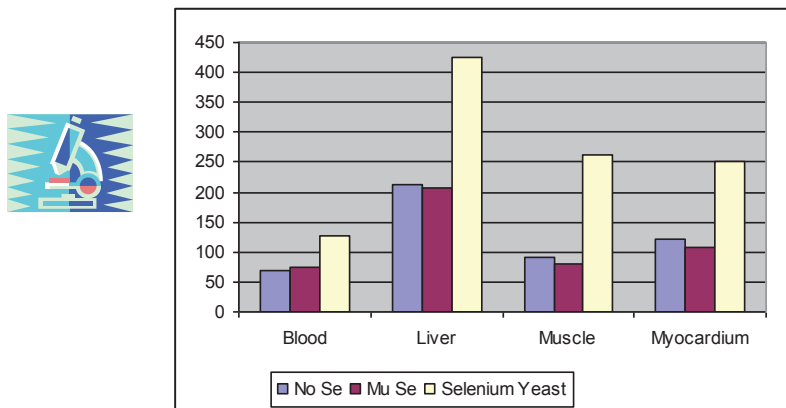
- Selenium can improve ADG (Castellan, 1999) and livability (Spears, 1986)
- Selenium improved immune function (Gunter, 2003)

Whole milk is highly variable in selenium content: meta-analysis of 42 studies in 33 references shows variation from a low of 0.03 mg to a high of 0.5 mg Se / gallon. Only 28.6% of these studies showed Se meeting NRC requirement of 0.13 mg Se per gallon of whole milk.



## Calf Studies with Selenium Yeast

**Table. 1 - Selenium retention in calves at 2 months age**

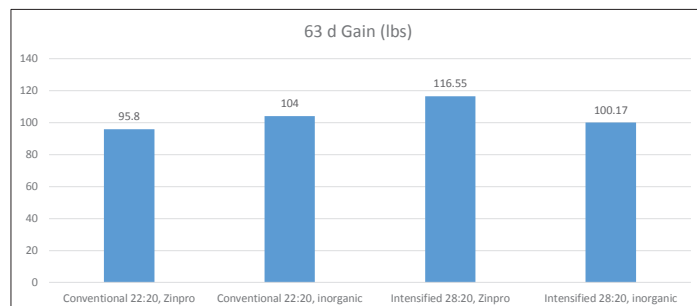


Pavlata et. al., Control vs. Selenium Yeast  $p < 0.01$ . 5 calves / treatment, 2 injections MuSe

## Organic Trace Mineral **Supplementation**

Calves fed either

- 28:20 at 1.8 lbs./d week 1; 2.5 lbs. week 2 – 6; 1.25 lbs. week 7, or
- 22:20 at 1.25 lbs. / day week 1 – 4; 0.625 / d week 5.
- 2 x 2 using either trace minerals 100% from sulfates, or 100% from Zinpro (Zn, Cu, Mn & Fe)



+16.4 lbs 63 day gain if feeding 100% Zinpro minerals vs. sulfates in the intensified program

## Take home messages

- Whole milk fails to meet the calf's TM and vitamin requirements
- Colostrum falls way short too. Fetal reserves are often inadequate.
- Starter grain intake is inadequate until 3 – 5 weeks age. No b-vits too.
- Data clearly shows supplementing vitamins improve health and growth
- B-vitamins likely under-fortified in milk replacers, particularly folic
- Data shows there is a vitamin C requirement, despite NRC conclusions
- Take note of critical nutrients like iron, selenium and vitamin D
- Feeding to genetic growth potential increases VTM requirements
- Use only highly dispersible, highly available sources of VTM's (Animix)

# **INTERACTIONS BETWEEN FEEDING BEHAVIOR, MANAGEMENT, AND HEALTH IN TRANSITION DAIRY COWS**

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## **Introduction**

Changes in behavior have for thousands of years been recognized as a sign of illness in animals; anorexia for example is frequently observed. In the last decade there has been a tremendous increase in research exploring the relationships between behavior and disease in part due to the development of a new conceptual perspective. It was long believed that changes in the behavior of sick animals was simply the result of the debilitating effects of the illness; for example, intake declines because an animal lacks the energy required to forage or compete for access to food. However, Hart (1988) and others (Danzer, 2004) have argued that many of the behaviors shown by ill animals are part of a coordinated strategy to fight illness. Behavior is an important means of influencing energy expenditure. Sick individuals may be highly motivated to decrease feeding time and increased time at rest as a means of conserving energy for responses of critical short-term value like mounting an immune response to fight an infection (Hart, 1988). With this new conceptual framework in mind it opens the door to considering the management of sick animals in a different light.

This proceedings chapter will review past and current research describing how feeding behavior changes before and after illness in dairy cattle during the period around calving (the transition period); it will also discuss the ways in which herd management may be influencing these interactions. By understanding the interactions between behavior, management, and health status, we may be able to improve existing herd health programs to better account for the needs and motivations of the animal.

## **Feeding Behavior and Health in Transition Cows**

The transition period, generally regarded as the period from 3 weeks before to 3 weeks after calving, is one of the

most challenging periods in a cows' production cycle. Nutrient requirements increase dramatically at this time to support the final stages of fetal growth, mammary development, and following parturition, lactation. Often energy obtained from dietary sources is insufficient to meet requirements, and so dairy cattle experience a period of negative energy balance after calving (Grummer et al., 2004). Insulin resistance and increased non-esterified fatty acid (NEFA) mobilization are some of the adaptations that occur to increase the availability of energetic substrates; however, these physiological adaptations also place cattle at increased risk for other health disorders (Drackley 1999).

An increasing body of literature now reveals that feeding behavior not only changes during the period of illness but can also be measured days to weeks before clinical signs of infectious and metabolic disease becomes evident. Urton et al. (2005) showed that Holstein dairy cows diagnosed with acute metritis (uterine infection) after calving spent less time at the feed bunk beginning 12 days before calving. In a follow-up study, Huzzey et al. (2007) found that metritic cows also had lower dry matter intake (DMI) up to 2 weeks before calving and 3 weeks before clinical signs of disease (Fig. 1a). Mastitis (an infection of the mammary gland) is another disease that is associated with reduced intake before and during the period of infection. Sepúlveda-Varas et al. (2014) reported that beginning 5 days prior to clinical diagnosis of mastitis, intake declined at a rate of 1.2 kg per day. Following treatment with an intramammary antibiotic (Cefa-Lak; Wyeth Animal Health, Division of Wyeth Canada, Guelph, ON, Canada), feed intake increase by approximately 60% within the first 24 hours of treatment (Sepúlveda-Varas et al., 2014).

Clinical ketosis occurs when there is an increase in production of hepatic ketones that serves as an energy source during periods of severe negative energy balance. Producers are often alerted to this condition when cows suddenly drop in both feed intake and milk production. Goldhawk et al. (2009) reported that cows that were diagnosed with subclinical ketosis after calving spent less time at the feed bunk, visited the feeder less often, and consumed less feed during the week before calving and the 2-week period after calving (Fig. 1b). Similarly, Jawor et al. (2012) found that cows with subclinical hypocalcemia also made fewer visits to the water trough during the first

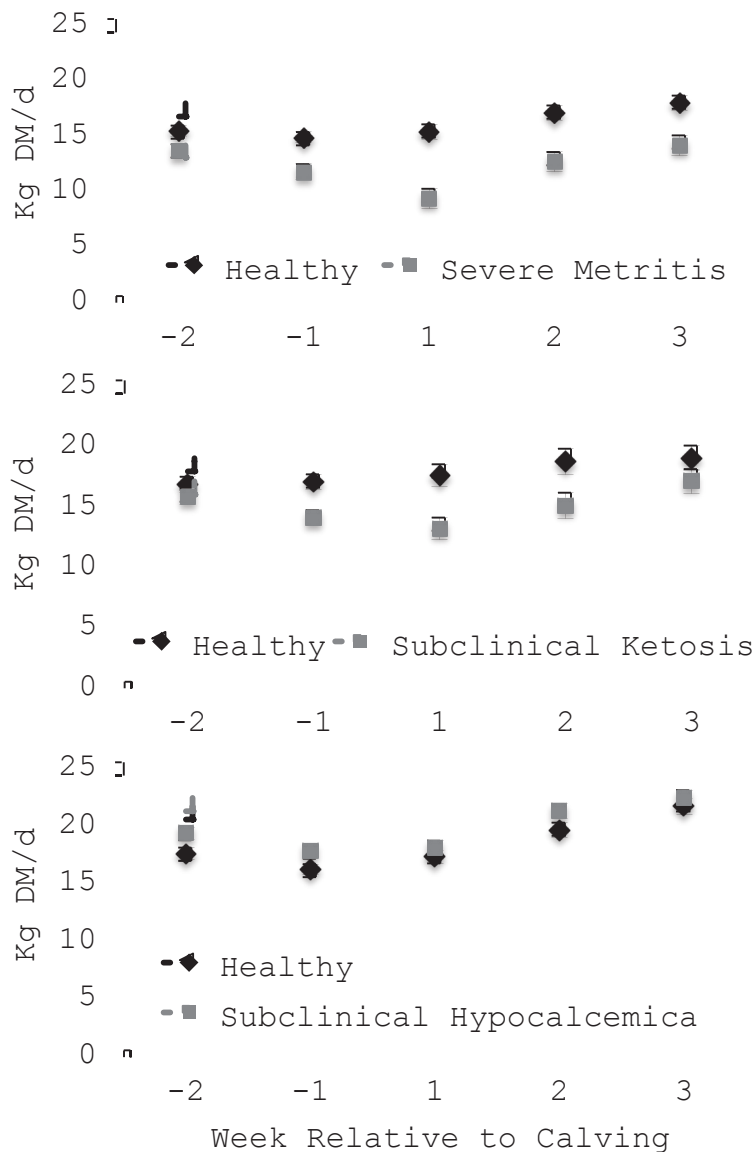
2 weeks after calving and tended to make fewer visits to the feed bins during weeks 1 and 3 postpartum.

Postpartum illness is not always associated with lower feed intake before calving. Cows diagnosed with subclinical hypocalcemia within 24-h after calving (serum calcium concentration < 1.8 mmol/L, without clinical milk fever) consumed more feed 2 weeks before calving than cows without subclinical hypocalcemia (Fig. 1c; Jawor et al. 2012). In that study cows with subclinical hypocalcemia produced nearly 6 kg/day more milk during the first 4 weeks of lactation but this higher level of production cannot fully explain the prepartum differences in feed intake, as this was a period during which the cows were not lactating.

Feeding behavior around calving also differs for cattle that develop claw horn lesions later in lactation compared with those that maintain good hoof health (Proudfoot et al., 2010). Lameness has not typically been considered a transition cow disease since hoof pathologies are generally not noticed until mid lactation. Hoof lesions, however, take months to become visible and the period around calving is where the lesions may first begin to develop (Cook and Nordlund, 2009). Proudfoot et al. (2010) reported that cows with lesions during mid-lactation had a faster feeding rate during the 2-week period before calving and consumed ~5 kg more DMI during the 24 h after calving, relative to cows without lesions. A high rate of intake is associated with feed sorting for small particles which, when combined with a higher feed intake, may increase risk for ruminal acidosis (DeVries et al., 2007; Fairfield et al., 2007). More research is required to determine if there are acidosis-related changes in hoof health and to what extent differences in feeding behavior around calving contribute to these conditions.

Social interactions at the feed bunk during the transition period may also be related to postpartum disease risk. Huzzey et al. (2007) reported that cows that developed metritis after calving displaced others from the feed bunk less often before calving, relative to cows that remained healthy. These sick cows also consumed the least amount of feed during the period following fresh feed delivery, a time when all cows are highly motivated to eat and when feed palatability and quality are highest (DeVries and von Keyserlingk, 2005). This peak feeding time is when the feed bunk is most crowded and thus competition for feed is

greatest, suggesting that cows that go on to become sick after calving may lack the motivation to compete for access to feed. Changes in the motivation to compete for important resources may be an expression of an energy conserving sickness behavior, but this behavior was also observed before clinical signs of disease suggesting that it could also be a risk factor for illness (by preventing adequate nutrition).



**Figure 1.** Dry matter (DM) intake (kg DM/d) of cows that were healthy throughout the first 21 days of lactation and those diagnosed with severe metritis (A; data adapted from Huzzey *et al.*, 2007), subclinical ketosis (B; Goldhawk *et al.*, 2009) and subclinical hypocalcemia (C; Jawor *et al.*, 2012). Figure is re-drawn from Sepúlveda-Varas *et al.*, 2014.

### **Altered Feeding Behavior: Cause or Effect of Disease?**

In both the social and feeding behavior examples reviewed above, it is important to think carefully about the causal links: is the behavior an expression of classic sickness behavior due to some undiagnosed disease, or does the behavior increase the animals future risk of illness in some manner?

When animals are sick the immune system becomes activated and coordinates the release of immune cells that can have a direct effect on behavior. Proinflammatory cytokines such as interleukin-1 $\beta$  (IL-1 $\beta$ ) have been shown to communicate with the hypothalamus to reduce the motivation to eat. For example, rats that were injected with IL-1 $\beta$  consumed less feed than control rats and lost more body weight (Finck and Johnson, 1997). This reduction in intake appears to be important for survival as clearly demonstrated by Murray and Murray (1979). In that study, mice were infected with *Listeria monocytogenes* to induce illness and the researchers then let one group of mice consume food ad-libitum whereas the other group was force-fed to the level of uninfected controls. Infected mice that were allowed to regulate their own intake ate only 58% as much as the controls and were much more likely to survive than mice that were force-fed (Murray and Murray, 1979). A reduction in feeding activity conserves energy for the immune system and other vital systems. Cytokine-induced hypophagia may also reduce the intake of important nutrients (e.g. energy, protein) or micro-nutrients (e.g. zinc or iron) needed to support pathogen growth and in this manner may also facilitate recovery (Aubert, 1999).

Increased susceptibility to stress due a poor ability to cope with social or environmental change may also predispose animals to illness. It is well known that the period around calving is wrought with numerous environmental and social stressors. The transition period is characterized by pen moves, social regroupings, commingling cows and heifers, and the introduction of novel environments like the milking parlor (for heifers). There may also be challenges with overstocking particularly during the dry period, exposure to heat or cold stress, or aspects of facility design that affect cow comfort (Grant and Albright, 1995). In the short-term, physiological responses to stressors are adaptive, for example glucocorticoids facilitate the actions of catecholamines

helping to improve fitness by directly supporting energy mobilization (Raynaert et al., 1976) and corticosteroids are well known for their anti-inflammatory properties. However, during prolonged stressors, the effects of glucocorticoids eventually become suppressive (Sapolsky et al., 2000). Chronically high levels of glucocorticoids decrease overall fitness by contributing to immunosuppression, reduced intake (Tempel and Leibowitz, 1994), and compromised reproductive performance (Johnson et al., 1992).

While the research discussed thus far does not allow us to determine if changes in health are the result of changes in feeding behavior or vice versa, it is clear that the transition period is a time of significant change both physiologically and environmentally. Research has shown that management and environment can have significant effects on behavior and therefore management should be considered in combination with behavioral change when evaluating disease risk during the transition period.

### **Management Risk Factors**

As there appears to be a clear relationship between decreased feeding activity and increased risk of illness after calving, finding ways to improve access to feed and increase time spent at the feed bunk would likely be beneficial to a cows overall health and welfare. There is a growing body of science that demonstrates how frequency of feed delivery, overcrowding, feed bunk design, changes in TMR quality and frequent pen moves can influence feeding behavior.

Dairy cattle are gregarious animals and so prefer to engage in activities such as feeding as a group rather than individually. Fresh feed delivery has been found to be an important motivator for bringing cows to the feed bunk (DeVries and von Keyserlingk, 2005). Increasing the frequency of fresh feed delivery increases cows total daily feeding time, results in cows having more equal access to feed throughout the day and reduces the frequency with which subordinate cows are displaced from the feed bunk (DeVries et al., 2005). The hours following fresh feed delivery are also when bunk occupancy is the highest; when stocking rates in the pen are increased not all cows are able to access the feed during the same time, forcing some



cows to stand in the alley waiting for their turn at the feed bunk (Huzzey et al., 2006).

Overcrowding the feed bunk results in an increase in aggressive interactions as cows "fight" for access to this valuable resource. Not surprisingly as space decreases below the industry recommended level of 24 inches of linear space per animal (or 1 headlock per cow) the amount of competitive interactions increase (Huzzey et al., 2006). To compensate cows will increase their feeding rate; cows that are displaced from the feeding area most often, eat the fastest (Proudfoot et al., 2009). Changes in these feeding patterns likely explain why average daily feeding time is generally found to be lower when cows are overstocked at the feed bunk (e.g. Huzzey et al., 2006; Proudfoot et al., 2009). These lower feeding times do not necessarily translate to lower daily DMI however likely due to the increase in feeding rate (Olofsson, 1999; Proudfoot et al., 2009).

Although intake is not always affected during overcrowding recent research suggests that there are other physiological changes that occur during overcrowding that may negatively influence the nutritional health of dairy cattle. Huzzey et al. (2012) reported that when cows were overstocked at the feed bunk and lying stalls they had higher concentrations of the stress hormone cortisol, a hormone that is an important regulator of energy metabolism. In this study a two-week period of overcrowding was enough to significantly alter energy metabolism as evidenced by higher circulating NEFA concentrations during the 2-week period and a greater insulin response following a glucose tolerance test which could indicated reduced sensitivity to insulin (Huzzey et al., 2012). Therefore, while intake may not be affected during overstocking changes in energy metabolism may increase a cows' risk for other nutritionally related health problems.

Increased competition at the feed bunk may also occur when the quality of the diet is non-uniformly distributed across the length of the feed bunk. The goal of a total mixed ration (TMR) is to provide a balanced well mixed supply of nutrients to the cow. However, the quality of a TMR may vary between days (in relation to mixing and inputs), within days (due to sorting by cows or environmental exposure), and along the length of the feed bunk (due to improper mixing or uneven feed distribution and usage). The

frequency of competitive interactions were reported to be 3.5 times higher when TMR quality was non-uniformly distributed along the bunk compared to when it was uniformly distributed (Huzzey et al., 2013).

The design of the feeding area may offer dairy cattle some relief from social competition during feeding. Feed barriers that offer physical separation between the necks (i.e. headlocks) or bodies (feed stalls) of cows at the feed bunk can reduce the frequency of competitive displacements (Huzzey et al., 2006; DeVries and von Keyserlingk, 2006). A less aggressive feeding environment may promote longer feeding times and may also have long-term health benefits; cows that are aggressively competing for access to the food would likely be at increased risk for injury and hoof health problems.

Finally, moving animals into new social groups disrupts normal feeding behavior. The period around calving is marked by several group changes. Cows are often moved from a non-lactating group (dry off to > 3 weeks prepartum), to a close-up group (within 3 weeks prepartum), to an individual maternity pen for calving, and finally to the main lactating herd. Research has shown that competitive aggressive interactions at the feed bunk are highest on the day of regrouping and remain elevated for several days after (von Keyserlingk et al., 2008). Schirmann et al. (2011) reported that for the cows being moved into a new pen, intake decreased by 9%, feeding rate decreased by 10% and rumination time decreased by 9% following regrouping. These results suggest that regrouping has important effects on feeding behavior particularly for those animals being moved into a new pen.

## **Conclusions**

During the transition period dairy cattle must cope with numerous physiological and environmental changes that threaten their health and welfare. An expanding body of literature now provides evidence that behavioral changes around parturition not only identify which animals are sick, but also which animals are at increased risk of becoming sick. Herd management during this time can be an important modifier of behavior and as such may also be related to disease risk. Management related factors that may alter behavior at the feed bunk include frequency of feed delivery, changes in TMR quality, feed bunk design,

overcrowding, and frequent pen moves. Future work aimed at improving the overall health and welfare of cattle during the period around calving will need to consider the influence of both behavior and management.

#### **ACKNOWLEDGEMENTS**

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**Cooling dairy cows efficiently with water:  
Effects of soaker flow rate on body temperature and behavior**

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Dairy cattle are commonly cooled with soakers mounted over the feed bunk that intermittently spray the cows' backs. These use potable water – an increasingly scarce resource – but there is little experimental evidence about how much is needed to cool cows. Our objectives were to determine how soaker flow rate affects body temperature and cattle behavior, and to evaluate cooling effectiveness against water use. We administered 3 treatments at a shaded feed bunk: an unsprayed control and 2 soaker nozzles (1.3 or 4.9 L/min), which sprayed in cycles of 3 min on and 9 min off, 24 h/d. Data were collected from pairs ( $n = 9$  pairs) of high-producing lactating Holsteins (milk production =  $45 \pm 4$  kg/d, mean  $\pm$  SD) in ambient summer conditions (24-h maximum air temperature =  $33 \pm 3^\circ\text{C}$ , mean  $\pm$  SD). Each pair of cows received 1 treatment/d for 2 d each, with order of exposure balanced in a crossover design. Body temperature was recorded vaginally at 2-min intervals 24/d with loggers, and behavioral responses (time spent at the feed bunk and water trough, and lying or standing) were measured continuously from video recordings. Statistical analyses were performed using the GLM procedure in SAS software (version 9.4) with the pair of cows ( $n = 9$ ) as the experimental unit. We found no differences for any of these measures between the 2 soaker nozzles ( $P \geq 0.227$ ); thus, all differences are described between the spray treatments and the control. Compared to when they had only shade, when cows had access to soakers they spent  $\geq 23\%$  less time at the water trough ( $P \leq 0.044$ ) and their body temperature was  $\geq 0.3^\circ\text{C}$  lower from 1300 to 2000 h daily ( $P \leq 0.015$ ). When soakers were used, as air temperature increased, so did time spent at the feed bunk ( $\geq 22$  min/d for each  $1^\circ\text{C}$  increase in air temperature;  $P < 0.001$ ), and body temperature was relatively unchanged across weather conditions (for each  $10^\circ\text{C}$  increase in air temperature, body temperature increased by  $\leq 0.6^\circ\text{C}$  compared to  $1.5^\circ\text{C}$  without water cooling;  $P = 0.032$ ). Lying time averaged  $12.0 \pm 1.4$  h/d (mean  $\pm$  SD), regardless of treatment ( $P = 0.728$ ), and decreased in warmer weather ( $-14$  min/d for each  $1^\circ\text{C}$  increase in air temperature;  $P = 0.015$ ). In summary, when there were soakers over the feed bunk, body temperature was lower than when there was only shade, and cows spent more time at the feed bunk as air temperature increased. The 2 soaker flow rates we tested were equally effective for cooling cows, despite differing nearly 4-fold in the amount of water used, which suggests a potential opportunity for water savings.

## DESCRIPTION OF FRESH COW EVALUATIONS ON CALIFORNIA DAIRIES

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The objective of this study was to describe techniques used to identify sick cows after freshening on California dairies. Eight Holstein and two Jersey herds were enrolled in the study ranging in size from 980 to 9500 cows. Two bilingual veterinarians collected information through observations and on-site questionnaires. On nine dairies, fresh cow checks were performed daily by one (n=3), two (n=5) or three individuals (n=1); and, one dairy every other day by one evaluator. Fresh cow evaluations were done after (n=7) or before milking (n=3) and lasted, including treatment administration, [median (range)] 13.8 (1.5 to 45) s/cow. Calving issues were not recorded (n=5), chalked on cow's rump (n=1), entered in the computer (n=4) or chalked and entered in computer (n=1). Sick cows records were either chalked on cow's rump (n=4), entered in the computer (n=5) or not kept (n=1). To identify sick cows, evaluators relied on a thermometer (n=1), a stethoscope (n=5) or both (n=1). The stethoscope was used to check displaced abomasum (n=6) and pneumonia (n=1). All dairies evaluated abnormal uterine discharge of fresh-cows. In addition to uterine discharge, dairies evaluated the following signs of disease: none (n=3), udder fill and temperature (n=1); and three to five signs of diseases [n=6; rumen fill (n=5), eyes-ears (n=5), feces (n=5), milk yield or udder fill (n=4), appetite (n=5), temperature (n=1)]. Exploratory rectal palpation was routinely done at 5 DIM (n=1), daily from 1 to 12 DIM (n=1) or weekly (n=2). Retained placenta was defined as the failure to expel fetal membranes at 24 (n=8) or 72 (n=2) hours post-partum. Metritis was defined as foul-smell vaginal discharge (n=10) or abnormal vaginal discharge without (n=3) or with temperature (n=2). Most dairies (n=9) only diagnosed ketosis when obvious clinical signs were observed, and evaluators on one dairy were not familiar with this disease. A drop in milk yield (n=2), abnormal manure (n=2) or poor rumen fill (n=2) guaranteed the exploration for displaced abomasum. There is a wide difference on the exploratory signs evaluated during fresh cow checks across dairies.

### Keywords:

Dairy cattle  
Fresh cow  
Metritis

## Effects of Two Yeast based Direct Fed Microbials on Performance of Lactating Dairy Cows

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### Abstract

Direct fed microbials (DFM) are common dairy feed additives worldwide but, due to variability in animal responses and introduction of new DFM, continuing research is needed to evaluate their efficacy. Our aim was to determine effects of two relatively recent *S. cerevisiae* yeast based DFM feed additives on the productive response of high producing early lactation dairy cows. The study consisted of three high producing Holstein cow pens ( $\pm$  315 cows/pen) in a 3x3 Latin square design experiment with 3 periods of 28 d. The 3 treatments were: 1) Basal total mixed ration (Control), 2) Control supplemented with 'XPC' yeast culture (Diamond V Mills, Cedar Rapids, IA) at 14 g/cow/d and, 3) Control supplemented with 'Yeasture' DFM (Cenzon, San Marcos, CA) at 10 g/cow/d (both DFM were fed at their manufacturers' recommended levels). Dry matter intake was not impacted by either treatment (avg. 27.1 kg/cow/day). Milk ( $P=0.01$ ), milk true protein ( $P = 0.01$ ), lactose ( $P=0.01$ ) and energy ( $P=0.02$ ) outputs were higher for Yeasture supplemented *versus* Control cows, and there was a tendency for milk fat ( $P=0.07$ ) to be higher. In contrast, milk and component yields were not impacted by feeding XPC *versus* Control. Change in body condition score (avg. 0.08 units/cow/28 days) was unaffected by either treatment *versus* Control. Net energy (NE) output was higher for both treatments *versus* Control (Yeasture ( $P<0.01$ ) and XPC ( $P=0.01$ )), but neither treatment impacted the calculated NE level of the diets. Total tract apparent digestibility of organic matter (OM) and crude protein (CP) tended to be lower ( $P=0.08$  and  $0.05$  respectively) *versus* Control for the XPC fed cows, while total tract apparent digestibility of OM and CP for the Yeasture fed cows was lower ( $P=0.02$  and  $<0.01$  respectively) *versus* Control. Total tract apparent ash-free neutral detergent fibre (aNDFom) and starch digestibility was not affected by either treatment *versus* Control, and there was no effect of either treatment on microbial CP flow from the rumen. Total plasma essential amino acid (EAA) levels tended to be higher ( $P=0.07$ ) with the Yeasture fed cows *versus* Control, and this was mainly driven by increases in threonine ( $P=0.03$ ), tryptophan ( $P=0.02$ ), valine ( $P = 0.08$ ) and histidine ( $P=0.06$ ). Although total nonessential amino acids (NEAA) did not differ *versus* Control when Yeasture was fed, there was an increase in levels of glycine ( $P=0.04$ ), asparagine ( $P=0.03$ ), tyrosine ( $P=0.05$ ), serine ( $P=0.07$ ), proline ( $P=0.06$ ) and taurine ( $P=0.07$ ). In contrast, feeding XPC had no impact on plasma concentrations of any AA *versus* Control. Overall, microbial CP flow and whole tract aNDFom digestion data suggest no substantive impact of either DFM on rumen fermentation, but the reduced apparent whole tract digestibility of OM, and increased plasma AA levels, *versus* Control cows suggest a post-ruminal effect of Yeasture wherein gut health was improved leading to increased efficiency of nutrient absorption.

**Keywords:** DFM, XPC, Yeasture, allantoin



## **Fresh Cow Treatments on California Dairies**

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The objective was to describe treatments administered to fresh cows on eight Holstein and two Jersey California herds ranging in size from 980 to 9500 cows. Two bilingual veterinarians collected information through observations and questionnaires during fresh cow evaluations. Dairies systematically used non-antibiotic treatments at calving (n=5) [oral Ca (n=3), probiotics and vitamins (n=4), and NSAIDs (n=1)]; at 3 DIM (n=1; intrauterine flushing); and from 3 to 5 DIM (n=1; propilenglycol). Antibiotic therapy was given after twinning (n=5) and dystocic calvings [to all cows (n=5), to primiparous cows (n=1), or to severe cases (n=4)]. Additionally, dystocic cows were treated with NSAIDs (n=2), IV Ca (n=1) or IV dextrose and NSAIDs (n=1). Oxytocin was used after dystocia (n=1) and twinning (n=1). Cows with retained placenta were treated at 24 (n=5), 48 (n=2) and 72 (n=2) hours postpartum, or if metritis was observed (n=1). The first treatment option was systemic ceftiofur (n=6) or penicillin (n=3), or intrauterine urea (n=1). Cows with foul-smelling vaginal discharge were treated for metritis with systemic antibiotics (n=10), as well as with uterine flushing (n=2) and NSAIDs (n=3). The first antibiotic choice was ceftiofur (n=7) or penicillin (n=3). On four dairies uterine flushings were applied to cows with non-foul-smelling abnormal vaginal discharge. Clinical ketosis was treated with IV dextrose (n=9), as well as with oral propilenglycol and corticosteroids (n=3). Intravenous Ca (n=10) was used to treat clinical hypocalcemia, as well as IV dextrose (n=7), NSAIDs (n=2) and antibiotics (n=1). After displaced abomasum, dairies performed surgery on all cows (n=4), on high value cows (n=2) or none (n=4). Cows with loose feces were orally treated with a combination of pectin or charcoal (n=7), Mg oxide (n=5), vitamins (n=2), bicarbonate (n=2) and probiotics (n=1). Seven dairies treated cows without a defined diagnosis with all (n=1), three (n=1) or one (n=4) of the following: glucogenic precursors, probiotics, vitamins, NSAIDs, Mg oxide and antibiotics. These observations suggest that there is a large variation on treatments administered to fresh cows among dairies.

### **Keywords:**

Dairy cattle

Fresh cow

Treatments

## **Description of Close-up Cow Recipes in California Dairies**

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The objective of this study was to describe close-up cow (CU) recipes prepared on 25 California dairies ranging in size from 1,100 to 6,900 cows. Records from a consecutive twelve month period were extracted from the feeding management software FeedWatch 7.0. The variables included were: date, recipe, recipe number, ingredient, loading sequence, target weight, actual weight and tolerance level. Descriptive statistics were conducted with SAS 9.3. Dairies prepared a median of one (n=24) or two (n=1) CU recipes per day. The median number of ingredients included in the CU recipe ranged from three to five (n=18) and six to nine (n=7); and varied over time within dairy, by one (n=7), two to three (n=2), or zero (n=16) ingredients. The most commonly used ingredients in CU recipes were rolled corn (n=19), premix (n=17; five prepared it on farm), liquids (n=8), mineral-vitamins (n=7), anionic salts (n=6) and canola (n=5). The most common forages included were corn silage (n=24) and alfalfa hay (n=20), and some dairies also used straw hay (n=5) and oat hay (n=7). The ingredients most frequently added first were alfalfa hay (n=11), straw hay (n=5) oat hay (n=5), premix (n=2), yeast (n=1) and wheat (n=1). The ingredients most frequently added last were corn silage (n=11), liquids (n=7), premix (n=2), mineral-vitamins (n=2), canola (n=1), earlage (n=1) or rolled corn (n=1). The TL(kg) of the various ingredients for all dairies enrolled was: 0 (11.2%), 0.5-20 (31.7%), 25-40 (33.5%), 50-75 (18.0%) and 100-150 (5.6%) kg. The TL allowed a deviation from the median formulated target for the various ingredients across dairies of: 0% (11.2%), >0-2% (14.9%), >2-5% (25.5%), >5-10% (18.0%) and >10% (30.4%). Deviation from target >10% was allowed on 20 ingredient types on 20 dairies [alfalfa hay (n=11), rolled corn (n=8), mineral-vitamins (n=4), corn silage (n=3), canola (n=3) and others (n=2)]. Corn silage, alfalfa hay, rolled corn and premix were ingredients commonly found on CU recipes. In many dairies, the TL allowed to CU ingredients should be re-evaluated.

### **KEYWORDS**

dairy cattle

close up cow ration

feeding management software