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Choline – A Key to Transition Cow Success

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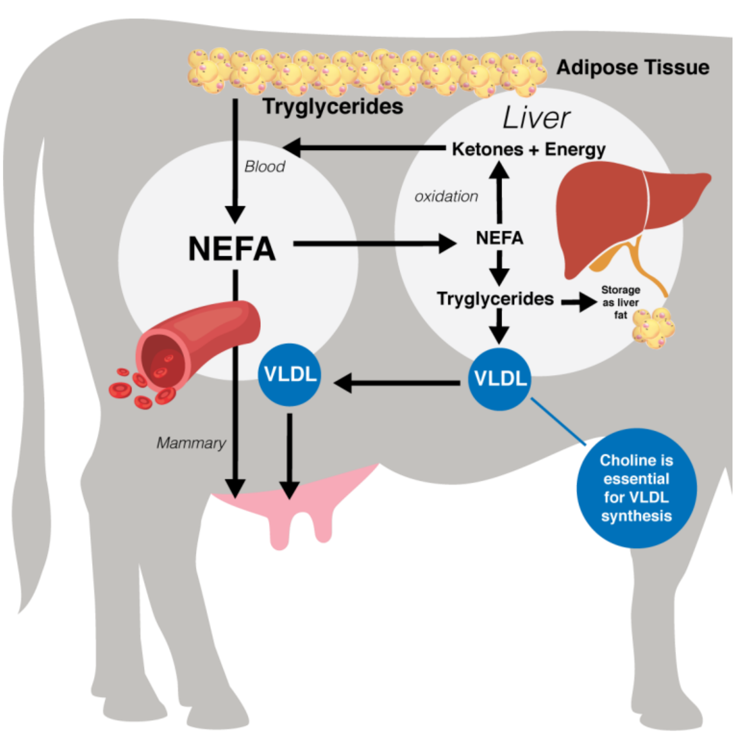
What is choline and why is it important?
Choline is an organic, water soluble molecule. While the chemical structure of choline is similar to some B vitamins, it is neither a vitamin nor a mineral. Choline is involved in many processes in the body and is crucial for normal function of all cells in the body. Choline is considered a required nutrient in many species and was recognized as an essential nutrient for humans by the Institute of Medicine in 1998. A recommended daily choline intake was established for humans in 2014.

Choline serves four main purposes: (1) Building and maintenance of cell membrane structure, (2) Promotion of fat metabolism in the liver, (3) Formation of acetylcholine, an important neurotransmitter involved in muscle control and brain function, and (4) Serving as a methyl donor aiding in DNA methylation. Choline is also critical for fetal brain and nervous system development. Typical symptoms of choline deficiency include development of fatty liver disease and liver damage, insulin resistance, and various metabolic disorders.

Choline Key Functions
Cell Membrane Structure Fat Metabolism in Liver Acetylcholine Formation Methyl Donor for DNA

Why does the transition cow need choline?
Dairy cows face abrupt hormonal and metabolic changes as they approach and enter lactation. The energetic requirements of lactation are tremendous, and dry matter intakes are low. As a result, the transition dairy cow is in a state of negative energy balance, meaning energy intake from feed is less than energy expenditure for maintenance and milk production.



Dairy cows are well-equipped to handle negative energy balance. Hormonal changes that occur around calving help the cow to mobilize energy that is stored as fat in adipose tissue and make it available to the cow for use to bridge the gap between energy intake and energy expenditure. This process occurs to some degree in all transitioning dairy cows. During this process, fatty acids, which are stored as triglycerides within adipose tissue, are lipolyzed and the resulting free fatty acids are released into the blood stream. This mobilized energy, in the form of non-esterified fatty acids (NEFAs), is transported to the liver. Blood NEFA concentrations typically increase 5- to 10-fold and blood flow to the liver doubles around calving, resulting in NEFA uptake in the liver at calving being 13 times greater than during the dry period.

The NEFAs entering the liver can either be oxidized for energy or repackaged for storage and transport. Those NEFAs that are oxidized are either converted to ATP, a usable energy source for the cow, or, when blood glucose concentrations are low such as during times of very low feed intake, converted to ketones. The NEFAs that are not readily oxidized in the liver are repackaged as triglycerides, which can either be exported out of the liver as part of very low-density lipoproteins (VLDL) or stored in liver cells.

Fatty Liver Disease Problems
Depressed Feed Intake Decreased Milk and Component Production Ketosis Increased Risk of Other Health and Metabolic Diseases

Unfortunately, dairy cows export VLDL at a very slow rate and majority of the NEFAs that are not oxidized are stored in the liver as triglyceride. During times of extreme negative energy balance such as the transition period or off-feed events, the amount of NEFAs entering the liver is large and the capacity to oxidize NEFAs is exceeded, resulting in an excess amount of fatty acids being stored in the liver and a condition known as fatty liver disease. Cows with fatty liver disease have depressed feed intake, decreased milk production, and often ketosis. Moreover, cows with fatty liver disease are at increased risk of clinical mastitis, metritis, displaced abomasum, and hypocalcemia. Over-conditioned cows are also at increased risk of fatty liver disease due to more pronounced feed intake depression around calving.

Slow export of VLDL from cow liver means that fatty liver disease often lingers, typically not resolving until cows return to positive energy balance several weeks after calving. Cows with fatty liver disease often are slow to reach peak milk production and feed intake postpartum as well.

Phosphatidylcholine is essential for formation of VLDL, the lipoprotein responsible for exporting fatty acids out of the liver, and therefore plays a very important role in fat metabolism in the transition dairy cow. Choline is required for phosphatidylcholine synthesis in the liver and subsequent VLDL formation. Several research studies in multiple species have demonstrated that the rate of VLDL export is highly related to the rate of phosphatidylcholine synthesis in the liver. Given that 50-60% of dairy cows experience moderate to severe fatty liver disease during transition, it is reasonable to conclude that fatty liver disease is somewhat "normal" for the transition dairy cow. Since fatty liver disease is a classic deficiency symptom for choline, it is more likely that transition dairy cows are typically deficient in choline. Increasing choline availability in the transition dairy cow helps prevent fatty liver disease, promotes dry matter intake, and improves milk and component production.

Supplementing transition cows with choline also benefits calves, as cows supplemented with choline during the transition period produce greater volumes of colostrum containing greater quantities of IgG than cows not supplemented with choline. The link between colostrum quantity and quality and subsequent calf health and performance is well-documented.

Why do cows need rumen-protected choline?

While a choline requirement for dairy cows has not yet been established by the National Research Council, it is clear that choline is essential for proper fat metabolism in the transition dairy cow. Dairy cows can synthesize low amounts of phosphatidylcholine from phospatidylethanolamine, but the high incidence of fatty liver in transition cows suggests that this is not enough to meet requirements. While some feedstuffs such as cereal germs, legumes and oilseed meals contain relatively high amounts of choline, most dairy feedstuffs, including corn, are low in choline. Moreover, studies show that the vast majority (85-99%) of dietary choline is destroyed in the rumen. Transition dairy cows require rumen-protected choline to make choline available for VLDL synthesis in the liver.

Choline Improves Milk and Component Production

Item	Control	Choline	Difference
Dry Matter Intake, lb/day	42.3	43.4	1.1
Milk Yield, lb/day	73.2	76.7	3.5
ECM, lb/day	76.7	80.5	3.8
Milk Fat, lb/day	2.84	2.99	0.15
Milk Protein, lb/day	2.34	2.45	0.11

What are the typical production responses to rumen-protected choline?

Supplementing transition dairy cows with rumen-protected choline often improves fat metabolism in the liver, which has larger ramifications on feed intake, milk and component production, and health and disease outcomes. Additionally, even though choline is only supplemented during the transition period, the increases in milk and component production sustain through peak lactation.

A recent meta-analysis summarized prepartum and postpartum production outcomes to rumen-protected choline supplementation from 21 experiments utilizing 1,313 cows. Rumen-protected choline supplementation averaged 12.9 grams/day from 22 days prior to calving thorough 57.5 days in milk. Prepartum cows supplemented with rumen-protected choline had increased dry matter intake (0.44 lb/day), body weight (50.7 lbs), and body condition score (0.08 units) compared to non-supplemented cows. In lactating cows, choline supplementation increased dry matter intake (1.1 lb/day), body weight (66 lbs), body condition score (0.09 units), milk yield (3.5 lbs/day), and energy corrected milk yield (3.8 lbs/day), as well as milk fat yield (0.15 lbs/day) and milk protein yield (0.11 lbs/day). Postpartum cows that were supplemented with rumen-protected choline also had decreased blood concentrations of NEFA and ketones and tended to have reduced incidences of retained placenta, mastitis, and total number of diseases per cow.

What are the economics behind feeding rumen-protected choline?

Supplementing rumen-protected choline to transition cows brings value in multiple way: improving milk and component yields directly impacts the milk check, and milk protein is more valuable than it has been in several years. Using October Class III prices for the Upper Midwest ($3.17/lb Protein; $2.40/lb Butterfat), the increases in milk fat and protein yields noted listed above are worth approximately $0.71 per cow per day. There is also value in rumen-protected choline supplementation due to improved body weight and body condition score in early lactation, which positively affects reproductive efficiency, and additional value in decreased incidences of metabolic and infectious disease in postpartum cows. Finally, choline brings even more value to the dairy farm by improving colostrum quantity and quality makes healthier, faster growing calves.

Take Home Message

Choline is an important nutrient for all species but is particularly important for the transitioning dairy cow due to increased fat mobilization to the liver and the propensity for transition cows to develop fatty liver disease. Fatty liver disease decreases production in postpartum dairy cows and is associated with increased risk of many other metabolic and infectious diseases postpartum. Supplementing rumen-protected choline during the transition period supports fat metabolism and prevents fatty liver disease, leading to production improvements and decrease disease incidence in postpartum cows, positively impacting the bottom line of the dairy.

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