ISSN–0974–0759 | ●●● Article ●●● |Visit us : *www.researchjournal.co.in*|

Choline : Essential nutrient for transition phase cattle

Aparna[1] and Jaspal Singh Hundal[2]
[1]Krishi Vigyan Kendra (PAU), Ludhiana (Punjab) India
[2]Department of Animal Nutrition, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Punjab) India

During transition phase dairy cows experience several physiological changes that impact their reproductive and productive functions. Tremendous changes have been identified in nutrient demand by the animals for co-ordination of metabolism during this phase. In case of not meeting these nutritional needs body metabolic system fails to efficiently co-ordinate lactation, leading to the occurrence of metabolic disorders thereby compromising profitability on commercial dairy farms. This is the reason that nutrition and management of the dairy animals during transition has become a priority.

Choline, a trimethylated quaternary amine $[(CH_3)_3N+CH_2CH_2OH]$, also called as trimethyl ethanolamine is a quasi vitamin (vitamin-like substance) and is a part of multi-function B-complex vitamin. Choline was founded by Andreas Strecker in 1862 and was found to be having properties of a colorless, viscous, strongly alkaline and hygroscopic liquid. Physical properties also indicated it to be soluble in water, formaldehyde and alcohol, and that it has no definite melting or boiling point. Best and Huntsman(1932) found that choline was essential in the prevention of fatty liver in rats and dogs. In ruminants it works in interrelationship with methionine, vitamin B12, and folic acid and has been found to be playing enough in animal production, reproduction, and health and hence it is a dietary essential. Its major functions are being a component of phospholipid contained in the membranes of all cells in the body (as phosphatidylcholine), a component of the neurotransmitter acetylcholine, and as a direct precursor to betaine in methyl metabolism. Being so important for physiology now a days choline chloride (chemicaliy synthesized) is being used in the feed industry.

Although the choline requirements for dairy cows have not been established (NRC, 2001) duodenal flow of choline is reported less than 30 per cent of the daily needs (Erdman, 1992) which indicates insufficiency of choline . Low availability of dietary choline, extensive secretion of choline through milk especially at the onset of lactation, suggests that choline may be a limiting nutrient for milk production for high-yielding dairy cows.

Need for choline during transition phase: In early lactation adipose tissue lipolysis causes release of nonesterified fatty acids (NEFA) into blood. These NEFA need to be managed effectively during transition phase as otherwise they may become reason behind fatty liver and ketosis influencing liver health. Fatty liver is the metabolic dysfunction which affects around 50 per cent of animals during transition phase. It is characterized by deposition of fats in liver leading to hepatocyte dysfunction thereby affecting capacity of liver to ureagenesis and gluconeogenesis eventually leading to ketosis, depression in feed intake and milk production. The condition may be prevented by two approaches:

– Decrease in the supply of NEFA to liver through diet and feeding management

– Optimization of capacity of liver to utilize NEFA either as fuel or exporting them to mammary gland as VLDL

Choline plays an essential role in fat metabolism in the liver. It can positively increase the utilization of fatty acids in the liver, promote the transport of fatty acids as lecithin (phosphotidyl choline), influence the synthesis of the components of VLDL to increase their secretion from liver or the metabolism of ketones by peripheral tissues and prevents abnormal accumulation of fat hence avoid fatty liver. Due to above cited reasons choline is referred to as a "lipotropic" factor.

Pomfret *et al*. (1990) also indicated that choline deficient rats showed three-fold increases in hepatic triglyceride concentrations and reduced plasma methionine as well as phosphatidylcholine concentrations compared to rats fed a choline adequate diet. Choline status, therefore, has been suggested as a factor in alleviating the severity and incidence of fatty liver in the transition dairy cow.

Recepients for choline supplementation: Maximum positive response to feeding of choline to transition cattle will occur in animals that are at greater risk for excessive fat accumulation in liver during the transition period. This can be assessed by body condition score loss (> 0.5 units) during early lactation. Greater body condition score during the dry period leads to higher loss of body condition score during early lactation (Contreras *et al.*, 2004) and increased fat accumulation in liver (Hartwell *et al.,* 2000), thus, herds with over conditioned dry cows are the most probable responders.

MOA of choline: At calving under the influence of hormones body fat gets mobilized in the form of NEFA into the blood (Fig. 1) due to which blood NEFA concentration increases to 5-10 folds which remains high during early lactation too but to lesser extent. At the same time blood flow to the liver doubles as a cow transitions from the dry period to lactation. (The presence of NEFA in blood is a direct indicator for NEBAL, Negative Energy Balance). Subsequently leading to magnified daily fatty acid uptake by liver at calving, from around 100g/day to 1300 g/day (Reynolds *et al.*,2003). These NEFA are either esterified to triglyclycerides (TG) or partially oxidized to ketones by liver to provide energy (ATP) for liver metabolism. Ketones are released into blood and further oxidized by muscle. Alternatively, liver TG can be stored as droplets (fatty liver) or packaged into very low density lipoproteins (VLDL) and exported into blood which may further serve as milk fat precursor. Desirable fate of fatty acids entering the liver would be complete oxidation to provide energy to the liver or they may undergo reesterification and exported as triglyceride from the liver as component of a very low density lipoprotein (VLDL). Hepatic oxidation increases approximately 20 per cent during the transition period But, liver can take up NEFA in proportion to their supply and does not have sufficient capacity to utilize them completely through export into the blood or catabolism for energy (Fig.1) (Pullen *et al.*, 1990) and thus, transition cows have got tendency for accumulation of triglycerides in the liver parenchyma called as fatty liver (Emery *et al.,* 1992) this is also known as hepatic lipidosis. This accumulation leads to liver dysfunctions like decreased capacity for ureagenesis (from ammonia) and gluconeogenesis (from propionate) (Strang *et al.*, 1998). In such situation Rumen-protected choline (RPC) supplementation, can help because it is the constituent of lipoproteins responsible for hepatic lipid export (Yao and Vance, 1988).

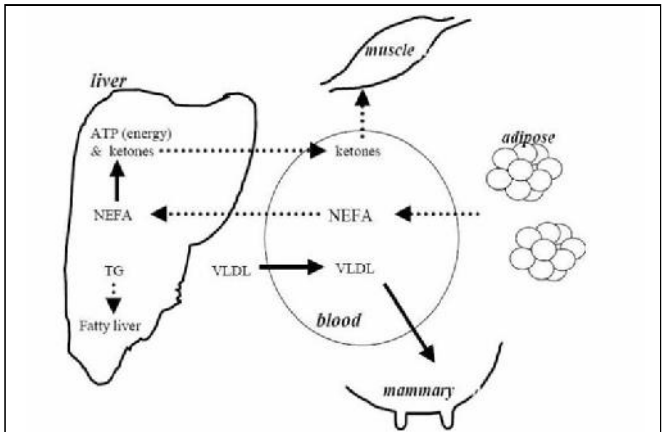

Fig. 1 : MOA of choline

Need for protection: Choline fed through feed ingredients undergoes degradation by rumen microbes. Denovo synthesis (endogenous choline synthesis) takes place which is difficult to be estimated in ruminants. Estimates of rumen degradation have ranged from 85 per cent to 99 per cent. In *in vivo* studies with dairy cows, when choline intake was increased upto 303 grams per day over controls, there was only a 1.3 gram per day increase in choline flow to the duodenum (Sharma and Erdman, 1988). Furthermore synthetic choline chloride is found to be more degradable than naturally occurring choline in the feed (Atkins *et al.*, 1988). Hence, supplementation of unprotected choline is an ineffective way to increase the choline supply and the rumen-protected form of choline is a necessity. Rumen protected choline has been developed to deliver higher quantity of choline to the small intestine for absorption (Pawar *et al.*, 2015). This way the supply of protected choline aids to increasing milk yield and milk components or alleviating development of fatty liver syndrome.

Impact of protected choline:

Impact on dry matter intake (*DMI*): Lima *et al.* (2007) reported that supplementing transition cows with rumen-protected choline improved dry matter intake, lactation and metabolism of dairy cows, but benefits were enhanced when it was fed prior to and after calving rather than only prior to calving.

Rahamani *et al.* (2014) reported that variable level of supplementation of RPC could not improve cattle's dry matter intake.

Impact on digestibility: Choline supplements increase the production of volatile fatty acid (VFA) acetate and rumen pH which increase digestibility of nutrients in rumen. Mohsen *et al*. (2011) studied the digestibility co-efficient in Friesian cows supplemented with RPC and reported increased DM, organic matter, crude protein, crude fibre, ether extract and nitrogen free extract digestibility significantly. This might be because RPC enhances the protozoal population in the rumen.

Impact on milk yield : Supplementation of RPC increases the milk production because of its characteristic to improve digestibility, increase total VFA concentration, decrease NH3-N and prevention of metabolic disorders such as ketosis and fatty liver syndrome (Mohsen *et al.,* 2011). Choline administration increased milk production and concentration of choline in milk during the first month of lactation but had no effect on fat or protein concentrations in milk, plasma levels of glucose, beta-hydroxybutyrate, cholesterol and non-esterified fatty acids (NEFA). However, around parturition, NEFA concentrations in plasma were lower in treated animals than in controls, suggesting improved lipid metabolism as a result of choline supplementation (Pinotti *et al.,* 2003) however, Rahamani *et al.* (2014) reported that RPC supplementation into the diets of early lactating dairy cows did not affect milk yield.

Impact on milk composition: Choline is essential lipotropic agent and prevents and corrects excessive fat deposition in the liver. Increase level of milk protein by supplementation of choline due to elevated casein contents. Supplementation of Choline facilitates phospholipid synthesis thereby enhancing lipid absorption and transport to the mammary gland, thereby favouring milk fat synthesis. Hence, supplementation of RPC significantly increases the milk fat yield, milk protein, lactose, solids not fat (SNF) and total solids (Garg *et al.,* 2012). However, Rahamani *et al.* (2014) could not observe any such significant effect in RPC-supplemented cows compared with control.

Impact of choline on health and body weight: Bindel *et al.* (2000) reported that RPC supplements can cause weight gain in heifers. Lima *et al.* (2012) observed reduced incidences of clinical ketosis, mastitis and morbidity when feeding RPC from 25 days prepartum to 80 days postpartum. however, Rahamani *et al.* (2014) reported that RPC supplementation into the diets of early lactating dairy cows did not affect body condition score and body weight.

Rate of feeding of RPC: No requirements for choline have been established in ruminants except for milk-fed calves, where 260 mg of choline per liter of synthetic milk prevented choline deficiency signs. As per NRC (1989) recommendations calves' milk replacer should have 0.26 per cent choline. For adults the recommendations for supplementation of choline have been mostly the addition of 15 g/d of choline in the form of choline chloride.

References:

Atkins, K.B., Erdman, R.A. and Vandersall, J.H. (1988). Dietary choline effects on milk yield and duodenal choline flow in dairy cattle. *J. Dairy Sci.,* **71**: 109-116.

Baldi, A. and Pinotti, L. (2006). Choline metabolism in high-producing dairy cows: Metabolic and nutritional basis. *Can. J. Anim. Sci.,* **86** : 207–212.

Best, C.H. and Huntsman, M.E. (1932). The effects of the components of lecithine upon deposition of fat in the liver. *J. Physiol.,* **10** : 405-412.

Bindel, D.J., Drouillard, J.S., Titgemeyer, E.C., Wessels, R.H. and Loest, C.A. (2000). Effects of ruminally protected choline and dietary fat on performance and blood metabolites of finishing heifers. *J. Anim. Sci.,* **78**(10): 2497-2503.

Contreras, L. L., Ryan,C. M. and Overton, T. R. (2004). Effects of dry cow grouping strategy and body condition score on performance and health of transition dairy cows. *J. Dairy Sci.,* **87** : 517-523.

Emery, R. S., Liesman, J. S. and Herdt, T. H. (1992). Metabolism of long-chain fatty acids by ruminant liver. *J. Nutr.,* **122** : 832-837.

Erdman, R.A. (1992). Vitamins. In: *Large dairy herd management* (H.H. Van Horn, C.J. Wilcox (eds.), American Dairy Science Association, Savoy, IL, 297-308pp.

Garg, M.R., Bhanderi, B.M. and Sherasia, P.L. (2012). Effect of supplementing bypass fat with rumen protected choline chloride on milk yield, milk composition and metabolic profile in crossbred cows. *Indian J. Dairy Sci.,* **65** (4): 319-323.

Hartwell, J. R., Cecava, M. J. and Donkin, S. S. (2000). Impact of dietary rumen undegradable protein and rumen-protected choline on intake, peripartum liver triacylglyceride, plasma metabolites and milk production in transition dairy cows. *J. Dairy Sci.,* **83** : 2907-2917.

Lima, F. S., Sa Filho, M. F., Greco, L. F., Susca, F., Magalhaes,V. M. and Santos, J. E. P. (2007). Effects of feeding rumen-protected choline on metabolism and lactation. *J. Dairy Sci*., **90** (Suppl. 1):174

Lima, F.S., Sa Filho, M.F., Creco,L. F. and Santos, J. E. P. (2012). Effects of feeding rumen-protected choline on incidence of diseases and reproduction in dairy cows. *Vet J.*, **193**(1):140-145.

Mohsen, M.K., Gaafar, H.M.A., Khalafalla, M.M., Shitta, A.A. and Yousif, A.M. (2011). Effect of rumen protected choline supplementation on digestibility, rumen activity and milk yield in lactating Friesian cows. *Slovak J.Anim. Sci.*, **44**(1): 13-20.

NRC (2001). *Nutrient requirements for dairy cattle*. 7th Revised Ed. National Academy Press, Washingdon, D.C., U.S.A.

Pawar, S.P., Kewalramani, N., Thakur, S.S. and Kaur, J. (2015). Effect of dietary rumen protected choline supplementation on milk choline content in crossbred cows. *Indian J. Anim. Nutr*., **32** (1): 30-35.

Pinotti, L., Baldi, A., Politis, I., Rebucci, R., Sangalli, L. and Dell Orto, V. (2003). Rumen-protected choline administration to transition cows: Effects on milk production and vitamin E status. *J. Vet. Med. A.*, **50** : 18-21.

Pomfret, E.A., DaCosta, K. and Ziesel, S.H. (1990). Effects of choline deficiency and meth-otrexate treatment upon rat liver. *J. Nutr.Biochem*., **1**:533-541.

Pullen, D. L., Liesman, J. S. and Emery, R. S. (1990). A species comparison of liver slice synthesis and secretion of tyriacylglycerol from nonesterified fatty acids in media. *J. Anim. Sci*., **68** : 1395-1399.

Rahamani, M., Dehghan-Banadaky, M. and Kamalyan, R. (2014). Effects of feeding rumen protected choline and Vitamin E on milk yield, milk composition, dry matter intake, body condition score and body weight in early lactating dairy cows. *Iran. J Appl. Anim. Sci.*, **4** (4): 693-698.

Reynolds, C. K., Aikman, P. C. Lupoli, B. Humphries, D. J. and Beaver, D. E. (2003). Splanchnic metabolism of dairy cows during the transition from late gestation through early lactation. *J. Dairy Sci.*,**86** : 1201-1217.

Sharma, B. K. and Erdman, R. A. (1988). Effect of high amounts of dietary choline supplementation on duodenal flow and production responses of dairy cows. *J. Dairy Sci.*,**71** : 2670-2676.

Strang, B. D., Bertics,S. J. Grummer, R. R. and Armentano, L. E. (1998a). Effect of long-chain fatty acids on triglyceride accumulation, gluconeogenesis, and ureagenesis in bovine hepatocytes. *J. Dairy Sci.*, **81**:728–739.

Yao, Z.M. and Vance, D.E. (1988). The active synthesis of phosphatidylcholine is required for very low density lipoprotein secretion from rat hepatocytes. *J. Biol. Chem*., **263**:2998–3004.

Received : *02.02.2019* ***Revised :*** *09.04.2019* ***Accepted :*** *23.04.2019*