Effects of Dietary Rumen-Protected Choline Supplementation on Colostrum Yields, Quality, and Choline Metabolites from Dairy Cattle

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Abstract. Choline is a kind of important and necessary nutrient for many animal species, which is always supplemented in the diet in order to support the postpartum health and production performance of periparturient dairy cows. Although choline and its metabolites have been characterized in milk, the effects of dietary rumen-protected choline (RPC) supplementation on choline metabolites in colostrum haven't been explored. Recently, the effects and dose of dietary RPC supplementation on colostrum yields, quality and choline metabolites have been explored. Cows with three different doses of choline ions indicated that adding dietary choline can increase the amount of colostrum without affecting the quality of colostrum. In addition, dietary choline supplementation increased phosphocholine concentrations from cows calving for the second time. However, it had no effect on phosphocholine concentrations in colostrum from older cows, which suggested that there may be parity preference for choline metabolic pathways. Finally, dietary choline supplementation increased trimethylamine N-oxide concentrations.

Keywords: Choline; colostrum; cow; supplementation.

1. Introduction

The term "choline" was created by Adolph Strecker to describe the compound he isolated from pig bile. Choline is a kind of micronutrient commonly grouped with B vitamins, which is essential in growth and development of life. Choline-containing biomolecules or derivatives play an essential role in various biological processes including neurotransmission, lipid metabolism, signaling and so on.

Choline is a trimethylated, positively charged, nitrogen-containing molecule. Its chemical formula is $(CH_3)_3N+CH_2CH_2OH$. Choline is stable to heat in acidic solution, absorbs carbon dioxide in air. Choline is soluble in water and alcohol. It decomposes in case of heat and has a bitter taste.

Choline, as free choline or a choline-containing biomolecule, exists in a wide range of food. Generally, animal source foods provide more choline per gram of food than plant source foods. Choline in the body is obtained either through food such as liver and eggs, or by endogenous synthesis of phosphatidylcholine. The deficiency of choline causes lower circulating concentrations of free choline and phosphatidylcholine, fatty liver, lymphocyte apoptosis and increased DNA damage. Among the symptoms of choline deficiency, fatty liver is the most common manifestation.

2.1. Two pathways for phosphatidylcholine synthesis

Phosphatidylcholine (PC) is the major lipid-soluble choline-containing biomolecule. There are two pathways for phosphatidylcholine synthesis: (1) CDP-choline pathway; (2) PEMT synthesis pathway.

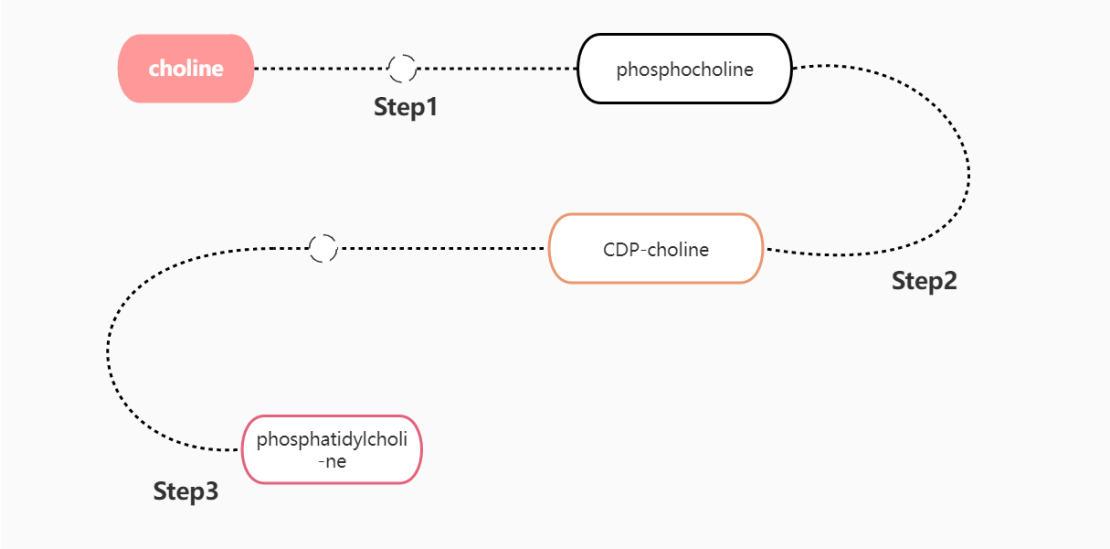


Fig.1 CDP-pathway: CDP-choline pathway, also known as the Kennedy pathway, which is present in all cell types with a nucleus.

Fig.1 CDP-pathway: CDP-choline pathway, also known as the Kennedy pathway, which is present in all cell types with a nucleus. The process of phosphatidylcholine synthesis via the CDP-choline pathway has three steps. Firstly, choline is phosphorylated to phosphocholine under the role of choline kinase. In the next step (rate-limiting step), phosphocholine cytidylyltransferase catalyzes the transfer of a cytidylyl group and produce CDP-choline. The third step is the transfer of the phosphocholine group of CDP-choline, producing phosphatidylcholine finally.

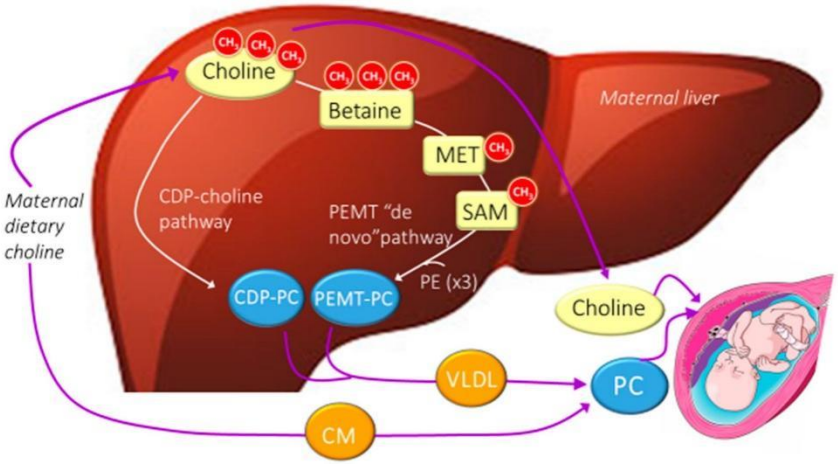


Fig.2 PC can also be produced by methylating phosphatidylethanolamine in PEMT pathway. (Korsmo et al., 2019)

Fig.2 PC can also be produced by methylating phosphatidylethanolamine in PEMT pathway. In the first step in the PEMT pathway, choline is converted irreversibly to betaine via the choline dehydrogenase. Next step is methylating homocysteine to methionine. Then methionine can be converted to S-adenosylmethionine under the role of methionine adenosyl transferase. Finally, S-Adenosylmethionine donates methyl groups to phosphatidylethanolamine and synthesize PC.

2.2. Dietary rumen-protected choline and colostrum from dairy cattle

Colostrum is the first milk expressed in very late pregnancy and after birth, which is the secretion a cow produces after mammary involution that is rich in various nutrients. It is important to protect newborn against disease as high in antibodies and other components. In addition to the nutritive value for newborn calves, immunoglobulins are of interest due to their role in developing the immune system of calves at birth (Lopez and Heinrichs, 2022). Colostrum acts as a critical nutrient source for newborn calves to provide passive immunity through the absorption of immunoglobulin across the

gut. According to the result from a research, a third of beef calves fail to achieve adequate transfer of passive immunity (**TPI**) through timely ingestion of colostrum, which significantly rises their risk of preweaning morbidity and mortality. (Gamsjäger et al., 2021). Therefore, taking in high-quality colostrum shortly after birth is critical for the transfer of passive immunity (**TPI**) in calves. (Weaver et al., 2000; Lombard et al., 2020). However, there are few research on the effects of RPC on colostrum.

In a recent experiment, scientists restricted the supplement with propylene glycol, monensin sodium and rumen-protected choline chloride in periparturient Ghezel ewes. The implications on production and performance of them and their offspring were recorded. During the final trimester of pregnancy, 48 ewes were randomly assigned to one of 6 kinds of treatments. This experimental results showed that although feed restriction lowered their production and offspring performance, simultaneous addition of propylene glycol, monensin sodium and rumen-protected choline chloride in restricted diets relieved those negative effects and the production of milk and offspring growth performance were noticeably improved. (Ahmadzadeh-Gavahan and Hosseinkhani, 2022).

According to a recent analysis, dietary RPC supplementation during the peripartum time can increase milk yield by almost 2 kg/d. (Arshad et al., 2020). Although it is well established that dietary choline supplementation enhances milk yield of postpartum dairy cows, the knowledge of its effect on colostrum is limited and even less is known about dose responses of RPC. Therefore, the objective of this research is to assess the effects of dietary supplementation and the dose of RPC on colostrum yields, quality, and choline metabolites from dairy cattle.

2. Methods & Results

To begin with, researchers hypothesized that the addition of dietary RPC would enhance colostrum yields and quality and increase the concentrations of choline metabolites. Cows were blocked according to their expected calving months and randomly assigned within block to receive 1 of 3 treatments. The total numbers of cows was 67. Besides, cows without functional mammary quarters were not enrolled. Dietary treatments were divided into three types: 45 g/d of RPC (CHOL45), 30 g/d of RPC (CHOL30), or no RPC (CON). The 30 and 45 g/d doses provided 13.6 and 20.4 g/d of choline ions respectively.

The RPC was mixed with ground corn and topdressed for a total weight of 150 g/d. Cows in the control group received 150 g/d of ground corn without containing RPC. It should be mentioned that the RPC supplement used in this research consisted of a choline chloride core and a lipid coating. According to Atkins and Deuchler et al.(Sales et al., 2010), "extensive degradation of unprotected dietary choline by rumen bacteria necessitates the use of rumen-protected supplements containing choline chloride, which subsequently allow the release and absorption of choline in the small intestine".

Colostrum was harvested and weighted within 6 hours. Finally, 6 samples were not collected, so the final total sample number was 61. Then two aliquots of colostrum were collected per cow.

The results showed that the yields of colostrum and component were affected. CHOL45 and CHOL30 cows produced 2.5 and 2.9 kg more colostrum than the control group respectively. Although the treatment influenced colostrum yields, it did not affect colostrum quality.

As for the colostrum fat, protein, lactose**,** no effect of treatment was found. Specifically, CHOL30 cows produced more colostrum fat, protein, and lactose yields than the CON; CHOL45 group produced more colostrum protein**,** whereas no difference was found in lactose or fat yields when compared with the CON.

In addition, of all choline metabolites detected, GPC was found in the greatest quantity in colostrum followed by SM, PCho, PC, betaine, and choline. TMAO were found in relatively small quantities, but acetylcholine and lysophosphatidylcholine were not detected.

What is more, researchers also found that PCho concentration depends on parity. The research result showed that coloctrum from second-parity cows receiving either 45 or 30 g of RPC had greater

PCho concentration than that from the control group. But no treatment effect was found in 3+ parity cows.

This study showed that dietary RPC supplementation can enhance colostrum yields and increase the concentrations and yields of certain choline metabolites with no effect on its quality. Moreover, no differences were found in colostrum from CHOL30 group as compared with CHOL45 group. In other words, the research data showed that dietary RPC addition has a significant effect on colostrum yields and choline metabolites, but the effect was small due to dose.

3. Conclusion

To sum up, firstly, the study proved that dietary RPC supplementation enhanced colostrum yields without affecting colostrum quality. Secondly, dietary RPC supplementation increased PCho concentrations in second-parity cows, but not for 3+ parity cows. Therefore, the study suggests that there may be parity preferences for choline metabolic pathways. Finally, researchers found that dietary RPC supplementation can enhance trimethylamine N-oxide (TMAO) concentrations in colostrum. TMAO is a kind of choline metabolite. Those findings and results can contribute to the development and further research of dairy production industry.

For future development, this research paper pointed out that future studies should focus on how altering the concentrations of choline metabolites in colostrum may influence the health and performance of periparturient dairy cows and newborn calves.(Swartz et al., 2022).

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