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AN IMPORTANCE OF CHOLINE CHLORIDE FOR POULTRY AND CATTLE: AN OVERVIEW

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Abstract: Choline chloride properties and physiological and metabolic functions were discussed. Requirement, role and effect of supplementation of choline chloride in poultry and cattle discussed with insight in degradation and protected choline chloride supplementation in cattle.

INTRODUCTION

Theodore Gobley, working in Paris in 1850 described a substance 'lecithine' after the Greek word "lekithos" means from egg yolk. Adolph Strecker in 1862 heated lecithine from bile, which generated a new nitrogenous chemical termed "choline". Oscar Liebreich identified a new substance from brain named "neurine". Neurine and choline were recognized to be same molecule and named adopted as "Choline", whereas lecithine identified as phosphatidylcholine.

Choline, is a water soluble colorless compound with vitamin-like properties as not a metabolic catalyst but forms an essential structural component of body tissues (McDonald *et al*., 2011). Choline is ubiquitously distributed in all plant and animal cells, mostly in the form of the phospholipids, phosphatidylcholine (lecithin), lysophosphatidylcholine, choline plasmalogens and sphingomyelin - essential components of all membranes (Zeisel, 1990).Choline degrades in hot alkali creating trimethylamine. Choline has ability to form salts with many organic and inorganic acids. It is well soluble in water and ethanol, but not in ether. Choline is chemically a strong alkali and hygroscopic nature. Choline is amino ethyl alcohol and have three methyl groups on the nitrogen atom, chemically termed as (2-Hydroxyethyl) trimethylammonium. Chemical formula of choline is $C_5H_{14}NO^+$ and of choline chloride is ($HOCH_2CH_2N$ $(CH_3)3HCl$). Cholinechloride have 139.63 g/mole molecular weight, 247^0c melting point, decompose on heating, 1.1 g/cm³ relative density at 20 °C (70% choline chloride in water) and practically stable at 20-30^0C.

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(https://ec.europa.eu/health/ph_risk/committees/04_sccp/docs/sccp_o_132.pdf, Dt.15.5.17).

Choline is present in the unsupplemented diet mainly in the form of lecithin, with less than 10% present either as the free base or as sphingomyelin. Choline is released from lecithin and sphingomyelin by digestive enzymes of the gastrointestinal tract, although 50% of ingested lecithin enters the thoracic duct intact (Chan, 1991). Both pancreatic secretions and intestinal mucosal cells contain enzymes capable of hydrolyzing lecithin in the diet. Within the gut mucosal cell, phospholipase A1 cleaves the alpha-fatty acid, and phospholipase B cleaves both fatty acids. Quantitatively, digestion by pancreatic lipase is the most important process (Zeisel, 1990).

Functions of choline chloride are 1. building and maintaining cell structures, 2. fat metabolism of the liver, 3. formation of acetylcholine (essential) and 4. methyl-group donor (non-essential) via betaine (Zeisel, 2006; Garrow, 2007; Rajalekshmy, 2010; Leeson and Summers, 2001).

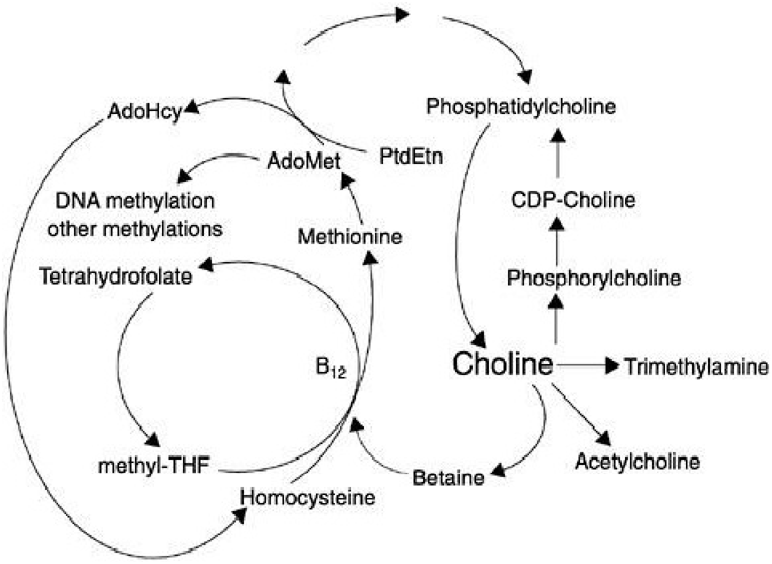
1. Choline is a metabolic essential for building and maintaining cell structure. Choline is a structural part of lecithin (phosphatidylcholine), certain plasmalogens and the sphingomyelins. Lecithin is a part of animal cell membranes and lipid transport moieties in cell plasma membranes. Phospholipids are present in the cell membrane bilayers, and the primary function of these phospholipids are to regulate cell membrane integrity and porosity. Choline is required as a constituent of the phospholipids needed for normal maturation of the cartilage matrix of the bone.

2. Choline is referred to as a “lipotropic” factor due to its function of acting on fat metabolism by hastening removal or decreasing deposition of fat in liver. Choline plays an essential role in fat metabolism in the liver. It prevents abnormal accumulation of fat (fatty livers) by promoting its transport as lipoprotein and lecithin or by increasing the utilization of fatty acids in the liver.

3. Choline is essential for the synthesis of acetylcholine by mitochondriaat the presynaptic terminal of the neural synapse, a substance that makes possible the transmission of nerve impulses.

4. Choline is a source of labile methyl groups. Choline furnishes labile methyl groups for formation of methionine from homocystine (Figure) and of creatine from guanidoacetic acid. The pathways of choline and 1-carbon metabolism intersect at the formation of methionine from homocysteine. Methionine is regenerated from homocysteine in a reaction catalyzed by betaine: homocysteinemethyl transferase, in which betaine, a metabolite of choline, serves as

the methyl donor (Finkelstein *et al*., 1982). To be a source of methyl groups, choline must be converted to betaine, which has been shown to perform methylation functions. Since choline contains biologically active methyl groups, methionine can partly be spared by choline and homocysteine. Research with lactating dairy cattle suggests that a high proportion of dietary methionine is used for choline synthesis (Erdman and Sharma, 1991; Benoit *et al*., 2010). The amino acid methionine is the source of the methyl donor S-adenosyl methionine, the metabolite that provides methyl groups in a variety of reactions including the *de novo* synthesis of choline from phosphatidylethanolamine. When choline is oxidized irreversibly to betaine, betaine can provide methyl groups that recycle homocysteine to methionine.



(Figure; Zeisel and Blusztajn, 1994)

CHOLINE IN POULTRY

The young chicken needs choline more due to inability to synthesize at sufficient rate. Female are less susceptible to choline deficiency, without exact clear mechanism. Egg contains 12-13 mg choline per gram dried whole egg mass. The bird needs 20,00-30,00 mgcholine /kg diet to induce toxicity (Leeson and Summers, 2001). White egg laying strain needs 1300, 900 and 500 mg choline/kg diet during 0-6, 6-12 week of age and 12 week to age at first egg, respectively and broiler needs 1300, 1000 and 750 mg/kg diet during 0-3, 3-6 and 6-8 week of age, respectively (NRC, 1994). Choline supplementation improves egg production in layer bird (Rajalekshmy, 2010), whereas weight gain (Igwe *et al*., 2015), feed conversion efficiency (Hossain, *et al*., 2014; Igwe *et al*., 2015) and decrease serum cholesterol (Rahman, 2005) in broiler. The supplementation of choline chloride at recommended rate is optimum for various production parameters. The supplementation of choline chloride @ 2000 mg/kg diet improved weight gain and feed conversion efficiency in quail (Alagawany *et al*., 2015). Symptoms of choline deficiency include reduced growth, fatty infiltration of liver andperosis in chicks (McDonald, 2011).

CHOLINE IN DAIRY CATTLE AND BUFFALOES

High degree of metabolic priority and flow of nutrients accorded to fetus and mammary tissues during late gestation and early lactation leads to hepatic lipidosis and ketosis. These hepatic lipidosis and ketosis compromise production, immune function, and fertility (Hayirli, 2006). Choline is lipotropic factor, transport fat from liver and improves production. The earliest investigations with unprotected choline (Erdman *et al*., 1984; Atkins *et al*., 1988; Sharma & Erdman, 1988a), reveal neither milk production nor milk composition was improved may be due to rapid choline degradation in the rumen (Atkins *et al.*, 1988; Sharma and Erdman, 1988a, NRC, 2001). The synthetic choline chloride was more degradable in rumen than natural form occurring in feed (Atkins *et al*., 1988) as 23 to 326 g/d intake of choline chloride, only raised duodenal choline flow from 1.2 to 2.5 g/day (Sharma & Erdman,1988b). *In vitro* rumen degradable of choline was 80-90% for common feedstuffs and supplements (Sharma and Erdman, 1989). The supplemental choline as staerate and chloride salt degrade to 98.0 % and more in rumen (Erdman and Sharma, 1991). Studies conducted in different lines of normal cattle, varying management systems and in different countries indicate that 50 to 60% of transitional cows experience moderate to severe fatty liver (Bobe *et al.*, 2004) as dry matter intake decrease and nutrients requirement for milk production increase dramatically leading fat catabolism. Rumen protected choline chloride improves milk yield, fat and reproductive parameters; reduces serum non-esterified fatty acids in transitional periods in cows (Jayaprakash *et al*., 2016). Indian experiment indicates fortification of rumen protected choline chloride @ 15 and 10 g/day in bypass fat supplemented diet improves milk yield, milk fat and reduction in non-esterified fatty acids and cholesterol in blood serum of Jaffarabadi buffaloes (Garg *et al.,* 2012a) and in crossbred cows (Garg *et al.,* 2012b), respectively.

SUMMARY

Choline chloride supplementation required for normal functioning, growth, production and feed efficiency in poultry and rumen protected choline improves milk yield and milk fat and reduce blood serum non-esterified fatty acids and cholesterol in dairy cattle and buffaloes. More research needed to arrive at optimum dose rate in dairy cattle.

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