

Choline and Betaine for Animal Nutrition

Introduction

Choline, a water soluble compound with vitamin-like properties, is widely distributed in feedstuffs as all natural fats contain choline. Choline serves a number of critical functions in the body (Combs, 2008). *It:*

1. Builds and maintains cell structure
2. Improves fat metabolism in the liver
3. Supports nervous system function and brain development
4. Serves as a source of methyl donors for methionine formation, an essential amino acid
5. Serves as a source of osmolytes that regulate cell volume

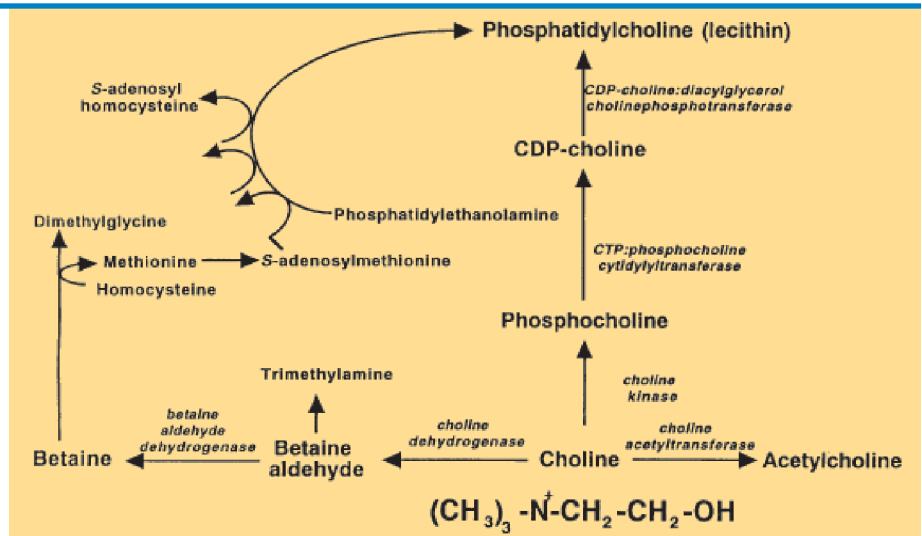
Betaine is a compound that is directly related to choline. During choline's oxidation, betaine is the first product formed and acts as a methyl donor and osmolyte in the body. Typically feeds contain less betaine than choline. Wheat and sugar beets, however, are exceptions as both are rich in betaine.

Metabolism of Choline and Betaine

The metabolic needs for choline can be supplied in two ways: through the diet and by choline synthesis in the body. In the case of the growing chick, an absolute requirement for dietary choline does exist as choline cannot be synthesized until about 13 weeks of age.

In many situations when the diet does not supply sufficient choline, the animal is able to utilize methionine to produce choline; however, dietary choline is required for optimal growth. When choline is supplemented, it is used first for essential functions. The body does not store choline so the remainder is oxidized to betaine (*Figure 1*). Therefore all choline in the body is metabolized and used in biochemical pathways. The oxidation of choline is an energy yielding process and one of the major sources of methyl groups to support the synthesis of methionine in the animal (Garrow, 2007).

Figure 1. Choline metabolism in the body (adapted from Canty and Zeisel, 1994).



Chemical Equivalence of Choline and Betaine

Both choline and betaine have three methyl groups. Their potential as methyl donors for methionine formation can be calculated based on their molecular weights. The molecular weight of choline, choline chloride (CC) and betaine are 104.2, 139.6 and 117.2, respectively (Table 1). This means that with each unit of CC 100% and betaine 100% supplemented 74.6% and 88.9% of choline is supplied respectively. Conversely, 1.34 and 1.12 times more CC and betaine must be supplemented respectively to provide the same level of choline. Accounting for differences in the level of choline and betaine in commercial products, a feeding rate of 0.75 units of CC 75% is equivalent to 1 unit of betaine 47% as methyl donors (Table 1).

Comparing Broiler Growth When Feeding Choline and Betaine

Many research trials have shown that betaine cannot fully replace choline in the diet of broilers. However as betaine can occupy only two of choline's functions (see Introduction), the efficacy of both compounds can be compared when sufficient baseline choline exists in the diet to meet the animal's essential needs. This was tested elegantly in a recent study by Dilger et al (2007) in which the control ration for young broilers contained no available choline and was supplemented with betaine and graded levels of choline. When supplementing betaine (1000 ppm), the authors found that broiler growth was maximized if the diet contained 412 ppm choline. In contrast, when no betaine was supplemented broiler growth was maximized if the diet contained 712 ppm choline alone. Therefore, 1000 ppm betaine spared only 310 ppm of added choline. This is a significant observation. It indicates that supplemental choline was 3.2 times more effective than supplemental betaine at increasing chick growth.

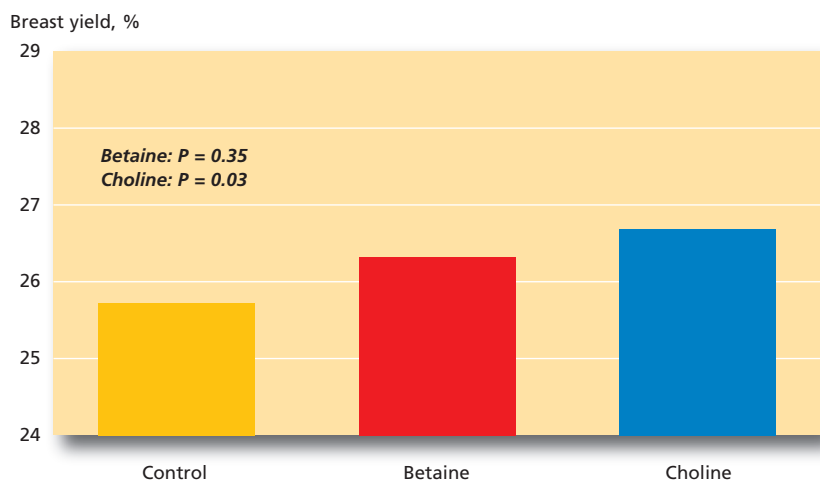
Table 1. Comparison of choline, choline chloride (CC) and betaine based on molecular weight. The value of CC (either as 70, 75 or 100%) or betaine (either as 47 or 100%) in products relative to choline and the multiplication factor to compare equivalence of products is indicated.

	MW	% Choline	Factor
Choline	104.2	100.0	1.00
CC 100%	139.6	74.6	1.34
CC 75%	139.6	56.0	1.79
CC 70%	139.6	52.2	1.91
Betaine 100%	117.2	88.9	1.12
Betaine 47%	117.2	41.8	2.39
CC 100% / Betaine 100%			1.19
CC 75% / Betaine 100%			1.59
CC 75% / Betaine 47%			0.75

Comparing Breast Meat Yield When Feeding Choline and Betaine

Two published studies directly compared the effect of choline and betaine on breast meat yield of broilers (Waldroup et al, 2005, 2006). The studies supplemented 1000 ppm of choline or betaine to diets formulated to the standards of five top U.S. broiler companies and found that choline and betaine improved breast meat yield. However, only choline alone was found to increase breast meat yield in both studies, with the greatest improvements (averaged 4.3%) seen in broilers that were harvested at less than 50 days of age (Figure 2).

Figure 2. Effect of choline and betaine on breast yield at 42 days of age (adapted from Waldroup et al, 2005).



Summary

Choline has an essential function in all animals. Dietary choline is required for optimal growth. Choline cannot be stored in the body so choline in excess of essential needs is oxidized to betaine. The equivalence of choline and betaine as methyl donors for methionine synthesis can be easily calculated based on their respective molecular weights because they share the same number of methyl groups. Finally recent research indicates that choline is more efficient at maximizing broiler growth and more consistent at improving breast meat yield than betaine.

References available upon request.