Betaine Concentration of Common Foods in the US.

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Abstract
Betaine, a choline derivative, is produced in the human body from choline and contributes methyl groups for the conversion of homocysteine to methionine. Elevated levels of plasma homocysteine can be harmful to blood vessels leading to the development of heart disease, stroke, and peripheral vascular disease. Our objective is to develop the first comprehensive database determining the amount of betaine concentration in a nationally representative sample of common foods consumed in the United States. Various food items were obtained from 12 – 24 retail outlets using the sampling plan developed for the USDA’s National Food and Nutrition Analysis Program. Pesticide residue, storage conditions, and freezing and thawing were monitored during sample processing and analysis using standardized procedures. The results showed that the foods analyzed, wheat bran and wheat germ have the highest concentration of betaine (>1gm/100g). Baked products (33 – 226 mg/100g), spinach, beets, crustaceans and finfish are also good sources of betaine. Meats, poultry, fruits, nuts, and wine are generally not good sources of betaine (<6 mg/100g).

Introduction
Betaine has also been studied in clinical trials in the treatment of alcohol-related diseases. The primary stage of alcoholic liver damage is the accumulation of fat in the liver. Betaine, because of its lipotropic effects, has been shown to produce significant improvements in this condition by assisting the liver in processing fats (lipids). Betaine has also been found to protect the liver against hepatotoxins such as ethanol and carbon tetrachloride. Thus, betaine has both lipotropic and hepatoprotective activity in humans (Vos et al, 1999).

Betaine, a choline derivative also known as trimethyglycine, is produced in the human body from choline and the amino acid glycine. As with folic acid, vitamin B6 and vitamin B12, betaine may function as a one-carbon donor and as a co-factor in the proper metabolism of folate, homocysteine, and other nutrients. Betaine is a methyl donor in the transmethylation metabolic pathways and is essential in the methylation of homocysteine to methionine. Betaine is also a methyl donor for the synthesis of SAM, which is involved in the synthesis of polyamines, DNA, RNA, coenzymes, and phospholipids. Betaine also assists the liver to process lipids and protect against chemical damage. The results showed that of the foods analyzed, wheat bran and wheat germ have the highest concentration of betaine (>1gm/100g). Baked products (33 – 226 mg/100g), spinach, beets, crustaceans and finfish are also good sources of betaine. Meats, poultry, fruits, nuts, and wine are generally not good sources of betaine (<6 mg/100g). Since, baked products like bread, crackers, cookies and tortillas are also consumed in large quantities they are major contributors to betaine intake in the US diet.

Method
•Samples of two hundred forty one food items of various types were obtained from 12-24 retail outlets in accordance with the nationwide sampling plan developed for the National Food and Nutrient Analysis Program (Pehrsson, P, et al, 2000).
•The sampling plan was based on a self-weighting stratified design. First, the US was divided into four regions, then each region was further divided into three implicit strata from which generalizing Consolidated Metropolitan Statistical (gCMSAs) areas were selected (Fig. 2). Specific brands of samples were selected based on current market share (amount consumed) and prepared for analysis of betaine concentration.
•Approximately 15% of the analyses were based on samples picked up locally (Chapel Hill, NC). Various cooking methods were used as appropriate. Packaged foods were prepared according to package directions.
•Products were analyzed as purchased or after cooking using liquid chromatography – electrospray ionization - isotopoe dilution mass spectrometry method (Zeisel et al, 2003).
•Quality assurance was monitored through the use of duplicate sampling, in-house control materials; Standard Reference materials for betaine are not available (Fig. 3).

Results
•Of the two hundred and forty one foods analyzed betaine concentration was the highest in wheat and wheat products (>1 gm/100g) (Fig: 4).
•Dry spaghetti, pretzels, cheese crackers, whole wheat bread, and oatmeal are good sources of betaine (>6 mg/100g) (Fig: 5).
•Beer, iced tea and ground beef are low to moderate sources of betaine (<6 mg/100g) (Fig: 5).
•Food categories like meats, dairy, fruits and beverages are low in betaine concentration (Fig: 5)
•Based on consumption data, all purpose flour, wheat products, beer, iced tea and ground beef are consumed in large quantities making them key foods for betaine contribution in the US diet (Fig: 6).

Conclusion
•Analytical data on the betaine content of foods is presently very limited. The establishment of a betaine database would provide researchers, consumers, nutrition professionals and government agencies the necessary information for assessing betaine intake in the US diet.
•In order to determine the dietary intake of betaine in the US population, nutrient concentration alone is not sufficient. Due to their extremely high consumption levels, foods relatively low in betaine, such as beer, iced tea and ground beef, become major betaine contributors in the US diet as is evidenced by the betaine key food data.

References
Abman SH, Verhoeof P, Phipps D, P Palmer, and A. Gilsanz. (2016). Cardiac phenotype in infants tightly interacts with betaine and folate in the formation of homocysteine (methionine -> homocysteine). Deficiency of betaine causes hyperhomocysteinemia (homocysteine -> methionine) -> remethylation homocysteine and increase folate requirements. Deficiency of folic acid increases the need for betaine for methylation of homocysteine. Therefore, adequate availability of betaine in the diet can serve to spare excess folate for methionine formation (Zielinski et al, 2001; Nicholas Mills, Zielinski, 2002).

Figure 1: Metabolic Pathway for homocysteine / methionine pathway. Research has shown that transmthylation metabolic pathways intersect with betaine and folate at the formation of methionine (methyl group) from homocysteine (Hcy). DEFiciency of betaine causes hyperhomocysteinemia (methionine -> homocysteine) - THF to remethylate homocysteine and increase folate requirements. Similarly, deficiency of folic acid increases the need for betaine for methylation of homocysteine. Therefore, adequate availability of betaine in the diet can serve to spare excess folate for methionine formation (Zielinski et al, 2001; Nicholas Mills, Zielinski, 2002).

Figure 2. Nationwide consumption of betaine. Data on betaine key food contributors of betaine intake in the US diet based on a sample size of one hundred eighty nine time foods.

Figure 3: Quality Assurance was monitored through the use of duplicate sampling, in-house control materials; Standard Reference materials for betaine are not available (Fig. 3).

Figure 4. Betaine concentration for the top ten food items analyzed. Total sample size two hundred forty one food items. Column height represents the concentration of betaine in each food.