# Nutritive and Non-nutritive Sweeteners

## NNNS: Aspartame, Methanol and Formaldehyde Relationships (2011)

### Relationship Between Aspartame, Methanol and Formaldehyde Explained

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Aspartame is a dipeptide molecule produced by joining phenylalanine and aspartic acid. Aspartame itself does not occur naturally but is a manufactured substance. When aspartame is consumed, it is completely broken down by the enzymes in the digestive system (esterases and peptidases) into the two amino acids and a type of alcohol called methanol. The amounts of these are much less than found in foods. For example, a serving of non-fat milk provides about six to nine times more phenylalanine and 13 times more aspartic acid than the same amount of beverage sweetened with aspartame. A serving of tomato juice provides about four to six times more methanol than the same amount of aspartame-sweetened beverage.

The scientific literature clearly confirms that aspartame *never* enters the bloodstream as aspartame, because it is so rapidly broken down to its constituent parts. Therefore, studies where aspartame is directly injected into the body or added to cells grown in a dish cannot be used to assess safety for humans. This also explains why aspartame does not and cannot possibly cross into the fetus during pregnancy or into breast milk and studies show that amounts normally consumed in the diet are safe during pregnancy and lactation.

It is important to understand that the human body is well-equipped to use small amounts of methanol produced from foods and beverages, as well as from aspartame. The metabolic pathway is well-understood and well-documented in the scientific literature. First, the methanol from the intestinal tract goes to the liver via portal blood, where the liver enzyme alcohol dehydrogenase converts methanol into formaldehyde. The body very rapidly uses formaldehyde and so formaldehyde never builds up in the body. If the body doesn't need it, formaldehyde is converted to formic acid within seconds. The formic acid will be either excreted in the urine or broken down to carbon dioxide and water.

The fact that methanol and formaldehyde are breakdown products of aspartame sounds scary to consumers. Therefore, it is important to know that formaldehyde is produced by our bodies every day in amounts thousands of times greater than you would ever get from aspartame, as it is a key metabolite that is needed to make other essential compounds, including DNA. Also, the known toxic effects of methanol relate not to formaldehyde, but to the build-up of formic acid in the blood. The breakdown of formic acid is slower than the breakdown of formaldehyde, so if there is a very large dose of methanol (or formaldehyde) coming into the body, formic acid can build up and that causes the adverse effects seen in methanol poisoning.

To put *this* into perspective, studies in healthy adults and infants consuming up to 200mg per kg of body weight (50 times the amounts Americans consume on average), showed no change in the levels of formic acid in the blood ( [1,2]).

One claim on the Internet that also is worthy of explanation is that "fruit and vegetables contain ethanol as well as methanol, therefore they are safe and aspartame is not."

The problem with many of the "aspartame toxin" stories is that they contain just enough science to make them sound plausible. Unless one understands the science, it is hard to figure out what is right. The short reply to this allegation is that it doesn't make any difference if there is ethanol in fruits and vegetables or in aspartame-sweetened products, because none provide enough methanol to cause toxicity.

The following rationale, based on scientific studies, explains why the presence of ethanol is inconsequential in a discussion of dietary methanol. Adverse effects from methanol occur when the amount that is consumed exceeds the body's ability to metabolize it completely to carbon dioxide and water. As discussed above, the first step in the metabolism of methanol is completed by the liver enzyme alcohol dehydrogenase, which converts methanol to formaldehyde. If the body doesn't need formaldehyde to synthesize other compounds, it converts formaldehyde to formic acid. If this occurs faster than the body can break down formic acid, it can build up and cause methanol poisoning.

This possible scenario was taken into consideration when the safety of aspartame was being assessed. Many studies were carried out to see whether consumption of aspartame would affect blood methanol, formaldehyde or formic acid levels ( [1-3]). Adults that consumed up to 200mg per kg (the average American daily consumption is five mg per kg) had a small increase in blood methanol (100 times lower than the amount needed to cause methanol poisoning) and no change in formic acid levels (there is always a small amount in blood). Formaldehyde was not detected in the subjects' blood. Studies in infants and children show the same thing. In one study, adults were given 10mg per kg (about double the daily amount) every hour for six hours. Individuals were monitored and there was no change in blood methanol or any other metabolites. The bottom line is that the amount of aspartame in diet sodas or foods produces so little methanol that there is no chance that it could cause a build-up of formic acid and cause adverse effects.

How does ethanol fit into this? Ethanol is metabolized by the same enzyme as methanol. So when someone comes into the emergency room with methanol poisoning (high blood methanol, high blood formic acid), the way to stop further production of the formic acid is to give ethanol, as the enzyme will preferentially metabolize it, and leave the methanol. This gives the body time to break down the formic acid before more is produced.

Therefore, the argument that the ethanol protects against methanol poisoning is correct. However, this fact applies only in cases of actual methanol poisoning and has absolutely nothing to do with dietary sources of methanol. In the case of consuming aspartame (as with fruit and vegetable drinks or other sources of methanol), the levels are so low that it makes absolutely no difference whether ethanol is present or not.


1. Stegink LD, Brummel MC, McMartin K, Martin-Amat G, Filer LJ Jr., Baker GL, Tephly TR (1981). Blood methanol concentrations in normal adult subjects administered abuse doses of aspartame. *Journal of Toxicology and Environmental Health* 7: 281- 290.
2. Stegink LD, Brummel MC, Filer LJ Jr., Baker GL. (1983). Blood methanol concentrations in one-year-old infants administered graded doses of aspartame. *Journal of Nutrition* 113: 1,600-1,606.
3. Stegink LD, Filer LJ Jr., Bell EF, Ziegler EE, and Tephly TR (1989). Effect of repeated

ingestion of aspartame-sweetened beverage on plasma amino acid, blood methanol, and blood formate concentrations in normal adults. *Metabolism* 38: 357-363.