

Aspartame: Sweet Or Bitter

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Abstract

Aspartame a non-saccharide sweetener has been surrounded with controversy for a long time. This review was to enlighten the public on its safety or otherwise. Several publications on aspartame and its metabolites were reviewed. Adverse effects of aspartame as reported were mostly on animal studies and in humans with certain dysfunction. Normal individuals were not affected though. These lead me to cautiously state that aspartame may be safe after all.

INTRODUCTION

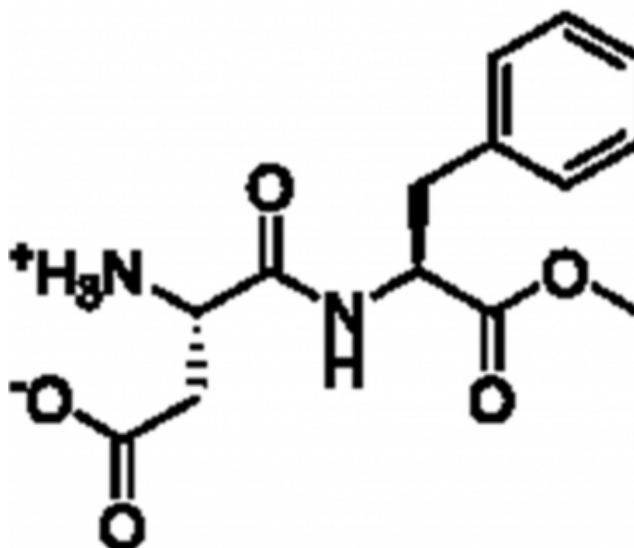
Have you been using Equal, NutraSweet, Spoonful or Canderl? Do they really taste sweet? Are there really worth the patronage? Next time when you want to use them, try and take a look at their contents because you may not need them after all. The above-named products are few brand names for aspartame.

Aspartame (APT) is an artificial sweetener present in most diet drinks or soda and in other diet products, while some are sold alone in brands as mentioned earlier. It is a non saccharide alternative of sugar used by people including diabetics, and it is about 180 times sweeter than sugar in typical concentration with the energy value of sugar. It has caloric value of 4kilocalories or 17kilojoules per gram₁₂.

APT is a methyl ester of the di-peptide of the amino acid, aspartic acid and phenylalanine with IUPAC name: N-(L-Aspartyl)-L-phenylalanine, 1 methyl ester and molecular formula: $C_{14}H_{18}N_2O_5$. It has a molar mass of 294.3gmol with a melting point of 246-247°C and decomposes into its metabolites on boiling₃.

Figure 1

Figure 1: Chemical structure of aspartame



At room temperature, APT is stable at pH 4.3 where its half-life is approximately 300 days. At pH of 7, its half-life is only a few days. Under strongly acidic or alkaline conditions, APT may generate methanol by hydrolysis, with the peptide bonds being hydrolyzed into free amino acids under severe conditions₃₄.

BACKGROUND

Like most food taken into the body, aspartame (APT) is metabolized into its constituents: aspartic acid (ASP), phenylalanine (PHE) and methanol. These are further broken down into formaldehyde, formic acid and dikeptopiperazine₅₆. ASP and PHE are not harmful per se, because both are amino acids useful in the body of every individual, but methanol is₇₈.

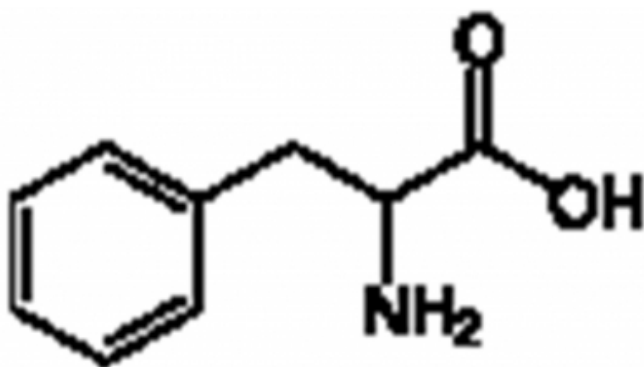
PHENYLALANINE (PHE)

PHE is an essential amino acid present in breast milk and this is very important to young children. It is also found in other protein-rich foods such as eggs, beef, pork, fish, cheese as well as leafy vegetables and whole grains. PHE comprises about 50% of APT⁸⁹¹⁰.

PHE is ketogenic and glucogenic, and serves in the synthesis of other tissue proteins. It is hydroxylated to tyrosine which serves as a precursor for epinephrine and nor epinephrine synthesis. Chemically it exists in three forms: L-Phenylalanine which is natural occurring; D-Phenylalanine is a mirror image of L-Phenylalanine and is artificially synthesized; DL-Phenylalanine is a combination of the two forms¹¹.

Figure 2

Figure 2: Chemical structure of phenylalanine



The D-Phenylalanine has been reported to help reduce chronic pain associated with certain health conditions by stimulating nerve pathways in the brain that control pain. It has also been reported to improve rigidity, walking, disabilities, speech difficulties and depression with Parkinson's disease. In combination with ultraviolet radiation, its improve vitiligo¹¹.

D-Phenylalanine undergoes bacterial breakdown in the intestine by bacterial enzymes and forms phenyl acetic acid, a toxin¹¹. In individuals who suffer from phenylketonuria, APT is contraindicated as it contains PHE. Inability of these individuals to metabolize PHE results in its build up in the blood forming phenyl pyruvic acid which may lead to array of side effects including mental retardation, loss of pigmentation in skin, hair and eye¹¹. PHE is metabolized into diketopiperazine, which has been implicated in brain tumor in animal experiment¹³¹⁴.

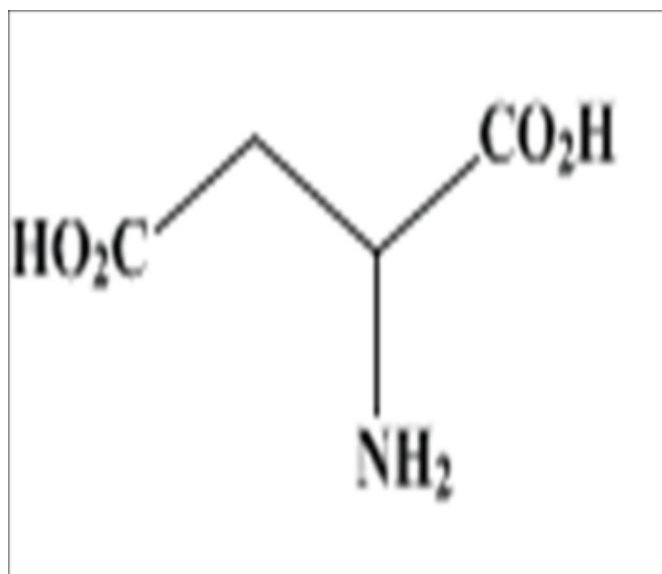
ASPARTIC ACID (ASP)

ASP is a non-essential amino acid that can be produced by our body. It comprises about 40% of APT. It is found in the brain, sprouting seeds, flakes, sausage meat, wild game, asparagus etc¹⁰¹⁵.

ASP functions as neurotransmitter in the brain and helps improve the function of the immune system. It also plays a crucial role in generating cellular energy where it is easily converted to glucose when the demand for glucose exceeds supply. The L-aspartic acid helps promote a robust metabolism and is sometimes used to treat fatigue and depression, while too much of it in the brain produces free radicals¹⁰. D-aspartic acid increases thymus weight, depressed ventilation in males and females and helps regulate local testosterone production[[[16,17.18]]].

Figure 4

Figure 4: Chemical structure of methanol



METHANOL

Methanol also called wood alcohol comprises about 10% of APT. It is a deadly poison liberated from APT at temperature in excess of 30°C. It has a low excretion, hence build up within the body. Its adverse effects include vision disorders, headache, tinnitus, dizziness, nausea, gastric and behavioral disturbances, numbness etc. Methanol is further metabolized to formaldehyde, another toxic product. This is in turn metabolized into formic acid which is also toxic¹⁰.

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DISCUSSION

Aspartame is metabolized into PHE, ASP and methanol⁵⁶. Adverse effects of PHE, ASP and methanol arise when the

normal plasma or general body levels are altered.²⁰²¹²² The amino acids become toxic because their increased levels are not compensated by other amino acids necessary for the normal functioning of the body.⁸ Koeppe et al.²¹ reported that a balance in protein diet does not cause changes in brain amino acid uptake. The quantity and form of APT ingested usually determines the plasma levels of its metabolites.²⁰²³

Another metabolite of APT, methanol has been implicated in the accumulation of aspartate, an excitotoxic amino acid affecting the optic nerve which may likely result in blindness.²⁴ Earlier reports have it that humans and other primates are not susceptible to excitotoxins as rodents and therefore the basis of comparison may be problematic.²⁵²⁶

Reports also have it that about 10% by mass of APT is broken down into methanol in the small intestine and most of the methanol are absorbed and converted to formaldehyde and subsequently formic acid.⁵²⁷ The accumulation of formaldehyde and formic acid in blood leads to blood acidosis.²⁸ Reports have it that the quantity of methanol produced is too small to disrupt normal physiological processes.²⁹³⁰

There have been different reports of severe adverse effects of APT.²²²²⁴³¹³²³³ some of these effects were reversed after stoppage of APT use or after adequate proteins were added to the diets of the individuals. Their reported effects include; multipotent carcinogenic properties, optic nerve damage, epileptic seizures, and other neurologic dysfunction, blindness and other ocular defects, tinnitus and other hearing defects, palpitations, tachycardia, nausea, diarrhea, skin allergies and endocrine and metabolic dysfunction and swelling at joints.

These reactions reported mimic, trigger or cause such diseases as chronic fatigue syndrome, Epstein-Barr, epilepsy, multiple sclerosis (MS), systemic lupus (ML), attention deficit disorder (ADD), lymphoma, Grave's disease, Marnier's disease etc.²

These results have caused agitations for the restriction and even ban of APT in the market and the resultant heated debates in different cycles.³⁴³⁵ Last year a bill was even sponsored with the aim of banning APT use.³⁶

Proponents of the safety of APT have reported significant testing associated to National and International Health Organizations. Reviewed articles have shown that some human and animal studies have revealed no adverse effects

of APT.¹³⁰³⁷³⁸³⁹⁴⁰⁴¹ Speirs et al.³⁷ reported that large daily intake of APT had no effect on neuropsychologic, neurophysiologic, or behavioral functioning in healthy young adults. Others reported that changes in plasma amino acids and brain serotonin produced by APT are insufficient to cause brain functional deficit.³⁸

Roman et al.³⁹ reported no significant modification of mono amine levels in rats administered doses of APT, while Schiffman et al.⁴⁰ stated that APT may cause headache but this is not different from any other normal cause of headache. Another report states that APT is beneficial in preventing destruction of brain tissue.⁴² Even with increased brain tumor rate which some has ascribed to APT use.⁴³⁴⁴ Gallus et al.⁴⁵ stated that no such association existed between APT, saccharin and other sweeteners in several common neoplasms.

CONCLUSION

Aspartame (APT) is an artificial sweetener and a source of PHE, ASP and methanol. The harmful effects ascribed to its consumption are usually seen in individuals with metabolic, neurologic, endocrine or genetic dysfunction. Apparent normal individuals with reports of adverse effect may have underlying disorders that may not have been diagnose or that the quantity ingested is far too large that the presence of other amino acids cannot modulate them and the excretion rate is not as fast. Thus the safety of APT especially in normal/healthy individuals has been supported with this review. Though safe, the continuous use of APT as sweetener should be done with caution especially by the individuals who may be sure of their health status.

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