The Safety of Aspartame

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Abstract

Aspartame is one of the most extensively tested food additives, yet public confusion remains about its safety. With an increase in sedentary lifestyles and rising obesity rates, a need exists to reduce the population's caloric intake. One way to accomplish this is by reducing sugar intake in food products by substituting sugar with a non-caloric sweetener such as aspartame. Aspartame is approximately 180 times sweeter than sucrose. Upon ingestion, it is metabolized into three molecules – aspartic acid, phenylalanine and methanol. Health Canada claims that there is no evidence that the consumption of aspartame, along with a healthy diet, poses a health risk to consumers. One can consume up to 40 mg/kg per day over the course of a lifetime without any risk. This is approximately 16 cans (351 mL each) of a diet soft drink per day for a 70kg (154 lb) individual. No scientific evidence exists to suggest that aspartame causes brain tumours, brain damage, multiple sclerosis, or any other pathological conditions. An instance where aspartame would need to be avoided altogether is in the case of a rare condition called phenylketonuria. It has been proposed that aspartame can increase appetite and preference for sweet tastes and thus, can contribute to increases in caloric intake and the prevalence of obesity, but there have been no studies conducted to support this claim. Ultimately, Health Canada, the Joint Expert Committee on Food Additives, and the World Health Organization have proved aspartame safe for human consumption.

Keywords: aspartame, artificial sweeteners, nutritive sweeteners, food additives

Introduction

In Canada, the majority of the population spends their time engaging in sedentary activities (Colley et al., 2011). At the same time, there has been an increase in easier access to palatable and energy-dense foods (Stanner, 2010). This strikes a need to consume fewer calories on a daily basis. One approach to reduce overall caloric intake is to consume fewer free sugars. Intense low-calorie sweeteners are available as a means to reduce intake of added sugar (Stanner, 2010). Other benefits of consuming low-calorie sweeteners are to reduce tooth decay and to assist in the management of diabetes mellitus (Kroger, Meister, & Kava, 2006). The low-calorie sweeteners that are approved for use in Canada are acesulfame-K, cyclamate, sugar alcohols, saccharin, sucralose, steviol glycosides, and aspartame. Aspartame is found in many prepared foods including carbonated and powdered soft drinks, confections, gelatins, dessert mixes, puddings and fillings, frozen desserts, yogurt, table-top sweetener, and some medications such as vitamins and sugar-free cough drops (Whitehouse, Boullata, & McCauley, 2008). Confusing media headlines about the effects and safety of sweeteners, especially aspartame, are common, and many writers and websites having described artificial sweeteners as 'dangerous additives' and 'poisons.' Many health professionals and consumers are unsure about aspartame and its safety (Stanner, 2010). The aim of this paper is to examine the safety of aspartame in foods and common misconceptions

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that health professionals and consumers may have regarding the consumption of aspartame.

Aspartame is a low nutrient sweetener produced by combining the amino acids phenylalanine and aspartic acid (O'Donnell, 2012). It was discovered in 1965 by James Schattler who worked for G.D. Searle and was then rigorously tested for safety before it first appeared in the US market in 1981 under the brand name NutraSweet. Aspartame was officially the first commercially available non-carbohydrate nutritive sweetener (Newberne & Conner, 1986). The brand was heavily promoted and contributed to the commercial success of aspartame as a sucrose replacement in the 1980s and 1990s (O'Donnell, 2012). In 1996, it was approved as a general-purpose sweetener in all foods and drinks (Whitehouse et al., 2008). Today, aspartame is widely used because it has a taste very close to that of sucrose. Many consumers today have made claims that the consumption of aspartame is related to weight gain, increased appetite and hunger, and a variety of neurological and behaviour problems such as seizures and hyperactivity. However, most of these claims have been made based on misconceptions found in the lay-media and have not been supported by scientific evidence (Kroger et al., 2006).

Synthesis, Sensory, and Physiochemical Properties

Production of aspartame uses the two amino acids L-phenylalanine and aspartic acid, which can both be chemically synthesized. The two amino acids are coupled together either chemically or enzymatically and their reactive groups are removed, and a series of crystallization steps removes impurities (O'Donnell, 2012).

Aspartame is known to have a 'clean sweet taste' and has approximately 180 times the sweetness of sucrose, making aspartame one of the best sucrose substitutes due to its similar sensory profiles (Swiader, Waszkiewicz-Robak, Swiderski, & Kostyra, 2009). Aspartame is frequently blended with acesulfame-K or saccharin and this can produce sweetness intensity synergy, meaning the total sweetness will be greater than expected from the chemical components. Additionally, aspartame-acesulfame salt is available in an alternate form where the two molecules are linked through an ionic bond. This provides the advantage of dissolving more quickly than aspartame and has benefits for stability in applications such as chewing gum (O'Donnell, 2012).

Aspartame is a white, odourless crystalline substance that is colourless when dissolved and is regarded as an ecologically safe and biodegradable non-regulated material. Dry aspartame is stable for more than five years, but it is less stable in liquid systems. This is primarily a function of pH, temperature, and time. In a liquid system, it is most stable in the pH range of 3 to 5, with an optimum pH of 4.2. This is why many diet soft drinks will decrease in sweetness over an extended period of time (O'Donnell, 2012).

Safety and Toxicity

Very few food additives have been subject to as much testing and scrutiny as aspartame – it may be one of the most rigorously tested food additives to date. Not only has aspartame undergone extensive testing, but its breakdown products have also gone through extensive testing to validate its safety (O'Donnell, 2012). This should provide additional confidence in the safety of aspartame for the public (Newberne & Conner, 1986).

According to Health Canada (2005), food additives such as aspartame are subjected to rigorous controls under the Food and Drugs Act and Regulations. Manufacturers must file a food additive submission in accordance with section B.16.002 of the Regulations before any food additive is permitted for use. This submission includes results of safety tests, detailed information, and potential benefits of the additive to the consumer. Health Canada states that there is no evidence to suggest that the consumption of foods containing aspartame, in accordance with the Food and Drug Regulations and as part of a well-balanced diet, would pose a risk to consumers. Additionally, the Scientific Committee for Food of the European Community and the Joint Expert Committee on Food Additives (JECFA) of the United Nations Food and Agriculture Organization (FAO) and World Health Organization (WHO) have thoroughly reviewed all available studies of the safety of aspartame and have found it to be safe (Health Canada, 2005).

The acceptable daily intake (ADI) is defined as the estimated amount that one can safely consume on average every day over a lifetime without any risk (Kroger et al., 2006). The Food Directorate of Health Canada established the ADI of aspartame to be 40 mg per kg of body weight per day. The ADI established by JECFA and the WHO is also 40 mg/kg and this is acknowledged internationally. Furthermore, studies done on actual consumption rates in Canada show that intakes of aspartame are well below the ADI, including the warmest months of the year when soft drink consumption is expected to be highest (Health Canada, 2005).

According to the Materials Safety Data Sheet for NutraSweet (2007), a brand that produces aspartame, the oral LD50 in rats is greater than 5000 mg/kg. Ultimately, aspartame would be regarded as toxic upon the ingestion of hundreds of grams. Inhalation exposure in rhesus monkeys at concentrations of 16 mg/m3 for six hours per day, for six

consecutive months, did not produce any consistent treatment related effects (NutraSweet, 2007). Although aspartame can be toxic at a certain level, it must be noted that even substances such as salt can be toxic when they are administered in inappropriate amounts (Stegink & Filer, 1984). Extensive research also suggests that aspartame is not cytotoxic (Humphries, Pretorius, & Naude, 2008).

Commercial products that contain aspartame must bear a label stating that the product should not be used in cooking or baking. Many consumers perceive this as a health warning, when in actuality its purpose is to inform individuals that aspartame does not maintain its sweetness at high temperatures (Kroger et al., 2006).

Metabolism

When aspartame is ingested it is broken down in the digestive tract into ordinary food components (Kroger et al., 2006). It is hydrolyzed in the intestinal lumen to aspartic acid, phenylalanine, and methanol by proteolytic and hydrolytic enzymes (Newberne & Conner, 1986). Aspartic acid, which makes up approximately 40% of the molecule, is an amino acid that is involved in nitrogen and energy metabolism in the mitochondria. Phenylalanine, which makes up approximately 50% of the molecule, is an essential amino acid, which means that the body cannot synthesize it and must obtain it from the diet for normal growth and maintenance (O'Donnell, 2012). These breakdown products are then absorbed from the lumen into the blood in the same way as other amino acids. Alternatively, aspartame can be absorbed directly into mucosal cells by peptide transport mechanisms and hydrolyzed within the cell to aspartic acid, phenylalanine and methanol. Upon ingestion of any amount, the three breakdown products are released into the portal blood and then metabolized or excreted (Newberne & Conner, 1986).

Toxicity of Methanol in Aspartame

Methanol, the third component of aspartame, is a potentially harmful metabolite. Toxic levels of methanol are in the range of 200 to 500 mg/kg of body weight. A 330 mL can of soft drink sweetened with 550 mg/L of aspartame theoretically generates 18.3 mg of methanol, approximately 0.26 mg/kg in a 70 kg (154 lb) person. To compare, a 220 mL glass of tomato juice generates approximately 47 mg of methanol or 0.67 mg/kg body weight in a 70 kg individual. This demonstrates that a glass of tomato juice generates more methanol than a can of an aspartame-sweetened soft drink, and that both are well below the toxic level. The methanol produced from aspartame is excreted from the body in the same way as methanol produced from other sources such as bananas or tomato juice (O'Donnell, 2012).

When healthy adults were administered aspartame up to 100 mg/kg of body weight (60 mg/kg above the ADI of 40mg/kg), their blood methanol concentrations returned to preloading values eight hours after administration. For a 70 kg individual, this equals approximately 39 cans of sweetened soft drink, where each can contains approximately 180 mg of aspartame (Newberne & Conner, 1986). Many studies have shown that even at abuse levels, the methanol concentrations produced by aspartame consumption are barely measurable and insignificant, posing no health risk (O'Donnell, 2012).

Common Misconceptions

Breakdown of Aspartame in Food Products

When aspartame is stored for long periods of time or exposed to high temperatures, it has a tendency to breakdown (Kroger et al., 2006). The products formed by the decomposition of aspartame are methanol and aspartyl-phenylalanine, which is further hydrolyzed to the amino acids aspartic acid and phenylalanine. Aspartyl-phenylalanine is tasteless, so products that have been sweetened with aspartame and stored for a long period of time will lose their sweetness as aspartyl-phenylalanine is formed. It is therefore recommended to consume aspartame-sweetened soft drinks within the specified number of years. At a pH of 5 and above, aspartame may cyclise to form diketopiperazine with the elimination of methanol (O'Donnell, 2012). Diketopiperazine is a carcinogen that is not well absorbed by the body and is readily excreted (Clarke, 2000; Ishii, Koshimizu, Usami, & Fujimoto, 1981). This compound is only found when aspartame storage conditions are not ideal, such as when the pH is above 5 (Clarke, 2000). Soft drinks are generally acidic with a pH lower than 4 (Jain, Nihill, Sobkowski, & Agustin, 2007).

Brain Damage Due to Phenylalanine

The statement, 'contains phenylalanine,' found on aspartame-sweetened beverages has been known to cause undue concern among consumers. Some individuals believe phenylalanine is an inherently dangerous substance rather than a normal component of proteins. Another misconception is the belief that the metabolic disorder known as phenylketonuria (PKU), affecting 1 in 15000 people, is a condition that an individual can have without knowledge (Kroger et al., 2006). Phenylketonuria results from a hereditary deficiency or lack of phenylalanine hydroxylase. In a normal individual, this enzyme converts phenylalanine to tyrosine, which can then be metabolized. In an individual that has PKU, the deficiency of this enzyme leads to elevated levels of phenylalanine in tissues, which

causes brain damage and mental retardation. Treatment for children born with PKU requires a life-long, strictly controlled diet that restricts phenylalanine intake to prevent elevated levels of phenylalanine in the blood. Because of this, it is a requirement in many markets for products containing aspartame to state on the packaging that the product contains phenylalanine (O'Donnell, 2012).

Influence on Brain Tumours, Multiple Sclerosis, and Pathological Conditions

Although aspartame's metabolites are common to those produced by other dietary foods and are similarly metabolized and excreted, there have been a number of reports linking aspartame to adverse effects. These allegations included neurotoxic effects, cancer, and epilepsy. However, they were based on unreliable reports and poorly controlled studies, and gained publicity via the lay-media (O'Donnell, 2012).

Health Canada (2005) recognizes, but does not support, the allegation that methanol in aspartame is toxic and is linked to numerous health problems including lupus, blindness, and multiple sclerosis because methanol is not foreign to the human diet. The pectin in many common foods, including fruits, vegetables, and their juices, contains low levels of methanol and substances that are metabolized to methanol. As mentioned previously, one cup of tomato juice contains approximately six times the amount of methanol as one cup of an aspartame-sweetened soft drink. The Multiple Sclerosis Society of Canada has also stated that there has been no published peer-reviewed evidence suggesting a link between aspartame and multiple sclerosis (MS) or that an MS epidemic exists (Health Canada, 2005). As well, scientists worldwide have conducted a review of studies determining the safety of aspartame and have found no link between aspartame consumption and the incidence of brain tumours or cancer (Health Canada, 2005).

Aspartame and Increased Appetite

There is a plethora of reasons why we choose the foods we eat and enjoy including taste, access, convenience, cost, and health. However, the most important factor is taste. We have an innate and strong preference for sweet tastes, which are associated with nutritional value and calories, whereas bitterness is associated with poisons and toxins (Stanner, 2010). Sweet foods are frequently energy dense and by using sweeteners, individuals can enjoy sweet taste without adding to caloric intake. Since using artificial sweeteners does not affect the energy or nutrient content of foods, no effect on satiety would be expected compared to foods with free sugars. More recent studies have suggested that there is a moderate decrease in energy intake in subjects consuming foods that contain intense sweeteners compared with regular products sweetened with sucrose. There are not currently any studies that suggest that consuming products containing sweeteners might encourage a craving for sweet foods (Stanner, 2010). Meta-analyses show that using foods and drinks sweetened with aspartame instead of sucrose results in a significant reduction in energy intakes and body weight (De La Hunty, Gibson, & Ashwell, 2006). Furthermore, statistics show that consumers have not replaced sugar in soft drinks with sugar from other sources. In this way, aspartame may prevent increased consumption of other sweets. This means aspartame can be regarded as a valuable tool in weight control (Drewnowski, 1995).

Further Research Considerations

Although aspartame is among the most tested food additives, there is still need for further research. More research is needed to determine if drinks and food have different effects on reducing caloric intake and ultimately body fat, as liquids may not regulate appetite as efficiently. Also, although overall evidence suggests that intense sweeteners can contribute to weight control, more randomized controlled trials are required (Stanner, 2010). Lastly, there seem to be only a minimal number of studies claiming that aspartame can cause serious pathologies such as cancer. The studies conducted by the Ramazzini Institute of Bologna in 2005 - 2006 on the carcinogenic effects of aspartame in rats were criticized by the European Food Safety Authority (EFSA) as they were poorly conducted (e.g. using old age rats that were not free of pathogens) (Stanner, 2010).

Conclusion

The Internet and media are mediums for speculation and false claims about food additives, regardless of scientific background. The exposure of society to the negative connotations of aspartame has resulted in uncertainty by many consumers and healthcare professionals. However, more than thirty years of safety and toxicity testing suggests that aspartame is safe for consumption. Aspartame is metabolized in the body and its components are utilized as amino acids or excreted as methanol. The WHO and the JECFA have extensively studied and analyzed all evidence on aspartame to date, and found that there is no reason for the public to be concerned about the consumption of aspartame. There is no body of evidence stating that aspartame causes brain damage, brain tumours, multiple sclerosis, or other pathological conditions to an otherwise healthy individual. Lastly, it has not been demonstrated that aspartame will increase appetite or a preference for sweet tastes. Ultimately, studies suggest

that aspartame is safe for human consumption within the acceptable daily intake range of 40 mg/kg.

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