Reflections on Higher Chemistry Education

----Study based on the aspartame carcinogenicity controversy

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Abstract: In this paper, we begin with a review of animal and human experiments on the carcinogenicity of aspartame, and then draw out the "seemingly contradictory" conclusions of two internationally renowned organizations, in order to arrive at a unanimous conclusion on the carcinogenicity of aspartame. Secondly, with the analysis of the in vivo reaction of aspartame, we analyze the criteria of the International Agency for Research on Cancer (IARC) for classifying the carcinogenicity grade of substances in order to dispel people's meaningless fears. Thirdly, based on the discussion of the carcinogenicity of aspartame, we reflect on the current problems in higher chemistry education. Finally, we will give rational advice on how to deal with aspartame in light of the lack of empirical studies.

Keywords: Aspartame; carcinogenicity; Carcinogenicity rating scale; Higher chemical education

1. Introduction

On June 29, 2023, the International Agency for Research on Cancer (IARC) evaluated the potential carcinogenicity of aspartame (identification of carcinogenic hazards), and aspartame is once again in the "spotlight" of food additives. As early as 1981 when aspartame entered the market, the controversy surrounding it is continuous. What is aspartame? Is it really carcinogenic?

Following the International Agency for Research on Cancer (IARC) assessment, the Joint FAO/WHO Expert Committee on Food Additives (JECFA) will update its aspartame risk assessment, including a revision of the Acceptable Daily Intake (ADI) and an assessment of aspartame-related dietary exposures.[1] . In fact, long before this fiasco, there was a proliferation of papers analyzing the carcinogenicity of aspartame, with heated arguments for and against, for example, aspartame's adverse effects on blood cells, the brain, the liver, the kidneys, the nervous system, and so on[2] . But on the other side, for example, the European Food Safety Authority re-examined critically all existing scientific research on the safety of aspartame in animal and human trials, and the agency's experts ruled out the potential risk of aspartame causing genetic damage and cancer. The report states that a safe intake dose of aspartame for the general population is no more than 40 mg per kilogram of body weight per day, but that this upper dose limit does not apply to people with phenylketonuria[3] The report states that the safe dose of aspartame for the general population is no more than 40 milligrams per kilogram of body weight per day, but this dose limit does not apply to people with phenylketonuria.

2. Discovery of aspartame and its structure

Aspartame is an artificial sweetener that is an amino acid dipeptide derivative. Aspartame entered the market in 1981 when it was officially approved by the FDA for use as a food additive, and like saccharin and sweetener, it is a product of chance. It has been reported that G . D . Searle chemist Jim Schlatter was synthesizing a tetrapeptide, a molecule containing four amino acids, to test drugs for stomach ulcers. Schlatter inadvertently got a small amount of the dipeptide intermediate aspartyl-phenylalanine methyl ester on his hands. Later, he unknowingly licked his fingers before picking up a piece of paper, and a sweet flavor bloomed on his taste buds. At first he thought it was a donut he had eaten before the experiment, but suddenly remembered that he had already washed his hands prior to the experiment. Thus, like Falberg and Sveda, Schlatter traced the sweet flavor back to his lab[4] . Aspartame is chemically known as methyl aspartyl phenylalaninate, and after it enters the body, it is broken down in the gastrointestinal tract by esterases and peptidases into phenylalanine, aspartic acid, and methanol[5] It is also known as aspartyl phenylalanine methyl ester. Its structural formula is shown in the figure.

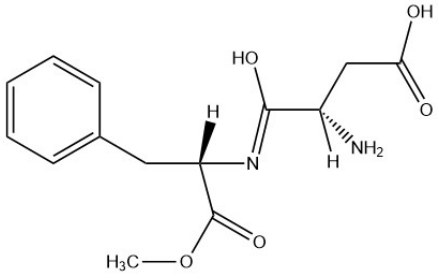

Figure 1 Chemical structure of aspartame

Aspartame is white powdery or needle crystal with hydrolysis degree of 1g/100ml (20℃). It is very stable at room temperature and weak acid environment[6] . Sweetness is 200 times that of sucrose; pure sweetness without any aftertaste; low-calorie weight loss; no need for insulin digestion, so it is suitable for obesity, diabetes and cardiovascular patients; anti-microbial, not afraid of mold, no caries; mixed with other sweeteners have a synergistic effect.[7] It has a synergistic effect when mixed with other sweeteners.

3. Aspartame in vivo reaction

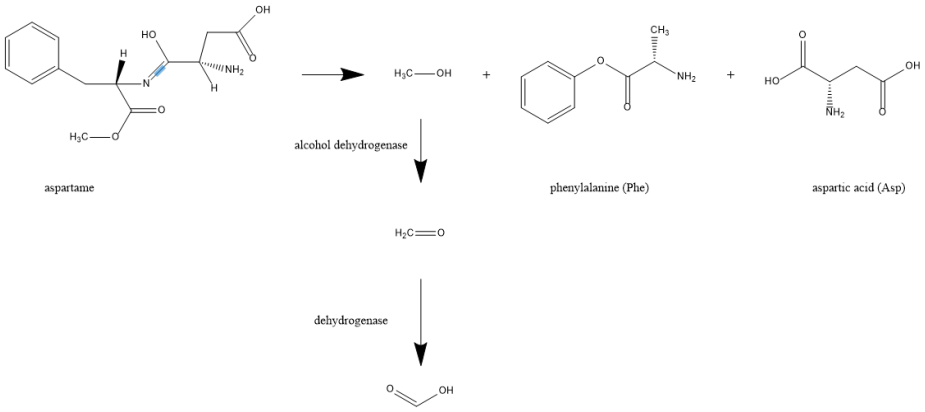

Figure 2 Reactions of aspartame in humans

As can be seen in Figure 2, aspartame undergoes the action of esterases and peptidases to produce substances such as methanol, which in turn reacts with alcohol dehydrogenase to produce formaldehyde, which is a class I carcinogen rated by WHO and the focus of many researchers' controversy over the carcinogenicity of aspartame. In addition to this, phenylalanine, as another in vivo product of aspartame, is also of concern because of its neurotoxicity[8] . Through the in vivo reaction of aspartame, we know that its breakdown products, methanol and phenylalanine, are biotoxic - further reaction of methanol produces formaldehyde, which is a class 1 carcinogen; when the concentration of phenylalanine is too high, it is difficult for other amino acids to pass through the blood-brain barrier, which affects neurotransmitter transmission.[2] . Formaldehyde may seem like strong evidence of aspartame's carcinogenicity, but the truth is that methanol from aspartame is rapidly metabolized to formaldehyde by alcohol dehydrogenase, which then oxidizes the formaldehyde to formic acid in a few minutes, and the formic acid enters the urine and is excreted, or it is further metabolized to carbon dioxide and excreted through respiration.[5] 。

4. Controversy over the carcinogenicity of aspartame

Whether aspartame is carcinogenic has been debated since its introduction. Zhang Aike objectively described domestic and international experiments on aspartame's carcinogenicity through the enumeration method, but did not reach a valid conclusion.[9] The experimental data are specific to the same experiments. The fact that the experimental data are for the same subjects, but with unrelated results, casts a veil of mystery over the carcinogenicity of aspartame. Let's try to analyze it from the perspective of official documents. There are two "contradictory" official documents about the carcinogenicity of aspartame, one is about the International Agency for Research on Cancer (IARC) classifying aspartame as a Group 2B carcinogen, and the other is about the Joint FAO/WHO Expert Committee on Food Additives (JECFA) Third As-

sessment of Aspartame reaffirming the safety of aspartame in trace amounts, and the other is about the Joint FAO/WHO Expert Committee on Food Additives (JECFA) Third Assessment of Aspartame. safety for consumption. Why did two very specialized international bodies come up with such very different results? In order to answer this question, we may need to first understand the responsibilities of these two bodies.

IARC is an agency of the World Health Organization, with offices in Lyon, France. Its main task is to study the causes of cancer, and it also carries out epidemiological surveys and research on cancer worldwide. However, it is only a purely operational technical organization and is not involved in risk management.[10] JECFA, on the other hand, is a Codex Alimentarius international organization. JECFA, on the other hand, is one of the three standing expert committees established by the Codex Alimentarius Commission in 1955, whose members are top experts in the field of food safety evaluation recommended by governments and international organizations, and are responsible for the establishment of quality standards for compounds, methods of analysis, and food safety standards, and the provision of technical advice and recommendations to the Codex Alimentarius Commission. From the point of view of the division of responsibilities of the above organizations, IARC is only a "technical party", without considering the interests of many parties involved in this substance, while JECFA is to weigh the advantages and disadvantages of many parties before coming to a conclusion, and its assessment results are the main scientific basis for the Codex Committee on Food Additives (CCFA) to develop international food additive standards. Secondly, we also need to understand the criteria of IARC classification, only by clarifying the evaluation criteria can we have a deeper understanding of the meaning of the "labels" put on the substances by the organization. IARC classifies substances in our life into four carcinogenicity classes - Class I, Class II (subdivided into A and B), Class B (subdivided into A and B) and Class B (subdivided into A, B and C). IARC classifies substances in our lives into four classes of carcinogenicity - Class I, Class II (subdivided into two categories, A and B), Class III, and Class IV.

Grade I, can be clearly recognized as carcinogenic to humans. The criteria that can be classified as Grade I are that there is clear experimental confirmation and data verification, the experiment excludes other possible factors that cause cancer, there is a direct relationship between the substance and cancer, there is a response relationship in terms of dosage, and the amount of dosage is more or less than the amount of dosage, and which kind of effect has on inducing cancer. Class IIA, likely to be carcinogenic. There is insufficient evidence of carcinogenicity in humans for these substances, but the evidence of carcinogenicity in experimental animals is conclusive. Class IIB, probably carcinogenic. There is limited evidence of carcinogenicity in humans and insufficient evidence of carcinogenicity in animals in this group. Aspartame belongs to Class IIB. Possible carcinogens in the same class as it include cell phone radiation and pickled vegetables. Class III, carcinogenicity to humans cannot be categorized. Grade IV, probably not carcinogenic to humans. To summarize in layman's terms, the substances belonging to Grade I will increase the incidence of cancer if they are eaten or contacted, for example, ethanol, as long as you drink any alcohol-containing liquor or beer, it may lead to oral cancer and esophageal cancer. Class II is divided into AB, the difference is that A is a substance with solid evidence of carcinogenicity to animals but limited evidence of carcinogenicity to humans, while B is a substance with limited evidence of carcinogenicity to both animals and humans. In general, as long as IARC classifies a substance as Class II it means that the substance has insufficient evidence of carcinogenicity to humans and may or may not be carcinogenic.

So, in fact, these two organizations are saying the same thing - both state that aspartame is safe to consume if in safe doses. Many substances can be harmful to health if people consume them unchecked, such as white sugar, lobelia, and even drinking plain water can lead to water intoxication. Max's philosophical principle mentions that one of the causes of material change is that quantitative change leads to qualitative change. Therefore, in our daily life, we do not need to be overly cautious and listen to the wind, but to eat and drink according to the international or domestic safety standards. The value of popularization of science is to dispel the public's myths and show the way. Therefore, this article suggests: still fear of aspartame crowd can choose to eat other safer natural sweeteners, such as sugar alcohols, glycosides class[5] And aspartame difficult to give up the "heavy patients" can also rest assured that there is no sufficient evidence to prove that aspartame must be carcinogenic. For enterprises can also be assured that the production, while saving for a rainy day for innovation - to create a more non-controversial, healthy sweeteners.

5. Implications of the aspartame carcinogenicity controversy for higher chemistry education

The aspartame carcinogenicity fiasco reflects not only the problems of basic chemistry education (dosage aside), but also the problems

of higher chemistry education. Higher chemical education refers to the study and training involving the chemical sciences provided in universities or other institutions of higher education, with the aim of assisting students in constructing a comprehensive understanding of the knowledge and principles of chemistry and in developing their scientific and critical thinking skills. However, many people who have received a higher chemistry education continue to unthinkingly boycott aspartame and even all sweeteners in general, lacking the necessary critical and investigative thinking. Higher chemistry education also provides opportunities for collaboration with other disciplines and fields, such as biology, physics, and engineering. It is the cross-application of chemistry and biology that has given birth to synthetic sweeteners that benefit the obese population[11] .

6. Conclusions

This article then generates significance by combing through the existing literature to draw succinct conclusions, thus helping to understand the current hot scientific issues and giving sound advice. Finally, this article also needs to make a reasonable summary of the mutually exclusive evidence that makes aspartame so complicated and dazzling - IARC and JECFA, the two international authorities on the carcinogenicity of aspartame debate to come to the same conclusion, that is, with regard to the current animal experiments, human experiments, and the study of a number of mechanisms, that are insufficient to prove the direct relationship between aspartame and carcinogenicity. With this clarification, we can treat aspartame more rationally. This article also has some limitations - it consolidates the findings of two major international organizations, but fails to make a clear judgment on whether aspartame is carcinogenic. The limited evidence from both domestic and international studies is not yet conclusive, and more experiments and longer follow-ups are needed to prove the carcinogenicity of aspartame.

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