JSIANE: Vol. 4, Issue 4, 2024, Page 99-101 ISSN (Online) 2583-2093

Journal of Science Innovations and Nature of Earth

Journal homepage : www.jsiane.com

Tartrazine-Induced Toxicity in Albino Rats: A Comprehensive Review of Biochemical and Physiological Impacts

Sonam Sagar*[1] and Jinesh Kumar[1]

[1]Department of Zoology, Agra College, Agra, Affiliated to Dr. Bhimrao Ambedkar University, Agra, Uttar Pradesh, India

Corresponding Author E-mail: Ss3238562@gmail.com

DOI: https://doi.org/10.59436/jsiane.330.2583-2093

Abstract

Tartrazine is a synthetic food dye commonly used in many foods and food products to enhance the appearance of such food products. Tartrazine toxicity results directly or indirectly from the metabolic reductive biotransformation of the azo linkage. Tartrazine's chemical characteristics, such as its stability and how it's metabolized in the liver, lead to the creation of aromatic amine metabolites that could cause tissue toxicity. Experimental studies show that exposure to tartrazine results in notable liver and kidney dysfunction, indicated by elevated serum levels of liver enzymes (ALT, AST) and kidney markers (creatinine, urea). Additionally, tartrazine triggers oxidative stress by increasing lipid peroxidation markers and reducing the activity of antioxidant enzymes, which worsens cellular damage. Neurobehavioral evaluations also suggest that tartrazine may lead to hyperactivity and anxiety-like behaviors, indicating a potential neurotoxic effect related to imbalances in neurotransmitters. Risk assessments highlight that these negative effects are dose-dependent, emphasizing the importance of continuous regulatory review and updated safety standards. Future studies should aim to clarify the molecular mechanisms behind tartrazine toxicity and investigate possible interventions to safeguard public health.

Keywords*:* Tartrazine, liver, kidney, oxidative stress, cancer

Received 07.10.2024 **Revised 02.12.2024** **Accepted 30.12.2024**

Introduction

Tartrazine (E102) is a synthetic azo dye that is commonly used in the food, pharmaceutical, and cosmetic industries because of its bright yellow color and affordability (McCann *et al*., 2007). It ranks among the most frequently consumed artificial colorants, found in drinks, candies, snacks, and processed foods. Despite its popularity, there are concerns about its potential toxic effects, especially regarding biochemical and physiological functions in mammals (Koutsogeorgopoulou *et al*., 1998). Regulatory agencies like the European Food Safety Authority (EFSA) and the U.S. Food and Drug Administration (FDA) have established acceptable daily intake (ADI) limits, but conflicting research indicates possible health risks, including liver toxicity, kidney toxicity, neurotoxicity, and changes in blood parameters (EFSA, 2009). Albino rats (*Rattus norvegicus*) are frequently used in toxicological research to assess the safety of food additives due to their physiological similarities to humans (Chung, Fulk, & Andrews, 1981). Studies have shown that exposure to tartrazine can result in oxidative stress, DNA damage, immune system dysfunction, and disruptions in endocrine function (Amin, Hameid, & Abd Elsttar, 2010). The main mechanisms involve the production of reactive oxygen species (ROS), mitochondrial dysfunction, and inflammatory responses, which could lead to long-term damage to organs (Mehedi *et al*., 2013). Additionally, behavioral studies indicate that tartrazine may be linked to hyperactivity and cognitive issues, raising concerns about its effects on the nervous system (Kamel & El-lethey, 2011). The studies included a description of the types of food additives and products containing tartrazine and focused on the effect of tartrazine on liver, kidney function, lipid profile, oxidative stress biomarkers, nervous system, hyperactivity, behavior, cancer, reproductive and developmental toxicity and some bioelement levels of tartrazine. Several studies were identified and some investigated advantage and disadvantage of tartrazine. Summary of the study provides potentially harmful effects of tartrazine on liver, renal function, lipid profiles, behavior, carcinogenicity and forthcoming research recommendation are outlined. This review gives a broad evaluation of the safety and various toxicity effects of tartrazine. It can be concluded that there is a need for professional assistance for consumers regarding food safety issues. Cumulative indications have been increased, demonstrating the potential danger of tartrazine, and the possibility to avoid its consumption.

Tartrazine: Chemical Properties and Metabolism

Tartrazine, a food colorant derived from petroleum, is well-known for its bright yellow color and stability (Chung *et al*., 1981). It is soluble in water and demonstrates high stability under various thermal and pH conditions, making it ideal for a range of processed foods, beverages, and pharmaceuticals (EFSA, 2009). The structure of tartrazine features an azo (-N=N-) bond, which is significant for its metabolic breakdown (Amin *et al*., 2010). After ingestion, tartrazine is absorbed in the gastrointestinal tract and primarily metabolized in the liver. Intestinal microbiota reduce it to aromatic amines, which could pose potential toxicological risks (Koutsogeorgopoulou *et al*., 1998). The body mainly excretes tartrazine and its metabolites through urine and feces, with some studies indicating possible bioaccumulation risks with chronic exposure (Mehedi *et al*., 2013). The

metabolic processes involved in the biotransformation of tartrazine can affect oxidative stress levels, potentially leading to cellular damage and organ toxicity.

Experimental Approaches In Tartrazine Toxicity Studies

Experimental studies investigating the toxicity of tartrazine mainly use albino rats (*Rattus norvegicus*) as a model organism. This choice is due to their genetic similarities to humans and their established role in toxicological research (Chung *et al*., 1981). Typically, these studies involve various exposure models, including acute, sub-chronic, and chronic, where tartrazine is given through drinking water or diet at different doses to assess its biochemical, physiological, and histopathological effects (Amin *et al*., 2010). Biochemical analyses focus on liver function markers like alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP) to evaluate hepatotoxicity (Mehedi *et al*., 2013). Tests for renal function, which measure creatinine and urea levels, help, assess nephrotoxicity (Kamel & El-lethey, 2011). Hematological studies look at changes in red and white blood cell counts, which can indicate immunotoxic or anemic effects (Koutsogeorgopoulou *et al*., 1998). Histopathological examinations of liver, kidney, and brain tissues show structural damage linked to tartrazine exposure (Abdelaziz *et al*., 2019). Neurobehavioral studies, utilizing open field tests and maze tests, evaluate cognitive and anxiety-related effects, often associated with imbalances in neurotransmitters (Kamel & El-lethey, 2011). Furthermore, oxidative stress markers such as malondialdehyde (MDA) and superoxide dismutase (SOD) are frequently measured to understand the oxidative damage caused by tartrazine. These experimental methods offer essential insights into the toxicity of tartrazine and its potential risks, highlighting the importance of regulatory review and the search for safer alternatives.

Biochemical Impacts of Tartrazine in Albino Rats

Research shows that exposure to tartrazine disrupts several important physiological processes, particularly impacting liver and kidney functions. In various studies, rats given tartrazine exhibited increased serum levels of liver enzymes, such as alanine aminotransferase (ALT) and aspartate aminotransferase (AST), which indicate liver cell damage and reduced liver function (Amin, Hameid, & Abd Elsttar, 2010). Similarly, signs of kidney dysfunction were observed through elevated serum creatinine and urea levels, suggesting that tartrazine negatively affects kidney filtration and overall function (Koutsogeorgopoulou, Maravelias, Methenitou, & Koutselinis, 1998). Beyond its effects on the liver and kidneys, tartrazine has been shown to induce oxidative stress by increasing lipid peroxidation, as evidenced by higher levels of malondialdehyde (MDA) and reduced activity of antioxidant enzymes like superoxide dismutase (SOD) and catalase (Kamel & El-lethey, 2011). This oxidative imbalance can lead to further cellular damage, compromising tissue integrity. Additionally, hematological changes have been noted, including decreases in red blood cell counts and hemoglobin levels, which may lead to anemia and hinder oxygen transport. These biochemical changes seem to be dose-dependent and worsen with prolonged exposure, highlighting the importance of determining safe intake levels for tartrazine in consumer products. Overall, these findings emphasize the toxic potential of tartrazine and the need for further research to clarify its mechanisms and long-term health effects. Furthermore, additional studies are necessary to establish safe exposure levels for tartrazine, ensuring consumer safety and compliance with regulatory standards.

Physiological and Behavioral Effects of Tartrazine Exposure

Exposure to tartrazine in albino rats has been linked to notable changes in both physiological and behavioral aspects. On the physiological side, tartrazine disrupts organ function. Research has shown that it can lead to liver dysfunction, with rats displaying increased levels of liver enzymes and histopathological signs of liver cell damage (Amin, Hameid, & Abd Elsttar, 2010). Similarly, kidney function appears to be compromised, as indicated by elevated serum creatinine and urea levels. Furthermore, tartrazine may disrupt hormonal balance by affecting cortisol and aldosterone levels, which could interfere with the hypothalamic-pituitary-adrenal axis and provoke systemic inflammation. On the behavioral front, exposure to tartrazine has been associated with neurobehavioral issues. Studies indicate that rats given tartrazine exhibit hyperactivity, heightened anxiety-like behaviors, and reduced cognitive abilities in maze tests (Kamel & El-lethey, 2011). These behavioral shifts are believed to stem from oxidative stress-related neuronal damage and imbalances in neurotransmitter systems. The interplay of physiological stress and neurobehavioral changes highlights the neurotoxic risks of tartrazine, raising alarms about its long-term use in food products. Overall, these results point to the need for a reassessment of tartrazine's safety and further investigation into its long-term health effects.

Risk Assessment and Regulatory Considerations

Risk assessment for tartrazine involves measuring exposure levels, establishing dose-response relationships, and evaluating biochemical and physiological effects observed in animal studies. Research conducted on albino rats has been crucial in identifying toxicological thresholds, as these studies show dose-dependent changes in liver and kidney enzymes, oxidative stress markers, and immune parameters (Amin, Hameid, & Abd Elsttar, 2010; Koutsogeorgopoulou, Maravelias, Methenitou, & Koutselinis, 1998). The results from these experiments provide essential data for evaluating the potential risks linked to tartrazine consumption. Regulatory bodies, such as the European Food Safety Authority (EFSA) and the U.S. Food and Drug Administration (FDA), have used these findings to set acceptable daily intake (ADI) limits for tartrazine. For example, the EFSA's assessments conclude that tartrazine is safe when consumed within these limits, although new evidence indicates that long-term exposure—particularly at higher doses—might lead to negative biochemical and physiological effects (EFSA, 2009). In light of these findings, current risk assessments emphasize the need for continuous re-evaluation of tartrazine's safety profile, considering individual susceptibility and cumulative exposure from various sources. Improved monitoring and the incorporation of the latest toxicological data into regulatory practices are essential for ensuring consumer safety and that food additive standards effectively protect public health.

Future Directions

Future research on the toxicity of tartrazine should explore its molecular mechanisms in greater detail to clarify the pathways that lead to oxidative stress, DNA damage, and mitochondrial dysfunction. Utilizing advanced technologies like genomics, proteomics, and metabolomics could uncover new biomarkers and pathways related to tartrazine-induced

toxicity (Amin, Hameid, & Abd Elsttar, 2010). Furthermore, conducting long-term, low-dose exposure studies in animal models, along with epidemiological research, is vital to connect experimental results with implications for human health. It is also important to investigate the potential synergistic effects of tartrazine when it is combined with other food additives, as well as how individual genetic differences may influence susceptibility to its toxic effects (Koutsogeorgopoulou, Maravelias, Methenitou, & Koutselinis, 1998). Additionally, research that focuses on natural antioxidants and dietary changes could offer strategies to reduce the negative impacts of tartrazine. This comprehensive approach is essential for improving risk assessments and guiding effective regulatory policies and public health initiatives.

Conclusion

Toxic effects on biochemical and physiological functions in mammals, especially in albino rats (*Rattus norvegicus*), have been observed. Various toxicological studies suggest that exposure to tartrazine may result in liver and kidney dysfunction, oxidative stress, changes in blood parameters, neurobehavioral issues, and possible carcinogenic risks. The main mechanisms behind these toxic effects include the production of reactive oxygen species (ROS), mitochondrial dysfunction, inflammatory responses, and metabolic disturbances. Biochemical analyses indicate that exposure to tartrazine correlates with increased levels of liver enzymes (ALT, AST, ALP), which point to hepatotoxicity, as well as elevated creatinine and urea levels, indicating nephrotoxicity. Moreover, markers of oxidative stress, such as malondialdehyde (MDA) and decreased activity of antioxidant enzymes (SOD, catalase), underscore the role of oxidative damage in the toxicity associated with tartrazine. Behavioral studies also suggest a link between tartrazine consumption and hyperactivity, cognitive deficits, and anxiety-like behaviors, raising concerns about its neurotoxic effects.While regulatory bodies like the European Food Safety Authority (EFSA) and the U.S. Food and Drug Administration (FDA) have set acceptable daily intake (ADI) limits for tartrazine, new evidence indicates that long-term and cumulative exposure could have negative health effects. Findings from experimental studies highlight the importance of ongoing monitoring, thorough risk assessments, and a reevaluation of current safety guidelines regarding tartrazine consumption.

Reference

Abdelaziz, D. H., Ali, S. A., Saad Eldien, H. M., & Hussein, M. M. (2019). Histological and biochemical impact of tartrazine on hepatic tissue and the protective role of vitamin C in albino rats. Anatomy and Cell Biology, 52(4), 425–433. https://doi.org/10.5115/acb.19.092

Amin, K. A., Hameid, H. A. H., & Abd Elsttar, A. H. (2010). Effects of food azo dyes tartrazine and carmoisine on biochemical parameters related to renal, hepatic function and oxidative stress biomarkers in young male rats. Food and Chemical Toxicology, 48(10), 2994–2999. https://doi.org/10.1016/j.fct.2010.07.039

Chung, K. T., Fulk, G. E., & Andrews, A. W. (1981). Mutagenicity testing of some commonly used dyes. Applied and Environmental Microbiology, 42(4), 641–648.

European Food Safety Authority (EFSA). (2009). Scientific opinion on the reevaluation of tartrazine (E 102) as a food additive. EFSA Journal, 7(11), 1331. https://doi.org/10.2903/j.efsa.2009.1331

Kamel, M. M., & El-lethey, H. S. (2011). The potential health hazard of tartrazine and levels of hyperactivity, anxiety-like symptoms, depression and anti-social behaviour in rats. Journal of American Science, 7(6), 1211–1218.

Koutsogeorgopoulou, L., Maravelias, C., Methenitou, G., & Koutselinis, A. (1998). Immunological aspects of the common food colorants, tartrazine and sunset yellow. Immunopharmacology and Immunotoxicology, 20(1), 1–11. https://doi.org/10.3109/08923979809034815

McCann, D., Barrett, A., Cooper, A., Crumpler, D., Dalen, L., Grimshaw, K., & Stevenson, J. (2007). Food additives and hyperactive behavior in 3-year-old and 8/9-year-old children in the community: a randomized, double-blinded, placebo-controlled trial. The Lancet, 370(9598), 1560–1567. https://doi.org/10.1016/S0140-6736(07)61306-3

Mehedi, N., Ainad-Tabet, L., Mokrane, N., Addou, S., Zaoui, C., Kheroua, O., & Saidi, D. (2013). A thirteen-week ad libitum administration toxicity study of tartrazine in Swiss mice. African Journal of Biotechnology, 12(28), 4519–4529. https://doi.org/10.5897/AJB2013.12296

Singh, Bharat & Maheshwari, Manish & Sharma, Harendra. (2024). Nutritional Studies on Fish *Catla Catla* Found In Ganga River With Hydrobiological Studies. Journal of Science Innovations and Nature of Earth. 4. 17-22. https://doi.org/10.59436/ht5mmg32

Singh, Bharat & Nath, Harendra & Prveen, & Singh, Sanjay. (2024). A review on Effect of Cypermethrin on Hematology of Fresh Water Fish Channa punctatus (Bloch.). 4. 52-57.
https://doi.org/10.59436/jsiane.271.2583-2093.