

Morphofunctional Changes in the Stomach Under the Influence of Food Colorants E-171 and E-173 and Their Assessment

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Abstract This article examines the potential effects of the food colorants E-171 (titanium dioxide) and E-173 (aluminium), used in the food industry, on gastric tissues and considers the assessment of possible morphofunctional changes caused by their exposure. The literature review indicates that titanium dioxide particles may interact with biological barriers of the gastrointestinal tract and may be associated with local inflammatory processes and cellular changes. At the same time, the effects observed in experimental studies depend on particle size, dose, duration of exposure, and biological properties; the available data are insufficient to draw a uniform conclusion. The effects of E-173 on gastric tissues also require separate experimental assessment. A comprehensive study of the gastric mucosa, glandular structure, vascular changes, and functional parameters may help clarify potential mechanisms of tissue injury. These data are important for the scientific assessment of the biological safety of food colorants and for expanding current knowledge of their effects on the stomach.

Keywords Food additives, Food colorants, E-171, Titanium dioxide, E-173, Aluminium, Gastric mucosa, Morphofunctional changes, Histopathological alterations, Oxidative stress, Sesame oil, Biological safety

1. Introduction

Various food additives are used to improve the appearance, colour, and consumer properties of food products. Assessing their biological safety, particularly their potential effects on the digestive system under conditions of long-term intake, is an important task in modern experimental medicine and toxicology.

E-171 is titanium dioxide, which was widely used as a white colouring additive in food products. Its particle size and physicochemical properties may influence its interactions with biological systems. In 2021, the EFSA expert panel reassessed the available evidence and concluded that E-171 could no longer be considered safe as a food additive because concerns regarding genotoxicity could not be ruled out [1].

In an experimental study, Bettini and colleagues investigated the passage of food-grade titanium dioxide particles across the intestinal barrier, their effects on immune homeostasis, and their association with certain pathological changes in the rat colon [2]. However, findings on the effects of E-171 on the stomach are not uniform. In an experiment by Han and

colleagues, titanium dioxide particles were detected in gastric tissues, and changes in certain immunological indicators were reported; nevertheless, a dose-dependent relationship was not observed for all toxicological parameters [3]. E-173 is known as an aluminium colourant, and assessment of its biological effects requires clear specification of the composition, form, dose, and route of exposure. It is scientifically inappropriate to assume that E-171 and E-173 have identical effects. The gastric mucosa comes into direct contact with substances entering the body; therefore, studying changes in its epithelium, glands, stroma, and microcirculatory system is important for identifying possible mechanisms of toxic effects [6,7,8,9].

Aim of the study: to investigate the separate and combined effects of food colorants E-171 and E-173 on the morphofunctional status of the stomach and to assess the effectiveness of correction with sesame oil.

2. Materials and Methods

Adult white outbred male and female laboratory rats were selected for the study. The rats were divided into control, E-171, E-173, E-171 + E-173, and correction groups. The E-171 and E-173 colorants were administered for three months. Gastric tissue specimens, blood, and blood serum were selected as the study materials.

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The study used biochemical methods, histological staining methods (Masson's trichrome, haematoxylin and eosin, and Van Gieson staining), morphometry, biochemical analysis, biological correction methods, and statistical methods.

3. Results

We investigated the effects of titanium dioxide (E-171) and aluminium (E-173) food colorants, as well as morphofunctional changes arising from their combined effects on the structural and functional state of the rat stomach. The widespread use of inorganic compounds, nanoparticles, and metal compounds in the food industry may lead to their accumulation in the body and may adversely affect various organs and systems, particularly the digestive system, potentially causing pathomorphological changes.

Titanium dioxide had long been considered an inert substance. However, recent biomedical studies indicate that some food additives may cross mucosal barriers and have the potential to induce oxidative stress. The E-173 food colorant (aluminium metal) may affect microcirculation in small blood vessels and the enzymatic structures of epithelial cells. Particular attention is paid to their combined effects because, under real dietary conditions, people may consume these chemical substances together.

The fundic and pyloric regions of the stomach were the principal objects of morphological analysis because, owing to their anatomical and physiological characteristics, these regions may respond differently to chemical exposures. Morphological examination of parietal cells, chief cells, and mucosal cells (mucocytes) under experimental intoxication makes it possible to investigate tissue injury and potential mechanisms underlying disruption of the organ's secretory and protective functions. An accurate description of the normal morphology of the gastric fundus is an important step in understanding xenobiotic-induced changes, as it provides a reference for comparative assessment of destructive alterations (Figure 1).

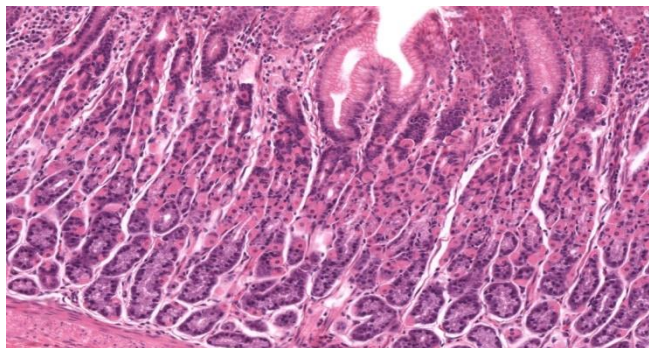


Figure 1. Structure of the fundic gastric mucosa in rats from the control group. Haematoxylin and eosin staining. Magnification: 10×10

Effect of E-171 on parietal cells.

Partial loss of the typical homogeneous oxyphilia is observed in many exocrine cells. The cytoplasm develops a

distinct fine-granular appearance, referred to as granular degeneration. This process is described as being associated with decompensation of intracellular protein-metabolism systems and mitochondrial swelling, considered a principal sign of E-171 accumulation. Another characteristic feature is the appearance of distinct zones and optically clear vacuoles in the cytoplasm. These changes indicate the development of hydropic (water-related) degeneration, which may result from altered membrane permeability and damage to the tubulovesicular system. In tissue sections, the vacuoles visibly displace the cytoplasmic matrix and reduce the apparent intensity of eosin staining. The cells appear enlarged due to increased hyaloplasmic volume. In some cases, this may mechanically displace organelles and alter cell shape, causing cells to lose their distinct polygonal form and become round or oval.

The nuclear apparatus shows pronounced euchromasia, while the nuclear shape remains preserved. The nuclei of many parietal cells are enlarged and occupy a subcentral position, with a discernible nuclear envelope. Pale areas and clearly visible nucleoli may indicate increased transcriptional activity. This appearance is interpreted as reactive hypertrophy and compensatory strain on the nuclear apparatus. When exposed to the cytotoxic effects of E-171, the cell may mobilise genetic resources for protein synthesis and repair of damaged organelles. Therefore, an increase in nuclear surface area is described as a morphological sign of an adaptive stage preceding irreversible pyknosis.

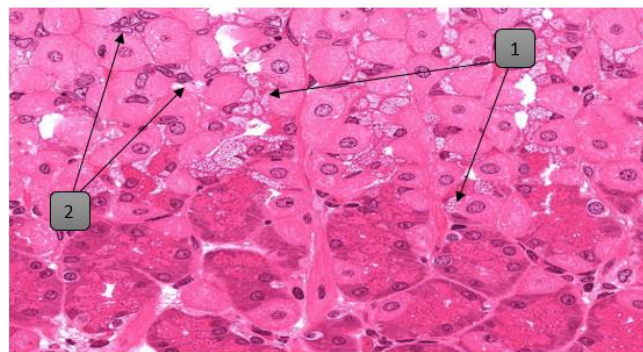


Figure 2. Morphological changes in epithelial cells of the fundic gastric mucosa under the influence of E-171. 1 — hydropic change in the cytoplasm; 2 — changes in the continuity and thickness of the nuclear envelope. Haematoxylin and eosin staining. Magnification: 10×20

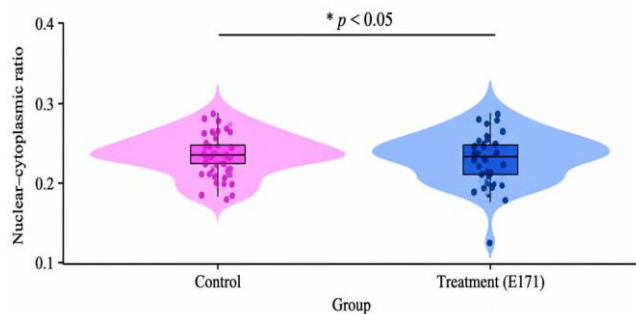


Figure 3. Comparative data on cellular parameters. RStudio

Under the influence of E-171, the cytoplasm of parietal cells is described as progressing from moderate granular dystrophy to pronounced hydropic degeneration. The nuclear-to-cytoplasmic ratio is one of the informative indicators of cellular decompensation; it may reflect cytoplasmic hyperhydration exceeding the compensatory capacity of the nucleus (Figure 2). The observed imbalance between nuclear and cytoplasmic volume may provide a pathomorphological basis for a reduction in gastric acid secretion.

Effect of E-173 on parietal cells.

According to our observations, regular oral administration of the E-173 food additive (aluminium) was associated with pronounced alternative-dystrophic changes in the parenchymal structures of the stomach. These changes are attributed in the source text to the direct cytotoxic effect of heavy-metal salts, altered cell-membrane permeability, and the development of marked intracellular hydropic dystrophy.

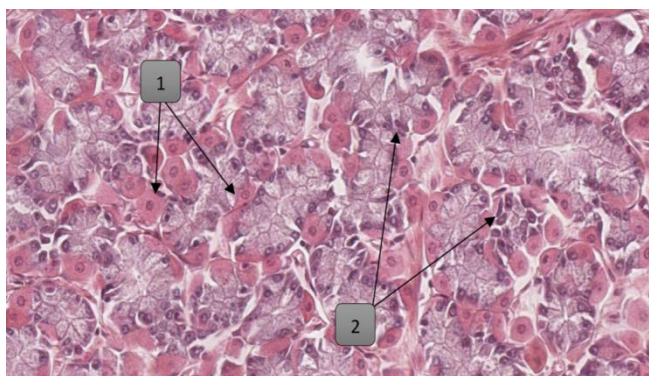


Figure 4. Fundic region of the stomach in rats from the experimental group. 1 — parietal cells; 2 — chief cells. Haematoxylin and eosin staining. Magnification: 10×20

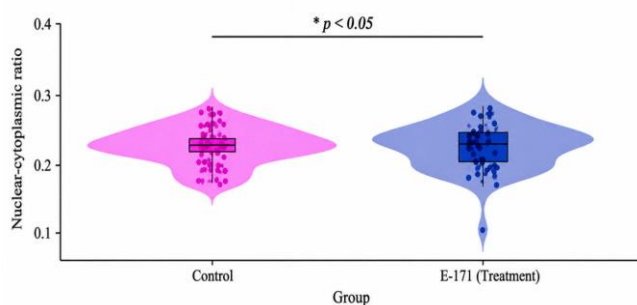


Figure 5. Comparative analysis of the nuclear-to-cytoplasmic ratio in parietal cells of the gastric fundus. RStudio

Analysis of epithelial cells in the fundic gastric mucosa identified parietal glandulocytes as particularly susceptible to the effects attributed to E-173. Their morphometric parameters showed marked changes manifested as severe intracellular swelling; the area of the parietal-cell cytoplasm increased 1.15-fold, resulting in a 1.1-fold increase in total cell area. However, this increase in geometric parameters was accompanied by a marked decline in nuclear parameters. The nuclear area of parietal glandulocytes decreased 1.34-fold under the influence of E-173, which the source text interprets as reactive karyopyknosis. The reduction in

karyoplasmic volume together with pronounced intracellular cytoplasmic hyperhydration resulted in a 1.5-fold decrease in the nuclear-to-cytoplasmic ratio (Figure 4).

The study examined comparative morphometric parameters of parietal cells in the glands of the fundic gastric mucosa under the influence of E-171 and E-173, comparative morphometric indicators of chief cells in the fundic glands, morphometric parameters of the proper gastric glands, and effects on the mucosa of the gastric antrum.

4. Discussion

This study focused on a comparative assessment of the morphometric parameters of glands, parietal cells, and chief cells in the fundic and antral mucosa of rat stomachs exposed to the food colorants E-171 and E-173. Cytoplasmic and nuclear parameters, the nuclear-to-cytoplasmic ratio, and the morphological state of glandular structures are important criteria for interpreting the findings. Their integrated assessment helps characterise the potential cytotoxic effects of food colorants on gastric tissues. The literature contains differing findings on the biological effects of titanium dioxide. Bettini and colleagues reported changes related to immune homeostasis and pathological findings in the rat colon following exposure to E-171 [2]. In contrast, Blevins and colleagues found no treatment-related significant changes in the histopathology of the small and large intestines or in certain immunological parameters in rats fed an E-171-containing diet for 7 or 100 days [4,5]. These differences highlight the importance of experimental design, route of administration, dose, duration of exposure, and tissue type assessed. Therefore, findings from intestinal studies cannot be directly applied to parietal or chief cells of the stomach.

5. Conclusions

Investigating the effects of the food colorants E-171 (titanium dioxide) and E-173 (aluminium) on the body, particularly assessing possible morphofunctional changes in gastric tissues, is an important area of modern toxicology and experimental morphology.

Assessing the structure of the gastric mucosa, glandular activity, cellular condition, and signs of local inflammation together with functional and biochemical parameters may provide a deeper understanding of the potential mechanisms of action of these colorants. Comparing exposed groups with the control group and analysing the findings using appropriate statistical methods, including assessment of dose-related changes where applicable, improves the scientific reliability of the study.

Thus, comprehensive morphofunctional assessment of the effects of E-171 and E-173 on the stomach is important for expanding scientific knowledge of their biological safety, identifying potential risk factors, and developing future preventive and practical recommendations. Final conclusions should be based only on experimental findings and reliable

scientific evidence.

REFERENCES

- [1] EFSA Panel on Food Additives and Flavourings (FAF), Younes M. et al. Safety assessment of titanium dioxide (E171) as a food additive. *EFSA Journal*. 2021; 19(5): 6585. DOI: 10.2903/j.efsa.2021.6585.
- [2] Bettini S., Boutet-Robinet E., Cartier C. et al. Food-grade TiO₂ impairs intestinal and systemic immune homeostasis, initiates preneoplastic lesions and promotes aberrant crypt development in the rat colon. *Scientific Reports*. 2017; 7: 40373. DOI: 10.1038/srep40373.
- [3] Han H.Y., Yang M.J., Yoon C. et al. Toxicity of orally administered food-grade titanium dioxide nanoparticles. *Journal of Applied Toxicology*. 2021; 41(7): 1127–1147. DOI: 10.1002/jat.4099.
- [4] Blevins L.K., Crawford R.B., Bach A. et al. Evaluation of immunologic and intestinal effects in rats administered an E 171-containing diet, a food grade titanium dioxide (TiO₂). *Food and Chemical Toxicology*. 2019; 133: 110793. DOI: 10.1016/j.fct.2019.110793.
- [5] Dorier M., Tisseyre C., Dussert F. et al. Toxicological impact of acute exposure to E171 food additive and TiO₂ nanoparticles on a co-culture of Caco-2 and HT29-MTX intestinal cells. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis*. 2019; 845: 402980. DOI: 10.1016/j.mrgentox.2018.11.004.
- [6] Abdullaev J.I., Usmonov. R.D j. Xudaybergenov. B.E. // Reactive changes in the stomach when exposed to an energy drink // (2024). American Journal of Interdisciplinary Research and Development, 25, 338-342. // Tashkent tibbiyot akademiyasi.
- [7] Abdel-Gawad DRI, Ibrahim MA, Moawad UK, Kamel S, El-Banna HA, El-Banna AH, Hassan WH, El-Ela FIA. // Effectiveness of natural biomaterials in the protection and healing of experimentally induced gastric mucosa Ulcer in rats. // Mol Biol Rep. 2023 Sep 23; 50(11): 9085-9098. doi: 10.1007/s11033-023-08776-9.// PMCID: PMC10635934.
- [8] Al-Wajeeh NS, Hajerezaie M, Noor SM, Halabi MF, Al-Henhena N, Azizan AH, Kamran S, Hassandarvish P, Shwter AN, Karimian H, Ali HM, Abdulla MA. // The gastro protective effects of Cibotium barometz hair on ethanol-induced gastric ulcer in Sprague-Dawley rats.//BMC Vet Res. 2017 Jan 19; 13(1): 27. doi: 10.1186/s12917-017-0949-z.// PMCID: PMC5244617.
- [9] Burkitt MD, Duckworth CA, Williams JM, Pritchard DM. Helicobacter pylori-induced gastric pathology: insights from in vivo and ex vivo models. Dis Model Mech. 2017 Feb 1; 10(2): 89-104. doi: 10.1242/dmm.027649. PMID: 28151409; PMCID: PMC5312008.