

Effects of Energy Drinks on the Digestive System of Humans and Animals

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Annotation: The review article highlights the prevalence of energy drinks (ED) consumption, characterizes their main ingredients (caffeine, taurine, guarana, ginseng, etc.). Facts are given that testify to the negative impact on human and animal health (including deaths) of the systematic use of large volumes of energy tonics, both alone and in combination with alcohol. It is shown that the walls of hollow organs and glands of the digestive system are most affected. An analysis of literature data with a high degree of persuasive evidence that excessive use of ED can adversely affect human health and can lead to the development of multiple organ failure, with damage to the digestive organs.

The study of the functional state of the body when toxicants enter and the prevention of their migration from waste to the environment, as well as the complete elimination or limitation of their effect on living organisms, is one of the most important directions in solving modern medical and toxicological problems. The results obtained reveal the mechanism of occurrence of various disorders in the structure of the mucous membrane of the large intestine of rats.

Material and methods: in the experiment, 1-month-old rats were given Red Bull ED at a dose of 2 ml per day for 3 months. The calculation of ED for the experiment was carried out on the basis of the indicators of the "Hygienic standards for maximum permissible concentrations of pollutants in the atmosphere and air of populated areas on the territory of the Republic of Uzbekistan". Animals were slaughtered at 3, 6, 9 months of age. Histological methods were used to study the structure of the rectal mucosa of the experimental groups in comparison with the control group.

Result and discussion: In the experimental group, when exposed to energy drinks in 4-6 month old rats, the thickness of the stratified squamous epithelium decreases in the sphincter zone.

Keywords: human health; energy drinks; caffeine; taurine; guarana; intestines; stomach; salivary glands; Red Bull.

The first energy drinks (ED) appeared on the market in the 80s of the XX century, drinks gained special popularity in the 2000s, as evidenced by increased sales volumes [29]. According to the Moscow marketing company Academy Service, the market for energy drinks, the leader of this market, Red Bull, is growing by 12% annually, and has already reached \$ 14 billion in 2015.

In European countries, the number of ED increased by 4.3% from 2013 to 2018 [23]. The Russian energy market is also expanding. So, if in 2010 106.4 million liters of these drinks were sold, then in 2015 this volume already amounted to 163 million liters [5].

ED have been developed to improve physical and mental performance during sports and recreation. ED is being promoted to encourage young people to consume these caffeinated liquids, promoting benefits such as increased energy, longer wakefulness, and enhanced physical and mental performance.

In various contexts, some authors deplore the fact that marketing strategies are targeted mainly at high school and college youth, thus encouraging them to consume caffeine, making it easier to consume these drinks [8]. Energy is mobilized by ED intake by stimulating the nervous system with ingredients such as taurine, caffeine, guarana, ginseng and vitamins [9], and some vitamins (B group) and minerals [47].

The rapid spread of a new type of drink among the younger generation caused fears, which were reinforced by reports that appeared in the media about the death of teenagers, presumably after drinking energy drinks with a high concentration of caffeine, alcohol-containing ED, or after mixing them with alcohol [11].

Today, the opinions of scientists and specialists are divided: some consider energy drinks to be quite harmless, similar to ordinary soda, while others, on the contrary, argue that ED can act like drugs and cause addiction and dependence [10].

Experts from the Estonian branch of WHO (2014) published the results of a study according to which in Europe 1/3 of adults, every fifth child and more than 2/3 of adolescents drink energy drinks. While adults get only 8% of their caffeine intake from them, this figure is much higher in children at 43%. Therefore, scientists warn of the dangers of caffeine intoxication, which is much more pronounced in children than in adults. Moreover, 70% of young people aged 18 to 29 drink ED by mixing it with alcohol or using alcohol-containing energy drinks.

Caffeinated ED has been investigated as a public health issue in the US. The Substance Abuse and Mental Health Services Administration reported that ED-related emergency room visits doubled from 10,068 visits in 2007 to 20,783 visits in 2011, with one in ten of these visits resulting in hospitalization.

According to the producers, the stimulating effect of these drinks is due to the interaction of various ingredients. They claim that these drinks improve physical endurance, reaction rate, and concentration [37]. There are several studies that have documented a modest improvement in physical endurance with ED consumption [12], and studies that have not shown a significant increase in endurance associated with consistent ED consumption [16].

The safe daily intake of caffeine varies according to Russian and Western guidelines. In Russia it is 150 mg/day, and in the West it is 400 mg/day [2,39]. These doses are applicable to healthy young and middle-aged adults, with the exception of women during pregnancy and lactation, for whom a safe dose has not yet been established [24]. With children, too, there are conflicting data; a reduction in their maximum allowable dose is currently being considered [43]. The effect of exposure to excessive doses of caffeine is replaced by even greater fatigue and fatigue. If you do not give the body a good rest, but drink another cup of coffee or black tea, then you can significantly exceed the allowable dose of caffeine, since it is slowly excreted from the body [13].

Due to the large amount of sugar and acids contained in ED, their frequent use disrupts the acid-base balance in the mouth, and also destroys tooth enamel, contributing to the development of caries. The sugar content in energy drinks is very high, which significantly increases the load on the endocrine function of the pancreas. [22].

According to a study by Díaz A. et al. (2016) chronic use of ED leads to an inflammatory response, oxidative stress, and cell death due to apoptosis. These changes were seen as a sign of caffeine toxicity, which is present in Red Bull ED.

According to Redman RS. (2008) stromal inflammation can interrupt the diffusion of oxygen and nutrients to parenchymal cells, resulting in a delay in the regeneration process by the remaining intact parenchymal cells. In the submandibular salivary gland, a compensatory reaction was observed in intact areas containing stem or progenitor cells after the abolition of Red Bull ED with partial restoration of the normal structure [15].

Indeed, some authors believe that coffee promotes digestion by affecting gastric acid production, bile and pancreatic secretions, and colonic motility [26]. In healthy young adults, caffeine administration has been reported to either activate [27] or not [28].

Expansion and hyperemia of the blood vessels of the gastric mucosa was found, which may be associated with an increase in collagen formation and re-epithelialization, which is accompanied by the result associated with hyperplasia of parietal cells, which may be associated with the main content of caffeine in the ED“Tiger” [49].

The high content of carbohydrates contained in ED, which can stimulate the release of insulin and glucose, which, in turn, will cause hyperplasia of the gastric epithelium [41].

Uwaifo G.I. (2019) found that drinking 2-3 cans of an energy drink over 4 months may be associated with gastritis, hepatitis, and pancreatitis. In addition, high levels of carbohydrates found in ED can interfere with fluid absorption and cause gastrointestinal disturbances [6].

A high dose of ED(Tiger) showed degenerative changes in the surface epithelium and infiltration of mononuclear cells, which may indicate an inflammatory process due to oxidative stress and tissue damage as a result of chronic energy consumption [7].

Goblet cell metaplasia, which occurs in this group, may be a marker of early progression of gastric cancer [33]. This conclusion is consistent with the conclusion [31] who described lipids present in the cell membrane, and this leads to marked cellular degeneration and apoptosis. But this is not consistent with the conclusion of Manzini R et al. (2021) who found that ED consumption may have an unexpected anti-inflammatory effect on the intestinal epithelium.

The cause of occlusion of intestinal vessels is the effect of ED on the increase in platelet activity through arachidonic acid-induced platelet aggregation [36].

According to scientists, a marked loss of intestinal villi with marked degeneration of the intestinal epithelium, combined with mononuclear cell infiltration and goblet cell hyperplasia, especially in the presence of a large amount of fluid, so goblet cells will be present in large numbers to accommodate a large amount of fluid, and this may also predispose to bowel cancer, this mechanism has not been mentioned by other researchers due to the lack of sufficient research in this area [19].

Revealed plethora of intestinal vessels associated with complete hyalinization of the layer, with partial loss of intestinal villi. Another reason may be due to the presence of caffeine, which causes an increase in the level of tumor necrosis factor-alpha, which leads to the synthesis of nitric oxide, which causes an oxidant-antioxidant imbalance, which may be the cause of increased oxidative stress and subsequent cell damage [18,22].

Another mechanism for the loss of intestinal villi is the additive effect of taurine on the intestinal mucosa, leading to conjugation of taurine with bile acid, leading to lipid digestion [34].

The effect of coffee on gastric acid secretion raises the question of a possible increase in dyspepsia (poor digestion, discomfort, nausea, heartburn, belching and flatulence) or esophageal burns, gastritis or ulcers and gastroesophageal reflux disease (GERD). Diet plays an important role in heartburn, and many foods can relax the lower esophageal sphincter (LES), allowing food to enter the esophagus and cause heartburn. Changes in the structure and function of the IVC may predispose to GERD [45].

Research by Duncanson K.R. et al. (2018) reported that replacing coffee with a decaffeinated substitute improved symptoms of functional dyspepsia in 51 patients with this syndrome, but coffee components responsible for the effect on functional dyspepsia have not been studied.

Some authors have even concluded that, because of the conflicting data and unclear association between the occurrence of gastrointestinal symptoms and coffee consumption, patients with gastrointestinal symptoms should not routinely be advised to avoid coffee.

For duodenal ulcer and at the same intake levels, the relative risk was reduced by 46%, respectively. Several earlier studies did not report any association between caffeine, caffeinated drinks or decaffeinated coffee and the risk of developing duodenal ulcers [40].

EDconsumption causes a wide variety of clinical side effects resulting from irritation of many tissues and an increase in gastric mucus production has been observed after eight weeks of EDuse. Caffeine increases the production of stomach acid and reduces its neutralization by various mechanisms. The data obtained prove that caffeine interferes with the production of nitric oxide, which leads to secondary vasoconstriction and the absence of blood flow to the mucous membrane.

Nitric oxide increases mucus secretion in the gastric mucosa, inhibits the activation of leukocytes in the microcirculation, and inhibits the natural release of reactive oxygen metabolites and proteases.

Moreover, taurine plays many biological roles in the human body. Taurine is involved in lipid and glucose metabolism. The antiemetic properties of taurine may increase the safety of EDconsumption and neutralize the harmful effects of other ingredients, but it is still unknown whether higher than therapeutic doses of taurine are safe.

Changes in the transport of glucose and electrolytes by the gastrointestinal wall increase the risk of dehydration and diabetes in EDdrinkers. Ingredients such as vitamins and inositol do not play a major role in causing side effects, although they may cause mild diarrhea or nausea. In addition, inositol may promote female fertility, regulate glucose metabolism, and is an antidepressant [46].

A study shows that EDconsumption leads to microscopic changes in the gastric mucosa of rats [48]. In particular, the authors observed an increase in mucus production, which is largely dependent on the main substances contained in ED, such as taurine. Further research is needed to identify the long-term effects of EDconsumption in humans [3].

The addition of taurine and vitamins reduces some of the side effects of these drinks, but this is not enough to prevent numerous irreparable pathological changes in the functioning of the body [4].

According to Schubert M.L. (2015) coffee does not affect small intestinal motility but stimulates colonic motility in 29% of subjects [14]. The mobility of the distal colon increases as early as 4 minutes after drinking coffee [14]. These effects are unlikely to be due to caffeine; instead, an indirect effect on the colon [25] mediated by neural mechanisms or gastrointestinal hormones [42] is assumed, but this effect, according to scientists, depends on individual characteristics.

Research by Schubert M.L. (2015) found that 29% described an overwhelming need to defecate after drinking a cup of coffee, suggesting colon and rectal stimulation [1]. In these people, regular

and decaffeinated coffee stimulated a motor response at the rectosigmoid level between 4 and 30 minutes after ingestion. In another study, strong coffee increased rectal tone by 45%.

According to Chang J.Y. et al. (2007) coffee consumption is not associated with chronic constipation, but rather is associated with chronic constipation [32]. The nature of coffee's components involved in its effect on colonic motility has not been studied in detail, but since both regular and decaffeinated coffee are active, caffeine does not appear to be involved in this effect. The role of other components has not been studied. Some indirect effects have been induced, such as the effects of cholecystokinin, gastrin, and motilin, whose secretion is stimulated by coffee consumption [35].

In the case of mucosal inflammation, coffee may have a protective effect, but its role in the intestinal tract before the onset of the disease may vary depending on many factors [51].

The authors reviewed the effects of coffee and ED on different layers of the gut wall and the relationship between the gut and the brain [26].

Materials and methods: in the experiment, 1-month-old rats were given Red Bull ED at a dose of 2 ml per day for 3 months. The calculation of ED for the experiment was carried out on the basis of the indicators of the "Hygienic standards for maximum permissible concentrations of pollutants in the atmosphere and air of populated areas on the territory of the Republic of Uzbekistan". Animals were slaughtered at 3, 6, 9 months of age. Histological methods were used to study the structure of the rectal mucosa of the experimental groups in comparison with the control group.

Result and discussion: In our study, prolonged use of Red Bull ED caused noticeable changes in the normal histological structure of acinar and ductal cells of the submandibular salivary gland of albino rats. They were in the form of disorganized, destroyed cells, cytoplasmic vacuoles, and unevenly compressed or pyknotic nuclei.

Possible mechanisms, metabolic disturbance leads to an increase in blood glucose levels, lipolysis and gluconeogenesis, which are accompanied by a decrease in peripheral glucose uptake due to inhibition of glycolytic enzymes. The hyperglycemic environment leads to subsequent glycation of cell membrane phospholipids or even intracellular organelles, leading to lipid peroxidation and DNA damage in organs. According to scientists, this imbalance leads to cell damage.

Conclusion. Thus, the walls of hollow organs and glands of the digestive system are most affected by ED. An analysis of literature data with a high degree of persuasive evidence that excessive use of ED can adversely affect human health and can lead to the development of multiple organ failure, with damage to the digestive organs.

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