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REAL AND PERCEIVED RISK (FOOD ADDITIVES)

Abstract: The food additive is any substance of known chemical composition that is not usually used as food for itself, nor is a typical food ingredient, regardless of nutritional value, and is added specifically for technological and organoleptic properties of food in the technological process of production, preparation, processing, finishing, processing, shaping, packaging, transport, and storage, which leads or can be expected to lead itself or its by-product to become a food ingredient directly or indirectly. Food additives are a necessity in food production technology. Their use causes consumer distrust and controversy among the professional public. The negative attitude of a significant number of consumers is due to the lack of awareness of legislation that can be removed before the approval of food additives through open, transparent, independent, responsible/timely communication on risk. On the other hand, research on inadequate labelling, toxicity, and the use of illicit food additives requires continuous monitoring, improved system control, and elimination of deficiencies. The safe use of food additives is a joint responsibility of the state, producers, distributors, the profession, i.e. the laboratory, but also the consumers themselves.

Keywords: food, additives, risk

INTRODUCTION

Definition of food additives

Rulebook on the use of food additives in food intended for human consumption ("Official Gazette of BiH", No. 83/08) defines "food additive" as any substance of known chemical composition that is not normally used as food in itself or is a typical food ingredient, regardless of nutritional value, and is added specifically for the techno-

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logical and organoleptic properties of food in the technological process of production, during preparation, processing, finishing, processing, shaping, packaging, transport, and storage, which leads or can be expected to lead to that he or his by-product directly or indirectly becomes an ingredient of that food[1,2]. Food additives do not include chemical contaminants or contaminants (metals and metalloids, pesticide residues, aflatoxins, other environmental organic substances, etc.), unwanted microorganisms, substances added to food to improve the nutritional value of foods, plant-based spices, their extracts and ferments, table salt and the like[3].

Division of food additives

The use of food additives is directly related to their basic functional, technological properties, so today they are divided into 22 categories: dyes, preservatives, antioxidants, emulsifiers, stabilizers, thickeners, gelling agents, acidity regulators, acids, anti-caking agents, flavour enhancers, sweetening or sweetening matter, modified starches, polishing agents, moisture-retaining agents, flour treating agents, hardeners, bulking agents, propellants, emulsifying salts, antifoaming agents and loosening agents[3]. The basic functional or technological property does not exclude the possibility that a certain food additive may have some other functional properties by changing the concentration and/or quantity[3]. Food additives can be of natural or synthetic origin[3]. Natural food additives of water originating from animals (animal gelatin, cholic acid, bile extract, mono- and diglycerides, amino acids), plants (guar gum, carob seeds, methylcellulose, pectin, gum tragacanth, agar, alginic acid, carrageenan, and the like), minerals (calcium carbonate, calcium phosphate, calcium sulfate, iron phosphate, iodine, magnesium chloride, magnesium oxide, magnesium phosphates, etc.) and microorganisms[4]. Synthetic food additives are produced by classical chemical synthesis from simple organic and inorganic compounds (such as sodium bicarbonate, formic acid, acetic acid)[4]. According to the degree of health safety, we distinguish food additives to be avoided (artificial colours, sodium nitrate, sodium nitrite, sodium benzoate, artificial sweeteners, sulphites, sulphur dioxide, artificial colours, orthophosphoric and similar acids), probably healthy food additives (pectin, lecithin, gelatin, vitamins, minerals, citric, lactic acid, alginates, natural flavours, natural colours, casein, lactose, natural vanillin), food additives with the limited content that can be used with caution (monosodium glutamate, aspartame, butyl hydroxyanisole, butylhydroxytoluene tertiary butyl hydroquinone, caffeine, propylene glycol, gums, xylitol), aromatic substances and natural ingredients used as food additives without special data on scientific tests of the safety of their use or with a limited amount of information[1,5,6].

Health and safety aspects of food additives

All food additives must be tested and evaluated before use in food production[5]. Toxicological studies include acute, subacute, and chronic toxicity, genotoxicity, allergenicity, and carcinogenicity [5]. It determines the maximum amount of food additive that has no toxicological effects on human health (NOAEL), the minimum amount of food additive that can have a detrimental effect on human health (Lowest observed advance effect level, LOAEL), acceptable daily intake of food additive, i.e. the amount of food additive that as an integral part of the food can be consumed daily for a lifetime without any risk to health (Acceptable Daily Intake, ADI) [5,6,7]. Food additives can be added to food if their use is technologically justified (the final effect cannot be achieved in ways that are economically and technologically more applicable), their quantities allowed by special regulations, do not significantly affect the natural taste and smell of food to which they are added. do not mislead consumers as to the true nature, ingredients or nutritional value of the food (unless it is for a specific purpose), its use in the production of basic or seasonal foods must be limited, their mixing and addition to food does not lead to toxic substances (products) during processing, storage, and use, their use does not endanger the health of consumers [1,3,8].

Labelling of food additives

Food additives are marked with an E-number as a confirmation of toxicological evaluation and classification of an individual food additive [3]. E numbers are categorized as follows: E100 - E181 (dyes), E200 - E285 and 1105 (preservatives), E300 - E340 (antioxidants), different numbers (acidity regulators), E 322, E400 - E499 and 1400 - 1451 (thickeners) , emulsifiers), E500 - E572 (anti-caking agents), E600 - E650 (flavour enhancers), E900 - E910 (polishing agents), E420 - 421 and E950 - 97 (substances for sweeteners) [5,9]. According to the Rulebook on providing information to consumers about food ("Official Gazette of BiH", No. 68/13), food additives may be placed on the market only if they are marked with data in accordance with the Rulebook on Food Additives ("Official Gazette of BiH", No. 33/18), which must be clearly visible, clearly legible, indelible, and accessible in one of the official languages and scripts in use in Bosnia and Herzegovina, comprehensible to the user [10].

Risk perception

Risk implies the likelihood of harm or danger (a threat that may be personal or directed at people or things we value) [11]. Probability (an uncertain aspect of risk) is associated with disagreement about its size and severity [11]. Interpretation and subjective risk assessment mean risk perception [11]. Risk perception has two components,

cognitive (knowledge and understanding of risk) and emotional (feelings towards it)[11]. Consumers generally assess risk according to subjective perception, intuitive assessment, and conclusions from media reporting and other sources [11,12]. In decisions related to a particular health risk (such as risks associated with food additives), the most significant components of risk perception are perceived sensitivity, perceived weight, perceived benefit, and perceived barrier[11,13]. Perceived sensitivity implies a belief in one's own vulnerability (sensitivity to disease or another health risk) [11,13]. Perceived severity defines the severity of the agent's belief in the health risk, i.e. the possibility of causing negative physical (death, disability, illness) and/or social consequences (alienation, stigma, shame) [11,13]. Perceived benefit means the belief that health-responsible behavior will enable health risk management [11,13]. The perceived barrier defines the fear that the adoption of healthy responsible behavior will be prevented by the costs or negative aspects of the same [12,13].

Risk communication

Risk communication involves the exchange or sharing of risk information between decision-makers and other stakeholders [14]. Quality risk communication can significantly contribute to the success of a comprehensive and accountable risk management program (build public confidence in meaningful decisions related to risk assessment, risk management, and related risk and benefit considerations) [14]. Quality risk communication is based on openness, transparency, independence, accountability/timeliness and requires compliance with four basic guidelines: starting with a critical examination of the effectiveness of self-assessment and risk management, creating an integrated risk communication program (continuous communication with key stakeholders, including consumers) beginning of the evaluation process), adapting the communication to the needs of the target audience (not the needs of the information source) and harmonizing and adapting the communication program in an organized effort to gather feedback and recognize changes in values and preferences [15]. Successful communication requires hazard identification and characterization, exposure assessment, and risk characterization [15]. To achieve it, it is necessary to use tools and channels suitable for participants and set goals (media, websites, printed and digital communications, meetings and workshops, public consultations, partner networks, social networks, blogging) [15,16].

THE REAL RISK OF FOOD ADDITIVES

Toxicological effects of food additives

Toxicological effects of food additives include acute, subacute, and chronic toxicity, genotoxicity, allergenicity, and carcinogenicity[17]. A study in the United

Kingdom involving 1,873 three-year-olds found a statistically significant effect of excessive consumption of artificial colors and sodium benzoate on the development of attention deficit hyperactivity disorder (ADHD) in previously healthy children [11]. Another group of British researchers came to similar conclusions in a randomized, double-blind, placebo-controlled study of 153 three-year-olds and 144 eight-year-olds and nine-year-olds [18]. Although most later similar studies had a non-standardized diagnosis, questionable sample selection, imperfect blindness, and non-standardized outcome measures of the European Union countries made the decision on mandatory labelling of foods containing artificial colors (warning of hyperactivity and attention deficit disorder) [19,20,21]. Studies by authors from the United States have found that the nine colors allowed are potentially carcinogenic (red 40, yellow 5 and yellow 6 are contaminated with benzidine or other carcinogens), genotoxic (yellow 5), allergenic (blue 1, red 40, yellow 5 and yellow 6) and toxic (citrus red 2) health22. Some of the artificial colors have been declared illegal due to proven harm to human health [22]. Despite the same, a significant number of studies indicate that the acceptable daily intake of artificial colors is exceeded, as well as the presence of illegal colors in the diet [23-31]. New evidence suggests that permitted dietary emulsifiers may impair intestinal barrier function and increase exposure to antigen and/or modulating microbiota, potentially increasing the incidence of inflammatory bowel disease (irritable bowel syndrome, Crohn's disease) and metabolic syndrome (glucose intolerance) [32]. A group of Japanese authors found a strong correlation between emulsifier consumption (including polysorbates, sorbate esters, and lecithin) and the incidence of Crohn's disease [33]. A significant number of studies have shown a statistically significant association between fast food and margarine emulsifiers and ulcerative colitis and Crohn's disease [34,35]. Dietary lecithin, or more specifically phosphatidylcholine, has been indicated as a possible risk factor for coronary artery disease (as a consequence of the intestinal microbiota-mediated conversion of choline to the proatherogenic metabolite trimethylamine-N-oxide) [36]. Dihydroxy bile acid intestinal microbiota mediated by bile dehydroxylation (loss of 7a-hydro-hydroxyl group on the bile salt nucleus) increase the intake of bacteria in the human colon [37]. A significant increase in bacterial deoxyribonucleic acid in the blood was verified in patients with cardiovascular disease, type 2 diabetes, and Crohn's disease [37]. The concentration of bacterial deoxyribonucleic acid in the blood of patients with Crohn's disease is an important prognostic factor for later relapses [31]. A prospective fourteen-year cohort study conducted in France involving 66,118 women found a statistically significant association between artificial sweetener consumption and the development of type 2 diabetes mellitus [38]. A seven-year study in the United States found that consuming more than one artificially sweetened beverage associated with a 36% higher relative risk of metabolic syndrome and 67% higher relative risk of type 2 diabetes compared to not consuming the same [39]. Research by Japanese authors has yielded similar results [40]. Artificial sweeteners are thought to

increase hedonistic cravings for sweetness and energy-rich foods [38,39,40]. Consumption of artificially sweetened beverages and consequent overestimation of the number of saved calories results in excessive consumption of other foods / beverages [38,39,40]. In addition, their use is an early confirmation of unsuccessful weight maintenance [38,39,40]. A promising twenty-two-year study by American authors found a statistically significant association between total aspartame intake and the development of non-Hodgkin's lymphoma and multiple myeloma in men and leukemia in men and women [41,42]. An in vitro model study established the interaction of aspartame and its metabolites with deoxyribonucleic acid [42]. Aspartame can cause the deoxyribonucleic acid chain to break down in the bone marrow cells of mice [42]. Its metabolite formaldehyde can cause an increase in lymphoma and leukemia in rats [42]. The acidity regulator, synthetic citric acid is a fermented discharge of the black mold Aspergillus niger [43]. Proteins or other by-products of Aspergillus niger that remain in citric acid after the manufacturing process or the highly concentrated synthetic form of citric acid itself with repeated exposure leads to the growth of proinflammatory cytokines and/or the formation of antibodies against Aspergillus [43]. Synthetic citric acid is thought to play a significant role in the development of fibromyalgia, idiopathic juvenile arthritis, allergic asthma, and autism spectrum disorders [43]. Aspergillus niger contains ochratoxin A, mycotoxin with nephrotoxic, immunotoxic, and carcinogenic effects [43,44]. Studies by Bulgarian authors have revealed a statistically significantly higher concentration of ochratoxins in the blood of people with Balkan endemic nephropathy [44]. Its immunosuppressive action is characterized by a decrease in the size of vital immune organs, depression of antibody function, changes in the number and function of immune cells, and modulation of cytokine production [44]. A statistically significant association between food consumption containing ochratoxin A and the incidence of testicular cancer was found in 20 countries of the European Union [44]. Amaranth dye in animals causes the formation of kidney stones and induces abortions, and due to its potential carcinogenicity, it is banned in the United States and Russia [45.46]. The dye tartrazine is an allergen for people sensitive to aspirin or benzoic acid, and there may be respiratory problems, rashes, visual disturbances, hyperactivity in children. Its use is prohibited in Norway [45]. In sensitive individuals, glutamic acid in high concentrations can cause numbness in the back of the head, back, and arms, palpitations, headaches, and a feeling of weakness (so-called Chinese restaurant syndrome) [45]. Allergic and pseudo allergic reactions of people suffering from asthma and neurodermatitis are possible [45]. High concentrations can lead to brain cell damage and neurodegenerative diseases (Alzheimer's, Parkinson's, and Huntington's disease) [45]. Nitrites interfere with the transport of oxygen in the blood [45]. At temperatures above 130 ° C they can form carcinogenic nitrosamines [45]. In high doses, they lead to acute poisoning45. They can cause hyperactivity syndrome in children [45]. The association between dietary nitrate, nitrite, and nitrosamine intake and gastric cancer risk (measured as relative risk) varied between 0.69–0.93

[39.40]. Butylhydroxyanisole is a synthetic antioxidant that increases the concentration of cholesterol and fatty acids in the blood and can cause numbness and allergies [45]. It is banned in Japan in baby food because it can cause hyperactivity syndrome [45].

Excessive intake of food additives

Exposure studies of children in 16 Indian states on the use of artificial colors found that most sweets, sugar toys, mouth fresheners, ice candies, soft drinks, and bakery products exceeded the prescribed limit of 100 mg/kg [24]. Intake of a mixture of artificial colors sunset yellow FCF and tartrazine exceeded the limits of acceptable daily intake three to twelve times, while erythrosine intake was two to six times higher at average levels of detected dyes [24]. Another group of Indian researchers found in crushed ice samples that the permitted intake of a mixture of artificial colors sunset yellow FCF and tartrazine was exceeded eight to twenty times in urban areas, as well as excessive intake of a mixture of colors sunset yellow FCF, tartrazine and carmoisine by 15 to 23 times in rural areas [25]. A study in India, which included 545 finished products with artificial colors, found that 73% of them contained an excessive amount of permitted colors, among which tartrazine was in the lead [26]. Investigating the intake of sweeteners in beverages, the Norwegian Scientific Commission for Food Safety found that the intake of acesulfame K is very close to the acceptable daily intake, not counting the intake from other sources3. As such beverages are often intended for young children up to four years of age, the intake of benzoate preservatives exceeds the permissible acceptable daily intake [3]. This is an important fact because the daily intake does not include the conversion of benzyl derivatives from aromas that are metabolized in the body into benzoic acid, nor the intake of benzoic acid from cosmetics and syrups [3]. Studies in Finland have found that the average daily intake of nitrite in children was up to 89% of the acceptable daily intake [47]. A study conducted in France examined the intake of 13 additives (dyes, preservatives, antioxidants, stabilizers, emulsifiers, and sweeteners) according to two assumptions: consumers consume food that may or may not contain food additives, consumers always eat food that contains food additives) possible [48]. Under the first assumption, there is an excess of acceptable daily intake of nitrite and sulfite in adults, 155% and 118.4%, respectively, and an excess of acceptable daily intake of nitrite in children, 275% [42]. According to the second assumption, the average dietary exposure to children exceeds acceptable daily intake, 146.7% [49]. For large consumers, the average exposure of adults exceeds nitrite and sulfite acceptable daily intakes (223 and 156.4% respectively), while children exceed nitrite, anatase, and sulfite acceptable daily intakes (416.7, 124.6, and 130.6% respectively) [49]. A three-year study by a group of authors in Austria assessing exposure to preservatives (sulfites, benzoic and sorbic acid) in the high intake scenario, assuming that consumers have some loyalty and always consume food products containing food additives, found

that the acceptable daily intake for sulfites in adults (119 and 124%, respectively) and benzoic was exceeded. acids in all population groups (135% in preschool children, 124% in women, and 118% in men) [50]. A study conducted among children in Estonia found that 137 out of 346 children take excessive amounts of nitrite (up to 140% of acceptable daily intake) for children aged 1-6 years) [51]. Studies by Kuwaiti authors that included 3141 children under the age of fourteen found that the acceptable daily intake was exceeded for four of the nine permitted colors: tartrazine, sun yellow, carmoisine, and alura red51. A dietary study of anata (E160b), nitrites (E249-250), sulfites (E220-228), and tartaric acid (E334) in France found that 2.9% of the adult population consuming alcoholic beverages exceeded the acceptable daily intake of sulfite, primarily vine [52]. A study in Belgium on 211 food and beverage samples (including 85 wine samples) prepared according to the usual domestic recipe found that the acceptable daily intake for children and adults was exceeded [53]. A group of authors from Hong Kong found that the acceptable daily exposure to nitrates in raw vegetables was exceeded by 20% for average consumers and 250% for large consumers [54]. In cooked vegetables, the excess of acceptable daily intake was found for large consumers in the amount of 170% [48]. A study by Indian authors followed the consumption of 14 food additives among 311 teenagers aged 13-19 [54,55]. Statistically, significantly higher consumption of food additives was recorded in teenagers aged 13-15 [54,55]. The probable mean daily intake for sulfites and erythrosine for large consumers was 105% and 344% of the acceptable daily intake [48.49], respectively. A study in Norway found that the acceptable daily intake of benzoic acid was exceeded in children aged 1-13 years, especially among the youngest [56].

Presence of illicit food additives

A study by Iranian authors found the presence of illicit colors rhodamine B, methanil yellow, orange II, malachite green, auramine, quinoline yellow, amaranth, and sudan in various food products [25]. A study conducted in India, which included 545 finished products with artificial colors, found that 2% of them contain a combination of allowed and illegal colors, 8% only illegal colors [26]. Among the illicit colors, rhodamine was in the lead [26]. Studies by Pakistani researchers have found the presence of unauthorized colors in 46.57% of confectionery products selected by random sampling [27]. Studies in Iran 573 samples of restaurant food determined the presence of illicit artificial colors in 0.5% of samples with a solution of saffron [28]. By liquid chromatography/ tandem mass spectrometry, a group of Thai researchers proved the presence of the illicit artificial color aramant in imported fruit preserved with syrup [29]. Examination of food products sold near educational institutions in Pakistan found the presence of illicit colors in 11% of branded food products and 44% of unbranded food products, 4% of branded and 30% of non-branded beverages [31]. Studies of im-

ported food products in Indonesia have revealed the presence of harmful substances such as formaldehyde, rhodamine B, saccharin, benzoic acid, methanol, cyclamate, and other illicit dyes [31]. The inefficiency of regulations on the control of imported food products, limited staff/field officials, an unfounded form of supervision (many lanes of unofficial goods in the border region), low producer responsibility, poor legal awareness of consumers about reporting problematic food products, and poor law enforcement are identified as the most important reasons [31] . Preventive measures such as rigorous import regulations, strict product controls and adequate sanctions are cited as possible solutions [31].

Inadequate labelling of food additives

A study conducted in Ghana found that 90% of the sampled products labelled "No additives" (fruit juices, then milk and soft drinks) contained one or more food additives57. In the research of residual sulfur dioxide in dried fruit samples from the Belgrade market, out of the analysed twelve samples, the sulfur dioxide content in eight was significantly higher than declared, while in two samples it was above the maximum allowed concentration58. In a study by a group of authors from Brazil, 31.4% of the analysed products had some kind of non-compliance, and 12.1% of the products did not have any consumer warning about the presence of allergens59. A study conducted in Malawi found that none of the 105 locally produced products have an allergen declaration60. Research by the Chinese State Food and Drug Administration 257,000 food samples identified 8,224 inadequate samples, of which 33.6% were caused by abuse or overuse of food additives [61].

Perceived risk of food additives

Due to different assessment strategies and resources, the scientific opinion and perceptions of lay people about the risk of food additives very often do not match [56]. Scientific risk perception is a very complex process (based on risk assessment and management), while lay consumers rarely do so due to lack of time or motivation [62]. When the risks are unknown, consumers will form ratings using subjective perception, intuitive assessment and conclusions from media reporting [11,12,56]. The study was conducted in Australia among 572 high school students aged 12 to 15 years identified dyes and sweeteners for the most controversial food additives, as they are not necessary for food safety as preservatives [63]. A study by a group of authors from Switzerland found a lack of awareness of the legislation that precedes the approval of food additives, which could lead consumers to overestimate the uncertainty regarding their risk assessment [64]. Numerous, but not always reliable, print and electronic media

information contribute to this [64]. Abuse and/or overuse of food additives in China has jeopardized the rational understanding of food safety and worsens the perception of risk [61]. A survey by a group of Danish authors found that the vast majority of respondents, 95%, believe that many or almost all products contain processing additives [64]. When it comes to labelling food additives, 65% of respondents believe that there is a need for labelling, but only 15% (every seventh respondent) believe in its benefits [65]. About 15% often think about food additives when buying food, almost 40% think every time they buy food, 15% never think, while 30% think when they are mentioned by the media [65]. About 25% of respondents think that it is easy to assess the risk of using food additives, while 55% do not think that it is not so [65]. Almost 40% of respondents try to avoid dyes, 30% sweeteners, while 15% try to avoid all food additives [65]. About 30% of respondents believe that food additives serve to cover poor product quality, 20% do not believe safety risk assessments, 15% believe that food additives increase profits for large companies, 75% partially or completely agree that food additives cause allergies, 70% partially or completely agree that they are the cause of hormonal disorders, 60% of respondents believe that they are carcinogenic, while 40% of respondents link them to infertility, obesity, and hyperactivity in children [65]. A study by Hungarian authors found that most respondents have a negative feeling towards food additives [65]. Although they understand that these are substances that have some technological functions, they believe that their main task is to increase profits for food producers [66]. The greatest concern was caused by preservatives and dyes due to the potential carcinogenic effect [66]. Consumers were virtually unaware of the rigorous system of approval and control of food additives [66]. Although they assume that there are regulations on food safety, they doubt their effectiveness [60]. They believe that the regulatory authorities do not have enough money and that the testing period is too short [66]. Research in the UK indicates that a significant number of consumers believe that the use of food additives is associated with the development of allergies (44%) and hyperactivity (24%) [67]. The perceived health risks associated with the consumption of food additives include Chinese consumers hyperactivity, development of allergies, asthma, hay fever, and cancer [68]. Second, a group of researchers in the UK pointed to poor knowledge of food additives by consumers (around 65% of all respondents had never checked food additives on food labels) [69]. Studies by Dutch authors have found that low reliability in the food industry and the prevalence of negative information about food additives on the Internet and social networks are the main causes of high-risk perception [70]. A series of scandals in Taiwan that are included the addition of illegal food additives, which led to high perceptions of danger among the population and consequent rejection of food containing chemical additives [71]. About 64% of consumers interviewed in Brazilian supermarkets knew the definition of a food additive72. 87% of them considered them harmful to health [66]. The same profile was recorded among university students and patients [66]. A study by authors from the United States found

difficulties in pronouncing the names of food additives, real or imagined, associated with the perception of their risk [73]. Food additives whose names are more difficult to pronounce are usually considered new or less well-known and harmful to health [73]. In a study conducted among workers in the Czech Republic and Germany, the perception of risk is related to the size of the name of the food additive [74].

CONCLUSION

Food additives are a necessity in food production technology. Their use causes consumer distrust and controversy among the professional public. The negative attitude of a significant number of consumers due to the lack of awareness of the legislation that precedes the approval of food additives can be removed through open, transparent, independent, responsible/timely communication on risk. On the other hand, research on inadequate labelling, toxicity, and the use of illicit food additives requires continuous monitoring, improvement of the control system, and elimination of deficiencies. The safe use of food additives is a joint responsibility of the state, producers, distributors, the profession, i.e. laboratories, but also the consumers themselves.

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