Marijana C. Jandrić-Kočić¹

STVARNI PERCIPIRANI RIZIK (PREHRAMBENI ADITIVI)

Apstrakt: Prehrambeni aditiv je svaka tvar poznatog hemijskog sastava koja se uobičajeno ne upotrebljava kao hrana sama za sebe, niti je tipičan sastojak hrane, bez obzira na prehrambenu vrijednost, a dodaje se namjenski radi tehnoloških i organoleptičkih svojstava hrane u tehnološkom postupku proizvodnje, tokom pripreme, obrade, dorade, prerade, oblikovanja, pakovanja, transporta i čuvanja, što dovodi ili se može očekivati da dovede do toga da on sam ili njegov sekundarni proizvod direktno ili indirektno postaje sastojak te hrane. Prehrambeni aditivi su nužnost u tehnologiji proizvodnje hrane. Njihova upotreba izaziva nepovjerenja potrošača i kontroverzu stručne javnosti. Negativan stav značajnog broja potrošača usljed nedostatka svijesti o zakonskoj regulativi, koja prethodi odobrenju prehrambenih aditiva, može se ukloniti kroz otvorenu, transparentnu, nezavisnu, odgovornu/pravovremenu komunikaciju o riziku. S druge strane, istraživanja o neadekvatnom označavanju, toksičnosti i upotrebi nedozvoljenih prehrambenih aditiva zahtijevaju kontinuirano praćenje, unapređenje sistema kontrole i uklanjanja nedostataka. Sigurna upotreba prehrambenih aditiva je zajednička odgovornost države, proizvođača, distributera, struke, odnosno laboratorija, ali i samih potrošača.

Ključne riječi: hrana, aditivi, rizik

Summar: Food additive is 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 technological 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 the fact that he or his by-product directly or indirectly becomes an ingredient of that food. 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,

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independent, responsible / timely communication on risk. On the other hand, research on inadequate labeling, 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, ie laboratories, but also the consumers themselves.

Keywords: food, additives, risk

UVOD

Definicija prehrambenih aditiva

Pravilnik o upotrebi prehrambenih aditiva u hrani namijenjenoj prehrani ljudi („Službeni glasnik BiH”, broj 83/08) definiše „prehrambeni aditiv” kao svaku tvar poznatog hemijskog sastava koja se uobičajeno ne upotrebljava kao hrana sama za sebe, niti je tipičan sastojak hrane, bez obzira na prehrambenu vrijednost, a dodaje se namjenski radi tehnoloških i organoleptičkih svojstava hrane u tehnološkom postupku proizvodnje, tokom pripreme, obrade, dorade, prerade, oblikovanja, pakovanja, transporta i čuvanja, što dovodi ili se može očekivati da dovede do toga da on sam ili njegov sekundarni proizvod direktno ili indirektno postaje sastojak te hrane.^{1,2}

Prehrambenim aditivima se ne smatraju hemijska onečišćenja ili kontaminanti (metali i metaloidi, ostaci pesticida, aflatoksina, druge organske tvari iz okoliša i slično), neželjeni mikroorganizmi, tvari koje se dodaju hrani radi poboljšanja hranjive vrijednosti namirnica, začini na bazi biljaka, njihovi ekstrakti i fermenti, kuhinjska sol i slično.³

Podjela prehrambenih aditiva

Upotreba prehrambenih aditiva neposredno je vezana za njihovo osnovno funkcionalno, tehnološko svojstvo tako da su danas podijeljeni u 22 kategorije: bojila, konzervansi, antioksidansi, emulgatori, stabilizatori, zgušnjivači, tvari za želiranje, regulatori kiselosti, kiseline, tvari za sprječavanje zgrudnjavanja, pojačivači okusa, tvari za zaslađivanje ili sladila, modificirani škrobovi, tvari za poliranje, tvari za zadržavanje vlage, tvari za tretiranje brašna, učvršćivači, povećivači volumena, potisni plinovi, emulgatorske soli, tvari protiv pjenjenja i tvari za rahljenje.³ Osnovno funkcionalno ili tehnološko svojstvo ne isključuje mogućnost da pojedini prehrambeni aditiv može imati i neka druga funkcionalna svojstva promjenom koncentracije i/ili količine.³ Prehrambeni aditivi mogu biti prirodnog i sintetskog porijekla.³ Prirodni prehrambeni aditivi vode porijekla iz životinja (životinjski želatin, holna kiselina, žučni ekstrakt,

mono- i digliceridi, aminokiseline), biljaka (guar guma, sjemenke rogača, metil-celuloza, pektin, tragakanat guma, agar, alginska kiselina, karagenan i slično), minerala (kalcij-karbonat, kalcij-fosfat, kalcij-sulfat, željezo-fosfat, jod, magnezij-klorid, magnezij-oksidi, magnezij fosfati i slično) i mikroorganizama.⁴ Sintetski prehrambeni aditivi se proizvode klasičnom hemijskom sintezom od jednostavnih organskih i neorganskih spojeva (kao što su natrijev hidrokarbonat, mravlja kiselina, sirćetna kiselina).⁴ Prema stepenu zdravstvene sigurnosti razlikujemo: prehrambene aditive koje treba izbjegavati (vještačke boje, natrijum-nitrat, natrijum-nitrit, natrijum-benzoat, umjetni zaslađivači, sulfiti, sumpor-dioksid, vještačke boje, ortofosforna i slične kiseline), vjerovatno zdravstveno sigurne prehrambene aditive (pektin, lecitin, želatin, vitamini, minerali, limunska, mliječna kiselina, alginati, prirodne arome, prirodne boje, kazein, laktoza, prirodni vanillin), prehrambene aditive sa ograničenim udjelom koji se mogu koristiti uz oprez (mononatrijum glutaminat, aspartman, butil-hidroksianisol, butil-hidroksitoluen tercijalni butil-hidrokinon, kofein, propilen-glikol, gume, ksilitol), aromatske supstance i prirodne sastojke koji se koriste kao prehrambeni aditivi bez posebnih podataka o naučnim ispitivanjima sigurnosti njihove upotrebe ili sa ograničenim brojem informacija.^{1,5,6}

Zdravstveni i sigurnosni aspekti prehrambenih aditiva

Prije upotrebe u proizvodnji namirnica svi prehrambeni aditivi moraju biti ispitani i ocijenjeni.⁵ Toksikološka ispitivanja uključuju akutnu, subakutnu i hroničnu toksičnost, genotoksičnost, alergogenost i kancerogenost.⁵ Istim se utvrđuje najveća količina prehrambenog aditiva koja nema toksikoloških učinaka na zdravlje ljudi (engl. No observed advance effect level, NOAEL), najmanja količina prehrambenog aditiva koja može štetno djelovati na zdravlje ljudi (Lowest observed advance effect level, LOAEL), prihvatljiv dnevni unos prehrambenog aditiva, odnosno količina prehrambenog aditiva koja se kao sastavni dio namirnice može svakodnevno konzumirati čitav životni vijek bez postojanja ikakva rizika za zdravlje (engl. Acceptable Daily Intake, ADI).^{5,6,7}

Prehrambeni aditivi se mogu dodati hrani ukoliko je njihova upotreba tehnološki opravdana (konačni učinak se ne može postići načinima koji su ekonomski i tehnološki primjenjivi), njihova količina dopuštena je posebnim propisima, bitno ne utječu na prirodno svojstveni okus i miris hrane kojoj su dodani, svojim prisustvom ne dovode u zabludu potrošača u pogledu prave prirode, sastojaka ili prehrambene vrijednosti hrane (osim ako im to nije posebna namjena), njegova upotreba u proizvodnji osnovnih namirnica ili namirnica koje se sezonski uživaju mora biti ograničena, njihovo miješanje i dodavanje hrani ne dovodi do stvaranja toksičnih tvari (produkata) tijekom prerade, čuvanja i upotrebe, njihova upotreba ne ugrožava zdravlje potrošača.^{1,3,8}

Označavanje prehrambenih aditiva

Prehrambeni aditivi se označavaju E-brojem kao potvrdom toksikološke evaluacije i klasifikacije pojedinog prehrambenog aditiva.³ E-brojevi su kategorisani na sljedeći način: E100 – E181 (bojila), E200 – E285 i 1105 (konzervansi), E300 – E340 (antioksidansi), različiti brojevi (regulatori kiselosti), E322, E400 – E499 i 1400 – 1451 (zgušnjivači, emulgatori), E500 – E572 (tvari za sprječavanje zgrudnjavanja), E600 – E650 (pojačivači okusa), E900 – E910 (tvari za poliranje), E420 – 421 i E950 – 97 (tvari za ili sladila).^{5,9} Prema Pravilniku o pružanju informacija potrošačima o hrani („Službeni glasnik BiH”, broj 68/13), prehrambeni aditivi se mogu stavljati na tržište samo ako su označeni podacima u skladu sa Pravilnikom o prehrambenim aditivima („Službeni glasnik BiH”, broj 33/18), koji moraju biti dobro vidljivi, jasno čitljivi, neizbrisivi i dostupni na jednom od službenih jezika i pisama u upotrebi u Bosni i Hercegovini, razumljivom za korisnika.¹⁰

Percepcija rizika

Rizik podrazumjeva vjerovatnoću nanošenja štete ili opasnosti (prijetnja koja može biti lična ili usmjerena prema osobama ili stvarima koje cijenimo).¹¹ Vjerovatnoća (nesiguran aspekt rizika) povezan je sa neslaganjem oko veličine i težine istog.¹¹ Tumačenje i subjektivna procjena rizika označava percepciju rizika.¹¹ Percepcija rizika ima dvije komponente, kognitivnu (poznavanje i razumijevanje rizika) i emocionalnu (osjećanja prema istom).¹¹ Potrošači uglavnom procjenjuju rizik prema subjektivnoj percepciji, intuitivnoj procjeni i zaključcima iz medijskog izvještavanja i drugih izvora.^{11,12} U odlukama povezanim sa određenim zdravstvenim rizikom (poput rizika povezanih sa prehrambenim aditivima) najznačajnije komponente percepcije rizika su: percipirana osjetljivost, percipirana težina, percipirana korist i percipirana barijera.^{11,13} Percipirana osjetljivost podrazumjeva uvjerenje o sopstvenoj ranjivosti (osjetljivost na bolest ili drugi zdravstveni rizik).^{11,13} Percipirana ozbiljnost definiše ozbiljnost uvjerenja o zdravstvenom riziku agensa, odnosno mogućnosti da izazove negativne fizičke (smrt, invalidnost, bolest) i/ili socijalne posljedice (otuđenost, stigma, sram).^{11,13} Percipirana korist označava vjerovanje da će zdravstveno odgovorno ponašanje omogućiti upravljanje zdravstvenim rizikom.^{11,13} Percipirana barijera definiše bojazan da će usvajanje zdravstveno odgovornog ponašanja spriječiti troškovi ili negativni aspekti istog.^{12,13}

Komunikacija rizikom

Komunikacija rizikom podrazumjeva razmjenu ili dijeljenje informacija o rizicima između donositelja odluka i drugih zainteresovanih strana.¹⁴ Kvalitetna

komunikacija rizikom može značajno doprinijeti uspjehu opsežnog i odgovornog programa upravljanja rizikom (izgraditi povjerenje javnosti u svrsishodne odluke vezane za procjenu rizika, upravljanje rizikom i s njima povezanih razmatranja o riziku i dobrobiti).¹⁴ Kvalitetna komunikacija rizikom zasnovana je na otvorenosti, transparentnosti, nezavisnosti, odgovornosti/pravovremenosti i zahtjeva poštovanje četiri osnovne smjernice: početak s kritičkom provjerom djelotvornosti vlastite procjene i upravljanja rizikom, stvaranje integrisanog programa komunikacije rizikom (neprekidna komunikacija s najvažnijim sudionicima, uključujući potrošače, od samog početka postupka procjene), prilagođavanje komunikacije potrebama ciljne publike (ne potrebama izvora informacija) i usklađivanje i prilagođavanje programa komunikacije u organiziranom nastojanju prikupljanja povratne informacije, te uviđanja promjena u vrijednostima i preferencijama.¹⁵ Uspješna komunikacija zahtijeva identifikaciju i karakterizaciju opasnosti, procjenu izloženosti i karakterizaciju rizika.¹⁵ Za njeno ostvarivanje neophodna je primjena alata i kanala prikladnih sudionicima i postavljenim ciljevima (mediji, internetske stranice, štampane i digitalne komunikacije, sastanci i radionice, javne konsultacije, mreža partnera, socijalne mreže, blogiranje).^{15,16}

STVARNI RIZIK PREHRAMBENIH ADITIVA

Toksikološki efekti prehrambenih aditiva

Toksikološki efekti prehrambenih aditiva obuhvataju akutnu, subakutnu i hroničnu toksičnost, genotoksičnost, alergogenost i kancerogenost.¹⁷ Studija u Velikoj Britaniji, koja je obuhvatila 1.873 djece uzrasta od tri godine, utvrdila je postojanje statistički značajnog uticaja prekomjerne konzumacije umjetnih boja i natrijum-benzolata na razvoj poremećaja pažnje i hiperaktivnosti (engl. attention deficit hyperactivity disorder, ADHD) kod prethodno zdrave djece.¹¹ Druga grupa britanskih istraživača je u randomiziranom, dvostruko slijepom, placebo kontrolisanom istraživanju 153 trogodišnje i 144 osmogodišnje i devetogodišnje djece došla do sličnih zaključaka.¹⁸ Iako je većina kasnijih sličnih istraživanja imala nestandardizovanu dijagnozu, sumnjiv odabir uzorka, nesavršeno zasljepljivanje i nestandardizovane mjere ishoda zemlje Europske unije donijele su odluku o obaveznom označavanju hrane koja sadrži vještačke boje (upozorenje na mogućnost razvoja hiperaktivnosti i poremećaja pažnje).^{19,20,21} Studije autora iz Sjedinjenih Američkih Država utvrdile su da devet dozvoljenih boja djeluju potencijalno kancerogeno (crvena 40, žuta 5 i žuta 6 su kontaminirane benzidinom ili drugim karcinogenima), genotoksično (žuta 5), alergogeno (plava 1, crvena 40, žuta 5 i žuta 6) i toksično (citrus crvena 2) po zdravlje.²² Neke od vještačkih boja su proglašene nedozvoljenim zbog dokazane štetnosti po ljudsko zdravlje.²² Uprkos istom, značajan broj istraživanja ukazuje na prekoračenje prihvatljivog dnevnog unosa vještačkih boja, kao i prisustvo nedozvoljenih boja u ishrani.^{23–31} Novi dokazi

sugeriraju da dozvoljeni dijetalni emulgatori mogu narušiti funkciju crijevne barijere i povećavati izloženost antigenu i/ili modulirajućoj mikrobioti, čime potencijalno povećavaju učestalost upalnih bolesti crijeva (sindroma iritabilnog kolona, Kronova bolest) i metaboličkog sindroma (intolerancije glukoze).³² Grupa autora iz Japana utvrdila je snažnu korelaciju između potrošnje emulgatora (uključujući polisorbate, estere sorbata i lecitin) i učestalosti Crohnove bolesti.³³ Značajan broj istraživanja je dokazao statistički značajnu povezanost upotrebe emulgatora u brzoj hrani i margarinu sa razvojem ulceroznog kolitisa i Kronove bolesti.^{34,35} Prehrambeni lecitin, ili preciznije fosfatidilholin, naznačen je kao mogući faktor rizika za bolest koronarnih arterija (kao posljedice crijevnom mikrobiotom posredovane konverzije holina u pro-aterogeni metabolit trimetilamin-N-oksida).³⁶ Dihidroksi žučne kiseline (npr. henodeoksiholna i deoksiholna kiselina), nastale crijevnom mikrobiotom posredovanom dehidroksilacijom žučnih kiselina (gubitak 7 α -hidro-droksilna grupa na jezgri žučne soli), povećavaju unos bakterija u debelom crijevu čoveka.³⁷ Značajno povećanje bakterijske dezoksiribonukleinske kiseline u krvi verifikovano je kod oboljelih od kardiovaskularnih bolesti, dijabetesa tipa 2 i Kronove bolesti.³⁷ Koncentracija bakterijske dezoksiribonukleinske kiseline u krvi oboljelih od Kronove bolesti je važan prognostički faktor kasnijih recidiva.³¹ Prospektivna kohortna studija provedena u Francuskoj u trajanju od četrnaest godina, koja je obuhvatila 66.118 žena, utvrdila je postojanje statistički značajnu povezanost konzumiranja umjetnih zaslađivača i razvoja dijabetesa melitusa tipa 2.³⁸ Istraživanje provedeno u Sjedinjenim Američkim Državama, u trajanju od sedam godina, utvrdilo je da je konzumiranje više od jednog umjetno zaslađenog napitka povezano sa 36% većim relativnim rizikom od metaboličkog sindroma i 67% većim relativnim rizikom od dijabetesa tipa 2 u poređenju sa nekonzumiranjem istih.³⁹ Istraživanje autora iz Japana došlo je do sličnih rezultata.⁴⁰ Smatra se da umjetni zaslađivači povećavaju hedonističke želje za slatkoćom i energetski bogatom hranom.^{38,39,40} Konzumiranjem umjetno zaslađenih napitaka i posljedično precjenjivanje broja uštedjenih kalorija rezultira prekomjernom konzumacijom druge hrane/pića.^{38,39,40} Osim toga, njihova upotreba je rana potvrda neuspješnog održavanja tjelesne težine.^{38,39,40} Perspektivna dvadesetdvogodišnja studija američkih autora utvrdila je statistički značajnu povezanost ukupnog unosa aspartama i razvoja Non-Hoćkin limfoma i multiplog mijeloma kod muškaraca i leukemije kod muškaraca i žena.^{41,42} Studija na in vitro modelu utvrdila je interakciju aspartama i njegovih metabolita s dezoksiribonukleinskom kiselinom.⁴² Aspartam može izazvati pucanje lanca dezoksiribonukleinske kiseline u ćelijama koštane srži miševa.⁴² Njegov metabolit formaldehid može uzrokovati porast limfoma i leukemija kod štakora.⁴² Regulator kiselosti, sintetska limunska kiselina predstavlja fermentirani iscjedak crne plijesni *Aspergillus niger*.⁴³ Proteini ili drugi nusproizvodi *Aspergillus niger* koji ostaju u limunskoj kiselini nakon proizvodnog procesa ili sam visokokonzentrovani sintetski oblik limunske kiseline s ponovljenim izlaganjem dovodi do rasta proupalnih

citokina i/ili stvaranja antitijela protiv *Asprrgilusa*.⁴³ Smatra se da sintetska limunska kiselina ima značajnu ulogu u razvoju fibromijagije, idiopatskog juvenilnog artritisa, alergijske astme i poremećaja iz spektra autizma.⁴³ *Aspergillus niger* sadrži ohratoksin A, mikotoksin sa nefrotoksičnim, imunotoksičnim i kancerogenim dejstvom.^{43,44} Studije bugarskih autora otkrile su statistički značajno veću koncentraciju ohratoksina u krvi osoba oboljelih od Balkanske endemske nefropatije.⁴⁴ Njegovo imunosupresivno djelovanje karakteriše smanjenje veličine vitalnih imunoloških organa, depresije funkcije antitijela, promjena broja i funkcije imunih ćelija i modulacije proizvodnje citokina.⁴⁴ Ohratoksin Akoji ometa sistem reparacije dezoksiribonukleinske kiseline i može poslužiti kao početna točka karcinogeneze.^{43,44} Statistički značajna povezanost potrošnje hrane koja sadrži ohratoksin A i učestalost raka testisa utvrđena je u 20 zemalja Europske unije.⁴⁴ Bojilo amarant kod životinja uzrokuje stvaranje bubrežnih kamenaca i indukuje pobačaje, a zbog potencijalne karcinogenosti zabranjen je u Sjedinjenim Američkim Državama i Rusiji.^{45,46} Bojilo tartrazin alergogen je za osobe osjetljive na aspirin ili benzojevu kiselinu, a moguće su smetnje disanja, osip, poremećaji vida, hiperaktivnost kod djece. Njegova upotreba zabranjena je u Norveškoj.⁴⁵ Kod osjetljivih osoba glutaminska kiselina u visokim koncentracijama može izazvati osjećaj obamrlosti u potiljku, leđima i rukama, lupanje srca, glavobolju i osjećaj slabosti (tzv. sindrom kineskog restorana).⁴⁵ Moguće su alergijske i pseudoalergijske reakcije osoba koje boluju od astme i neurodermatitisa.⁴⁵ Visoke koncentracije mogu dovesti do oštećenja moždanih stanica i neurodegenerativnih bolesti (Alzeheimerova, Parkinsonova i Huntingtonova bolest).⁴⁵ Nitriti ometaju transport kiseonika u krvi.⁴⁵ Pri temperaturama višim od 130°C mogu stvarati karcinogene nitrozamine.⁴⁵ U visokim dozama dovode do akutnog trovanja.⁴⁵ Kod djece mogu izazvati sindrom ahiperaktivnosti.⁴⁵ Povezanost između unosa nitrata, nitrita i nitrosamina u ishrani i rizika od raka želuca (mjereno kao relativni rizik) varirala je između 0,69–0,93.^{39,40} Butilhidroksianisol je sintetski antioksidans koji povisuje koncentraciju holesterola i masnih kiselina u krvi, te može izazvati obamrlost i alergije.⁴⁵ Zabranjen je u Japanu u hrani za djecu, jer može uzrokovati sindrom hiperaktivnost.⁴⁵

Prekomjeran unos prehrambenih aditiva

Studije izloženosti djece provedene u 16 država Indije o upotrebi vještačkih boja utvrdile su da je većina slatkiša, šećernih igračaka, osvježivača usta, ledenih bombona, bezalkoholnih pića i pekarskih proizvoda premašila propisanu granicu od 100 mg/kg.²⁴ Unos smjese vještačkih boja zalazak sunca žuti FCF i tartrazin je premašio granice prihvatljivog dnevnog unosa tri do dvanaest puta, dok je unos eritrozina bio veći za dva do šest puta na prosječnim nivoima otkrivenih boja.²⁴ Druga grupa indijskih istraživača je u uzorcima drobljenog leda utvrdila prekoračenje dozvoljenog unosa smjese vještačkih boja zalazak sunca žuti FCF i tartrazin osam do dvadeset puta u urbanim

sredinama, kao i prekomjerni unos smjese boja zalazak sunca žuti FCF, tartrazin i karmoizin za 15 do 23 puta u ruralnim sredinama.²⁵ Istraživanje u Indiji, koje je obuhvatilo 545 gotovih proizvoda sa vještačkim bojama, utvrdilo je da 73% istih sadrži prekomjernu količinu dozvoljenih boja među kojim je prednjačio tartazin.²⁶ Istražujući unos sladila u napicima Norveška naučna komisija za sigurnost hrane utvrdila je da je unos acesulfama K vrlo blizu prihvatljivog dnevnog unosa ne računajući unos iz drugih izvora.³ Kako su takva pića često namijenjena za malu djecu do četiri godine, unos konzervansa benzoata prelazi dopušteni prihvatljivi dnevni unos.³ Ovo je važan podatak jer u dnevni unos nisu računate konverzije benzilnih derivata iz aroma koje se u tijelu metaboliziraju u benzojevu kiselinu, a ni unos benzojeve kiseline iz kozmetičkih proizvoda i sirupastih lijekova.³ Istraživanja u Finskoj utvrdila su da je prosječni dnevni unos nitrita kod djece iznosio i do 89% prihvatljivog dnevnog unosa.⁴⁷ Studija provedena u Francuskoj istraživala je unos 13 aditiva (boja, konzervansa, antioksidansa, stabilizatora, emulgatora i zaslađivača) prema dvije pretpostavke: potrošači konzumiraju hranu koja može ali ne mora sadržavati prehrambene aditive, potrošači uvijek jedu hranu koja sadrži prehrambene aditive) kad je to moguće.⁴⁸ Pod prvom pretpostavkom, postoji prekoračenje prihvatljivog dnevnog unosa nitrita i sulfita kod odraslih osoba, 155%, odnosno 118,4%, i prekoračenje prihvatljivog dnevnog unosa nitrita kod djece, 275%.⁴² Prema drugoj pretpostavci, prosječna izloženost nitritima ishrani u djece premašuje prihvatljivi dnevni unos, 146,7%⁴⁹. Za velike potrošače, prosječna izloženost odraslih premašuje nitritne i sulfite prihvatljive dnevne unose (223 i 156,4% respektivno), dok djeca premašuju nitritne, anatozne i sulfite prihvatljive dnevne unose (416,7, 124,6 i 130,6% respektivno).⁴⁹ Trogodišnja studija grupe autora u Austriji, koja je procjenjivala izloženost konzervansima (sulfiti, benzojeva i sorbinska kiselina) u scenariju visokog unosa, pod pretpostavkom da potrošači imaju određen vid lojalnosti i uvijek konzumiraju prehrambene proizvode koji sadrže prehrambene aditive, utvrdila je prekoračenje prihvatljivog dnevnog unosa za sulfite kod odraslih (119, odnosno 124%) i benzojeve kiseline u svim populacijskim skupinama (135% kod djece predškolskog uzrasta, 124% kod žena i 118% kod muškaraca).⁵⁰ Istraživanje provedeno među djecom u Estoniji utvrdilo je da 137 od 346 djece uzima prekomjernu količinu nitrita (do 140% prihvatljivog dnevnog unosa za djecu uzrasta 1–6 godina).⁵¹ Studije kuvajtskih autora, koje su obuhvatile 3.141 dijete uzrasta do četrnaest godina, utvrdile su prekoračenje prihvatljivog dnevnog unosa za četiri od devet dozvoljenih boja: tartrazin, žuta boja sunca, karmoizin i alura crvena.⁵¹ Istraživanje izloženosti prehrane anatu (E160b), nitritima (E249–250), sulfitima (E220–228) i vinskoj kiselini (E334) u Francuskoj utvrdilo je prekoračenje prihvatljivog dnevnog unosa sulfita kod 2,9% odrasle populacije koja je konzumirala alkoholna pića, prvenstveno vina.⁵² Istraživanje u Belgiji na 211 uzoraka hrane i pića (uključujući 85 uzoraka vina), pripremljenim prema uobičajenoj domaćoj recepturi, utvrdilo je

prekoračenje prihvatljivog dnevnog unosa za djecu i odrasle.⁵³ Grupa autora iz Hong Konga utvrdila je prekoračenje prihvatljive dnevne izloženosti nitratima u sirovom povrću za 20% za prosječne potrošače i 250% za velike potrošače.⁵⁴ U kuvanom povrću prekoračenje prihvatljivog dnevnog unosa je utvrđeno za velike potrošače u iznosu od 170%.⁴⁸ Studija indijskih autora pratila je potrošnju 14 prehrambenih aditiva među 311 tinejdžera uzrasta 13–19 godina.^{54,55} Statistički značajno veća konzumacija prehrambenih aditiva zabilježena je kod tinejdžera uzrasta 13–15 godina.^{54,55} Vjerovatni srednji dnevni unos za sulfite i eritrozine za velike potrošače iznosio je 105%, odnosno 344% prihvatljivog dnevnog unosa.^{48,49} Studija u Norveškoj utvrdila je prekoračenje prihvatljivog dnevnog unosa benzojeve kiseline kod djece starosti 1–13 godina, posebno među najmlađima.⁵⁶

Prisustvo nedozvoljenih prehrambenih aditiva

Istraživanje iranskih autora utvrdilo je prisustvo nedozvoljenih boja rodamin B, metanil žuta, naranča II, malahit zelena, auramin, kinolin žuta, amarant i sudan različitim prehrambenim proizvodima.²⁵ Studija provedena u Indiji, koja je obuhvatila 545 gotovih proizvoda sa vještačkim bojama, utvrdila je da 2% istih sadrži kombinaciju dozvoljenih i nedozvoljenih boja, 8% samo nedozvoljene boje. Među nedozvoljenim bojama prednjačio je rodamin.²⁶ Studije pakistanskih istraživača utvrdile su prisustvo nedozvoljenih boja u 46,57% konditorskih proizvoda odabranih metodom slučajnog uzorka.²⁷ Istraživanja u Iranu 573 uzorka restoranske hrane utvrdilo je prisustvo nedozvoljenih vještačkih boja u 0,5% uzoraka sa otopinom šafrana.²⁸ Tečnom hromatografijom/tandemskom masenom spektrometrijom grupa tajlandskih istraživača je dokazala prisustvo nedozvoljene vještačke boje aramant u uvezenom voću konzerviranom sirupom.²⁹ Ispitivanje prehrambenih proizvoda koji se prodaju u blizini obrazovnih institucija u Pakistanu utvrdilo je prisustvo nedozvoljenih boja u 11% prehrambenih proizvoda s robnom markom i 44% prehrambenih proizvoda bez robne marke, 4% brendiranih i 30% nebrendiranih pića.³¹ Istraživanja uvezenih prehrambenih proizvoda u Indoneziji otkrila su prisustvo štetne tvari poput formaldehida, rodamina B, saharina, benzojeve kiseline, metanola, ciklamata i drugih nedozvoljenih boja.³¹ Neefikasnost propisa o nadzoru uvoznih prehrambenih proizvoda, ograničeno osoblje/terenski službenici, neutemeljen obrazac nadzora (mnogo saobraćajnih traka nezvanične robe u pograničnom regionu), niska odgovornost proizvođača, slaba pravna svijest potrošača o prijavljivanju problematičnih prehrambenih proizvoda i slabo provođenje zakona označeni su kao najznačajniji razlozi.³¹ Preventivne mjere, poput rigoroznih uvoznih propisa, stroge kontrole proizvoda i adekvatnog sankcionisanja, navode se kao moguće rješenje.³¹

Neadekvatno označavanje prehrambenih aditiva

Istraživanje provedeno u Gani utvrdilo je da je 90% uzorkovanih proizvoda s oznakom „Bez aditiva” (voćni sokovi, zatim mlijeko i bezalkoholna pića) sadržavalo jedan ili više aditiva za hranu.⁵⁷ U istraživanju rezidualnog sumpor–dioksida u uzorcima suvog voća sa beogradskog tržišta od analiziranih dvanaest uzoraka u osam je sadržaj sumpor–dioksida bio značajno veći od deklarisanog, dok je u dva uzorka bio iznad maksimalne dozvoljene koncentracije.⁵⁸ U studiji grupe autora iz Brazila 31,4% analiziranih proizvoda imalo je neku vrstu neusaglašenosti, a 12,1% proizvoda nije imalo nikakvo upozorenje potrošača o prisustvu alergena.⁵⁹ Studija provedena u Malaviju utvrdila je da niti jedan od 105 lokalno proizvedenih proizvoda nema deklaraciju alergena.⁶⁰ Istraživanja kineske Državne uprave za hranu i lijekove 257.000 uzoraka hrane utvrdila je 8.224 neadekvatna uzorka, od čega 33,6% uzrokovano zloupotrebom ili prekomjernom upotrebom prehrambenih aditiva.⁶¹

Percipirani rizik prehrambenih aditiva

Zbog različitih strategija i resursa procjene naučno mišljenje i percepcije laika o riziku prehrambenih aditiva vrlo često se ne podudaraju.⁵⁶ Naučna percepcija rizika je vrlo složen postupak (zasnovan na procjeni rizika i upravljanju istim), dok laički potrošači to rijetko čine zbog nedostatka vremena ili motivacije.⁶² Kada su rizici nepoznati potrošači će formirati ocjene koristeći subjektivnu percepciju, intuitivnu procjenu i zaključke iz medijskog izvještavanja.^{11,12,56} Istraživanje provedeno u Australiji među 572 srednjoškolca uzrasta od 12 do 15 godina utvrdilo je bojila i zaslađivače za najspornije prehrambene aditive, jer nisu neophodni za sigurnost hrane kao konzervansi.⁶³ Studija grupe autora iz Švicarske utvrdila je nedostatak svijesti o zakonskoj regulativi koja prethodi odobrenju prehrambenih aditiva, što bi moglo navesti potrošače da precijene nesigurnost u vezi s procjenom rizika istih.⁶⁴ Tome doprinose brojne, ali ne uvijek pouzdane informacije stampanih i elektronskih medija.⁶⁴ Zloupotreba i/ili prekomerna upotreba prehrambenih aditiva u Kini ugrozili su racionalno razumijevanje sigurnosti prehrambenih aditiva i pogoršavaju percepciju rizika.⁶¹ Istraživanje grupe danskih autora utvrdilo je da ogromna većina ispitanika, njih 95%, vjeruje da u mnogim ili gotovo svim proizvodima ima prehrambenih aditiva.⁶⁴ Kada je riječ o označavanju prehrambenih aditiva 65% ispitanika vjeruje da postoji potreba za označavanjem, ali samo 15% (svaki sedmi ispitanik) vjeruje u koristi istog.⁶⁵ Oko 15% često razmišlja o prehrambenim aditivima prilikom kupovine hrane, gotovo 40% razmišlja svaki put kad kupuju hranu, 15% nikada ne razmišlja, dok 30% razmišlja kada ih spomenu mediji.⁶⁵ Oko 25% ispitanika misli da je lako procijeniti rizik upotrebe prehrambenih aditiva, dok 55% misli da nije tako.⁶⁵ Gotovo 40% ispitanika pokušava izbjeći bojila, 30% zaslađivače, dok 15% pokušava izbjeći

sve prehrambene aditive.⁶⁵ Oko 30% ispitanika smatra da prehrambeni aditivi služe za pokrivanje lošeg kvaliteta proizvoda, 20% ne vjeruje sigurnosnim procjenama rizika, 15% smatra da prehrambeni aditivi povećavaju profit velikim kompanijama, 75% se djelimično ili u potpunosti slaže da prehrambeni aditivi izazivaju alergije, 70% se djelimično ili u potpunosti slaže da su uzrok hormonskih poremećaja, 60% ispitanika smatra da su kancerogeni, dok ih 40% ispitanika dovodi u vezu sa neplodnošću, gojaznosti i hiperaktivnosti djece.⁶⁵ Studija mađarskih autora utvrdila je da većina ispitanika ima negativan osjećaj prema prehrambenim aditivima.⁶⁵ Iako shvataju da je riječ o supstancama koje imaju neke tehnološke funkcije, smatraju da je njihov osnovni zadatak povećanje profita proizvođačima hrane.⁶⁶ Najveću zabrinutost izazivali su konzervansi i bojila zbog potencijalnog kancerogenog dejstva.⁶⁶ Potrošači praktično nisu bili svjesni rigoroznog sistema odobrenja i kontrole prehrambenih aditiva.⁶⁶ Iako pretpostavljaju da postoje propisi o sigurnosti hrane oni sumnjaju u njihovu efikasnost.⁶⁰ Smatraju da regulatorni organi ne raspolažu sa dovoljno novca, kao i da je period testiranja suviše kratak.⁶⁶ Istraživanje u Velikoj Britaniji ukazuje da značajan broj potrošača smatra da je upotreba prehrambenih aditiva povezana sa razvojem alergije (44%) i hiperaktivnosti (24%).⁶⁷ U percipirane zdravstvene rizike povezane sa konzumacijom prehrambenih aditiva kineski potrošači uključuju hiperaktivnost, razvoj alergije, astmu, peludnu groznicu i karcinom.⁶⁸ Druga grupa istraživača u Velikoj Britaniji ukazala je na slabo poznavanje prehrambenih aditiva od strane potrošača (oko 65% svih ispitanika nikada nije provjerilo prehrambene aditive na etiketama hrane).⁶⁹ Studije holandskih autora utvrdile su da su niska pouzdanost u prehrambenoj industriji i prevladavanje negativnih informacija o prehrambenim aditivima na internetu i društvenim mrežama glavni uzroci percepcije visokog rizika.⁷⁰ Niz skandala u Tajvanu, koji su uključivali dodavanje ilegalnih prehrambenih aditiva, dovelo je do visoke percepcije opasnosti kod stanovništva i posljedičnog odbijanja hrane koja sadrži hemijske aditive.⁷¹ Oko 64% potrošača intervjuiranih u supermarketima Brazila poznavalo je definiciju prehrambenog aditiva.⁷² Njih 87% ih je smatralo štetnim po zdravlje.⁶⁶ Isti profil zabilježen je među studentima univerziteta i pacijentima.⁶⁶ Istraživanje autora iz Sjedinjenih Američkih Država utvrdilo je su poteškoće u izgovaranju imena prehrambenih aditiva, stvarnog ili izmišljenog, povezane s percepcijom njihovog rizika. Prehrambeni aditivi čija se imena teže izgovaraju obično se smatraju novim ili manje poznatim i štetnim po zdravlje.⁷³ Studija provedena među radnicima u Češkoj i Njemačkoj utvrdila je da je percepcija rizika povezana s veličinom imena prehrambenog aditiva.⁷⁴

Zaključak

Prehrambeni aditivi su nužnost u tehnologiji proizvodnje hrane. Njihova upotreba izaziva nepovjerenja potrošača i kontroverzu stručne javnosti. Negativan stav zna-

čajnog broja potrošača usljed nedostatka svijesti o zakonskoj regulativi koja prethodi odobrenju prehrambenih aditiva može se ukloniti kroz otvorenu, transparentnu, nezavisnu, odgovornu/pravovremenu komunikaciju o riziku. S druge strane, istraživanja o neadekvatnom označavanju, toksičnosti i upotrebi nedozvoljenih prehrambenih aditiva zahtijevaju kontinuirano praćenje, unapređenje sistema kontrole i uklanjanja nedostataka. Sigurna upotreba prehrambenih aditiva je zajednička odgovornost države, proizvođača, distributera, struke, odnosno laboratorija, ali i samih potrošača.

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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 like³.

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 agents³. 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 quantity³. Food additives can be of natural or synthetic origin³. 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 microorganisms⁴. 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 production⁵. Toxicological studies include acute, subacute, and chronic toxicity, genotoxicity, allergenicity, and carcinogenicity⁵. 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 additive³. 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 user¹⁰.

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 severity¹¹. Interpretation and subjective risk assessment mean risk perception¹¹. 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 stakeholders¹⁴. 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 preferences¹⁵. Successful communication requires hazard identification and characterization, exposure assessment, and risk characterization¹⁵. 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 carcinogenicity¹⁷. 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) health ²². 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 7 α -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 acid⁴². Aspartame can cause the deoxyribonucleic acid chain to break down in the bone marrow cells of mice⁴². Its metabolite formaldehyde can cause an increase in lymphoma and leukemia in rats⁴². 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 disorders⁴³. *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 nephropathy⁴⁴. 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 production⁴⁴. A statistically significant association between food consumption containing ochratoxin A and the incidence of testicular cancer was found in 20 countries of the European Union⁴⁴. 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 Norway⁴⁵. 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 possible⁴⁵. 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 blood⁴⁵. At temperatures above 130 °C they can form carcinogenic nitrosamines⁴⁵. In high doses, they lead to acute poisoning⁴⁵. They can cause hyperactivity syndrome in children⁴⁵. 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 dyes³¹. 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 reasons³¹. Preventive measures such as rigorous import regulations, strict product controls and adequate sanctions are cited as possible solutions³¹.

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 additives⁶¹.

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 match⁵⁶. 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 motivation⁶². 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 preservatives⁶³. 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 assessment⁶⁴. 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 additive ⁷². 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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