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OPTMIZING HUMAN HEALTH THROUGH EFFECTIVE FOOD SAFETY MEASURES

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ABSTRACT

INTRODUCTION: Food safety affects everyone worldwide. Individuals and the public can experience health problems when proper food safety measures are compromised in any country. Food production needs to be conducted safely to optimize individual and public health. Food safety entails the protection of food supply chain at all the stages involved by preventing the introduction, growth, and survival of risky chemical and microbial agents in food items. Unsafe food containing harmful micro-organisms (bacteria, viruses, parasites), or chemical substances cause more than 200 diseases. A high burden of health problems results from unsafe food procedures annually worldwide. It is preferred that safety food measures are put in place to prevent food-diseases globally among individuals and public for health security. The aim of the article is to demonstrate the food safety issues existing in the communities

from available evidence, their health implications and ways to optimize the safety procedures to ensure healthy populations.

MATERIAL AND METHOD: A secondary study in the form of review of literature through online search for articles and other academic publications from credible sources was conducted. Relevant resources were identified and evidence extracted for the review.

RESULTS: Various food safety issues were recognized, including microbial food contamination, chemical food contamination, food adulteration, food additive misuse, mislabeling, genetically modified foods, and marketing of expired foods. They can affect food products at any stage in the food supply chain.

DISCUSSION: Health impact of inadequate food safety includes diseases that affect individuals and populations from insufficient food safety procedures. The health consequences were identified and means to prevent them discussed.

CONCLUSIONS: As the health impact of inadequate food measures affect individuals and populations, it is essential that all stakeholders including physicians collaborate in ensuring proper food safety measures in order to prevent and manage the menace in humans.

Keywords: Food safety measures; Food safety issues; Public health; Foodborne illness.

INTRODUCTION

Food safety is an essential issue that affects everyone globally. Many countries throughout the world are increasingly interdependent on the availability of their food supply and on its safety. Thus, many people are becoming aware of the need to ensure food safety which they increasingly value. Food production needs to be conducted safely to optimize public health benefits and environmental gains. Food safety entails the protection of food supply chain through introduction, growth, and survival of risky chemical and microbial agents [1,2]. Unsafe food that contains harmful micro-organisms (bacteria, viruses, parasites), or chemical substances are responsible for greater than 200 diseases, ranging from infectious diseases to cancers. About 600 million people worldwide fall ill after ingesting contaminated food, and up to 420,000 die annually, leading to the loss of approximately 33 million disability adjusted life years (DALYs) [3]. Under-5 children carry 40% of the burden of food borne diseases, resulting in 125,000 deaths yearly [3]. Diarrheal diseases constitute the most common

illnesses arising from the intake of contaminated food, causing up to 550 million people becoming ill and 230,000 deaths annually [3]. Currently, the global dimensions within food supply chains are challenging food safety procedures [1,4,5]. Food within the network of national or international market may become frauded at any or different stages of the chain such as manufacturing, co-packing, distribution and others [6,7,8].

Under public health, food safety within the food market remains one of the chief areas of focus. This is because it affects individuals and groups of people worldwide, irrespective of age, gender, race, or income level. Both the local and international food supply chains continues to have significant impacts on food safety and therefore health of the public. As food supply channel now cross numerous national borders thereby it poses huge health risks to international health [9,10,11]. As foods are substances that we ingest in order to derive nutrients required for maintaining our anatomical, physiologic, and biochemical mileu, they present to our body usually with micro-organisms from the external environment which could be hazardous to our body. It is therefore important that food safety measures are effectively and optimally conducted in order to prevent diseases for individuals and the public. This review article was conducted in order to identify the common public health risks associated with food safety issues within the food supply chain. The review provides evidence to improve food safety in the food market using risk-based food safety strategies. Healthcare providers, researchers, and policy makers may utilize the results of this review to establish protection of the public from undue health effects arising from due to consumption of poor quality and unsafe foods.

FOOD SAFETY ISSUES IN THE FOOD MARKET

Numerous issues regarding food safety are in existence, thus, there is the need to ensure adequate food safety measures to safeguard the health of the public. Studies have revealed the forms of food safety issues as follows:

Microbial Contamination of Foods

Pathogenic micro-organisms have been found in various food items within the food market. Disease-causing bacteria identified include Alklegens spp., Arcobacter spp., Bacillus cereus, Campylobacter spp., Citrobacter spp., Clostridium perfringens, Escherichia coli, Enterobacter spp., Enterococcus spp., Klebsiella spp., Listeria spp., Proteus spp., Pseudomonas spp., Salmonella spp., Shigella spp., Staphylococcus aureus, and Vibrio spp. Furthermore, various

fungus like Aspergillus flavus, Aspergillus niger, Blastomyces, Fusarium avenaceum, Fusarium solani, Fusarium spp., Mucor spp., Penicillium digitatum, Rhizopus stolonifer, Saccharomyces species, Saccharomyces dairensis, and Saccharomyces exiguus were identified from diverse food items obtained from food stores and shops. As resistance to different antimicrobials have been reported from various studies, it is therefore vital that the safety of food is ensured at all stages from production of the raw form to the final product [12, 13-23].

Chemical Contamination of Foods

Chemical contamination of foods results in millions of food poisoning cases with thousands of hospitalizations and deaths annually. Many chemicals have been found to be hazardous and could result in food contamination. Chemicals in food, therefore constitute a major public health concern regarding the food market and supply chain. Identified chemicals include heavy metals, (e.g cadmium, copper, iron, nickel, lead, manganese, mercury, and zinc), hydrocarbons (e.g benzo[a]pyrene and toluene), and other chemical compounds (e.g calcium carbide and cyanide), persistent organic pollutants (e.g aldrin, dichlorodiphenyltrichloroethane metabolites, endosulfans, perfluorooctanoic acid and polychlorinated biphenyls), pesticide residuals (e.g dichlorvos, dimethoate, parathion, parathion-methyl, and pirimiphos-methyl), non-volatile organic compounds (e.g chloroform, formalin, patulin and urea), and volatile organic compounds (e.g benzene, ethyl benzene, and o-xylene), are chemical contaminants identified by scientists. Mostly, the chemical concentrations exceeded the tolerable set limit for consumable food items [24-33].

Food Adulteration

Food adulteration involves intentional or unintentional addition of unnecessary and often harmful biological, chemical and physical, agents to food substances thereby decreasing the quality of food. It also entails removal of genuine constituents and food processing conducted in unhygienic manner [34]. The adulteration of food poses a key public health risk concerning food safety issues in the food supply chain. Majority of the food items in the market been adulterated in different degrees. The most common adulterants being added to food products include chemicals (like ammonium sulfate, artificial color flavors, argemone oil, boric acid, burnt mobil, burnt oil, caustic soda, copper chlorophyll, chlorofluorocarbon; DDT powder, dimethyl/diethyl yellow, formalin, detergents, hydrogen peroxide, maleic anhydride, metanil yellow, neutralizers, sorbitol, textile dye, ultramarine blue, rhodamine B., sodium bicarbonate, sodium chloride, copper chlorophyll, urea fertilizer); items which are ingenuine food

component (like cow's fat and intestine in ghee, potato smash, sugar in honey, water in milk, etc.); poor-quality products; and physical or inert agents (like brick powder and saw dust) are the commonest adulterants added to different food items [35-42]. The aforementioned chemicals which are used as adulterants possess a vast range of deleterious effects like cancer on the health of consumers [34].

Misuse of Food additives

Food additives are substances which are not normally consumed as food alone, not typically used as ideal ingredient in food (with or without nutritive value), but added intentionally to food items for an industrial purpose during the production process in order to maintain the nutritional quality of food. For instance, by preventing the degradation of essential amino acids, unsaturated fats and vitamins; prolonging a product's shelf life, for example through inhibiting microbial growth; and maintaining and enhancing a product's sensory features, like colour, consistency, flavor, taste, and texture [43]. Certain substances are generally recognized to be safe (GRAS) and can be utilized as food additives. However, misuse of substances in forms like exceeding the maximum allowable concentration; utilizing non-permitted substances; and mixing both permitted and non-permitted substances together results in health hazards [44].

Food additives are known to be in wide misuse in the food market, and pose danger to individual and public health. Reports showed that certain food sweeteners and colorants are permitted for use, such as erythrosine, new coccine, ponceau, saccharin, sunset yellow FCF (SSYFCF), and tartrazine, others may not be legalized based on different countries food regulation, because their concentrations do exceed the allowed limit. In addition, some colorants and sweeteners such as auramine, amaranth, carmoisine, cyclamate, malachite green, metanil yellow, orange II, quinolone yellow, rhodamine B, and Sudan dyes (while some may be acceptable depending on countries food regulation [45-51].

Mislabelling

The use of wrong labels on food products have been identified to pose major risk to people's health. Studies have revealed that substantial proportion of the food samples obtained from food stores, restaurants, shops and restaurants were found to be entirely different through genetic identification, from what was stated on the food labels, and thus regarded as mislabeled. Seafood was identified as the food product most commonly mislabeled [52-67].

Genetically Modified Foods

Foods subjected to genetic modification have been found to pose risk to the health of man due to the various diseases reported to be associated to such foods. The diseases include Acute kidney failure, Alzheimer's, diabetes, cancers of the thyroid/liver/bladder/pancreas/kidney, end-stage renal disease, hepatitis C, hormonal imbalances, hypertension, end-stage renal disease, lipoprotein metabolism disorder, myeloid leukemia, obesity, respiratory problems, stroke, and susceptibility to infection or immunosuppression [68-71].

The potential hazards of GM foods include the potential for pleiotropic and insertional effects (silencing of genes, changes in their level of expression or, potentially, the turning on of existing genes that were not previously being expressed), effects on animal and human health resulting from the increase of anti-nutrients, potential effects on human health resulting from the use of viral DNA in plants, possible transfer of antibiotic-resistant genes to bacteria in gastrointestinal tract, and possible effects of GM foods on allergic responses [72,73].

Expired Foods

Foods that have exceeded their use-by dates, or outdated foods have been noted to be sold in restaurants, food stores and shops. The dubious act is contributing huge environmental and public health risk, and several food products that have expired have been found to be on sale of food stores [12].

FOOD RELATED HAZARDS AND HUMAN HEALTH

The food related issues stated earlier are the common public health risks concerning food safety dilemmas in the food market. Food items or products can be contaminated in a place and result in health problems in another place. The issues lead to consumers being exposed to physical, biological and chemical hazards, thereby endangering the health of the public [74-78]. Foods hazards are in a chain which can originate right from the source, through the stage of transport, to processing, merchandising activities, and finally at the consumer level [79-83]. The risks associated with food safety are more prevalent in developing nations than developed ones. The justification was identified in the easier contamination of food with microbes as a result of inadequate hygiene and sanitation in developing countries [84-87]. Furthermore, regulatory services are insufficient in low-income countries where a significant proportion of food sellers do not comply with requirements and standards set by the regulatory agencies

[88-90]. The enforcement of food safety laws is weak in developing nations especially regarding the regulating the concentration of detrimental contaminants in food [91,92]. Information and technology needed for detecting fake and fraud products is mostly inadequate in third world countries [93,95].

Lack of food safety protocols in each stage of the food supply chain, such as non-standard food handling practices, unwholesome production process, inadequate agricultural practices, inefficient transport system, ineffective marketing practices, and poor sanitation practices can result in unpredictable microbial food contamination [96-100]. In addition, food safety issues like adulteration, mislabeling, and marketing of expired food products also cause microbial food contamination [23, 101-103]. Evidences globally have shown that microbial contamination of foods is causing millions of diseases and thousands of deaths worldwide [104]. This review has found that various microbial contaminants are more commonly in found in developing countries than in developed countries. This is likely resulting from faecal contamination of food items which appears to be common in developing nations due to prominent poor sanitation conditions [105-107]. Furthermore, atmospheric conditions like temperature and air system in food storage machineries are often not properly regulated in developing nations. Therefore, the environment enables growth of molds. Various Campylobacter species have been reported in developing countries, possibly due to lack of advanced molecular techniques for identification of the microorganisms and specialized cultivation techniques for culturing the microbes [108].

FOOD SAFETY MEASURES

Diagnostic Measures

The tracking and detection of microbials particularly pathogenic bacteria in food items/products from their sources pose daunting challenges to all stakeholders including producer, processor, distributor, and consumer of food alike. Moreover, epidemiologists and clinicians are often faced with diagnostic and treatment dilemmas of patients with presenting with symptoms of foodborne infectious diseases in health facilities. In preventing foodborne infections, and ensuring safety of foods, rapid and diagnostic methods for detecting foodborne pathogens is vital under public health bio-surveillance [109-111].

In general, culture-based tests are becoming outdated, now being substituted by more sensitive and culture-independent diagnostic tests like PCR panels and antigen-based assays

[112]. Although, the tests are utilized mainly in public health laboratories, they are not readily handy for practitioners in industrial settings and clinical fields [113].

Nuclear Magnetic Resonance (NMR) nanotechnology platform functions by detecting multiple target microbials that are hybridizing to the DNA or protein of pathogen in the device chamber for running assays using antibodies, nucleic acid, and other biomarkers [114].

Another method is the Polymerase chain reaction (PCR) based assay, enzyme linked immuno-sorbent assay (ELISA) and instruments rely on wide enrichment (up to 24 h) to generate enough cells for detection. After enrichment, the assay entails DNA amplification and detection. The whole process from enrichment to detection can take numerous hours to days. [115, 116].

PHYSICIAN'S ROLE IN FOOD THERAPY

Medical professionals mainly focus on treating diseases without consideration for whether the cause is due to long-term exposure to unhygienic or contaminated food items or products. Many dietitians lay emphasis on counting the amount of calories of macronutrients regardless of chemicals added to the food product which have lack nutrient values. The food industry may be targeting profit for obvious business reasons, without consideration for the health of people. Therefore, medical experts in food therapy have a vital role to play. They were asked to exercise duty to enhance ensure food quality and safety of populations [117]. Therefore, it is vital that physicians are aware of the various types of food products that are available for people in their environment and which they consume. In addition, it is essential for the physicians to *go extra mile* in knowing the chemical substances that have been added to the food products. This step on the part of health professionals would enhance safety measures by finding out which disease conditions that could arise from the known chemical agents. Thus, epidemiologic studies by health researchers could help to associate the risk associated with excessive consumption of the chemical substances, and thus prevention could be made possible. The physician-scientist would be able to raise alarm of outbreaks of food poisoning arising from suspected food products, and guide appropriate measures to be taken at the clinical and population health levels.

GOVERNMENT ROLE IN REGULATING FOOD SAFETY

Food safety is regulated in different countries using equitable law enforcement and sound science. Laws and regulations are enacted to protect the continuous supply of foods that are safe for people's consumption to ensure health and wellness. The core aim of establishing Food and Drug Administration (FDA) agencies is to be responsible for ensuring compliance to food safety laws and regulations, generally through three goals in protecting people's health and safety: (a) Informing people of nutrition and food product components (b) Enforcing contemporary laws and regulations regarding food industry for ensuring the supply of healthy food products (c) Investigating and eliminating potential contaminants and prosecuting economic fraud through monitoring and surveillance on food supply chain [113,118].

FOOD SAFETY PROGRAMS AND TOOLS

Food surveillance entails investigating and controlling the movement of potentially contaminated food products. Field inspecting officers are granted power to conduct activities according to the government agency laws. Agencies may obtain tips from secret agents who may initiate search for some food products to undergo surveillance testing if there is suspicion of foul play like inconsistent labeling, or questionable sources. Contaminants exceeding legal limits would be re-tested within fragmented samples sent to two different laboratories for ensuring fairness. Food safety inspectors are response for inspecting foods during packaging, labeling, distribution and storage. Likewise, inspector officer can assume responsibility for food safety measures when food products are retail stores. Reports of "accidental" exposure program is in use and works well in various countries. Food products can accidentally be exposed to contaminants undeliberately or unknowingly through use of contaminated products like microbials, pesticides, industrial chemicals and natural toxicants. In such events, the manufacturer or merchant can willingly report such contamination to FDA. The agency will then send specialists trained in food safety procedures to go and to conduct regulatory and scientific actions in the food industry [114].

CONCLUSION.

To conclude, human health at both individual and population levels is affected by the nature of foods and chemical substances ingested. There exists various forms of food substances that are added to foods for different functions. However, unsafe levels in, or inappropriate addition of many chemicals to food result in diseases affecting human health. Many chronic diseases have been linked to the ingestion of different chemical substances directly or indirectly ingested. It is important that a collaborative effort by all stakeholders including the food industry, food scientists, government authorities, regulatory agencies, and health professionals, is ensured in all nations in other to optimize the health of man through effective and efficient food safety measures.

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REFERENCES

[1] Uyttendaele M, Franz E, Schlüter O. Food safety, a global challenge. Int J Environ Res Public Health. 2016;13(1):67. https://doi.org/10.3390/ ijerph13010067.

[2] Radovanovic R. Food safety: the global problem as a challenge for future initiatives and activities. Advances in Food Protection: Springer; 2011. p. 27- 48.

[3] World Health Organization (WHO). Food safety fact sheet. Available at https://www.who.int/news-room/fact-sheets/detail/food-safety. Accessed on 06 May 2023

[4] Hawkes C. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. Global Health. 2006;2(1):4.

[5] Athukorala PC, Jayasuriya S. Food safety issues, trade and WTO rules: a developing country perspective. World Econ. 2003;26(9):1395–416.

[6] Negri S. Food safety and global health: an international law perspective. Global Health Governance. 2009;3(1).

[7] Kruse H. Food safety in an international perspective. J. Verbr. Lebensm. 2015;10:105–7. https://doi.org/10.1007/s00003-015-0948-6.

[8] Spink J, Moyer DC. Defining the public health threat of food fraud. J Food Sc. 2011;76(9):R157–R63.

[9] Aung MM, Chang YS. Traceability in a food supply chain: safety and quality perspectives. Food Control. 2014;39:172–84.

[10] Wu F. Global impacts of aflatoxin in maize: trade and human health. World Mycotoxin J. 2014;8(2):137–42.

[11] Bryden WL. Mycotoxins in the food chain: human health implications. Asia Pacific J Clin Nutr. 2007;16(S1):95–101.

[12] Gizaw Z. Public health risks related to food safety issues in the food market: a systematic literature review. Environmental Health and Preventive Medicine 2019;24:68 https://doi.org/10.1186/s12199-019-0825-5

[13] Adeyanju GT, Ishola O. Salmonella and Escherichia coli contamination of poultry meat from a processing plant and retail markets in Ibadan, Oyo State, Nigeria. Springerplus. 2014;3(1):139.

[14] Giammanco GM, Pepe A, Aleo A, D'Agostino V, Milone S, Mammina C. Microbiological quality of Pecorino Siciliano "primosale" cheese on retail sale in the street markets of Palermo, Italy. 2011;34(2):New Microbiologica, 179–85.

[15] Zhao C, Ge B, De Villena J, Sudler R, Yeh E, Zhao S, et al. Prevalence of Campylobacter spp., Escherichia coli, and Salmonella serovars in retail chicken, turkey, pork, and beef from the Greater Washington, DC, area. Appl Environ Microbiol. 2001;67(12):5431–6.

[16] Cárdenas C, Molina K, Heredia N, García S. Evaluation of microbial contamination of tomatoes and peppers at retail markets in Monterrey, Mexico. J Food Protect. 2013;76(8):1475–9.

[17] Pérez-Rodríguez F, Castro R, Posada-Izquierdo G, Valero A, Carrasco E, García-Gimeno R, et al. Evaluation of hygiene practices and microbiological quality of cooked meat products during slicing and handling at retail. Meat Science. 2010;86(2):479–85.

[18] Kumari S, Sarkar PK. Prevalence and characterization of Bacillus cereus group from various marketed dairy products in India. Dairy Sci Technol. 2014;94(5): 483–97.

[19] Vantarakis A, Affifi M, Kokkinos P, Tsibouxi M, Papapetropoulou M. Occurrence of microorganisms of public health and spoilage significance in fruit juices sold in retail markets in Greece. Anaerobe. 2011;17(6):288–91.

[20] Hosseini A. The prevalence of bacterial contamination of table eggs from retails markets by Salmonella spp., Listeria monocytogenes, Campylobacter jejuni and Escherichia coli in Shahrekord, Iran. Jundishapur J Microbiol 2011; 4(4):249.

[21] Simforian E, Nonga H, Ndabikunze B. Assessment of microbiological quality of raw fruit juice vended in Dar es Salaam City, Tanzania. Food Control. 2015;57:302–7.

[22] Mailafia S, God'spower Richard Okoh HO, Olabode K, Osanupin R. Isolation and identification of fungi associated with spoilt fruits vended in Gwagwalada market, Abuja, Nigeria. Veterinary World. 2017;10(4):393.

[23] Islam M. Study on bacteriological quality of street-vended and expired food items collected from different areas in Dhaka City. Bangladesh: East West University; 2017.

[24] Bai Y, Zhou L, Wang J. Organophosphorus pesticide residues in market foods in Shaanxi area, China. Food Chem. 2006;98(2):240–2.

[25] Othman ZAA. Lead contamination in selected foods from Riyadh City market and estimation of the daily intake. Molecules. 2010;15(10):7482–97.

[26] Zaied C, Abid S, Hlel W, Bacha H. Occurrence of patulin in apple-based foods largely consumed in Tunisia. Food Control. 2013;31(2):263–7.

[27] Schecter A, Colacino J, Haffner D, Patel K, Opel M, Päpke O, et al. Perfluorinated compounds, polychlorinated biphenyls, and organochlorine pesticide contamination in composite food samples from Dallas, Texas, USA. Environmental health perspectives. 2010;118(6):796–802.

[28] Onianwa P, Adeyemo A, Idowu O, Ogabiela E. Copper and zinc contents of Nigerian foods and estimates of the adult dietary intakes. Food Chem. 2001; 72(1):89–95.

[29] Vinci RM, Jacxsens L, De Meulenaer B, Deconink E, Matsiko E, Lachat C, et al. Occurrence of volatile organic compounds in foods from the Belgian market and dietary exposure assessment. Food Control. 2015;52:1–8.

[30] Tittlemier SA, Forsyth D, Breakell K, Verigin V, Ryan JJ, Hayward S. Polybrominated diphenyl ethers in retail fish and shellfish samples purchased from Canadian markets. J Agricult Food Chem. 2004;52(25):7740–5.

[31] Ali MH, Al-Qahtani KM. Assessment of some heavy metals in vegetables, cereals and fruits in Saudi Arabian markets. Egypt J Aquatic Res. 2012;38(1):31–7.

[32] Moret S, Purcaro G, Conte LS. Polycyclic aromatic hydrocarbons (PAHs) levels in propolis and propolis-based dietary supplements from the Italian market. Food Chem. 2010;122(1):333–8.

[33] Ali ANMA. Food safety and public health issues in Bangladesh: a regulatory concern. Eur Food Feed Law Rev. 2013:31–40.

[34] Bansal S, Singh A, Mangal M, Mangal AK, Kumar S. Food adulteration: Sources, health risks, and detection methods. Crit Rev Food Sci Nutr. 2017; 57(6):1174–89.

[35] Nasreen S, Ahmed T. Food adulteration and consumer awareness in Dhaka City, 1995-2011. Journal of health, population, and nutrition. 2014;32(3):452.

[36] Chanda T, Debnath G, Hossain M, Islam M, Begum M. Adulteration of raw milk in the rural areas of Barisal district of Bangladesh. Bangladesh J Anim Science. 2012;41(2):112–5.

[37] Singuluri H, Sukumaran M. Milk adulteration in Hyderabad, India-a comparative study on the levels of different adulterants present in milk. J Chromatogr Sep Techn. 2014;5(1):1.

[38] Barham GS, Khaskheli M, Soomro AH, Nizamani ZA. Extent of extraneous water and detection of various adulterants in market milk at Mirpurkhas, Pakistan. J Agri Vet Sci. 2014;7(3):83–9.

[39] Waghray K, Gulla S, Thyagarajan P, Vinod G. Adulteration pattern in different food products sold in the twin cities of Hyderabad and Secunderabad-India. Journal of Dairying Foods & Home Sciences. 2011;30(2).

[40] Peng G-J, Chang M-H, Fang M, Liao C-D, Tsai C-F, Tseng S-H, et al. Incidents of major food adulteration in Taiwan between 2011 and 2015. Food Control. 2017;72:145–52.

[41] Woldemariam HW, Abera BD. The extent of adulteration of selected foods at Bahir Dar, Ethiopia. Int J Interdisciplin Res. 2014;1(6):1–6.

[42] Assefa A, Teka F, Guta M, Melaku D, Naser E, Tesfaye B, et al. Laboratory investigation of epidemic dropsy in Addis Ababa, Ethiopia. Ethiop Med J. 2013:21–32.

[43] Carocho M et al. Adding molecules to food, pros and cons: A review on synthetic and natural food additives. Comprehensive Reviews in Food Science and Food Safety. 2014;13(4):377-379.

[44] Inetianbor JE, Yakubu BM, Ezeonu SC. Effects of food additives and preservatives on man – a review. Asian Journal of Science and Technology. 2015;6(2):1118-1135.

[45] Dixit S, Purshottam S, Khanna S, Das M. Usage pattern of synthetic food colours in different states of India and exposure assessment through commodities preferentially consumed by children. Food Addit Contam Part A Chem Anal Control Expo Risk Assess. 2011;28(8):996–1005.

[46] Stevens LJ, Burgess JR, Stochelski MA, Kuczek T. Amounts of artificial food colors in commonly consumed beverages and potential behavioral implications for consumption in children. Clin Pediatr. 2014;53(2):133–40.

[47] Tsai C-F, Kuo C-H, Shih DY-C. Determination of 20 synthetic dyes in chili powders and syrup-preserved fruits by liquid chromatography/tandem mass spectrometry. J Food Drug Anal. 2015;23(3):453–62.

[48] Moradi-Khatoonabadi Z, Amirpour M, AkbariAzam M. Synthetic food colours in saffron solutions, saffron rice and saffron chicken from restaurants in Tehran, Iran. Food Additives Contaminants: Part B. 2015;8(1):12–7.

[49] Saleem N, Umar ZN. Survey on the use of synthetic food colors in food samples procured from different educational institutes of Karachi City. J Trop Life Sci. 2013;3(1):1–7.

[50] Petigara Harp B, Miranda-Bermudez E, Barrows JN. Determination of seven certified color additives in food products using liquid chromatography. J Agricul Food Chem. 2013;61(15):3726–

[51] Sood M. The supervision of government on implementation of import of processed food products in effort of legal protection for consumers. JL Pol'y & Globalization. 2014;25:72

[52] Miller DD, Mariani S. Smoke, mirrors, and mislabeled cod: poor transparency in the European seafood industry. Front Ecol Environ. 2010;8(10):517–21.

[53] Jacquet JL, Pauly D. Trade secrets: renaming and mislabeling of seafood. Marine Policy. 2008;32(3):309–18.

[54] Chin TC, Adibah A, Hariz ZD, Azizah MS. Detection of mislabelled seafood products in Malaysia by DNA barcoding: improving transparency in food market. Food Control. 2016;64:247–56.

[55] Nagalakshmi K, Annam P-K, Venkateshwarlu G, Pathakota G-B, Lakra WS. Mislabeling in Indian seafood: an investigation using DNA barcoding. Food Control. 2016;59:196–200.

[56] Galal-Khallaf A, Ardura A, Mohammed-Geba K, Borrell YJ, Garcia-Vazquez E. DNA barcoding reveals a high level of mislabeling in Egyptian fish fillets. Food Control. 2014;46:441–5.

[57] Cawthorn D-M, Steinman HA, Witthuhn RC. DNA barcoding reveals a high incidence of fish species misrepresentation and substitution on the South African market. Food Res Int. 2012;46(1):30–40.

[58] Di Pinto A, Bottaro M, Bonerba E, Bozzo G, Ceci E, Marchetti P, et al. Occurrence of mislabeling in meat products using DNA-based assay. J Food Sci Technol. 2015;52(4):2479–84.

[59] Carvalho DC, Palhares RM, Drummond MG, Gadanho M. Food metagenomics: next generation sequencing identifies species mixtures and mislabeling within highly processed cod products. Food Control. 2017;80:183–6.

[60] Garcia-Vazquez E, Perez J, Martinez JL, Pardinas AF, Lopez B, Karaiskou N, et al. High level of mislabeling in Spanish and Greek hake markets suggests the fraudulent introduction of African species. J Agric Food Chemistry. 2010; 59(2):475–80.

[61] Staffen CF, Staffen MD, Becker ML, Löfgren SE, Muniz YCN, de Freitas RHA, et al. DNA barcoding reveals the mislabeling of fish in a popular tourist destination in Brazil. PeerJ. 2017;5:e4006.

[62] Muñoz-Colmenero M, Juanes F, Dopico E, Martinez JL, Garcia-Vazquez E. Economy matters: a study of mislabeling in salmon products from two regions, Alaska and Canada (Northwest of America) and Asturias (Northwest of Spain). Fisheries Res. 2017;195:180–5.

[63] Muñoz-Colmenero M, Blanco O, Arias V, Martinez JL, Garcia-Vazquez E. DNA authentication of fish products reveals mislabeling associated with seafood processing. Fisheries. 2016;41(3):128–38.

[64] Bosko SA, Foley DM, Hellberg RS. Species substitution and country of origin mislabeling of catfish products on the US commercial market. Aquaculture. 2018;495:715–20.

[65] Christiansen H, Fournier N, Hellemans B, Volckaert FA. Seafood substitution and mislabeling in Brussels' restaurants and canteens. Food Control. 2018; 85:66–75.

[66] Christiansen H, Fournier N, Hellemans B, Volckaert FA. Seafood substitution and mislabeling in Brussels' restaurants and canteens. Food Control. 2018; 85:66–75.

[67] Galal-Khallaf A, Ardura A, Borrell YJ, Garcia-Vazquez E. PCR-based assessment of shellfish traceability and sustainability in international Mediterranean seafood markets. Food Chemistry. 2016;202:302–8.

[68] Swanson NL, Leu A, Abrahamson J, Wallet B. Genetically engineered crops, glyphosate and the deterioration of health in the United States of America. J Organ Syst. 2014;9(2):6–37.

[69] Pattron DD. A survey of genetically modified foods consumed, health implications and recommendations for public health food safety in Trinidad. Internet J Food Safety. 2005;7:4–14

[70] Bakshi A. Potential adverse health effects of genetically modified crops. J Toxicol Environ Health Part B. 2003;6(3):211–25.

[71] Aris A, Leblanc S. Maternal and fetal exposure to pesticides associated to genetically modified foods in Eastern Townships of Quebec, Canada. Reprod Toxicol. 2011;31(4):528–33.

[72] Bawa AS, Anilakumar KR. Genetically modified foods: safety, risks and public concerns – a review. J Food Sci Technol 2013;50(6):1035-1046.

[73] Karalis DT, Karalis T, Kralis S, Kleisiari AS. Genetically Modified Products, Perspectives and Challenges. Cureus 2020;12(3):e7306.

[74] Rhodehamel E.J. Overview of biological, chemical, and physical hazards. In: Pierson M.D., Corlett D.A. (eds) HACCP. Springer, Boston, MA, 1992. DOI https://doi.org/10.1007/978-1-4684-8818-0_3

[75] Aruoma OI. The impact of food regulation on the food supply chain. Toxicology. 2006;221(1):119–27.

[76] Horchner PM, Brett D, Gormley B, Jenson I, Pointon AM. HACCP-based approach to the derivation of an on-farm food safety program for the Australian red meat industry. Food Control. 2006;17(7):497–510.

[77] Sun Y-M, Ockerman H. A review of the needs and current applications of hazard analysis and critical control point (HACCP) system in foodservice areas. Food Control. 2005;16(4):325–32.

[78] Kleter G, Prandini A, Filippi L, Marvin H. Identification of potentially emerging food safety issues by analysis of reports published by the European Community's Rapid Alert System for Food and Feed (RASFF) during a four-year period. Food Chem Toxicol. 2009;47(5):932–50.

[79] Ahl A, Buntain B. Risk and the food safety chain: animal health, public health and the environment. Revue Scientifique et Technique-Office International des Epizooties. 1997;16(2):322–30.

[80] Scheule B, Sneed J. From farm to fork: critical control points for food safety. J Nutr Recipe Menu Dev. 2001;3(2):3–23.

[81] Bagumire A, Todd EC, Nasinyama GW, Muyanja C, Rumbeiha WK, Harris C, et al. Potential sources of food hazards in emerging commercial aquaculture industry in sub-Saharan Africa: a case study for Uganda. Int J Food Sci Technol. 2009;44(9):1677–87.

[82] Frewer LJ, Scholderer J, Bredahl L. Communicating about the risks and benefits of genetically modified foods: the mediating role of trust. Risk Anal. 2003;23(6):1117–33.

[83] Albert I, Grenier E, Denis JB, Rousseau J. Quantitative risk assessment from farm to fork and beyond: a global Bayesian approach concerning foodborne diseases. Risk Anal. 2008;28(2):557–71.

[84] Khairuzzaman M, Chowdhury FM, Zaman S, Al Mamun A, Bari M. Food safety challenges towards safe, healthy, and nutritious street foods in Bangladesh. Int J Food Sci. 2014;2014.

[85] Baluka SA, Miller R, Kaneene JB. Hygiene practices and food contamination in managed food service facilities in Uganda. African J Food Sci. 2015;9(1):31–42.

[86] Dharod JM, Paciello S, Bermúdez-Millán A, Venkitanarayanan K, Damio G, Pérez-Escamilla R. Bacterial contamination of hands increases risk of crosscontamination among low-income Puerto Rican meal preparers. J Nutr Educ Behav. 2009;41(6):389–97.

[87] Paudyal N, Anihouvi V, Hounhouigan J, Matsheka MI, Sekwati-Monang B, AmoaAwua W, et al. Prevalence of foodborne pathogens in food from selected African countries–a meta-analysis. IntJ Food Microbiol. 2017;249:35–43.

[88] Henson S, Jaffee S. Food safety standards and trade: enhancing competitiveness and avoiding exclusion of developing countries. Eur J Dev Res. 2006;18(4):593–621.

[89] Henson S, Jaffee S. Understanding developing country strategic responses to the enhancement of food safety standards. World Econ. 2008;31(4):548–68.

[90] Grace D. Food safety in low and middle income countries. Int J Environ Res Public Health. 2015;12(9):10490–507.

[91] Villanueva CM, Kogevinas M, Cordier S, Templeton MR, Vermeulen R, Nuckols JR, et al. Assessing exposure and health consequences of chemicals in drinking water: current state of knowledge and research needs. Environ Health Perspect. 2014;122(3):213–21.

[92] Rather IA, Koh WY, Paek WK, Lim J. The sources of chemical contaminants in food and their health implications. Front Pharmacol. 2017;8:830.

[93] Lawal B. Overview of the socioeconomic implications and management of product faking and adulteration. Greener J Bus Manag Stud. 2013;3(3):119–31.

[94] Ayza A, Belete E. Food adulteration: its challenges and impacts. Food Sci Qual Manag. 2015;41:50–6.

[95] Salih MAM, Yang S. Common milk adulteration in developing countries cases study in China and Sudan: a review. J Adv Dairy Res. 2017;5:192.

[96] Podolak R, Enache E, Stone W, Black DG, Elliott PH. Sources and risk factors for contamination, survival, persistence, and heat resistance of Salmonella in low-moisture foods. J Food Protect. 2010;73(10):1919–36.

[97] Nicolas B, Razack BA, Yollande I, Aly S, Tidiane OCA, Philippe NA, et al. Streetvended foods improvement: contamination mechanisms and application of food safety objective strategy: critical review. Pakistan J Nutri. 2007;6(1):1–10.

[98] Legnani P, Leoni E, Berveglieri M, Mirolo G, Alvaro N. Hygienic control of mass catering establishments, microbiological monitoring of food and equipment. Food Control. 2004;15(3):205–11.

[99] Sousa CPd. The impact of food manufacturing practices on food borne diseases. Brazilian Arch Biol Technology. 2008;51(4):615-623.

[100] Carrasco E, Morales-Rueda A, García-Gimeno RM. Cross-contamination and recontamination by Salmonella in foods: a review. Food Res Int. 2012;45(2): 545–56.

[101] Lyhs U, Korkeala H, Björkroth J. Identification of lactic acid bacteria from spoiled, vacuum-packaged 'gravad'rainbow trout using ribotyping. Int J Food Microbiol. 2002;72(1-2):147–53.

[102] Rossi F, Gaio E, Torriani S. Staphylococcus aureus and Zygosaccharomyces bailii as primary microbial contaminants of a spoiled herbal food supplement and evaluation of their survival during shelf life. Food Microbiol. 2010;27(3):356–62.

[103] Lyhs U, Björkroth JK. Lactobacillus sakei/curvatus is the prevailing lactic acid bacterium group in spoiled maatjes herring. Food Microbiol. 2008;25(3):529–33.

[104] Hoffmann S, Scallan E. Epidemiology, cost, and risk analysis of foodborne disease. Foodborne Diseases, 3rd ediciton: Elsevier; 2017. p. 31-63. DOI: https://doi.org/10.1016/B978-0-12-385007-2.00002-4.

[105] De Bon H, Parrot L, Moustier P. Sustainable urban agriculture in developing countries. A review. Agronomy Sustain Dev. 2010;30(1):21–32.

[106] Abdulkadir A, Dossa L, Lompo D-P, Abdu N, Van Keulen H. Characterization of urban and peri-urban agroecosystems in three West African cities. Int J Agric Sustain. 2012;10(4):289–314.

[107] Atidégla SC, Huat J, Agbossou EK, Saint-Macary H, Glèlè KR. Vegetable contamination by the fecal bacteria of poultry manure: case study of gardening sites in southern Benin. Int J Food Sci. 2016;2016.

[108] Man SM. The clinical importance of emerging Campylobacter species. Nat Rev Gastroenterol Hepatol. 2011;8(12):669–85.

[109] Collignon P. Superbugs in food: a severe public health concern. Lancet 2013;13:641e3.

[110] Devaraj NK, Weissleder R. Biomedical applications of tetrazine cycloadditions. Acc Chem Res 2011;44:816e27.

[111] Mangal M, Sangita B, Satish SK, Ram GK. Molecular detection of foodborne pathogens: a rapid and accurate answer to food safety. Crit Rev Food Sci Nutr 2016;56:1568e84.

[112] Huang JY, Henao OL, Griffin PM, Vugia DJ, Cronquist AB, Hurd S, et al. Infection with pathogens transmitted Commonly through food and the effect of increasing use of culture-independent diagnostic tests on surveillance d foodborne diseases active surveillance network, 10 U.S. Sites, 2012e2015. MMWR Morb Mortal Wkly Rep 2016;65:368e71.

[113] Fung F, Wang H, Menon S. Food safety in the 21st century. Bio Med J 2018;41:88-95.

[114] Yang P, Hash S, Park K, Wong C, Doraisamy L, Petterson J, et al. Application of nuclear magnetic resonance to detect toxigenic Clostridium difficile from stool specimens: a proof of concept. J Mol Diagn 2017;19:230e5.

[115] Yang P, Wong C, Hash S, Fung F, Menon S. Rapid detection of Salmonella spp using magnetic resonance. J Food Saf 2018;e12473.

[116] Ferguson BA. Look at the microbiology testing market. Food Safety Magazine; February/March 2017. https://www.foodsafetymagazine.com/magazine-archive1/februarymarch-2017/a-look-at-the-microbiology-testingmarket/. [Accessed 15 May 2023].

[117] Yen TH, Lin-Tan DT, Lin JL. Food safety involving ingestion of foods and beverages prepared with phthalate-plasticizer

[118] Billy TJ, Wachsmuth IK. Hazard analysis and critical control point systems in the United States Department of Agriculture regulatory policy. Rev Sci Tech 1997;16:342e8.