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Spread Bacterial Toxins through Food

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Abstract

Background: Bacterial toxins in food cause widespread foodborne illnesses. These illnesses are a major public health concern globally. Bacteria are responsible for most food poisoning cases. Food safety measures are crucial to prevent the spread of these toxins. Millions of people are affected by foodborne illnesses annually, leading to hospitalizations and deaths. The problem is exacerbated by global socioeconomic development and the increasing complexity of food supply chains.

Objective

This study aimed to review the spread of bacterial toxins through food.

Discussion

Bacterial toxins in food cause widespread illness and death. Poor food handling, weak regulations, and inadequate education contribute to the problem. Common foodborne pathogens include *Campylobacter spp*., *E. coli*, *Non-typhoid salmonellosis*. *Bacillus cereus. Shigella spp*., and *Listeria monocytogenes*. These bacteria produce toxins that cause various illnesses, such as diarrhea and kidney failure. Improving food safety practices is crucial to prevent the spread of bacterial toxins.

Conclusion

The intricate problem of bacterial toxins spread through food necessitates enhancing food handling, improving sanitation practices, reinforcing regulations, and educating food handlers are vital measures to enhance food safety and reduce foodborne illnesses caused by bacterial toxins.

Keywords: Spread Bacterial Toxins, Foodborne Illness, Bacteria Strains, Human and Health

Introduction

Food contaminated with bacterial toxins commonly leads to the high spread of foodborne illness. Foodborne illness or foodborne disease (FBD) is a growing public health concern. Millions of foodborne illnesses cases are reported worldwide annually [1]. FBD are classified based on the World Health Organization (WHO) as infectious or toxic diseases caused by food or water [2]. Food-borne pathogens are biological organisms (bacteria, viruses, and parasites) and their produced toxins and chemicals that can cause infections through food [1, 3].

Foodborne illness contaminated by bacteria is presently one of the main problems with food safety and human health. Bacteria are responsible for about 66% of food poisoning from food contaminated with pathogenic organisms [4].

Although there have been about 250 different food-borne diseases, bacteria are the primary cause of two-thirds of outbreaks [5]. In recent years bacterial food-borne illness has been one of the most widespread global public health issues [6]. Among the goals of protecting public health is food safety which includes maintaining, supplying, and distributing to satisfy customer Expectations [7].

In the European Union (2013), foodborne outbreaks reported 43, 183 infected people; 5, 946 hospitalizations, and 11 deaths [8]. In the United States, foodborne illnesses are estimated to cause approximately 9.4 million cases, 55,961 hospitalizations, and 1,351 deaths each year [9].

Foodborne disease and intoxication of food contamination can result from environmental, animal, or human sources at any stage in the farm-to-fork continuum [10]. Food safety risks can rise due to pathogenic microorganisms growing on food surfaces and attaching to them [11].

Thus, global socioeconomic development is severely hampered by illness and death from contaminated food diseases. Therefore, this review article aims to provide an overview of the spread of bacterial toxins through food.

Material and Methods

The method used in this present article is a literature review with a narrative procedure. The review examines the latest research on the spreading of bacterial toxins through food. To identify the most relevant publications, international databases such as PubMed, Science Direct, ProQuest, ResearchGate, and Google Scholar were used to access secondary data. The selection criteria included full-text availability for studies published between 1997-2022.

Discussion

Several foodborne outbreaks have been related to bacterial toxins due to ingesting contaminated or raw food products. Rapid population growth and food commercialization have created pathogens that cause the rapid spread of foodborne illness by bacterial toxins [11]. The spread of bacterial toxins and the associated challenges are driven by factors such as improper food handling and hygiene practices, weak regulatory frameworks for food safety, inadequate enforcement of existing regulations, limited resources for procuring safer equipment, and insufficient training for individuals involved in food handling [12-15].

According to recent estimates by the World Health Organization, foodborne outbreaks and illnesses globally result in over 600 million cases of disease and 420,000 deaths annually [16]. The main foodborne risks, in terms of the number of cases of foodborne diseases worldwide, are *Campylobacter spp.*, *Escherichia coli (E. coli)*, *non-typhoidal Salmonella spp*., and *Shigella spp.*; Along with other foodborne risks namely *Bacillus cereus (B. cereus)*, *Listeria monocytogenes (L. monocytogenes)*, *Brucella spp.*, *and Clostridium botulinum*. In contrast, the main hazards caused by the global number of deaths are *S. typhi*, *Campylobacter spp*., *Vibrio cholerae, enteropathogenic E. coli*, *and enterotoxigenic E. coli* [17].

Campylobacter spp

Campylobacter spp strains are the most spread pathogens related to human infections such as *s. Campylobacter jejuni*, *Campylobacter lari, and Campylobacter coli*. Studies have reported that *Campylobacter spp* food-borne diseases related with the digestion of chicken and milk products [18]. Environmental factors, including grass, water, milking equipment, animal feed, air, soil, teats, and other sources, are common contributors to milk contamination. The presence of Campylobacter species in raw milk samples is believed to be due to fecal contamination [19]. Campylobacter species detected in bulk tank milk samples include *C. jejuni*, *C. lari*, and *C. coli* [20]. Various cytotoxins and cell-damaging substances produced by Campylobacter, such as cytolethal distending toxin (CDT), lead to diarrhea in humans and animals by disrupting cell division in the intestinal crypts [21]. Acute diarrhea, acute appendicitis, and acute colitis of inflammatory bowel disease are the main infections caused by Campylobacter species [22, 23].

Escherichia coli (E. coli)

E. coli is a gram-negative and belongs to the family Enterobactereriae [24]. According to the pathogenic mechanism, *E. coli* has been categorized into six groups; Enteropathogenic *E. coli* (EPEC), Enterohemorrhagic *E. coli* (EHEC), Enterotoxigenic *E. coli* (ETEC), Enteroaggregative *E. coli* (EAggEC), Attaching and Effacing *E. coli* (A/EEC); and Enteroinvasive *E. coli* (EIEC) [25, 26]. They are rod-like microorganisms and typically measure up to 3 microns in length.(6)

Vegetable irrigation by untreated human sewage is one of the sources of transmission of *E. coli* to humans [27]. *E. coli* also can be spread by Hamburgers, non-pasteurized milk, contaminated water, fresh fruits, and vegetables, and lettuce [28]. *E. coli* bacteria strains that can produce one or more Shiga toxins are capable of causing disease and illness. They can result in diarrhea, inflammatory condition of the colon with bleeding, a type of kidney failure accompanied by the destruction of red blood cells, as well as other symptoms depending on the specific strain [29, 30].

Non-typhoid salmonellosis

Non-typhoidal Salmonella is a gram-negative, rod-shaped, motile bacterium that is facultatively anaerobic and belongs to the family Enterobacteriaceae. Transmission to humans can occur particularly through animal-origin food consumption, such as eggs, milk, and poultry meat, and also through direct transmission by contact with animals or their environments [31, 32] *Non-typhoid Salmonella* causes food-borne illnesses and a serious human health problem [33]. *Salmonella typhoid* toxin contributes to typhoid fever progression and chronic infection in humans [34].

Shigella spp.

Shigella gram-negative species belong to the family Enterobacteriaceae. Shigella is a non-motile, facultatively anaerobic bacterium classified into four serogroups: A (*Shigella dysenteriae*), B (*Shigella flexneri*), C (*Shigella boydii*) and D (*Shigella monteri*) [35].

Transmission of Shigella occurs either directly through person-to-person contact or indirectly through consumption of contaminated food items, such as fresh vegetable, poultry, dairy products, and water [36, 37]. Shigella produces enterotoxins 1 and 2 which impair fluid and nutrient absorption causing diarrhea. The cytotoxin produced by *Shigella dysenteriae* serotype 1 causes vascular damage in the colon and other organs, leading to bloody diarrhea [38].

Bacillus cereus

Bacillus cereus is a gram-positive bacterium commonly found in contaminated food. It can multiply rapidly with abundant preformed toxin at room temperature [39, 40]. *B. cereus* has been isolated from a variety of food products, including meats, dairy items, fish, seafood, rice, starchy foods, spices, herbs, vegetables, infant formula, powdered milk, and pastries. The foodborne pathogenic bacteria responsible for emetic syndrome that caused by the preformed toxin cereulide. The other diarrheal syndrome. associated with the hemolysin BL (HBL), the cytotoxin K (CYTK), and the non-hemolytic enterotoxin (NHE) [41].

Listeria monocytogenes

Listeria monocytogenes is a Gram-positive bacterium

recognized as a significant foodborne pathogen. It can be transmitted to humans through food consumption and has been found in milk production, raw meats, delicatessen meats, seafood, fruits, and vegetables [42, 45]. Infections caused by *L. monocytogenes* may result as non-invasive gastrointestinal listeriosis in otherwise healthy individuals or as invasive listeriosis, particularly in immunocompromised populations [46, 47]. The most infected by *L. monocytogenes* are infants and pregnant women, which could cause abortion in pregnant women [48, 49]. The major encoded toxins of *L. monocytogenes* strain LIPI-1 and LIPI-3 are associated with human listeriosis outbreak [50].

It is important to note that this review article only provides an overview of the spread of bacterial toxins through food. Further research and studies are needed to delve deeper into specific pathogens, their sources, and effective prevention strategies. By continuously improving our understanding of these bacteria and their transmission routes, we can develop more targeted interventions to mitigate the spread of bacterial toxins and enhance food safety.

Conclusion

In conclusion, the spreading of bacterial toxins in food requires a comprehensive and integrated strategy due to the complexity of the issue. By addressing factors such as poor food handling, inadequate sanitation procedures, weak food safety regulations, and inadequate training for food handlers, we can work towards ensuring food safety and reducing the prevalence of foodborne diseases caused by bacterial toxins. Continued research and collaboration between stakeholders are essential to develop effective prevention and control measures in the field of international business management.

Conflict of Interest

The author declares no conflict of interest.

References

1. Martinović T, Andjelković U, Gajdošik MŠ, Rešetar D, Josić D. Foodborne pathogens and their toxins. J Proteomics. 2016; 147:226-235.
2. Kadariya J, Smith TC, Thapaliya D. Staphylococcus aureus and staphylococcal food-borne disease: An ongoing challenge in public health. Biomed Res Int. 2014; (1):827965.
3. Martinez MLO, Duran MEM, García OEP, Bonilla HQ. Intoxicaciones por sustancias químicas, 2016.
4. Wu S, Duan N, Gu H, Hao L, Ye H, Gong W, *et al*. A Review of the Methods for Detection of Staphylococcus aureus Enterotoxins. Toxins (Basel). 2016; 8(7):176.
5. Argaw S, Addis M. A review on staphylococcal food poisoning. Food Sci Qual Manag. 2015; 40:59-72.
6. Addis M, Sisay D. A review on major food borne bacterial illnesses. J Trop Dis. 2015; 3(4):1-7.
7. Schirone M, Visciano P, Tofalo R, Suzzi G. Biological hazards in food. Vol. 7, Frontiers in Microbiology. Frontiers Media SA, 2017, 2154.
8. Authority EFS. The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2013, 2015.
9. Scallan E, Hoekstra RM, Angulo FJ, Tauxe R V, Widdowson MA, Roy SL, *et al*. Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis. 2011; 17(1):7.
10. Yang SC, Lin CH, Aljuffali IA, Fang JY. Current pathogenic Escherichia coli foodborne outbreak cases and therapy development. Arch Microbiol. 2017; 199:811-825.
11. Hoveida L, Halaji M, Rostami S, Mobasherizadeh S. Biofilm-producing ability of Staphylococcus spp isolated from different foodstuff products. Ann Di Ig Med Prev E Di Comunita. 2019; 31(2):140-147.
12. Haileselassie M, Taddele H, Adhana K, Kalayou S. Food safety knowledge and practices of abattoir and butchery shops and the microbial profile of meat in Mekelle City, Ethiopia. Asian Pac J Trop Biomed. 2013; 3(5):407-412.
13. Ayana Z, Yohannis M, Abera Z. Food-borne bacterial diseases in Ethiopia. Acad J Nutr. 2015; 4(1):62-76.
14. Disassa N, Sibhat B, Mengistu S, Muktar Y, Belina D. Prevalence and antimicrobial susceptibility pattern of E. coli O157: H7 isolated from traditionally marketed raw cow milk in and around Asosa town, western Ethiopia. Vet Med Int. 2017; (1):7581531.
15. Kebede T, Afera B, Taddele H, Bsrat A. Assessment of bacteriological quality of sold meat in the butcher shops of Adigrat, Tigray, Ethiopia. Appl J Hyg. 2014; 3(3):38-44.
16. Pires SM, Desta BN, Mughini-Gras L, Mmbaga BT, Fayemi OE, Salvador EM, *et al*. Burden of foodborne diseases: Think global, act local. Curr Opin Food Sci. 2021; 39:152-159.
17. Bintsis T. Foodborne pathogens. AIMS microbiol. 2017; 3:529-563.
18. Di Giannatale E, Garofolo G, Alessiani A, Di Donato G, Candeloro L, Vencia W, *et al*. Tracing back clinical Campylobacter jejuni in the Northwest of Italy and assessing their potential source. Front Microbiol. 2016; 7:887.
19. Igwaran A, Okoh AI. Human campylobacteriosis: A public health concern of global importance. Heliyon. 2019; 5(11).
20. Del Collo LP, Karns JS, Biswas D, Lombard JE, Haley BJ, Kristensen RC, *et al*. Prevalence, antimicrobial resistance, and molecular characterization of Campylobacter spp. in bulk tank milk and milk filters from US dairies. J Dairy Sci. 2017; 100(5):3470-3479.
21. Carvalho AF de, Silva DM da, Azevedo SS, Piatti RM, Genovez ME, Scarcelli E. Detection of CDT toxin genes in Campylobacter spp. strains isolated from broiler carcasses and vegetables in São Paulo, Brazil. Brazilian J Microbiol. 2013; 44:693-699.
22. Allos BM, Calderwood SB, Baron EL. Clinical manifestations, diagnosis, and treatment of Campylobacter infection. UpToDate, Waltham, MA, 2013.
23. Lagler H, Kiesewetter B, Raderer M. Infection with multidrug-resistant Campylobacter coli mimicking recurrence of carcinoid syndrome: A case report of a neuroendocrine tumor patient with repeated diarrhea. BMC Infect Dis. 2016; 16:1-4.
24. Wiguna IGWW, Darwinata AE, Pinatih KJP, Fatmawati NND. Contamination of Escherichia coli, Salmonella sp. and Vibrio sp. on ice cubes at food stalls in Karangasem Regency, Bali Province in 2021. Intisari Sains Medis. 2022; 13(1):280-283.
25. García A, Fox JG, Besser TE. Zoonotic

enterohemorrhagic Escherichia coli: A one health perspective. Ilar J. 2010; 51(3):221-232.
26. Croxen MA, Law RJ, Scholz R, Keeney KM, Wlodarska M, Finlay BB. Recent advances in understanding enteric pathogenic Escherichia coli. Clin Microbiol Rev. 2013; 26(4):822-880.
27. Rajwar A, Srivastava P, Sahgal M. Microbiology of fresh produce: Route of contamination, detection methods, and remedy. Crit Rev Food Sci Nutr. 2016; 56(14):2383-2390.
28. Hernández-Cortez C, Palma-Martínez I, Gonzalez-Avila LU, Guerrero-Mandujano A, Solís RC, Castro-Escarpulli G. Food poisoning caused by bacteria (food toxins). Poisoning From Specif toxic agents to Nov rapid Simpl Tech Anal. 2017; 33.
29. Wang R, Bono JL, Kalchayanand N, Shackelford S, Harhay DM. Biofilm formation by Shiga toxin–producing Escherichia coli O157: H7 and Non-O157 strains and their tolerance to sanitizers commonly used in the food processing environment. J Food Prot. 2012; 75(8):1418-1428.
30. Luna-Guevara JJ, Arenas-Hernandez MMP, Martínez de la Peña C, Silva JL, Luna-Guevara ML. The role of pathogenic E. coli in fresh vegetables: Behavior, contamination factors, and preventive measures. Int J Microbiol. 2019; (1):2894328.
31. Angulo FJ, Tippen S, Sharp DJ, Payne BJ, Collier C, Hill JE, *et al*. A community waterborne outbreak of salmonellosis and the effectiveness of a boil water order. Am J Public Health. 1997; 87(4):580-584.
32. Hendriksen RS, Vieira AR, Karlsmose S, Lo Fo Wong DMA, Jensen AB, Wegener HC, *et al*. Global monitoring of Salmonella serovar distribution from the World Health Organization Global Foodborne Infections Network Country Data Bank: Results of quality assured laboratories from 2001 to 2007. Foodborne Pathog Dis. 2011; 8(8):887-900.
33. Ejo M, Garedew L, Alebachew Z, Worku W. Prevalence and antimicrobial resistance of Salmonella isolated from animal-origin food items in Gondar, Ethiopia. Biomed Res Int. 2016; (1):4290506.
34. Lee S, Yang YA, Milano SK, Nguyen T, Ahn C, Sim JH, *et al*. Salmonella typhoid toxin PltB subunit and its non-typhoidal Salmonella ortholog confer differential host adaptation and virulence. Cell Host Microbe. 2020; 27(6):937-949.
35. Shahin K, Zhang L, Delfan AS, Komijani M, Hedayatkhah A, Bao H, *et al*. Effective control of Shigella contamination in different foods using a novel six-phage cocktail. Lwt [Internet]. 2021; 144(February):111137. Available from: https://doi.org/10.1016/j.lwt.2021.111137
36. Shahin K, Bouzari M, Wang R, Yazdi M. Prevalence and molecular characterization of multidrug-resistant Shigella species of food origins and their inactivation by specific lytic bacteriophages. Int J Food Microbiol [Internet]. 2019; 305(June):108252. Available from: https://doi.org/10.1016/j.ijfoodmicro.2019.108252
37. Shahin K, Bouzari M, Wang R, Khorasgani MR. Distribution of antimicrobial resistance genes and integrons among Shigella spp. isolated from water sources. J Glob Antimicrob Resist [Internet]. 2019; 19:122-128. Available from: https://doi.org/10.1016/j.jgar.2019.04.020
38. Khan WA, Griffiths JK, Bennish ML. Gastrointestinal and Extra-Intestinal Manifestations of Childhood Shigellosis in a Region Where All Four Species of Shigella Are Endemic. PLoS One. 2013; 8(5).
39. Oh MH, Ham JS, Seol KH, Jang AR, Lee SG, Kang ES, *et al*. Growth Profile and Toxigenicity of Bacillus cereus in Ready-to-eat Food Products of Animal Origin. Food Sci Anim Resour. 2011; 31(1):40-46.
40. Carroll LM, Wiedmann M, Kovac J. Proposal of a taxonomic nomenclature for the Bacillus cereus group which reconciles genomic definitions of bacterial species with clinical and industrial phenotypes. MBio. 2020; 11(1):10-1128.
41. Can HY, Elmalı M, Karagöz A, Dişli HB. Propriedades psicrotróficas, características toxigênicas e perfis PFGE de Bacillus cereus isolado de diferentes alimentos e especiarias. Cienc Rural. 2022; 52(4):14.
42. Chen M, Wu Q, Zhang J, Wang J. Prevalence and characterization of Listeria monocytogenes isolated from retail-level ready-to-eat foods in South China. Food Control. 2014; 38:1-7.
43. Chen M, Cheng J, Wu Q, Zhang J, Chen Y, Xue L, *et al*. Occurrence, antibiotic resistance, and population diversity of Listeria monocytogenes isolated from fresh aquatic products in China. Front Microbiol. 2018; 9:2215.
44. Wu S, Wu Q, Zhang J, Chen M, Yan Z an, Hu H. Listeria monocytogenes prevalence and characteristics in retail raw foods in China. PLoS One. 2015; 10(8):e0136682.
45. Shi W, Qingping W, Jumei Z, Moutong C, Zéan Y. Prevalence, antibiotic resistance and genetic diversity of Listeria monocytogenes isolated from retail ready-to-eat foods in China. Food Control. 2015; 47:340-347.
46. Allen KJ, Wałecka-Zacharska E, Chen JC, Katarzyna KP, Devlieghere F, Van Meervenne E, *et al*. Listeria monocytogenes–An examination of food chain factors potentially contributing to antimicrobial resistance. Food Microbiol. 2016; 54:178-189.
47. Iwu CD, Okoh AI. Characterization of antibiogram fingerprints in Listeria monocytogenes recovered from irrigation water and agricultural soil samples. PLoS One. 2020; 15(2):e0228956.
48. Matereke LT, Okoh AI. Listeria monocytogenes virulence, antimicrobial resistance and environmental persistence: A review. Pathogens. 2020; 9(7):528.
49. Desai AN, Anyoha A, Madoff LC, Lassmann B. Changing epidemiology of Listeria monocytogenes outbreaks, sporadic cases, and recalls globally: A review of ProMED reports from 1996 to 2018. Int J Infect Dis. 2019; 84:48-53.
50. Quereda JJ, Andersson C, Cossart P, Johansson J, Pizarro-Cerdá J. Role in virulence of phospholipases, listeriolysin O and listeriolysin S from epidemic Listeria monocytogenes using the chicken embryo infection model. Vet Res. 2018; 49:1-9.