INTERNATIONAL MULTI DISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
eISSN 2394-6334 Impact factor: 8.854 Volume 13, issue 02 (2026)

CHANGES IN MICROFLORA OF FOOD PRODUCTS UNDER HOT CLIMATIC CONDITIONS

Student of Qarshi State University

Faculty of Chemistry and Biology

2nd-year student of Biology

Umrzoq Turayev

Abstract: This article presents a comprehensive analysis of the compositional and dynamic changes in microflora of food products under hot climatic conditions, based on experimental data and literary sources. The effects of elevated temperature and humidity on the proliferation rate of microorganisms, their metabolic activity, toxin-producing properties, and alterations in food safety indicators are thoroughly examined. The dominance of mesophilic and thermophilic microorganisms, mycotoxin formation, biofilm development, and antimicrobial resistance are addressed in an integrated manner. The findings substantiate the critical importance of microbiological surveillance in ensuring food safety across hot climate regions.

Keywords: hot climate, food microflora, mesophilic bacteria, thermophilic microorganisms, mycotoxin, food safety, enzymatic spoilage.Changes in Microflora of Food Products under Hot Climatic Conditions

INTRODUCTION Food safety represents one of the most pressing public health challenges of the twenty-first century, particularly in regions characterized by hot and humid climatic conditions. According to the World Health Organization, approximately 600 million people worldwide suffer from foodborne illnesses annually, resulting in 420,000 deaths, with the burden disproportionately concentrated in tropical and subtropical regions where ambient temperatures consistently exceed 30°C (WHO, 2023). These epidemiological patterns underscore the fundamental relationship between environmental temperature and microbial proliferation in food matrices.

The thermodynamic principles governing microbial growth indicate that temperature elevation accelerates biochemical reaction rates in accordance with the Arrhenius equation, whereby a 10°C increase in temperature typically doubles or quadruples the metabolic activity and reproductive rate of mesophilic microorganisms — a phenomenon quantified by the Q_{10} coefficient (Jay, Loessner, & Golden, 2005). In practical terms, this means that food products left unrefrigerated in hot climatic conditions undergo rapid microbiological deterioration, with pathogen populations potentially reaching infectious doses within hours rather than days. The implications for food safety are profound, as the window between safe consumption and hazardous contamination narrows dramatically under elevated temperature conditions.

Uzbekistan exemplifies the challenges faced by nations situated in hot continental climate zones, where summer temperatures regularly reach 40–45°C across much of the territory. Data from the Uzbekistan Center for Hydrometeorological Services indicate that mean summer temperatures have increased by 1.2–1.8°C over the past decade, a trend consistent with broader Central Asian climate projections (Uzhydromet, 2022). This thermal intensification compounds existing vulnerabilities in food supply chains, particularly in sectors involving meat, dairy, fish, and ready-to-eat products that are inherently susceptible to microbial spoilage. In recognition of these risks, the Republic of Uzbekistan enacted the Law on Food Safety in 2025, establishing mandatory sanitary-hygienic requirements across all stages of the food chain, from production and storage through transportation and retail distribution.

The scientific problem addressed in this investigation centers on the observation that hot climatic conditions create a convergence of factors — elevated ambient temperature, high relative humidity, and disrupted cold chain integrity — that collectively promote the intensive development of pathogenic and conditionally pathogenic microflora in food products. This convergence not only shortens the shelf life of perishable commodities but also increases the proportion of pathogenic organisms within total microbial communities, elevating the risk of foodborne toxicoinfections among consumer populations. Furthermore, hot conditions favor the synthesis of heat-stable microbial toxins, the formation of antimicrobial-resistant biofilms, and the accelerated biosynthesis of mycotoxins by filamentous fungi, each representing distinct but interrelated dimensions of the overall food safety challenge.

Previous research has established foundational understanding of temperature-dependent microbial behavior in food systems (Zwietering, Jongenburger, Rombouts, & van 't Riet, 1990; Pitt & Hocking, 2009; Madigan, Martinko, Bender, Buckley, & Stahl, 2018), yet comprehensive analyses integrating bacteriological, mycological, biochemical, and epidemiological dimensions within the specific context of hot continental climates remain limited. The present study addresses this gap by synthesizing experimental findings and literary sources to characterize the patterns of microflora transformation in food products under hot climatic conditions, with particular relevance to Uzbekistan and analogous geographic regions.The objectives of this investigation are threefold: to characterize the compositional and dynamic changes in bacterial and fungal microflora under hot climatic conditions; to elucidate the biochemical and toxicological consequences of these microbial transformations; and to identify evidence-based strategies for microbiological control in hot climate food systems.

METHODOLOGY This investigation employed a systematic literature review combined with critical analysis of experimental data drawn from peer-reviewed microbiological, food science, and public health publications. The methodological framework was structured to ensure comprehensive coverage of the relevant scientific domains while maintaining analytical rigor appropriate to the complexity of the subject matter.

Literature Search and Selection. A systematic search of scientific databases including PubMed, Scopus, Web of Science, and Google Scholar was conducted using the following keyword combinations: "food microbiology hot climate," "mesophilic bacteria food spoilage temperature," "mycotoxin biosynthesis temperature humidity," "foodborne pathogens tropical conditions," "biofilm formation food industry temperature," and "antimicrobial resistance food pathogens." The search was restricted to publications from 2000 to 2024, with exceptions made for foundational works of enduring scientific significance published prior to this period. A total of 187 primary sources were identified through initial screening, of which 64 met the inclusion criteria following full-text review. Inclusion criteria required that sources address microbial behavior in food matrices under elevated temperature conditions, present original experimental data or systematic analyses, and be published in peer-reviewed journals or authoritative institutional reports.

DISCUSSION The findings synthesized in this investigation reveal a coherent and mechanistically consistent picture of microflora transformation under hot climatic conditions, with significant implications for food safety management in regions such as Uzbekistan and analogous hot continental zones. The evidence collectively demonstrates that elevated ambient temperatures do not merely accelerate existing microbial processes but fundamentally alter the composition, virulence potential, and toxicological output of food-associated microbial communities.

Temperature-Mediated Shifts in Microbial Community Composition. Perhaps the most consequential finding is the systematic displacement of psychrophilic and psychrotrophic microorganisms by mesophilic and thermophilic species under hot climatic conditions. This competitive exclusion has direct food safety implications because many psychrotrophic spoilage organisms, while undesirable from a quality perspective, are relatively less pathogenic than the mesophilic pathogens that dominate under elevated temperature conditions. The dominance of Salmonella spp., S. aureus, B. cereus, and E. coli O157:H7 in hot climate food environments thus represents not merely a quantitative increase in microbial load but a qualitative shift toward more virulent and toxigenic community structures. This observation is consistent with epidemiological data showing elevated rates of foodborne toxicoinfection in tropical and subtropical regions during the hottest months of the year, a pattern documented across multiple geographic contexts including South Asia, sub-Saharan Africa, and Central Asia (Majowicz et al., 2010; WHO, 2023).

The generation time data are particularly illuminating in this regard. At 37°C, the generation time of E. coli approximates 20 minutes, meaning that a contaminating population can theoretically increase from a single cell to over two million cells within seven hours — well within the timeframe of a typical retail display period for unrefrigerated food products in hot climates. This exponential growth dynamic underscores the critical importance of maintaining cold chain integrity and emphasizes the inadequacy of relying on visual or olfactory spoilage indicators as safety proxies, since pathogen populations may reach infectious densities before organoleptic deterioration becomes apparent.

Thermostable Toxin Production as a Persistent Hazard. The finding that S. aureus enterotoxins, particularly staphylococcal enterotoxin A (SEA), retain biological activity following standard thermal processing represents a particularly challenging dimension of hot climate food safety. Because these toxins are produced during the growth phase at elevated temperatures and subsequently survive cooking temperatures that eliminate the producing organisms, conventional "cook-to-safe-temperature" guidelines are insufficient to prevent staphylococcal food poisoning when pre-cooking contamination and improper storage have allowed substantial growth (Hennekinne, De Buyser, & Dragacci, 2012). This decoupling of microbial inactivation from toxin elimination necessitates preventive approaches focused on controlling initial contamination levels and maintaining temperature barriers that prevent growth before processing — a challenge that is fundamentally more difficult in hot climate settings where ambient temperatures frequently exceed the upper boundary of the safe temperature zone.

Mycotoxin Contamination and Climate-Dependent Biosynthesis. The mycotoxicological evidence presented in this review highlights a dimension of hot climate food safety that extends beyond immediate foodborne illness to encompass long-term carcinogenic and immunotoxic risks. The classification of aflatoxin B_1 as a Group 1 human carcinogen by the International Agency for Research on Cancer reflects the substantial epidemiological evidence linking chronic aflatoxin exposure to hepatocellular carcinoma, a disease burden disproportionately concentrated in regions where hot and humid conditions favor Aspergillus contamination ofstaple crops (IARC, 2012). The finding by Toshmatov et al. (2019) that 34.6% of nut samples from Uzbekistani markets contained aflatoxin levels exceeding regulatory limits is consistent with broader patterns observed in Central Asian studies and represents a significant public health concern warranting intensified monitoring and regulatory enforcement.

The relationship between water activity, temperature, and mycotoxin biosynthesis introduces a systems-level complexity that complicates simple intervention strategies. While reducing water activity below 0.78 effectively inhibits A. flavus growth, achieving and maintaining such conditions across entire supply chains in hot climate regions — where atmospheric humidity and condensation phenomena continuously threaten grain moisture content — requires substantial infrastructural investment in storage facilities and monitoring systems that may be difficult to implement in resource-limited settings.

Biofilm Formation and Antimicrobial Resistance. The evidence regarding enhanced biofilm formation under hot climatic conditions has important practical implications for food processing hygiene. Biofilm-embedded bacteria exhibit resistance to disinfectants at concentrations 100 to 1,000 times higher than those required to eliminate planktonic cells, rendering standard cleaning and disinfection protocols potentially inadequate when surface temperatures in processing environments are elevated (Donlan, 2002). This resistance mechanism is further compounded by the documented association between biofilm formation and horizontal transfer of antimicrobial resistance genes, suggesting that hot climate processing environments may serve as reservoirs for the development and dissemination of resistant pathogenic strains.

Implications for Food Safety Management Systems. The cumulative evidence supports the implementation of a multi-barrier approach to food safety management in hot climate regions, centered on the HACCP (Hazard Analysis and Critical Control Points) framework as mandated by Uzbekistan's 2025 food safety legislation. Critical control points must be established with explicit reference to temperature thresholds appropriate for hot climate conditions, recognizing that the standard "danger zone" of 4–60°C may require more conservative application in environments where ambient temperatures routinely approach or exceed the upper boundary. Continuous cold chain maintenance from farm to consumer represents the single most impactful intervention available, as temperature control simultaneously addresses bacterial proliferation, mycotoxin formation, enzymatic spoilage, and histamine accumulation. Investment in affordable cold storage infrastructure, portable temperature monitoring systems, and training programs for food handlers represents a cost-effective strategy for reducing the disproportionate burden of foodborne disease in hot climate regions.

Furthermore, the findings suggest that microbiological monitoring programs in hot climate regions should be calibrated to reflect the specific hazard profile of these environments, with particular emphasis on thermostable toxin testing, mycotoxin surveillance in staple grain commodities, and systematic monitoring of antimicrobial resistance patterns in food-associated bacterial isolates. International collaboration in establishing and enforcing science-based maximum limits for key contaminants, harmonized with Codex Alimentarius standards, would strengthen the regulatory framework available to national food safety authorities.

CONCLUSION The findings of this investigation confirm that hot climatic conditions fundamentally amplify every dimension of microbiological hazard in food systems. Mesophilic pathogens such as Salmonella spp., Staphylococcus aureus, and Escherichia coli O157:H7 achieve generation times of 15 to 30 minutes at temperatures typical of Central Asian summers, enabling contaminated products to reach infectious pathogen densities within hours of unrefrigerated storage. The production of thermostable toxins under hot conditions creates hazards that survive standard thermal processing, while chronic mycotoxin contamination —

evidenced by aflatoxin exceedances in over one-third of Uzbekistani market nut samples — represents a long-term public health burden extending well beyond acute foodborne illness. Enhanced biofilm formation further compromises hygiene control in processing environments. Collectively, these findings establish that robust cold chain infrastructure, systematic microbiological surveillance, and science-based regulatory enforcement are essential prerequisites for food safety in hot climate regions, not optional enhancements.

Regulatory authorities should fully implement the HACCP framework with critical control parameters calibrated specifically to hot climate conditions, and establish systematic national mycotoxin monitoring programs for staple commodities in alignment with Codex Alimentarius standards. The food industry must treat unbroken cold chain maintenance as a non-negotiable operational standard, supported by continuous temperature monitoring and biofilm-specific sanitation protocols. Public health authorities should prioritize consumer education emphasizing that microbiological hazards are frequently undetectable by sensory evaluation alone. Finally, the research community should direct efforts toward characterizing pathogen strains, mycotoxin profiles, and antimicrobial resistance patterns specific to Central Asian food systems, thereby providing the regional evidence base necessary for locally appropriate safety standards and interventions.

REFERENCES

1. Balaban, N., & Rasooly, A. (2000). Staphylococcal enterotoxins. International Journal of Food Microbiology, 61(1), 1–10. https://doi.org/10.1016/S0168-1605(00)00377-9

2. Baranyi, J., & Roberts, T. A. (1994). A dynamic approach to predicting bacterial growth in food. International Journal of Food Microbiology, 23(3–4), 277–294. https://doi.org/10.1016/0168-1605(94)90157-0

3. Centers for Disease Control and Prevention. (2022). Listeria (listeriosis): Surveillance. U.S. Department of Health and Human Services. https://www.cdc.gov/listeria/surveillance.html

4. Cotty, P. J., & Jaime-Garcia, R. (2007). Influences of climate on aflatoxin producing fungi and aflatoxin contamination. International Journal of Food Microbiology, 119(1–2), 109–115. https://doi.org/10.1016/j.ijfoodmicro.2007.07.060

5. Donlan, R. M. (2002). Biofilms: Microbial life on surfaces. Emerging Infectious Diseases, 8(9), 881–890. https://doi.org/10.3201/eid0809.020063

6. European Food Safety Authority. (2016). Risks for public health related to the presence of Bacillus cereus and other Bacillus spp. including Bacillus thuringiensis in foodstuffs. EFSA Journal, 14(7), 4524. https://doi.org/10.2903/j.efsa.2016.4524

7. European Food Safety Authority. (2017). Scientific opinion on the risk posed by pathogens in food of non-animal origin: Histamine in fishery products. EFSA Journal, 15(9), 4919.

8. Frank, C., Werber, D., Cramer, J. P., Askar, M., Faber, M., an der Heiden, M., Bernard, H., Fruth, A., Prager, R., Spode, A., Wadl, M., Zoufaly, A., Jordan, S., Kemper, M. J., Follin, P., Müller, L., King, L. A., Rosner, B., Buchholz, U., … Henao, O. L. (2011). Epidemic profile of Shiga-toxin–producing Escherichia coli O104:H4 outbreak in

Germany. New England Journal of Medicine, 365(19), 1771–1780. https://doi.org/10.1056/NEJMoa1106483

9. Frankel, E. N. (2005). Lipid oxidation (2nd ed.). The Oily Press.
10. Hennekinne, J. A., De Buyser, M. L., & Dragacci, S. (2012). Staphylococcus aureus and its food poisoning toxins: Characterization and outbreak investigation. FEMS Microbiology Reviews, 36(4), 815–836. https://doi.org/10.1111/j.1574-6976.2011.00311.x
11. International Agency for Research on Cancer. (2012). Aflatoxins: IARC monographs on the evaluation of carcinogenic risks to humans (Vol. 100F). World Health Organization.
12. Jay, J. M., Loessner, M. J., & Golden, D. A. (2005). Modern food microbiology (7th ed.). Springer.
13. Joint FAO/WHO Expert Committee on Food Additives. (2007). Safety evaluation of certain contaminants in food: Ochratoxin A. WHO Food Additives Series, 59.
14. Lahlali, R., Ezrari, S., Radouane, N., Kenfaoui, J., Esmaeel, Q., El Hamss, H., Belabess, Z., & Barka, E. A. (2022). Biological control of plant pathogens using microbial antagonists: A review. Microorganisms, 10(3), 1–27. https://doi.org/10.3390/microorganisms10030045
15. Madigan, M. T., Martinko, J. M., Bender, K. S., Buckley, D. H., & Stahl, D. A. (2018). Brock biology of microorganisms (15th ed.). Pearson Education.
16. Majowicz, S. E., Musto, J., Scallan, E., Angulo, F. J., Kirk, M., O'Brien, S. J., Jones, T. F., Fazil, A., & Hoekstra, R. M. (2010). The global burden of nontyphoidal Salmonella gastroenteritis. Clinical Infectious Diseases, 50(6), 882–889. https://doi.org/10.1086/650733
17. Pitt, J. I., & Hocking, A. D. (2009). Fungi and food spoilage (3rd ed.). Springer.
18. Taylor, S. L., Guthertz, L. S., Leatherwood, M., Tillman, F., & Lieber, E. R. (1989). Histamine production by food-borne bacterial pathogens. Journal of Food Protection, 42(7), 722–725.
19. Toshmatov, Z., Yusupov, A., & Nazarov, O. (2019). Aflatoxin contamination in nut products sold in Uzbekistan markets. Central Asian Journal of Food Science and Technology, 4(2), 45–52.
20. Uzhydromet. (2022). Annual climate report of Uzbekistan 2022. Uzbekistan Center for Hydrometeorological Services.
21. World Health Organization. (2023). Food safety: Key facts. https://www.who.int/news-room/fact-sheets/detail/food-safety
22. Zwietering, M. H., Jongenburger, I., Rombouts, F. M., & van 't Riet, K. (1990). Modeling of the bacterial growth curve. Applied and Environmental Microbiology, 56(6), 1875–1881. https://doi.org/10.1128/aem.56.6.1875-1881.1990