Review



# Food Microbiology in the Post-COVID-19 Era: Insights from Bibliometric Analysis in Bioeconomics

Carlos Alberto Zúniga-Gonzalez *

Posted Date: 19 August 2024

doi: 10.20944/preprints202408.1192.v1

Keywords: Bioeconomy; Food safety; Eco-Intensification; Productive pathway; Biotechnology; Nutrition

*Article*

# Food Microbiology in the Post-COVID-19 Era: Insights from Bibliometric Analysis in Bioeconomics

**Zuniga-Gonzalez, C. A.**

National Autonomous University of Nicaragua, Leon. School of Agrarian and Veterinary Sciences. Bioeconomy and Climate Change Research Center. czuniga@ct.unanleon.edu.ni https://orcid.org/0000-0002-2545-8304

Jel Classification: L78, Q16, Q57

**Abstract: Background:** Before the COVID-19 outbreak, food microbiology was crucial in identifying and preventing foodborne pathogens like Salmonella and E. coli. The pandemic underscored the importance of this discipline, highlighting the need for enhanced surveillance and microbiological control in the food chain to prevent future global public health threats. This research aimed to advance knowledge management in Bioeconomy, focusing on Eco-Intensification and biotechnology applications that directly affect food microbiology, especially in the context of the COVID-19 crisis. **Methodology:** The study involved a comprehensive literature review grounded in the epistemological principles of Bioeconomy, utilizing the Bibliometric Scopus database. This approach facilitated the exploration of the development of eco-intensification and biotechnology applications within food safety and nutrition microbiology. **Results:** The findings emphasize the importance of understanding the social and economic impacts of microbiological activities in food intake through a Bioeconomy lens. The research highlights the need for integrating microbiological insights into broader bioeconomic frameworks to address food safety and sustainability challenges effectively. **Conclusion:** Recommendations are provided for decision-makers to enhance public health agendas from a bioeconomic perspective. These recommendations aim to strengthen the focus on Bioeconomy and improve the management of interactions between food microbiology and the challenges exacerbated by the COVID-19 pandemic.

**Keywords:** bioeconomy; food safety; eco-intensification; productive pathway; biotechnology; nutrition

## 1. Introduction

The potential linkage of COVID-19's origins with wastewater and community food markets, identified as high transmission points for the pathogenic agent, has significantly altered food safety protocols (Wannigama *et al*., 2023). The pandemic has led to increased scrutiny and adaptation of procedures within the food industry to mitigate transmission risks. Amidst this scenario, the role of the bioeconomy has become increasingly crucial, particularly in relation to its impact on agriculture and food production. Food security during a pandemic becomes paramount, demanding sustainable food production practices. Research by Awasthi et al. (2022) and von Braun (2018) has highlighted the necessity of adopting environmentally friendly agricultural approaches within the bioeconomy framework to address these challenges.

Biotechnology and bio-pharmaceuticals play pivotal roles within the bioeconomy domain. The rapid development and deployment of mRNA-based vaccines during the pandemic underscore the significant contribution of biotechnological advancements in addressing global health crises (López *et al*., 2018). These advancements demonstrate the potential of bioeconomy to enhance not only medical responses but also to support sustainable practices in other sectors, such as food production.

There exists a research gap in linking bioeconomy and food microbiology as a prioritized area, particularly concerning the impact of the pandemic on ecological intensification of production and biotechnological applications. Zúniga et al. (2022) emphasize the need for a thorough analysis of

 doi:10.20944/preprints202408.1192.v1



microbial activities crucial for ensuring food security in the post-COVID era. Understanding how microorganisms affect global food production in this new economic paradigm shaped by the pandemic is essential, as emphasized by Bloom (2015).

Eco-intensification and biotechnology associated with microorganisms form the crux of this study. Previous research has illustrated how microorganisms can both positively and negatively impact food safety, underlining the importance of their role in sustainable food practices (Zuniga *et al.*, 2014; Capilice & Fitzgerald, 1999; Singh *et al.*, 2020). In light of the pandemic, there is an urgent need to reassess and enhance our understanding of these microorganisms to ensure food safety and sustainability in a post-COVID context.

This study aims to comprehend the intricate dynamics of microorganisms within the bioeconomy, crucial for ensuring food safety and sustainability in the post-COVID era. It seeks to leverage microbial studies to develop more efficient and sustainable food production strategies, reflecting the significant shifts in practices and policies driven by the pandemic.

The research contributes to three key areas. Firstly, it proposes a new epistemological approach within the bioeconomy to analyze microorganisms affecting sanitary quality and water. Secondly, it investigates eco-intensification and biotechnology, with a focus on how these fields can be optimized in the context of pandemic-driven changes in microbial composition of food. Lastly, it offers insights for food policy within the agri-food sector, defining the biochemical and morphological characteristics of contaminating microorganisms.

Structured as follows, the literature review section introduces the Bioeconomy and its primary pathways, namely Eco-Intensification and Biotechnology Applications. The subsequent section details the methodology employed. Following that, the results presented, culminating in the conclusions and discussion section, where the findings are contextualized and compared with existing studies.

## 2. Methodology

The methodology adopted for this research aligns with the interpretive paradigm within the epistemology of Bioeconomy, following the established guidelines outlined by Zuniga et al. (2022) and Zúniga et al. (2016). This approach embraces a qualitative epistemological framework similar to that proposed by Gómez (2012). This qualitative framework is essential for understanding how the COVID-19 pandemic has influenced practices within the field of Bioeconomy and how these practices relate to food microbiology.

The study identifies two primary paths for analysis: eco-intensification and biotechnology applications, derived from the study's objectives. Identifying these paths is crucial for addressing how the pandemic has altered practices in these areas and how these practices can contribute to post-COVID food security and sustainability. A structured script for the literature review was developed based on these identified paths.

VOSviewer software was used to analyze the dataset consisting of 21,841 documents sourced from the Scopus database. Analyzing these documents will help identify trends and changes in the literature related to the pandemic and its impact on Bioeconomy and food microbiology. All reviews were meticulously documented in electronic format, and the Transcript tool facilitated subsequent transcription. During the analysis phase, two productive paths or subcategories closely associated with food microbiology were discerned (refer to Table 1 for details, and Figure 1).

**Table 1. Methodological approach of Bioeconomics for food microbiology**.

| Category | Productive paths in food production | Codes for food microbiology |
|---|---|---|
| | Reasonable use of biological diversity assets | Eco intensification: No-till agricultural practices, precision agriculture strategies, integrated pest management, sustainable land management, clean |

 doi:10.20944/preprints202408.1192.v1



| | | |
|---|---|---|
| | | technologies for processing (waste water), bio inputs, bio stimulants, bio regulators, etc. |
| **Bioeconomy of the agricultural sector** | Bio Technology applications | Biotechnology applications: plant genetic engineering, human and animal health, environmental biotechnology, functional foods. Foods |
| | Biorefineries and Bioproducts | Improving efficiency in the value chain |
| | Natural environment services | Renewable energy and energy efficiency |

Source: Own elaboration (Zuniga *et al.,* 2014).

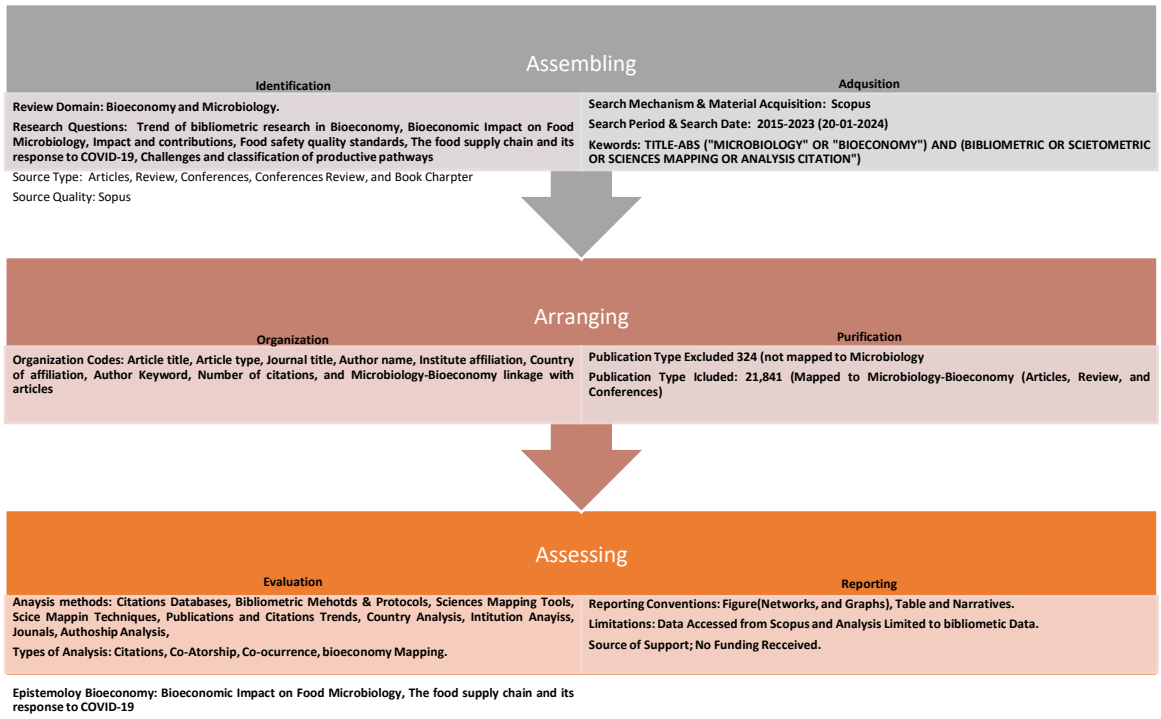


**Figure 1.** Research protocol.

In this analysis, the Scientific Procedures and Rationales for Systematic Literature Reviews (SPAR-4-SLR) protocol, originally developed by Paul et al. and widely utilized by other researchers (Lim *et al.,* 2022; Raman *et al.,* 2022), serves as a guiding framework for the tasks of assembling, arranging, and assessing, as illustrated in Figure 1. This methodology ensures a systematic and transparent review, which is crucial for understanding how bioeconomy and food microbiology practices have evolved due to the pandemic.

*2.1. Assembling*

The first step, referred to as assembling, entails gathering publications for examination. Since our work involves conducting, a bibliometric analysis of studies related to Bioeconomy and Microbiology research, our dataset consists of works at the intersection of Bioeconomy, microbiology,

 doi:10.20944/preprints202408.1192.v1



and bibliometric research. To obtain bibliographic data from Scopus on January 18, 2024, we utilized the following search query. Scopus is widely recognized and commonly used for quantitative analyses, serving as a premier multi-disciplinary database containing peer-reviewed literature Donthu et al. (2020). We chose the study period from 2015 to 2023 to focus on recent developments following the formal adoption of the bioeconomy. Our search criteria resulted in 21,841 publications. The search query employed for retrieval is as follows:

TITLE-ABS ("BIOECONOMY" OR "MICROBIOLOGY") AND (bibliometric OR scientometric OR "Science mapping" OR "citation analysis" OR bibliographic) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "cr")) AND (LIMIT-TO (PUBYEAR,2022) OR LIMIT-TO (PUBYEAR,2022) OR LIMIT-TO (PUBYEAR,2020) OR LIMIT-TO (PUBYEAR,2019) OR LIMIT-TO (PUBYEAR,2019) OR LIMIT-TO (PUBYEAR,2018) OR LIMIT-TO (PUBYEAR,2015) OR LIMIT-TO (PUBYEAR, English)) AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (SRCTYPE, "j")).

### *2.2. Arranging*

In the research protocol (Figure 1), the arranging phase involves sorting codes and refining articles by applying exclusion and inclusion criteria to the search results. For organization, we downloaded bibliometric data from Scopus and arranged it based on article title, journal title, author name, institute affiliation, country of affiliation, author keywords, number of citations, and the articles' linkage with Bioeconomy-Microbiology (BM). It was utilized the VOSviewer Software to identify the BM linkage of articles. Regarding purification, we excluded 324 articles, as they could not be associated with BM.

### *2.3. Assessing*

In the final phase, pivotal roles are played by assessment, evaluation, and reporting. The evaluation section of the article highlights the analytical approach and constraints encountered during the research. Various software tools, including VOSviewer (van, 2009), and MS Excel, were employed based on specific requirements. Tasks such as data filtering, sorting, listing, and graph creation were carried out using MS Excel. VOSviewer played a crucial role in identifying the most and least researched Bioeconomy-Microbiology (BM), mapping BM to journals, countries, institutions, and authors, and identifying emerging research topics with their BM focus. It was primarily used to visualize keyword co-occurrence mapping and co-citation mapping of BM. Additionally, VOSviewer assisted in designing the Sankey diagram to map the top countries, institutions, and journals. BM Mapper determined the percentage of BM mappings of keywords in different clusters, while VOSviewer constructed a BM network based on eigenvector and betweenness for analyzing the principles of the BM network.

## 3. Results and Discussion

### *3.1. Literature Review and Overview*

The information search in this section was organized starting with the epistemology of bioeconomy. Subsequently, the challenges and classification of bioeconomy were reviewed to position eco-intensification and biotechnology applications as important pathways in food microbiology. A third subsection addresses in vitro agriculture and its seasonal submersion.

Microorganisms, also known as microbes, are tiny living organisms that can only be observed using microscopes. Unlike plants and animals, microorganisms are unicellular organisms and, according to Pérez, Rojas, and Vale (2009), are characterized by their individuality. They are classified into various categories, including viruses, bacteria, fungi, cyanophyceae algae, and protists, as documented by Rodríguez (2010) and Ramos et al. (2021). The specific study of these microorganisms is conducted in the field of bacteriology, as indicated by Delgado and Torres (2003). These biological

 doi:10.20944/preprints202408.1192.v1



entities, unlike plants and animals, exhibit a fundamental biological organization, according to Caballero (2008).

In the literature review, Zúniga et al. (2022) investigated the epistemology of bioeconomy and its productive pathways. Following this theory, the work was oriented towards reviewing literature that applied this concept and research results that serve as fundamental examples, primarily in food microbiology in the post-COVID-19 context (See Table 2).

The literature review utilized the Scopus database, analyzing a dataset of 21,841 documents related to food microbiology and bioeconomy. Figures 2 and 3 illustrate the lack of significant connections among researchers on the intersection of Bioeconomy and food microbiology. Additionally, these figures highlight the primary countries involved in this research field.

The analysis reveals a noticeable gap between research efforts in Bioeconomy and food microbiology, emphasizing the need for enhanced interdisciplinary collaboration to bridge this gap. Such collaboration could significantly advance both fields, particularly in addressing food security and sustainable production challenges in the post-COVID era.

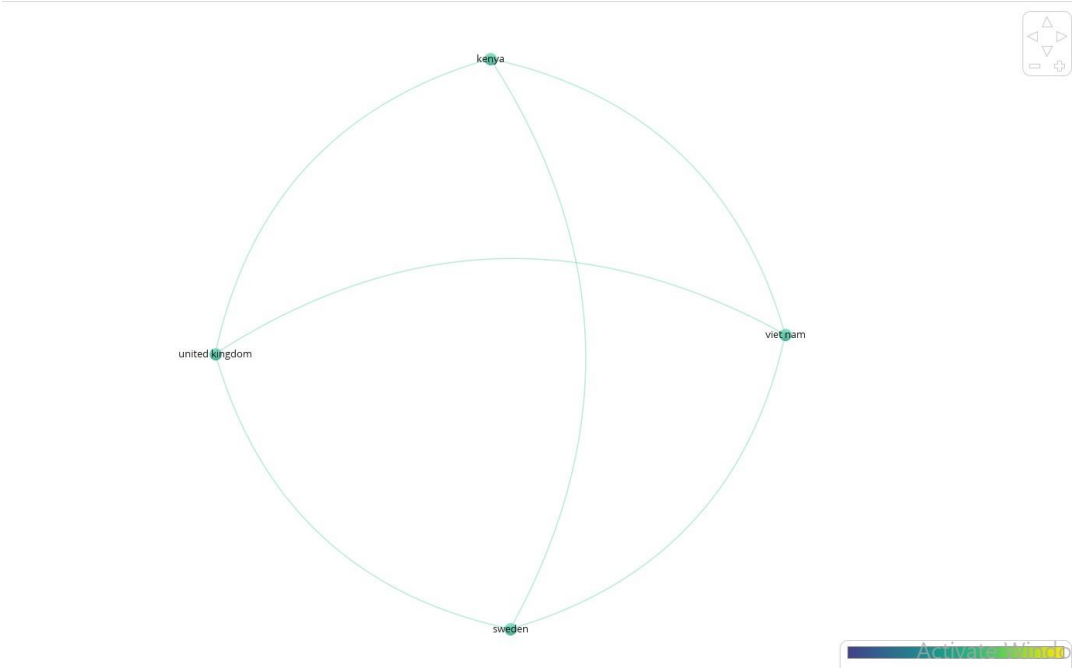


**Figure 2.** Map of countries that linked to the topic of Bioeconomy and food microbiology, Scopus database.

 doi:10.20944/preprints202408.1192.v1



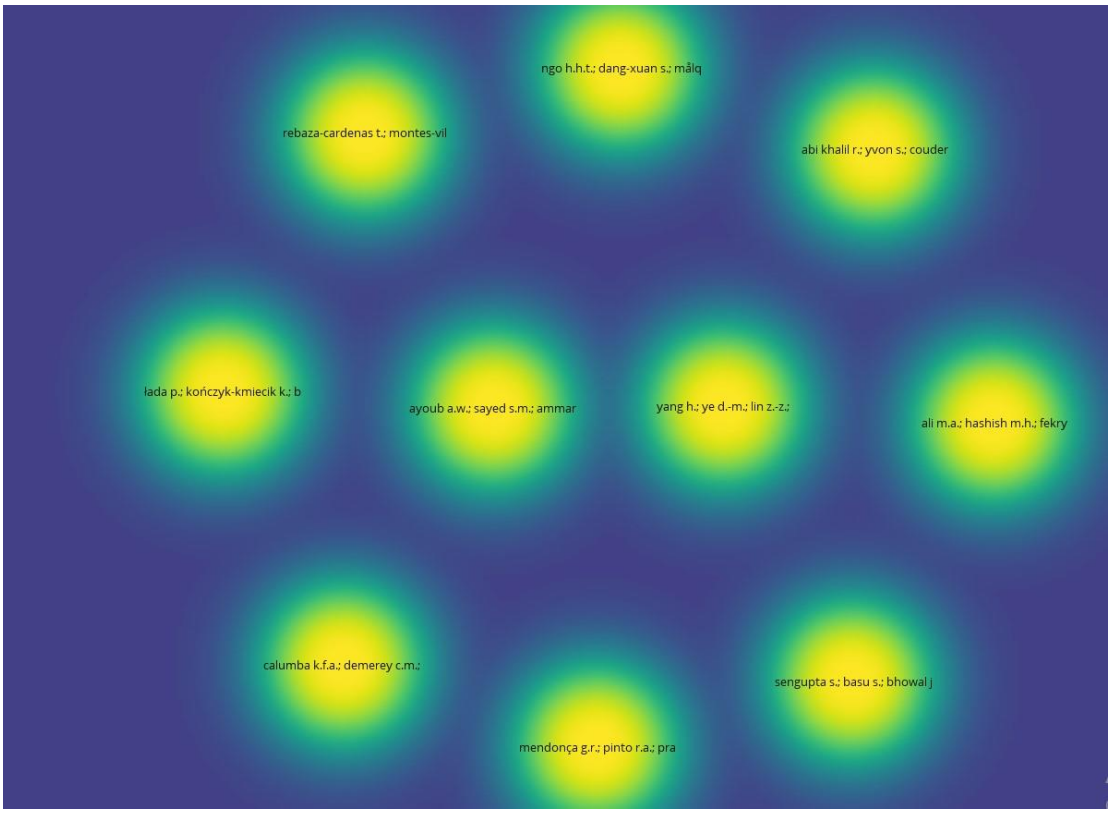


**Figure 3.** Relationship map of the main authors on the topic of Bioeconomics and food microbiology, Scopus database.

*3.2. Challenges and Classification of Productive Pathways*

The Key Challenges were:

Population Growth: The urgent need to address the expectation of a global population of 9 million or more (Bloom, 2003).

Fossil Fuel Depletion: Consequences of the diminishing availability of fossil fuels.

Resource Limitations: Constraints on acquiring and managing native resources such as land, water, and biodiversity (Conde-Álvarez & Saldaña-Zorrilla, 2007; Zuniga *et al*., 2014).

These challenges call for a dual approach: aligning with governmental guidelines to address food issues and strengthening the scientific-technical basis for proposing solutions based on biomass or microbial resources (Zapata-Hernández, 2020; Medina-Herrera et al., 2020; Zúniga-González et al., 2014). The Canadian model, based on the NAICS system, serves as a potential model for addressing these challenges (Bui et al., 2020; Pellerin & Taylor, 2008).

Bioeconomy Pathways and Economic Sectors

Table 2 presents a comparative analysis of bioeconomy pathways and traditional economic sectors. This classification highlights the various approaches within the bioeconomy, such as eco-intensification, biorefineries, and biotechnological applications, alongside traditional economic sectors (Lodeiro, 2020; Fernández-Rodríguez *et al.*, 2020).

**Table 2. Comparative table of the bioeconomy and its productive paths with the economic sectors**.

| Main category | Economic sector traditional economics approach | Productive paths (Zuniga *et al.*, 2022) Bioeconomy approach |
|---|---|---|
| | 1. Health: Includes health services and social assistance goods that are non- | 1. Reasonable use of biological diversity heritage. Discovery and domestication of local biodiversity (genetics of species |

 doi:10.20944/preprints202408.1192.v1



| | | |
|---|---|---|
| | commercial health and social activities Lodeiro (2020); Fernandez (2020). | and ecosystems). Transformation of distinctive biodiversity into valuable products. |
| **Bioeconomy** | 2. Agricultural manufacturing: These are the tasks of manufacturing seeds and oilseed oils. Clients who demand, coffee processing, sugar cane, beans, corn, paddy rice, soybeans, sorghum, peanuts, sesame, raw tobacco, new forage plantations Bermeo and Velasteguí (2020), Fernández-Rodríguez et al. (2020). | 2. Echo intensification. Agronomic practices aimed at improving the environmental performance of agricultural activities without sacrificing existing levels of production or productivity. Balance of agricultural, environmental, economic and social benefits, seeking a more efficient use of energy resources and aiming to reduce the use of fossil fuels, pesticides and other pollutants. |
| | 3. Bioprocesses used in agriculture Extractive exploitation of gold and silver. | 3. Biorefineries and Bioproducts. Use of biomass to produce bioenergy and processes aimed at replacing industrial inputs of fossil fuels (Biofuels, Biomaterials). |
| | 4. Manufacturing of pharmaceutical goods and medicines Manufacturing of drug goods, health chemicals and herbal substances. | 4. Biotechnological applications. Biotechnological products, tools and processes, including industrial tissue culture, marker-assisted selection in crops and breeding, genetically modified (GM) seeds and plants, molecular-based diagnostics, breeding through molecular techniques, modified enzymes, microorganisms and yeasts, etc. |
| | 5. Other organic chemistry manufacturing Manufacture of primary synthetic goods, manufacture of cleaning and purifying products, cleaning and polishing preparations, fragrances and styling preparations, Manufacture of other synthetic goods, local industry, Manufacture of drug goods, synthetic health and botanical substances (Cicco *et al*., 2020). | 5. Improved efficiency in the value chain. Increase in the quantity and/or value of production or in markets as a result of the use of residual biomass and the development of market links for innovative bio-based products. |
| | 6. Alcohol ethers, organic and derived acids and peroxides Manufacture of distinguished fuel products. | 6. Natural environment services. Economic and cultural benefits that humans obtain from ecosystems. |
| | 7. Yeasts, alcohols and factories Manufacture of | 7. Renewable energy and energy efficiency. These sources are considered |

 doi:10.20944/preprints202408.1192.v1



| | | |
|---|---|---|
| | malt and malt liquors, transformation of soft drinks, production of inorganic waters. | inexhaustible, characterized either by their immense energy content, which prevents consumption on a human scale during transformation and use processes, or by their ability to regenerate over time. |

Source: self-made.

*3.3. In Vitro Agriculture and Seasonal Submersion*

In vitro agriculture has emerged as a critical methodology for the mass production of plants, encompassing over 1000 species, including tropical crops. It offers advantages such as pathogen-free plant production and reduced genetic erosion (Engelmann, 1991; Cañal *et al.*, 2001; Maiquetía, 2020). Seasonal submersion, as shown by Escalona (2006), enhances production efficiency by utilizing semi-liquid culture media, benefiting tissue micropropagation.

**Table 3. Advantages of In Vitro Agriculture**.

| Advantages |
|---|
| High duplication rates |
| Pathogen-free plants |
| Reduced production area |
| Decreased genetic erosion |
| Lower greenhouse management tasks |
| High duplication rates |

Source: self-made.

Bioeconomic Impact on Food Microbiology

The impact of bioeconomy on food microbiology involves (Table 4):

Microbial Role in Food: Studying microorganisms involved in food spoilage, preservation, and foodborne illnesses (Morcillo *et al.*, 2021; Girón *et al.*, 2021).

Bioeconomic Principles in Latin America: Significant socio-economic impacts observed, including biodiversity valorization and biotechnology applications (Sasson & Malpica, 2018; Figueroa-Sepúlveda *et al.*, 2021).

Advancements in Detection Methods: Molecular biological methods for detecting foodborne pathogens have improved significantly (Feng, 1997).

Interdisciplinary Research and Innovation: The bioeconomy encourages creativity and interdisciplinary research, focusing on effective technology transfer (Borge & Bröring, 2017; Domínguez *et al.*, 2016).

**Table 4. Impact of the bioeconomy on food microbiology**.

| **Area** | **Impact and contributions** | **Authors** |
|---|---|---|
| Social | Valorization of biodiversity heritage in medicine | (Figueroa-Sepúlveda *et al.*, 2021) |
| Food diagnosis | Molecular biological methods that use antibodies and nucleic acids to detect specific foodborne bacterial pathogens | Feng (1997) |
| Emerging bioeconomy | Biofuel production | Hooper, Basseler, and Kolter, (2012) |

 doi:10.20944/preprints202408.1192.v1



| | | |
|---|---|---|
| Bioeconomics | Predicts the economic and bioeconomic impact of food safety and security in perspective of increased food and feed consumption during 2030-2100 | Bogdan et al. (2010) |
| Food safety quality standards | Risks and Critical Control Points, based on current international standards of the ISO 9001-9002 series (Quality Management System) | Escanciano & Santos-Vijande (2014) |
| Bioeconomics | potential for creativity and innovation | Borge & Bröring, (2017) |
| Interdisciplinary bioeconomics | Bozeman's "Contingent Effectiveness Model of Technology Transfer" | Domínguez *et al.*, 2016 |
| Agri-food system | "Synthetic pesticides and fertilizers" | Egmond *et al.*, 2007; Spano *et al.*, 2010; Pozo-Bayón *et al.*, 2012 |
| Food safety | Economic and bioeconomic influence of food safety and security in perspective of the increase in food and feed consumption during 2030-2100. | Ludith et al. (2010) |

Source: self-made.

*3.4. The food Supply Chain and Its Response to COVID-19:*

The COVID-19 pandemic has had a profound impact on global psychology and food production sectors. Evaluations of Wuhan's 'wet markets' reveal potential origins of SARS-CoV-2 and underscore the need for effective crisis management within the food supply chain (Hernández, 2020). The Key Observations were:

Restaurant Sector: Severely affected, with many establishments closed or operating through delivery services.

Online Food Orders: Significant increase in online food orders and essential goods, driving a shift towards online purchasing.

Hygiene Practices: The pandemic has heightened awareness of hand hygiene and good manufacturing practices.

**Conclusions**

The COVID-19 pandemic has underscored the importance of understanding the microbial world and its implications for food production. The crisis has driven significant changes in the food industry, emphasizing the need for worker safety, supply assurance, and adaptable crisis management strategies.

The pandemic has highlighted the need for improved food safety practices and the integration of bioeconomic tools to address emerging challenges in food processing. This crisis has reinforced the importance of interdisciplinary research and innovation in fostering safer and more sustainable food practices.

**Author Contributions**: Conceptualization, ZG.-C.A. ; methodology, ZG.-CA., software, ZG.-C.A.; validation, ZG.-C.A.; data curation, ZG.-C.A.; writing—original draft preparation, ZG.-C.A.;

writing—review and editing, ZG.-C.A., ; visualization, ZG.-C.A.; supervision ZG.-C.A. All authors have read and agreed to the published version of the manuscript.

**Funding**: This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Acknowledgments**: Not applicable.

**Conflicts of Interest**: The authors declare no conflict of interest.

## References

1. Awasthi, M. K., Yan, B., Sar, T., Gómez-García, R., Ren, L., Sharma, P., ... & Taherzadeh, M. J. (2022). Organic waste recycling for carbon smart circular bioeconomy and sustainable development: A review. Bioresource Technology, 360, 127620.
2. Borge, L., & Bröring, S. (2017). Exploring the effectiveness of technology transfer in interdisciplinary settings: The case of the bioeconomy. Creativity and Innovation Management, 26(3), 311-322. https://doi.org/10.1111/caim.12222
3. Bogdan, A. T., Ipate, I., Bara, V., Diaconescu, D., Purcarea, C., & Strateanu, A. G. (2010). Ecoeconomic and bioeconomic impact of food safety and security in perspective increased consumption of food and feed during 2030-2100. Analele Universității din Oradea, Fascicula: Ecotoxicologie, Zootehnie și Tehnologii de Industrie Alimentară, 115-128.
4. Bloom, D.E. (2015) Valuing vaccines: deficiencies and remedies. Vaccine 33: B29–B33.
5. Bloom, D., Canning, D. and Sevilla, J. (2003) The demographic dividend – a new perspective on the economic consequences of population change. RAND. URL https://www.rand.org/content/dam/rand/pubs/monograph_reports/2007/MR1274.pdf. No esta citado en el documento
6. Bui, D. P., McCaffrey, K., Friedrichs, M., LaCross, N., Lewis, N. M., Sage, K., ... & Dunn, A. (2020). Racial and ethnic disparities among COVID-19 cases in workplace outbreaks by industry sector—Utah, March 6–June 5, 2020. Morbidity and Mortality Weekly Report, 69(33), 1133.
7. Bermeo Jara, D. A., & Lasluisa Velasteguí, P. S. (2020). Calidad del suelo mediante parámetros físicos químicos y microbiológicos en los Cultivos de Café (Coffea arabica, Coffea canephora) del Centro de Investigación y posgrado para la Conservación Amazónica (Bachelor's thesis, Universidad Estatal Amazónica).
8. Bhunia, S., Bhowmik, A., Mallick, R., & Mukherjee, J. (2021). Agronomic Efficiency of Animal-Derived Organic Fertilizers and Their Effects on Biology and Fertility of Soil: A Review. Agronomy, 11(5), 823.
9. Bertola, M., Ferrarini, A., & Visioli, G. (2021). Improvement of soil microbial diversity through sustainable agricultural practices and its evaluation by-omics approaches A perspective for the environment, food quality, and human safety. Microorganisms, 9(7), 1400.
10. Conde-Álvarez, C., & Saldaña-Zorrilla, S. (2007). Cambio climático en América Latina y el Caribe: Impactos, vulnerabilidad y adaptación. Ambiente y desarrollo, 23(2), 23-30.
11. Cañal, MJ; Rodríguez, R; Fernández, B; Sánchez-Tamez, R; Majada, JP. (2001). Fisiología de cultivo In vitro. Biotecnología Vegetal 1:3-9.
12. Caballero, Lorena (2008). La búsqueda del Comienzo: El pensamiento complejo en Biología. CopIt ArXives, 2008.
13. Caplice, E., & Fitzgerald, G. F. (1999). Food fermentations: role of microorganisms in food production and preservation. International journal of food microbiology, 50(1-2), 131-149., https://doi.org/10.1016/S0168-1605(99)00082-3. (https://www.sciencedirect.com/science/article/pii/S0168160599000823)
14. Cicco, L., Fombona-Pascual, A., Sánchez-Condado, A., Carriedo, G. A., Perna, F. M., Capriati, V., ... & García-Álvarez, J. (2020). Fast and Chemoselective Addition of Highly Polarized Lithium Phosphides Generated in Deep Eutectic Solvents to Aldehydes and Epoxides. ChemSusChem, 13(18), 4967-4973.
15. Delgado, R. L. C., & Torres, D. J. M. (2003). Evaluación bacteriológica de quesos frescos artesanales comercializados en Lima, Perú, y la supuesta acción bactericida de Lactobacillus spp. Revista Panamericana de Salud Pública, 14, 158-164.
16. Donthu N, Kumar S, Pattnaik D. Forty-five years of Journal of Business Research: A bibliometric analysis (2020). J Bus Res. 2020;109:1–14. https://doi.org/10.1016/J.JBUSRES.2019.10.039.

 doi:10.20944/preprints202408.1192.v1




17. Domínguez, D. P., Márquez, A. C. T., & Contreras, M. P. M. (2016). Modelo de transferencia de tecnología del potencial de innovación en el IPN. Repositorio de la Red Internacional de Investigadores en Competitividad, 10.
18. Escanciano, C., & Santos-Vijande, M. L. (2014). Reasons and constraints to implementing an ISO 22000 food safety management system: Evidence from Spain. Food Control, 40, 50-57.
19. Engelmann, F. (1991). In vitro conservation of tropical plant germplasm- a review. Euphytica 57: 227-243.
20. Egmond, H. P., Schothorst, R. C., and Jonker, M. A. (2007). Regulations relating to mycotoxins in food. Anal. Bioanal. Chem. 389, 147–157.
21. Escalona, M. (2006). Temporary immersion beats traditional techniques on all fronts. A novel bioreactor for plant tissue culture. Prophyta Annual. 48-49 p.
22. Feng, P. Impact of molecular biology on the detection of foodborne pathogens. Mol Biotechnol 7, 267 (1997). https://doi.org/10.1007/BF02740817
23. Fernández-Rodríguez, A., Casas, I., Culebras, E., Morilla, E., Cohen, M. C., & Alberola, J. (2020). COVID-19 y estudios microbiológicos post mortem. Revista española de medicina legal, 46(3), 127-138.
24. Figueroa-Sepúlveda, K a t h e r i n e., Castillo-Robles, N. Z., & Martínez-Girón, J. A. D. E. R. (2021). Application of high pressures and other technologies in fruits as an alternative to conventional thermal treatments. Biotecnología en el Sector Agropecuario y Agroindustrial, 19(2), 271-285.
25. Hooper, D., Bassler, B., & Kolter, R. (2012). Microbiology and the Bioeconomy Blueprint. Microbe, 7(4), 156-157.
26. Hamilton, M. E. (1998). Strategies Used by Small-and-medium-sized Service Organizations to Humanize the Implementation of ISO 9001/9002 (Doctoral dissertation, University of Guelph).
27. Girón, J. M., Sepúlveda, K. F., & Robles, N. Z. C. (2021). Aplicación de altas presiones y otras tecnologías en frutas como alternativa de tratamientos térmicos convencionales. Biotecnología en el Sector Agropecuario y Agroindustrial, 19(2), 269-283.
28. Gonzales, C., Trigo, E., Herrera Estrella, L., & Farias, A. (2013). Current status and future potential of knowledge-based bio-economy related research & innovation in Latin America and the Caribbean and policy recommendations (No. 2013-02). Bioeconomy Working Paper.
29. Hooper, D., Bassler, B., & Kolter, R. (2012). Microbiology and the Bioeconomy Blueprint. Microbe, 7(4), 156-157.
30. Henríquez, V. (2021). Aspectos Genéticos de Microalgas. Aguas Residuales, 12(2), 35-39.
31. Hernandez-Rodriguez, J. (2020). Impacto del Covid sobre la salud mental de las personas. Medicentro electrónica, 24 (3), 578-594.
32. Ludith, I., Vasile, B., Denis, D., Purcarea, C., & Strateanu, A. G. (2010). Ecoeconomic and bioeconomic impact of food safety and security in perspective increased consumption of food and feed during 2030-2100.
33. Khan, A. A. (2013). Bio-economic impacts of vertebrate pests on crops with special reference to rodent pests in Pakistan and other countries. In Proceedings of Pakistan Congress of Zoology (Vol. 33, pp. 75-108). Zoological Society of Pakistan.
34. Kaczmarski, M., Wasilewska, J., Jarocka-Cyrta, E., Cudowska, B., Żur, E., Matuszewska, E., ... & Jastrzębska-Piotrowska, J. (2011). Polish statement on food allergy in children and adolescents. Postępy Dermatologii i Alergologii, 28(5).
35. Lodeiro, A. R. (2020). Esperanza de vida al nacer. Contribuciones y desafíos de la microbiología. Revista Argentina de Microbiología, 52(2), 85.
36. Lassevich, D., Trasante, T., García, S., Platero, R., & Bajsa, N. (2020). Caracterización y evaluación agronómica de tres biopreparados: bokashi, supermagro y microorganismos eficientes nativos. Cadernos de Agroecologia, 15(2).
37. Ludith, I., Vasile, B., Denis, D., Purcarea, C., & Strateanu, A. G. (2010). Ecoeconomic and bioeconomic impact of food safety and security in perspective increased consumption of food and feed during 2030-2100.
38. Luzzi, G., Brinks, E., Fritsche, J., & Franz, C. M. (2021). Effect of reduction of sodium content on the microbial ecology of Edam cheese samples. AMB Express, 11(1), 1-9.
39. López, M. J., Suárez-Estrella, F., & Casco, J. M. (2018). Los microorganismos como elementos clave de la bioeconomía. Mediterráneo Económico, 31, 291-307.
40. Consum Stud. 2021;45(4):O1–16. https://doi.org/10.1111/IJCS.12695.
41. Lim WM, Rasul T, Kumar S, Ala M. Past, present, and future of customer engagement. J Bus Res. (2022);140:439–58. https://doi.org/10.1016/J.JBUSRES.2021.11.014
42. Medina-Herrera, M. D. R., Negrete-Rodríguez, M. D. L. L. X., Gámez-Vázquez, F. P., Álvarez-Bernal, D., & Conde-Barajas, E. (2020). La aplicación de lodos residuales afecta, a corto plazo, la biomasa microbiana y su actividad en suelos sódicos. Revista internacional de contaminación ambiental, 36(3), 577-591.

43. Morcillo, J. M., Martínez, E. P., & Ruiz-Gallardo, J. R. (2021). Microorganismos y hábitos de higiene. Estudio longitudinal en los cursos iniciales de Educación Primaria. Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 18(2), 2201-2201.
44. Maiquetía, M., Vargas, E. T., García, M. T., & de García, E. C. G. (2020). Estudios en la germinación y propagación in vitro de tres especies de Leguminosae: Calopogonium sp., Stylosantes capitata Y Cassia moschata. REVISTA CIENTÍFICA ECOCIENCIA, 7(6), 1-25.
45. Pozo-Bayón, M. Á., Monagas, M., Bartolomé, B., and Moreno-Arribas, M. V. (2012). Wine features related to safety and consumer health: an integrated perspective. Crit. Rev. Food Sci. Nutr. 52, 31–54.
46. Pellerin, William and Taylor Wayne D. (2008). Measuring the bio-based economy: A Canadian perspective. Gen Publising Inc., A Mary Ann Liberty Inc. Company. Vol 4. No 4 Pp 363-366 Winter 2008.
47. Petruş-Vancea, A. (2011). New methods to improve the bioeconomic and economic impact of plant biotechnology. Studia Univ. Vasile Goldiş, Seria Şt. Vieţii, 21(3), 613-618.
48. Peñalosa-Martinell, D., Araneda-Padilla, M., Dumas, S., Martinez-Díaz, S., & Vela-Magaña, M. (2021). The use of probiotics in larval whiteleg shrimp (Litopenaeus vannamei) production: A marginal analysis of bioeconomic feasibility. Aquaculture Research, 52(3), 943-951.
49. Pintado, T., Muñoz-González, I., Salvador, M., Ruiz-Capillas, C., & Herrero, A. M. (2021). Phenolic compounds in emulsion gel-based delivery systems applied as animal fat replacers in frankfurters: Physico-chemical, structural and microbiological approach. Food Chemistry, 340, 128095.
50. Pérez, Alexander, Johanna Rojas, and M. Helson Vale (2009). "Biología y perspectiva de microorganismos endófitos asociados a plantas." Revista Colombiana de Ciencia Animal-RECIA 1.2 (2009): 286-301.
51. Pozo-Bayón, M. Á., Monagas, M., Bartolome, B., & Moreno-Arribas, M. V. (2012). Wine features related to safety and consumer health: an integrated perspective. Critical reviews in food science and nutrition, 52(1), 31-54.
52. Paul J, Lim WM, O'Cass A, Hao AW, Bresciani S. Scientifc procedures and rationales for systematic literature reviews (SPAR-4-SLR). Int J
53. Consum Stud. 2021;45(4):O1–16. https://doi.org/10.1111/IJCS.12695.Rodríguez, Boris Luis García (2010). Biología general. Firmas Press, 2010
54. Raman R, Subramaniam N, Nair VK, Shivdas A, Achuthan K, Nedungadi P. Women Entrepreneurship and Sustainable Development: bibliometric analysis and emerging research trends. Sustainability. 2022;14(15):9160. https://doi.org/10.3390/SU14159160.
55. Ramos, G. L., Nascimento, J. S., Margalho, L. P., Duarte, M. C. K., Esmerino, E. A., Freitas, M. Q., ... & Sant'Ana, A. S. (2021). Quantitative microbiological risk assessment in dairy products: Concepts and applications. Trends in Food Science & Technology, 111, 610-616.
56. Ramos, R., de la Villa, S., García-Ramos, S., Padilla, B., García-Olivares, P., Piñero, P., ... & Garutti, I. (2021). Sobreinfecciones en pacientes ingresados en UCI con COVID-19: análisis retrospectivo en un hospital de tercer nivel. Enfermedades Infecciosas y Microbiología Clínica.
57. Rangel Cura, R., Zúniga González, C., Colón García, A., Losilla Solano, L., & Berrios, R. (2015). Measuring the contribution of the bioeconomy in Latin America: the case of Cuba. Ibero-American Journal on Bioeconomy and Climate Change, 1(1), 223-240. https://doi.org/10.5377/ribcc.v1i1.2150
58. Rodríguez, M., Milián, G., Rondón, A. J., Sarduy, L., & Beruvides, A. (2020). Caracterización química y microbiológica de cremas de Saccharomyces cerevisiae, obtenidas en diferentes destilerías cubanas. Cuban Journal of Agricultural Science, 54(3), 323-330.
59. Sasson, A., & Malpica, C. (2018). Bioeconomy in Latin America. New Biotechnology, 40, 40-45. https://doi.org/10.1016/j.nbt.2017.07.007
60. Singh, A., Kumari, R., Yadav, A. N., Mishra, S., Sachan, A., & Sachan, S. G. (2020). Tiny microbes, big yields: Microorganisms for enhancing food crop production for sustainable development. In New and Future Developments in Microbial Biotechnology and Bioengineering (pp. 1-15). Elsevier.
61. Sánchez, M. F. (2009). Cómo implantar un sistema de gestión ambiental según la norma ISO 14001: 2004. FC Editorial.
62. Spano, G., Russo, P., Lonvaud-Funel, A., Lucas, P., Alexandre, H., Grandvalet, C., Coton, E., Coton, M., Barnavon, L., Bach, B., Rattray, F., Bunte, A., Magni, C., Ladero, V., Alvarez, M., FernÁndez, M., Lopez, P., de Palencia, P. F., Corbi, A., Trip, H., and Lolkema, J. S. (2010). Biogenic amines in fermented foods. Eur. J. Clin. Nutr. 64, S95–S100.
63. Schifferstein, H. N., de Boer, A., & Lemke, M. (2021). Conveying information through food packaging: A literature review comparing legislation with consumer perception. Journal of Functional Foods, 86, 104734.
64. Talley, N. J. (2020). What causes functional gastrointestinal disorders? A proposed disease model. Official journal of the American College of Gastroenterology| ACG, 115(1), 41-48.
65. Uribe, R. P., & Bejarano, A. (2008). Sistema de gestión ambiental: Serie ISO 14000. revista Escuela de Administración de Negocios, (62), 89-105.
66. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2009;84(2):523–38. https://doi.org/10.1007/S11192-009-0146-3

 doi:10.20944/preprints202408.1192.v1



67. von Braun, J. (2018). Bioeconomy–The global trend and its implications for sustainability and food security. Global food security, 19, 81-83.
68. Wannigama, D. L., Amarasiri, M., Hongsing, P., Hurst, C., Modchang, C., Chadsuthi, S., ... & Ishikawa, H. (2023). COVID-19 monitoring with sparse sampling of sewered and non-sewered wastewater in urban and rural communities. Science, 26(7), 107019.
69. Zúniga González, C. A., & Trejos, R. (2014). Measuring the contribution of the Bioeconomy: Nicaragua Case. Universitas (León): Revista Científica De La UNAN León, 5(1), 59-82. https://doi.org/10.5377/universitas.v5i1.1479
70. Zúniga-González, C. A., Durán Zarabozo, O., Dios Palomares, R., Sol Sánchez, A., Guzman Moreno, M. A., Quiros, O., & Montoya Gaviria, G. D. J. (2014). Estado del arte de la bioeconomía y el cambio climático (No. 1133-2016-92457, pp. 20-329) https://doi.org/10.22004/ag.econ.168356 ISBN : 978-99924-28-40-5.
71. Zapata-Hernández, I., Zamora-Natera, J. F., Trujillo-Tapia, M., & Ramírez-Fuentes, E. (2020). ¿ La incorporación de residuos de diferentes especies de Lupinus, como abono verde, afecta la actividad microbiana del suelo?. Terra Latinoamericana, 38(1), 45-56.
72. Zúniga-González, C. A., López, M. R., Icabaceta, J. L., Vivas-Viachica, E. A., & Blanco-Orozco, N. (2022). Epistemología de la Bioeconomia. Rev. Iberoam. Bioecon. Cambio Clim., 8(15), 1786–1796. https://doi.org/10.5377/ribcc.v8i15.13986