



RESEARCH ARTICLE

A scientometric study on radiation in bananas in the nutrition industry: Visualization, thematic evolution and emerging patterns

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Abstract

This scientometric study aimed to analyze the literature on banana radiation in the nutrition industry from 1996 to 2023, to visualize the thematic evolution and identify emerging patterns in this field. On May 20, 2024, a literature search was performed in the Web of Science (WoS) database. The retrieved documents were analyzed using Bibliometrix and CiteSpace for the extraction of bibliographic information. Several bibliometric indicators were calculated, such as number of documents, number of sources, annual growth rate, average age of documents, average number of citations per document, number of keywords, and number of authors. A total of 9 documents related to the topic were found in the period from 1996 to 2023. The papers covered a diversity of topics, reflecting the interdisciplinary nature of the research. There was a strong presence of literature in the field of physics focusing on plant ecology. In addition, the most cited authors, Zaman HU and Sanjay K, appear to have had a lasting impact on this field of study. This study provides valuable insight into the thematic evolution and emerging patterns in banana radiation research in the nutrition industry. These findings may be useful in guiding future research and practice in this field.

Keywords

bananas; nutrition; radiation; scientometric study

Introduction

Bananas are one of the best-selling fruits in the world, with cultivation increasing significantly during the last century, and production occurring in more than 135 countries in across tropical and subtropical regions (1, 2). This major increase in its production is due to the growing popularity of this fruit, which has been associated with improvements in gastrointestinal symptoms/diseases, renal and hepatic complications, as well as a reductions in total cholesterol, LDL (low density lipoproteins), glucose and HbA1c, making it useful in the glycemic control of patients with pre-diabetes and diabetes (1, 3-5). In addition, banana by-products are reported to contain many bioactive substances with antibacterial, anti-inflammatory and antioxidant properties (6). However, banana by-products have been used in the treatment of diabetes for some time.

Nonetheless, nearly 90% of the countries with the highest banana production are affected by climate change, and virus or insect infections, which may eventually lead to deficiencies in their cultivation (7-9). To address these deficiencies, one solution may be food irradiation, which consists of exposing food to low or high doses (depending on the organism to be eradicated) of ionizing radiation (gamma rays, electron beams or X-rays) to kill insects, molds and other microbes harmful to food (10). While this may represent a solution for crop management, it should be kept in mind that there are many foods that are naturally radioactive, one of these being bananas as they are rich in potassium-40. This isotope gives them radioactive properties that are even used in medical therapy to standardize the level of radiation that patients will receive after procedures (11). This highlights the need to establish the current knowledge on the consumption of bananas in human health, as this topic has not yet been evaluated in human populations (12). To achieve this, conducting bibliometric studies seems a good option as they analyze scientific productivity on a given topic to identify gaps in knowledge (13, 14).

The results of this bibliometric study should serve as a basis for future studies analyzing the direct effect of banana radioactivity on human health through trials or prospective studies. Therefore, the objective of the study was to analyze scientific productivity related to banana radiation in the nutrition industry.

Material and Methods

Study design

This observational study had a scientometric approach and was designed to analyze the literature on banana radiation in the nutrition industry from 1996 to 2023.

Search strategy

Metadata extraction was performed on May 20, 2024. The literature search was performed using the Web of Science (WoS) database. The search strategy used was TS = ("Radioactive Musa" OR "Irradiated banana" OR "Contaminated banana" OR "Radiation-exposed banana" OR "Radiation banana" OR "Banana with radioactive isotopes" OR "Radioactive fruit" OR "Nuclear banana" OR "Radioactive produce" OR "Banana with radiation levels" OR "Radiologically active banana" OR "Radioactive banana"). This exhaustive search term was designed to capture all relevant literature on the topic.

Analysis procedure

The retrieved documents were analyzed using Bibliometrix R version 4.3.2 and CiteSpace 6.3.R2 software. Bibliometrix was used for initial analysis of the documents, including extraction of bibliographic information and calculation of bibliometric indicators. While CiteSpace was used for the visualization of the bibliography, including the creation of dual map overlays and time zone visualizations.

Bibliometric indicators

Several bibliometric indicators were calculated, such as

number of documents, number of sources, annual growth rate, average age of documents, average number of citations per document, number of keywords, and number of authors. These indicators provided insight into the patterns of production and collaboration in this field.

Results

Main scientometric information

During the period from 1996 to 2023, a total of 9 documents were identified from 9 different sources. Despite the length of the period, the annual growth rate was 0%, indicating that the number of documents remained constant. The average age of the documents was 8.67 years, and each document received on average 7 citations, resulting in a total of 259 references. Regarding the content of the papers, 41 additional keywords were identified, and the authors provided 30 specific keywords. In total, 31 authors contributed to the publication of these papers, but no papers written by a single author were recorded. Collaboration among authors was notable, with an average of 3.78 coauthors per paper and 11.11% international coauthorships. In terms of document types, the majority were articles (7), followed by conference proceedings papers (2). These results provide a valuable insight into the scientific production and collaboration in this field during the period studied (Table 1).

Table 1. Main scientometric information on radiation in bananas in the nutrition industry

Indicators	Results
Period	1996:2023
Sources	9
Articles	9
Annual Growth %	0
Document Average Age	8.67
Average citations per document	7
References	259
Author's Keywords	30
Authors	31
Authors of single-authored docs	0
Single-authored docs	0
Co-Authors per Doc	3.78
International co-authorships %	11.11
Article	7
Proceedings paper	2

Tree map on radiation in bananas

Once in the documents, some of the most prominent terms include “banana fiber”, “banana post-harvest”, “banana weevil”, “cell wall apposition”, “cell wall lignification” among others. Each of these terms provides unique insight into the issues and concepts discussed in the papers analyzed. However, since each term appears only once, it is not possible to identify a dominant theme based on word frequency (Fig. 1).

Core sources and author productivity on radiation in bananas

In Zone 1, the most productive sources identified are

Tree

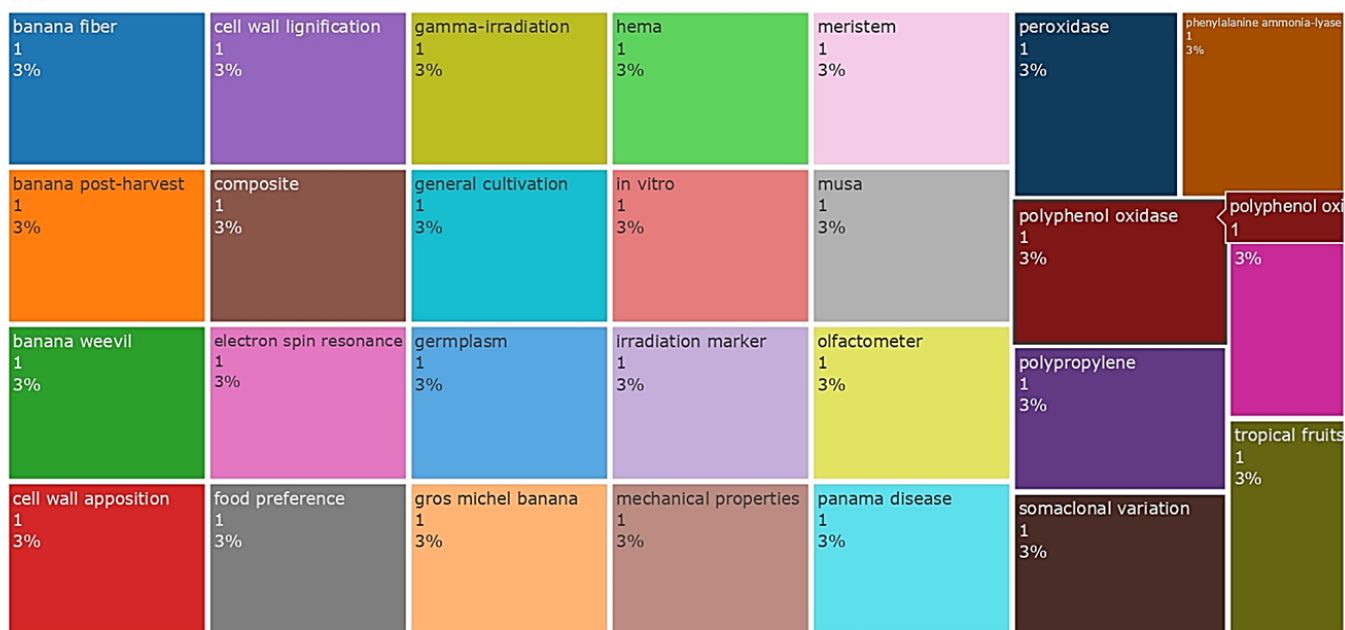


Fig. 1. Tree map on radiation in bananas in the nutrition industry.

“Applied Biological Chemistry,” “Fibers and Polymers,” and the “International Conference on Green Agro-Industry and Bioeconomy,” each contributing one paper. Zone 2 includes “Journal of Applied Entomology,” “Pesquisa Agropecuaria Brasileira,” “Polymer Composites,” and “Postharvest Biology and Technology,” with each source also contributing one paper. Finally, Zone 3 features “Scientific Reports.” This distribution suggests that a small number of sources produce most of the papers, while many sources produce only a few papers. According to Lotka's Law, which describes the productivity of authors, it was found that most authors (90.3%) have written only one paper. On the other hand, a small group of authors (9.7%) have written two papers. This distribution reflects the principle that a few authors are responsible for most of the production in each field (Fig. 2).

Dual map overlay on radiation in bananas

On the left side of the Dual map overlay graph, different scientific disciplines could be observed, being cluster 5 (Physics, Materials, Chemistry) the most representative, which ends up being joined on the right side, with cluster 10 (Plant, Ecology, Zoology), this indicates that there is a large amount of literature in the field of Physics that focuses on Plant, and Ecology. In addition, a thicker line is evident than the others, which means that there is a particularly large amount of literature in that area (Fig. 3).

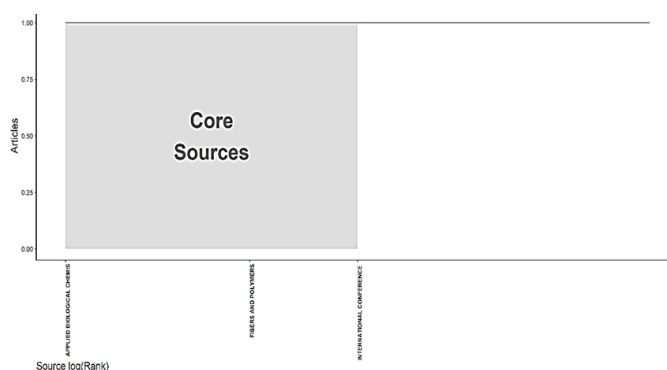


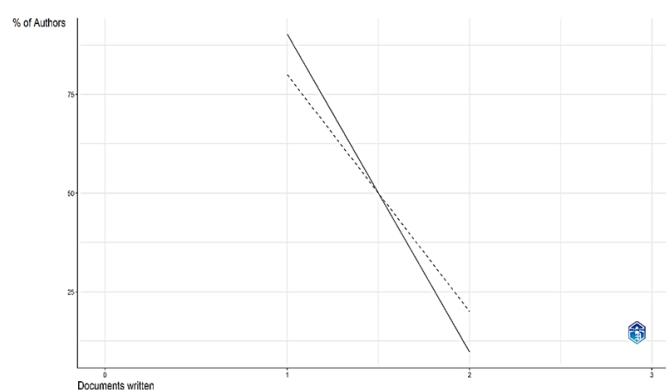
Fig. 2. Core sources and author productivity on radiation in bananas in the nutrition industry.

Time view clustering

The time zone visualization graph shows the most cited authors over time, represented as nodes located in the “time zone” corresponding to the publication date in the dataset. The largest nodes are mainly concentrated in the year 2011, highlighting authors Zaman HU and Sanjay K as the most representative. This suggests that these authors are pioneers in their field and have been frequently cited, indicating their significant influence. Furthermore, the presence of numerous connections extending into more recent time zones suggests that the work of these authors has had a lasting impact and remains relevant to current research. The persistence of these connections over time reflects the continuing importance of their contributions and their ability to influence subsequent research. This pattern of citations and connections underscores the sustained relevance of their work and their pivotal role in the development of the field (Fig. 4).

Discussion

During 1996-2023, only 9 studies (mostly articles) with 259 references described a relationship between radioactivity and banana consumption. Overall, 31 authors participated and most of them published only 1 article, with an average of 3.78 co-authors per paper and 11.11% international



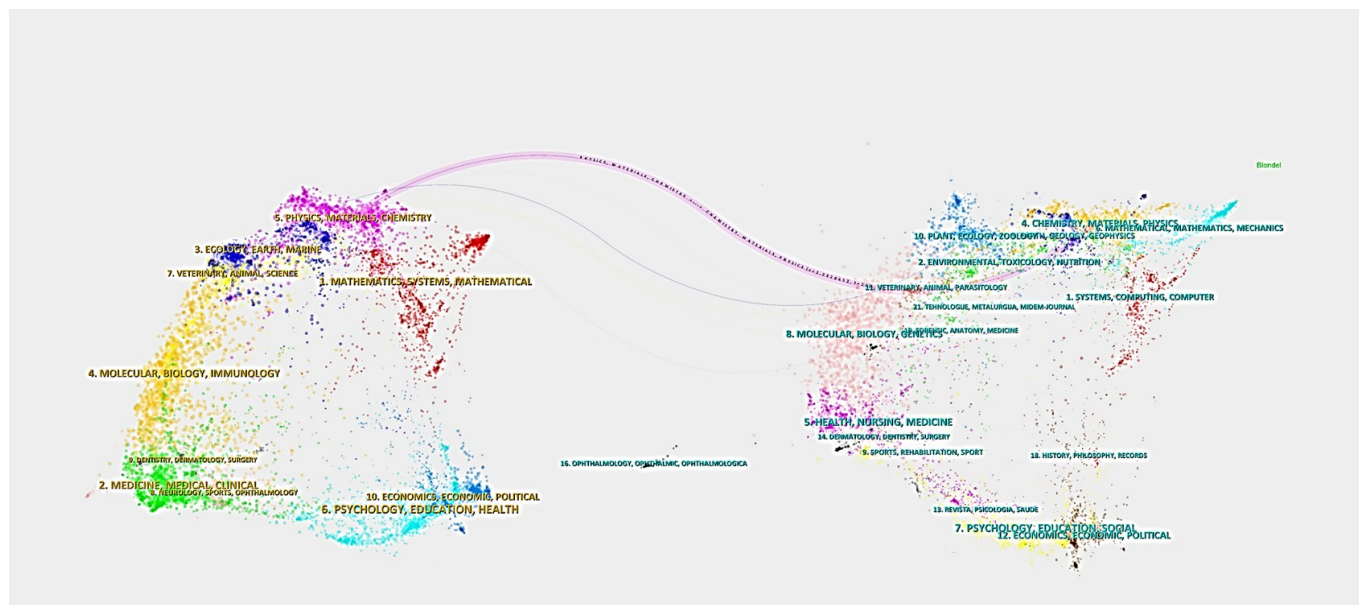


Fig. 3. Dual map overlay on radiation in bananas in the nutrition industry.

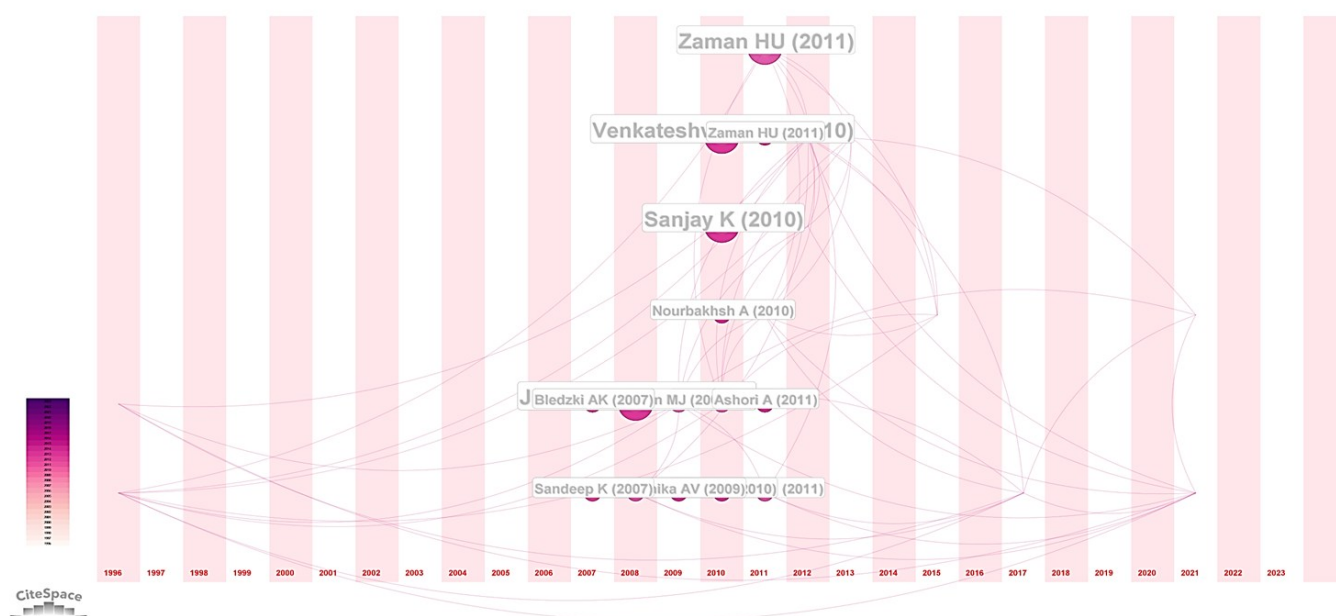


Fig. 4. Time view clustering on radiation in bananas in the nutrition industry.

collaboration.

Although the journals “International Conference on Green Agro-Industry and Bioeconomy”, “Applied Biological Chemistry” and “Fibers and Polymers”; only these last two have the most cited publications. The 3 most cited publications are the study describing the mechanical properties of UV-irradiated banana fiber reinforced polypropylene matrix composites (15). The use of luminescence analysis and spectroscopy techniques to identify radiation-induced markers in commercial fruits (16). The biochemical alterations in the cell wall of banana (Musa AAA 'Berangan') fruits irradiated with UVC rays to combat fungal infection (17).

Polypropylene (PP) composites reinforced with banana fibers showed significant improvements in their mechanical properties after UV irradiation. This treatment was found to be effective in increasing the strength and

durability of the composites (15). In addition, treatment with 2-hydroxyethyl methacrylate (HEMA) and oven curing further optimized these properties, highlighting the importance of adjusting monomer concentration, temperature, and curing time (15).

In the analysis of irradiated commercial fruits, photo-stimulated luminescence (PSL), thermoluminescence (TL), and electron spin resonance spectroscopy (ESR) techniques were effective in identifying irradiation in all fruits except banana. The fruit minerals showed typical TL brightness curves, confirming the feasibility of TL analysis to detect irradiation (16). Crown rot reduction in UVC-irradiated 'Berangan' bananas was associated with activation of defense mechanisms, such as increased peroxidase and polyphenol oxidase activity, and accumulation of lignin and phenolic compounds. UVC irradiation also retarded cell disintegration and promoted the formation of physical barriers that prevent the

diffusion of toxins and fungal enzymes (17).

Regarding the scientific disciplines evaluated, physics and chemistry were the most studied areas, focusing specifically on plant and animal populations (18). A bibliometric analysis was carried out and it was found that biochemistry was among the most productive topics regarding food safety (18). Similarly, research on food chemistry has reported an increasing trend in publications between 1976-2016, which could explain the most studied disciplines in this study (19). On the other hand, a peak of representativeness was evidenced in 2011 by authors Zaman and Sanjay, which could place these authors as pioneers in this field. However, all this evidence the lack of studies with human populations, so the results of this study should be taken as a basis for the generation of cohorts or trials in which the radioactive effect of banana consumption in human patients is analyzed.

This study presents both limitations and strengths. One primary limitation is that the systematic search was confined to the Web of Science (WoS) database, thereby excluding relevant publications from other databases, such as PubMed and Scopus, as well as those published before 2018. However, the study also has notable strengths. The WoS database was selected because, along with Scopus, it facilitates a more precise systematic search compared to other databases and indexes high-quality methodological publications, making it one of the principal databases recommended for bibliometric analysis (13, 20-22). Furthermore, it is anticipated that the findings of this study will stimulate the production of future research involving human populations (23-27).

Conclusion

Within the limitations of this study, it was concluded that the production of papers on banana radiation remained constant from 1996 to 2023. The papers covered a diversity of topics, reflecting the interdisciplinary nature of the research. There was a strong presence of physics literature focused on plant ecology. The most cited authors, Zaman HU and Sanjay K, have made a lasting impact on the field. Therefore, the study provides valuable insights into the thematic evolution and emerging patterns in banana radiation research, which may guide future research and practice in this field.

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Authors' Contributions

FMT and FEC designed the experiment. CQV, JM, DGV, CMV and FEC carried out the search information. FEC and FMT performed statistical analysis. DGV, CMV, JM and LQT wrote and reviewed the manuscript. All authors read and approved the final version.

Compliance with Ethical Standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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