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The Science Of Food Upcycling; Does The Perception Of Consumer Is Changed? - A Bibliometric Analysis

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Abstract
Food waste has become one of the unavoidable but urgent issue in today's world. Even today a someone in the world is starving for food and dying due to hunger, but on the other side lot of food is getting wasted, it has become the most important and required problem to be addressed. the most viable solution is the science of food upcycling, that is converting the food by-products and waste materials into new and edible food products. Continuous research in the subject of upcycling of food and strategies to making it as acceptable by the consumer is need of the day. The researcher has performed bibliometric analysis on the literature on the science of food upcycling along with consumers changing perception on its acceptance and highlight gaps in knowledge. The results highlighted, the developed countries were realised the importance of food upcycling and they have already started working on the area. The results also emphasis that, India is gradually giving focus on research in upcycling which is considered to be a good indicator. Similarly, the changing perception of consumers on upcycled food is a good sign for growing market potential for upcycled food.

Keywords: Environmental Conscious, Food Upcycling, Food Waste, Global Warming, Volatile Organic Compounds.

1.Introduction

Growing population, is creating more need for food products for consume, but the limited resources doesn't allow us to produce required food to cater the needs of everyone(Kaur & Kaur, 2024). In the food system, it is wasted in two levels that is before reaching consumer (pre-consumption) and after reaching consumer (post-consumer). Before consumption waste occurs during manufacturing, processing, distributing, and retailing. On the other hand, after reaching consumer, the food is wasted due to poor management and also due to careless consumption (Dorward, 2012). The production of food products involves the use of limited and scarce natural resources, and when food is wasted, these unproducible natural resources are also lost (McCarthy et al., 2020). The Detrition of natural resources has negative consequences for the environment, the economy, and public health (Scherhaufer et al., 2018). When food waste decomposes, it releases methane (CH_4) and carbon dioxide (CO_2), two major gases that trap heat in the atmosphere, contributing to global warming. This, in turn drives climate change, leading to more extreme weather events, rising sea levels, and ecosystem disruptions, which can result in food and water shortages, displacement, and health crises. Climate change intensifies heatwaves, increasing the

risk of heat-related illnesses, worsens air quality, and facilitates the spread of diseases by altering ecosystems (Tchonkouang et al., 2023). Methane contributes to the formation of ground-level ozone, which is dangerous when inhaled and can cause respiratory problems such as asthma and bronchitis. Prolonged exposure to ozone is linked to higher mortality rates from respiratory and cardiovascular diseases. Volatile Organic Compounds (VOCs) and other decomposition by-products can degrade air quality, especially in communities near landfills. Exposure to these pollutants may result in headaches, eye and throat irritation, and long-term respiratory issues (da S. Pereira et al., 2024). Landfills containing decomposing food waste can release hazardous gases, posing health risks to nearby residents. Furthermore, inadequately managed landfills can contaminate soil and water, heightening public health concerns. Decomposing food waste also attracts pests like rodents and flies, which can transmit diseases such as Salmonella and E. coli. Poor waste management, particularly in densely populated areas, can intensify these issues (Aschemann-Witzel et al., 2023). The economic loss of food waste is also substantial, impacting both businesses and consumers. Globally, it's estimated that around one-third of all food produced is wasted, resulting in an annual economic loss of nearly $1 trillion(Papargyropoulou et al., 2014).

The food waste cannot be completed avoided but one appropriate solution to avoid these complications the science of reusing the food waste or value addition to the unusable products which is termed as "upcycled food". The concept of upcycling is not new to Indian scenario, they have the habit of preparing some sort of food items from vegetable peels like beetroot and cucumber. In recent days its capturing the attention of people all over the world and considered to be the best solution to moderate the consequences of food waste (O'Donnell et al., 2015).

Upcycled food product typically utilizes ingredients that would otherwise go to waste, that includes byproducts and foods that are not commercially viable for sale in the market(Spratt et al., 2021). Since the concept of upcycling is new Bhatt et al., (2021) has proposed various related terminologies to define the process of reusing the food waste to stakeholders and finally they arrived to a conclusion that, "upcycling" is the appropriate term. Moshtaghian et al., (2021) introduced a definition of upcycled food more likely to be supported in that "sustainable ingredients used as inputs for the elaboration of human-edible products, came from streams outside the edible fraction such as damaged fruits and veggies (byproducts); scraped-moved dehydrated veggie scraps removed off-consumption (scraps)"

Even though the upcycled food is good for environmental and economical concern, Bhatt et al., (2021) had the fear about the acceptance of consumer on unfamiliar food and they found that consumers are hesitant and unwilling to buy food made from unfamiliar ingredients. It has become the responsibility of the upcycled food manufacturers to develop innovative products to meet the consumer expectations and to satisfy them(Perito et al., 2020). They also responsible to evolve better marketing strategies, so that it will reach the consumers(Asioli & Grasso, 2021). Providing nutritional and environmental information about upcycled foods increases consumers' willingness to pay for these products (Zhang et al., 2021).

Table 1: Consumers' acceptance of upcycled food-Generation based classification

Generation	Perception	Source
Baby Boomers (Born between 1944-1964)	They are so health conscious, willing to cook for themselves rather than buying cooked food, they are also having less impulsive buying behaviour. While targeting baby boomers for upcycled food it's better to give as an ingredient rather than cooked food. Since they are environmental conscious, they are interested in buying quality upcycled food available in physical stores, than online shopping sites.	Cleaver, Green, & Muller, (2000); Valkeneers & Vanhoomissen, (2012); LeRouge, Van Slyke, Seale, & Wright, (2014)

Gen X (Born Between 1965-1979)	Gen X are least interested in eating outside, they are so cost conscious and it is very hard to persuade them to purchase. Their perception on upcycled food is not so positive and their purchase intention for upcycled food is also comparatively low. Therefore, while targeting Gen X use conventional channels, provide more assurance on quality of upcycled food.	Pitta & Gurau,(2012); Agnihotri, (2015); Bathmanathan, Rajadurai, & Sohail, (2018); Anderson & Narus, (1990); Lissitsa & Kol, (2016); Chaudhuri & Ligas, (2009)
Gen Y or Millennials Born between 1980 and 1994	This generation has witnessed drastic technological change and very much active in digital space. Their perception on upcycled food in terms of quality and purchase intention is comparatively better than Babyboomers and Gen X. Unlike previous generations they are interested in eating outside, hence prepared upcycled food would be appropriate for this generation.	Sullivan & Heitmeyer, (2008); Bilgihan, (2016); Regine, (2011)
Gen Z Born between 1995 to 2015	The youngest group of consumers influenced by social media sites and comparatively interested in online shopping. Since they are less interested in cook for themselves, they prefer ready to serve upcycled food.	Gutfreund, (2016); Weinswig, (2016); Bryła, (2018); Yang et al., (2018)

2. Review of Literature

Table 2: Boolean keyword used in the Scopus advanced search

Component	Terms
Food Upcycling	TITLE-ABS-KEY ("Food Waste") AND ("Upcycled Food") AND PUBYEAR > 2013 AND PUBYEAR < 2025

Source: Author's own work

3. Research Methodology

Upcycling, Food, Consumer Perception and Consumer acceptance 176 documents from 84 sources using Boolean operators in the advanced search option via Elsevier Scopus (Table 2) The collected data were screened with PRISMA. The above results when filtered with the database most relevant 105 papers from 64 sources was considered for our bibliometric analysis, which gives an overall perspective on published works to find out the

trends and as well as research gaps (Murali & Mohamed Jasim,2022). The "biblometrix"– package was used for systematic analysis to come at a comprehensive finding after going through adequate number of papers and results (Aria & Cuccurullo, 2017).

3.1 Inclusion and exclusion criteria

The researcher paper investigates the perception of upcycled food which includes "**Food Waste"** and **"Upcycled Food"** within the title, abstract, or keywords, and must be published between **2014 and 2024**. The selected literature should specifically focus on topics related to food waste management or upcycled food practices, including innovative solutions, strategies, policies, or environmental impacts. Additionally, only studies published in English (or another specified language) will be considered. Conversely, the exclusion criteria involve excluding papers focused on upcycling non-food materials (e.g., textiles, plastics) will be excluded unless they directly relate to food waste. Finally, publications in languages that cannot be translated by the research team will not be included in the analysis.

Figure 1 PRISMA flowchart illustrating the entire selection process (Page et al., 2021).

3.2 The rationale of the data analysis

Various ways of data rendering were employed to appropriately expose the results obtained from our bibliometric analysis. Network diagrams were generated to show links and clusters of the central concepts in form through Vos Viewer After that, trend analysis graphs indicated the topic of nurse retention receiving more scholarly attention over time as illustrated by increasing bars. Citation impact charts compared earlier works that were seminal and had a lasting influence with more recent publications. Maps showed the geographical distribution of publications per country, expressed worldwide scientific production in health. We chose each of these methods to help better understand the complicated data, and simplify it for our readers as well.

3.3 Research questions

RQ1. What trends and shifts in focus can be observed in the scholarly articles related to Upcycling of food over the period?

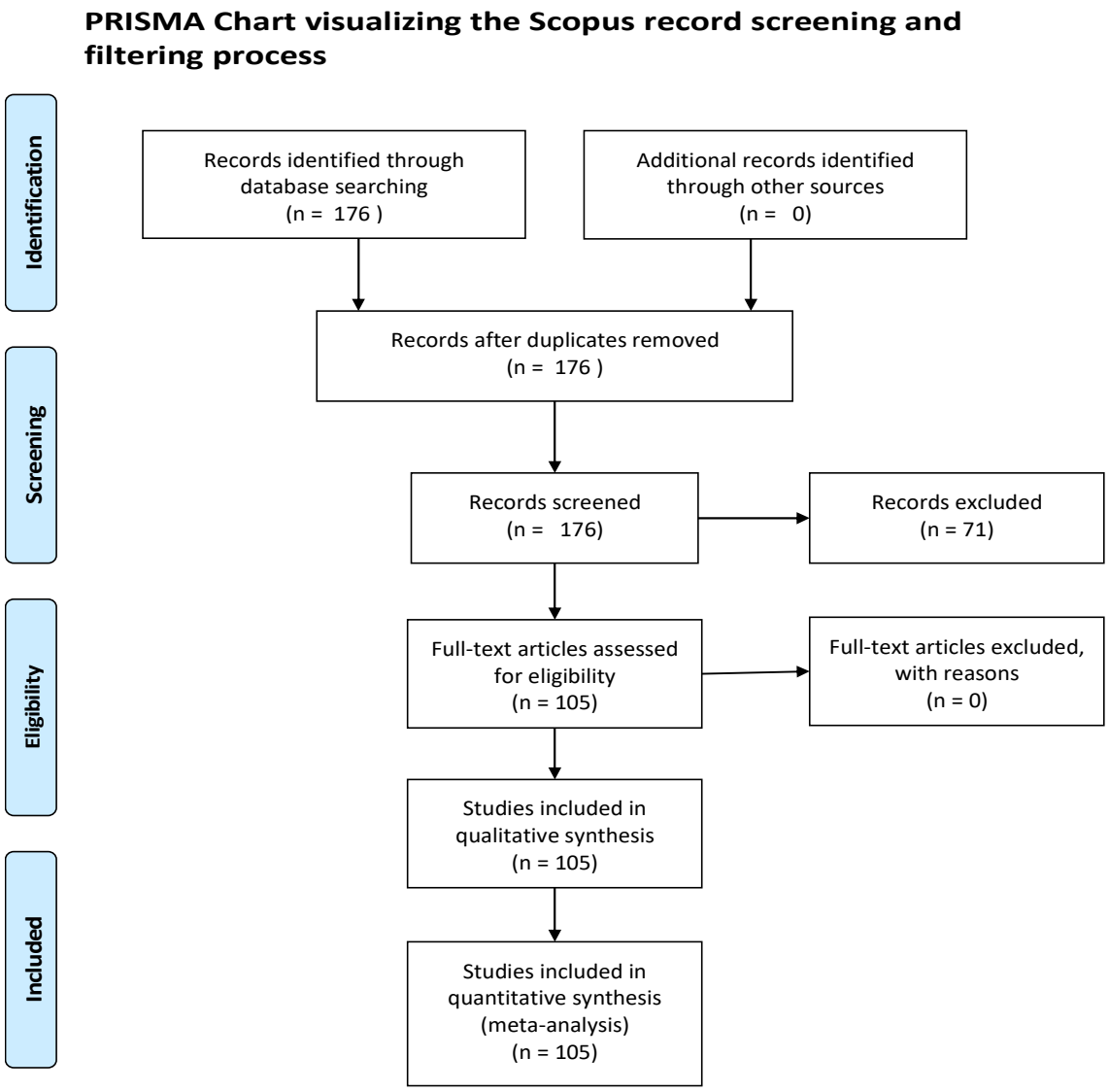
RQ2. What is the trend shift in customer perception on upcycled food?

RQ3. What are most addressed key words and themes in the area of food upcycling

3.4 Overview of the articles included in the bibliometric analysis

Scopus Bibliometric Analysis A bibliometric analysis of 2017–2024 perspectives on upcycled food (176 documents/84 sources) This field has an annual growth rate of 64.79 %, demonstrating high academic appeal. Overall the subjects are average age 1.24 years and together receive an average of no less than 9.8 citations apiece, testifying to their incipient appeal. In addition, 348 keywords have been analyzed for prominent themes. Forty-one other countries are represented on the rest of your team members, which means international collaboration accounts for 39.05% of co-authorships—underscoring just how far-reaching upcycled food is around the globe!

Figure 1: PRISMA Chart visualizing the Scopus record screening and filtering process

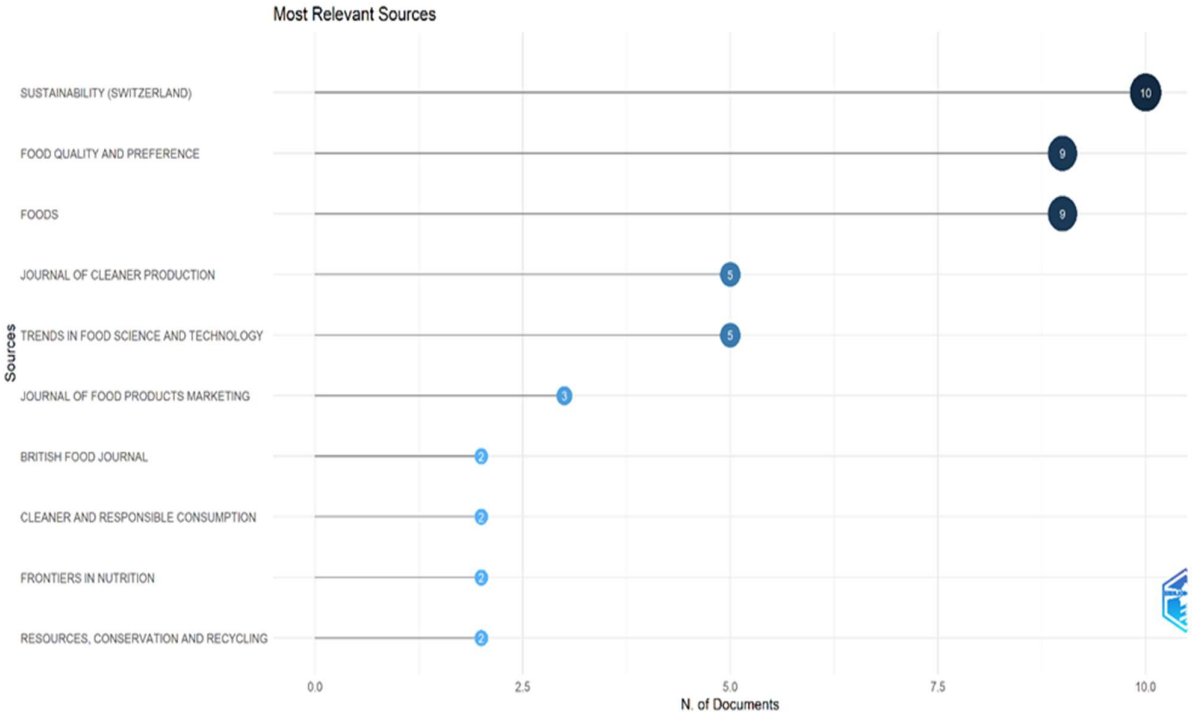


Source: Adapted from page et al. (2021)

4. Data analysis and visualization of the papers included for the bibliometric analysis

4.1 Most relevant source of publication

Figure 2: Most Relevant Sources



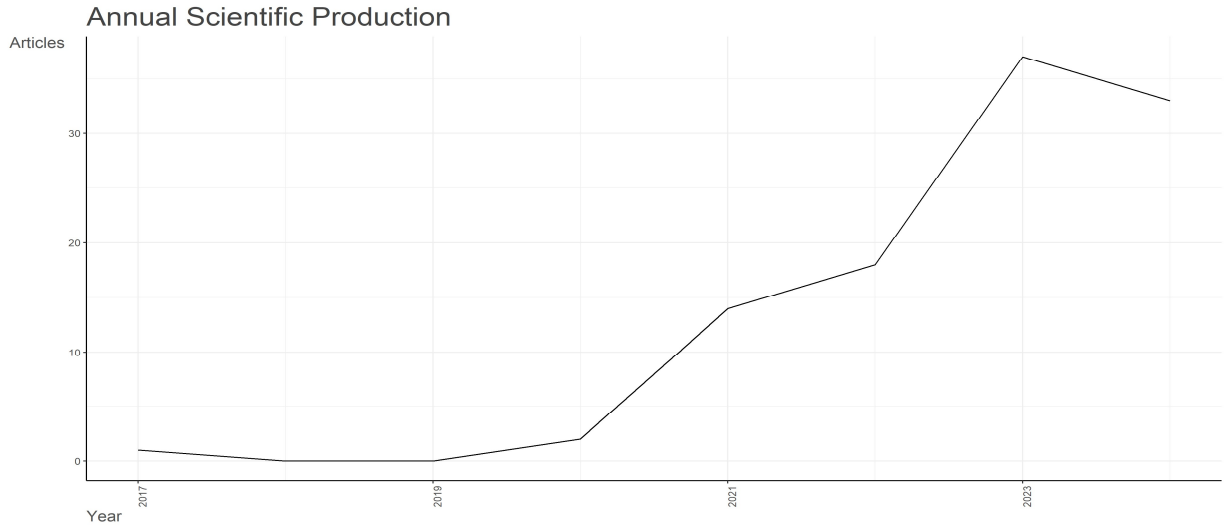
Source: Author's own work

Figure 2 represents the most relevant sources of publications related to upcycling of food. Sustainability (Switzerland) emerges as the leading journal, with 10 documents, indicating a dominant focus on sustainability issues within the food industry. Both Food Quality and Preference and Foods follow closely with 9 documents each, emphasizing the importance of consumer preferences and food quality in shaping sustainable practices. The Journal of Cleaner Production and Trends in Food Science and Technology, each with 5 documents, underscore the relevance of clean production processes and technological advancements in promoting sustainable food consumption and production.

4.2 Annual Scientific Production

Figure 3 exhibits the growing trend of research in upcycling of food. From 2017 to 2020, the publications addressing the above top was very few, but from 2021 the trend has changed. The number of research works in upcycling of food is considerably growing in recent years and this indagates the growing importance of research topic.

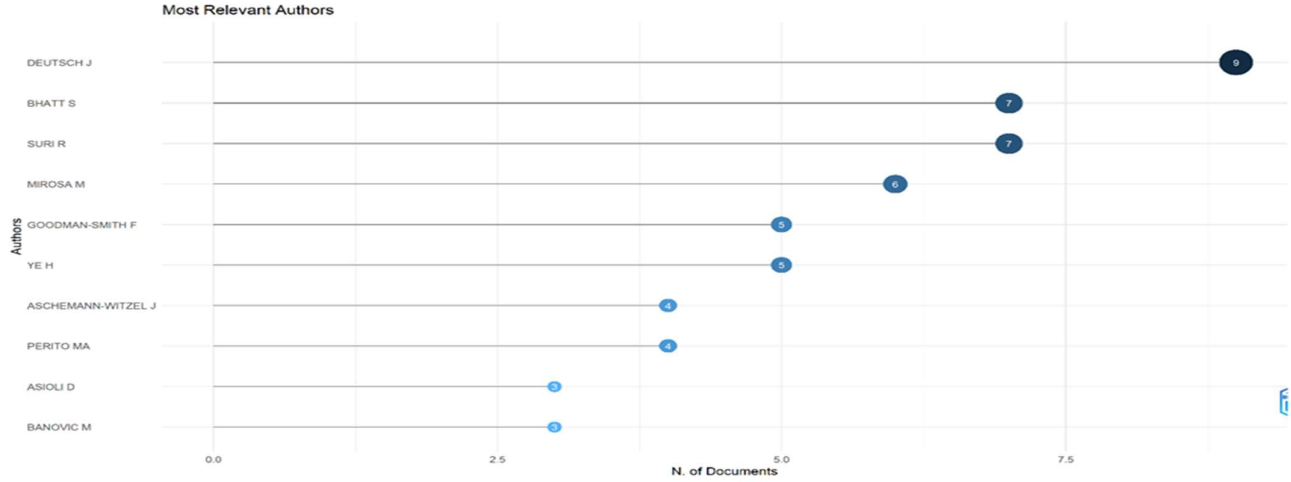
Figure 3: Annual Scientific Production



Source: Author's own work

4.3 Most relevant Authors

Figure 4: Most Relevant Authors



Source: Author's own work

Figure 4 explains the most relevant authors contributed to the area of food upcycling. Deutsch J has made maximum contribution (9 works) followed by Bhatt S and Suri R (each 7 works). Apart from the above, Mirosa, Goodman Smith F, Ye H, Aschmann-Witzel J and Parito Ma have also significantly contributed to the research on Upcycled food.

4.4 Authors Production Over Time

Table 3: Authors Production Over Time

Author	year	Title	Source	DOI

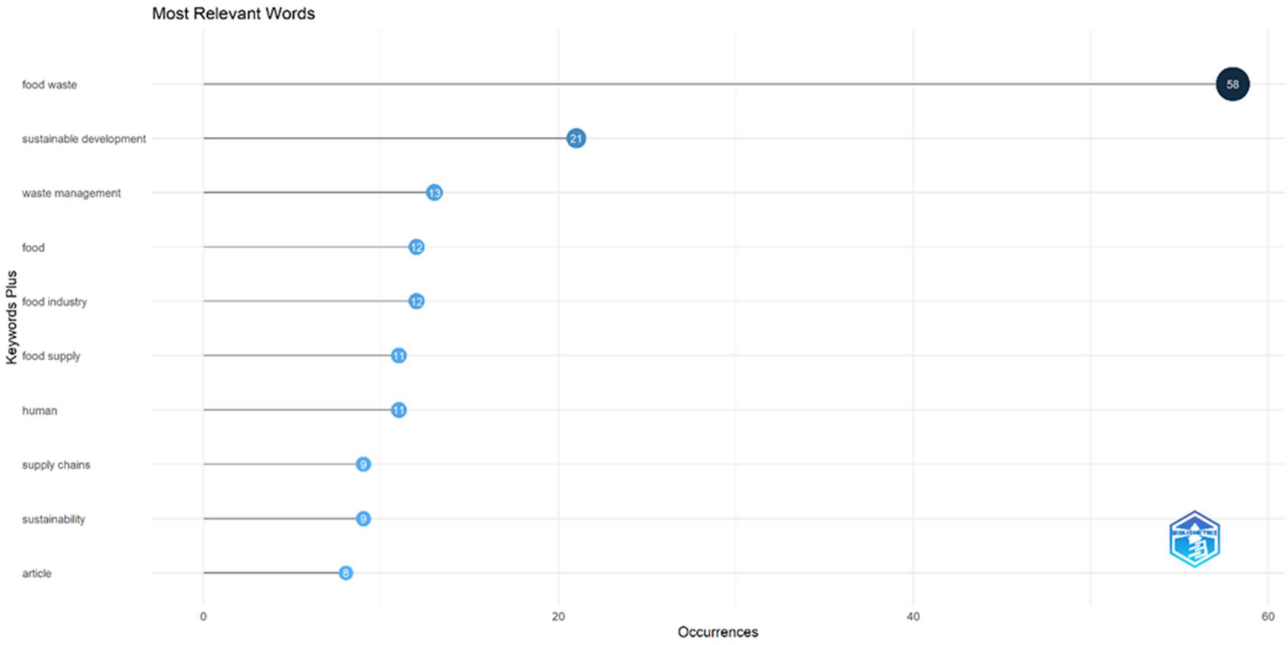
Deutsch J	2023	Consumer acceptance of upcycled Craft beer: A New Zealand case study	Frontiers in nutrition	10.3389/fnut.2023. 1235137
Deutsch J	2022	Is there a market for upcycled pet food?	Journal of cleaner production	10.1016/j.jclepro.2022. 130960
Deutsch J	2022	Accessing supermarket shelves: Retail category managers advice to Upcycled food manufacturers	Journal of food products marketing	10.1080/10454446.2022. 2072695
Deutsch J	2021	Retail potential for upcycled foods: Evidence from New Zealand	Sustainability (Switzerland)	10.3390/su13052624
Deutsch J	2021	Addressing food waste: How to position upcycled foods To different generations	Journal of consumer behaviour	10.1002/cb.1844
Deutsch J	2021	Differentiating price sensitivity from willingness to pay: Role of pricing in consumer acceptance of upcycled foods	Journal of food products marketing	10.1080/10454446.2021. 2016536
Deutsch J	2021	Food waste and upcycled foods: Can a logo increase acceptance of upcycled foods?	Journal of food products marketing	10.1080/10454446.2021. 1955798
Deutsch J	2020	Consumers' willingness To pay for upcycled foods	Food quality and preference	10.1016/j.foodqual.2020. 104035
Deutsch J	2020	Defining upcycled food products	Journal of culinary science and technology	10.1080/15428052.2020. 1790074
Bhatt S	2023	Consumer acceptance of upcycled craft beer: a New Zealand case study	Frontiers in nutrition	10.3389/fnut.2023. 1235137

Source: Author's own work

Table 2 explains the various authors contribution over a span of time. Deutsch J has made prominent contribution from 2020 to 2023. Bhatt S has also worked with Deutsch J to research on food upcycling.

4.5 Most Frequent Keywords Used

Figure 5: Most Frequent Keywords Used



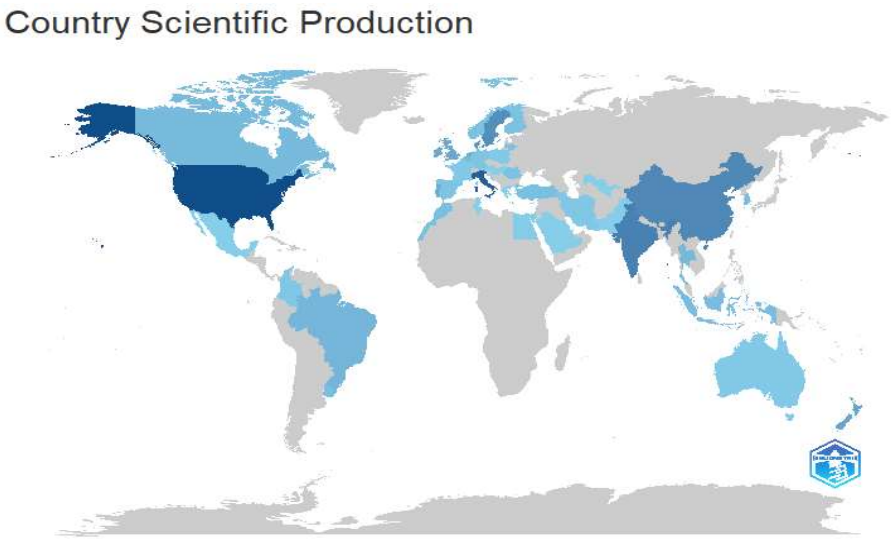
Source: Author's own work

Figure 5 depicts the most frequent keywords used in the research on upcycled food. "Food Waste" is the most used keyword (58 times) followed by "Sustainable development", "Waste Management", "Food" and "Food industry".

4.6 Scientific production of articles by country

As explained in Figure 6, the top three countries having highest contribution on upcycling of food is USA, Italy and India. China, Sweden and Denmark are also showing considerable interest in this area.

Figure 6: Country Scientific Production



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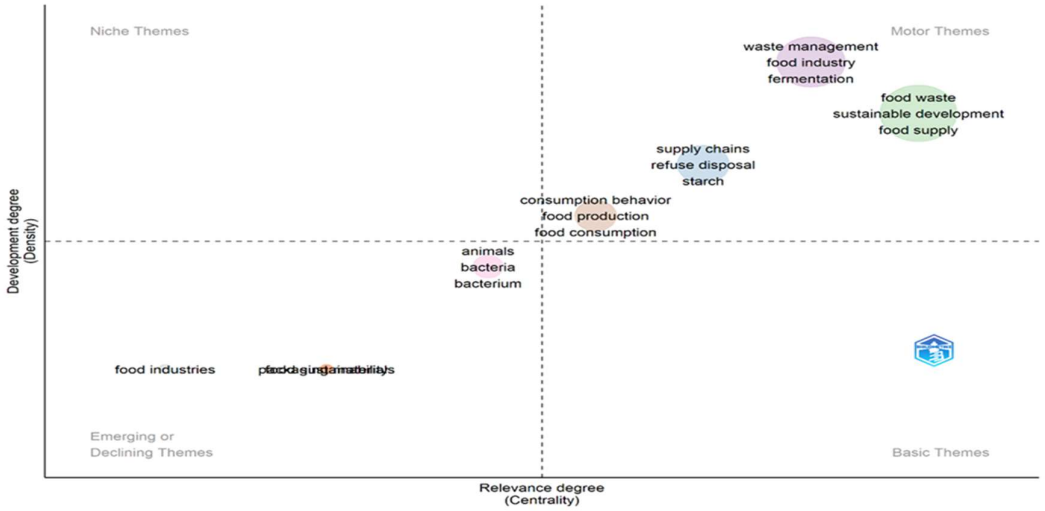
4.7 Thematic Map

Figure 7: Thematic Map



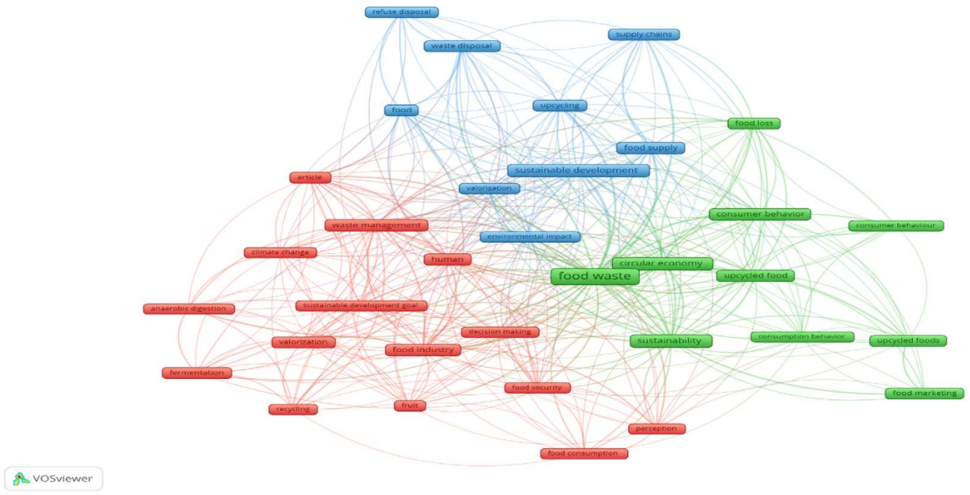
Source: Author's own work

The Thematic Map on **Figure 7,** Motor Themes are both well-developed and highly relevant. Themes here includes Waste management, Food industry, Fermentation, Food waste and Sustainable development. These topics are likely driving much of the research or discussions in the field and are central to ongoing developments. Basic Themes indicates these themes are important but less developed or elaborated. Themes here includes Consumption behaviour, Food production, Food consumption and Supply chains. These topics may be foundational but are not the primary focus of current advancements. Niche Themes are well-developed in specialized or niche areas but are not central to broader discussions. There are no specific terms displayed in this quadrant. Emerging or Declining Themes may either be emerging areas or ones that are in decline. Themes here are Food industries and Packaging materials These topics are either becoming less relevant or are new areas yet to gain significant attention.

5. Findings

Establishes the logical connections in Figure 8 using Vos Viewer which is a bibliometric mapping tool developed by van Eck and Waltman (2010). In Table 3, the connections were also displayed cluster-wise. In Cluster 1 we were able to identify logical relationships such as those that relate climate change to the sustainable development goals, food industry or recycling. Interestingly, Cluster 2 illustrated a relation between upcycled foods to consumer behaviours and food marketing. Cluster 3 (Waste disposal, Refusal disposal and Environmental impact)

Figure 8: Logical Connections



Source: Author's own work

5.1 Clusters of Keywords Tabulated using VOS Viewer

Table 3: Clusters of Keywords Tabulated using VOS Viewer

Cluster	Broder Theme	Specific Keywords
Cluster 1	Environmental Sustainability in the Food System	Waste Management, Sustainable development, Climate change, Food industry, Fermentation.
Cluster 2	Transforming Food Systems	Sustainability, Consumption Pattern, Consumer Bheaviour, Food waste, Food Marketing, Upcycled food.
Cluster 3	Mitigating Environmental Impact through food upcycling	Food disposal, Refusal disposal, Environmental Impact, Food waste.

5.2 Most relevant source of publication

Upcycling of food is a major focus in recent research, with journals titled “Sustainability” (Switzerland), “Food Quality and Preference”, and “Foods” leading the field. Journals like “Journal of Cleaner Production” and “Trends in food science and technology”, were also publishing significantly in this topic.

5.3 Annual Scientific Production

The chart shows a significant increase in annual scientific production between 2017 and 2023. After a slow start with minimal articles up to 2020, there was a sharp rise in scientific output, peaking around 2022. Although there was a slight decline after 2022, the overall trend indicates a growing interest and research activity in the field.

5.4 Most relevant Authors

Deutsch J is the most prolific author, contributing 9 articles, followed by Bhatt S and Suri R with 7 articles each. Mirosa M has authored 6 articles, while Goodman-Smith F and Ye H have each written 5 articles in upcycling of food.

5.5 Most Frequent Keywords used

"Food waste" is the most frequent term with 58 occurrences. Other prominent terms include "sustainable development" (21 occurrences), "waste management" (13 occurrences), and "food" (12 occurrences). Terms related to the food industry and supply, such as "food industry" (12 occurrences) and "food supply" (11 occurrences), also appear frequently.

5.6 Country Scientific Production

USA leads in publications, With 58 publications on upcycling, suggesting strong interest or research activity in this area. European countries show high interest, Italy (50), Sweden (28), Denmark (25), Ireland (17), Portugal (16), and the UK (17) all contribute significantly, indicating that upcycling is a popular topic across Europe.

6. Discussion and social implications

The growing body of research on upcycling, particularly in the food sector, demonstrates the increasing global interest in sustainable practices. The sharp rise in scientific output between 2017 and 2023, peaking in 2022, reflects the urgency with which researchers are addressing food waste and indicates the growing importance of research in this topic after COVID pandemic. The overall upward trend highlights a sustained interest in exploring innovative solutions for food waste reduction and resource efficiency. The change in consumer perception across generations, highlights the changing perception and growing market potential for upcycled food. Frequent keywords such as "food waste," "sustainable development," and "waste management" indicate that research is centred on improving the sustainability of food systems, both in production and consumption. From a practical perspective, this research has significant implications for policy-making, industry practices, and public awareness. The prominent role of the USA and several European countries. indicates a strong focus on integrating upcycling into national sustainability agendas. These findings suggest that governments and industries could adopt upcycling practices more widely, reducing environmental impacts and promoting circular economies, particularly in the food industry. Additionally, being a highly populated developing countries, India and Chaina must place greater emphasis on research and development in food upcycling. With its significant population and growing economy, they have the potential to make substantial contributions to sustainability efforts and improve its food waste

management practices and need to create more awareness to the customers on importance of using upcycled food.

7. Conclusion

The increasing focus on food upcycling reflects a global commitment to sustainability, with significant contributions from leading journals and a notable rise in scientific output. While countries like the USA and several European nations are leading the charge, India's role is becoming increasingly important. As a highly populated developing country, India faces substantial challenges related to food waste and resource management. Prioritizing food upcycling research is crucial for India to address these challenges effectively and contribute to global sustainability efforts. Positioning the upcycled food in the minds of Indian consumers is essential for fostering widespread adoption. Educating the public about the benefits of upcycling—such as reducing food waste, conserving resources, and enhancing food security—can drive consumer interest and demand. By integrating upcycling into national policies and promoting it through consumer education campaigns, India can not only improve its sustainability practices but also lead by example in the global arena.

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