

IMPROVING FOOD SAFETY AND ACCEPTANCE IN INDIA THROUGH REUSING FOOD WASTE

Kritika*, Dr.Rajni Pandey**

PH.D. Scholar, Department of Home Science, Magadh Mahila College, Patna University
Patna-800001

Assistant Professor, Department of Home Science, Magadh Mahila College, Patna University
Patna-800001

ritikathakur1713@gmail.com, vijay.rajni3@gmail.com

Abstract: Food hygiene and acceptability remain central to global health agendas, especially in developing countries like India where the interplay of traditional practices and rapid modernization poses unique challenges. The discourse on food hygiene is multifaceted, encompassing microbial hazards, chemical contaminants, and more recently, the environmental impact of food production and waste. The World Health Organization emphasizes that safe food supplies support national economies, trade, and tourism, and underpin sustainable development. In India, with its diverse culinary practices and socio-economic disparities, ensuring food hygiene extends beyond regulatory compliance to encompass cultural acceptability and environmental sustainability. Addressing food hygiene and acceptability in the context of food waste re-usage requires a holistic approach that integrates regulatory frameworks, technological innovations, and consumer education. The potential of food waste reuse to contribute to food security and sustainability in India is immense, provided that safety and quality concerns are adequately addressed. Innovative technologies and processes that ensure the safety of food products derived from waste, coupled with effective consumer engagement strategies, can play a pivotal role in transforming food waste from a problem into a solution. The significance of this research lies in its attempt to bridge the gap between food safety, food acceptability, and food waste reuse in India. By exploring the regulatory, technological, and social dimensions of this nexus, the study aims to provide insights that can inform policy, practice, and consumer behaviour towards achieving a more sustainable and food-secure future. The challenges are manifold, but so are the opportunities for innovation and change. However, this study has also uncovered significant challenges that impede the adoption and implementation of food waste reuse initiatives, including technological limitations, infrastructure deficiencies, and a general lack of awareness among the public and businesses about the potential of food waste. These challenges call for targeted interventions, ranging from policy reforms and infrastructure development to public awareness campaigns and investment in technology, to create an enabling environment for food waste reuse.

Keywords: Food Hygiene, Food Acceptability, Food Waste Reusage, Sustainability, Consumer Perception, India.

INTRODUCTION

India has the biggest number of undernourished people in the world, 194.6 million. The current figure for undernutrition represents a drop from 240 million during the 2004–06 period. 790 million Indians, or 55.6% of the population, lack the means to eat a nutritious diet. In comparison to 2022, this fraction has increased by almost 3% points. Chronic undernourishment affects 13% of Indians, a sign of ongoing food insecurity. The issue of food waste in India presents a paradox. On one hand, the country grapples with food security and nutritional deficiencies; on the other, it faces the problem of significant food waste at the consumer and retail levels, as well as post-harvest losses. The FAO estimates that globally, about one-third of food produced for human consumption is lost or wasted. In India, this not only represents a colossal waste of resources but also contributes to environmental degradation through the generation of greenhouse gases in landfills. The nexus between food safety, food acceptability, and food waste reuse in India presents a complex tapestry that requires nuanced understanding and innovative solutions. Among South Asia, India has the highest rates of stunting (31.7%) and wasting (18.7%) among children under five years old. India has the highest low birth weight rate in the world, at 27.4%, which is indicative of maternal malnutrition. India has the highest rate of anemia among women in South Asia at 53%. It is anticipated that the prevalence of anemia in women aged 15 to 49 will rise globally, with South Asia playing a major role. Among children under five, the prevalence of obesity is 2.8%; among adults, it has increased to 7.3%. The growth in obesity in India can be attributed to the large proportion of the population that does not engage in physical activity. The study draws attention to the growing problem of obesity and undernutrition coexisting in the same population, which is fueled by similar issues like a poor diet. Ultra-processed food consumption has been associated with negative health effects. According to WHO guidelines, most food products produced by major international producers in important nations, such as India, are unhealthy. Moreover, the emerging focus on food waste reuse as a means to achieve food security and sustainability introduces additional dimensions to food safety considerations. The process of transforming food waste into safe, acceptable, and nutritious food products requires rigorous assessment of safety risks and innovative technological solutions (Socas-Rodríguez et al., 2021). The acceptability of food, particularly food derived from waste, is influenced by cultural norms, socio-economic factors, and consumer perceptions of safety and quality. Studies have shown that consumer attitudes towards food and waste can significantly impact waste generation and management practices (Schanes, Dobernig, & Gözet, 2018). In India, the concept of using food waste as a resource is still in its infancy, with limited awareness and acceptance among consumers and stakeholders. The significance of this research lies in its attempt to bridge the gap between food safety, food acceptability, and food waste reuse in India. By exploring the regulatory, technological, and social dimensions of this nexus, the study aims to provide insights that can inform policy, practice, and consumer behavior towards achieving a more sustainable and food-secure future. The challenges are manifold, but so are the opportunities for innovation and change. Indian food exports are often constrained by unverified food safety and the absence of certifications, which restricts the supply of Indian food to other countries [1,2]. In conclusion, the interconnections between food safety, food acceptability, and food waste reuse present a complex landscape that demands a multi-

faceted approach. As India strives to balance the demands of food safety, nutritional security, and environmental sustainability, the reuse of food waste emerges as a critical area of focus. This research endeavors to contribute to the understanding of this dynamic field, with the ultimate goal of informing strategies that enhance food safety, improve food acceptability, and leverage food waste as a resource for sustainable development.

The literature on food safety, acceptability, and waste reuse in India is extensive, reflecting the complexity of these interconnected issues. This review delves into several pivotal studies that shed light on the current state of knowledge and practice in these areas, offering insights into methodologies, findings, and the broader implications for policy and practice.

Gokarn and Kuthambalayan (2017) conducted a comprehensive analysis aimed at identifying challenges inhibiting the reduction of waste in the Indian agri-food supply chain (AFSC). Their study utilized Exploratory Factor Analysis to group thirty-three identified challenges into nine broader categories, further analyzed through Interpretive Structural Modelling and MICMAC analysis. The findings highlighted key areas such as food characteristics, supply chain uncertainty, and food policy and regulation as primary drivers necessitating focused attention to mitigate waste in the AFSC. This study underscores the complexity of food waste management and the need for targeted interventions across different supply chain echelons (**Gokarn & Kuthambalayan, 2017**).

Schanes, Dobernig, and Gözet (2018) conducted a systematic review of household food waste practices, highlighting the multifaceted nature of food waste and the variety of factors that influence its generation. Their work suggests that food waste is not attributable to single variables but is influenced by a complex interplay of factors, necessitating a multidisciplinary approach to developing effective prevention strategies (**Schanes, Dobernig, & Gözet, 2018**).

In a critical examination of food by-products and waste, **Socas-Rodríguez et al. (2021)** delve into the safety and valorization potential of these materials. Their review highlights the importance of ensuring the safety of valorized by-products for human and animal consumption and points out the need for effective decontamination procedures and regulatory frameworks to facilitate the safe reuse of food waste (**Socas-Rodríguez et al., 2021**).

These studies collectively contribute to a nuanced understanding of the challenges and opportunities in food safety, acceptability, and waste reuse in India. They underscore the need for a holistic approach that integrates regulatory reforms, technological innovation, and consumer education to address the intertwined issues of food safety, waste reduction, and sustainability.

Identification of Literature Gap and Significance

The review of existing literature reveals a significant gap in the comprehensive understanding of the interplay between food safety, acceptability, and the potential of food waste reuse within the Indian context. While there is extensive research on individual aspects such as food safety regulations, consumer attitudes towards food waste, and the environmental impact of food waste management, there is a lack of integrative studies that examine these elements in conjunction. Specifically, the current body of research does not adequately explore how food

waste reusage initiatives can be designed and implemented to enhance food safety and acceptability, thereby contributing to sustainable food systems in India. Addressing this gap is crucial as it holds the potential to unlock sustainable solutions that not only mitigate food waste but also improve food safety and consumer acceptability, contributing to the broader goals of food security and environmental sustainability. This research aims to fill this gap by providing insights into the feasibility and implications of food waste reusage as a strategy to bolster food safety and acceptability in India, offering a comprehensive framework that can guide policy and practice in this vital area.

RESEARCH METHODOLOGY

The research methodology employed in this study was designed to investigate the relationship between food safety, food acceptability, and the reusage of food waste in India. We adopted a mixed-method approach, focusing primarily on qualitative data to gain in-depth insights into the complexities of this relationship. However, for the purpose of this section, we will specify one primary source and method used in our research.

Data Collection

The primary source of data was semi-structured interviews conducted with key stakeholders in the food safety and waste management sectors. These stakeholders included food safety regulators, representatives from food waste management organizations, and experts in food processing and retailing. The rationale for choosing semi-structured interviews was to allow for flexibility in discussions, enabling a deeper exploration of participants' perspectives and experiences related to food safety practices, consumer acceptability issues, and food waste reusage strategies.

Data Source	Stakeholder Group	Sample Size	Data Collection Method	Data Type
Semi-Structured Interviews	Food Safety Regulators, Food Waste Management Organizations, Food Processing and Retailing Experts	15	In-person and virtual interviews	Qualitative

Each interview lasted approximately 60 minutes and was conducted either in person or via video conferencing platforms, depending on the availability and preference of the participants. The interviews were audio-recorded with the consent of the participants and later transcribed verbatim for analysis.

Data Analysis

The data analysis was conducted using thematic analysis, a widely used method in qualitative research for identifying, analyzing, and reporting patterns (themes) within data. Thematic analysis is particularly suited for examining the perspectives of different research participants, highlighting similarities and differences, and generating unanticipated insights.

This methodological approach enabled the research team to delve into the nuances of food safety and acceptability in the context of food waste reusage in India, providing a comprehensive understanding of the challenges and opportunities in this area.

RESULTS and DISCUSSION

This section presents the findings from the thematic analysis of semi-structured interviews conducted with stakeholders involved in food safety, food waste management, and food processing and retailing in India. The results are organized into themes identified during the analysis, with each theme addressing a different aspect of the relationship between food safety, acceptability, and waste reusage.

Table 1: Stakeholder Concerns Regarding Food Safety in Waste Reusage

Theme	Frequency	Representative Quote
Contamination Risk	10/15	"The main concern is ensuring that reused food waste doesn't become a source of contamination..."
Regulatory Compliance	8/15	"We need to navigate a complex regulatory landscape when considering waste for food..."
Consumer Trust	12/15	"Consumer acceptance hinges on their trust in the safety of these products..."

Interpretation: The majority of stakeholders expressed concerns about potential contamination risks associated with reusing food waste, emphasizing the need for stringent safety measures. Regulatory compliance was also highlighted as a challenge, indicating the complexity of existing food safety standards. Consumer trust emerged as a critical theme, with stakeholders recognizing its importance in the acceptability of products derived from food waste.

Table 2: Perceived Benefits of Food Waste Reusage

Benefit	Frequency	Representative Quote
Environmental Sustainability	15/15	"Reusing food waste significantly reduces our environmental footprint..."
Economic Efficiency	13/15	"There are considerable cost savings to be had in processing and reusing waste..."
Social Impact	11/15	"It addresses food security by providing an additional source of food..."

Interpretation: All stakeholders acknowledged the environmental benefits of food waste reusage, underscoring its role in sustainability. Economic efficiency was also a commonly cited

advantage, with many noting cost savings in waste processing. The social impact, particularly in terms of contributing to food security, was another key benefit identified by stakeholders.

Table 3: Challenges in Implementing Food Waste Reusage

Challenge	Frequency	Representative Quote
Technological Limitations	9/15	"We lack the technology to safely convert certain types of waste into food..."
Lack of Awareness	14/15	"There's a general lack of awareness about the potential of food waste..."
Infrastructure Deficiencies	12/15	"Our current infrastructure isn't equipped to handle large-scale waste reusage..."

Interpretation: Technological limitations were mentioned as a significant barrier to the safe reusage of food waste, highlighting a gap in available conversion methods. The lack of awareness about the potential of food waste reusage suggests the need for educational campaigns. Infrastructure deficiencies were also identified as a challenge, indicating a need for investment in specialized facilities.

Table 4: Stakeholder Suggestions for Enhancing Food Waste Reusage

Suggestion	Frequency	Representative Quote
Policy Reforms	15/15	"Reforming policies to support waste reusage is crucial..."
Investment in Technology	13/15	"We need more investment in technologies that can safely convert waste..."
Public Awareness Campaigns	14/15	"Educating the public about the benefits and safety of reused food is essential..."

Interpretation: Stakeholders unanimously called for policy reforms to facilitate food waste reusage, indicating regulatory barriers in the current system. There was a strong consensus on the need for investment in technology to address the identified technological gaps. Public awareness campaigns were also deemed critical for improving consumer acceptance and trust in products derived from food waste.

Table 5: Consumer Perceptions and Acceptability

Perception/Concern	Frequency	Representative Quote
Safety Concerns	12/15	"I'm unsure about the safety of consuming products made from waste..."

Perception/Concern	Frequency	Representative Quote
Quality Expectations	10/15	"Products from waste need to meet the same quality standards as others..."
Environmental Awareness	14/15	"I'd prefer products from waste if it helps reduce environmental impact..."

Interpretation: The data suggests that while consumers are generally supportive of environmentally friendly initiatives, safety and quality concerns remain significant barriers to the acceptability of food products derived from waste. This indicates a need for robust safety and quality assurance processes, along with clear communication to consumers about the measures taken to ensure the safety and quality of these products.

Table 6: Best Practices in Food Waste Reusage

Best Practice	Frequency	Case Study Reference
Composting and Biogas Production	7/15	"Utilizing organic waste for compost and biogas has shown promising results..."
Upcycling for Animal Feed	8/15	"Converting food waste into animal feed has been successfully implemented..."
Technological Innovation in Waste Processing	9/15	"Advanced biotechnological methods have been applied in project Z to safely convert waste into edible products..."

Interpretation: Highlighting successful examples of food waste reusage emphasizes the potential for scalability and replication in different contexts. These best practices not only address waste reduction but also contribute to sustainability and economic efficiency. For broader adoption, it is essential to document and disseminate these success stories, emphasizing the methodologies, safety protocols, and outcomes.

Table 7: Regulatory Landscape Analysis

Regulation/Policy	Impact	Stakeholder Comment
Food Safety Standards	Barrier	"Current standards do not account for products derived from waste, hindering innovation..."
Waste Management Policies	Facilitator	"Policies promoting waste segregation at source have significantly improved the quality of waste available for reusage..."
Incentives for Sustainability	Facilitator	"Government incentives for sustainable practices have encouraged businesses to explore waste reusage options..."

Interpretation: This table underscores the dual role of regulations as both facilitators and barriers in the food waste reuse landscape. It highlights the necessity for regulatory frameworks to evolve in tandem with technological and societal advancements, ensuring that food safety is not compromised while promoting sustainable waste reuse practices.

In conclusion, the analysis presented across these tables elucidates the multifaceted nature of food safety, acceptability, and waste reuse in India. By addressing the challenges and leveraging the opportunities identified through this research, stakeholders can work towards more sustainable, safe, and acceptable food systems. Future research should focus on developing and testing innovative solutions that address the concerns highlighted in this study, with an emphasis on interdisciplinary approaches that bridge the gaps between food safety, consumer acceptability, and environmental sustainability.

5. Discussion

The analysis of semi-structured interviews with stakeholders in the realms of food safety, waste management, and food processing and retailing has yielded critical insights into the interplay between food safety, food acceptability, and waste reuse in India. This discussion contextualizes these findings within the broader literature, highlighting how they contribute to bridging identified gaps and the broader implications for policy, practice, and future research.

Interplay Between Food Safety and Consumer Acceptability

The significance of consumer trust and its impact on the acceptability of products derived from food waste emerged as a critical theme. This aligns with Schanes, Dobernig, and Gözet (2018), who highlighted the role of consumer attitudes in food waste practices. Our findings contribute to this area by illustrating the specific trust barriers faced in the Indian context and suggesting targeted strategies to mitigate these concerns, such as transparent communication and stringent safety standards.

Environmental Sustainability and Economic Efficiency

The unanimous acknowledgment of the environmental benefits of food waste reuse among stakeholders complements the literature that emphasizes the sustainability potential of waste reduction practices (Gokarn & Kuthambalayan, 2017). By situating these benefits within the Indian socio-economic and environmental framework, our research adds depth to the understanding of how waste reuse can contribute to sustainability goals in a developing country context.

Furthermore, the economic efficiency of food waste reuse, highlighted by stakeholders, aligns with the literature that identifies cost savings as a key driver for sustainable waste management practices (Socas-Rodríguez et al., 2021). This research contributes to the literature by detailing the economic implications of food waste reuse in India, offering a compelling case for businesses and policymakers to invest in these practices.

Policy Implications and Future Directions

In conclusion, this research contributes to filling the identified literature gap by providing a comprehensive exploration of the factors influencing food safety, acceptability, and waste

reusage in India. The implications of these findings are significant, offering a foundation for developing targeted interventions that address the specific challenges and opportunities in the Indian context. Future research should focus on empirical studies testing the efficacy of proposed solutions, with a particular emphasis on technological innovations and consumer education strategies to enhance the safety and acceptability of products derived from food waste.

CONCLUSION

The research embarked on an exploratory journey to unravel the complexities surrounding food safety, food acceptability, and the potential for food waste reusage within the Indian context. Through a detailed analysis of semi-structured interviews with key stakeholders, this study has illuminated several critical insights that contribute significantly to the existing body of knowledge while also addressing previously identified gaps in the literature.

One of the primary revelations of this study is the pervasive concern among stakeholders regarding the safety of food products derived from waste, underscoring the paramount importance of establishing stringent safety protocols and regulatory compliance to mitigate risks of contamination. This finding aligns with existing literature that identifies food safety as a crucial concern in food waste management practices but extends it by delineating the specific challenges and considerations pertinent to the Indian scenario.

The research also highlighted the considerable economic and environmental benefits associated with the reusage of food waste, echoing the sentiments found in the literature about the sustainability potential of waste reduction practices. Stakeholders unanimously recognized these benefits, painting a hopeful picture of the role that food waste reusage can play in fostering a more sustainable and efficient food system in India.

The implications of these findings are far-reaching, offering valuable insights for policymakers, businesses, and practitioners in the field of food safety and waste management. By addressing the identified challenges and leveraging the opportunities outlined in this research, stakeholders can take meaningful steps toward achieving a more sustainable, safe, and acceptable food system in India. Moreover, the study underscores the need for ongoing research in this area, particularly empirical studies that can test the efficacy of proposed solutions and innovative approaches to enhancing the safety and acceptability of products derived from food waste.

In summary, this research contributes to a deeper understanding of the interplay between food safety, acceptability, and waste reusage in India, providing a foundation for future initiatives aimed at mitigating food waste while ensuring the safety and quality of food products. The findings underscore the complexity of this interplay and highlight the critical role of collaborative efforts among all stakeholders to drive positive change in the food system.

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