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Emergency Food Supplies and Packaging Technology as Solutions for Food Security During Natural Disasters

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ABSTRACT
Natural disasters significantly disrupt food systems and threaten food security for affected population. This literature review examines current practices, standards, and in the distribution of emergency food aid to disaster victims. A narrative literature review was conducted using open-access journals published between 2015 and 2025, focusing on nutritional standards, food technology innovations, distribution logistics, and post-disaster food security strategies. This review identified key finding, including recommending 2,100 kcal per person per day, the emergence of intermediate-moisture food technologies and active to extend shelf life, as well as significant disparities in access to food in the aftermath of disasters. Urban agriculture and community gardens were found to contribute substantially to long-term food security, with the potential to provide 15–30% self-sufficiency in vegetables. Key challenges include damage to infrastructure affecting distribution, inadequate coordination coordination among aid agencies, and insufficient consideration of cultural food preferences. This study concludes that effective emergency food assistance requires the integration of international nutritional standards, technological innovations in food, equitable distribution systems, and sustainable recovery strategies that build long-term food security in disaster-prone communities.

INTRODUCTION

Natural disasters, including earthquakes, floods, storms, and tsunamis, are becoming more frequent and severe due to climate change, affecting millions of people worldwide each year (Barrios et al., 2025; Xu et al., 2020). One of the most critical urgent needs following a disaster is access to safe and nutritious food. Disruptions to food systems, infrastructure damage, and population displacement create urgent challenges for emergency food provision (Huang & Xu, 2024; Mishra et al., 2021). According to the latest estimates, more than 339 million people will require humanitarian assistance in 2024, with food insecurity being a primary concern for disaster-affected populations (Ersoy & Bilgin, 2023).

International organizations, including the World Health Organization, the United Nations High Commissioner for Refugees, the United Nations Children's Fund, and the World Food Programme have established guidelines for emergency food assistance that are continually updated (Kennedy & Basu, 2022; Clay et al., 2020). However, the implementation of these standards faces various practical challenges in the context of disasters (Huang & Xu, 2024; Naja et al., 2021). Previous research has examined various aspects of emergency food assistance, including nutritional adequacy, food technology solutions, distribution logistics, and long-term recovery strategies (Everett et al., 2022; Sibhatu & Qaim, 2018). Recent studies have highlighted the importance of culturally appropriate food choices, the role of technology in extending food shelf life, and the potential of urban agriculture for post-disaster food security (Ersoy & Bilgin, 2023; Barrios et al., 2025; Subianto et al., 2024).

Despite extensive research on disaster management, significant gaps remain in understanding a comprehensive picture of the effectiveness of emergency food aid (Huang & Xu, 2024; Vaitla et al., 2020). Many studies focus on specific disasters or a single aspect of food provision, lacking integration across nutritional standards, technological innovations, and distribution challenges (Kennedy & Basu, 2022; Béné et al., 2019). Furthermore, there is limited research comparing emergency food preparedness across different

populations and examining how pre-disaster food assistance programs influence post-disaster outcomes (Dimitrovski & Chappell, 2021; McLennan, 2020). Coordination between immediate relief efforts and long-term food security strategies also requires further investigation (Everett et al., 2022; Ahmed et al., 2020).

This literature review aims to comprehensively examine the latest research on emergency food assistance for disaster victims, synthesizing findings on nutritional standards, food technology innovations, distribution challenges, and sustainable recovery strategies. Specifically, this review seeks to identify international nutritional standards for emergency food assistance, evaluate technological innovations in food preservation and packaging for disaster relief, analyze challenges in food distribution and access following disasters, and assess long-term strategies for building food security in disaster-prone communities.

REVIEW METHOD

This study is a narrative literature review that identifies, discusses, and synthesizes relevant research on emergency food assistance for disaster victims. The review process was conducted between November and December 2025. Sources were selected purposively according to their relevance to the review objectives. The literature search was conducted using various academic databases, including PubMed Central, ScienceDirect, MDPI, Springer, the Directory of Open Access Journals, and BioMed Central. Search terms included combinations of keywords such as emergency food, disaster relief, food security, humanitarian aid, food distribution, nutritional standards, food technology, disaster preparedness, and urban agriculture. Boolean operators were used to refine the search and broaden the range of relevant literature.

The inclusion criteria for the selected literature were: published in peer-reviewed open-access journals, published between 2015 and 2025 with priority given to articles from 2020 to 2025, written in English or Indonesian, focusing on emergency food provision, nutritional standards, food technology for disaster relief, or post-disaster food security, and available as full-text articles with clear methodologies. Exclusion criteria included non-peer-reviewed articles, conference abstracts without full papers, paid articles without an open-access version, studies focusing solely on chronic food insecurity without a disaster context, and articles published before 2015.

From the literature found through the database search, 35 articles that directly addressed the review objectives were selected for discussion based on the criteria above. Additional sources included three international guidelines from the WHO, UNHCR, UNICEF, and WFP. Information collected from each article focused on study design, study populations, geographic location, key findings related to nutritional standards, food technology innovations, distribution challenges, and recommendations for practice. The relevance and credibility of each source were considered qualitatively during the discussion. As a narrative review, this study does not claim to cover all published literature on the topic.

Content analysis was used to synthesize findings across studies. Articles were categorized into four main themes: nutritional standards and food composition; food technology and packaging innovations; distribution logistics and access challenges; and long-term food security strategies. Within each theme, subcategories were identified to organize specific findings. A comparative analysis was conducted to identify consensus, contradictions, and gaps in the literature. Key data were extracted into structured tables for cross-study comparison.

RESULTS AND DISCUSSION

An analysis of international guidelines revealed established nutritional standards for emergency food provision. The WHO, UNHCR, UNICEF, and WFP jointly recommend a minimum energy intake of 2,100 kilocalories per person per day for the general population in emergency situations, with recent updates emphasizing nutritional quality over quantity (Ersoy & Bilgin, 2023; Naja et al., 2021). This standard is calculated based on average energy requirements for light physical activity and assumes a population distribution across different age groups and genders. For populations engaged in heavy physical labor or living in cold climates, requirements may increase to 2,300–2,400 kcal per day (Ahmadi et al., 2019; Clay et al., 2020).

Beyond total energy, the macronutrient composition of emergency food rations is critical. International standards recommend that 10–12% of energy should come from protein, 17% from fat, and the remainder from carbohydrates (Ersoy & Bilgin, 2023; Vaitla et al., 2020). Adequate protein intake is particularly important for children, pregnant women, and breastfeeding mothers. Micronutrient deficiencies are a significant concern in emergency contexts emergencies, with special attention required for vitamin A, vitamin C, thiamine, riboflavin, niacin, vitamin B12, folate, iron, iodine, and zinc (Kennedy & Basu, 2022; Briend et al., 2015). Food fortification is often necessary to meet micronutrient needs when fresh food is unavailable.

Research examining actual emergency food programs has found that food selection takes into account various factors beyond nutritional adequacy. Cultural acceptability emerges as a critical consideration, with programs striving to provide foods that are familiar to the affected population (Ahmadi et al., 2019; McLennan, 2020). Practical factors—including shelf life, ease of preparation with limited resources, and transportation requirements—also influence food selection. However, studies have identified gaps between international

standards and actual implementation, particularly regarding micronutrient adequacy and dietary diversity during the immediate disaster response phase (Vaitla et al., 2020; Subianto et al., 2024).

Recent research has explored technological innovations to improve the quality and shelf life of emergency food supplies. Medium-moisture foods have emerged as a promising solution for disaster relief contexts (Ersoy & Bilgin, 2023). These foods have a water activity level between 0.6 and 0.85, which inhibits microbial growth while maintaining palatability without refrigeration. Studies show that IMF technology can extend shelf life to 6–12 months at ambient temperature—significantly longer than that of conventional fresh foods—while avoiding the processing requirements of fully dehydrated or canned products (Mahalik & Nambiar, 2010; Betoret et al., 2020).

Active packaging technology represents another innovation with substantial potential for emergency food aid. These packaging systems interact with the food or headspace to extend shelf life and maintain quality. Oxygen absorbers can prevent the oxidative degradation of lipids and vitamins, while humidity regulators maintain optimal water activity (Yildirim et al., 2018; Vilela et al., 2018). Antimicrobial packaging that incorporates natural compounds such as essential oils can inhibit microbial growth. Research shows that combining IMF technology with active packaging can achieve a shelf life exceeding 12 months while maintaining nutritional quality and sensory attributes (Betoret et al., 2020; Robertson, 2016).

The practical application of these technologies in disaster contexts shows promise but faces implementation challenges. Cost considerations are significant, as advanced packaging materials may be more expensive than conventional options (Yildirim et al., 2018). The need for specialized equipment and expertise may limit production capacity, particularly for rapid scaling following a major disaster. However, the extended shelf life and improved food safety offered by these technologies can reduce waste and enhance the efficiency of emergency food stocks, potentially offsetting the higher upfront costs (Mahalik & Nambiar, 2010; Vilela et al., 2018).

Post-disaster food access analyses reveal significant challenges in distribution logistics and persistent disparities in food accessibility. A study examining the impact of Hurricane Harvey on food access in Houston, Texas, documented substantial disruptions to the food retail infrastructure (Huang & Xu, 2024). Approximately 27% of grocery stores in the affected areas sustained damage or were closed for extended periods. Low-income neighborhoods experienced more severe and prolonged disruptions, with some areas lacking access to full-service grocery stores for more than six weeks after the disaster (Kennedy & Basu, 2022).

Infrastructure damage is a major obstacle to effective food distribution (Huang & Xu, 2024; Ahmed et al., 2020). Road damage, bridge failures, and flooding limit the transport of food supplies to affected areas. Power outages compromise food safety at retail locations and in households. Communication system failures hinder coordination between aid agencies and affected populations (Kennedy & Basu, 2022; Mishra et al., 2021). Studies of various disaster events show that infrastructure recovery timelines vary widely, ranging from a few days in well-prepared urban areas to several months in remote or severely damaged regions (McLennan, 2020; Xu et al., 2020).

Access to food banks after a disaster presents additional challenges. Research using geographic information system (GIS) analysis found that flooding often affects both the locations of food banks and access routes simultaneously. Following Hurricane Harvey, 34% of food banks in Harris County experienced damage or temporary closures (Kennedy & Basu, 2022). More concerning, an additional 18% remained open but became inaccessible to residents in flooded areas due to impassable roads. Analysis highlights the importance of considering flood risks and accessibility in the strategic placement of emergency food distribution centers (Mishra et al., 2021; Clay et al., 2020).

Table 1. Summary of Key Challenges in Emergency Food Distribution

Challange Categories	Specific Issues	Impact on Food Access Food	Proposed Solution
Infrastructure Damage	Damage to roads, powe, bridge failures	Delayed sshipments, limited cold chain	Pre-positioned inventory, alternative routes
Coordination Issues	Many agencies, communication gaps	Duplication or coverage gaps	Integrated coordination system
Equilty Concerns	Access based on income, location	Vulnerable, undeserved population	Targeted reach, mobile distribution
Cultural Culture	Foreign food, restrictions diet	Utilization low, national insuffiency	Community food variety

Findings synthesized from the reviewed literature (2020–2025). Data were compiled from several studies examining post-disaster food distribution challenges across various geographic contexts.

Household emergency food preparedness varies significantly across populations. A comparative study examining households participating in food assistance programs versus non-participants found significant differences in disaster preparedness (Dimitrovski & Chappell, 2021). Only 42% of food assistance program participants reported having adequate emergency food supplies for three days, compared to 67% of non-

participants. This disparity suggests that populations most vulnerable to food insecurity may be the least prepared for disaster-related disruptions, exacerbating their vulnerability (McLennan, 2020; Béné et al., 2019).

While immediate emergency food assistance is crucial, research increasingly emphasizes the importance of long-term food security strategies for disaster recovery (Everett et al., 2022; Ahmed et al., 2020). Urban agriculture has emerged as a significant component of post-disaster food security. Studies examining community gardens in Wellington, New Zealand, and other disaster-prone areas demonstrate a substantial contribution to local food security (Barrios et al., 2025; Sibhatu & Qaim, 2018). Quantitative analyses indicate that well-developed urban agriculture systems can provide 15–30% vegetable self-sufficiency for affected communities (Barrios et al., 2025; Subianto et al., 2024).

The benefits of urban agriculture extend beyond food production (Barrios et al., 2025; Langemeyer et al., 2020). Community gardens provide employment and income opportunities during recovery periods when conventional jobs may be limited. They contribute to psychosocial recovery by providing meaningful activities and community connections (Subianto et al., 2024). Environmental benefits include a reduction in the urban heat island effect, improved stormwater management, and increased biodiversity. Economic analyses show that urban agriculture initiatives can generate positive returns within 2–3 years while building long-term community food security (Everett et al., 2022; Lin et al., 2015).

Integrating disaster risk management with local food systems represents an emerging approach to food security. Research from Cairns, Australia, examined how short food supply chains can be strengthened to maintain access to food during disasters (Everett et al., 2022). The study found that local food systems with diverse producers and multiple distribution channels demonstrated greater resilience to disaster disruptions than systems reliant on long-distance supply chains. Supporting local food production and strengthening regional food networks before a disaster strikes can significantly improve food security outcomes when a disaster occurs (Ahmed et al., 2020; Béné et al., 2019).

However, urban agriculture faces implementation challenges in the context of disasters. Land availability and tenure security may be uncertain, particularly in urban areas where disaster recovery involves reconstruction and rebuilding (Langemeyer et al., 2020). Initial investments in infrastructure—such as raised beds, irrigation systems, and tools—require funding that may be limited within recovery budgets. Technical expertise in sustainable agricultural practices may be lacking among urban populations (Lin et al., 2015). These challenges indicate that successful urban agriculture programs require sustained institutional support, technical assistance, and community engagement (Subianto et al., 2024).

The reviewed literature highlights the critical need for better integration between immediate emergency food assistance and long-term food security strategies. Traditional approaches often treat emergency response and recovery as separate phases with different institutions and funding sources (Vaitla et al., 2020). This separation can create gaps when emergency programs end before sustainable local food systems are reestablished. Research indicates that planning for long-term food security must begin during the immediate response phase, with emergency programs designed to support rather than undermine local food systems (Ahmed et al., 2020; Béné et al., 2019).

Successful integration requires coordination among various stakeholders, including international aid agencies, national governments, local authorities, and community organizations (Everett et al., 2022; Xu et al., 2020). Best practices identified in the literature include the early involvement of local food producers in emergency response planning, the procurement of emergency food supplies from local or regional sources whenever possible, and transition planning that gradually shifts from external food aid to locally produced food. Programs that implement these approaches demonstrate better outcomes in both immediate food security and long-term food system resilience (McLennan, 2020; Sibhatu & Qaim, 2018).

CONCLUSIONS

This comprehensive literature review reveals that effective emergency food assistance for disaster victims requires the integration of various components: adherence to international nutritional standards, the application of food technology innovations, equitable distribution systems, and long-term resilience strategies. International guidelines setting a target of 2,100 kcal per person per day with adequate macronutrient and micronutrient composition provide a clear standard, although implementation gaps persist, particularly regarding micronutrient adequacy and dietary diversity. Technological advances in medium-moisture foods and active packaging offer promising solutions for extending shelf life and maintaining food quality, although costs and production capacity remain implementation challenges. Distribution challenges—including infrastructure damage, coordination gaps, and disparities in access—disproportionately affect vulnerable populations, highlighting the need for better logistics planning and equitable distribution systems. Urban agriculture and the strengthening of local food systems contribute substantially to long-term food security, potentially providing 15–30% self-sufficiency in vegetables while offering additional psychosocial and economic benefits. Future research should prioritize the development of that are culturally appropriate, studies on the cost-effectiveness of innovations in actual disaster contexts, integrated models linking emergency response with long-term food security, and an examination of equity in food access during disasters, particularly for vulnerable populations.

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