

Application of Advanced Drying Technologies for Reducing Post-Harvest Losses of Fruits and Vegetables in Urban Bangalore: A Home Science Perspective

Dr Belinda Lopez

Assistant Professor,

Dept. of Home Science,

Smt. VHD Central Institute of Home Science (DCE),

Maharani Cluster University,

Bangalore.

Abstract

Post-harvest losses of fruits and vegetables remain a significant concern in urban regions like Bangalore, where increasing population and changing food consumption patterns place pressure on food systems. Fruits and vegetables, being highly perishable due to their high moisture content, require efficient preservation techniques to extend shelf life and reduce waste. This review examines the applicability of fourth-generation drying technologies, such as microwave drying, infrared drying, flash drying, freeze drying, and combined drying methods, within the context of home science and urban food management.

The paper highlights how these technologies can be adapted for household-level, small-scale, and entrepreneurial applications in Bangalore. Emphasis is placed on their role in improving nutritional retention, reducing food wastage, and supporting women-led micro-enterprises and home-based food processing units. The study concludes that integrating modern drying technologies into home science practices can significantly contribute to sustainable food consumption and livelihood generation in urban settings.

Keywords: Home Science, Bangalore, food preservation, drying techniques, urban food waste, women entrepreneurship

I. INTRODUCTION

Fruits and vegetables form an essential part of daily diets in urban households in Bangalore. However, due to their high moisture content (80–95%), they are highly perishable and prone to rapid spoilage (Nath et al., 2007). In metropolitan cities like Bangalore, post-harvest losses occur not only during transportation and storage but also at the household level due to over-purchasing and improper storage practices.

From a Home Science perspective, food preservation is crucial for ensuring food security, reducing wastage, and promoting efficient household management. Drying is one of the most practical and accessible methods of preservation, traditionally practiced in Indian households through sun drying. With technological advancements, modern drying techniques have emerged that offer better efficiency, hygiene, and quality retention. These fourth-generation drying methods can be integrated into urban households, small-scale food businesses, and self-help groups, especially benefiting women entrepreneurs.

In recent years, Bangalore has witnessed rapid urbanization, lifestyle changes, and increased dependency on market-purchased fresh produce. The shift towards nuclear families, busy work schedules, and changing consumption patterns has led to a rise in food wastage at the consumer level. According to recent estimates, a significant proportion of fruits and vegetables purchased in urban households is discarded due to spoilage before consumption. This not only results in economic losses for households but also contributes to environmental issues such as increased organic waste generation.

Food waste management has therefore become an important area of concern within the domain of Home Science. Efficient utilization and preservation of perishable food items are essential strategies to address this issue. Drying, as a preservation technique, reduces moisture content and inhibits microbial growth, thereby extending shelf life and enabling long-term storage. Additionally, dried products are lightweight, require less storage space, and can be conveniently used in various culinary preparations.

Traditional drying methods such as sun drying, although cost-effective, are often associated with limitations including contamination, dependency on weather conditions, uneven drying, and loss of nutritional quality. These limitations have led to the development and adoption of improved drying technologies. Modern or fourth-generation drying techniques, such as microwave drying, infrared drying, and hybrid drying systems, offer controlled processing conditions, faster drying rates, and better preservation of sensory and nutritional attributes (Moses et al., 2014).

In the context of Bangalore, the application of these advanced drying technologies holds significant potential not only at the industrial level but also at the household and community levels. With increasing awareness of healthy eating and demand for minimally processed foods, there is a growing market for dried fruits, vegetable powders, and ready-to-use food products. Small-scale food processing units and home-based enterprises can leverage these technologies to produce value-added products, thereby enhancing income opportunities.

Furthermore, the integration of drying technologies into Home Science practices can contribute to women empowerment. Many women in urban and semi-urban areas are engaged in self-help groups and micro-enterprises related to food processing. Access to efficient and affordable drying technologies can enable them to improve product quality, increase production capacity, and expand their market reach. This aligns with the broader goals of sustainable development and inclusive economic growth.

Another important aspect is the nutritional implication of drying methods. While preservation aims to extend shelf life, it is equally important to retain the nutritional quality of food. Advanced drying techniques are designed to minimize the loss of vitamins, minerals, and bioactive compounds, ensuring that the dried products remain nutritionally valuable. This is particularly relevant in addressing issues related to dietary deficiencies and promoting balanced nutrition in urban populations.

In addition, the adoption of modern drying methods contributes to environmental sustainability. By reducing food waste and promoting efficient resource utilization, these technologies support sustainable consumption patterns. Reduced wastage also implies lower pressure on food supply chains and agricultural production systems.

Despite these advantages, the adoption of advanced drying technologies at the household level is still limited due to factors such as cost, lack of awareness, and technical knowledge. Therefore, there is a need for educational initiatives, training programs, and policy support to promote their usage. Home Science professionals and institutions can play a key role in disseminating knowledge and facilitating the adoption of these technologies.

In this context, the present review aims to explore the role and applicability of fourth-generation drying techniques in reducing post-harvest losses of fruits and vegetables in urban Bangalore. The study emphasizes their relevance in household management, small-scale food processing, and entrepreneurship development within the framework of Home Science.

Relevance to Home Science and Urban Bangalore

Table 1

Role of Drying Techniques in Home Science Applications

Area	Application in Bangalore Context
Household Management	Reducing daily food waste
Nutrition	Preserving vitamins and minerals
Food Processing	Value-added products (chips, powders)
Entrepreneurship	Small-scale drying units for women
Sustainability	Minimizing urban food waste

Fourth-Generation Drying Techniques in Urban Context

Microwave Drying (Household Feasibility)

Microwave drying is highly relevant in urban Bangalore households due to the widespread availability of microwave ovens. It allows rapid drying of fruits such as bananas, apples, and vegetables like carrots and beans.

- Suitable for **home use**
- Saves time and energy
- Ideal for small-scale food processing

(Chandrasekaran et al., 2013)

Infrared Drying (Small Enterprise Use)

Infrared drying is useful for small food processing units and start-ups in Bangalore. It offers faster drying with better retention of colour and nutrients.

- Suitable for **home-based businesses**
- Efficient for **vegetable slices and snacks**

(Doymaz, 2015)

Flash Drying (Industrial/Start-up Level)

Flash drying is more applicable at a semi-industrial level and can be used by food start-ups in Bangalore focusing on powdered food products.

- Useful for **spice powders, fruit powders**
- High efficiency for bulk processing

(Marta et al., 2012)

Osmotic Dehydration (Traditional + Modern Integration)

This method aligns well with traditional Indian food practices, such as making pickles and preserves.

- Can be practiced at **household level**
- Maintains taste and texture
- Suitable for **fruits like mango and amla**

(Chavan, 2012)

Freeze Drying (High-End Urban Market)

Freeze drying is suitable for premium markets in Bangalore, such as organic stores and export-oriented businesses.

- Produces **high-quality dried products**
- Used for **ready-to-eat snacks and health foods**

(Karam et al., 2016)

Combined Drying Methods (Emerging Opportunities)

Hybrid drying methods are gaining popularity in urban food processing due to their efficiency.

- Ideal for **start-ups and food entrepreneurs**
- Reduces energy and improves quality

(Szadzińska et al., 2017)

Comparative Suitability for Bangalore

Table 2

Suitability of Drying Techniques in Bangalore Context

Technique	Household Use	Small Business	Cost Level	Suitability
Microwave	High	Medium	Low	Very High
Infrared	Medium	High	Medium	High
Flash Drying	Low	High	High	Moderate
Osmotic	High	Medium	Low	Very High
Freeze Drying	Low	High	Very High	Niche
Combined Methods	Medium	High	Medium	High

Impact on Nutrition and Food Security

Table 3

Benefits in Home Science Perspective

Aspect	Impact
Food Waste Reduction	Significant decrease in household waste
Nutritional Retention	Preserves vitamins and minerals
Economic Benefit	Income generation through food products
Women Empowerment	Supports self-help groups and home businesses
Sustainability	Promotes eco-friendly food practices

Discussion

In Bangalore, rapid urbanization and changing lifestyle patterns have significantly influenced food consumption and waste generation behaviors. Increased reliance on supermarkets, bulk purchasing habits, and limited time for food preparation often result in higher levels of food wastage, particularly of perishable items such as fruits and vegetables. Within this context, the adoption of modern drying techniques presents a practical and sustainable intervention to minimize such losses.

From a Home Science perspective, drying technologies are not merely preservation tools but also instruments for improving household efficiency and resource management. By converting perishable produce into shelf-stable forms, households can better plan consumption, reduce frequency of purchases, and avoid unnecessary disposal of food. Moreover, dried products such as fruit chips, vegetable flakes, and powders can be easily incorporated into daily cooking, thereby enhancing dietary diversity and convenience.

The role of fourth-generation drying technologies becomes particularly significant due to their ability to preserve nutritional quality and sensory attributes. Unlike traditional sun drying, which often leads to contamination and nutrient loss, advanced techniques such as microwave and infrared drying ensure controlled conditions, faster processing, and improved product quality (Moses et al., 2014). This is especially important in urban settings where consumers increasingly demand hygienic, safe, and high-quality food products.

Another critical dimension is the potential of these technologies to support income generation and entrepreneurship. In Bangalore, a large number of women are engaged in self-help groups (SHGs), micro-enterprises, and home-based food businesses. The adoption of small-scale drying technologies can enable these groups to produce value-added products such as dried fruits, vegetable powders, spice mixes, and ready-to-cook ingredients. These products have a growing demand in urban markets due to rising health consciousness and preference for natural, preservative-free foods.

Furthermore, such entrepreneurial activities contribute to women empowerment by providing financial independence and skill development opportunities. Home Science as a discipline plays a vital role in facilitating this process by offering training in food processing, preservation techniques, packaging, and marketing strategies. The integration of modern drying technologies into these training programs can significantly enhance the productivity and competitiveness of small-scale enterprises.

Despite these advantages, several challenges hinder the widespread adoption of advanced drying technologies. One of the primary barriers is the cost associated with equipment such as infrared dryers or freeze-drying systems, which may not be affordable for low-income households or small entrepreneurs. Additionally, there is a lack of awareness and technical knowledge regarding the operation and benefits of these technologies. Many households continue to rely on traditional methods due to familiarity and accessibility, despite their limitations.

Infrastructure and policy-related issues also play a role. Limited access to credit facilities, inadequate support systems, and lack of organized marketing channels restrict the growth of small-scale food processing units. To address these challenges, there is a need for targeted interventions such as government subsidies, training workshops, and extension services. Institutions and organizations can collaborate to provide skill development programs that focus on low-cost and user-friendly drying technologies suitable for household and micro-enterprise applications.

Moreover, the promotion of community-level processing units equipped with shared drying facilities can be an effective strategy. Such models can reduce individual investment costs while enabling collective production and marketing. This approach aligns with sustainable development goals by promoting resource efficiency, reducing food waste, and enhancing livelihoods.

In addition, awareness campaigns highlighting the importance of food preservation and waste reduction can encourage behavioural changes among urban consumers. Educational initiatives integrated into Home Science curricula can further strengthen knowledge dissemination and practical application of these technologies.

II. CONCLUSION

The integration of fourth-generation drying technologies into Home Science practices offers a viable and sustainable solution to the growing issue of food wastage in urban areas like Bangalore. These technologies effectively bridge the gap between traditional preservation methods and modern efficiency requirements by providing improved control, faster processing, and better retention of nutritional and sensory qualities.

At the household level, the adoption of modern drying techniques can significantly reduce post-purchase losses of fruits and vegetables, leading to better resource utilization and cost savings. From a nutritional perspective, the availability of preserved, ready-to-use food products supports balanced diets and enhances food security in urban settings.

At the community and entrepreneurial levels, these technologies present valuable opportunities for income generation, particularly for women engaged in self-help groups and home-based enterprises. The production of value-added dried products not only meets the growing urban demand but also contributes to economic empowerment and livelihood development.

However, for these benefits to be realized on a larger scale, challenges related to affordability, awareness, and technical accessibility must be addressed. Policy support, capacity-building initiatives, and the development of low-cost, user-friendly technologies are essential to promote widespread adoption. Collaborative efforts between government agencies, educational institutions, and community organizations can play a crucial role in this regard.

Future research should focus on developing cost-effective and energy-efficient drying technologies tailored to the needs of urban households and small-scale enterprises. Additionally, studies exploring consumer acceptance, market potential, and the socio-economic impact of dried food products in urban Indian contexts would further strengthen the applicability of these technologies.

In conclusion, the adoption of advanced drying techniques within the framework of Home Science not only addresses the issue of food wastage but also contributes to sustainable living, improved nutrition, and inclusive economic development in rapidly urbanizing cities like Bangalore.

III. REFERENCES

1. Chandrasekaran, S., Ramanathan, S., & Basak, T. (2013). Microwave food processing—A review. *Food Research International*, 52(1), 243–261. <https://doi.org/10.1016/j.foodres.2013.02.033>
2. Chavan, U. D., & Amarowicz, R. (2012). Osmotic dehydration of fruits and vegetables. *Journal of Food Research*, 1(2), 202–209.
3. Doymaz, I. (2015). Infrared drying kinetics of carrot slices. *Journal of Food Processing and Preservation*, 39(6), 2738–2745.
4. Karam, M. C., Petit, J., Zimmer, D., Djantou, E. B., & Scher, J. (2016). Effects of drying and grinding in production of fruit and vegetable powders. *Journal of Food Engineering*, 188, 32–49. <https://doi.org/10.1016/j.jfoodeng.2016.05.001>
5. Marta, F. Z., Dotta, B., Almeida, P., & Laurindo, J. B. (2012). Convective multi-flash drying process for producing dehydrated crispy fruits. *Journal of Food Engineering*, 108(4), 523–531.
6. Moses, J. A., Norton, T., Alagusundaram, K., & Tiwari, B. K. (2014). Novel drying techniques for the food industry. *Food Engineering Reviews*, 6, 43–55. <https://doi.org/10.1007/s12393-014-9078-7>

7. Mujumdar, A. S. (2000). *Handbook of industrial drying* (3rd ed.). CRC Press.
8. Nath, S., et al. (2007). Preservation and storage of perishable fruits and vegetables.
9. Onwude, D. I., Hashim, N., Abdan, K., Janius, R., & Chen, G. (2019). Experimental studies and mathematical simulation of intermittent infrared and convective drying of sweet potato (*Ipomoea batatas* L.). *Food and Bioproducts Processing*, 114, 163–174. <https://doi.org/10.1016/j.fbp.2018.12.006>
10. Onwude, D. I., Hashim, N., Abdan, K., Janius, R., & Chen, G. (2019). The effectiveness of combined infrared and hot-air drying strategies for sweet potato. *Journal of Food Engineering*, 241, 75–87. <https://doi.org/10.1016/j.jfoodeng.2018.08.008>
11. Pani, P., Signorelli, M., Schiraldi, A., et al. (2010). Osmotic dehydration of apple pulp studied using thermogravimetric approach. *Journal of Thermal Analysis and Calorimetry*, 102, 383–390. <https://doi.org/10.1007/s10973-009-0544-z>
12. Pokharkar, S. M. (2001). Kinetic model for osmotic dehydration of green peas prior to air drying. *Journal of Food Science and Technology*, 38, 557–560.
13. Punathil, L., & Basak, T. (2016). Microwave processing of frozen and packaged food materials. *Reference Module in Food Science*. <https://doi.org/10.1016/B978-0-08-100596-5.21009-3>
14. Raj, G. V. S. B., & Dash, K. K. (2022). Effect of intermittent microwave convective drying on physicochemical properties of dragon fruit. *Food Science and Biotechnology*, 31(5), 549–560. <https://doi.org/10.1007/s10068-022-01057-4>
15. Rehman, M. S. (2007). *Handbook of food preservation* (2nd ed.). CRC Press.
16. Ricardo, L. M., Bruno, A. M., & Laurindo, J. B. (2016). Microwave multi-flash drying process for producing crispy banana. *Journal of Food Engineering*, 178, 1–11.
17. Monteiro, R. L., Link, J. V., Tribuzi, G., & Laurindo, J. B. (2018). Microwave vacuum drying and multi-flash drying of pumpkin slices. *Journal of Food Engineering*.
18. Sadat, K. A., Uddin, M., Rahman, R., Islam, S. M. R., & Khan, M. S. (2017). Mechanisms and commercial aspects of food preservation and processing. *Agriculture & Food Security*, 6, 51. <https://doi.org/10.1186/s40066-017-0130-8>
19. Sadeghi, M., Mirzabeigi, O., & Mireei, S. A. (2013). Mass transfer characteristics during convective and microwave drying of lemon slices.

- Journal of the Science of Food and Agriculture*, 93(3), 471–478.
<https://doi.org/10.1002/jsfa.5786>
20. Singham, P., & Birwal, P. (2014). Technological revolution in drying of fruits and vegetables. *International Journal of Science and Research*, 705–711.
 21. Sridhar, A., Ponnuchamy, M., Kumar, P. S., et al. (2021). Food preservation techniques and nanotechnology for increased shelf life. *Environmental Chemistry Letters*, 19, 1715–1735. <https://doi.org/10.1007/s10311-020-01126-2>
 22. Sutar, P. P., & Prasad, S. (2008). Microwave drying technology: Developments and R&D needs in India. *ISAE Proceedings*, 1–3.
 23. Szadzińska, J., Lechtańska, J., Kowalski, S. J., & Stasiak, M. (2017). Effect of ultrasound and microwaves on convective drying effectiveness. *Ultrasonics Sonochemistry*, 34, 531–539. <https://doi.org/10.1016/j.ultsonch.2016.06.030>
 24. Tiwari, R. B. (2005). Application of osmo-air dehydration for tropical fruits. *Indian Food Industry*, 24(6), 62–69.
 25. Tulbek, M. C., Lam, R. S. H., Asavajaru, P., & Lam, A. (2017). Pea as a sustainable protein crop. In *Sustainable Protein Sources* (pp. 145–164). Academic Press.
 26. United Nations Environment Programme. (2021). *Food Waste Index Report 2021*. Nairobi.
 27. Valérie, O., Viboon, C., & Vijaya, R. (2006). Microwave drying of fruits and vegetables. *Stewart Postharvest Review*, 2(6), 1–7.
 28. Ward, K. R., & Matejtschuk, P. (2021). Principles of freeze-drying and analytical technologies. In *Cryopreservation and Freeze-Drying Protocols*. Springer. https://doi.org/10.1007/978-1-0716-0783-1_3
 29. Wu, X., & Zhang, M. (2019). Infrared drying applications in food processing. *Innovative Food Science & Emerging Technologies*, 54, 34–42.
 30. Zielinska, M., Zapotoczny, P., Alves-Filho, O., Eikevik, T. M., & Blaszczyk, W. (2013). Microwave vacuum-assisted drying of green peas. *Drying Technology*, 31(6), 633–642. <https://doi.org/10.1080/07373937.2012.751921>