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# Challenges and innovations in the post harvesting management of medicinal and aromatic plants

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**Abstract**

Medicinal and aromatic plants play a significant role in pharmaceuticals, cosmetics, and traditional medicine. However, post-harvest management challenges, such as physical, chemical, biological challenges, loss of bioactive compounds, and quality degradation, can hinder the effectiveness and marketability of these plants. The challenges in post-harvest management of medicinal and aromatic plants can be rectified by recent innovations in drying, storage, packaging, and processing technologies that aim to improve the quality and sustainability of these valuable plants.

**Keywords:** Post harvesting, medicinal, aromatic, innovations, cosmetics, pharmaceuticals

## Introduction

Medicinal and aromatic plants have emerged as a major economic activity in India and witnessed rapid growth this sector (Chaudhary, 2006) [3]. These resources are produced and offered in a wide variety of products, from crude materials to processed and packaged products (Lange 2006) [16]. As result, there is an enormous demand in plants produce or products for domestic use and for international trade resulting in huge trade in local, regional and international level. The instant rising demand of plant-based drugs is unfortunately creating heavy pressure in some selected high-value medicinal plant population in the wild due to over Harvesting (Kala *et al.* 2006) [12]. Over harvesting decreased their populations and a number of species became threatened in natural habitat (Mushtaq, *et al*., 2016) [20]. Due to this increase in the demand worldwide, the safety, quality and efficacy of these products have become a major concern for health authorities and the consumers. This safety and efficacy are governed by the quality of products. The effort to achieve the quality, safety and efficacy of these important resources must begin well before harvest.

Application of post-harvest techniques makes it possible. Improper handling after harvesting often results in quality deterioration and significant economic loss. Post harvest loss of medicinal and aromatic plants has been defined as "the loss of weight of product (exclusive of moisture content) that is normally utilized or consumed for drugs by humankind. Post harvest losses can be attributed to several factors, however, improper handling and packaging, low level technology, lack of the collection centers or packing houses and lack of trained personnel are prevalent (Chaudhary, 2006) [3]. Due to poor infrastructure of storage, processing and marketing, the postharvest losses of Horticultural crops including Medicinal and aromatic plants in Asia Pacific region, including India, have been reported to vary between 10-10% (Rosa, 2006) [23].

In some instances, the figures can exceed 50%, depending on the handling and distribution chain which vary with different countries. This loss is more in case of MAPS because they are composed of secondary metabolites (active constituents) in bio-available form. These secondary metabolites must keep in stable condition throughout the process of marketing and require care and maintenance. In addition, improper post-harvest management techniques may adversely affect their quality, chemical composition of active ingredients, efficacy, composition and content, meaning a measurable qualitative and quantitative loss in each product. Not only quantity and quality but even the appearance of the produced material is affected, and their market value is reduced.

The rising demand for herbal plant-based medicines has amplified the importance of Medicinal and Aromatic Plants (MAPs) in production and consumption, with potential for significant socio-economic and sustainable development gains in countries like India. However, poor post-harvest management leads to substantial losses in MAPs, greatly impacting producer income. Studies estimate that India faces annual post-harvest losses of Rs. 75,000-1,00,000 crore, spanning storage, handling, and processing. Effective transfer and adaptation of post-harvest technologies could reduce these losses by 50%, improving quality, safety, efficacy, and market competitiveness, and thus increasing profits for producers. Therefore, innovative techniques in

MAP post-harvest management are essential to meet these goals and reduce losses.

**Challenges in Post-Harvest Management**
**Physical Challenges**
Medicinal and aromatic plants with high moisture content are vulnerable to microbial growth, affecting shelf life and quality. Handling processes lead to bruising and damage, reducing marketability and quality.

**Biological Challenges**
Contaminants like molds and bacteria reduce the medicinal efficacy of MAPs and pose health risks. Improper storage can attract pests, damaging MAPs and leading to quality loss.

**Chemical Challenges**
Exposure to oxygen causes degradation of active compounds like essential oils, impacting efficacy. Essential oils evaporate quickly, affecting the therapeutic value and aroma.

**Logistic Challenges**
Limited cold or controlled storage leads to rapid quality loss in MAPs. Delays expose MAPs to varying temperatures and humidity, affecting freshness.

**Post-Harvest Techniques and Their Limitations**
**Drying Methods**
Drying is a critical step in post-harvest processing, as it reduces moisture content, inhibiting microbial growth and enzymatic activity. Traditional sun drying is widely used but can expose plants to contamination and environmental variations. Modern drying techniques, such as hot-air drying, freeze-drying, and microwave drying, offer controlled environments but often require high energy inputs and may be cost-prohibitive for small-scale farmers.

**Extraction Processes**
Extracting active compounds from MAPs is essential for their use in pharmaceuticals and cosmetics. Traditional solvent extraction and steam distillation are commonly used but can be time-consuming and inefficient. Newer techniques, such as supercritical $CO_2$ extraction, are more efficient and environmentally friendly but require significant capital investment.

**Packaging and Transportation**
Proper packaging is essential to prevent moisture uptake and protect against environmental contaminants. Vacuum sealing and modified-atmosphere packaging are effective but costly solutions. Transporting MAPs also requires careful handling to avoid degradation from temperature fluctuations and physical damage.

**Innovations in Post-Harvest Management**
**1. Advances in Drying Technologies**
**Freeze Drying**
Effective for high-value MAPs. Freeze-drying properly preserves the medicinal qualities of plants and is superior to other preservation methods. (Abacal *et al.*, 2005) [2].

**Infrared Drying**
To carry out the tests, the infrared dryer was made and optimized in Shahrekord University of Iran. This dryer has the capability to dry with the use of both hot air and infrared methods. Infrared radiation rapidly reduces moisture content. Fast and energy efficient. (Samani *et al.*, 2017) [24].

**2. Controlled- Atmospheric storage**
Modified Atmosphere Packaging (MAP) is an improved method of storage under which the normal composition of air is changed or modified. Adjusts oxygen, carbon dioxide, and humidity levels in storage environments. It Preserves bioactive compounds, extends shelf life and retains aroma and color.

**3. Packaging Innovations**
**Vacuum Packaging**
Vacuum packaging is removing air from the product pouch and hermetically sealing it. This increases storage or shelf life by inhibiting the growth of microorganisms and improves hygiene by reducing the danger of cross contamination. Vacuum packing also preserves flavor and protects against dehydration and weight loss (Meena *et al.*, 2017) [19].

**Antimicrobial and Nanoparticle-Enhanced Packaging**
An important phenomenon of bacterial infection is biofilm formation. Bacteria alternate between two forms—free-living planktonic and surface-attached biofilm—depending on the environmental conditions. It extends Shelf Life and enhances Barrier Properties. It also improves thequality retention

**4. Advanced Extraction Techniques**
**Supercritical $CO_2$ Extraction**
Supercritical $CO_2$ extraction (SFE) has emerged as an efficient and environmentally friendly alternative to these traditional methods. In SFE, carbon dioxide ($CO_2$) is used in its supercritical state—above its critical temperature (31.1 °C) and pressure (73.8 bar)—where it exhibits both liquid and gas-like properties. This unique state enables $CO_2$ to diffuse through plant matrices like a gas and dissolve compounds like a liquid, providing a versatile method for extracting the mobile and volatile compounds without compromising their integrity. Supercritical fluid extraction, particularly with carbon dioxide, has been emphasized, due to its efficiency in extracting bioactive compounds like essential oils from various natural plant materials, including herbs, spices, aromatics, and medicinal plants. (Haboubi *et al.*, 2023) [7].

**Ultrasonic Extraction**
It is a simple, inexpensive extraction method with high reproducibility, environmentally friendly and shorter extraction time. It maximizes yield with minimal heat damage.

**5. Quality Control Standards**
Quality standards is utmost important in medicinal plants. It is, therefore, essential to establish internationally recognized guidelines for assessing their quality. Important for

standardizing the phytochemical content and the consumer interest (Efferth *et al.*, 2012) [4].

**Analytical Techniques**

**High-Performance Liquid Chromatography (HPLC)**

HPLC is a powerful technique for rapid analysis of bioactive constituents because it enables systematic profiling of the complex plant samples and specifically focuses on their identification and consistent evaluation of the identified compounds. However, a valuable and convincing chromatographic fingerprint must assign most of its peaks corresponding to the active constituents and toxic ingredients (Kumar, 2017) [15].

**Gas Chromatography-Mass Spectrometry (GC-MS)**

It is a very sensitive and selective technique. It is widely used for separation and determination of volatile compounds. It is employed for qualitative identification quantitative determination of volatile compounds organic compound in air pollution monitoring (Hashmi *et al.,* 2013) [9].

## 6. Good Agricultural and Collection Practices (GACP)

Good Agricultural and Collection Practices for Medicinal Plants (or GACP for short) are a set of guidelines developed in 2003 by the World Health Organization (WHO), aimed at improving the quality of medicinal plant material being used in herbal medicines in the market.

The main objectives of the GACP guidelines, as stated by the WHO, are as follows:

To contribute to the quality assurance of medicinal plant materials used as the source for herbal medicines to improve the quality, safety and efficacy of finished herbal products; • To guide the formulation of national and/or regional GACP guidelines and GACP monographs for medicinal plants and related standard operating procedures; and • To encourage and support the sustainable cultivation and collection of medicinal plants of good quality in ways that respect and support the conservation of medicinal plants and the environment in general.

## 7. Emerging Technologies: AI and IoT in MAP Management

**AI in MAP management**

AI is transforming the field of medicinal and aromatic plants (MAPs) by efficiently analyzing data on plant chemistry, growth, and medicinal properties. Key applications include plant identification, where AI precisely classifies species; phytochemical analysis, which ensures consistency and quality; and drug discovery, where AI detects therapeutic compounds. It also aids in disease diagnosis for crop health, aroma analysis for essential oil profiling, and image analysis to monitor growth patterns and optimize cultivation. Together, these applications streamline research and production, enhance quality control, and open new possibilities for MAP-based pharmaceuticals and wellness products (Gasinmeilu1 *et al.*, 2023) [6].

**IoT Sensors for Real-Time Monitoring**

IoT (Internet of Things) sensors in medicinal and aromatic plants (MAPs) cultivation provide real-time monitoring of key conditions like soil moisture, temperature, humidity, light, and $CO_2$ levels. This technology enables precise control over the growing environment, ensuring optimal conditions for phytochemical production, which is crucial for maintaining the plants' medicinal qualities. IoT also supports early detection of diseases and pests, optimizes resource use, and identifies the best harvest times. By enhancing quality control and reducing waste, IoT sensors help make MAPs cultivation more sustainable, cost-effective, and efficient, benefiting both growers and the end-users who rely on these plants (Taj *et al.*, 2011) [25].

## 8. Genetic Approaches: CRISPR and MAO Durability

Genetic approaches like CRISPR and Marker-Assisted Selection (MAS) are crucial for improving the durability and quality of medicinal and aromatic plants (MAPs). CRISPR enables precise gene editing to boost disease resistance, pest tolerance, and phytochemical production, enhancing plant resilience and medicinal value. MAS aids in identifying and breeding plants with desirable traits, streamlining the process for developing durable varieties with high phytochemical consistency. These methods reduce reliance on pesticides, promote sustainable practices, and ensure reliable, high-quality MAP yields. Together, CRISPR and MAS make MAP cultivation more resilient, efficient, and suitable for pharmaceutical and therapeutic applications (Hasan *et al.*, 2024) [8].

## 9. Block chain for Traceability in MAP Supply Chains

Block chain technology enhances traceability in medicinal and aromatic plants (MAPs) by creating transparent, secure records of each stage in the supply chain. This ensures authenticity, quality, and safety by tracking plants from cultivation to end product. Block chain prevents fraud, verifies organic or sustainable practices, and allows consumers to access detailed information on sourcing and handling. For MAP industries, it builds trust, supports regulatory compliance, and safeguards against counterfeit products, ultimately improving market value and consumer confidence. Block chain's immutable records make it a powerful tool for ensuring integrity and traceability in MAP supply chains (Prashar *et al.*,2020) [22].

## Conclusion

MAPs face biological, chemical, physical, and logistical issues that can reduce quality and shelf life. Advanced techniques like vacuum drying and controlled atmosphere storage help preserve medicinal value. Effective management supports rural incomes and reduces environmental impact. Consistent protocols ensure quality and consumer trust. Continued research and improved technologies are essential for sustainable MAP production.

## References

1. Anonymous. Good agricultural and collection practices (GACP) for medicinal plants. World Health Organization Report. Geneva: WHO; 2003.
2. Abascal K, Ganora L, Yarnell E. The effect of freeze-drying and its implications for botanical medicine: A review. Phytother Res. 2005;19:655-60.
3. Chaudhary ML. Recent development in reducing postharvest losses in the Asia Pacific region. Asian Productivity Organization and FAO; 2006. p. 15-22.

4. Efferth T, Greten HJ. Quality control for medicinal plants. Med Aromat Plants. 2012;1(7):1-3.
5. Fernandez J. Innovative research directions for sustainable management of medicinal and aromatic plants. J Herb Res. 2023;15(2):58-66.
6. Gasinmeilu K, Langangmeilu G. Artificial intelligence technology in medicinal and aromatic plants (MAPs). J Just Agric. 2023:17-21.
7. Haboubi K, Abdouni AE, Hammoudani YE, Dimane F, Haboubi C. Estimating biogas production in the controlled landfill of Fez (Morocco) using the LandGEM model. J Environ Eng Manag. 2023;22:1813-20.
8. Hasan N, Laskar RA, Farooqui SA, Naaz N, Sharma N. Genetic improvement of medicinal and aromatic plant species: Breeding techniques, conservative practices and future prospects. J Crop Des. 2024;3(4):100-8.
9. Hashmi LS, Hossain MA, Weli AM, Riyami Q, Sabahi JN. GC-MS analysis of different organic crude extracts from the local medicinal plant *Thymus vulgaris* L. Asian Pac J Trop Biomed. 2013;3(1):69-73.
10. Herzyk F, Pietras DP, Korzeniowska M. Supercritical extraction techniques for obtaining biologically active substances from a variety of plant byproducts. 2024;13(11):13-7.
11. Jhu MY, Ellison E, Sinha NR. CRISPR gene editing to improve crop resistance to parasitic crops. J Genome-Editing. 2023;5(20):1-8.
12. Kala CP, Dhyani PP, Sajwan BS. Developing the medicinal plants sector in northern India: Challenges and opportunities. J Ethnobiol Ethnomed. 2006;2(32):1-15.
13. Krüger H, Schulz H. Analytical techniques for medicinal and aromatic plants. J Postharvest Biol Technol. 2014;3(4):1-1.
14. Kumar A. Blockchain technology for improving traceability and quality in the supply chains of medicinal and aromatic plants. J Supply Chain Manag. 2023;19(1):34-41.
15. Kumar BR. Application of HPLC and ESI-MS techniques in the analysis of phenolic acids and flavonoids from green leafy vegetables (GLVs). J Pharm Anal. 2017;7(6):349-64.
16. Lange D. International trade in medicinal and aromatic plants. Med Aromat Plants. 2006;8(3):115-70.
17. Mariusz T. Innovative packaging improving food quality and extending its shelf life. Pol J Commodity Sci. 2019;58(1):15-20.
18. Matityahu I, Marciano P, Holland D, Ben-Arie R, Amir R. Differential effects of regular and controlled atmosphere storage on the quality of three cultivars of pomegranate (*Punica granatum* L.). Postharvest Biol Technol. 2015;115:132-41.
19. Meena MK, Chetti MB, Nawalagatti CM, Naik CM. Vacuum packaging technology: A novel approach for extending the storability and quality of agricultural produce. Adv Plants Agric Res. 2017;7(1):221-5.
20. Mushtaq T, Gangoo SA, Naseer AM, Mir AA, Wani MS. Raw drug trade record of medicinal and aromatic plants in foothills of north-western Himalayas. Asian J Agric Ext Econ Sociol. 2016;14(1):1-9.
21. Nurhaslina CR, Bacho SA, Mustapa AN. Review on drying methods for herbal plants. J Mater Today Proc. 2024;63(4):12-8.
22. Prashar D, Jha N, Jha S, Lee Y, Joshi GP. Blockchain-based traceability and visibility for agricultural products: A decentralized way of ensuring food safety in India. J Sustain. 2020;12(8):3497.
23. Rosa SR. Processing of fruits and vegetables for reducing postharvest losses and adding value. Asian Productivity Organization and FAO Report; 2006. p. 43-8.
24. Samani BH, Lorigooini Z, Zareiforoush H, Jafari S. Effect of ultrasound and infrared drying methods on quantitative and qualitative characteristics of *Satureja bachtiarica* essential oil. J Essent Oil Bear Plants. 2017;20(5):1196-1208.
25. Taj MP, Ajesh. IoT-based automatic medicinal herbs monitoring and controlling. Int J Eng Res Comput Sci Eng. 2011;8(11):2394-2320.
26. Tanko H, Carrier DJ, Duan L, Clausen E. Pre- and post-harvest processing of medicinal plants. Plant Genet Resour. 2005;3(2):16-56.