Advanced International Journal for Research (AIJFR)
E-ISSN: 3048-7641 ● Website: www.aijfr.com ● Email: editor@aijfr.com

Underutilized Forest Produce as a Source of Nutritional and Functional Components: Review on Current Status and Future Opportunities

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Abstract

Mahua (*Madhuca longifolia*) is important indigenous food resources of India that contribute significantly to rural nutrition, livelihood security, and traditional food systems. Mahua flowers are extensively utilized in tribal and forest regions for food, beverages, and medicinal preparations. Despite their nutritional and economic importance, both commodities are valued not only for their traditional culinary and medicinal applications but also for their rich nutritional composition, including carbohydrates, dietary fiber, essential micronutrients, and bioactive phytochemicals. However, their high perishable nature and seasonal availability major challenges to post-harvest management, limiting year-round availability and large-scale commercialization. Drying remains the most widely adopted preservation technique to enhance shelf life and ensure safe storage, though it may influence physicochemical characteristics, nutrient retention, and functional quality. Recent advances in processing technologies, including improved drying methods and value-added product development, for enhancing their utilization. This review critically examines the nutritional and functional properties of Mahua, with determine their processing behavior, quality changes during preservation, storage stability and highlights future prospects for commercialization and value addition to promote sustainable agriculture, nutrition security, and rural economic development.

Keywords: Madhuca longifolia, Drying, Nutrition, Value addition

1. Introduction

India possesses a rich diversity of underutilized food resources that support the nutritional and economic well-being of rural populations. Among these, Mahua is highly valued due to their nutritional value, medicinal properties, and cultural significance. Mahua (*Madhuca longifolia*) is a typical tree in the forest of Central India. The term Madhuca is derived from “Madhu” (Sanskrit word) which means honey. It is also known as Indian butter tree. These trees are the loveliest when they have flowers in full bloom between March and April and is endowed with the fruit that ripens between June and August. *Madhuca longifolia* belongs to family sapotaceae and finds origin in different regions of India, Sri Lanka, Myanmar and Nepal (Saluja, M. S., 2011). It is a multipurpose tree that meets the three basic requirements of tribal communities: food, fodder, and fuel (Patel, M., R. Pradhan, 2011). Mahua (*Madhuca longifolia*) is a multipurpose forest tree commonly found in central and tribal regions of India. It is a tree that is very nutritious and also be use as herbal remedy to cure a variety of disease. Its flowers are rich in fermentable

sugars and are traditionally used for preparing beverages, sweets, and medicinal products. Mahua has the hygroscopic property so it can easily absorb moisture during monsoon in case of traditional method. However, due to their high sugar content and moisture level, fresh flowers deteriorate rapidly after harvesting. Post-harvest spoilage resulting from improper handling and drying is considered one of the major constraints in Mahua utilization (Mishra, A., & Poonia, 2019).

Hence, the present review aims to provide an overview of recent advancements in the food and medicinal applications of mahua flowers and to discuss their future potential for value-added product development.

2. Area and Production

Mahua is a frost-tolerant species that thrives in marginal regions of dry tropical and subtropical forests, reaching altitudes of about 1200–1800 meters in India. It grows well under mean annual temperatures ranging from 2°C to 46°C, with average annual rainfall between 550 and 1500 mm and relative humidity levels of 40–90% (Thorat, S. S., & Patil, 2016).

In India, large quantities of mahua trees are found in the states of Uttar Pradesh, Madhya Pradesh, Orissa, Jharkhand, Chhattisgarh, Andhra Pradesh, Maharashtra, Bihar, West Bengal, Karnataka, Gujarat, Rajasthan and the evaluated annual production of mahua flowers is 45000 Million tonnes during the yield of mahua flowers varies from 80-320 kg for every tree (Siddiqui, B. S., Khan, S., & Nadeem Kardar, 2010).

3. Botanical Description and Distribution

Botanical profile of mahua (Banerji, R., & Mitra, 1996)
Botanical Name: Madhuca spp.
Family: Sapotaceae
Genus: Madhuca ;Species: longifolia
Common name : Mahua, Madkam, Mahuwa, Iluppai, Mowa
Edible part: Flowers, seeds & fruits
Distribution: Madhya Pradesh, Chhattisgarh, Jharkhand, Odisha, Maharashtra, and tribal regions of India (Ranjana, K., Amit, P., & Kumar, 2018).

4. Processing of Mahua

In processing operations like collection of material, drying, stamen removal, storage are carried out in this phase.

4.1 Collection

The fresh mahua flowers fall on the ground early in the morning and are picked up with hands by primary collectors. At times, a long bamboo stick with an anchoring arrangement is used to pluck the flowers from the tree by shaking the branches (Bakhara, 2016). A lot of time is spent on the collection of flowers because Mahua flowers are collected manually one by one from the ground (Ranjana, K., Amit, P., & Kumar, 2018).

4.2 Pre-processing

Pre-processing treatment of fresh mahua flowers comprising of washing, grading and blanching with preservatives can be performed.

4.3 Drying

Collected mahua flowers are spread in clean place evenly for 3-4 days in sunlight (40 to 43°C) for drying (Chandel, P. K., Prajapati, R. K., & Dhurwe, 2018). In some places modern drying technology is used for drying of sangri and mahua. Solar drying is an effective modern drying technique for mahua flowers. It reduces moisture to safe storage levels while maintaining quality, color, flavor, and nutritional value. Compared with traditional sun drying, solar dryers provide faster drying, better hygiene, reduced losses, and improved market value, making them highly suitable for rural and commercial processing operations (Bal, Jijnasha, Kumar, V. Kavan, Panwar, 2026).

4.4 Storage

The dried mahua flowers are packed in polyethylene and gunny bags and stored at safe places. Mahua flowers show hygroscopicity, i.e. tends to absorb moisture, especially during the rainy season as at that time moisture infiltrates from the earthen floors and roofs (Behera, S., Mohanty, R. C., & Ray, 2012).

Processed Mahua, pack them in suitable packaging material and market this product all over India. The community are making money by realizing the sale of dried mahua at excelling cost.

5. Nutritional and Medicinal Importance

Mahua flowers are high in sugars, which gives them a sweet flavor, and they may be used to produce traditional or modern alcoholic drinks. Flowers are also high in minerals such as calcium and phosphorus. Mahua flowers also contain a little number of proteins and lipids[18]. Major phytochemicals reported in mahua flowers are total sugars 45-78% (Patel, M., R. Pradhan, 2011) (reducing sugars 46-58% and non-reducing sugars 2-17%), crude protein(amino acids) 4-7%, crude fibre 1.5-2% (Jayasree, B., Harishankar, N., & Rukmini, 1998), Fats 0.5-1.5%, and Ash(minerals) 2.5-4.5% (Sinha, J., Singh, V., Singh, J., & Rai, 2017). Despite being a rich source of sugar, vitamins like A and C are also found in Mahua flowers. Various minerals like Ca, P, Fe and K are also found in the flowers (Patel, M., R. Pradhan, 2011). Madhuca flowers are used to treat the symptoms of chronic bronchitis. Coughs can also be relieved with flowers. Mahua flowers have a long history of being used to prevent and treat a range of illnesses (Dwivedi, A., Priyadarshini, A., & Induar, 2022).

6. General Uses

The mahua tree is found in many parts of India, it is not used as a food source. In various regions of India, the mahua flower plays a significant role in tribal life. Every part of this versatile tree species posses some medicinal properties, either in small of large proportion. Different parts of tree often contain a quit different active ingredients. The most useful parts of mahua consist of flowers, seeds, leaves etc. It is observed that only a small quantity of flowers is consumed raw, cooked or fried in different parts of country (Asish Bhaumik, A. B., Kumar, M. U., Khan, K. A., & Srinivas, 2014). Roasted Mahua flowers, boiled Mahua flowers, preparation of traditional liquor, pan cake and Mahua laddoo are some traditional preparations of Mahua flowers in tribal areas (Bakhara, 2016). Its leaves, flowers, and fruits serve as nutritious fodder for goats and sheep, while cattle are also fed with seed cake. When it comes to fermented products, flowers are also used as a raw material for the manufacturing of alcohol and alcoholic drinks. Locals in North-West India gathered and dried mahua flowers for the manufacturing of "mahua daaru," which contains 20-40 percent alcohol.Mahua blossoms are put in a dish with water and allowed to ferment for a few days. The wood is strong, durable, and heavy, making it suitable for construction purposes such

as house building, and door and window frames. Ecologically, mahua helps in soil conservation through its wide-spreading root system that reduces erosion and supports land stability. Its broad canopy provides shade and shelter for animals, and it is also useful in land reclamation, particularly in degraded or lateritic soils. The species contributes to soil fertility through nitrogen fixation and mycorrhizal associations, while its seed cake is used as an organic fertilizer. Additionally, mahua is planted as an ornamental avenue tree and along field boundaries as a natural barrier or support system. It is also suitable for intercropping with agricultural crops, making it an important component of sustainable farming systems (Dwivedi, A., Priyadarshini, A., & Induar, 2022).

7. Value Addition

Mahua flowers were utilized to develop a range of value-added food products, including dried flowers, ready-to-serve (RTS) beverages, squash, jam, jelly, fruit bars, candied flowers, glazed flowers, laddus, biscuits and cakes. Sensory evaluation revealed that these products were well accepted by consumers, indicating a high level of preference for the value-added foods prepared from mahua flowers (Dwivedi, A., Priyadarshini, A., & Induar, 2022).

Jam, jelly, marmalade, candy, cake, biscuits : Mature yet unripe fruits are utilized for preparing jam by incorporating citric acid. The fruit pulp can also be processed into marmalade or syrup, which is commonly used as a food additive in various food products. All of the Mahua goods created were judged to be very acceptable based on the findings of the hedonic test. A liquid sweetener developed using Mahua juice concentrate have been used for preparation of candy, biscuits and cakes (Sinha, J., Singh, V., Singh, J., & Rai, 2017). Mahua flower powder has been utilized as a natural sugar substitute in the production of gluten-free biscuits by blending it with a gluten-free composite flour made from soybean and ragi.

Sugar syrup : The syrup derived from the Mahua flower is used for a variety of purposes, including the production of chocolate and as a sweetening agent. Sugar syrup derived from dried mahua flowers is rich in various sugars, including sucrose, glucose, fructose, arabinose, and smaller amounts of maltose and rhamnose. Owing to its high sugar content, it can be used as a natural sweetening agent in a variety of food preparations such as halwa, kheer, and other traditional dishes (Benerji, D. S. N., 2010).

Fermented product : Dried mahua flowers contain a high concentration of sugars, making them a promising raw material for the production of fermented products. It has also been reported that fresh mahua flowers can be used to prepare mahua wine. The dry Mahua flowers have been used in production of alcohol, brandy, acetone, ethanol, lactic acid and various other fermented products (Malavade, D. M., & Jadhav, 2000). In industrial applications, mahua flowers can be processed using modern methods to produce distilled liquor, alcoholic spirits, vinegar, and other products typically derived from cane sugar, replacing traditional processing techniques (Dwivedi, A., Priyadarshini, A., & Induar, 2022).

Mahua flowers can also be mixed with organic waste materials to produce organic manure (Patel, M., & Naik, 2010). The flower extract of *M. longifolia* has been used for the one-step, eco-friendly synthesis of silver nanoparticles (AgNPs), which can be applied as antibacterial agents in therapeutic uses (Patil, Maheshkumar Prakash, 2018).

8. Conclusion and Future Prospects

Mahua (*Madhuca longifolia*) has been traditionally recognized as a valuable multipurpose tree owing to its nutritional, medicinal, and socioeconomic significance. Its flowers and fruits serve as important sources of essential nutrients, including carbohydrates, proteins, fats, vitamins, minerals, and

bioactive compounds with antioxidant properties. These natural antioxidants have attracted considerable scientific and consumer interest due to their potential role in reducing the risk of chronic diseases, particularly cardiovascular disorders. Despite its immense nutritional and therapeutic potential, the industrial utilization of mahua flowers remains largely confined to liquor production. The quality and market value of fresh mahua flowers are often compromised by inadequate post-harvest handling, traditional preservation practices, and inefficient supply chain management. Such limitations contribute to spoilage, quality deterioration, and underutilization of this valuable natural resource. Strengthening and optimizing the supply chain from collection to processing, along with the adoption of improved processing and preservation technologies, is essential to maintain product quality and expand its applications in the food industry. Furthermore, systematic documentation, conservation, and scientific utilization of mahua are necessary to preserve its biodiversity and enhance its role as a source of food, medicine, and livelihood, particularly for tribal and economically disadvantaged communities. The development of innovative value-added products, year-round availability through appropriate preservation techniques, and effective commercialization strategies can significantly enhance the economic potential of mahua. Such initiatives would not only improve income opportunities for rural and tribal populations but also contribute to nutrition security, sustainable resource utilization, and overall rural development.

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