



Calamondin: An Underexploited and Potential Citrus Fruit Crop of India

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Abstract

Calamondin, a lesser-known citrus fruit, is garnering attention due to its potential as a versatile and commercially valuable crop. Historically relegated to ornamental use or rootstock, recent recognition has been spurred by its aromatic and flavorful attributes, coupled with its nutritional benefits. Emerging as an appealing choice for health-conscious consumers, Calamondin offers an economical substitute for limes. Its resilience against pests and diseases, coupled with year-round fruiting and adaptability as an intercrop, further enhances its commercial viability. Particularly advantageous for small-scale farmers, its cost-effective cultivation holds the potential to stimulate local economies through processed products like juice and essential oil, enhancing employment and income avenues. This newfound attention to Calamondin underscores its promise as a catalyst for agricultural diversification and economic growth.

Keywords: Citrus, Fruit, Ornamental, Underutilised crop

Introduction

Calamondin (*Citrus x macrocarpa* Syn. *Citrofortunella macrocarpa*, *Citrus madurensis*) also referred to as Calamansi, Chinese Orange, Philippine lime and Hazara (in India) has its origins traced back to China. It's a natural hybrid resulting from the cross between a sour mandarin, *Citrus reticulata* var. *austera* and the kumquat, *Citrus japonica* Thunb. 'Nagami'. This distinctive fruit made its way to Indonesia and the Philippines long ago, gaining popularity due to its resistance to pests and diseases. Consequently, it became a vital source of citrus juice, serving as an alternative to lime. This quality positioned it as a significant economic asset, being exported to various countries including the United States, Japan, South Korea, Canada and Hong Kong. Today, Calamondin is extensively cultivated across southern and South-eastern Asian nations. However, it's worth noting that the Philippines holds the primary role as a major Calamondin producer. Within the Philippines, it ranks as the fourth most cultivated fruit crop, trailing behind banana, mango and pineapple. The country exports a substantial annual volume of Calamondin juice, ranging

between 160,000 and 190,000 metric tons, still not meeting the robust global demand. Beyond its native regions, Calamondin has found its way to places like India, Europe and America. It has been introduced as an ornamental plant for gardens, potted plants and container gardens on terraces, prized for its aesthetic value.

Botany

Calamondin is a tropical plant widely distributed across various tropical countries (Figure 1). It can be propagated through both sexual by seeds and asexual by cuttings, layering, budding and/or grafting methods. It assumes a medium-sized shrub form, growing to heights of 1.5-3.0 m. Its branches are densely clustered, that takes on a tree-like shape. Remarkably, Calamondin undergoes continuous flowering and fruiting throughout the entire year. Singular white flowers emerge in small clusters along the auxiliary branches and ends, emitting a potent fragrance. This characteristic makes Calamondin a favored choice for ornamental landscaping and potted decoration, as it steadily produces fruit across the seasons. Unlike other citrus fruits, Calamondin's fruit matures gradually, lengthening

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Figure 1: Calamondin plant with (a) new flush, (b) flower, (c) plant full of fruits, (d & e) mature and ripe fruit, and (f) juicy segments

its ornamental appeal within the landscape. The fruit itself is round, about 1.5 to 3 cm in diameter and features a thin green fragrant skin. Divided into 7 to 10 segments, the fruit contains 1 to 7 seeds. As it ripens, the fruit transforms into a vivid orange color, tinged with light green and becomes brimming with juice. The fresh Calamondin fruit contains 47.5 g of juice and 52.5 g of byproducts resulting from the juicing process, including the peel, seeds and pulp (Mapalo and Rosillo-Magno, 2018).

Agroecology

Calamondin is well-suited to warm climates, showcasing a remarkable cold tolerance while remaining sensitive to frost. Its resilience in cold conditions is comparable to that of the Satsuma orange, allowing it to be cultivated across tropical and subtropical areas of India. Ideally, regions with consistently distributed rainfall ranging from 1,500 to 2,000 mm year⁻¹ provide optimal conditions. Moreover, it displays adaptability to locales with extended dry spells, given the availability of irrigation. Predominantly cultivated in lowland areas, Calamondin exhibits versatility in its soil preferences. It can thrive in a diverse range of soil types, including clay-loams, calcareous soils and sandy soils. Optimal growth is

achieved in well-draining soils, particularly sandy loams or clay loams that are enriched with organic matter and maintain a pH level between 5.5 and 7. Notably, the plant demonstrates a moderate capacity to withstand drought conditions, although it proves vulnerable to strong winds.

Uses

The flesh of the fruit is incredibly juicy, striking a balance between sweetness and sourness. It comes in vibrant shades of yellow to orange and carries a distinct, delightful aroma. The juice offers a blend of a mandarin's sweet aroma, zesty lime flavor, a subtle peel-like essence of orange and a touch of tangy astringency. Commonly used as a seasoning in culinary dishes, Calamondin serves as a versatile flavor enhancer. While it can be consumed fresh, it's more commonly transformed into juice, beverages, or dried products, adding a flavorful touch to preserves, pickles and various dishes. Calamondin finds its way into marmalades, chutneys and herbal teas and it's particularly popular in Hawaii, where Calamondin-papaya marmalade is a local favorite. Its tangy juice is processed into both bottled concentrate and juice, prized for its acidic attributes in creating beverages. Furthermore, the juice is concentrated

into syrup for various culinary applications, often replacing lime or lemon juice in recipes for salads, desserts and custard pies adding a tangy flair. Beyond its culinary uses, Calamondin's leaves yield a distilled oil with carminative properties that surpass those of peppermint oil. The fruit extract boasts antioxidant qualities and acts as a skin-whitening agent, making it a sought-after ingredient for cosmetic and cosmeceutical products. From an agronomic perspective, Calamondin also finds its purpose as a dwarfing rootstock for lemon, kumquats and other citrus species (Kawai *et al.*, 2018).

Nutritive and Medicinal Properties

The 100 g of the edible fruit portion contains 93.6 g of water, protein (0.4 g), fat (0.3 g), carbohydrates (5.1 g), dietary fiber (0.1 g), potassium (79 mg), carotene (470 mg), vitamin A (78 µg) and niacin (0.2 mg). Notably, the juice of Calamondin fruit provides an economical source of vitamin C (41.6 mg). The whole Calamondin fruit has displayed a range of biological and pharmacological attributes, including antioxidant effects, as well as antimicrobial, anti-inflammatory, anti-hyperglycemic, anti-diabetic, anti-angiogenic and anti-tumor properties, with the peel being particularly noteworthy in this regard. Calamondin fruit offers a wealth of vitamins C, aromatic oils, carotenoids and other natural compounds that offer a multitude of health advantages. These benefits encompass positive impacts on human vision, efficacy in treating coughs, asthma, high blood pressure and prevention of arteriosclerosis, among others. Historically, the fruit has been employed for treating coughs, alleviating skin irritations and even serving as a mild laxative. Additionally, it has skin-clarifying properties, aiding in the fading of freckles and contributing to the resolution of conditions such as *acne vulgaris* and *pruritus vulvae*. Fruit juice is recognized for its cooling effects (attributed to its rich vitamin C content) and is ingested as a remedy for coughs and as an antiphlogistic (Venkatachalam *et al.*, 2023).

Commercially Processed Products

- **Juice and Juice Concentrate:** Calamondin fruit possesses a TSS content of 9.0 °Brix, pH levels ranging from 2.40 to 3.00 and citric acid between 4.50% and 5.80%.
- **Pectin:** A polysaccharide found in the peel and pulp of Calamondin fruits. Notably, the highest pectin yield from Calamondin, achieved through ethanol extraction, was 45.7%. This suggests that Calamondin pectin has the potential to replace gelatin in various industries, such as food, cosmetics and pharmaceuticals.
- **Tea:** Calamondin fruit serves as a common raw material for crafting a variety of fruit teas and desserts. The process involves steeping slices or peels of the fruit in boiling water. Particularly in Taiwan, Calamondin fruit tea is enjoyed during the winter months for its comforting aroma and distinctive flavor.
- **Fruit Powder:** Featuring its distinctive sour taste and a high citric acid content, Calamondin fruit powder is frequently employed as a flavoring agent in a diverse range of food and beverage items.

- **Candy and Marmalade:** Calamondin fruit candy is characterized by its vibrant yellow color, citrus fragrance and flavor and firm texture.

- **Essential Oil:** The essential oil is derived from the peel of mature green Calamondin fruits. This oil is in demand across food additives, fragrances, cosmetics and pharmaceutical applications. The oil yield can vary from 2% to 9%.

Indian Perspective

In India, Calamondin has been an unexploited and underutilised citrus fruit crop, often grown for ornamental or rootstock purposes. However, in recent times, there has emerged a potential opportunity for Calamondin to transition into a commercially viable crop due to the fruit's appealing aroma, flavor and nutritional value. Calamondin is versatile, meeting health-conscious consumers' needs and serving as a cost-effective lime substitute during short supply and expensive. It offers a higher juice yield compared to lime, making it commercially viable. With easy cultivation, year-round fruiting and disease and pest resistance, it fits well as an intercrop in orchards and plantations. Calamondin's low-cost cultivation suits smallholder farmers with limited space and processing its products like juice and essential oil can boost local economies through jobs and income. This potential for economic growth translates into stability and prosperity within farming communities.

Conclusion

Calamondin emerges as a promising citrus fruit crop with a multitude of uses and benefits. Its continuous flowering and fruiting, along with its versatility in cultivation and resilience to various conditions, make it a valuable asset in tropical and subtropical regions, particularly in India. With its rich nutritional profile and numerous medicinal properties, Calamondin offers both health and economic advantages, potentially transforming into a commercially viable crop. By harnessing its potential through cultivation, processing and marketing, India can leverage Calamondin to boost local economies, provide livelihood opportunities and contribute to agricultural sustainability and food security.

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