

DEPARTMENT OF AGRICULTURE DEVELOPMENT  
& FARMERS' WELFARE, GOVERNMENT OF KERALA



FARM INFORMATION BUREAU

# KERALA KARSHAKAN

THE FIRST ENGLISH FARM JOURNAL FROM  
THE HOUSE OF KERALA KARSHAKAN

APRIL 2026  
VOLUME 13 ISSUE 14

E-JOURNAL



## GI Tags Branding Tastes and Traditions

Where tradition, place, and quality come together  
to shape a resilient agricultural future.

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# GI Tags Branding Tastes and Traditions

Where tradition,  
place, and quality  
come together to  
shape a resilient  
agricultural future.





Agriculture is deeply rooted in place. The soil, climate, and knowledge passed through generations shape not just what we grow, but how we grow and value it. In recent years, Geographical Indication (GI) has emerged as a powerful way to recognise this connection. It gives identity to region-specific crops and protects the uniqueness that farmers have carefully preserved over time. In a country like India, where diversity is a strength, GI is not just about protection—it is about pride, ownership, and recognition.

For farmers, GI is also an opportunity. In an increasingly competitive market, identity adds value. When a product is known for its origin and quality, it creates trust among consumers and opens the door for better pricing and wider markets. Beyond economics, GI supports the continuation of traditional practices, strengthens local ecosystems, and promotes community-based farming systems.

Kerala offers a strong example of how diversity and tradition can work together. From unique rice systems to distinctive fruits and spices, the state's agriculture reflects a close relationship between nature and farming. At the same time, emerging challenges such as climate variability, crop health issues, and changing consumer demands highlight the need to combine traditional strengths with scientific innovation.

This issue is centred on Geographical Indication (GI) crops, and you can read more about their significance in the pages that follow. As we move forward, protecting identity must go hand in hand with improving quality, strengthening value chains, and ensuring that benefits reach farmers. When we value what is unique and support those who sustain it, agriculture becomes stronger, more resilient, and truly future-ready.

# Geographical Indications Protecting the Identity and Heritage of Regional Products



अतुल्य भारत की अमूल्य निधि  
Invaluable Treasures of Incredible India

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**A** Geographical Indication (GI) is a sign used on products that originate from a specific region and possess qualities, characteristics, or a reputation that are closely linked to that place of origin. According to the World Intellectual Property Organization, these qualities may arise from natural factors such as soil, climate, and raw materials, as well as human factors such as traditional skills, local expertise, and established quality standards. India's cultural and agricultural diversity is reflected in the wide range of products that come from different regions of the country. From

the aromatic Kashmir saffron of the Himalayan foothills to the intricate Kanchipuram silk and the fragrant Mysore sandalwood, many Indian products are closely tied to the regions where they are produced. These connections extend beyond geography, encompassing history, culture, and generations of traditional knowledge.

In countries like India, where agriculture and traditional crafts are deeply connected to regional environments and cultural practices, GIs have become increasingly important. India's diverse agro-climatic conditions allow the cultivation



of a wide range of unique crops, each associated with a particular region. Products such as Darjeeling tea, basmati rice, and Malabar pepper are well-known examples of how geographical conditions and traditional practices combine to create distinctive agricultural products. By granting legal recognition and protection, GI tags help safeguard these products from imitation and misuse, ensuring that the economic benefits reach the local farming communities and artisans who maintain these traditions.

### Development of the GI System in India

India's interest in protecting its traditional agricultural products gained urgency in the late 1990s. A notable incident occurred in 1997, when a US-based company, RiceTec, obtained a patent for certain lines of basmati rice and marketed them under names such as Texmati and Kasmati. This led to significant concern in India, as it threatened the

reputation and export potential of authentic basmati rice. The dispute prompted India to strengthen its legal framework, resulting in the enactment of the Geographical Indications of Goods (Registration and Protection) Act, 1999. The Act came into force on 15 September 2003, providing a dedicated sui generis system for the registration and protection of GI products in India.

Shortly after the Act was implemented, the Tea Board of India successfully registered Darjeeling tea as India's first GI product in 2004, setting an important precedent for other commodities.

Over the years, some states have been more active in registering their traditional products than others. Southern and western states have shown strong participation in the GI system, while several regions with rich biodiversity and cultural heritage still have relatively few registered products. This uneven

distribution suggests that awareness, institutional support, and administrative capacity play a significant role in determining how effectively regions benefit from the GI system.

### The Role of the Geographical Indications Registry

To administer the GI system, the Government of India established the Geographical Indications Registry under the Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry. Located in Chennai, this registry is responsible for processing applications, maintaining records, and ensuring the proper use of GI tags. Under the GI Act, the term "goods" includes agricultural products, natural products, manufactured goods, handicrafts, and food items, reflecting the broad scope of the system in protecting both traditional crafts and agricultural diversity.

# What is a GI Tag?



## The Process of GI Registration in India

The registration of a GI product follows a systematic procedure designed to ensure authenticity and transparency. The process begins with the filing of an application by a group of producers, an association, or a cooperative society representing the interests of the product's producers. The application is examined by experts to verify whether the product truly qualifies as a geographical indication. If objections are raised, the applicants are allowed to respond or present their case. Once the application is accepted, it is published in the official GI Journal to allow public opposition. If no valid opposition is received, the product is officially registered and a certificate is issued. A registered GI remains valid for 10 years and can be renewed

thereafter. Individual producers must also register themselves as authorised users to legally use the GI name on their products.

**GI registration covers five broad categories:** agricultural goods, handicrafts, manufactured goods, food products, and natural goods. Among these, handicrafts account for a large share of registered products, reflecting India's rich tradition of handloom and craft-based industries. Agricultural products also form an important segment, including fruits, spices, rice varieties, plantation crops, and vegetables. This wide coverage shows that GI protection is not limited to a single sector but acts as a bridge between culture, agriculture, and industry.

## Introduction of the Indian GI Logo

In order to improve public

awareness and promote GI-tagged products, the Government of India introduced a unified GI logo and the tagline "Invaluable Treasures of Incredible India" on 1 August 2018. The logo serves as a visual symbol that helps consumers easily identify genuine Indian GI products in the market.

## Current Global Status of Geographical Indications

Geographical Indications have become a widely recognised form of intellectual property protection across the world. A significant share of GI goods (94 %) belongs to the categories of wines, spirits, and agricultural products, highlighting the importance of GIs in food and agricultural trade. Europe continues to dominate in terms of the number of registered GIs, while China tops in country-wise status with nearly ten thousand

GIs. India's rank is 51 in the global country list.

## Status of GI Registration in India

India has made steady progress in expanding its GI portfolio. By July 2024, the country had registered 643 GI products, covering categories such as handicrafts, agricultural goods, manufactured products, and foodstuffs. Among these, handicrafts accounted for the largest share, while agricultural products constituted around one-third of the total registrations. States such as Uttar Pradesh, Tamil Nadu, Maharashtra, Karnataka, and Kerala have been particularly active in registering their regional products. This regional distribution highlights both the diversity of India's cultural heritage and the varying levels

sustainable agriculture and the conservation of local genetic resources. For rural communities, GI recognition can open doors to better market opportunities. It allows producers to differentiate their products from ordinary goods, often enabling them to command premium prices and improve their livelihood security. At the same time, GI protection ensures that producers receive recognition for their traditional skills while preserving local heritage.

From a consumer's perspective, a GI tag guarantees authenticity and quality by certifying that a product originates from a specific region and possesses the characteristics associated with that location. This transparency builds trust in the market, helps consumers make informed purchasing decisions,

producers register themselves as authorised users, which reduces the overall impact of GI protection on rural livelihoods. Another challenge is the time and effort required to complete the registration process, which can discourage smaller producer groups from applying. Documentation, verification, and legal formalities can be particularly difficult for farmers and artisans who may not have access to technical or legal assistance.

## Conclusion

Geographical Indications represent an important intersection of intellectual property rights, cultural heritage, and rural development. After more than two decades of implementation, the GI system in India has achieved

India has made steady progress in expanding its GI portfolio. By July 2024, the country had registered 643 GI products, covering categories such as handicrafts, agricultural goods, manufactured products, and foodstuffs.

of awareness and institutional support across states.

## Importance of Geographical Indications in the Agricultural Sector

Geographical Indications play a vital role in protecting traditional agricultural practices and promoting biodiversity. GI protection helps prevent imitation and misuse of well-known product names in the market. Many GI crops are cultivated using indigenous techniques that are well adapted to local environmental conditions. By encouraging farmers to continue these practices, GIs contribute to

and enhances global awareness of traditional foods, crafts, and agricultural products. As a result, GI products can also promote tourism, strengthen rural economies, and contribute to India's cultural and economic development.

## Challenges in the Current System

Despite its advantages, the GI system in India faces several challenges. One of the major issues is the lack of awareness among producers about the benefits and procedures involved in GI registration. In many cases, even after a product receives a GI tag, only a limited number of

notable success in identifying and protecting many unique products. However, there is still considerable untapped potential, as many traditional products—especially from remote and tribal regions—remain outside the GI framework. Strengthening awareness programmes, simplifying registration procedures, and promoting GI products through effective branding and marketing can help India fully realise the benefits of this system. With growing consumer interest in authentic and region-specific goods, Geographical Indications are likely to become even more important in the years ahead. ■



# GI Registration Process in India

## An Overview

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**H**ave you ever thought about why certain products feel inseparable from the places they come from? Recently, we have seen heated discussions globally about instances where traditional Indian products like Kolhapuri chappals, or even something as simple as a dupatta, reappearing as a “Scandinavian scarf,” have been presented on international platforms without meaningful cultural acknowledgement. Such debates are not entirely new, nor are they limited to the fashion industry. They reflect a broader concern about the thin line between cultural appreciation and appropriation.

In India, many unique products are closely tied to their regions, shaped by local climate, soil, and traditional knowledge, holding economic and cultural value. To protect and promote them, the Geographical Indications of Goods (Registration and Protection) Act, 1999, was enacted to preserve heritage, prevent imitation, and boost market recognition and exports. The GI Registry in Chennai, under DPIIT, Ministry of Commerce and Industry, implements the Act. By mid-2025, over 600 products—including agricultural goods, food items, handicrafts, and natural products—have been registered as GIs.

## Understanding the GI Registration Journey

Since the foundation of Geographical Indications lies in the registration process, understanding it is essential for securing proper recognition and legal protection for region-specific products. The GI registration in India follows a structured ten-step procedure as outlined on the official IP India website. The GI Register is maintained in two parts. Part A contains details of registered Geographical Indications, while Part B includes information on authorised users. The procedure for both is broadly similar and is explained below.

### Step 1: Filing of Application

The process begins by verifying if the product qualifies as a GI under Section 2(1)(e), showing a clear link between its quality, reputation, or characteristics and its geographical origin. Only an association, group of producers, or organisation representing them can apply, supported by an affidavit confirming genuine representation. The application, prepared in triplicate, must include a detailed description of the product, its unique features, quality maintenance, geographical map, producer

India has made steady progress in expanding its GI portfolio. By July 2024, the country had registered 643 GI products, covering categories such as handicrafts, agricultural goods, manufactured products, and foodstuffs.

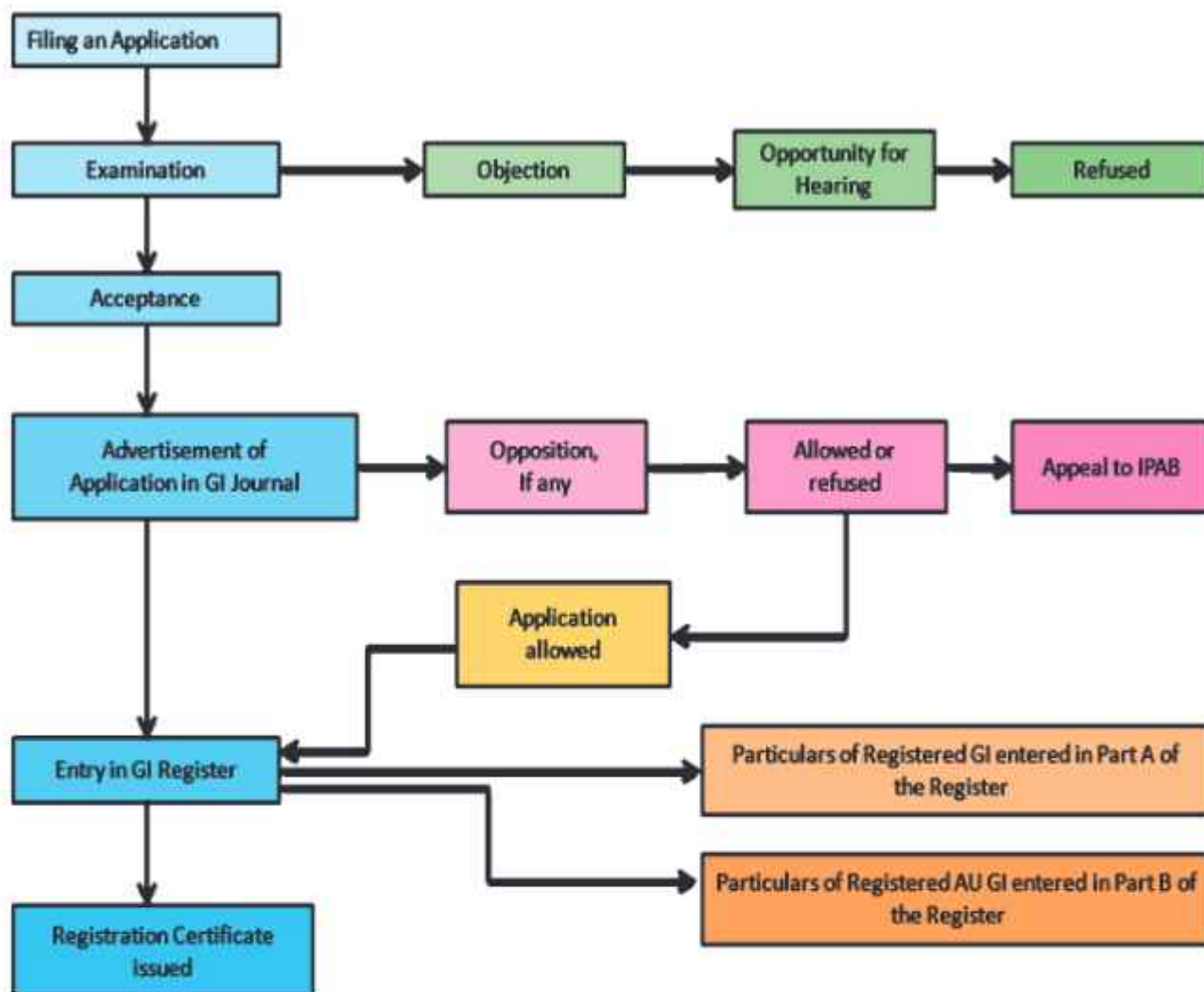


Figure 1: G.I. Registration Process - flow chart

details, and any regulatory or inspection system for quality control. It is submitted to the GI Registry in Chennai, usually via a legal practitioner or registered agent, with an address for service in India.

### Address for submission

Geographical Indications Registry, Intellectual Property Office Building, Industrial Estate, G.S.T Road, Guindy, Chennai – 600 032, Phone: 044 – 22502091-93 & 98, Fax: 044 – 22502090, E-mail: gir-ipo@nic.in, Website: ipindia.gov.in

### Step 2 and Step 3: Preliminary Scrutiny and Examination

Once submitted, the application is first checked for errors or missing information. If issues are found, the applicant must correct them within a month. Then, experts review the application to ensure the product meets Geographical Indication requirements, after which an Examination Report is issued.

### Step 4: Show Cause Notice

If the Registrar has objections, a

show-cause notice is issued. The applicant must respond within two months or request a hearing. After reviewing, the Registrar decides. Rejected applications can be appealed within a month, and the Registrar may withdraw a mistakenly accepted application after hearing the applicant.

### Step 5: Publication in the GI Journal

If accepted, the application is published in the GI Journal within three months, serving as public notice and allowing objections, ensuring transparency.



### Step 6: Opposition to Registration

After publication, anyone can oppose registration within three months (extendable by one month). The Registrar forwards the notice to the applicant, who must respond within two months. Both parties can submit evidence, followed by a hearing, after which a decision is made.

### Step 7: Registration

If there's no opposition, or if the applicant overcomes it, the GI is registered. The Registrar records it, issues a certificate with the official seal, and the registration date is the same as the application filing date.

### Step 8: Renewal

A registered GI is valid for a period of ten years. After this period, it must be renewed by paying the prescribed fee. This ensures that the registration remains active and continues to be legally protected.

### Step 9: Additional Protection to Notified Goods

The Act provides additional protection to certain notified goods, especially those with high commercial importance or vulnerability to misuse. This additional protection offers a higher level of legal safeguard against unauthorised use.

### Step 10: Appeal

If any person is dissatisfied with a decision made during the process, they can file an appeal within three months. The appeal is made to the Intellectual Property Appellate Board (IPAB), which reviews the case and gives a final decision.

Foreign applicants file GI registration using Form GI-1C/D, with proof of protection in their home country and an address for service in India. Unlike Indian applicants (Form GI-1A/B), they must claim reciprocity and prior registration, while the rest of the

process is the same.

The process of GI registration may seem detailed and technical, but it plays a crucial role in ensuring that products truly belonging to a place receive the recognition and protection they deserve. At a time when traditional products are increasingly being imitated, rebranded, or detached from their origins, understanding this process becomes even more important. It is not just about obtaining a tag, but about preserving identity, safeguarding livelihoods, and ensuring that the value of these products remains with the communities that create them. A stronger awareness and use of the GI registration system can go a long way in protecting India's rich and diverse heritage.

### Reference

Government of India, Department for Promotion of Industry and Internal Trade. (n.d.). Intellectual Property India. Available at: <https://ipindia.gov.in> ■

NAVARA RICE

# Kerala's GI Crops Where Tradition Meets Value and Sustainability

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**K**erala's agriculture has always reflected a close harmony between nature and human ingenuity. From coastal saline fields to high-altitude spice gardens, each agro-ecosystem has nurtured crops with distinct qualities. In recent years, this uniqueness has gained formal recognition through Geographical Indication (GI) tagging, transforming traditional crops into identity-based

products with economic potential.

With the recent inclusion of Thalnadan clove, Kerala now has 25 agricultural GI products. This is not merely a statistical achievement, but an indication of the state's rich agro-biodiversity and the success of efforts to protect region-specific crops. What makes Kerala unique is not just the number of GI products but also the diversity they

represent spanning rice, fruits, spices, plantation crops, and traditional specialities.

A significant share of these GI products belongs to traditional rice systems. Varieties such as Pokkali, Navara, Jeerakasala and Gandhakasala illustrate how crops evolve in response to local ecological conditions. Pokkali rice, for instance, thrives in saline coastal fields and is internationally recognised for

## Agricultural GI Products of Kerala (Year-wise)

Year	GI Product	Area of Production	Key Uniqueness
2007	Navara Rice	Across Kerala	Medicinal rice used in Ayurveda
2007	Palakkadan Matta Rice	Palakkad	Red rice, rich taste
2008	Malabar Pepper	Western Ghats	Strong aroma, global spice
2008	Alleppey Green Cardamom	Western Ghats	Sweet aroma
2008	Monsooned Malabar Arabica Coffee	Malabar coast	Specialised curing(monsooning) pale-yellow beans
2008	Monsooned Malabar Robusta Coffee	Malabar coast	Good body, mild acidity, sweeter and mellow taste
2008	Pokkali Rice	Coastal Kerala	Salt-tolerant
2009	Vazhakkulam Pineapple	Central Kerala	Sweet, aromatic
2010	Jeerakasala Rice	Wayanad	Aromatic
2010	Gandhakasala Rice	Wayanad	Fragrant
2010	Central Travancore Jaggery	Pathanamthitta, Kottayam, Alapuzha	Chemical-free
2014	Kaipad Rice	North Kerala	Saline farming system
2015	Chengalikodan Banana	Thrissur	Cultural importance
2017	Nilambur Teak	Malappuram	Durable timber
2019	Marayoor Jaggery	Idukki	Non-salty sweetness
2019	Tirur Betel Leaf	Malappuram	High pungency
2019	Wayanad Robusta Coffee	Wayanad	Chocolaty flavour
2021	Kuttiattoor Mango	Kannur	Early flowering, fruiting and appealing flesh colour
2021	Edayur Chilli	Malappuram	Low pungency
2022	Aattukombu Avara	Attappady	Unique shape, high phenolic content, pest and disease resistance
2022	Attappady Thuvara	Palakkad	Tribal pulse, less phenol and tannin content
2022	Vattavada Garlic	Idukki	High pungency
2022	Onattukara Ellu	Alappuzha	High antioxidants
2022	Kodungallur Pottuvellari	Thrissur	Fruit splitting, pleasant aroma
2025	Thalanadan Clove	Kottayam	High eugenol, spicier

its resilience. Navara rice, on the other hand, is valued for its medicinal applications in Ayurveda. Aromatic rice varieties from Wayanad continue to command premium demand due to their fragrance and culinary quality.

Horticultural crops add another layer of diversity. Vazhakkulam pineapple, Kuttiattoor mango and Chengalikodan Nendran banana are distinguished by



*PALAKKADAN MATTA RICE*



MALABAR PEPPER



VAZHAKKULAM PINEAPPLE



their taste, appearance and cultural relevance. These crops are deeply embedded in local traditions—whether as festive foods or temple offerings—and their unique characteristics are closely linked to soil, climate and farming practices.

Kerala's plantation crops further strengthen its GI profile at the global level. Malabar pepper, Alleppey green cardamom and Monsooned Malabar coffee are internationally known for their flavour and quality. The distinctive processing method of monsooned coffee along the Malabar coast is a striking example of how geography and human skill combine to create a

product with global appeal.

Alongside these, several GI products represent localized farming systems and community knowledge. Katpad rice cultivated in coastal wetlands, Marayoor jaggery produced using traditional methods, and Kodungallur pottuvellari known for its unique fruit characteristics highlight the strong link between agriculture and ecosystem-specific practices. These crops are not just commodities but carriers of cultural identity.

Scientifically, the uniqueness of GI products arises from the interaction of genetic traits, environmental factors and human

practices. Soil composition, rainfall, temperature and altitude influence crop characteristics, while traditional cultivation and processing methods enhance quality. Many GI products also exhibit superior nutritional or medicinal properties, making them increasingly relevant in modern markets.

The evolution of GI registration in Kerala shows a gradual but steady expansion—from early recognition of traditional rice and spices to a broader inclusion of horticultural and tribal crops in recent years. This transition reflects growing awareness and institutional support for protecting agricultural heritage. ■

# Thalanadan Clove enriching Kerala's growing GI legacy

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Kerala has long been celebrated as the land of spices. From the fragrant Malabar Pepper that once attracted global traders to the rich aroma of Alleppey Green Cardamom grown in its misty highlands, the state has built a strong reputation for quality spices. Continuing this legacy, Thalanadan Grambu (clove) has recently joined Kerala's prestigious list of Geographical Indication (GI) products, adding a new dimension to its spice heritage.

With 22 registered agricultural GIs, Kerala remains a leading state alongside Maharashtra and Karnataka. The distinct quality traits observed in GI tagged spices such as Edayur Chilli and Kanthalloor Vattavada Garlic highlight the influence of localized environmental factors and genetic variability, which is further strengthened by the



inclusion of Thalanadan Grambu. Renowned for its superior flavour, pungency, high essential oil content, and medicinal value, it holds significant importance in culinary as well as health-related applications.

The GI recognition, secured through the efforts of the Thalanadan Clove Growers & Processing Industrial Co-operative Society Ltd. with support from Kerala Agricultural University and the Department of Agriculture and Farmers' Welfare Kerala, not only ensures product authenticity and protection but also enhances its market potential and farmer livelihoods.

## Botany and Regional Importance of Thalanadan Grambu

Clove (*Syzygium aromaticum*) is the dried aromatic flower bud of an evergreen tree, valued for



*Clove Tree in Thalnad*

its strong pungent aroma due to essential oils, especially eugenol, which makes it important in food, medicine, and industrial applications. In India, clove cultivation is well established, particularly in Kerala where it is known as “Grambu” or “Karayampoo,” with a major cultivation belt in the Erattupetta Block Panchayat of Kottayam district. The locally adapted type, Thalnad Grambu, is renowned for its superior flavour, pungency, colour, and medicinal value, contributing to its premium market status and GI recognition.

Clove was introduced to India in the early 19th century by the East India Company through experimental gardens at Courtallam, and later spread

to the Nilgiris and Western Ghats regions of Tamil Nadu, Kerala, and Karnataka. In Kerala, Thalnad Grambu cultivation began about a century ago in Thalnad through the efforts of the Madappat family and gradually expanded to nearby areas, becoming a well-established traditional practice. It is presently cultivated in highland regions such as Erattupetta, Thalnad, Teekoy, Melukavu, Poonjar, Thalappalam, Thidanad, and Munnilavu, covering about 113.9 ha in the Meenachil river basin. The unique agro-climatic conditions of this region—cool climate, high rainfall, frequent fog, elevated humidity, and forest-based soils—play a crucial role in enhancing clove quality by reducing essential oil loss during bud development. These

environmental factors result in cloves with superior aroma, distinct flavour, larger size, and attractive colour, which collectively define the uniqueness and high market demand of Thalnad Grambu.

### **Unique Quality Traits Supporting GI Recognition**

Thalnad Grambu is distinguished by its superior flavour, pungency, colour, and medicinal value compared to cloves from other regions, which contributes to its premium market demand. The crop exhibits a defined phenology, with bud initiation during June–July and peak harvesting in December–January, when the region is characterized by a distinct clove aroma.

The buds of Thalnad Grambu are notably larger and more uniform, showing a characteristic colour transition from pale green to pink at maturity and developing a golden-brown hue upon drying. A key distinguishing feature is their bold size, with only about 8–10 buds per gram, indicating that the buds are longer, thicker, and heavier than those from other regions. This superior bud size and weight not only enhance visual appeal but also reflect better quality and higher yield potential (10–15 kg per tree). Its quality is further defined by a rich composition of essential oil constituents such as eugenol, acetyl eugenol, and caryophyllene, which impart a strong aroma and pungency. Elevated levels of polyphenols and crude fibre also contribute to its enhanced quality profile.

### **Cultivation Practices and Economics of Thalnad Grambu**

Cultivation of Thalnad Grambu is largely based on traditional knowledge combined



Harvested Buds (i): Before Drying, (ii): After Drying

with the favourable agro climatic conditions of the high ranges of Kerala. Clove is propagated through seeds collected during May to June from healthy, regularly bearing trees. Seeds are raised in shaded nursery beds rich in organic matter, and seedlings are typically transplanted after about one year, as practiced in the Thalnad region.

Clove trees begin bearing from 4 to 5 years, with economic yields from 7 to 8 years onwards, and higher productivity observed in mature trees. Bud initiation

occurs during June to July, and harvesting is carried out during December to January. Harvesting is done manually at the correct stage, just before bud opening, to ensure quality. On average, 4 kg of fresh harvested material comprises about 3 kg of flower buds and 1 kg of stems, yielding nearly 1 kg of dried buds and about 300 g of dried stems.

Post harvest processing involves separating buds from clusters and drying them immediately. If the buds are left in heaps for long, fermentation may

occur, resulting in inferior, whitish shriveled cloves known as "Khoker clove." Proper sun drying ensures the development of the characteristic golden brown colour and helps retain aroma and quality.

From an economic perspective, Thalnad clove commands a premium price due to its superior quality. The dried buds are marketed through local centres such as Thalnad and Erattupetta, as well as larger markets like Ernakulam. The average price of dried clove buds ranges from ₹500 to ₹2000 per kg, while clove stems fetch around ₹50 to ₹100 per kg, depending on quality and market conditions. Despite occasional price fluctuations, this crop remains highly remunerative, contributing significantly to farmers' income.

### Conclusion

The Thalnad Clove Growers & Processing Industrial Co-operative Society Ltd. plays a key role in ensuring the quality and authenticity of Thalnad Grambu through grading, labeling, and detailed product specifications, supported by institutions such as Kerala Agricultural University and the Department of Agriculture. The GI tag has improved market prospects by enabling premium pricing, protecting against imitation, and preserving traditional cultivation practices, thereby strengthening farmer livelihoods and consumer trust.

However, challenges such as the need for better branding, consistent quality assurance, and climate change impacts remain. Addressing these issues through coordinated efforts among farmers, researchers, and policymakers will be crucial to sustain the quality, productivity, and global recognition of this unique spice. ■

# A fruit that bursts open with heritage and identity The story of G.I. tagged Kodungallur snap melon in Kerala

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In the coastal plains of central Kerala, particularly in Kodungallur and the surrounding areas of Thrissur and Ernakulam districts, a traditional summer crop marks the intensifying season.

Locally known as pottuvellari, farmers cultivate in paddy fields low lands and as intercrop in coconut gardens due to short duration. It thrives in alluvial soils derived from recent marine deposits, whose sandy texture



provides ideal conditions for growth. Popularly recognised as the Kodungallur snap melon (*Cucumis melo* var. *momordica*), this lesser-known yet valued produce occupies a distinctive place in Kerala's agrarian landscape. Local communities value it as a refreshing and hydrating summer fruit, consuming it to reduce body heat during peak temperatures. Its mild sweetness and delicate aroma sustain high demand in local markets and roadside stalls, where it is commonly sold at ₹50–60 per kilogram of fruit. People purchase the whole fruit and allow it to split naturally at home rather than cut it with a knife, believing this enhances flavour and indicates proper maturity and freshness. Modest in appearance, it embodies cultural legacy, ecological uniqueness, nutritional relevance, and farmer livelihood. More over potuvellari has a historical significance in ensuring the nutritional security of a region.

**Keywords:** Authorised users, Farmers' livelihood, Nutritional security, Summer crop

### Geographical Indication status crowns Kodungallur snap melon

The Pottuvellari Ulppadaka Sangham, Alangad, a farmers' cooperative society, applied for the Geographical Indication (G.I.) registration of Pottuvellari in India under Class 31 (Agricultural goods). The Pottuvellari Ulppadaka Sangham, Alangad, a farmers' cooperative society, applied for the Geographical Indication (G.I.) registration of Pottuvellari in India. The application process was facilitated by the Centre for Intellectual Property Rights, Technology Management and Trade, Kerala Agricultural University (KAU), which guided the society in preparing and

submitting the necessary documentation for official recognition. The granting of G.I. status (2022) marked a significant milestone for Kodungallur snap melon. The recognition officially acknowledges the intrinsic connection between the fruit's quality and the unique coastal alluvial soils and humid climate stretching from Kodungallur to Aluva. GI protection prevents the misuse of the name, ensures authenticity, and restricts the marketing of products produced outside the designated geographical area under the same identity. For small and marginal farmers cultivating the crop, the G.I. tag offers potential opportunities for premium branding and improved



market positioning; however, these benefits remain largely underutilised due to limited consumer awareness low outside the traditional scale area and low registration among producers as authorised users. With greater participation and effective implementation, the G.I. status could enhance price realisation and strengthen market identity. Beyond economic prospects, it underscores the importance of conserving native varieties adapted to local ecological conditions, symbolising regional pride, biodiversity conservation, and the potential to improve both farmer income and

nutritional security of the people of the region.

### A fruit of faith and folklore

The crop is deeply embedded in the cultural and spiritual life of Kodungallur. Local belief connects its origin to the presiding deity of the Kodungallur Sree Kurumba Bhagavathy Temple. According to folklore, the Goddess scattered turmeric, paddy, and pepper upon the land, from which pottuvellari plants emerged. It is the gift of Goddess to the people in summer to quench thirst and give them strength during the festival season. This sacred narrative has strengthened the emotional attachment of the local people and farming community to the crop, and cultivating it is viewed not merely as a profession but as a continuation of tradition. Its cultural significance further intensifies through its association with the annual Bharami festival at the Bhagavathy Temple in Kodungallur. Celebrated during the Malayalam month of Meenam (March–April), the festival attracts thousands of devotees from across Kerala and coincides with the peak harvesting period, symbolically linking the agricultural cycle with local spiritual traditions. During the festival, producers serve snap melon juice free of cost to devotees as an expression of faith and devotion. In an era dominated by commercial hybrids, such enduring associations contribute to sustaining indigenous varieties and conserving agro-biodiversity.

### More than a fruit: The unique characters of Kodungallur snap melon

Unlike the firm, orange-fleshed melons commonly available in other parts of India, Kodungallur snap melon is distinct in its appearance, texture, aroma, and

taste. The fruits are cylindrical and long, measuring 30-45 cm in length and 32-43 cm in girth. The flesh is soft, spongy, and mildly sweet, with numerous small seeds. Average fruit weight ranges from 1.5 to 3.0 kg, occasionally reaching 5 kg, and the average yield is 14-16 t/ha. Unlike firm, orange-fleshed melons found in other states, Kodungallur snap melon has spongy, creamy white flesh. At the tender stage, the immature fruits are sometimes used as a vegetable in local cuisine. From a nutritional perspective, the fruit is highly hydrating, easily digestible, and rich in essential vitamins and minerals, with moisture content exceeding 95 per cent, low fat (0.1-0.3%), moderate fibre (1-2%), and mean values of Vitamin C 125 mg/kg, iron 25.7 mg/kg, calcium 332 mg/kg, magnesium 287 mg/kg, potassium 616 mg/kg, and zinc 4.4 mg/kg, making it particularly valuable during the peak summer months.

Its most remarkable feature is the natural cracking that occurs at maturity, a characteristic reflected in the name pottuvellari, derived from the Malayalam words "pottu" meaning "cracking" and "vellari" meaning "cucumber" signifying its spontaneous splitting behaviour. Upon splitting, the fruit releases a pleasant aroma, and freshly cracked fruits are preferred for juice preparation to obtain the characteristic flavour. Farmers harvest the produce when the skin is firm and changes from green to cream or dull yellow, before surface cracks appear. In retail outlets, vendors sometimes secure partially cracked fruits with areca nut sheaths to prevent further splitting, which has led to the nickname "palayil pilla," meaning "baby in the areca nut sheath" (pala - areca nut sheath; pilla - baby). In certain areas, it is also known as kakkari.

However, the very characteristic that makes it special also limits its marketability. Due to its high moisture content, the fruit has an extremely short shelf life and must be consumed quickly after cracking. For this reason, snap melon is predominantly used for preparing a refreshing summer juice, lightly blended to preserve its texture and aroma, and consumed fresh within the local market.

### **Farming with tradition and care: Cultivation practices of snap melon**

Sowing is generally undertaken in December, and harvesting occurs during February and March,

when summer temperatures rise, and demand for hydrating foods increases. The crop is of short-duration, completing its life cycle within 75 to 80 days, which makes it suitable for inclusion in diversified cropping systems. Its ability to grow in residual moisture conditions makes it economically attractive for farmers seeking to maximize land use efficiency. Cultivation remains largely traditional and organic, with farmers avoiding chemical fertilizers and pesticides, relying instead on locally available inputs such as dry cow dung powder, neem cake, bone meal, groundnut cake, and cow dung slurry mixed



with neem cake. Although traditionally grown, many farmers have recently adopted drip irrigation as a modern technology to improve water use efficiency, enhance yield, and reduce production costs. The crop is monoecious, producing separate male and female flowers on the same plant. Pistillate flowers generally appear within 14 to 18 days after sowing, and fruiting begins soon thereafter. Harvesting typically starts around 45 to 55 days after sowing. Pest and disease incidence are relatively low, though yellow spot disease appears occasionally and is managed using traditional organic remedies. Such low external input requirements further strengthen the crop's suitability for sustainable agriculture. Studies conducted by Kerala Agricultural University in the G.I. production area indicate that snap melon cultivation is financially viable, with strong economic performance, reflecting better returns per rupee invested.

### Pottuvellari juice preparation

Snapmelon is marketed primarily as fresh fruit to prepare pottuvellari juice. The juice is prepared by carefully selecting naturally split, fully ripened fruits that are ideal for pulp extraction because of their unique taste and aroma. The seeds are carefully removed to maintain a smooth texture, and the fleshy pulp is scooped out. The extracted pulp is mixed with locally available ingredients such as crushed groundnuts, jaggery, or sugar, which enhance not only the sweetness and taste but also the nutritional value of the pulp. A small amount of cardamom is added to give it a characteristic aroma that appeals to consumers. In some regions, especially where a creamy texture is preferred, coconut milk or



cow's milk are added to enhance the flavor taste. Preparation is generally done in very small quantities to maintain freshness and quality. The juice is typically sold in glasses at farm-side stalls or local outlets, prepared in small batches, and replenished according to consumer demand.

### From challenges to opportunity: Paths to protecting the crop and livelihood

Snap melon is a remarkable fruit, but it comes with its own set of challenges. The moment it cracks open, its journey is time-sensitive. It must reach the consumer immediately, or it risks going to waste. Perishability, limited transportation, and the influence of middlemen make marketing a daily struggle. Many farmers resort to distress sales when prices drop unexpectedly or when the fruit spoils before it can be sold. On the production side, nature itself adds to the uncertainty. Untimely rains can damage ripening fruits and induce splitting before the

expected harvesting period. High cost and shortage of labour during peak seasons, and small landholding size challenges to snap melon production. Rising costs of inputs like manure and seeds add to the cultivation cost.

With value addition, processing, and proper storage facilities, and collective marketing through Farmer-Producer Organizations, farmers can protect their harvest and increase profits. Harvesting at the right stage using appropriate maturity indices and digital tools, adoption of drip irrigation, mechanization, crop insurance, and participation in regional and national G.I. exhibitions and trade fairs can help farmers effectively manage both production and market-related uncertainties. Promoting this crop through heritage tourism initiatives of the Tourism Department can enhance its market visibility and attract potential. By strategically integrating these interventions, the long-term sustainability of this GI-tagged crop can be strengthened. ■

# Jhabua Kadaknath Black Chicken Meat The Only Gi-Tagged Meat

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**A** Geographical Indication (GI) can be simply defined as a tool that protects certain products from exploitation while preserving their local, cultural, ethnic, and traditional production identity. It is a type of Intellectual Property Right that plays an important role in trade, as products granted GI tags are often valuable and profitable in the market. It plays an important role in cultural authenticity and is therefore

beneficial to both consumers and producers. GI tags are issued per the Geographical Indications of Goods (Registration and Protection) Act, 1999 (GI Act).

The Geographical Indications of Goods (Registration and Protection) Act came into force on 15th September 2003. This act defines goods eligible for Geographical Indication (GI) registration, including agricultural products, natural

goods, and manufactured goods. The Geographical Indications Registry is located in Chennai, and the Registrar of Geographical Indications is responsible for processing and managing all GI applications.

Among the 724 GI-registered products as of March 2026, the majority fall under agricultural, handicraft, and foodstuff categories. Interestingly, only one non-dairy animal/poultry



product has been bestowed with a GI tag, namely Jhabua Kadaknath Black Chicken Meat. Kadaknath chicken is recognized as a poultry breed known as "Kali Masi" from the Jhabua and Dharin districts of Madhya Pradesh and adjoining areas of Gujarat and Rajasthan, it is renowned for its high-protein black meat and notable medicinal value. This breed is featured with black legs, black toe nails, a black comb and a black beak, along with dark-colored meat and bones. The eggs are light brown in color, while the feet, toes, shanks, and beak have a slate-like appearance. It also has a purple tongue and some internal organs show intense black pigmentation. On average, it produces about 80 eggs per year, with an average egg weight of 46.8 g.

The black pigmentation is due to the excessive accumulation of eumelanin, a type of melanin pigment, in various parts of the chicken's body. This condition is caused by the incompletely dominant autosomal fibromelanosis (Fm) gene. In recent times, Kadaknath birds have spread across the country due to the high demand for their meat and eggs.

Kadaknath is a small-sized, slow-growing bird. Under field conditions in its native environment, it reaches about 1.0 kg in 6–7 months and around 1.5 kg in one year. Under an intensive rearing system at a single location, the average body weight of 40-week-old Kadaknath hens over five generations was 1248 g. The average body weights of cocks and hens at 40 weeks at different locations were 1571 g and 1266 g, respectively. Under field conditions, the body weights of males and females at 52 weeks were 1701 g and 1445 g, respectively.

The dressing percentage of Kadaknath at the age of 12

weeks is 61.1% and there is an increase in dressing percentage up to 65.2% at 20 weeks of age. The dressing percentage in Kadaknath is generally lower. This may be due to its thick feather covering or a higher proportion of feathers relative to body weight.

At 12 weeks of age, the abdominal fat in Kadaknath was low, accounting for 0.11% of dressed weight and 0.52% of live weight. Overall, Kadaknath birds have lower body fat content. The breast and thigh meat of Kadaknath is also significantly tougher in texture, low in moisture content, and higher in protein and fat percentage compared to the commercial poultry breeds.

The meat and eggs of native chickens like Kadaknath command a premium price compared to those of improved or commercial breeds due to their unique taste, flavour, texture and superior nutritional qualities, such as lean meat, higher protein content and perceived health benefits.

The variation in pigmentation intensity of muscle tissues (meat cuts) largely follows the melanotic patterns seen in the bird's skin. When the skin is darkly pigmented, higher pigment deposition is also observed in internal organs such as the gizzard, trachea, periosteum, ovary/testes, heart, and liver, compared to carcasses with slate or lighter pigmentation. The black and slate-colored carcasses can be clearly distinguished based on the intensity of pigmentation across internal organs.

The changing food landscape is leading to a shift in the rearing of native chickens from traditional backyard or free-range systems in tribal and rural areas to semi-intensive systems in peri-urban regions. Although Kadaknath

is highly valued for its unique qualities and strong consumer preference for its meat and eggs, its slow growth rate and lower production potential compared to other native breeds result in higher production costs, making its products pricier. The University Poultry and Duck Farm under the Kerala Veterinary and Animal Sciences University at Mannuthy maintains Kadaknath parent stock birds and provides day-old chicks as per requirement.

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# Sick Seeds and Rising Heat The Climate-Virus Crisis Facing the Global Yam production

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In the lush yam belt of West Africa and the verdant Parambu gardens of Kerala, a silent crisis is threatening the yams (*Dioscorea* spp.) have long been celebrated for their resilience, they are currently facing a stress, convergence of chronic viral infections and climatic volatility. Unlike grains, yams are vegetatively propagated from the previous year's tubers, a process that inadvertently allows viral infections to pass from generation to generation. As rising temperatures act as a force multiplier, aphid populations are surging, turning these tiny insects into high-speed taxis for devastating viruses. Today, the reliance on these "sick seeds" in an increasingly unpredictable climate is pushing a global food staple to its absolute limit, turning a traditional farming

practice into a high-stakes gamble for food security.

## Economic and food security impact

Unlike a sudden blight that destroys a field overnight, these viruses operate as a chronic drain on plant vitality. In India, where yams are a vital horticultural staple, crops are besieged by a complex of pathogens including Yam mosaic virus (YMV), Yam mild mosaic virus (YMMV), Yam mottling virus (YMoV) and *Dioscorea* Bacilliform virus (DBV). Beyond the individual impact, a more complex and reality exists: mixed viral infections. In the field, it is common to find yams playing host to several viruses simultaneously, a phenomenon scientists refer to as synergistic co-infection. The Yam mosaic

virus (YMV) alone is responsible for yield losses exceeding 50% in *Dioscorea rotundata* (white yam) across West Africa. Yam mild mosaic virus (YMMV), though often less aggressive, still causes significant stunting and mottling. Research indicates that the broader "stress synergistic" of viral infection and environmental pressure can lead to cumulative tuber losses ranging from 10% to as high as 90% depending on the severity and variety of the crop. These statistics are particularly alarming given that Nigeria, Ghana, and neighbouring nations produce over 90% of the world's yams. Because approximately 25% of each year's harvest is recycled as "seed" for the next season, the viral load is perpetually renewed, creating a self-sustaining cycle of poverty and food scarcity. This viral



*Dioscorea alata* tuber under attack by mealybugs, the biological vector for *Dioscorea* Bacilliform Virus (DBV).

infection does more than just reduce weight; it compromises the sprouting capacity and nutritional quality of the tubers, effectively stealing the future of the crop from the very hands of the farmers who sustain it. Indian agricultural data highlights that in states like Kerala, *Dioscorea alata* often carry viral loads due to the recycling of approximately 25% of each harvest as seed for the next season. Yams have a multiplication ratio as low as 1:4 or 1:6. Viral pathogens act as an invisible tax on global food security, siphoning off a significant portion of potential harvests before they ever reach a plate.

### **Rising Heat: A Playground for Viral Vectors**

As the planet warms, the

change in climate acts as a force multiplier for viral spread by supercharging the metabolism of aphids, the tiny insects that serve as vectors for devastating diseases like the Yam mosaic virus (YMV). Research indicates that even a 2°C rise in mean temperature can double viral transmission rates within a single season, as warmer weather triggers faster breeding cycles and more aggressive probing behavior from these pests. The crisis deepens when rising heat is paired with erratic rainfall. Under the pressure yam plants are forced into a desperate biological trade off: they must divert energy away from their immune systems simply to stay hydrated. This breakdown in defense leads to a higher viral titre within the plant tissue. Consequently, any aphid biting a drought stressed yam is

virtually guaranteed to pick up a lethal load to carry to the next healthy vine. The consequences of this climate-virus synergy are staggering while a viral infection alone might typically reduce a harvest by 40%, the interaction with climate-induced stress can push yield losses toward a catastrophic 90%. In countries like Nigeria and Benin, where yams are a primary source of starch and income, these outbreaks translate directly into food price spikes and deepening rural poverty. Once a manageable agricultural hurdle has now become a critical flashpoint for global food security.

### **The Yam Detective: Reading the language of infection in the field**

To the untrained eye, a struggling yam field might

## Major Viral Constraints of Yam Productivity

Virus	Severity	Key Symptom	Primary Host
Yam mosaic virus (YMV)	High (Most Destructive)	Mosaic / Shoe-string	<i>D. rotundata</i>
Yam mild mosaic virus (YMMV)	Moderate (Often Silent)	Faint Mottling / Stunting	<i>D. alata</i> , <i>D. esculenta</i>
Yam Mottling Virus	Variable	Bumpy leaves / Puckering	Various <i>Dioscorea</i> spp.



*Symptoms of viral infection in different yam leaves.*

simply look a bit yellow, but to a plant pathologist, the leaves are shouting a story of biological hijacking. Understanding this language of the virus is the first step in protecting the global food supply. When a virus like the Yam mosaic virus (YMV) enters a plant, it essentially seizes the internal machinery, leading to three unmistakable visual cues. The most famous is the mosaic pattern, where the leaf loses its solid, healthy green and transforms into a patchwork quilt of yellow and dark green blotches. This occurs as the virus destroys the plant's chlorophyll, effectively blinding its ability to turn sunlight into food. In more advanced stages, farmers might spot shoe stringing; a severe distortion where the plant stops producing broad leaves entirely. Instead, it grows thin, strap-like tendrils that look like green shoelaces, ensuring the tuber beneath will remain stunted and small. Finally, there is vein-banding, a subtle clue where the tissue along the leaf veins remains dark green while the rest of the leaf turns pale as if the virus has highlighted the plant's vascular system in a grim marker of infection.

### How Experts Diagnose Yam Viruses to Secure Food Security

Proper diagnosis is the fundamental cornerstone of yam viral management, requiring a sophisticated, tiered approach standardized by expert organizations like ICAR-Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram, Kerala, India. This diagnostic journey begins in the field with the identification of visual markers such as mosaic patterns, leaf distortion, and stunting which serve as the first level of screening. To move beyond visual observation, experts employ serological techniques,

specifically the ELISA (Enzyme Linked Immunosorbent Assay), which remains the gold standard for large-scale routine testing due to its ability to use specific antibodies to detect viral proteins in seed tubers. For cases requiring even higher sensitivity, such as detecting low viral loads in asymptomatic plants or sterile tissue cultures, molecular diagnostics are utilized. Because primary threats like the Yam mosaic virus (YMV) and Yam mid mosaic virus (YMMV) are RNA-based, scientists perform RT-PCR (Reverse Transcription Polymerase Chain Reaction) to convert viral RNA into cDNA for amplification. By using specialized primers designed to target the unique genetic signatures of these pathogens, ICAR-CTCRI researchers achieved nearly 100% accuracy in identification, ensuring that only certified, virus-free planting material reaches the hands of farmers.

### A Comprehensive Framework for Controlling Viral Infections in Yam Cultivation

To effectively manage viral infections in *Dioscorea* species, farmers and researchers must employ an Integrated Disease Management (IDM) approach that prioritizes prevention, as there are no chemical cures for viruses once a plant is infected. Because yams are vegetatively propagated, the most critical step is the use of virus-free planting material; this can be achieved by selecting seeds from healthy, mother plants or by using plantlets derived from meristem tip culture and thermotherapy, which thermally cleanse the plant tissue. In the field, cultural practices such as rouging, the immediate removal and destruction of symptomatic plants and strict tool sanitation

are essential to prevent the mechanical spread of viral sap. Controlling the insect vectors, primarily mealybugs and aphids is also very important. Although aphid infestations on *Dioscorea* have not been observed in Kerala, precautionary measures are recommended. Increasing ambient temperatures are known to accelerate insect reproduction rates, which may alter pest dynamics and host selection in the future. Through regular weeding of alternative hosts and strategic intercropping can further reduce transmission rates. Ultimately, the long term solution lies in host plant resistance, utilizing improved varieties and ensuring higher yields even in high-pressure environments.

### Conclusion

The dual threat of infected planting materials and rising global temperatures represents one of the most significant challenges to tropical agriculture today. As climate change shifts the geographic range of insect vectors and places greater physiological stress on the plant, the traditional methods of yam cultivation are no longer sufficient to guarantee a harvest. However, the path forward is illuminated by the integration of traditional wisdom and modern science. By scaling up the diagnostic precision of institutes such as ICAR-CTCRI and ensuring that virus-free, climate-ready varieties reach the smallholder farmers who need them most, we can break the cycle of cultivar degeneration. Securing the future of the yam is not merely about protecting a crop; it is about safeguarding the food security, cultural heritage, and economic stability of millions in a warming world. The battle against the viruses is winnable; we treat the health of the seed as seriously as the health of the soil. ■

# HYDRANGEA

A Vibrant Whispers  
of the Garden

**H**ydrangeas prized for their showy blooms are commonly referred as “Queen of flowering shrubs” belongs to the plant family Hydrangeaceae. Originated from temperate parts of the world viz., eastern Asia, eastern North America and South America. It includes diverse species of evergreen and deciduous shrubs, small trees and even woody climbers. Hydrangeas are in great demand among retail florists and garden stores from the Easter season to Mother’s Day. Their enormous, globe shaped clusters of flowers exude a unique elegance among potted plants. Hydrangeas are commonly regarded by many gardeners as the chameleons of the plant kingdom due to their blossom colour variation according to

pH. In acidic soil pH conditions (4.5 to 5.5) the hue appears in blue due to the presence of aluminium. A pH range of 6.0 to 7.0 flower turn in pink colour. At pH levels ranging from 5.5 to 6.5 flowers may exhibit colours such as pink, blue, lavender or combinations on the same plant. Hydrangea comes from Greek word means “hydro, “signifying “water” and “angeton” meaning “vessel”.

### Morphology

Hydrangeas are native to Mexico comprises 25 resilient species of plants that can attain a height of up to 1.5 meters in medium and high-altitude regions. Their star shaped flowers are sterile and appears in two arrangements i.e., corymbs or panicles

typically found at the end of stems. Usually, flower heads have two types of flowers: small inconspicuous ones in the centre or interior, and large showy ones with vibrant sepals includes white, red, purple, pink, and blue. Their foliage is captivating, characterized by exquisite oval to round leaves with undulating margins and prominent veins.

### Garden Uses

It can be grown as specimen shrub to create a focal point, a hedge plant, a container plant for patio and decks, or a cut flower, and its versatility allows it to merge seamlessly into mixed borders and shrubbery planting. Besides, hydrangeas are also popular for flower arrangements because of their large, showy and



long-lasting blossoms.

## Types of Hydrangea

**Hydrangea macrophylla:** It is deciduous shrub renowned for its large, showy flower heads. Commonly referred as big leaf, garden or mophead hydrangeas. These vivid flowers usually adorn the gardens from May to early July, enhancing summer vistas with their brightness. While the initial flowering period may fade, some reblooming varieties offer a second wave of blooms in the fall. Mophead varieties feature rounded, globe-like clusters of flowers, while lace-cap varieties exhibit a more delicate appearance with a ring of larger, showy outer petals surrounding a central cluster of smaller flowers. Flower colors can range from vibrant blues and purples to soft pinks, reds, and whites. Soil pH plays a significant role in determining flower color in some varieties.

**Hydrangea anomala:** The climbing hydrangea is a deciduous vine native to Asia. It can climb up to 60 ft with its clinging aerial roots but will grow shrubby and sprawling manner without support. The leaves are circular, heart shaped and green in colour that are 3-6 inches long. Mature plant produce short flowering branches covered in flat white blooms. As the plant ages, it turns woody. Only once the vine has established itself and begun to climb can it be clipped to remove the excessive growth. Mature plants produce short flowering branches covered in flat white blooms. As the plant ages, it turns woody. Only once the vine has established itself and begun to climb can it be clipped to remove excessive growth. To rejuvenate, prune back to the framework late in the dormant season.

**Hydrangea arborescent:** It is a deciduous shrub grows upright

and dense which reaches up to 5 feet in both height and width. The oval, greyish green leaves are measuring about 3-6 inches long. It has white, pink or green flower with maximum are fertile and few are sterile. The 'Annabelle' variety is much showier, producing enormous globular clusters of sterile flowers up to one foot in diameter on a plant that grows about four feet tall and wide. 'Grandiflora' is another variety that reaches four feet in height, with flower clusters six inches across. Prune in late winter, as hard pruning results in larger flowers.

## Propagation

Hydrangeas can be propagated by both sexually through seed and asexually by soft wood cutting and micropropagation. Commercially they are propagated by soft wood stem cuttings. Typically, cuttings taken during the early in the season (may) will yield more vigorous and rapidly growing plants compared to those taken in late summer. Cutting should be taken from a healthy, flexible stem from the current season growth. With a clean sharp knife cut a 4 to 6 inch section from the tip of the stem, just below the leaf node. Remove the lower leave, keeping only 2-3 leaves at the top. For faster initiation of the roots dip the cutting in IBA rooting media at concentration of 1000 ppm. Place the cuttings in a container filled with well-draining potting soil. Place the container in a warm, bright spot with indirect sunlight. Maintain regular moisture in the media but avoid overwatering. After few weeks carefully pull out the cutting to assess the root development. After the roots are developed properly transplant them to permanent location.

## Climate and soil

It can grow on mild climate. They grow luxuriantly at a

temperature of 10°C to 21°C. Hydrangeas generally prefer to grow in partial shade during hotter climates. A cool, moist climate is considered beneficial for growth and development.

## Planting Time and method

Ideal season for planting is during the autumn and early spring as they provide ample time for strong root system before flowering. It is always recommended to plant during the early morning or late evening hours to shield the plant from heat stress during the cooler part of the day. It is advisable to maintain the newly planted hydrangeas well-watered until they are fully established. Recent study reveals that the optimal potting media is a mixture of soil, farmyard manure and sand (1:1:1). During the planting dig a hole about 2 feet wider than the root ball to keep the plant level or slightly above the soil.

## Watering

Hydrangeas require a weekly watering at a rate of 25-50 litres per square meter throughout the growing season. It is advisable that water them thrice a week for better root establishment.

## Nutrition Requirement

Hydrangea respond well to good nutrition. The application of fertilizer in hydrangeas is crucial, as it affects the color of sepals. The sepals contain red anthocyanin pigments that interact with aluminium and certain other elements to produce a blue colour. 80g/m<sup>2</sup> of Nitrogen and 50g/m<sup>2</sup> Potassium is recommended for better growth and development. Hydrangea thrives best in a balanced ratio of NPK 10-10-10 or 10-4-8 NPK. It is also noted that to increase size and quality of blooms more phosphorous



is effective. Fertilizer with the NPK 10-20-10 can also be used. For bigleaf hydrangeas, apply light fertilizer multiple times: in March, May, and June. Oak leaf and panicle hydrangeas thrive with two applications: in April and June. Smooth hydrangeas typically require fertilization once, typically in late winter.

### **Pest and disease management**

Insect pests viz., weevils, caspids, bugs, aphids, scale and chafer beetle may infest the plants. Hydrangea commonly suffers from diseases like leaf spot, blight and powdery mildew. The most effective strategy to mitigate these problems is

to provide appropriate care for your hydrangeas. Employ IPM strategies to control pests and diseases. This includes monitoring, using biological controls, and applying chemical treatments only when necessary. Remove and destroy diseased plant material to prevent the spread of pathogens. ■

# Nutritional and Health Significance of Multi-Source Vegetable Oils in Achieving a Balanced Fatty Acid Profile

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**D**ietary fats are an essential component of human nutrition, playing critical roles in energy supply, cellular structure, hormone production, and the absorption of fat-soluble vitamins (A, D, E, and K). However, the health impact of fats largely depends on the type and balance of fatty acids present in the diet. Modern nutritional guidelines emphasise the importance of maintaining an appropriate balance of saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA), along with a suitable omega-6 to omega-3 fatty acid ratio. The World Health Organisation (WHO) and other health agencies recommend a balanced intake of these fatty acids to reduce the risk of non-communicable diseases such as cardiovascular disease, obesity, diabetes, and metabolic disorders (FAO & WHO, 2010; WHO, 2018; Sacks et al., 2017).

The American Heart Association recommends a heart-healthy dietary pattern to reduce the

risk of cardiovascular diseases. According to AHA guidelines, total fat intake should constitute about 25–35% of daily energy intake, with saturated fat limited to less than 5–6% of total calories. Replacing saturated fats with monounsaturated and polyunsaturated fatty acids is strongly encouraged, as these fats help improve lipid profiles by lowering low-density lipoprotein (LDL) cholesterol while maintaining or increasing high-density lipoprotein (HDL) cholesterol. The AHA also advises minimising trans-fat intake due to its adverse effects on cardiovascular health. Additionally, omega-3 fatty acids from plant and marine sources are recommended for their cardioprotective benefits (Sacks et al., 2017; Lichtenstein et al., 2021).

However, none of the single oils/fats meets these guidelines. There are many oil modification approaches, such as hydrogenation, interesterification, fractionation, and blending. Blending is the

most practical approach to modify the oil to achieve the desired fatty acid composition.

According to the Food Safety and Standards Authority of India (FSSAI), Multi Source Edible Oil is defined as: “An admixture of any two edible vegetable oils where the proportion by weight of any edible vegetable oil used in the admixture shall not be less than 20 per cent. The individual oils in the blend shall conform to the respective standards prescribed by these regulations” (FSSAI, 2011). Even after blending, fatty acid composition may be achieved, but the omega-6 to omega-3 ratio is difficult to achieve. To solve this problem, the addition of a third oil as a source of omega-3 was permitted.

## Key Regulatory Requirements by FSSAI

The FSSAI regulations also specify several conditions for multi-source edible oils:

### 1. Minimum proportion of each oil



Each oil used in the blend must constitute at least 20% by weight of the total oil mixture.

## 2. Limit on saturated fatty acids (SFA)

The blended oil should not contain more than 33% saturated fatty acids.

## 3. Recommended omega-6 to omega-3 ratio

The oil blend may maintain an omega-6 : omega-3 ratio between 5:1 and 10:1 for improved nutritional balance.

## 4. Addition of omega-3-rich oils

To achieve the desired fatty acid ratio, flaxseed (linseed) oil or chia oil may be added up to 5% of the total oil blend.

## 5. Quality requirements

The blend must be clear and free from rancidity, foreign matter, mineral oil, animal fats, and other non-edible oils (FSSAI, 2011; FSSAI, 2018).

**Nutritional Importance of Dietary Fatty Acids:** Dietary fats are composed of various fatty acids that differ in their chemical structures and physiological functions. The three major categories include saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) (FAO & WHO, 2010).

**Saturated Fatty Acids (SFA):** SFA are typically solid at room temperature and are found in animal fats and in certain plant oils, such as coconut and palm oils. While these fatty acids provide energy and structural support for cell membranes, excessive intake has been associated with elevated low-density lipoprotein (LDL) cholesterol levels, which may contribute to the development of atherosclerosis and coronary heart disease. Health organisations therefore recommend limiting SFA intake to less than 10% of total daily energy consumption (WHO, 2018; Sacks et al., 2017). Oils rich in saturated fatty acids

(SFA) are typically more solid or semi-solid at room temperature and are commonly derived from tropical plant sources. Some major examples include:

- **Coconut oil** – one of the richest sources of saturated fats, particularly lauric acid
- **Palm oil** – widely used in cooking and food processing, contains a high proportion of palmitic acid
- **Palm kernel oil** – even higher in saturated fats than palm oil

**Monounsaturated Fatty Acids (MUFA):** MUFA are considered heart-friendly fats and play an important role in maintaining cardiovascular health. They help lower LDL cholesterol while maintaining or even increasing high-density lipoprotein (HDL) cholesterol. MUFA also improve insulin sensitivity and supports metabolic health. Oils such as groundnut, olive, sesame, and rice bran oil are rich sources of MUFA. Regular consumption of MUFA-rich oils has been linked



with reduced risk of heart disease and improved lipid profiles.

**Polyunsaturated Fatty Acids (PUFA):** PUFA include essential fatty acids such as omega-6 (linoleic acid) and omega-3 (alpha-linolenic acid). The human body cannot synthesise these fatty acids and must therefore be obtained through the diet. PUFAs play critical roles in brain development, immune function, inflammatory regulation, and maintaining the integrity of cell membranes. Since linoleic acid is abundant in nature and its deficiency of omega-6 is rare, safflower is the richest source of linoleic acid. Linseed, chia, and mustard are the richest sources of omega-3 fatty acids.

### Importance of Omega-6 and Omega-3 Fatty Acid Balance

Omega-6 and omega-3 fatty acids are essential for normal physiological functioning, but the dietary ratio between them is crucial for maintaining health. Omega-6 fatty acids promote normal growth and development,

support immune responses, and support skin health. However, excessive intake without adequate omega-3 may promote pro-inflammatory processes in the body.

Omega-3 fatty acids, on the other hand, possess strong anti-inflammatory, cardioprotective, and neuroprotective properties. They contribute to improved heart health by reducing triglyceride levels, lowering blood pressure, and preventing abnormal blood clotting.

The WHO and nutrition experts recommend maintaining an omega-6-to-omega-3 ratio of approximately 5:1 to 10:1 in the daily diet. Unfortunately, many modern diets have ratios exceeding 20:1 due to high consumption of omega-6-rich oils and low intake of omega-3 sources. Such imbalances may increase the risk of chronic inflammatory diseases, cardiovascular disorders, arthritis, and metabolic syndrome.

### Limitations of Using a Single Edible Oil

Each vegetable oil has a distinct fatty acid composition, so that no single oil can provide the optimal balance of SFA, MUFA, PUFA, and essential fatty acids recommended for human health. For example:

- Sunflower and safflower oils are rich in PUFA but contain limited MUFA and negligible omega-3 fatty acids.
- Olive oils have high amounts of MUFA but relatively lower amounts of PUFA.
- Soybean and mustard oils contain both omega-6 and omega-3 fatty acids.
- Sesame oil contains almost an equal amount of MUFA and PUFA, along with antioxidant compounds such as sesamol and sesamin.

Therefore, relying exclusively on one type of oil may lead to an imbalance in fatty acid intake and may not meet recommended nutritional guidelines.

## Advantages of Multi-Source Vegetable Oils

The concept of multi-source vegetable oils involves combining or rotating different edible oils to obtain a more balanced fatty acid profile. This approach offers several nutritional and health advantages.

First, combining MUFA-rich and PUFA-rich oils helps achieve a healthier distribution of fatty acids in the diet. For example, using groundnut or sesame oil along with soybean or mustard oil can help balance MUFA and PUFA intake.

Second, multi-source oil consumption can improve the omega-6-to-omega-3 ratio in the diet. Oils such as soybean, mustard, and canola contain moderate levels of omega-3 fatty acids, which help offset the high omega-6 content present in oils like sunflower or corn oil.

Third, consuming a variety of oils increases intake of bioactive compounds, including phytosterols, tocopherols (vitamin E), phenolic antioxidants, and lignans. These compounds help reduce oxidative stress, lower cholesterol levels, and protect against chronic diseases.

## Health Benefits of Balanced Fatty Acid Intake

A balanced intake of MUFA, PUFA, and limited SFA offers several health benefits:

**Cardiovascular Health:** Balanced dietary fats help reduce LDL cholesterol, maintain HDL cholesterol, and improve blood lipid profiles, thereby reducing the risk of coronary heart disease and stroke.

**Anti-Inflammatory Effects:** Adequate omega-3 fatty acid intake helps regulate

inflammatory processes and may reduce the risk of chronic diseases such as arthritis, diabetes, and certain cancers.

**Brain and Cognitive Function:** PUFA, especially omega-3 fatty acids, play a critical role in brain development and cognitive function. They are essential for neuronal membrane integrity and neurotransmission.

**Metabolic Health:** Balanced fatty acid consumption improves insulin sensitivity, supports healthy body weight management, and reduces the risk of metabolic syndrome.

**Immune Function:** Essential fatty acids help regulate immune responses and support the body's defence mechanisms against infections and diseases.

## Conclusion

Maintaining an optimal balance of dietary fatty acids is essential for promoting long-term health and preventing chronic diseases. Since individual vegetable oils vary significantly in their fatty acid composition, relying on a single oil may not meet nutritional recommendations. The use of multiple vegetable oils provides a practical, scientifically supported approach to achieving the recommended proportions of SFA, MUFA, and PUFA, as well as an appropriate omega-6-to-omega-3 ratio. Adopting this strategy not only enhances the nutritional quality of the diet but also contributes to improved cardiovascular health, better metabolic function, and overall well-being. Overall, multisource vegetable oils enhance the nutritional profile, improve oxidative stability, and provide a balanced fatty acid composition that may not be achieved using a single oil source.

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# Unseen but Significant The Physiological and Biochemical Effect of Cassava Mosaic Disease

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Cassava (*Manihot esculenta*) is an important staple and industrial crop cultivated widely across tropical regions. In India, it plays a crucial role in food security and serves as a raw material for starch and processing industries. However, cassava productivity is increasingly threatened by cassava mosaic disease (CMD), one of the most damaging viral diseases affecting this crop. CMD is caused by a group of begomoviruses collectively known as cassava mosaic viruses, including Sri Lankan cassava mosaic virus and Indian cassava mosaic virus, which are widely reported in South Asia. These viruses are transmitted primarily by the whitefly *Bemisia tabaci* and through infected stem cuttings used for vegetative propagation. Unlike many plant diseases that cause rapid plant death, CMD develops gradually. Infected plants often survive and continue to produce leaves and tubers. Because of this, farmers

may not immediately recognize the seriousness of the disease. However, within the plant, the virus interferes with critical physiological and metabolic processes. Photosynthesis becomes inefficient, energy production declines, and the movement of carbohydrates to storage roots is reduced. Over time, these hidden physiological disturbances result in significant yield losses even when the crop appears relatively healthy in the field.

## Impact on Leaf Physiology

Leaves are the primary site of energy production in cassava plants. CMD mainly affects young and developing leaves, which are responsible for active photosynthesis. Infected leaves often display mosaic patterns consisting of irregular green and yellow patches. In severe cases, leaves may also become slightly distorted or reduced in size. These external symptoms reflect

deeper changes occurring within leaf tissues. Viral infection interferes with the normal structure and functioning of chloroplasts, the organelles that convert sunlight into chemical energy. Microscopic observations of infected leaves reveal abnormalities such as swelling of chloroplasts, disruption of internal membranes, and irregular stacking of grana. These structural changes reduce the efficiency with which chloroplasts capture light energy and convert it into biochemical energy. As a result, the overall capacity of the leaf to produce carbohydrates declines.

## Chlorophyll Degradation and Photosynthetic Decline

A hallmark of CMD is the reduction in chlorophyll content, which impairs the leaf's ability to absorb and utilize light energy effectively. Chlorophyll biosynthesis is a tightly regulated process, dependent



Fig 1. Effect of Cassava Mosaic Virus Infection on Leaf Morphology of Cassava

on coordinated enzymatic activity and sufficient nutrient availability. Viral infection disrupts this balance by diverting precursors and interfering with gene regulation. Simultaneously, increased production of reactive oxygen species (ROS) accelerates chlorophyll degradation. The consequence is a functional decline in photosynthesis. Leaves may remain partially green, yet their light-harvesting efficiency drops significantly. This reduction in photosynthetic output translates into lower carbohydrate production, directly impacting growth and storage root development. In effect, CMD leaves operate as if the plant were experiencing chronic shade stress, even under optimal sunlight (Liu et al., 2014).

### Metabolic and Biochemical Alterations

Beyond structural and pigment-related changes, CMD triggers a suite of biochemical responses that further impair plant productivity. Viruses are obligate parasites and lack independent metabolic machinery; they rely entirely on host resources for replication. Consequently, infected cassava cells redirect

energy, sugars, amino acids, and nucleotides toward viral replication, creating metabolic sinks within leaf tissue. This diversion reduces the availability of assimilates for growth and storage organ development.

In parallel, viral infection induces oxidative stress. Accumulation of ROS such as superoxide radicals and hydrogen peroxide occurs as a part of the plant's defense response. While ROS act as signaling molecules to activate defense pathways, excessive concentrations damage lipids, proteins, and nucleic acids. Chloroplast membranes and electron transport components are particularly susceptible, exacerbating photosynthetic impairment. To mitigate oxidative damage, cassava activates antioxidant systems including superoxide dismutase, catalase, and peroxidases. Maintaining these systems consumes additional energy, creating a feedback loop in which defense mechanisms compete with growth and yield processes for metabolic resources (Raju et al., 2025).

Hormonal imbalances induced by viral infection further modify metabolism. Elevated levels

of salicylic acid, jasmonic acid, and ethylene, while critical for antiviral defense, can reduce carbohydrate allocation to roots and alter vegetative growth patterns. Collectively, these biochemical disruptions contribute to a systemic reduction in metabolic efficiency, even in plants that appear outwardly healthy.

### Source-Sink Disruption and Root Development

Cassava productivity relies on a tightly regulated source-sink relationship, wherein leaves act as carbohydrate sources and storage roots as sinks. CMD disrupts this balance through multiple mechanisms. Reduced photosynthetic efficiency diminishes source strength, while viral-induced metabolic and hormonal changes can alter sink strength and assimilate partitioning. In infected plants, a greater proportion of carbohydrates is diverted toward maintaining leaf tissue and supporting viral replication, leaving storage roots undernourished. The result is smaller roots with lower starch content, even in plants that maintain normal vegetative growth. This "hidden yield loss"

## Cassava Mosaic Disease (CMD): A Hidden Threat to Cassava Productivity

Cassava mosaic disease (CMD), caused by **Cassava mosaic viruses**, silently reduces yield by affecting photosynthesis, chloroplast structure, and carbohydrate transport, even when plants appear healthy.

### How CMD Affects the Plant

- Reduces Photosynthesis
- Damages Chloroplasts
- Disrupts Carbon Fixation
- Induces Oxidative Stress
- Alters Carbohydrate Allocation

### Impact on Yield

- Reduced Carbohydrate Storage
- Lower Tuber Weight & Quality

### Visible Symptoms

- Mosaic & Chlorosis
- Leaf Distortion
- Stunted Growth

### Exacerbated by

- Drought
- Heat
- Nutrient Deficiency

often goes unnoticed by farmers, as visual assessment focuses on plant appearance rather than biochemical productivity. Over successive planting cycles, vegetative propagation of infected material amplifies the effects, leading to cumulative degeneration in both vigor and yield (Zanini et al., 2020).

### Interaction with Environmental Stress

CMD rarely occurs in isolation. In real-world agricultural settings, cassava plants are subjected to additional abiotic stresses such as drought, heat, and nutrient deficiency. Viral infection reduces the plant's capacity to respond to these stresses. For example, compromised photosynthetic efficiency limits energy available for osmotic adjustment during drought. Similarly, destabilized chloroplast function reduces thermal tolerance, making plants more susceptible to high-temperature stress. When viral

and abiotic stresses coincide, their effects are often synergistic rather than additive, accelerating physiological decline. Such interactions are particularly concerning in regions experiencing climate variability, where cassava cultivation is increasingly exposed to marginal growing conditions. The combined impact of CMD and environmental stress underscores the importance of integrating disease management with broader agronomic strategies.

### Varietal Differences in Response

Not all cassava varieties respond equally to CMD. Resistant or tolerant varieties often maintain higher photosynthetic rates and accumulate more carbohydrates despite viral infection. These genotypes exhibit traits such as reduced viral replication, enhanced antioxidant activity, stable chloroplast structure, and

efficient assimilate partitioning. Rather than achieving complete immunity, these traits mitigate the functional impact of CMD, preserving yield potential under viral pressure. Understanding these varietal differences is critical for breeding programs. Emphasizing functional resilience rather than solely symptom suppression ensures that new varieties maintain productivity even when exposed to persistent viral pressure.

### Silent Yield Loss: The Deceptive Nature of CMD

CMD is often described as deceptive because its visual impact does not always correlate with productivity loss. Fields may appear green and vigorous, and farmers may harvest seemingly adequate tubers. However, scientific studies reveal that virus-infected plants often experience yield reductions ranging from 20-50%, depending

on virus strain, infection timing, and environmental conditions (Collavino et al., 2022).

### This discrepancy arises from several factors

- Infection severity is variable and sometimes latent
- Visual recovery can occur as plants mature
- Farmers typically compare infected fields to other infected fields, masking relative losses

The concept of “hidden yield loss” highlights the importance of systematic assessment, using virus-free controls and

4. Limited access to resistant varieties – While tolerant genotypes exist, availability and adoption remain low in many regions.

5. Complex environmental interactions – CMD impact is compounded by drought, heat, and nutrient stress, making management context-dependent.

Effective control requires integrated approaches, combining certified virus-free planting material, resistant varieties, vector management, and routine monitoring. Early detection and removal of infected plants, coupled with education

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A hallmark of CMD is the reduction in chlorophyll content, which impairs the leaf's ability to absorb and utilize light energy effectively. Chlorophyll biosynthesis is a tightly regulated process, dependent on coordinated enzymatic activity and sufficient nutrient availability.

quantification of physiological and biochemical parameters, to accurately determine CMD impact.

## Management Challenges

Despite decades of awareness, CMD remains difficult to manage. Key challenges include:

1. Vegetative propagation – The use of infected stem cuttings perpetuates the virus across planting cycles.
2. Vector control – Whiteflies (*Bemisia tabaci*) are highly efficient vectors, capable of rapid population growth and developing resistance to chemical control.
3. Latent infections – Mildly infected plants or asymptomatic plants may be used as planting material, unknowingly spreading CMD.

on proper propagation practices, are critical for minimizing cumulative yield loss (Mkamilo et al., 2024).

## Conclusion

Cassava mosaic disease subtly reduces yield by impairing photosynthesis, altering metabolism, and disrupting source-sink dynamics. Healthy-looking plants can mask significant losses in energy production and starch accumulation. Over successive cycles, these hidden losses accumulate, threatening productivity and food security. Recognizing CMD as a chronic, degenerative disease emphasizes the need to focus on functional performance, using integrated management, resistant varieties, and proactive monitoring to sustain cassava production.

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# Chilling injury in muskmelon

## Cupping of Leaf and Stunting of Plant

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**M**uskmelon (*Cucumis melo* L.) is a subtropical crop that grows best under warm conditions and is highly sensitive to low temperatures. Exposure to non-freezing temperatures between 10–25 °C—particularly below 10–12 °C—induces a range of physiological and cytological disturbances collectively known as chilling injury. Temperatures below 10 °C are reported to cause significant damage in muskmelon.

The severity of chilling injury in muskmelon is influenced by several factors, including the precise temperature experienced, the duration of exposure, and the light intensity during chilling. Additionally, environmental conditions before and after chilling—such as light regime, plant temperature, and water status—play critical roles in determining the extent of injury.

### Cellular basis of chilling injury

The cell membrane is the primary site affected during chilling injury. At low temperatures, membrane lipids undergo a

phase transition from a flexible, liquid-crystalline state to a rigid, gel-like state. This transition reduces membrane fluidity and compromises membrane stability. Consequently, membrane permeability increases, leading to electrolyte leakage, impaired protoplasmic streaming, and localized collapse of cellular compartments. Contraction of the plasma membrane away from the cell wall results in plasmolysis, and sac-like intrusions may develop within the vacuole.

Crystalline deposits may also form in epidermal, mesophyll, and vascular tissues, contributing to irreversible disruption of the tonoplast. The lipid composition of cellular membranes plays a critical role in determining a plant's chilling tolerance. Chilling-resistant plants typically possess a higher proportion of unsaturated fatty acids, which help maintain membrane fluidity at low temperatures. In contrast, muskmelon has relatively fewer unsaturated fatty acids, causing its membranes to rigidify more rapidly and making the plant particularly susceptible to chilling stress.

### Ultrastructural alterations in organelles

Loss of membrane integrity under chilling stress triggers a cascade of severe ultrastructural disturbances in muskmelon cells. Chloroplasts show pronounced swelling of thylakoid membranes, disintegration of grana, and a noticeable reduction in both the size and number of starch grains. Plastoglobules become larger and more abundant, indicating disruptions in lipid metabolism. Mitochondria are similarly affected, swelling to nearly twice their normal size, losing cristae, and developing a translucent matrix—changes that lead to a marked decline in ATP production and overall respiratory efficiency.

The endoplasmic reticulum (ER), one of the most dynamic cellular components, undergoes extensive dilation and vesiculation. Ribosomes detach from the rough ER, causing it to diminish and convert into vacuolated smooth ER, where cryoprotective substances often accumulate—an early hallmark of chilling stress. Although ER structure may recover if stress is



Figure 1. View of muskmelon of health plant and plant with chilling injury. a) Normal health leaf, b) health shoot divide of meristem tissues, c) healthy plant, d) Leaf cupping due to chilling injury, e) breakdown of meristematic tissue of plant shoot tip due to chilling injury, f). stunted and deformed plant after chilling injury.

alleviated promptly, prolonged exposure results in irreversible degeneration. Dictyosomes (Golgi bodies) also swell initially, but extended chilling ultimately leads to their disintegration, signalling a collapse of the cellular secretory and transport machinery.

Collectively, these cytological disruptions severely impair photosynthesis, respiration, intracellular transport, and overall metabolic homeostasis, laying the groundwork for the visible symptoms of chilling injury in muskmelon leaves.

### Physiological effects and symptom development

The earliest observable symptom of chilling injury in muskmelon is the appearance of water-soaked areas on leaves, cotyledons, and growing points. These water-logged patches develop as a result of cellular leakage and localized tissue collapse. As exposure to low temperatures continues—or when the tissues are rewarmed—these regions gradually turn yellow, wilt, or progress to necrosis. Because the injury develops irregularly across the leaf surface, turgor pressure

becomes uneven, causing different portions of the leaf to shrink or contract at different rates.

This differential contraction leads to a characteristic distortion of the leaf, commonly referred to as leaf cupping or upward leaf rolling. Leaf margins curl inward while the central portion bends upward, reflecting underlying cellular damage—particularly membrane disruption and disturbances in water balance. Upon rewarming, the initially depressed water-soaked areas dry and form necrotic patches, which further accentuate the cupped appearance of the affected leaves.

### Overall impact of chilling stress

- Leaf cupping in muskmelon is a direct, visible manifestation of the complex cellular and physiological disturbances triggered by chilling stress. It results from:
  - Phase transitions in membrane lipids and reduced membrane fluidity
  - Electrolyte leakage and subsequent solute imbalance
  - Low levels of unsaturated fatty

acids causing rapid membrane rigidification

- Structural damage to chloroplasts, mitochondria, the endoplasmic reticulum, and dictyosomes
- Localized tissue collapse accompanied by loss of turgor
- Irregular contraction and deformation of the leaf lamina
- Together, these factors make muskmelon particularly vulnerable to low-temperature injury, underscoring the need to maintain warm, optimal growing conditions for healthy plant development.

### Control measures

- Avoid planting in November, as low night temperatures during this period significantly increase the risk of chilling injury.
- Cover nursery beds or young plants with polythene sheets to retain soil warmth and shield seedlings from cold stress.
- Use crop covers or protective structures to create a warmer microclimate around the plants and minimize exposure to chilling temperatures. ■

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